SAMPLE Invitation for Bid

COMMUNICATIONS SYSTEM
FOR CENTRAL LINK LIGHT RAIL

SAMPLE IFB NO. RTA/LR 101-03 / C803

Volume 2 of 7
Book 1 of 2
Contract Specifications

FEBRUARY 2004

THIS PROCUREMENT MAY BE SUBJECT TO ONE OR MORE FINANCIAL ASSISTANCE CONTRACTS BETWEEN SOUND TRANSIT AND THE U.S. DEPARTMENT OF TRANSPORTATION, WHICH INCORPORATE THE CURRENT FTA MASTER AGREEMENT AND CIRCULAR 4220.1E AS AMENDED. U.S. DEPARTMENT OF TRANSPORTATION’S LEVEL OF FINANCIAL ASSISTANCE MAY BE BETWEEN ZERO AND EIGHTY PERCENT (0-80%).
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DIVISION 1

GENERAL REQUIREMENTS
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SECTION 01110
SUMMARY OF WORK

PART 1 - GENERAL

1.01 OVERVIEW

This Section provides an overview of Communications Scope of Work as it relates to the Project, Sound Transit's Link Light Rail. Subsequent Sections provide detailed descriptions of the project requirements.

1.02 DESCRIPTION OF THE LINK LIGHT RAIL SYSTEM

A. The Link Light Rail Initial Segment will be a 14 mile line from north of the existing bus tunnel in downtown Seattle to South 154th Street Station in Tukwila, near the SeaTac Airport (see Figure 1 below.)

B. This initial 14 mile light rail line will serve downtown Seattle, the industrial area south of downtown, and residential and commercial neighborhoods in Beacon Hill, the Rainier Valley, Tukwila, and SeaTac. A shuttle bus will connect passengers to SeaTac International Airport, which is just a few minutes away from the South 154th Station.

C. In the Downtown area, Link will utilize the existing Downtown Seattle Transit Tunnel (DSTT) owned and operated by King County Metro. As part of the construction of Link, DSTT will be retrofitted to accommodate bus and train operations taking place simultaneously in this 1.3 mile segment. The current plan calls for trains every six minutes to alternate with buses in the DSTT.

1.03 CONFIGURATION

The 14 mile initial segment of the Link Light Rail will consist of approximately 1.3 miles of existing tunnel, one mile of new tunnel, 6.8 miles of new at-grade trackway, and 4.5 miles of new aerial trackway. Stations will include four existing tunnel stations, one new tunnel station, two new aerial stations, and four new at-grade stations. Additionally, Sound Transit has deferred one at-grade station, Royal Brougham, and one aerial station, Boeing Access Road, for future expansion.

1.04 DESCRIPTION OF THE COMMUNICATIONS SYSTEMS

A. The Link Communications Systems shall be designed to transmit, receive, store, process, and display all non-vital voice, data, and video communications for the benefit of Link Operations, Link Maintenance, Link Security, Sound Transit Administration, customer service, the public, and other agencies as required. While specifically non-vital, many of the subsystems of the Communications Systems can be considered mission critical.
FIGURE 1
Link Light Rail System Map
These sub-systems can be described as an integrated set of sub-systems that make up the fully integrated Communications System as represented in Figure 2 below and described as follows:

1. Central Control System (CCS) – The hardware and software required to provide a data processing and Human Machine Interface system enabling the reliable operations of Link from central location(s). CCS is part of the voice, video, and data network located at the Link management center.

2. Field Control System (FCS) – The hardware and software required to directly monitor and control specific remote hardware.

3. Communications Backbone (CB) – The hardware and firmware required to provide highly available communications between remote facilities/equipment and the management center(s) of Link.

4. Public Address and Variable Message Signs (PA/VMS) – The hardware and software required to provide the public and Link staff in key areas with ADA compliant information in a dynamic mode.

5. Tunnel Radio Distribution System – The hardware and software required to extend reliable radio frequency communications to mobile Link Staff, equipment, and emergency services such as Fire and Police in the underground facilities on Link.


7. PABX Phone System (PABX) – The hardware and firmware required to provide voice communications in specific locations for Link staff use. PABX is part of the voice, video, and data network located at the Link management center.

8. Emergency Phone System (ETEL) – The hardware and firmware required to provide Link staff and emergency services personnel, such as Fire and Police, with back-up voice communications in key areas in the event of an emergency.

9. Passenger Emergency Telephone (PET) – The hardware and firmware required to provide communications between distressed passengers and dedicated Link staff assigned to deal with passenger emergencies.

10. Network Management System (NMS) – The hardware and software required to monitor, control, and configure the Communications Systems from a centralized location. NMS is part of the central maintenance function.

11. Emergency Management Panel (EMP) – The hardware and software required to monitor and control the emergency facilities and systems designated in station(s) and on line sections in the event of an emergency.

12. Access Control Network (CAN) – The hardware and software required to provide intelligent key card access control and intrusion detection capability on Link.
1.05 SUMMARY OF WORK FOR C803

A. Design, furnish, install, and test a complete Communications System as generally described in 1.04 above. All design documents, equipment, software, and as-built documentation expressly required by the Contract Documents or implied by the functionality expressed in the Contract Documents shall be included in the scope of this Contract. It shall be the responsibility of Contractor to make the systems and equipment described herein to work as intended.

B. Contractor shall also supply the following additional cabling and equipment for use by others:

1. Design, furnish, install, and test 12-fibers for City of Seattle traffic signal system.

2. Design, furnish, install, and test six (6) fiber cable to Traction Power C807 Contract, as shown in Contract Drawings.

3. Design, furnish, install, and test six (6) fibers for Signals C802 Contract, as shown in Drawings.

4. Design, furnish, install, and test various communications and data circuits for King County Metro.

5. Design, furnish, install, and test 12 fibers to Union Station to connect to Sound Transit information systems and Sounder CCTV systems.

6. Design, furnish, install, and test new PA system at King County Metro’s Convention Place Station for bus only operation.

7. Design, furnish, install, and test LonWorks data network for C802 non-vital communications as shown in Contract Drawings.

C. Contractor shall also perform the following services, in addition to the minimal requirements of design, furnish, install, and test:

1. Factory Testing.

   Conduct an integrated factory test of all equipment as indicated.


   Conduct field tests of the completed Communications Systems as required by the Contract and as directed by the Resident Engineer.

3. Training.

   Develop a training program and train Sound Transit and/or its representatives to enable those trained to fully understand, utilize, configure, test, and train their future employees on the equipment, systems, and processes supplied under this Agreement and as indicated.
4. Integrated System Testing.

Perform integrated system testing indicated.

5. Reliability Demonstration Testing.

Perform reliability demonstration testing as indicated.


Provide technical and logistics support as indicated.

1.06 WORK NOT INCLUDED

A. In general, Contractor shall not be responsible for the civil, architectural, mechanical, or electrical power elements of Link. Meaning that stations, trackways, conduits, and electrical power should be in place prior to the start of Communications Work. The notable exception to this would be in rooms specific to communications such as Communications Rooms/Cabinets/Buildings at stations, OCC, CCER and Communications Maintenance where Contractor shall be responsible to complete the architectural and electrical attributes as well as provide any communications specific free standing enclosures or buildings. Additionally, Contractor may need to perform minor extensions (less than 25 ft) conduits or electrical power to meet its needs.

1. Systems elements not included in Contract.

a.) Traction Power – C807.

b.) Train or Bus Signaling – C802.

c.) Tunnel Emergency Fans and Motor Controllers.

d.) Light Rail Trains – P801.

e.) Ticket Vending Machines – P809.

f.) Station devices such as elevators, escalators, lighting, fire alarm systems, emergency generators or UPS (except as noted in this Contract), fire control, or suppression systems.

1.07 DEFINITIONS

A. “Design” means produce documentation of equipment, software, and systems including shop, fabrication, software designs, and schematic plans necessary to manufacture, assemble, or code those equipment, software, and systems and demonstrate to the Resident Engineer that the Design meets Contract specifications and functionality for intended use.

B. “Furnish” means to purchase materials or equipment and transport to the Project location where the Contractor will receive, verify integrity, store, secure, and protect the materials or equipment.
C. “Install” means to transport materials or equipment to the Work location, place and secure in position, connect power and other connections required, make final adjustments, and test and verify operation.

D. “Provide” means to furnish and install materials or equipment.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 PHASING

A. This Contract shall be built in two (2) phases: DSTT and Bus Only and Integrated Bus/Rail.

1. Phase 1 - DSTT Bus Only.

This phase includes bus only operations from Convention Place Station to Royal Brougham Way. Because of the need to transport passengers, DSTT operators including all fire/life/safety elements, bus signaling, radio, and other communications in the DSTT and at-grade line section from International District Station to Royal Brougham Way must be full tested and integrated. Other systems elements such as signaling (train only) and traction power for rail vehicles will be integrated in Phase 2.


This phase will turn over all rail operations and integrated operations with Rail/Buses in the DSTT.

PART 4 - MEASUREMENT AND PAYMENT

4.01 SUMMARY

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01110
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PART 1 - GENERAL

1.01 SECTION INCLUDES

Specifications for measurement and payment as they apply to the Work.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Unit measurement shall be for a specified unit of measure as defined in Schedule of Values or Bid Schedule.

B. Lump sum measurement shall be for the entire bid item, unit of Work, structure, or combination thereof, as listed indicated in the Schedule of Values or Bid Schedule.

4.02 PAYMENT

A. Schedule of Values.

All payments for Contract shall be paid according to Schedule of Values. Schedule of Values shall identify all payments whether Unit measure or Lump sum and shall break down costs of the designated lump sum payments to identify specific and quantifiable milestones or deliverables. Schedule of Values shall be developed by Contractor based upon:

1. Pay items in Table 01270-1.

2. An even distribution of payment across the term of Contract.

3. Not more than 35 percent of total Contract Value can be placed on design/engineering or project management items.

Schedule of Values shall be submitted for approval 15 days after Notice to Proceed.

B. Pay Items.

“Pay Items” such as program plans, designs submittals, technical data, manuals, test planning, procedures, etc., will be acceptable for payment when the completed documentation has been reviewed and approved by Resident Engineer. Payments shall be made according to Schedule of Values.
# TABLE 01270-1

C803 Communications - Pay Items

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<td>Emergency Telephone</td>
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<td>Passenger Emergency Telephone</td>
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C. Allowances.

Certain Pay Items shall be designated as “Allowance”. An allowance is an estimated dollar value for a specific Pay Item. Contractor shall for each Allowance submit a detailed explanation and recommendation of the type and amount of goods or services it intends to provide. Sound Transit may elect to purchase more or less than Contractor’s recommendation. Contractor shall invoice actual amount for all goods and services purchased under the designated allowance. No Change shall be required so long as all items invoiced by Contractor are approved by Sound Transit.

D. Progress Payments.

Not more than once per month Contractor shall submit to Resident Engineer invoice for Work completed on forms supplied by Resident Engineer. Invoice shall be certified and supported with evidence, if required by Resident Engineer, that Work invoiced has been completed. All items shall reference both Pay Items and Schedule of Values. Unless otherwise agreed to in writing, no equipment or materials shall be accepted for payment until fully installed, tested and verified. Partial payment for Pay Items shall only be acceptable if provided for in the Schedule of Values or agreed to, in writing, by Resident Engineer.

E. Compensation.

Payment for Work under Progress Payments shall constitute payment in full, as defined in the General Provisions, for all labor, materials, tools, equipment, transportation, services, and incidentals used in the performance of Work for each Pay Item.

F. Conditions of Payment.

1. Progress payment shall be made within 30 days of approval of invoice. In addition to providing satisfactory evidence that Work was completed, the following shall also be a condition of payment and must be submitted with invoice to Sound Transit:

   a.) Evidence satisfactory that all costs incurred by Contractor and its subcontractor have been paid.

   b.) Written unconditional waivers and releases of liens, stop notices and bond rights signed by the Contractor and each of its subcontractors and suppliers.

   c.) Retention, Sound Transit shall retain 10 percent of each progress payment until Final Payment.

G. Final Payment.

Upon final determination of all Contractor’s claims and acceptance of Work by Resident Engineer, Sound Transit shall pay entire sum found due on the approved Final Invoice including the amount, if any, allowed on claims. Sound Transit may elect to withhold sums sufficient to pay any outstanding claims, liens, or other rights or judgments against Contractor until such time as the Contractor can provide sufficient evidence that no such claims, liens or other rights or judgments exist on Work performed pursuant to Contract.
4.03 REJECTED, EXCESS, OR WASTED MATERIALS

Quantities of material wasted or disposed of in a manner not called for under the Contract; rejected loads of material, including material rejected after it has been placed by reasons of the failure of the Contractor to conform to the provisions of the Contract; material not unloaded from the transporting vehicle; material placed outside the lines indicated on the Contract drawings; or material remaining on hand after completion of the Work, will not be paid for, and such quantities shall not be included in the final total quantities. No additional compensation will be permitted for removing, loading, hauling, and disposing of rejected material.

END OF SECTION 01270
PART 1 - GENERAL

1.01 SECTION INCLUDES

Project meeting requirements.

1.02 SUBMITTALS

Provide comments on minutes of meetings produced by Resident Engineer. Provide additional information as needed to facilitate meeting or as directed by Resident Engineer.

1.03 POST AWARD MEETING

A. Attend an initial construction meeting not more than fifteen working days after the effective date of the Notice To Proceed. Contractor’s sponsor, superintendent, safety representative, EEO Officer, subcontractor representatives, and community relations representatives shall attend. A meeting notice and agenda will be distributed not less than four working days before the meeting.

B. Resident Engineer shall perform the following at this meeting:

1. Introduce Sound Transit and Resident Engineer and discuss organization as it relates to Work.

2. Explain and discuss responsibilities and authorities of Resident Engineer and Sound Transit.

3. Equal Employment Opportunity (EEO) and affirmative action requirements along with the Community Relations functions.

4. Explain and discuss quality control, inspection, and coordination of Work with Resident Engineer.

5. Discuss Contractor Health and Safety Plan, as specified in Section 01545, Health and Safety Plan Requirements, and arrangements for safety, first-aid, emergency actions, security, and full-time safety representative.

6. Discuss laws, codes, traffic regulations, permit requirements of public agencies and their regulations.

7. Establish procedures for processing progress payments, change notices, change orders, shop drawings, product data and samples.

8. Discuss community concerns.
C. Contractor shall perform the following at this meeting:

1. Introduce Contractor's representatives, and briefly describe each person's roll and responsibilities.

2. Distribute and discuss the list of major and Disadvantaged Business Enterprises (DBE) subcontractors including their areas of responsibility.

3. Discuss use of office, storage areas, staging areas, construction areas, and temporary easements.

4. Describe construction sequencing of entire Contract, identification of areas of concern, and preliminary schedule of work.

5. Discuss coordination and notifications required for any utility work/services, permitting, and third party inspections.

6. Discuss deliveries and priorities of major equipment and Factory Test.

7. Discuss Training Program.

8. Distribute and discuss proposed Schedule of Values.

1.04 INITIAL SAFETY AND INSURANCE MEETING

A. Meeting will be scheduled after the Post Award meeting.

B. The following will be discussed:

1. Owner-controlled insurance program, and introduce representatives of the Owner’s Insurance Administrator.

2. Submittal of the Contractor’s Health and Safety Plan, and introduction of the Owner’s construction safety and security representatives.

3. Construction "Hotline" telephone number, which will be answered by the community affairs representative, or during evening hours, by the answering service.

4. Define arrangements for safety, first-aid, emergency actions, security, and full-time safety representative.

1.05 PROGRESS MEETINGS

A. Progress meetings shall be scheduled each month and more often as necessary for the competent and timely execution of Contract. Progress meetings shall include at a minimum the Resident Engineer and Contractor’s Representative for the identification and resolution of issues. Additional persons that should be in attendance include representatives from any party scheduled to perform Work within the previous or next 30 days.
B. Contractor shall perform the following:

1. Prepare agenda with input and concurrence of Resident Engineer.

2. Distribute meeting agenda after concurrence and 48 hours prior to meeting to Resident Engineer and subcontractors engaged in Work.

3. Review and comment on Resident Engineer’s meeting minutes within 48 hours of receipt.

C. Resident Engineer shall perform the following:

1. Prepare meeting minutes with input and concurrence of Contractor.

2. Submit draft meeting minutes to Contractor within 72 hours of meeting for concurrence.

D. Progress Meetings shall include the following, at a minimum:

1. Introduction of attendees including explanation of duties on project.

2. Review minutes from previous meetings, amend minutes as necessary, and accept minutes.

3. Present Monthly Progress Report with analysis of issues, proposals of solutions, and corrective measures take or to be taken.

4. Discuss Work quality observations, problems, and employee Work standards.

5. Discuss changed conditions, time extensions, and other relevant subjects as they affect the progress of Work.

6. Discuss upcoming month’s Work.

7. Discussion and status of RFI’s.

E. Design Review Meetings.

1. Design reviews specified in the following paragraphs will be conducted by Resident Engineer. These reviews shall be conducted to evaluate the progress and technical adequacy of the design and the compatibility with the performance requirements of Contract. Approval, without a Change Order, by Resident Engineer shall not authorize departure from Contract requirements nor shall it relieve the Contractor from responsibility for design errors. Design reviews shall be scheduled by Contractor and shall be noted in approved schedule. Unless otherwise agreed, all design submittals shall be presented orally with visual and audible aids as necessary to convey concepts in an intelligible manner.

2. Design reviews shall include in chronological order as follows:

   a.) Conceptual Design Review: General overview of design process and tasks including presentation of materials as noted in various Sections.
b.) Preliminary Design Review: First substantial design review shall include all Sectional requirements and presentation of design issues and requests for information.

c.) Intermediate Design Review.

   1.) Presentation of all intermediate designs as noted in various Sections throughout Contract.

   2.) Resolution of RFI’s and issues.

d.) Final Design Review

   1.) Presentation of design progress and all final designs as noted in various Sections throughout Contract.

   2.) Resolution of RFI’s and issues

   3.) Installation Details Review: Completed design presentation including reliability analysis.

   4.) Test Plan & Commissioning Review: review of Contractors plans to test and commission system.

e.) Miscellaneous meetings as needed to review additional details.

1.06 WEEKLY CONSTRUCTION MEETINGS

Contractor shall interface and coordinate Work with other contractors also working for Sound Transit or near Contractor’s Work site. In as much as feasible, Contractor shall attend and participate in weekly coordination meetings held by other contractors for a period starting four weeks prior to start of Work in that specific area until Work is completed in that area. Contractor is expected to develop a look-ahead schedule for Work showing sufficient detail, key interfaces, and the relative critical path.

1.07 OTHER MEETINGS

Resident Engineer shall, at his/her own discretion, require additional meetings to inform, address issues, or review designs. Contractor shall make him/herself available as requested.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01310
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SECTION 01314
PROJECT SITE ADMINISTRATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

Requirements for project site Work.

1.02 SUPERINTENDENCE

A. Contractor shall maintain qualified and competent superintendence acceptable to the Resident Engineer on site at all times during the progress of Work. As such, Contractor shall submit qualifications, experience, and other documentation as may be required, in writing, on Contractor’s Representative and Deputies to Resident Engineer within 5 days after NTP and prior to starting Work. Resident Engineer may at its option require interview prior to acceptance of any or all Contractor Representatives.

1. Contractor’s Representative.

   a.) Contractor’s proposed Representative, upon approval by Resident Engineer, shall have full authority to act on the behalf of Contractor on all matters concerning Contract. In the event of an emergency or unplanned absence of Representative, Representative or Contractor shall designate approved deputies to act on behalf of the Contractor.

   b.) Contractor may, at its option, provide more than one lead Representative. However, this shall be limited to a total of three (3) persons and Contacto must establish clear and discernable lines of authority between the parties such as different functional areas. All representatives are subject to approval and removal by Resident Engineer at anytime.

2. Deputy Representatives.

   One or more senior project staff proposed by Contractor, upon approval by Resident Engineer, shall have full authority to act on behalf of Contractor from time to time during the course of Work while the Representative is unavailable as noted above.

3. Temporary Replacement of Representative.

   A temporary transfer of duties from Representative to Deputy Representative for a period of not more than 60 calendar days in any calendar year due to planned or unplanned absence of Representative is allowed. Contractor shall notify Resident Engineer in writing upon the temporary transfer of authority from Representative to Deputy.

4. Replacement of Superintendence.

   a.) Contractor shall notify Resident Engineer in writing when Contractor desires to replace any Representative or Deputy Representative once approved. Contractor shall provide all necessary information per this Section on proposed candidate for approval by Resident Engineer.
b.) Resident Engineer may, at its option, request replacement of any or all Contractor’s Representatives. Contractor shall have up to 90 calendar days to comply. Contractor shall be entitled to mobilization/demobilization expenses unless request is made for cause (i.e. sexual harassment, discrimination, repeat safety violations, reporting to work under the influence, or competence).

1.03 SUBCONTRACTORS, SUPPLIERS, AND HIRED FORCES

A. Contractor may choose to employ third party forces to complete various Sections of Work. This Section outlines Contractor’s responsibilities.

1. Subcontracting.

a.) Contractor shall comply with the Federal, State, and Local requirements concerning the listing of subcontractors by all persons submitting bids for public Work. Contractor shall furnish copies of all subcontracts to Resident Engineer.

b.) Contractor shall give its personal attention to the fulfillment of Contract and shall keep Work under Contractor’s control. No contractual relationship shall exist under Contract other than the contractual relationship between Sound Transit and Contractor. Contractor shall be obligated to Sound Transit for any rights, including those under equipment warranties that Sound Transit has against any of its subcontractors, suppliers, or other hired forces.

c.) Any claim by Contractor for additional compensation or schedule extension based upon a subcontractor, supplier, or hired third party shall be passed on only after an independent review and determination by Contractor that such claim has merit under the terms and conditions of the Contract.

d.) When a portion of Work, which is subcontracted by Contractor, is not performed in accordance with the Contract, the subcontractor shall be replaced on the request of Resident Engineer and shall not again be employed on Work.

2. Liability.

Contractor is liable for the performance, delays, or other acts by its subcontractors, suppliers, or hired third parties in the performance of Work. Contractor shall defend, hold harmless and indemnify Sound Transit and its directors, officers, representatives, agents, consultants, and employees against any and all liability arising out of or in any way attributable to Contractor’s relationship with any subcontractor, supplier, or hired third party in the performance of Work.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 4 - MEASUREMENT AND PAYMENT

4.01 SUMMARY

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01314
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SECTION 01320
CONSTRUCTION CONTRACT/SCHEDULES

PART 1 - GENERAL

1.01 SECTION INCLUDES

General requirements for the preparation, revision, and submittal of project progress schedules and the Monthly Progress Status Report.

1.02 QUALITY CONTROL

Comply with Section 01450, Systems Quality Requirements.

1.03 SUBMITTALS

A. Refer to Section 01330, Submittals, for submittal procedures.

B. The time scaled network diagram shall be submitted on sheets no smaller than 22 inches wide by 34 inches long or larger than 34 inches wide by 44 inches long. Three-week Work plan shall not be larger than 11 inches x 17 inches. Reports shall be on 8 ½ inches x 11 inches paper.

C. Schedule submittals shall include the following:

1. Preliminary 60-Day Schedule - One (1) reproducible and six (6) full size copies together with six (6) copies of narrative.

2. Project CPM Schedule - One (1) reproducible and six (6) full size copies together with six (6) copies of narrative.

3. Updates of Preliminary 60-Day and Project CPM Schedule - One (1) reproducible and six (6) full size copies together with six copies of narrative.


D. Re-submittals shall conform to the same requirements as original submittals.

E. Submit the Preliminary 60-Day, the Project CPM Schedule, and the updates as compressed electronic backup files on 3.5-inch diskettes, CD-ROM, or other permanent electronic storage medium.

F. Other format requirements shall be coordinated with Resident Engineer.

1.04 GENERAL

A. Schedules shall represent a practical plan to complete the Work within the Contract time and shall convey the Contractor's intent in the manner of prosecution and progress of the Work.

B. The scheduling and execution of construction in accordance with the Contract Documents for Construction are the responsibility of the Contractor.
C. The submittal of schedules shall be understood to be the Contractor's representation that the schedule meets the requirements of the Contract Documents and that the Work will be executed in the sequence and duration indicated in the schedule.

D. All schedule submittals are subject to review and acceptance by the Resident Engineer. Sound Transit retains the right to withhold progress payments until the Contractor submits a schedule, payment schedule, and schedule updates acceptable to the Resident Engineer.

E. The Contractor shall certify in writing that the Preliminary 60-Day and Project CPM Schedules have been discussed in detail with all subcontractors and major suppliers as it relates to their respective work and a copy submitted to the Resident Engineer.

F. The Contractor shall maintain on the project a scheduler qualified in CPM scheduling techniques and familiar with Primavera Project Planner scheduling software. The scheduler shall have the primary responsibility for monitoring status, updating progress and revising the Contract Schedule to reflect current Contract status. The Contractor shall verify qualification of the scheduler by providing a description of construction projects to which successful CPM network analysis has been applied. Submit a resume of the proposed schedule for approval by the Resident Engineer.

G. The Resident Engineer will provide the Contractor with formats for additional coding and reports. The Contractor shall incorporate these codes and report formats into the current version of the schedule.

H. The schedule shall conform to the Work-hours and constraints as outlined in the General Provisions of the Contract.

1.05 PRELIMINARY 60-DAY SCHEDULE

A. A schedule covering the first 60 calendar days of the Contract shall be submitted within 15 calendar days following the date of the Notice to Proceed.

B. The schedule shall be time-scaled and may be submitted in Critical Path Method (CPM) format.

C. Construction Work items defined in the schedule shall not exceed 14 calendar days in duration.

D. The submittal shall be accompanied by a written narrative that describes the schedule and the approach to the Work that the Contractor intends to employ during the initial 60-day period of the Contract.

1.06 PROJECT CPM SCHEDULE

A. A calendar time scaled CPM network diagram schedule covering the complete project shall be submitted within 45 days following the date of the Notice to Proceed. The Project CPM Schedule, acceptable to the Resident Engineer, shall be in place prior to the third Progress Payment Invoice being submitted.

B. The schedule shall be in accordance with all of the Contract requirements at the time of Notice to Proceed.
C. A schedule showing the Work completed in less than the Contract time, which is found practical by the Resident Engineer, shall be considered to have float. The float shall be the time between the scheduled completion of the Work and the Contract completion date. Float shall not be for the exclusive benefit of either Sound Transit or the Contractor. Float shall be a resource available to both parties as indicated in the General Provisions.

D. A schedule found to be impractical for the preceding reasons or any other reasons shall be revised by the Contractor and resubmitted.

E. The schedule shall be prepared utilizing the Precedence Diagram Method (PDM) of CPM scheduling technique.

F. The schedule shall show clearly the sequence and interdependence of activities and shall list specifically:
   1. Interim milestone completion dates. Phasing and staging of the Work as specified shall be prominently identified.
   2. Procurement, fabrication, delivery, installation, and testing of major materials and equipment.
   3. Submittals and Sound Transit review of shop drawings and material samples.
   4. Interfacing, coordination, and dependencies with preceding, concurrent, and follow-on Contractors.
   5. Restrictions of manpower, material, and/or equipment, if any.
   6. Delivery of Sound Transit-furnished equipment, if any.
   7. Inspection of the Work including punch list and acceptance.
   8. Work to be performed by other agencies which affect the schedule.
   9. Acquisition of permits.
   10. The costs of the Work for that activity in accordance with Schedule of Values (SOV). The costs of the individual activities and that of the total schedule shall conform to the Contract SOV.

G. Individual schedule construction activities shall not exceed 14 days in duration. Activities exceeding 14 days in duration shall be subdivided to an appropriate level.

H. Schedule activities shall be sufficiently described to include what is to be accomplished and which Work areas. Activity durations shall be expressed in whole days. Work that is to be performed by subcontract shall be clearly defined.

I. The schedule diagram shall indicate a clearly defined critical path, which shall be prominently distinguished.
J. A written narrative shall accompany the schedule submittal describing the Contractor's approach and methods for completion of the Work. The narrative shall be adequate for Sound Transit to understand the schedule.

1.07 THREE-WEEK LOOK AHEAD SCHEDULE

A. A schedule in a calendar time-scaled bar chart format depicting the Contractor's intended Work activities for the upcoming three (3) week period plus a one (1) week retrospective look shall be submitted on a weekly basis. Each activity lasting one day in duration shall be prominently noted.

B. Any deviations, including but not limited to sequences of Work, timing, and durations of activities, from the Preliminary 60-Day or Project CPM Schedule shall be noted and explained in writing.

C. The form of submittal may be in a medium no larger than 11 inches by 17 inches and no smaller than 8 ½ inches by 11 inches in size.

D. The schedule shall be submitted one (1) working day (24 hours) prior to the weekly progress meeting.

1.08 MONTHLY PROGRESS STATUS REPORT

A. The Monthly Progress Status Report is a narrative report that will describe Work activities accomplished in the reporting period, intended Work activities for upcoming reporting period, problem areas and actions intended by the Contractor to mitigate the problem areas, Work that is being performed out of sequence with accepted schedules, status of change orders, notices of potential claims, status of submittals, status of Contractor procurement items, and Community Relations activities. The Resident Engineer will provide format(s) for the narrative reporting at the pre-construction meeting.

B. The Monthly Progress Status Report shall be submitted in a medium 8 ½ inches by 11 inches in size. Charts may be submitted in a medium up to 11 inches by 17 inches in size.

1.09 REVIEW, UPDATE AND REVISIONS

A. Contractor shall allow for Sound Transit review with comments according to the following schedule from the date of receipt:

1. Preliminary 60-Day Schedule: Seven (7) calendar days

2. Project CPM Schedule: 14 calendar days

3. Three-Week Look Ahead Schedule: One (1) day

B. The Contractor shall make all corrections to the schedule requested by the Resident Engineer and resubmit the schedule for approval. If the Contractor does not agree with Sound Transit’s comments, the Contractor shall provide written notice of disagreement within five (5) days from the receipt of Sound Transit’s comments for the Project CPM Schedule. Sound Transit’s comments to the Preliminary 60-Day and Project CPM Schedules, and Three-Week Look Ahead Schedules for which the Contractor disagrees shall be resolved in a meeting held for that purpose, if necessary.
C. At least once each month, the Contractor shall submit an updated schedule showing the progress of the Work to date and anticipated activities to be worked on and the Monthly Progress Report. The update shall include the updated Schedule of Values. The update shall also include a tabular report sorted by early start and total float, a tabular report sorted by total float and early start, and a time scaled logic diagram showing the activities of the Project CPM Schedule and the balance of the schedule’s critical path. The update shall also include an electronic back-up of the Primavera Project Planner schedule file. Payment will not be made without an approved update of the Preliminary 60-Day or Project CPM Schedules.

D. The Project CPM schedule shall not be revised to include additional activities, deleted activities, revised activity durations, revised network logic, or any other changes to the schedule unless approved in advance by Sound Transit. Only actual progress, completion dates, and anticipated future progress shall be incorporated in a schedule update.

E. If according to the current updated project CPM schedule, the Contractor is thirty or more days behind the Contract completion date of any milestone, or the schedule contains thirty or more days of negative floats considering all granted time extensions, the Contractor shall submit a revised schedule showing a practical plan to complete the Work within the Contract time. Sound Transit may withhold progress payments until a revised schedule, acceptable to the Resident Engineer, is submitted by the Contractor at no additional cost.

F. Any changes to the planned sequence, activity durations, interdependency of activities and any other change to the schedule shall be submitted separately for review. Written notification and explanation for the proposed changes and separately revised CPM network schedule and reports shall accompany the submittal. Changes shall not be incorporated into the current schedule until the submittal has been accepted by Sound Transit at no additional cost.

G. Change Orders will be addressed in accordance with General Provisions and Special Provisions and incorporated into the detailed Project CPM Schedule as individual schedule activities.

1.10 REQUESTS FOR TIME EXTENSIONS

A. The Contractor is responsible for submitting a written request for any extensions of Contract Time within the time specified by the Contract. Requests not submitted in writing, without the required documentation, and not submitted in a timely manner will not be considered. Refer to General Provisions.

B. The request shall include documentation with written justification for the extension of time, supporting evidence and specific references to the Contract for which the basis of the request is being made.

C. The request shall also include an analysis of a calendar time-scaled CPM network schedule (FRAGNET) and reports depicting the time impact basis of the request with the affected areas prominently highlighted. The Schedule to be used in determining the time extension request shall be the current and accepted schedule at the time of the event.

D. If the Resident Engineer finds that the Contractor is entitled to an extension of time of any completion date under the provisions of the Contract, Sound Transit’s determination of the total number of days extension will be based upon the current analysis of the schedule and upon data relevant to the extension. Extensions of time for performance under any and all of the provisions of the Contract will be granted only to the extent that equitable time
adjustments for the activity or activities affected exceed the total float along the paths involved of the accepted and current schedule.

PART 2 - PRODUCTS

2.01 SCHEDULING SOFTWARE

Contractor shall use Primavera Project Planner (P3), Version 3.0 or later.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01320
SECTION 01330
SUBMITTALS

PART 1 - GENERAL

1.01 SECTION INCLUDES

General requirements and procedures for preparing and transmitting data to the Resident Engineer for approval.

1.02 RELATED SECTIONS

A. Section 01320 – Construction Contract Schedules.

B. Section 01335 – Shop Drawings, Product Data and Samples.

1.03 QUALITY CONTROL

Comply with Section 01450, Systems Quality Requirements.

1.04 REFERENCE STANDARDS

ANSI Y14, American Drafting Standards.

1.05 SUBMITTALS

A. Procedures.

1. This Section includes specifications for the general requirements and procedures for preparing and transmitting data to the Resident Engineer for information and approval. Detailed requirements for each submittal shall be contained in other Sections.

a.) All documents shall be in the English Language. Submittal shall clearly identify the purpose and intent of the submittal including specification and/or pay item reference. Contractor shall identify in the description all interfaces with other documents that are required to identify and interpret the submittal. All drawing match lines shall be identified and cross-referenced.

b.) Unless otherwise indicated, all submittals shall be prepared sufficiently in advance to allow Resident Engineer at least 30 calendar days to review before commencement of related Work.

c.) Submittal responses shall be within 30 days of receipt of submittal by Resident Engineer. A single marked-up copy of submittal with additional Submittal Review Form shall be returned to Contractor after submittals have been reviewed.

d.) Submittals not approved by Resident Engineer shall be corrected or completed and resubmitted by Contractor without impacting Contractor’s Schedule.
e.) No equipment, materials or software shall be used in Work without prior approval of Submittal by Resident Engineer.

f.) Submittals shall be shipped prepaid.

g.) Changes in accepted submittals will not be permitted unless those changes have been resubmitted in the same manner as the original submittal and accepted by the Resident Engineer.

h.) All submittals shall be complete with all relevant data required for review and acceptance by the Resident Engineer. Lack of data will be the cause for rejection of the submittal and the restart of the submittal cycle at the time of resubmittal. Partial submittals are not acceptable should only be submitted if directed to do so by Resident Engineer.

i.) Submit for approval, all construction that involves meeting the requirements of the Americans with Disabilities Act (ADA Compliance).

j.) All submittals shall be reviewed, approved, and signed by Contractor before submitting. The Contractor represents that it has determined and approved materials, field measurements and field construction criteria related thereto, and has checked and coordinated the information contained within such submittals with the requirements of the Work and the Contract requirements.

1.06 SUBMITTAL IDENTIFICATION

A. Resident Engineer will supply sample of transmittal sheet during Post Award Meeting and Contractor shall submit for approval the specific template for transmittal forms. Transmittal forms shall be supplied in duplicate for each submittal and the form shall contain at least the following information.

B. Title Block: Showing the following information:

1. Contractor’s name, address and telephone number.

2. Submittal number and date/revision date.

3. Contract title and number.

4. Supplier’s, manufacturer’s, or subcontractor’s name address and telephone number (as necessary).

5. When applicable, the seal and signature of a Resident Engineer and land surveyor, architect or landscape architect currently registered in the State of Washington, for the involved discipline.

6. Identification of product by description, model number, style number, serial number or lot number.

C. Description of Submittal.

A one or two sentence description of the material or information contained therein and the intent of that material or information as it relates to Work.

D. Action Block.

Include a 5 inch square blank space, in the lower right corner, just above the title block, in which the Resident Engineer may indicate the action taken.

E. Signature Block.

Each submittal and incorporate the following statement "Having checked this submission, we certify that it conforms to the requirements of the Contract in all respects, except as otherwise indicated": Contractor shall sign to that effect and date.

1.07 SUBMITTAL MATERIALS

A. Reports, Narratives, Calculations, and Diagrams.

1. Reports, Narratives, calculations and diagrams shall be submitted with the following:

a.) Cover (80 lb. minimum) identifying the following at a minimum:

1.) Contractor’s name, address, and telephone number.

2.) Submittal name, number, revision number, and date.

3.) Contract title and number.

4.) Transmittal number.

b.) Internal Sheets shall be submitted with the following:

1.) Nominally 8.5” by 11” 20 lb. white bond.

2.) Optionally 11” by 17” 20 lb. white bond – folded to 8.5” by 11”.

3.) Font: Arial, Text Size 11 point.

4.) Margins 1.5” bound side, 1” on all others.

5.) Header that identifies submittal name, number, and revision.

6.) Footer that identifies Contractor name, contract number, contract title, page number and date.
7.) Binding that shall be staples for submittals under 50 pages and screw posts for submittals over 50 pages.

2. All submittals over ten (10) pages in length or with excessive calculations shall require an executive summary and table of contents.

3. Drawings.
   a.) Drawings shall be submitted with the following:
      1.) Cover (80 lb. minimum) identifying the following at a minimum:
          - Contractor’s name, address, and telephone number.
          - Submittal name, number, revision number, and date.
          - Contract title and number.
          - Transmittal number.
   b.) Internal Sheets shall be submitted with the following:
      1.) Nominally 11” by 17” 20 lb. white bond.
      2.) Optionally full size drawings may be used: 22” x 34” 20 lb. white bond.
   c.) Binding that shall be staples for submittals under 50 pages and screw posts for submittals over 50 pages.
   d.) All submittals over ten (10) pages in length or with excessive calculations shall require an executive summary and table of contents.

4. Schedules.
   a.) Schedules shall be submitted with the following:
      1.) Cover (80 lb. minimum) identifying the following at a minimum:
          - Contractor’s name, address, and telephone number.
          - Submittal name, number, revision number, and date.
          - Contract title and number.
          - Transmittal number.
b.) Internal Sheets shall be submitted with the following:

   1.) Nominally 8.5” by 11” 20 lb. white bond.

   2.) Optionally 11” by 17” 20 lb. white bond – folded to 8.5” by 11”.

   3.) Margins 1.5” bound side, 1” on all others.

   4.) Header that identifies submittal name, number, and revision.

   5.) Footer that identifies Contractor name, contract number, contract title, page number and date.

c.) Binding that shall be stapled for submittals under 50 pages and screw posts for submittals over 50 pages.

d.) All submittals over ten (10) pages in length or with excessive calculations shall require an executive summary and table of contents.

5. Data and Photographs.

Data and Photographs that require submittal to Resident Engineer shall be provided in a format acceptable to Resident Engineer.

6. Product Data and Samples.

   a.) Contractor shall submit cover letter with all product data and samples that clearly identifies the following at a minimum:

      1.) Contract title and number.

      2.) Reference contract drawing numbers where product is to be used.

      3.) Applicable Contract Specification Section Numbers.

      4.) Applicable standards.

      5.) Identification of deviations from the Contract Drawings and Specifications.

      6.) Contractor’s stamp, initialed or signed, certifying compatibility for intended use and compliance with Contract standards and specifications.

   b.) Product Data shall consist of, at a minimum, the manufacturer’s standard catalog cuts, brochures, diagrams, schedules, performance charts, illustrations, calculations, and other descriptive data that is applicable to Contract. Contractor shall clearly identify the option or options it desires approval. Contractor, at his own risk, shall be responsible to ensure Resident Engineer understands the intent of submittal and the material, equipment, or software to be used.
c.) Samples shall also clearly identify the make, model, or version number of material, equipment or software that is being provided. Contractor, at his own risk, shall be responsible to ensure Resident Engineer understands the intent of submittal and the material, equipment, or software to be used. Contractor shall make available all samples for a minimum of 30 days for review including software.

1.08 COPIES AND ELECTRONIC FILES

A. Contractor shall submit six (6) material copies of all submittals and a single electronic copy.

B. Electronic versions of all paper submittals except drawings or schedules shall be submitted in Adobe Acrobat format (pdf) version to be approved prior to first submittal.

C. Electronic versions of all drawing submittals shall be submitted in Sound Transit approved Auto Cad format (dwg).

D. Electronic versions of all schedule submittals shall be submitted in Sound Transit approved Primavera format.

E. Electronic submittals of software shall be submitted in an agreed format for evaluation.

1.09 CONTRACTOR REVIEW

Review submittals and stamp and sign each submitted item as reviewed and approved before submission to the Resident Engineer.

1.10 SOUND TRANSIT REVIEW

A. All submittals will be reviewed for conformance to requirements of the Contract Documents. Review of a separate item will not constitute review of an assembly in which the item functions. Review will not relieve Contractor from its responsibility for accuracy of submittals, for conformity of submittals to requirements of Contract Documents, for compatibility of described product with contiguous products and the rest of the system, or for prosecution and completion of the Contract in accordance with the Contract Documents.

B. Submittals will have a review stamp affixed. The review stamp will have an indicated action, date and reviewer signature.

C. The submittals will be reviewed for general conformance with the Contract Documents. One set of the submittal will be returned to the Contractor marked accordingly to the required actions. Sound Transit has the right of disapproval of any submission.

D. The action block stamp marks will have the following meanings:

1. The mark ‘NO EXCEPTIONS TAKEN’ is an acceptance, and means that every illustration and description appears to conform to the respective requirements of the Contract Documents; that fabrication, assembly, manufacture, installation, application and erection of the illustrated and described product may proceed; and that the submittal need not be resubmitted.

2. The mark ‘EXCEPTIONS NOTED’ is an acceptance, and means that every illustration and description appears to conform to the respective requirements of the Contract Documents upon incorporation of the reviewer’s corrections, and that fabrication,
assembly, manufacture, installation, application and erection of the illustrated and described product may proceed. Submittals so marked need not be resubmitted immediately unless the Contractor challenges the reviewer's exception. Noted correction shall be resubmitted for record within 30 days of date approved as noted.

3. The mark ‘REJECTED, REVISE AND RESUBMIT’ is a disapproval, and means that the submittal is deficient to the degree that the reviewer cannot correct the submittal with a reasonable degree of effort, has not made a thorough review of the submittal, and that the submittal needs revision, correction and to be resubmitted.

E. In the event a submittal is rejected twice, contractor shall pay Sound Transit for review based on $100.00 per one hour of review.

1.11 CONTRACTOR RESPONSIBILITIES

A. Coordinate each submittal with the requirements of the Work. Place particular emphasis upon assuring that each submittal of one trade is compatible with other submittals of that trade and with submittals of other trades.

B. Approval of drawings and associated calculations by the Resident Engineer does not relieve the Contractor from the responsibility for errors or omissions in the drawings and associated calculations, or from deviations from the Contract Documents, unless such deviations were specifically called to the attention of the Resident Engineer in the letter of transmittal submitted with the drawings and approved as a Contract change. The Contractor is responsible for the correctness of the drawings, for shop fits and field connections, and for the results obtained by use of such drawings.

C. Distribution of Submittals After Review.

Distribute prints of accepted submittals, bearing the Resident Engineer's signature, to Contractor's field office and the Resident Engineer's field office; to concerned subcontractors, suppliers and fabricators; and to concerned members of the Contractor's workforce.

D. Contractor's Liability to Sound Transit.

In case of deviations in the submittals from the requirements of the Contract Documents, is not relieved by the Resident Engineer's review and approval of submittals containing deviations, unless Sound Transit expressly approves the deviations by issuing a change order.

PART 2 - PRODUCTS

As noted above.

PART 3 - EXECUTION

3.01 CONTRACT REQUIREMENTS DATA LIST

Contractor shall follow submittals listed in the Contract Requirements Data List (CDRL) in Appendix G, Contract Data Requirements List, and as noted elsewhere in this Contract.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01330
SECTION 01335
SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

PART 1 - GENERAL

1.01 SECTION INCLUDES

General requirements and procedures for preparing and submitting Shop Drawings, Working Drawings, Product Data, and Samples required by individual Specification Sections.

1.02 RELATED SECTIONS

A. Section 01330 – Submittals.

B. Section 01785 – Operations and Maintenance Manuals.

1.03 QUALITY CONTROL

Comply with Section 01450, Systems Quality Requirements.

1.04 REFERENCE STANDARDS

ANSI Y14, American Drafting Standards.

1.05 SUBMITTALS

A. Refer to Section 01330, Submittals, for submittal procedures and quantities.

B. Unless otherwise directed, submit one (1) reproducible and two (2) copies of working drawings to the Resident Engineer at least 30 calendar days in advance of their being required for the Work.

1.06 CONTRACTOR RESPONSIBILITIES

A. Verify field measurements, catalog numbers, and similar data.

B. Do not start Work for which submittals are required until submittals bearing the stamp of the Resident Engineer and signatures indicating review and verification have been received.

1.07 REVIEW BY THE RESIDENT ENGINEER

One (1) marked up reproducible copy of shop drawings, one (1) copy of product data, and one (1) sample will be returned to the Contractor within 30 calendar days after submittals have been received.
1.08 SHOP DRAWINGS

A. General

1. Shop Drawings will have been approved by the Resident Engineer before any Work involving such Drawings is performed. Shop Drawings shall be submitted not less than 30 days before any Work involving such drawings shall be performed.

2. All approved Shop Drawings and catalog cuts shall be submitted to the Resident Engineer upon completion of the Work. All pages of catalog cuts shall be clear, legible, and permanent. The Shop Drawings shall be original and reproducible. These Shop Drawings and catalog cuts shall be marked "As Built" and will become the property of Sound Transit.

B. Shop drawings shall be submitted in accordance with the following requirements:

1. Shop drawings shall be limited to the following standard sizes (in inches), except as otherwise permitted by the Resident Engineer:

<table>
<thead>
<tr>
<th>WIDTH (Vertical)</th>
<th>x</th>
<th>LENGTH (Horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>x</td>
<td>11.0</td>
</tr>
<tr>
<td>11.0</td>
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<td>8.5</td>
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<td>11.0</td>
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<td>22.0 Maximum</td>
<td>x</td>
<td>34.0 Maximum</td>
</tr>
</tbody>
</table>

2. Shop Drawings shall have a title block in the lower right hand corner which shall identify Contractor, subcontractor, the Contract by number and title, the subject matter of the drawing, the sheet number and date of original issue of the drawing, and the serial number and date of each revision. A space 5 inches square for an Resident Engineer's stamp shall be left above the title block.

C. Final Shop Drawings shall be submitted to Sound Transit, except as indicated below. In addition to the requirements of ANSI Y14.2, Shop Drawings submitted shall be the original or of equal quality in a reproducible form and electronic AutoCAD (version agreed to by Resident Engineer) Drawing file with all related files and an Acrobat (version agreed to by Resident Engineer) PDF file of the original. Sufficient dimensions shall be provided on engineering drawings so that size, shape, and location may be determined without calculation. As a minimum, the following dimension conditions are required:

1. Each dimension shall be shown clearly so that only one interpretation is possible.

2. Dimensions shall be shown between points, lines, or surfaces having a necessary and specific relationship to each other or which control the location of mating parts or components.

3. Dimensions shall be selected and arranged to avoid accumulation of tolerances that might ultimately permit more than one interpretation resulting in unsatisfactory mating of parts and failure in use.

4. Each dimension for a feature shall be shown once.

5. When possible, each feature shall be dimensioned in the view where it appears in profile or the one depicting its true profile.
6. Applicable dimensioning and tolerance practices shall be followed as specified in ANSI Y14.5.

7. Each Shop Drawing shall be updated to reflect the latest configuration, which shall include all change orders.

8. The Shop Drawings shall include details necessary for the installation, maintenance, and repair of all equipment provided.

9. Sample Drawings.

The first drawings submitted by Contractor or subcontractor or vendor will be reviewed by the Resident Engineer for conformance to the requirements of this Section. Once approval is given, use this drawing as the standard and prepare subsequent drawings to a quality equal to the approved standard.

D. Shop Drawings which will not be submitted, will be those determined by the Resident Engineer to be unnecessary.

1. Working drawings of temporary installation, which will not be a part of the finished installation.

2. Drawings showing method or schemes for accomplishing Work.

3. Drawings that duplicate details of Work shown on the Contract Drawings.

4. Drawings or catalogue cuts which are incorporated in Operations and Maintenance Manuals.

1.09 PRODUCT DATA

In general, Contractor shall use manufacturer's standard product data with specific features and options clearly identified as they are to be supplied to Sound Transit. Modifications to the manufacturer's standard information may be required as follows:

A. Modify manufacturers' standard schematic drawings to delete excessive information, which is not applicable to the Contract. Supplement standard information with additional information applicable to this Contract.

B. Modify manufacturers' standard catalog cuts, brochures, diagrams, schedules, performance charts, illustrations, calculations, and other descriptive data to delete excessive information that is not applicable to the Contract. Ensure that dimensions, clearances, performance characteristics, capacities, wiring and piping diagrams, and controls are clear and comprehensive enough that Resident Engineer can determine that product or service meets the Specifications.

C. Modify manufacturer's printed installation, erection, application, and placing instructions to delete excessive information, which is not applicable to the Contract and ensure all key parameters are spelled out.
D. Include the following:

1. Contract title and number.

2. Reference Drawing numbers.

3. Applicable Specification Section numbers.

4. Applicable standards, such as ASTM or Federal Specification numbers.

5. Identification of deviations from the Drawings and Specifications.

6. Contractor's stamp, initialed or signed, shall certify the following

   a.) Dimensional compatibility of the product with the space in which it is intended to be used.

   b.) Review of submittals for compliance with the specified requirements.

   c.) Compatibility of the product with other products with which it is to perform or with which it will be contiguous.

   d.) Certificate of Compliance: As defined in Section 01450, Systems Quality Requirements.

1.) The Resident Engineer may permit the use of certain materials prior to sampling and testing if accompanied by a certificate of compliance stating that the materials involved comply in all respects with the requirements of the Specifications. The certificate shall be signed by the manufacturer of the material. A certificate of compliance shall be furnished with each lot of material delivered to the worksite and the lot so certified shall be clearly identified in the certificate.

2.) All materials used on the basis of a certificate of compliance may be sampled and tested at any time. The fact that material is used on the basis of a certificate of compliance shall not relieve the Contractor of responsibility for incorporating material in the Work which conforms to the requirements of the Contract Drawings and Specifications and any such material not conforming to such requirements will be subject to rejection whether in place or not.

3.) The Resident Engineer reserves the right to refuse to permit the use of material on the basis of a certificate of compliance without test data.

1.10 SAMPLES

A. Furnish to the Resident Engineer samples indicated in the Special Provisions or these Specifications. Submit samples without charge, with shipping charges prepaid. Materials for which samples are required shall not be used in the Work until samples are provided and reviewed.
B. Each sample shall be labeled with the following data:

1. Name, number, and location on project.
2. Name of Contractor.
3. Material or equipment represented, and location in the project.
4. Name of producer, brand, trade name if applicable, and place of origin.
5. Date of submittal.

C. Forward a letter in triplicate to the Resident Engineer submitting each shipment of samples and containing the information required in the previous article. Verification of a sample will be only for the characteristics and use named in the submittal and verification, and shall not be construed to change or modify any Contract requirement. Before submitting samples, assure the Resident Engineer that the materials or equipment will be available in the quantities required in the project.

D. Samples of material from local sources shall be taken by or in the presence of the Resident Engineer; otherwise the samples will not be considered for testing.

E. Samples approved to be in compliance with the Contract Documents and not damaged in testing may be incorporated in the finished Work if marked for identification and approved by the Resident Engineer. Materials incorporated in the Work shall match the approved samples.

F. Failure of any material to pass the specified tests will be sufficient cause for refusal to consider, under this Contract, any further samples of the same brand, make, or source of that material. The Resident Engineer reserves the right to disapprove any material, which has previously proven unsatisfactory in service.

G. Samples of material delivered on the worksite or in place may be taken by the Resident Engineer for testing. Failure of samples to meet Contract requirements will annul previous approvals of the item tested.

1.11 OTHER SUBMITTALS

A. Other submittals shall be furnished upon request for the Resident Engineer to verify compliance of all equipment and materials with the Contract Documents. These submittals shall include in addition to shop drawings:

1. Catalog Cuts.
2. Certifications of Compliance.
3. Any other substantiating information or samples of material items as necessary.

B. Operation and Maintenance manuals shall be submitted as indicated in Section 01785, Operation and Maintenance Manuals.
1.12 CHANGES

Changes in products for which shop drawings, product data, or samples have been submitted will not be permitted unless those changes have been reviewed and are in conformance with the Contract Documents and acknowledged by the Resident Engineer, in writing, as provided in the General Provisions.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01335
SECTION 01420
REFERENCE STANDARDS

PART 1 - GENERAL

1.01 OVERVIEW

This Section is provided to list all references used in the production of Work.

1.02 USAGE

A. Referenced standards provided in this Section are intended for use as a guide in the performance of Work. Contractor shall be prepared to demonstrate compliance with applicable standards for Work, upon request by Resident Engineer.

B. Upon request, Contractor shall provide Resident Engineer with one print copy of each specific standard requested.

C. Unless otherwise stated, Contractor shall use the latest standards in use at the time of Contract Award.

1.03 REFERENCE STANDARDS

A. 47 CFR.

1. 47 CFR 1.1310, "Radio Frequency Radiation Exposure Limits".

2. 47 CFR 15.105, "Radiated Emission Limits".

3. 47 CFR 68.218(b)(1), “Connection of Terminal Equipment to the Telephone Network”.


D. (AASHTO) American Association of State Highway and Transportation Officials Standards.


F. (AHDGA) American Hot-Dip Galvanizers Association, Inc.

AHDGA Inspection Manual for Hot-Dip Galvanized Products.


3. ANSI C80.1 Rigid Steel Conduit - Zinc Coated.

4. ANSI MC96.1 Temperature Measurement Thermocouples.


7. ANSI T1.101-1999 “Telecommunications - Synchronization Interface Standards for Digital Networks”.

8. ANSI T1.102.01-1996 (R2001), “Telecommunications - Digital Hierarchy - VT1.5 Electrical Interface”.


11. ANSI T1.105, “Telecommunications-Synchronous Optical Network (SONET)-Basic Description including Multiplex Structure, Rates, and Formats”.


15. ANSI T1.105.04-1995 (R2001), "Telecommunications-Synchronous Optical Network (SONET)- Communications Channel Protocols and Architectures".


19. ANSI T1.105.08-2001, “Directory Service for Telecommunications Management Network (TMN) and Synchronous Optical Network (SONET)”.


22. ANSI T1.403, "Carrier to Customer Installation DS1 Metallic Interface".  

23. ANSI Y.14 American Drafting Standards.  

24. ANSI Z87.1 Practice for Occupational Educational Eye and Face Protection.  

25. ANSI/AWS A2.4 Standard Symbols for Welding, Brazing, and Nondestructive Examination.  


27. ANSI/AWS A5 Series Filler Metal Specifications.  


29. ANSI/AWS D1.1 Structural Welding Code – Steel.  

30. ANSI/AWS D1.3 Structural Welding Code - Sheet Steel.  

31. ANSI/EIA/TIA-232, “Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange”.  


38. ANSI/NFPA 70 National Electrical Code.  

39. ANSI/TIA/EIA-310-D, “Cabinets, Racks, Panels, and Associated Equipment”.  


41. ANSI/TIA/EIA-455 Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components.
42. ANSI/TIA/EIA-464-B, “Requirements for Private Branch Exchange (PBX) Switching Equipment for Voiceband Applications”.


44. ANSI/TIA/EIA- 569, 569-A Commercial Building Standard for Telecommunications Pathways and Spaces.


46. ANSI/TIA/EIA-598 Optical Fiber Color Coding.


48. ANSI/TIA/EIA-607, Commercial Building Grounding and Bonding Requirements for Telecommunications.


H. (ANST) American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A.


11. ASTM A307 Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

12. ASTM A316 Specification for Acid Resistant Austenitic Stainless Steel.

13. ASTM A384 Practice for Safeguarding Against Warpage and Distortion during Hot-Dip Galvanizing of Steel Assemblies.


15. ASTM A449 Specification for Quenched and Tempered Steel Bolts and Studs.

16. ASTM A500 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

17. ASTM A501 Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.

18. ASTM A536 Specifications for Ductile Iron Castings.


20. ASTM A607 Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Columbium or Vanadium, or Both, Hot-Rolled and Cold-Rolled.

21. ASTM A615 Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

22. ASTM A653 Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

23. ASTM A668 Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use.


25. ASTM B3 Specification for Soft or Annealed Copper Wire.

26. ASTM B6 Zinc.

27. ASTM B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

28. ASTM B33 Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.


30. ASTM B172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors.


34. ASTM C33 Specification for Concrete Aggregates.

35. ASTM D5-97, Standard Test Method for Penetration of Bituminous Materials

36. ASTM D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

37. ASTM D257-99, Standard Test Methods for DC Resistance or Conductance of Insulating Materials

38. ASTM D523 Standard Test Method for Specular Gloss


42. ASTM D2092 Standard Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting.


45. ASTM D2671 Test Methods for Heat-Shrinkable Tubing for Electrical Use.

46. ASTM D3363 Standard Test Method for Film Hardness by Pencil Test.


49. ASTM E164 Practice for Ultrasonic Contact Examination of Weldments.


52. ASTM E709 Guide for Magnetic Particle Examination.


54. ASTM E1032 Method for Radiographic Examination of Weldments.

55. ASTM F436 Specification for Hardened Steel Washers.


J. ATIS T1.101, “Synchronization Interface for Digital Network, for Telecommunications”.


AWS QCI Standard for AWS Certification of Welding Inspectors.


N. Electronic Industries Association (EIA).


2. EIA Standards RS 222-C, RS 485.


4. EIA-709.3 Free-Topology Twisted-Pair Channel Specification.


2. FCC Part 15 Class A.


Q. Institute of Electrical and Electronics Engineers (IEEE).


3. IEEE 802 – Local and Metropolitan Area Networks.

4. IEEE 802.1 – Bridging and Management.


6. IEEE 802.1P – Local and Metropolitan Area Networks (Prioritization).

7. IEEE 802.1Q – Local and Metropolitan Area Networks (VLAN Tagging).


9. IEEE 802.3 – Local and Metropolitan Area Networks.


S. ITU - International Telecommunication Union.


3. ITU-T G.711, “Pulse Code Modulation (PCM) of Voice Frequencies”.


5. ITU-T V.90, “Series V: Data Communications Over The Telephone Network; A Digital Modem and Analogue Modem Pair For Use On The Public Switched Telephone Network (PSTN) At Data Signaling Rates Of Up To 56 000 Bits/S Downstream And Up To 33 600 Bits/s Upstream”.

T. J-STD-607, “Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications”.

U. MIL Standards.


2. MIL-STD 1472, "Human Engineering".


V. The Modbus Organization.


1. NAAMM 531 Metal Bar Grating Manual.

X. (NEBS) Network Equipment Building Systems.

1. NEBS GR-63 Physical Protection.

2. NEBS GR-1089 Electromagnetic Compatibility and Electric Safety.


1. NEC 100.

2. NEC 250 Part C and NEC 250-90.

3. NEC 800-30 Protective Devices.
   1. FG-1-1993: Fiberglass Cable Tray Systems
   3. TC-2-2003: Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
   4. TC-3-1999: PVC Fittings for Use with Rigid PVC Conduit and Tubing
   5. TC-14-2002: Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
   6. VE-1-2002: Metal Cable Tray Systems
   7. WC70: Nonshielded Power Cables Rated 2000 Volts or less for the Distribution of Electrical Energy
   9. NEMA: FG1, TC6, VE 1, and VE 2.


   2. NFPA 70 (National Electrical Code) Sections 100-300 and Section 800.

CC. (OSHA) Occupational Safety and Health Administration.

   Occupational Safety and Health Administration (OSHA), Standards and Regulations, 29 CFR 1910 and 29 CFR 1926.
DD. RFC.
   1. RFC-958 “Network Time Protocol”.
   2. RFC-1059 “Network Time Protocol version 1”.
   4. RFC-1305 “Network Time Protocol version 3”.

EE. RUS Bulletin 1753E-001, “General Specification for Digital, Stored Program Controlled Central Office Equipment”.

FF. Software Cost Estimation with Cocomo II – Barry W. Boehm, et al.


HH. Telcordia.
   6. Telcordia GR-820-CORE, "OTGR Section 5.1: Generic Transmission Surveillance".
   11. Telcordia TR-NPL-000320, "Fundamental Generic Requirements for Metallic Digital Signal Cross-Connect Systems DSX-1, -1C, -2, -3".


II. Telecommunications Industries Association (TIA).


2. TIA/EIA 136, Rev B; TIA/EIA-95-B.

3. TIA/EIA 603-1 – Land Mobile FM or PM Communications Equipment Measurement and Performance.


5. TIA/EIA TSB-72 Centralized Optical Fiber Cabling Guidelines.

6. TIA/EIA/IS-811, “Performance and Interoperability Requirements for Voice-over IP (VoIP) Feature Telephones”.

7. TIA/EIA/IS-968, “Connection of Terminal Equipment to the Telephone Network”.

8. TIA/EIA/TSB116, “IP Telephony Equipment - Voice Quality Recommendations for IP Telephony”.


10. TIA/EIA-3700, "Telephone Network Transmission Model for Evaluating Analog Modem Performance".

11. TIA/EIA-455: Fiber Optic Test Standards.


16. TIA/EIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.

17. TIA/EIA-758: Customer Owned Outside Plant.


JJ. TSB-129-A, "U.S. Network Connections Regulatory Approval Guide".

KK. Underwriters Laboratories (UL).

1. UL 50, "Standards for Safety for Enclosures of Electrical Equipment".

2. UL 508, "Electrical Safety Standard".

3. UL 924A, "Standard for Emergency Lighting and Power Equipment".

4. UL 969, "Marking and Labeling Systems".

5. UL: 1, 6, 514A, 514B, 514C, 651, and 1666.

6. UL 497, "Protectors for Paired Conductor Communication Circuits".

7. UL 910, "Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air".

8. UL 969, "Marking and Labeling Systems".

9. UL 1778, "Uninterruptible Power Supply Equipment".


MM. Uniform Building Code, Including the Seismic Requirements of Section 2312, for Earthquake Zone 3.

NN. United States Department of Health and Human Services, (DHHS) "NIOSH Sampling and Analytical Methods, "DHHS (NIOSH) Publication 84-100.


PP. Washington Industrial Safety and Health Act.

QQ. Writing Effective Use Cases – Alistair Cockburn.
PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01420
PART 1 - GENERAL

1.01 DESCRIPTION

This section defines the requirements for the Contractor to establish, implement and maintain an effective Quality Program to manage, control, document and assure that the work complies with the requirements of the Contract Documents. The Quality Program shall consist of plans, programs, procedures and the organization necessary to assure quality for materials, equipment, workmanship, manufacturing, installation and operations covering both on site and off site work by the Contractor, including its subcontractors, suppliers, technical laboratories and consultants.

1.02 REFERENCE STANDARDS


C. FTA–IT-90-5001-02.1, Quality Assurance and Quality Control Guidelines.

1.03 SUBMITTALS

A. Refer to Section 01330, Submittals, for submittal procedures.

B. Submit draft Quality Plan with a Quality Organizational Chart and the Quality Assurance Manager’s resume at the Post Award Meeting specified in Section 01310, Project Meetings.

C. Submit final Quality Plan along with the Conceptual Design Report.

D. Submit Monthly Quality Report within seven (7) calendar days after the end of each month.

1.04 QUALIFICATIONS

A. The Contractor shall assign a Quality Assurance (QA) Manager assigned to this Contract who shall be responsible for managing and acting on all quality matters and shall have the authority to act on all quality matters as a representative of the Contractor. The Quality Assurance Manager shall not be subordinate to Contractor’s personnel that directly perform, supervise or progress the work. The Quality Assurance Manager shall not be responsible for directly performing, supervising or progressing the work or have any responsibilities for this project that conflict or appear to conflict with his primary responsibility for quality matters. The QA Manager shall be fully qualified by experience and technical training to perform the Quality Control (QC) and QA activities and implement the Quality Plan (QP). The resume of the Quality Assurance Manager must include a description of the duties, responsibilities, and the QC and QA record of assignments for the preceding ten-year period that establishes the candidate’s Quality Management experience. The QA Manager’s qualifications shall be submitted for approval with the QP.

B. The QA Manager shall be responsible for developing and implementing the QP. The QA Manager shall maintain a diary or activity log indicating all major activities related to the management of quality on this project that were personally performed by the QA Manager,
and each entry in the diary or log shall be personally signed and dated. The QA Manager or his/her representative shall attend the periodic progress meetings.

C. The Quality Assurance Manager, or his/her designated quality representative, shall submit a Monthly Quality Report of all major activities and quality issues related to the management of quality that were performed by the Quality Assurance Manager or his/her staff. The Monthly Quality Report shall be submitted to ENGINEER within seven calendar days after the end of each month.

PART 2 - PRODUCTS

2.01 CONTRACTOR QUALITY PLAN

A. The Contractor Quality Plan (QP) shall provide descriptions of, and references to Quality procedures and instructions, including specific requirements unique to this Contract, which relate to the quality system elements defined in: FTA Quality Assurance and Quality Control Guidelines, FTA–IT-90-5001-02.1; Quality Management Systems – Fundamentals and Vocabulary ANSI/ISO/ASQ 9000:2000, and; Quality Management Systems Requirements, ANSI/ISO/ASQ 9001:2000. The QP shall include, but not be limited to, the following sections:

1. QA/QC organization and staff, including job description, and an organizational chart showing the relationship between the Contractor’s General Manager, Project Manager, QA Manager, subcontractors and consultants.

2. Documented Quality System.

3. Design Control.


5. Subcontractor, Consultant and Supplier control.

6. Receiving, Handling, Storage and Control of Materials and Equipment.

7. Process Control and Control of Special Fabrication Processes, i.e. Welding, Plating, Soldering, etc.

8. Inspection and Test Plans.


10. Inspection and Test Status.

11. Identification, Control and Correction of Non-conforming Conditions.

12. Corrective Actions.


15. Training (QA/QC).

B. Acceptance of the QP is conditional and will be predicated on satisfactory performance during design, procurement, manufacturing, installation, construction and testing. As the work progresses the Contractor shall evaluate the effectiveness of the QP. If the QP is determined to be unable to obtain the quality of work required in the Contract Documents, the Contractor shall revise the QP to meet those requirements, and submit the updated QP as a revised submittal for review and approval.

C. If the Contractor fails to submit an acceptable Quality Plan within the prescribed time, at the discretion of Engineer, payments shall be withheld until Contractor submits an acceptable QP.

2.02 ELEMENTS OF THE QUALITY PLAN

A. Documented Quality System.

Written procedures and instructions shall be developed and implemented by the Contractor for activities affecting quality in design, procurement, manufacturing, and construction as it applies to the work to be performed. The documented procedures and instructions shall be described and referenced in the Contractor QP and the references shall be attached as an appendix to the QP. References shall also be made to any other existing procedures that are applicable to the Contract. Quality procedures shall contain a statement of the purpose and scope, references to applicable codes, standards or specifications, and identify responsibilities and records to be kept.

B. Design Control.

1. The Contractor shall develop procedures for control of design, design review and verification, which describes responsibilities for different design elements, interfacing between various groups producing and commenting on the design, and assignment of qualified personnel. The procedures shall specify how information shall be documented, transmitted, and reviewed and shall address the various types of documents used to develop the design, i.e. drawings, specifications, calculations and reports. Provide written design quality procedure for the configuration control of engineering drawings, specifications, shop drawings and as-built drawings and for design reviews. Design control shall incorporate the assurance that all of the design requirements are understood and that the design is in compliance with all applicable regulatory agency requirements and with the Contract Documents. All Contractor proposed design changes and requests for deviation shall be documented, reviewed and approved prior to implementation.

a.) The design control procedures shall ensure that the following controls and Contract Document requirements are satisfied:

1.) That designer has reviewed the applicable portions of the Contract Documents and change orders for relevance and has access to them during the design.

2.) That work defined in the Contract Documents as requiring the services of a professional engineer from the State of Washington is performed by a person meeting those requirements.
3.) That design interfaces with subcontractors, third parties, or existing infrastructure have been listed and that the required interfacing information has been documented.

4.) That any required pre-requisite submittals have been approved.

5.) Where design calculations are required, each set of calculations shall be filed with its checking documentation. The documentation shall include calculations that are legible, initialed and dated, design assumptions are noted, formula and symbols defined, backup material is included and in proper order.

6.) That the design utilizes the nomenclature and abbreviations as defined in the Contract Documents and that any additional abbreviations are defined in the submittal or previously approved submittals.

7.) That applicable codes were investigated and the requirements satisfied.

8.) That applicable reliability plan requirements for the design are satisfied.

9.) That an internal design audit has been performed by the Contractor’s QA Manager or his/her designee.

b.) The design checking procedures, and release to manufacturing procedures shall ensure that the following requirements are satisfied:

1.) The designer has signed each design submittal.

2.) A qualified person (or persons) independent of that portion of the design has checked the design. Depending on the nature of the submittal, checking shall verify circuit safety, dimensions, drafting standards, calculations, conformance with Contract Documents, and interfaces.

3.) The procedures shall document how comments made during the checking process are incorporated into the design and how the checker verifies the corrections.

4.) The design submittals from subcontractors have been designed and checked per the procedures.

5.) The submittal responds completely to the contract document requirement for that submittal and is complete with any information necessary for the review.

6.) The design review approval acts as a hold point before manufacture of the assembly.

7.) First article configuration inspections or other preliminary tests shall be performed and act as a hold before proceeding with further assembly wherever designated in the Contract Documents, test plans, test procedures or the Contractor’s Quality Plan.
C. Submittal Management, Control of Documents and Document Changes.

1. The QP shall contain procedures for scheduling and managing submittals in accordance with the technical submittal list, including those of Subcontractors, Consultants and Suppliers.

2. Status updates and revisions to the submittal list shall be available for reference in progress meetings.

3. The QP shall contain provisions for Document Control which defines the responsibility and authority for preparing, reviewing, approving, issuing, recording, revising and distributing documents for activities affecting the quality of the work. The Contractor’s Project Document Control procedures shall include, but are not limited to, control of correspondence, criteria, drawings, specifications and procedures. Documents shall be protected from damage or loss. Quality records shall be kept at in a secure and accessible location, with a duplicate set maintained at another location.

4. All changes to documents shall be processed in writing and records maintained of changes as they are made. Documents approved shall not be changed or altered without prior written approval. The Document Control system shall provide assurance that the latest approved drawing and/or specification is available prior to the start of the work effort and that the work was in fact performed to the latest approved document.

5. Detailed project document and drawing control procedures including establishment of document control processes, and shall be developed and implemented to assure the following:
   
a.) Controlled distribution to appropriate personnel.

   b.) Review by appropriate personnel.

   c.) Establishment of filing indices, registers, etc.

   d.) Safely secured storage and reliable retrieval.

   e.) Elimination of obsolete documents.

   f.) Control of document changes.

   g.) Proper reproduction of controlled documents.

   h.) Coordination with configuration management to establish and control the drawing and part number assignment of the system, subsystem, assembly, subassembly and component parts.

   i.) Document modifications.

6. The contractor or supplier shall assure that complete and current documents, such as drawings, specifications, changes, requests for information, work orders, change requests, approved contract change orders, purchase orders, procedures and quality control records (including documentation from approved inspection and testing plans) are provided at the work site. Documents shall be identified, logged, and maintained in an organized manner and shall be made available upon request.
7. The Contractor shall support the Resident Engineer in the identification of documents required for the Resident Engineer to complete the ST Link Safety Certification Specification Conformance Checklist.

8. Redlined, marked up and dated plans for Records drawings (as-built drawings) shall be provided by the contractor prior to acceptance.

D. Subcontractor, Consultants and Supplier Control.

1. The Contractor’s QP shall assure that the items and services are procured from subcontractors, consultants and suppliers capable of meeting all requirements of the Contract Documents. All subcontractors, consultants and suppliers shall comply with the Contractor’s Quality Plan or their own approved plan. If the subcontractor, consultant and suppliers elect to submit their own Quality Plan it must be certified as meeting the requirements of this section by the Contractor’s Quality Assurance Manager. The Contractor shall review the consultant and subcontractors-supplier’s agreements to insure the inclusion of applicable quality requirements. The Contractor shall maintain and use procedures for selection and control of suppliers and subcontractors including:

   a.) Evaluation and assessment of supplier’s and subcontractor’s quality systems.

   b.) Methods of monitoring supplier’s and subcontractor’s quality performance.

2. Source inspection may also be performed by Engineer at its own discretion at the Subcontractor’s facility or at the Subcontractor’s Supplier’s facilities. Those quality characteristics that cannot or will not be verified during subsequent processing shall be subject to source inspection. Source inspection may not be necessary when the quality of the item can be fully and adequately verified by review of inspection and test reports, inspection on receipt or other means. The QP shall identify those items that require source inspection.

E. Receiving, Handling, Storage and Control of Materials and Equipment.

1. The QP shall contain provisions for quality testing and verification by the contractor as necessary, that the material and equipment meet specified quality and contractual requirements and that they are properly received and handled to ensure that the quality is not degraded. Independent laboratory testing shall be used when designated by the Contract Documents. The Contractor shall ensure that all contract-furnished materials and equipment are positively identifiable and traceable to a specified origin point.

2. All contract-furnished materials and equipment entering construction areas shall be identified and inspected for damage. Certificates of compliance and/or conformance shall be submitted for materials and equipment, as required in the various sections of the specifications and on the contract drawing.

3. The QP shall provide for written procedures to assure that the desired quality of an item is not compromised or degraded as a consequence of inappropriate handling, lifting, transporting and rigging methods.

4. The Contractor shall provide for written procedures for cleaning, preservation and storage of materials and equipment. Proper records shall be maintained of all required maintenance activities during storage.
5. Purchased material and equipment shall be clearly marked so that it can easily be identified without excessive handling or opening of crates and boxes.

6. The materials storage area(s) shall be arranged for ease of retrieval and to prevent damage, deterioration or loss. In general, materials received first shall be used first. Items with a self life shall be marked with the expiration date to indicate it has a shelf life.

F. Process Control and Control of Special Manufacturing Processes.

1. To ensure accuracy and consistency, procedures or work instructions shall be developed for manufacturing and installation processes that are complex, have an extensive number of assembly steps, or require test or inspection hold points.

2. The QP shall contain provisions for controlling special manufacturing and installation processes, which limit the Contractor to prescriptive procedures that are specified for the work to obtain the desired end product. Also included is work which, must comply with the regulations of other agencies and certification requirements of field personnel.

3. The Contractor shall assure that the work is performed in accordance with the applicable codes, standards, specifications or other special contractual requirements using qualified personnel and/or equipment. The procedure should identify equipment to be used as well as any special requirements to be observed.

G. Inspection and Testing Plans.

1. The Contractor’s QP shall reference the test plan which has a list of inspections and tests planned subject to approval to verify that items conform to the requirements of the Contract Documents. QP plan shall define requirements that shall be included in the test plan such as test name, conditions and pre-requisites, organization and responsibilities of test personnel, description of each test, location of each test, test sequencing, references to the contract requirements.

2. Any first article inspections and tests shall be included in the Contractor’s three-week look-ahead schedule. First article inspections and tests may be witnessed by the Resident Engineer.

H. Control of Measuring and Testing Equipment.

1. The QP shall establish the responsibilities and procedures for the calibration, storage, use and control of measuring and test equipment. All measurement and testing equipment shall be calibrated at intervals recommended by the manufacturer and shall be calibrated to known national standards. All equipment shall be labeled showing the current status, as well as, the date of re-calibration or certification. A log of all equipment requiring calibration shall be maintained which identifies the equipment by name, serial number, date of calibration, date of next calibration, the name of calibration entity, and the pass-fail status. The Contractor shall verify calibration records and logs are complete, accurate and up-to-date.

2. All testing and measuring equipment suspected of being out of calibration, broken or damaged shall immediately be re-calibrated and re-certified. All work products tested or inspected with testing and measuring equipment known or suspected of being out of calibration, damaged or broken shall be re-tested and/or re-inspected.
I. Inspection and Test Status.

The QP shall describe the method with which the inspection and test status of a product is identified to assure that it has been accepted before it is used or installed. Inspection and testing status identification shall indicate conformance or non-conformance or the work product by means of markings, approval stamps, tags, labels, routing cards, inspection and test records, physical location or other suitable means.

J. Identification, Control and Correction of Non-conforming Conditions.

1. The QP shall contain provisions for identifying, recording, controlling and correcting non-conforming items including provisions for re-inspecting and re-testing repaired and reworked items. It is the Contractor’s responsibility to promptly identify, document and segregate items detrimental to quality to prevent inadvertent use.

2. The Contractor shall document non-conforming work products that occur prior to the shipment of work products and submit the information to the Resident Engineer as part of the test report of that assembly along with an explanation of the corrective action taken to provide an acceptable test result. Work products found to be non-conforming after shipment will be documented as such on the Non Conformance Report form by the Resident Engineer. A “repair” or use-as-is” disposition of a nonconforming work product requires the review and acceptance by the ST Link Material Review Board (MRB) prior to acceptance.

3. The Contractor shall investigate the cause of non-conformance and take appropriate corrective actions to prevent recurrence. The identification, care and corrective action planned and taken shall be documented on a weekly non-conformance report and in the Monthly Quality Report.

4. Personnel performing evaluations to determine conformance shall have demonstrated competence in the specific area involved, have an adequate understanding of the requirements and have access to pertinent background information.

K. Corrective Actions.

The QP shall establish a procedure for the methods and responsibilities used to process, determine and document corrective actions for non-conforming work products and how corrective and preventative actions to prevent recurrence of the non-conformance shall be implemented and verified. All contributing causes of the nonconforming work products shall be identified and documented. The procedure shall define how the process will result in the elimination of potential non-conformances. This information shall be transmitted to the Resident Engineer for review and approval.

L. Quality Records.

The QP shall contain provisions for and reference procedures for identification of types of quality records to be maintained, their retrievability and retention periods and shall include a sample or blank copy of the type of quality records. The Contractor shall maintain quality records as evidence that all of its activities and those of its subcontractors and suppliers comply with the requirements of the QP. The Contractor shall establish a numbered filing system, log all quality records with essential data and ensure all records have been signed and dated. Copies of all records shall be made available upon request.
M. Contractor Audits.

1. The Contractor’s QA Manager shall perform audits to assure compliance with the requirements of the Quality Plan on the part of the Contractor, Subcontractor and Suppliers. Each element of the Contractor’s QP shall be audited by the Contractor’s Manager of Quality Assurance at least once in the first 180 days and at least once each year thereafter plus an audit no more than 60 days before the substantial completion date.

2. The Audit Schedule shall be submitted to the Engineer. An initial audit schedule will be submitted at the Post Award Meeting. The audit schedule shall be submitted with the Monthly Quality Report. The audit schedule should include systematic audits of, but not limited to:
   a.) Submittals.
   b.) Test Results.
   c.) Workmanship.
   d.) Control of Measuring and Testing Equipment.
   e.) Receiving, Handling, Storage and Control of Materials and Equipment.
   f.) Warranties.
   g.) Document Control.
   h.) Quality Records.
   i.) Subcontractors’ QC.
   j.) Punch List.
   k.) As-Built Drawings.
   l.) Contractor QC.
   m.) Non-Conformances and Corrective Actions

3. The Contractor shall perform independent audits of its Quality Program to assure compliance with the requirements of the Quality Plan as it relates to the Contractor, Subcontractors and Suppliers. ST’s Manager of Quality Assurance shall be provided the opportunity to attend the internal audit. The audits shall be documented and the results used to correct deficiencies in the QP and Quality System, and used to improve work processes. The audit results shall be submitted in the Monthly Quality Report.

N. Training (QA/QC).

The QP shall describe the method in which control shall be maintained for quality training, as required, for all quality personnel assigned to the Contract. Personnel performing activities
affecting quality shall be qualified through appropriate training and/or experience. Records for training shall be maintained.

2.03 AGENCY AUDITS

The Link Manager of Quality Assurance will audit the Contractor and Subcontractors' activities during the course of the Contract. Audits conducted may include, but not be limited to submittals, material and system testing results, Contractor audit records, as-built documents, change orders, workmanship, quality records and closeout. Additional audits will be conducted as needed. Audits performed by ST do not relieve the Contractor of the requirements of performing its own audits.

2.04 MONTHLY QUALITY REPORTS

A. Monthly Quality Reports shall include:
   1. Audits planned.
   2. Audits completed along with audit reports.
   3. Nonconformance reports, dispositions and verified corrective action.
   4. Failed tests with reason for failure and subsequent corrective actions taken.
   5. Quality related submittals submitted.
   6. Other quality issues.

PART 3 - EXECUTION

3.01 FAILURE TO PERFORM

In the event the Contractor fails to adequately perform any or all of the provisions of this Section, the applicable requirements of the General Provisions shall apply.

PART 4 - MEASUREMENT AND PAYMENT

Separate measurement and payment will not be made for Work required under this Section. All costs in connection with this work specified herein will be considered to be included with the related items of work in the Contract Price Schedule, or incidental to the Work.

END OF SECTION 01450
SECTION 01452
CONTRACTOR CONSTRUCTION CONTROL REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section specifies the Contractor's requirements for defining, coordinating, and controlling
in process Work. Contractor shall submit to Resident Engineer a Contractor Work Practices
Manual for approval detailing plans and procedures on items affecting Work including but not
limited to:

1. Project management practices.

Invoice preparation practices, payment procedures for subcontractors and suppliers,
schedule preparation, and internal project status updates.

2. Engineering practices.

Criteria development, preparation of information requests, internal design reviews, CAD,
and preparation of submittals.

3. Procurement practices.

Selection of suppliers and subcontractors, bidding process, sample supplier and
subcontractor agreements, vendor quality audits, acceptance of equipment and
materials, storage of equipment and materials, shipping, and internal/factory testing
practices.


Job site hazard analyses, construction Work plans, construction coordination meetings,
daily safety tool box meetings, field change procedures, field issue resolution, resolution
of non-conformance reports, as-built preparation and site clean-up procedures.

5. Testing practices.

Test plan, detailed test procedures, list of tests to be performed by independent testing
lab(s), and documentation procedures.

1.02 SUBMITTALS

A. A draft Contractor Work Practices Manual shall be developed by the Contractor and
submitted with the Conceptual Design Report.

B. Final Version of Contractor Practices Manual shall be submitted for approval with Preliminary
Engineering Submittal.

C. Construction Work Plans shall be submitted 30-days prior to start of Work.

D. Test Reports shall be submitted within five (5) working days of testing.
E. Field Change requests shall be submitted within 24 hours of identification.

F. Responses to Nonconformance Reports within 10 working days after receipt. Extensions may be granted by Resident Engineer if the situation warrants it.

G. Names and qualifications of Independent Test Lab personnel performing Work within 30 days of performing test.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

The Contractor is responsible for implementing and maintaining a program that will define how the Work is to be performed and who is responsible to ensure Work meets Contract Document requirements. This shall be detailed by Contractor’s Work Practices Manual for each phase of the Work to be performed. Resident Engineer shall review and approve the Contractor’s practices in Work Practices Manual. Conformance of actual Work to the WPM shall be determined through inspections and audits. Contractor shall not proceed with Work after Preliminary Engineering without approval of WPM. Once approved, Contractor shall make no changes in WPM without prior written approval from Resident Engineer. Contractor is not entitled to extension of time or additional monies because of a failure to secure an Approved WPM.

3.02 WORK PRACTICES MANUAL

A. Work Practices Manual shall be the prevailing mechanism to inform the Resident Engineer and Sound Transit on the methods and procedures Contractor intends to perform Work and to assist Resident Engineer in coordination between Contractor’s and Sound Transit’s processes. Contractor shall be responsible to keep Manual current with Work actually performed. Other manuals such as QC and Safety called for in other Sections of the Specifications are considered to be incorporated so long as they are referenced in the Work Practices Manual.

B. Submittal of Work Practices Manual shall comply with Section 01330, Submittals. Sections of this Manual shall be comprised as follows:


   a.) Contractor shall fully define its project management practices that affect the flow of Work including but not limited to:

      1.) Invoice Preparation Procedures.

         Those procedures actually performed to ensure compliance with Section 01270, Measurement and Payment, as it relates to the Contractor's organization. This should include sample forms with explanations to clear up any potential miscommunications that may be associated with approving invoices.

      2.) Payment procedures for subcontractors and suppliers.
Those policies and procedures used in approving and paying subcontractors, suppliers and others.

C. Scheduling Procedures.

Those procedures actually performed to ensure compliance with Section 01320, Construction Contract/Schedules as they relate to the Contractor's organization. They should include sample forms with explanations to clear up any potential miscommunications that may be associated with approving schedules.

D. Change Order Procedures.

Procedures used by Contractor to process charges both with Sound Transit and with its subcontractors and suppliers shall be in accordance with this Contract.

E. Internal project status updates.

1. Those procedures Contractor uses to inform and collect information from staff, subcontractors, and suppliers of Work, Changes, issues, and emergency events.

   a.) Document Control.

      1.) Document Control shall detail the control of receipt, status, maintenance, and transmittal of project records and documents.

      2.) The Contractor shall establish a document control system to store and record the large quantity of correspondence, drawings, progress reports, technical reports, specifications, Contract Documents, Submittals, calculations, and administrative documents generated under the Contract. The Contractor shall establish correspondence routing, filing, control, and retrieval methods that are compatible with the system currently in use by Sound Transit.

      3.) Technical document control, storage, and retrieval methods shall include the use of both hard copies and electronic records. Technical document control methods shall be capable of handling documents being developed (progress), finalized documents (for construction) and documents representing as-built conditions.

      4.) All correspondence of the Contractor to and from Sound Transit and its representatives (including the Resident Engineer) shall be serialized, and separate incoming and outgoing correspondence logs shall be maintained by the Contractor. At a minimum, a serialization similar to the following is required:

         Serial No: [ ] Prefix - Letter No. [ ]

         Example Prefixes:

         KOR/RE Contractor to Resident Engineer.

         RE/KOR Resident Engineer to Contractor.
5.) Ensure current revisions of procedures, instructions, drawings, and other documents are provided at Work locations.

6.) Identify and maintain records and documents in an organized manner. Make records available to Sound Transit upon request.

7.) Protect records and documents from damage, deterioration, and loss. Keep records in fireproof cabinets at the Contractor's work-site or maintain a duplicate set at another location.

F. Project Record Documents.

This Section includes specifications for the maintenance, completion and submission of project record drawings, specifications, and other related documents as required per Section 01780, Project Record Documents.

G. Engineering Practices.

1. Contractor shall define those procedures and practices that shall be employed to guarantee compliance with the Contract Specifications, Contract Drawings, and user requirements including but not limited to:

   a.) Criteria and user interface development.

       Those procedures actually performed to ensure capture of design criteria and user requirements as it relates to the Contractors organization. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

   b.) Preparation of information requests.

       Resident Engineer will return Requests for Information (RFI) within 30 days of receipt. Contractor’s procedures should take this into account and optimize information flow via RFI to only those critical items that need to be addressed formally. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

   c.) Internal design reviews.

       Those procedures actually performed to ensure a complete design as it relates to the Contractors organization. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

H. Preparation of CAD drawings.

1. Those procedures actually performed to ensure compliance with Section 01320, Construction Contract Schedules, and 01335, Shop Drawings, Product Data and Samples, as it relates to the Contractor's organization. Should include sample forms with explanations to clear up any potential miscommunications that may be associated with approving drawings.
a.) Preparation of design submittals and presentations.

1.) Those procedures actually performed to ensure compliance with Section 01330, Submittals, as it relates to the Contractor’s organization. Should include sample forms with explanations to clear up any potential miscommunications that may be associated with approving submittals.

2.) Additionally, procedures to develop the presentation portion of the submittal should be addressed.

I. Preparation of calculations.

Those procedures actually performed to ensure accurate computations during the design process as it relates to the Contractor’s organization and in compliance with Section 01450, Systems Quality Requirements. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

J. Configuration Management.

Those procedures actually performed to ensure compliance with Section 17050, Configuration Management, as it relates to the Contractor’s organization. Should include sample forms with explanations to clear up any potential miscommunications that may be associated with approving submittals.

K. Verification of designs with actual conditions.

Those procedures actually performed to ensure designs match actual conditions throughout the design process as it relates to the Contractor’s organization. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

L. Procurement Practices.

Contractor to define those procedures and practices that shall be employed to guarantee compliance with the Contract including but not limited to:

1. Selection of suppliers and subcontractors.

   a.) Those procedures actually performed to during the procurement of suppliers and subs to ensure that the material or Work will meet the requirements of the Contract and Schedule as it relates to the Contractor’s organization. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

      1.) Sample and actual supplier and subcontractor agreements.

      2.) Supplier Control.
a. Submit and maintain list of all suppliers supplying material for Contract. The list shall include:

(1.) Name of the supplier or fabricator.

(2.) Address and telephone number of the supplier or fabricator.

(3.) Description of material or fabricated item to be procured from the supplier or fabricator.

(4.) Contract Specifications Section, article number and/or drawing references of the material or item to be purchased.

3.) Vendor quality audits.

Those procedures actually performed during the term of agreement by suppliers and subs to ensure that the material or Work will meet the requirements of the Contract and Schedule as it relates to the Contractor’s organization. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

4.) Acceptance of equipment and materials.

Those procedures actually performed during the receipt of materials and equipment to ensure that the material or Work will meet the requirements of the Contract as it relates to the Contractor’s organization. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

5.) Storage of equipment and materials.

Those procedures actually to be used in storing materials and equipment to ensure that the material or Work will not be damaged or stolen as it relates to the Contractor’s organization. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

6.) Shipping.

a. Those procedures, terms and conditions actually performed or used during the shipping of materials and equipment to ensure that the material or equipment will meet the requirements of the Contract, as it relates to the Contractor’s organization. Should include sample forms with explanations to clear up any potential miscommunications or missed opportunities.

b. A large concern here is how the Contractor shall ensure on-time deliveries of equipment and materials as well as ensure the quality of the product up to the point where it is delivered to the jobsite. This part of WPM should address this concern.
M. Construction Practices.

1. Contractor to define those procedures used in the field to minimize delays and ensure a safe and quality job is performed. As a minimum, Contractor should define the procedures it will use, with sample forms as necessary, the following:

   a.) Field Surveys and Site Condition Surveys.

   b.) External Contractor coordination.

   c.) Internal Contractor coordination.

   d.) Job site hazard analyses as defined in Section 01545, Health and Safety Plan Requirements.

   e.) Control of Special Processes.

      1.) Submit detailed procedures for Control of Special Processes (e.g., fiber splicing, LonWorks programming, and software testing.)

      2.) Contractor or Subcontractor personnel performing special processes shall be qualified in accordance with applicable codes, standards, and manufacturer’s recommendations. Qualification records of personnel performing special processes shall be current and maintained in the worksite files.

      3.) Submit qualification records of personnel performing special processes to Sound Transit before they start Work on the Project.

   f.) Field worker practices of conduct.

   g.) Field Supervisor’s practices.

   h.) Daily safety tool box meetings.

      As defined in Section 01545, Health and Safety Plan Requirements.

   i.) Daily site clean up.

      Detail procedures to perform site clean up per Section 01740, Cleaning.

   j.) Field change procedures.

   k.) Field issue resolution.

      1.) Should include variety of issues, such as:
a. Worker conflict.

b. Site Damage.

c. Union Issues.

d. Other issues as arise.

l.) Resolution of non-conformance reports and punch lists.

m.) As-built preparation and field documentation.

n.) Final site clean-up procedures per Section 01740, Cleaning.

o.) Construction Work Plans.

1.) In addition to its internal practices above, Contractor shall implement Construction Work Plans for each definable piece of Work or as recommended by the Resident Engineer. Construction Work Plans are detailed descriptions of a specific Work activity. Resident Engineer, in consultation with the Contractor, will determine which Work activities require submission and approval of a CWP. The Contractor shall prepare and submit a list of CWPs to the Resident Engineer. The Resident Engineer may add CWPs to the list. Upon approval of the CWP list, prepare and submit a CWP for each of these Work activities. No Work shall begin without Sound Transit acceptance of a CWP. As a minimum, each CWP shall include:

a. Scope of Work.

b. List of persons responsible for supervision of the Work.

c. List of required submittals, drawings, and job hazard analysis.

d. Planned start-work date, progress rate expected, and work hours.

e. Sequence of events and construction methods for performing the Work - include Sound Transit hold points and inspection requirements.

f. Tests required by Contractor and/or Sound Transit.

g. Prerequisite activities and related safety issues.

h. Off-site activities and locations.

i. Procedures for controlling hazardous materials as applicable.
j. Actions defined as “Special Events”, which may expose the general public to danger or inconvenience, and which may require a third party to be notified.

Upon approval of a CWP, at the request of the Resident Engineer, and before beginning associated Work activities, a Readiness Review Meeting will be conducted by the Resident Engineer with Contractors, Subcontractors, and applicable third party representatives to discuss all elements contained in the CWP. The Resident Engineer will document the meeting with an agenda and minutes of the meeting including an attendance record.

N. Testing Practices.

Contractor shall fully define its practices as per Section 17075, Human Factors Engineering and Ergonomics.

3.03 AUDITS AND INSPECTIONS

A. Sound Transit will have access to areas where Work is performed under the Contract to conduct audits, surveillance, inspections, and tests to verify compliance with the Contract requirements. Access includes on-site and off-site Work areas of the Contractor, Subcontractors, manufacturers, and suppliers.

B. Surveillance and inspections are informal events that will be unscheduled and take place "at-will" while Work is being performed. The intent is to determine the actual progress of Work and informally assess the quality of Work and procedures used to perform the Work. The Contractor shall facilitate inspections/surveillance by providing access to its facilities, personnel, and records. Findings will be documented in a Daily Report and be placed on file with Resident Engineer’s office.

C. Audits are multi-day functions, which include scheduled reviews of the Contractors Work activities as required by the Contract, including a formal 48-hour notification, audit entrance/exit meetings, an audit plan, performance of the audit, and issuance of an audit report. The Contractor shall facilitate audits by providing access to its facilities, personnel, and records.

D. Work found in non-compliance with the Contract Specifications and Drawings shall generate a Non-Conformance report from Resident Engineer. Work practices found in violation of Contractor’s Work Practices Manual shall generate a comprehensive audit, rejection of Work, and/or re-issuance of Work Practices Manual at the sole discretion of the Resident Engineer. No additional time or moneys shall be afforded to Contractor for any corrections necessary to bring Work or Work Practices Manual in agreement under these provisions.

3.04 WORK STOPPAGE

A. Resident Engineer or its representative shall be authorized to stop Work on site if and only if Contractor, its subcontractors, or suppliers are:

1. Performing Work in violation of Sound Transit Safety practices.

2. Unnecessarily disrupting the Work of others.

3. Performing Work in the wrong location.
4. Damaging existing facilities or systems installed by others.

5. And/or damaging its own Work through improper installation practices.

B. Contractor will not be allowed to return to Work until it can demonstrate to Resident Engineer that the Work methods and procedures have been corrected to ensure that any of the above issues will not happen in the future.

3.05 CONTROL OF NON-CONFORMING ITEMS

A. Sound Transit will document nonconforming items on a Non-Conformance Report (NCR).

B. The Resident Engineer will be responsible for controlling Non-Conformance Reports through use of a sequential numbering system and updated by use of a Non-Conformance Log.

C. Upon receipt of a Non-Conformance Report, the Contractor shall be responsible for investigating and describing the root cause of the nonconformance and recommending a disposition. The following disposition codes shall be used for determining disposition:

1. “USE AS IS” - allows the use of an item that does not meet specified Contract requirements without the need for corrective action.

2. “REPAIR/REWORK” - item must be reworked or repaired to bring it into conformance with the requirements of the Contract.

3. “REJECT” - item is unsuitable for its intended use, is economically or physically incapable of being reworked or repaired, and must be replaced to bring it into conformance with the Contract Requirements.

4. Nonconforming items disposed as "USE AS IS" or “REPAIR/REWORK,” require review and approval of the Design Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01452
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Organization and mobilization of the Contractor's forces.

B. Transporting construction plant and equipment to the worksite and setting up of same.

C. Transporting various tools, materials, and equipment to the Project Office.

D. Erection of temporary buildings and facilities required for staging and construction operations.

E. Selected staging areas will be provided by Sound Transit as indicated in the Special Provisions. Any additional staging areas that may be required by the Contractor are the responsibility of the Contractor.

1.02 QUALITY CONTROL

Comply with Section 01450, Systems Quality Requirements.

1.03 DEFINITIONS

A. Project Office shall consist of Contractor’s local facilities not on Sound Transit property organized for the purpose, either in whole or in part, of performing work. Such facilities shall include but not limited to:

1. Office space

2. Warehouse space

3. Subcontractor's dedicated space

B. Jobsite shall consist of all Work(s) of Contractor resident on Sound Transit owned property or pursuant to Work outside of Project Office.

1.04 SUBMITTALS

A. Refer to Section 01330, Submittals, for submittal procedures.

B. Provide a layout of the Project Office including fences, roads, parking, buildings, staging, and storage areas at Post Award Meeting or 30 days prior to any subsequent changes in location or major additions to facilities.

1.05 DELIVERY

Delivery to the jobsite of construction tools, equipment, materials, and supplies shall be accomplished in conformance with local governing ordinances and regulations.
1.06 TOOLS AND SUPPLIES

A. Provide construction tools, equipment, materials, and supplies of the types and quantities which will facilitate the timely execution of the Work.

B. Provide personnel, products, construction materials, equipment, tools, and supplies at the jobsite at the time they are scheduled to be installed or utilized.

1.07 MOBILIZATION

A. Mobilization shall include mobilization of all equipment, materials, supplies, appurtenances, and the like, staffed and ready for commencing and executing the Work.

B. Mobilization shall also include assembly and delivery to the project office of plant, equipment, materials, and supplies necessary for the execution of Work which are not intended to be incorporated in the Work.

1.08 DEMOBILIZATION

Upon completion of the Work, remove construction tools, apparatus, equipment, unused materials and supplies, plant, temporary facilities, and personnel from the Project Office. Demobilization shall include cleaning, remediation and site restoration necessary to restore construction sites, lay-down areas, yards, access roads and other real property to a useable state ready for intended good use.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 SOUND TRANSIT FURNISHED LAYDOWN AREAS OR JOBSITE TRAILERS

Sound Transit will not provide laydown areas or jobsite trailers for Contractor.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01505
PART 1 - GENERAL

1.01 SECTION INCLUDES

Health and Safety Plan requirements.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):
   Z87.1. Practice for Occupational Educational Eye and Face Protection.

B. Occupational Safety and Health Administration (OSHA), Standards and Regulations, 29 CFR 1910 and 29 CFR 1926.

C. United States Department of Health and Human Services, (DHHS) "NIOSH Sampling and Analytical Methods, "DHHS (NIOSH) Publication 84-100.


E. Washington Industrial Safety and Health Act.

1.03 QUALITY CONTROL

Comply with Section 01450, Systems Quality Requirements.

1.04 SUBMITTALS

A. Submit the Health and Safety Plan to the Resident Engineer for review at or prior to Post Award Meeting and prior to start of any Work and in accordance with this Section.

B. The Contractor's Health and Safety Plan shall be submitted for review, but not approved. Comments will indicate whether it contains the minimum necessary information as indicated herein.

1.05 SAFETY PRECAUTIONS

A. Products and materials used in connection with Work shall remain asbestos-free.

B. Notify the Resident Engineer immediately if during the course of Work there should be a discovery of any undetermined substance.

C. Adhere to the applicable environmental protection guidelines, OSHA guidelines and regulations and the environmental specifications for the entire duration of the Project.

D. The Contractor is responsible for the health and safety of its employees, subcontractors and vendors.
1.06 HEALTH AND SAFETY PLAN

A. Plan shall meet the requirements of ANSI Z87.1, OSHA Standards and Regulations, DHHS NIOSH Sampling and Analytical Methods, USEPA Standard Operating Safety Guidelines and the Washington Industrial Safety and Health Act. Health and Safety Plan shall include but not be limited to the following:

1. Contractor's policy concerning health and safety.

2. Scope of health and safety policy as it applies to the Contract.

3. Health and Safety Organization: Designate an individual and an alternate in its organization who is responsible for Site Safety who has the background and authority to determine what constitutes safe practice and ability to direct implementation at the site.

4. Special Provisions for Project health and safety programs, if applicable. Example: trenching, welding, hoists, cranes, maintenance and protection of traffic.

5. Health and safety training including the Contractor's plan for regularly scheduled safety meetings and other training to ensure safe practices. Confirm that personnel are adequately trained to perform their job responsibilities and to handle the specific hazardous situations they may encounter.

6. Reporting and Records Requirements: Including posting of emergency numbers and information and liaison with the Resident Engineer.


9. Description of the level of protection and equipment to be worn by personnel during various site operations according to applicable regulations.


11. Fire Protection and Prevention: Including fire extinguisher, fire drills and training.

12. Electrical Safe Practices: Including lighting, temporary circuits, insulated tools, grounding, fault interruption and high-voltage testing.

13. Industrial hygiene, including "Right-to-Know, Material Safety Data Sheets (MSDS) and/or a description of contaminants or suspected contaminants on-site. Description of the program for appropriate periodic air monitoring, personnel monitoring and environmental sampling, if needed, based on the type of suspected contaminants presented.

14. Environmental Protection: Including protection of the public, the Contractor and Sound Transit's agents, and the prevention of contamination of air, water or soil.

15. Description of any site-specific medical surveillance requirements, such as lead poisoning from lead base paint.
16. Cold weather/hot weather safe practices.

17. Use of Power Activated Tools: Special permits or licenses as required.

18. Maintenance and protection of traffic plans.

19. Establishment of Standard Operating Procedures (SOPs) for such activities that can be standardized (such as decontamination and respirator fit testing, etc.).

20. Description of the actions to be taken to mitigate existing hazards (e.g., containment of contaminated materials) to make the Work environment less hazardous.

21. Definition of site access control measures and include a site map and the route to the nearest hospital having an emergency section.

1.07 ACCIDENTS

A. Provide such equipment and facilities as are necessary or required, in the case of accident, for first aid service to any who may be injured in the progress of the Work. Have a standing arrangement for the removal and hospital treatment of any person who may be injured or may become ill.

B. Report within 24 hours to the Resident Engineer every accident to persons or damage to property; and furnish in writing full information, including testimony of witnesses regarding any and all accidents.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01545
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PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes specifications for general requirements for materials and equipment, including the packaging, handling, delivery, and storage thereof. Additional requirements are included in the General Provisions.

1.02 SUBMITTALS

A. Submit the following:

1. Label and nameplate samples for approval by Resident Engineer.

2. List of cabinet and panels with proposed naming scheme.

3. Information verifying all specific materials and equipment to be used in Work shall meet Specifications.

1.03 REFERENCES

A. The following references shall be adhered to in the performance of this Section:

1. ADA, American’s with Disabilities Act.


3. UL 969, Marking and Labeling Systems.


PART 2 - PRODUCTS

2.01 PRODUCT SCHEDULE

A. Prepare a schedule listing the principal products (by generic names) required for the Work. For each product show the proprietary product names and manufacturer names proposed for incorporation in the Work.

B. Submittal.

Submit the product-listing schedule with Conceptual Design Review submittal in accordance with Section 01330, Submittals.

C. The list of products is not a substitute for required submittals, acceptance of products or a vehicle for submitting substitutions to products specified.
2.02 PROCEDURES FOR SELECTING PRODUCTS

A. General.

1. The specified requirements for individual products indicated in the Contract are multiple in nature and may include generic, descriptive, proprietary, performance, prescriptive, proscriptive, compliance with standards, compliance with codes, conformance with graphic details, and other similar forms of requirements.

   a.) Provide products conforming to all specified requirements unless otherwise directed. Other products will be considered only if requested as substitution.

   b.) Contractor's Options.

       Where an option or choice is indicated, provide only one of the options. The choice of an option is the Contractor's. Where submittals are required, state which option has been chosen.

   c.) An option is not a consideration of whether a product or method shall be provided, but which of the several indicated products or methods shall be provided.

   d.) Non-compliance of a Named Product.

       If it is known that a named product or product source does not comply with requirements or is no longer available, advise the Resident Engineer before proceeding.

   e.) Equivalent Materials and Equipment.

       Whenever a material or article is specified or described by using the name of a proprietary product or the name of a particular manufacturer or vendor, the specific item mentioned is understood as establishing type, function, dimension, appearance, and quality desired. Another manufacturer's product maybe acceptable provided that it is not a "Designated Matching Product or a "no substitution" product, and provided that sufficient information is submitted as required by Section 01330, Submittals, to allow the Resident Engineer to determine that products proposed are equal to those named.

2. Procedures.

The Contractor's options for selecting products are limited by the specified requirements and governing regulations. Following are some of the various selection procedures for specified requirements.

   a.) Qualities or Performance Requirements.

       Provide products that comply with the specific qualities indicated, and which are recommended or certified in writing by manufacturer for the specific use indicated. General performance of a product is implied where product is specified for specific performances.
b.) Prescriptive Requirements.

Provide products produced in accordance with the prescriptive requirements, using the specified ingredients and components, and complying with the specified requirements for mixing, fabricating, curing, finishing, testing, and similar operations.

c.) Standards, Codes, and Regulations.

Provide product that complies with the specified standards, codes, and regulations and with the other requirements.

d.) Or Equal.

Where named products or sources are accompanied by the term "or equal" or other language of similar effect, provide one of the specified products, or submit a request for substitution for a product not named, in accordance with the General Provisions, which the Contractor judges to be of equal or better quality.

e.) Product Names.

Unless otherwise indicated, products identified by name mean a manufacturer's product as recorded in published literature, of latest issue preceding the date of Contract Documents. Submit request for substitution in order to use products of a later or earlier model.

f.) Visual Matching.

Where matching an established sample is required, the Resident Engineer will make final judgment of whether a product proposed by Contractor matches the sample satisfactorily.

g.) Visual Selection.

Where product requirements include "... as selected from manufacturer's standard colors, patterns, textures..." or words of similar effect, the selection of manufacturing source and basic product, which complies with the requirements, is the Contractor's option, but the selection of color, pattern and texture is the Resident Engineer's responsibility.


Use of a product not conforming to specified requirements may only be approved by means of a request for substitution as specified elsewhere.

a.) If it occurs that a product cannot be supplied to meet all requirements, the following order of precedence will be followed:

1.) Qualities.

For product specified by qualities or description, and also by reference standard or by source and name, the specified qualities or description shall take precedence.

2.) Reference Standards.

For product specified by reference to a published standard, and by source or name, the reference standard shall take precedence over the source.

5. Request for Substitutions.

a.) On a form provided by Sound Transit, the Contractor shall provide all information necessary or requested to demonstrate and document substantial compliance of the proposed substitution with the Contract Documents. Each request for substitution shall be limited to one item of substitution and shall be submitted, as per Section 01330, Submittals, to the Resident Engineer. The following information is required as a minimum:

1.) The reason for the request.

2.) Complete data substantiating that the function, quality, and performance of the proposed substitution will be equal or superior in all respects to the performance of the specified item.

3.) Detailed description and drawings of the proposed construction and fabrication methods.

4.) Product identification, including manufacturer's name and address, contact person, and telephone number.

5.) Manufacturer's literature, including product description, performance and test data, and reference standards.

6.) Samples, if appropriate or required by Sound Transit.

7.) The name and address of a reference person to similar projects on which the product, equipment service, method or technique, was used, date of installation and reliability and service record.

8.) An itemized comparison of the proposed substitution with the specified product, equipment, service, method or technique.

9.) Assurance that the proposed substitution will not affect dimensions or other elements of the Work, or full disclosure of any such effects.
10.) The name and address of the nearest supplier of maintenance and service parts and repair services for the proposed substitution, and substantiation that adequate supplies of parts and repair services are readily available.

11.) A schedule analysis indicating the effect of the substitution on the critical path.

2.03 PRODUCT REQUIREMENTS

Where available, provide standard products of types that have been produced and used previously and successfully in similar applications.

2.04 LABELING

A. Except as otherwise indicated, nameplates and labels shall be required on all installed equipment and material as noted below.

1. Labels.

   a.) Provide at least one label on each piece of equipment and cable supplied for permanent installation. Label shall be of a permanent nature suitable for the environment intended. Ink and label material shall be non-dullable, corrosion resistant, UV resistant, scratch resistant, heat resistant, and chemical resistant for long life. Adhesive shall be suitable for the maximum intended life of the equipment and environment intended.

   b.) Labels shall be located in conspicuous locations such as:

      1.) Front and back of equipment in upper right hand corner.

      2.) Cables on each end and at all pull points or raceway transitions.

   c.) Labels should fit within the form factor of the equipment or cable. Cable labels should be a tight fit directly to the cable sheath and equipment labels should not stick out so that labels do not snag or become damaged.

B. Equipment Nameplates.

1. Provide a permanent nameplate on each composite assembly such as a rack, cabinet, or panel. Locate nameplate on an accessible surface a conspicuous exterior surface, such as the upper center of cabinet door, matching the height of all other similar labels within sight. Where more than one door or side is accessible, both sides shall have a nameplate.

   a.) Nameplates.

      1.) Black in color with white etched lettering.

      2.) Letters shall be a minimum of 2” in height.
3.) Affixed to exterior cabinet with rivets or some other permanent mechanical device.

4.) Permanent in nature suitable for the environment intended. Ink and nameplate material shall be non-dullable, corrosion resistant, UV resistant, scratch resistant, heat resistant, and chemical resistant for long life.

C. Information.

1. Both labels and nameplates shall be for identification purposes, the following guidelines shall apply:

a.) Labels.

1.) Font: Arial or other approved non-serif font.

2.) Size: As recommended by MIL-STD-1472D.

3.) Information: Specific equipment or cable ID including instance number.

b.) Nameplates.

1.) Font: Arial or other approved non-serif font.

2.) Size: As recommended by MIL-STD-1472D, minimum 2”.

3.) Information: Specific cabinet or panel number and general function of equipment located on the panel or in the cabinet (i.e. Communication Distribution Cabinet, Public Address, Communications Backbone, etc.). General function should be labeled in both English and Braille.

2.05 MANUFACTURERS’ INSTRUCTIONS

A. When the Contract Documents require that installation of Work comply with manufacturers' instructions, obtain and distribute copies of such instructions to parties involved in the installation and seven copies to the Resident Engineer. Maintain one set at the site until installation is complete.

B. Handle, install, connect, clean, condition, and adjust products in strict compliance with the instructions and specified requirements. Should job conditions or specified requirements conflict with the manufacturers' instructions, notify the Resident Engineer. Handle all equipment in strict accordance with the manufacturer's written handling instructions.

C. Perform Work in accordance with the manufacturer's instructions. Do not omit any steps unless specifically modified or exempted by the Contract Documents.

2.06 HANDLING OF MATERIALS

A. Handle all materials and equipment to be incorporated in the Work in a manner that will prevent misalignment of parts or the occurrence of damage of any kind.
B. Protect all materials and equipment at all times from all environmental conditions that might cause damage in a secure and dry storage facility.

C. Verify with the manufacturer all information regarding scheduling, delivery, and preparations necessary for installation.

D. Verify that equipment and installation supplied under other Contracts, but required for the Work in this Contract, are compatible.

E. Contractor shall ensure that each item is marked in accordance with referenced codes and standards.

F. Ship each unit securely wrapped, crated or packaged, and labeled for safe handling in shipment and to avoid damage or distortion.

G. Supply all necessary supervision and coordination information to accommodate the installations of equipment.

H. Adhere to manufacturer’s handling requirements when off-loading equipment and materials at the jobsite.

2.07 STORAGE OF MATERIALS AND EQUIPMENT

A. All equipment and materials shall be stored in accordance with the manufacturer’s recommendations, or as specified in the Contract Documents to preserve their quality and fitness for the Work. Stored equipment and materials shall be the responsibility of Contractor until installed and tested on-site by Resident Engineer.

B. Sound Transit-furnished materials shall be stored in secure locations approved in writing by Sound Transit in a manner that will preserve their full value. Such materials shall be prominently labeled as property of Sound Transit and shall not be commingled with non-Sound Transit materials. If necessary, storage shall be in controlled environment buildings.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.
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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes specifications for the acceptance, unloading, handling, storage, protection, and utilization of materials and equipment furnished by Sound Transit for installation by the Contractor pursuant to the General and Special Provisions.

B. Refer to Section 01600, Products, Materials and Equipment, for handling, storage, and other pertinent requirements.

1.02 ABBREVIATIONS

Sound Transit-furnished equipment and materials may be referred to herein and in other Sections, where applicable, by the abbreviations STFE and STFM respectively.

1.03 CONTRACTOR'S RESPONSIBILITIES

A. Requirements.

The Contractor shall assume custody of and provide protection for STFE and STFM from the time of delivery and acceptance by the Contractor until Substantial Completion of the Work and the return of excess materials and equipment.

B. Protection.

Protect STFE and STFM while in custody from theft, vandalism, loss, damage, and deterioration due to moisture and temperature during unloading, storing, handling, distributing, and installing the materials and equipment. Lost or damaged materials and equipment, as documented by Sound Transit, shall be replaced by the Contractor at no additional cost to Sound Transit.

C. Delivery Schedule.

1. STFE and STFM will be delivered by the respective suppliers to the delivery sites indicated within the dates indicated in the Special Provisions. STFE and STFM will be delivered to the delivery sites between the hours of 10:00 a.m. and 3:00 p.m., Monday through Friday.

2. The method and rate of material delivery will be determined by the respective suppliers, and this information will be reported by Sound Transit to the Contractor at least one month before the initial delivery of each type of material.

3. All Contractor requests for modification to the delivery method, location, rate, or date(s) shall be made through the Resident Engineer. Should an agreement be reached to modify any delivery parameter, all additional costs due to the modification shall be paid by the Contractor.
D. Unloading.

The Contractor shall provide the labor, equipment, and materials necessary to unload, handle, stockpile, and store STFM and STFE. The Contractor shall unload and stockpile or store STFE and STFM within 4 hours of their arrival at the delivery site. Unloading and handling shall be in accordance with the respective supplier's requirements. A Sound Transit representative will verify the quantity and condition of materials delivered.

E. Storage Plan.

Prepare a storage plan for each storage area where STFM and STFE are proposed to be stored or stockpiled. The plan shall be in sufficient detail to demonstrate that efficient handling environmental controls and security provisions have been provided, that supporting soils will not be overloaded, and that materials will not be overstressed due to bending or shear. No material or equipment shall be placed directly on the ground. Provide cribbing. A current inventory of the materials on hand shall be provided and kept by the Contractor. The Contractor shall notify the Resident Engineer at least 30 days in advance of anticipated shortages.

F. STFM and STFE Acceptance.

Inspect STFE and STFM at time of delivery by the respective suppliers to the delivery sites and submit certification to the Resident Engineer showing the quantity of accepted materials and equipment. Set aside damaged materials and equipment and immediately notify the Resident Engineer and the delivery carrier in writing of the damage and circumstances of discovery.

G. Inventory Records.

Prepare and maintain perpetual inventory records of Sound Transit-furnished materials and equipment, and assign stock number, date of receipt from Sound Transit, and approximate date of construction placement. Checkout and returns of STFE and STFM or other transfer of materials and equipment between the Contractor and Sound Transit shall be accompanied by an inventory record form.

H. Excess Materials.

Upon Substantial Completion of the Work, the Contractor shall transport, unload, and stockpile excess STFE and STFM to a delivery location within a 25-mile radius of the jobsite, as determined by the Resident Engineer.

1.04 INSTALLATION

STFE and STFM shall be installed accurately and efficiently to avoid waste, such as that due to incorrect or inaccurate installations. Wasted materials and equipment, as documented by the Resident Engineer, shall be replaced by the Contractor at no additional cost to Sound Transit.

1.05 INSTALLATION INSTRUCTIONS, TRADESMEN, AND SUPERVISION

A. The Contractor shall be responsible for providing appropriate tradesmen experienced in the installation of similar equipment.
B. The Contractor shall be responsible for coordinating the Work and cooperating with the Resident Engineer in scheduling the time when each installation supervisor will be needed in order to best conform with the installation and testing schedules and still allow sufficient advance notice to the manufacturer for scheduling the most suitable installation supervisor.

C. The Contractor shall be responsible for Work performed in the absence of the installation supervisor, or Work which does not conform to such supervisor’s instructions. Errors in assembly or installation resulting there from shall be corrected by the Contractor without additional cost to Sound Transit.

D. The Contractor will not be held responsible for faulty manufacture of the equipment or for errors in the manufacturers’ assembly drawings.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

No materials or equipment will be provided by Sound Transit.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01640
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SECTION 01650
PRODUCT DELIVERY REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Packing, shipping, delivery, and acceptance of products at site.

B. Transportation of equipment to installation sites, to test sites, or to any other sites.

1.02 PACKING

A. Pack equipment and appurtenances to protect against rough handling and corrosion due to exposure to salt atmosphere or open storage. Packages shall be such that they may be safely handled with the type of equipment and hoists required for large and heavy equipment, including forklifts and slings. Plainly mark the center of gravity of each package on each side.

B. Use international markings on packages indicating "This Side Up," "Fragile," "Use No Hooks," etc., as required.

C. Packaging shall be such as to permit as much inspection as practicable at the point of delivery.

D. Unpacking and repacking necessary to comply with U.S. Customs regulations shall be the responsibility of the Contractor, at no additional cost to Sound Transit.

1.03 SHIPMENT

A. Ship equipment in one fully assembled package unit when possible.

B. Assume risk of loss or damage in transit.

C. Schedule shipments to arrive at the site for unloading during normal working hours. Provide forty-eight hours notice prior to the arrival of the shipment to Sound Transit.

D. Coordinate all deliveries to Jobsite and all third parties with Resident Engineer. For deliveries to Sound Transit facilities in operation, Contractor shall obtain prior written authorization.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

Upon arrival, inspect all equipment for shipping damage.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01650
SECTION 01740
CLEANING

PART 1 - GENERAL

1.01 SECTION INCLUDES

Requirements for cleanup during construction and final cleaning of the facilities and site.

1.02 CLEANUP DURING CONSTRUCTION

A. Keep the worksite in a neat and orderly condition. The Resident Engineer may, at any time during construction, order a general cleanup of the site as a part of the Work. Provide general daily cleanup and disposal service for removal of waste and rubbish away from the worksite. Clean material as necessary prior to incorporating into the Work.

B. Dispose of waste, trash, and debris in a safe, acceptable manner, in accordance with applicable laws and ordinances and as prescribed by authorities having jurisdiction. Bury no waste material and debris on the site. Burning of trash and debris on the site will not be permitted.

1.03 FINAL CLEANING OF FACILITIES

A. Prior to final inspection by the Resident Engineer, and after all construction Work is essentially complete, thoroughly clean Jobsite, utilizing professional cleaners where appropriate.

B. Items to be cleaned include, but are not limited to: communications rooms, interior and exterior of communications cabinets, any dirt or debris brought onto Jobsite.

C. Vacuum-clean where appropriate and remove all spots, smears, dust, debris, hand prints, and defacements of every sort, including those of vandals. Use commercial cleaning compounds where necessary.

D. Follow the manufacturers’ recommendations for the materials and items to be cleaned.

1.04 FINAL SITE CLEANUP

A. Also prior to final inspection, thoroughly clean the worksite and put it into a neat, acceptable condition. Remove from the worksite all construction waste and unused materials, and debris of any description resulting from the Work.

B. Clean exposed exterior hard-surfaced finishes to a dirt-free condition, free of dust, stains, films and similar noticeable substances. Except as otherwise indicated, avoid the disturbance of natural weathering of exterior surfaces.

C. Clean worksite, including landscape development areas, of litter and foreign substances. Sweep paved areas to a broom-clean condition; remove stains, petrol-chemical spills and other foreign deposits.

D. All conduits shall be cleaned and openings protected as specified in Division 16, Electrical.
E. Removal of Protection.

Except as otherwise indicated or requested by the Resident Engineer, remove temporary protective devices and facilities such as warning, regulatory, or guide signs which were installed during the course of the Work to protect previously completed Work during the remainder of the construction period.

F. Compliances.

Comply with safety standards and governing regulations for cleaning operations. Do not burn waste Materials at the site, nor bury debris or excess materials on the property, or discharge volatile or other hazardous materials into drainage systems. Remove waste materials from the site and dispose of in accordance with local, state and Federal requirements.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01740
SECTION 01770
CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Requirements for substantial completion and final completion of the Work.

B. Assisting in the Resident Engineer's final inspection.

1.02 RELATED SECTIONS

A. Section 01780 – Project Record Documents.

B. Section 01740 – Cleaning.

1.03 QUALITY CONTROL

Comply with Section 01450, Systems Quality Requirements.

1.04 CLOSEOUT SCHEDULE AND PROCEDURE

A. Requirements Preparatory to Final Inspection.

1. Complete record drawings and specifications, and submit to the Resident Engineer as specified in Section 01780, Project Record Documents.

2. List of items yet to be completed.


4. Final inspection/test certificates and all other documents necessary for full and unrestricted use of the Work and access to services and facilities.

5. A list of all deviations or non-conformances currently in effect for which Work is to be performed and close-out action is required. Prepare and submit detailed plan to close-out all open issues including touch-up repair and restore marred exposed finishes to the satisfaction of the Resident Engineer.

6. Notify the Resident Engineer to perform a preliminary final inspection for the purpose of determining the state of completion of the Contract Work. Notify the Resident Engineer at least seven days in advance of the requested inspection. From the information gathered from this inspection, a "punch list" will be provided of Work to be performed, corrected, or completed before the Contract Work will be accepted. All Work on the punch list shall be completed by the Contractor prior to final inspection.

7. Temporary facilities excepted as may be required for "punch list work" shall be removed from the Worksite.
8. Clean the site and all applicable appurtenances and improvements as specified in Section 01740, Cleaning.

9. Properly mount operating instructions for equipment and post as specified or required.

10. Submit guarantees and warranties to the Resident Engineer, as specified in the General Provisions and various Sections of the Specifications.

B. Final Inspection.

1. After all requirements preparatory to the final inspection have been completed and the Work has been completed in accordance with the Contract, as herein before specified, request the Resident Engineer to perform the final inspection. Notice shall be given at least seven days in advance of the time the Work will be available for final inspection. If the Work is accepted at the final inspection and no further corrective measures are required, the requested date will be the acceptance date for the Certificate of Final Completion.

2. Contractor or its principal superintendent, authorized to act in behalf of the Contractor, shall accompany the Resident Engineer on the final inspection tour, as well as any principal subcontractors that the Resident Engineer may request to be present.

3. If the Work has been substantially completed in accordance with the Contract Documents, and the Work can be used for its intended purpose with only minor corrective measures required, a conditional acceptance of the Work may occur and a Certificate of Substantial Completion issued, based upon the Contractor’s assurance that corrective measures will be completed within the shortest practicable time period. A fixed schedule for such corrective measures shall be submitted to the Resident Engineer for approval.

4. If the Work has not been substantially completed in accordance with the Contract Documents, and several or many corrective measures are still required, a Certificate of Substantial Completion will not be granted. Instead, a new punch list will be prepared based on the information gathered from the final inspection, and the Contractor shall be required to complete this Work and then call for another final inspection, following the procedure outlined above.

5. Should Sound Transit perform re-inspections due to failure of the Work to comply with the claims of status of completion made by the Contractor, the Contractor will compensate Sound Transit for such additional services at the rate of $100.00 (one hundred dollars) per labor hour amount of such compensation to be deducted from the final payment to the Contractor.

6. Upon acceptance of the Work by Sound Transit, submit a request for final payment. Final payment will be made in accordance with General Provisions.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01770
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes preparation, maintenance, completion and submission of Project Record Drawings or As-Builts, Specifications and related documents as required.

1.02 RELATED SECTIONS

A. Section 01330 – Submittals.

B. Section 01770 – Contract Closeout.

1.03 SUBMITTALS

Comply with Section 01330, Submittals.

1.04 MAINTENANCE OF RECORD DOCUMENTS

A. Maintain at the jobsite one (1) copy of the following Contract Documents for record purposes.


2. Change Orders.

3. Approved Shop Drawings.

4. Clarifications or Explanatory Details and Specifications.

5. Inspection Reports.


7. Field Test Records.

8. Additional drawings as identified in the technical Sections of these specifications.

9. Copy of standards applicable to Work.

B. Store documents used for record purposes in the field job office and one other approved location, such as a home office. Record documents should be stored apart from documents used for construction or other purposes.

C. Provide files, racks, and some form of non-volatile magnetic media for storage of documents. Such files, racks, etc. shall be secured and protected from damage, theft and/or use by others not authorized to do Work on the Project, including Contractor’s employees not authorized to perform Work on the Project.
D. File documents in accordance with the project filing format of the Construction Specification Institute's "Masterformat" latest edition.

E. Maintain documents in clean, dry, readable form by human or machine as may be appropriate.

F. Do not use record documents for construction purposes.

G. Label each document "Project Record".

H. Make documents available at all times for inspection by the Resident Engineer.

I. Keep three sets of documents updated with current markup information depicting the installed or "as-built" condition. Transmit one set as record documents to the Resident Engineer, maintain one set at the worksite, and maintain one in Contractor's home office.

1.05 RECORD DRAWINGS

A. Contract Drawings.

1. Maintain "as-built" or record drawings of all Work and subcontracts, continuously as the job progresses. A separate set of prints, for this purpose only, shall be kept at the worksite at all times.

2. Where the Contract Drawings are not of sufficient size, scale, or detail, furnish Shop Drawings for incorporation of details and dimensions.

3. Upon completion of the Work subsequent to Substantial Completion and prior to Final Acceptance, stamp the final record set of "as-built" drawings "As-Built", sign and date, and deliver to the Resident Engineer prior to requesting final inspection as specified in Section 01770, Contract Closeout.

B. Change Orders.

1. Incorporate changes to the Contract Drawings effected by Change Orders on the record set, and identify these changes by Change Order number and effective date.

2. When revised drawings are issued as the basis of, or along with, Change Orders, incorporate these revised drawings into the record set with appropriate annotation. Contract Drawings deleted by Change Order shall not be incorporated as part of the record set. Resident Engineer will furnish both electronic and paper copies of these revised drawings.

C. Shop Drawings.

1. Collect one (1) complete set of approved Shop Drawings, including manufacturers' printed catalog cuts and data, and maintain for record purposes.

2. File shop drawings and maintain separate from Contract Drawings. File shop drawings in 9 inch by 12 inch file folders to the greatest extent possible and index in accordance with the Specifications and CSI's "Masterformat" as herein before specified.
3. Deliver shop drawings in new paperboard boxes manufactured for the storage of file folders. Boxes shall have covers and cutout handles and shall be accurately identified as to the contents.

1.06 RECORD SPECIFICATIONS

A. Project Specifications.

1. File the specifications book for record purposes in a large-ring, 3-ring binder or binders.

2. Record information, changes, and notes in the specifications in blank areas, such as page margins or the backs of opposite pages, or on separate sheets inserted in the binder. Record all such information, changes, and notes with red pen, or tracked changes in red.

3. The Record Specifications book shall be complete and shall include all applicable Contract Documents other than drawings.

B. Change Orders.

1. Incorporate Change Orders into the front of the specifications book in reverse chronological order. Use appropriate page dividers to identify Change Orders and to separate Change Orders from the Specifications.

2. In addition, annotate changes to the Specifications effected by Change Order on the affected page or pages of the Specifications or adjacent thereto.

1.07 OTHER WORKS

Other Works of design, documentation, or testing that are deemed important to Sound Transit as designated by Resident Engineer shall be maintained as Record Documents. Format for storage, configuration management, display, inspection, and delivery to Sound Transit shall be determined by Resident Engineer.

1.08 SUBMISSION OF DOCUMENTS

A. At completion of the Work, and before requesting final inspection, deliver final record documents to the Resident Engineer.

B. Deliver record documents neatly and efficiently packaged.

C. Accompany submission of record documents with submittal letter as per Section 01330, Submittals.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01780
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General information on the preparation and submission of an Operation and Maintenance (O&M) Manual of all installed equipment and systems.

B. General information on posting operating and maintenance instructions of all installed equipment and systems.

1.02 RELATED SECTIONS

A. Section 01330 — Submittals.

B. Section 01770 — Contract Closeout.

C. Section 01780 – Project Record Documents.

D. Section 01820 — Training Program.

1.03 REFERENCED SPECIFICATIONS


1.04 SUBMITTALS

A. Operation and Maintenance Manuals.

1. In general, separate operations and maintenance manuals shall be provided for each system/sub-system (i.e. CCTV, PA, PABX, etc.). Specific requirements for the manuals are listed along with the requirements of the specific system/sub-system. General requirements of the manuals shall follow Bellcore GR-454 or equivalent. Contractor is encouraged to submit product vendor’s manuals where the manuals largely meet Bellcore GR-454 and as augmented below. However, should vendor manuals contain more than 15 percent extraneous information or material by volume that does not apply to Work, Contractor shall re-write manuals, at its own expense, more specific to Work meeting the following requirements:

a.) Submittal Process.

1.) Refer to Section 01330, Submittals, for submittal procedures.

2.) 30 days prior to Factory Test, forward to the Resident Engineer the draft Operation and Maintenance Manuals (O&M Manuals). O&M Manuals shall consist of instructions of each equipment plant and its component parts, including manufacturers’ certificates, warranty information, parts lists, descriptive brochures, and maintenance and operating instructions and other information as required below. Draft shall be printed on at least 20-pound bond white paper.
Manuals shall detail equipment, systems, and functions supplied by Contractor, properly tabbed and identified for easy reference.

3.) After review of the draft O&M Manuals, Resident Engineer will return one copy for Contractor action.

4.) Once Drafts Approved, Contractor shall issue final version on 40-pound bond white paper.

5.) If subsequent modifications to the equipment require revised operation and maintenance procedures, revise the O&M Manual to show the equipment as installed. Such revisions shall be by issue of replacement pages to the final O&M Manual, or by reissue of the O&M Manual, at the Contractor's option. Submit the revisions to the O&M Manual not later than 60 days following revision of the equipment.

b.) Format.

1.) Include in the O&M Manual a title page, contents page, frontispiece, and information covering description, installation, operation, preventive maintenance, corrective maintenance, overhaul, parts list, and list of recommended spare parts, and an appendix.

2.) Include on the title page, the name and function of the equipment, manufacturer's identification number, and the Contract Specifications number and title.

3.) List the contents of all Sections and subsection titles of the O&M Manual with reference to the page on which each starts and a list of included drawings.

4.) The frontispiece shall be a recognition illustration of the equipment described in the Manual.

5.) Pages shall be 40 pound paper weight, 8-1/2 inches by 11 inches in size or folded to that size, and placed in a three-ring binder. Each binder shall not be filled more than 2/3 of its capacity.

6.) All manuals shall be provided in the English language.

c.) Contents.

1.) As a minimum, the following topics shall be covered.

   - Full technical description of product including illustrated pictures of parts and operational concepts.

   - Theory of operations.

   - System and equipment specifications.
- Ordering information and part number identification.
- Configuration drawings for panels, racks, and screens.
- Equipment options.
- System configurations (DIP switch setting and software control settings).
- Applications engineering.
- Installation and commissioning test procedures.
- Operations of all user controlled functions.
- Software instructions and procedures.
- Preventative maintenance test procedures.
- Trouble shooting guide and flow chart.
- Return and repair procedures with vendor technical support and wiring schematics.
- Mechanical drawings, block and level diagrams, and wiring schematics.
- Registration form for document tracking by vendor.
- Provisional parameters stating range, default setting, description and procedure.
- Alarm clearing procedures.
- Material and safety data sheets.

B. Quick Reference Sheets.

1. Contractor shall supply quick reference sheets specific to project, even if vendor has supplied Operations and Maintenance Manuals.

   a.) Contractor shall develop from the Operations Manuals an ‘Operations’ quick reference sheet for the general operation of equipment. Sheet shall be an 8.5 inch by 11 inch or 11 inch by 17 inch folded, laminated sheet of 60 pound light blue paper. It shall contain the operating commands and most frequently used trouble shooting procedures. Font shall not be smaller than size 10 and margins shall be at least 0.5 inches.
b.) Contractor shall develop from the design and installation of equipment and/or software a ‘Settings’ quick reference sheet showing all switch settings and software settings for equipment and procedures to set them if not noted on Operations blue sheet. Sheet shall be an 8.5 inch by 11 inch or 11 inch by 17 inch folded, laminated sheet of 60 pound light yellow paper. Font shall not be smaller than size 10 and margins shall be at least 0.5 inches.

c.) Quick reference sheet shall be supplied in draft form with the Operations Manuals and used in the Training Program.

PART 2 - PRODUCTS

2.01 BINDERS

A. Binders shall be designed for service in a maintenance shop environment. Covers shall be oil, water and wear-resistant.

B. Binders shall be white in color with text printed in black lettering. Graphics and Sound Transit’s logo shall be printed in color. Text and Sound Transit’s logo shall be printed on both spine and cover. All printing shall be silkscreen applied using wear resistant inks.

C. Binders rings shall be locking type and able to withstand 1000 openings and closings without failure or misalignment of rings.

2.02 DIVIDER PAGES

A. Divider pages shall be white with white tabs, 8.5 inch by 11 inch 60 pound minimum, punched to fit in binders.

B. Tabs shall extend 3/8 inch from edge of divider page and be laser printed in black ink.

PART 3 - EXECUTION

3.01 SUPPLY OF MANUALS

A. Operations & Maintenance Manuals.

1. Contractor shall deliver to the Resident Engineer the final version of the Operations and Maintenance Manuals in quantities sufficient for the following:

   a.) Training – 20 copies of each manual.

   b.) Operations – 20 copies of each manual.

   c.) Maintenance – Five (5) for Communications Maintenance.

   d.) Reference – Two (2) for the library.

   e.) Electronic – Two (2) on CD-ROM or DVD in an index capable format suitable to Resident Engineer.
B. Quick Reference Sheets.

1. Contractor shall deliver to the Resident Engineer the final version of the Quick Reference Sheet in quantities sufficient for the following:

   a.) Training – 20 copies of each set.

   b.) Operations – 20 copies of each set.

   c.) Maintenance – One (1) set for each installation of equipment and 25 additional for maintenance staff.

   d.) Electronic – Two (2) on CD-ROM or DVD in an index capable format suitable to Resident Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01785
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SECTION 01820
TRAINING PROGRAM

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes general requirements for a training program. Specific elements of each system/sub-system are included under the specific Sections pertaining to each system/sub-system.

1.02 SUBMITTALS

A. Training Program Plan.

1. Contractor shall develop a comprehensive Training Program Plan with several tracks, one for each area such as communications technician or console operator. This approach specifies a certain number of courses shall be required to achieve certification or proficiency in the area of communications and control systems on Link. Contractor’s role in this program is to successfully train Sound Transit designated personnel to operate and maintain the Communication and Control System to the reliability standards defined by the Contractor in the design. Plan, at a minimum, shall define the following:

a.) Goals of training program.

   1.) Tracks offered including skills or education level recommended to begin, estimated time to complete, and minimum coursework to receive certification in track. Tracks to be offered include, but are not limited to the following:

   - Train Controller.
   - CCTV Operator.
   - Communications Maintainer.
   - Software/Database Administrator.
   - Communications/Control System Resident Engineer.
   - CCS Software Resident Engineer.
   - Management Overview.
   - Communications Instructor.

B. Document Submissions


2. Final Version of Training Plan shall be submitted 30-days prior to Factory Testing along with Draft Training Guides and Syllibi.
3. Final Version of Training Guides, Syllabi, and sample instructor exams shall be submitted 30-days prior to Training.

1.03 COURSE OFFERINGS

A. Courses shall include: course description syllabus, class size, dates offered, instructor(s), minimum requirements to take class, material used to teach class, minimum proficiency levels to receive class certificate, and facilities to be used for class. In addition to the specific courses mentioned for each system/sub-system, the following general courses shall be offered, as a minimum:

1. Introduction to the Link Communications and Control Systems.

   a.) Introduction to the Link Communications and Control Systems shall introduce Sound Transit to the systems and sub-systems supplied under the C803 Contract. Course work shall include description of the systems and sub-systems supplied, theory of operation, and training on operations of user operable equipment including but not limited to:

      1.) PABX phones.

      2.) PET phones and operators console.

      3.) ETEL phones and operators console.

      4.) CCTV operator console.

      5.) PA console, microphone, or from EMP.

      6.) VMS from console or EMP.

      7.) Basic CCS functions from consoles and EMPs.

   b.) Classroom Work shall be augmented with tours to see actual field equipment and hands off training of equipment. The training course shall be delivered by instructor-led training (ILT) for a minimum of two (2) days or 16 hours of classroom instruction. Computer-based training (CBT) may be used to augment classroom Work.

   1.) Course Objectives.

      - Upon Completion of this course the students will be able to:

         Understand equipment supplied in C803 and how it operates.

         Be able to use all features of any phone on the system.

         Be able to operate voicemail system.

         Be able to call up and view, record, and operate any CCTV camera.
2. Basic Telecommunications.

Basic Telecommunications shall explore analog and digital concepts, and introduce telecommunications basics such as networks, business communications systems, signaling, Internet telephony, and switching. The training course shall be delivered by ILT for a minimum of two (2) days or 16 hours of classroom instruction. CBT may be used to augment classroom Work.

**TABLE 1**

Course Outline

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<td>Typical CPE Features</td>
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<td>CO Digital Switches</td>
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<td>Digital Signals</td>
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</table>

#### Section IX – Signaling
Basic Types of Signaling
Signaling Transmission
Supervisory Signaling
In-Band Interswitch Signaling
Digital Processes
Address Signaling System
Out of Band Signaling (CCS)
SS7

#### a.) Objectives.

1.) Upon successful completion of this course, the learner will be able to:

- Describe the current environment of the telecommunications network.
- Describe the effect of the network's analog origins on today's environment.
- Define the basic terms necessary to discuss telecommunications.
- Define the local loop.
- Identify the different types of network providers and their functions.
- Describe the features and functions of station sets.
- Describe the key features of Centrex.
- Describe the features and functions of a Private Branch Exchange (PBX).
- Describe the features and functions of the different categories of key systems.
- Compare the various CPE options.
- Describe the features and functions of ISDN.
- Explain the increasing complexity in the networks communications options.
- Explain the evolution of key systems.
- Differentiate between standalone and integrated PBX.
- Differentiate between Centrex features and PBX features.
- Describe the primary trends in CPE development.
- Identify common features of CPE.
- Describe carrier services.
- Describe switched service.
- Describe dedicated services.
- Describe common types of dedicated services.
- Describe common types of switched services.
- Identify the network processes that are common to analog and digital transmission.
- Describe the characteristics of the analog voice signal.
- Describe the key transmission variables for the analog signal.
- Describe the most common method of multiplexing in analog transmission.
- Describe how FDM works.
- Describe the characteristics of the digital signal.
- Identify the advantages of digital technology.
- Describe how digital technology works with analog technology.
- Describe how pulse code modulation (PCM) works.
- Describe standards of digital voice transmission.
- Describe time division multiplexing (TDM).
- Describe optical signaling and its application.

- Describe digital loop carriers (DLCs).

- Describe the level of complexity in the PSTN.

- Describe how digital technology has affected the PSTN architecture.

- Explain how local service is provided.

- Explain how long distance service is provided.

- Describe how Companies are structured.

- Explain the functions of a cellular network.

- Describe the process of a simple transmission.

- Identify the most common types of transmission media.

- Describe two (2) wire circuits.

- Describe types of multi-circuit media.

- Discuss common problems in analog voice transmission.

- Describe how digital signals avoid the problems found in analog transmission.

- Identify the different types of signaling.

- Describe signaling transmission.

- Describe the most common supervisory signaling techniques.

- Describe interswitch supervisory signaling.

- Explain how the dialing process works.

- Describe the North American Dialing Plan's address system.

- Describe out of band signaling (CCS).

- Describe the signaling process in an SS7 network.
- Describe the function and evolution of analog switches.
- Describe digital switches.
- Describe time-division multiplexing (TDM).
- Describe time-division switching (TDS).
- Describe space-division switching (SDS).
- Describe a combined digital switch.
- Describe the status of optical switching.

3. Basic Data Communications.

   a.) Basic Data Communications exam tests a student's knowledge of related software and hardware. It introduces the technology of network architecture, packet-switching, fiber optics, data communications channels, and data communication devices. Training courses shall be delivered by ILT for a minimum of three (3) days or 24 hours of classroom instruction. CBT may be used to augment classroom instruction.

Table 2
Course Outline

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<tr>
<td></td>
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</table>
b.) Objectives.

1.) Upon successful completion of this course, the learner will be able to:

- Describe data communications networks.
- Identify types of signals and their features.
- Discuss transmission service providers, circuits, and forms of service.
- Identify and describe types of data terminal devices.
- Identify and describe types of computer networks.
- Describe the features and functions of an SNA network.
- Describe the features, functions, and applications of the TCP/IP protocol.
- Identify and define roles and features of various data transmission protocols.
- Identify and describe the implications of DCE/DCE protocols for transmission methods and modes and error checking.
- Describe the features of IEEE LAN protocols.
- Identify and describe types of packet technologies.
- Describe the features and functions of SONET.
- Describe the components of a data communications system.
- Identify and describe analog communications devices.
- Identify features, functions and types of modulation.
- Explain the role of digital communications devices in a data communications network.
- Define the role of line coding in a communications network.
- Describe the features and functions of multiplexers.
- Identify key considerations in selecting transmission media in networks.
- Identify the features, functions, and uses of twisted pair cable.

- Identify the features, functions, and uses of coaxial cable.

- Identify the features, functions, and uses of optical fiber.

- Identify the features, functions, and uses of infrared transmission.

- Identify the features, functions, and uses of microwave transmission.

- Identify the features, functions, and uses of satellite transmission.

4. Local Area Networks (LANs).

   a.) Local Area Networks (LANs) develop critical understanding of the concepts and technology of LAN topologies, information transfer, transmission techniques, media standards, and network management. The LAN courses shall be delivered by ILT for a minimum of three (3) days or 24 hours of class room instruction. CBT may be used to augment in class training.

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Table 3
Course Outline
### Table 3

#### Course Outline

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<td>Satellite</td>
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</table>

#### b.) Objectives

1. Upon successful completion of a LAN course, the learner will be able to:

- Describe network use before present-day LANs.
- Describe a present day LAN.
- Identify the primary advantages provided by a LAN.
- Identify the basic elements of a LAN.
- Identify common user groups of LAN technology.
- Identify the primary issues confronting the LAN market.
- Identify the four LAN topologies.
- Describe the features and functions of bus topologies.
- Describe the features and functions of ring topologies.
- Describe the features and functions of tree topologies.
- Describe the features and functions of star topologies.
- Identify type of hubs and their features and functions.
- Describe basic data transport in a LAN.
- Describe the primary access methods for LANs.
- Describe the features and functions of CSMA/CD (Ethernet) access method.
- Describe the features and functions of the token ring access method.

- Describe the features and functions of the token bus access method.

- Discuss the factors involved in choosing an access method.

- Describe the different types of signals that require transmission.

- Describe baseband transmission within a LAN.

- Describe broadband transmission within a LAN.

- Describe hybrid transmission techniques.

- Describe fiber optic transmission within a LAN.

- Differentiate between the transmissions techniques.

- Identify factors in choosing transmission media.

- Describe the features and functions of twisted pair cable.

- Describe the features and functions of coaxial cable.

- Describe the features and functions of fiber optic cable.

- Describe the features, functions, and uses of infrared transmission.

- Describe the features, functions, and uses of microwave transmission.

- Describe the features, functions, and uses of satellite transmission.

- Describe the current state of LAN standards.

- Describe the structure and function of the OSI reference model.

- Describe the TCP/IP network protocols.

- Describe the SNA network protocols.

- Describe the purpose of the IEEE committees.

- Identify IEEE 802.x standards.

- Describe components used in a network.
- Describe different types of network servers.

- Describe the features and functions of a network operating system (NOS).

- Describe the internetworking components used in networking.

- Discuss network management trends.

- Discuss common network management issues.

- Discuss the issues involving network user management.

- Discuss tools available for network hardware and software management.

- Discuss the ISO network management functional areas.

- Discuss the role of network management protocols.

- Describe the issues surrounding network planning.

- Discuss the issues behind the development of new LAN technology.

- Describe the basic WAN technology.

- Describe advanced data transmission technologies.

- Describe frame relay technology.

- Describe SONET technology.

- Describe cell relay technology.

5. Introduction to LonWorks.

a.) This introductory course is intended to be the starting point for your discovery of LonWorks for anyone who is interested in learning the basics of the LonWorks platform. This course introduces the new student to the fundamentals, terminology, and applications of the LonWorks Technology. The training begins with an overview of networks and protocols, highlighting the technical aspects of the LonTalk® protocol from a high level perspective. The Introduction to LonWorks course shall be delivered by ILT for a minimum of 1-days or 8 hours of classroom instruction. CBT may be used to augment in class training.
1.) Objectives.

- Upon successful completion of a LAN course, the learner will be able to:

  Articulate the benefits of a LonWorks Network.

  List 5 advantages of LonWorks technology.

  Explain what a LonWorks control Network does.

  Explain why the LonMark Organization is important.

  Explain the Charter of the Open Systems Organization.

  Describe key components used in a LonWorks Network.

  Describe the basics of LonTalk protocol.

  Identify the fundamental characteristics of LonWorks Architecture.

  Recognize key elements of LonWorks on a typical LonWorks Control Network Diagram.

  List the steps to LonWorks Network implementation.

  Explain the conditions necessary to properly commission a LonWorks device.

  List the proper steps to configure a LonWorks network.

  Demonstrate the procedure to be used when replacing a LonWorks device.

  Develop a troubleshooting plan for a common LonWorks Network problem.

  Describe at least two applications where a LonWorks network would be used.

  Identify appropriate LonWorks products for a given application.

6. Other Advanced Training.

   Contractor shall provide additional equipment and software specific training as noted in other sections throughout Specification. Training shall at least be equivalent to that offered by original manufacturer following guidelines identified in this Specification.

B. Training Schedule shall address who shall be trained, how many persons in each class, and when the classes shall take place.
C. Training Guides.

1. Contractor shall prepare Training Guides for both Instructor’s and Students for each course.

   a.) Student Guides.

       Student guides shall contain at least the following: the course syllabus, information on surrounding attractions (bathroom locations, facilities to have lunch, evacuation routes for emergencies, etc.), copies of any background reading material, copies of all overhead displays or visual aides used by instructor, and lined paper for taking notes.

   b.) Instructor Guides.

       Instructor Guides shall contain at least the following: the course syllabus, information on surrounding attractions (bathroom locations, facilities to have lunch, evacuation routes for emergencies, etc.), originals of all background reading material, originals of all visual aides, speaker’s notes for displays, sample quizzes for class with answers, and sample tests for class with answers. Also contained should be instructions on how to set up demonstrations for any hands-on training or testing.

   c.) Video Recording.

       Contractor shall professionally tape the first instance of every course to provide a refresher program for Link staff on each course. Video professional shall be experienced in producing training or educational videos. Resume and references shall be provided along with proposal from supplier with Training Plan. Contractor shall provide at least six (6) copies of each course on finished edited tape.

D. Tests for Instructor.

   Provide written test to trainers for evaluation of skills and effectiveness of the training program.

PART 2 - PRODUCTS

2.01 BINDERS

A. Binders shall be designed for service in a maintenance shop environment. Covers shall be oil, water and wear-resistant.

B. Binders shall be white in color with text printed in black lettering. Graphics and Sound Transit’s logo shall be printed in color. Text and Sound Transit’s logo shall be printed on both spine and cover. All printing shall be silkscreen applied using wear resistant inks.

C. Binders rings shall be locking type and able to withstand 1000 openings and closings without failure or misalignment of rings.
2.02 DIVIDER PAGES

A. Divider pages shall be white with white tabs, 8.5 inch by 11 inch 60 pound minimum, punched to fit in binders.

B. Tabs shall extend 3/8 inch from edge of divider page and be laser printed in black ink.

PART 3 - EXECUTION

3.01 TRAINING COURSES

A. Conduct training courses of designated personnel at or near Sound Transit facilities.

B. Contractor is to provide training facility and projectors, etc. Training classroom(s) shall be of two types:

1. Lecture Classroom – this shall hold up to 20 students with seats and desktops and shall be suitable for classroom style lecture for periods of eight (8) hours or more.

2. Lab Classroom – this shall hold up eight (8) students at four (4) workstations for hands on practical training.

C. Training to consist of class and field exercises/hands on training whenever feasible.

D. Trainers shall be certified professional trainers not designers or engineers. Submit resumes of proposed trainers for Resident Engineer’s approval.

E. Contractor shall assume all trainees are at least high school graduates with technicians having a two year degree in electronics technology.

F. Training course to supply the following training as a minimum:

**TABLE 4**
Basic Courses

<table>
<thead>
<tr>
<th>Track/Course Work</th>
<th>Intro to Link Comm</th>
<th>Basic Telecom</th>
<th>Basic Datacom</th>
<th>LAN</th>
<th>Lon Works</th>
<th>Advanced Training (hours)</th>
<th>Max. Persons Trained</th>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>200</td>
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</table>
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01820
PART 1 - GENERAL

1.01 SECTION INCLUDES

General information on the preparation and submission of Test Plans and Test Procedures for the testing of each subsystem, system, and integration with other systems.

1.02 RELATED SECTIONS

Section 01330 — Submittals.

1.03 REFERENCED SPECIFICATIONS


1.04 TEST PLAN

A. Definition.

The Test Plan is a document describing the scope, approach, resources, and schedule of intended testing activities. It identifies test items, the features to be tested, the testing tasks, who will do each task, and any risks requiring contingency planning.

B. Outline.

1. Test Plan Identifier.
   A unique identifier.

2. Introduction.
   a.) Summary of the items and features to be tested.

   b.) Need for and history of each item (optional).

   c.) References to related documents such as project authorization, project plan, QA plan, configuration management plan, relevant policies, relevant standards.

   d.) References to lower level test plans.

3. Test Items.
   a.) Test items and their version.

   b.) Characteristics of their transmittal media.

   c.) References to related documents such as requirements specification, design specification, users guide, operations guide, installation guide.
d.) References to bug reports related to test items.

e.) Items which are specifically not going to be tested (optional).

4. Features to be Tested.
   a.) All software features and combinations of features to be tested.
   b.) References to test-design specifications associated with each feature and combination of features.

5. Features Not to Be Tested.
   a.) All features and significant combinations of features which will not be tested.
   b.) The reasons these features won’t be tested.

   a.) Overall approach to testing.
   b.) For each major group of features of combinations of features, specify the approach.
   c.) Specify major activities, techniques, and tools which are to be used to test the groups.
   d.) Specify a minimum degree of comprehensiveness required.
   e.) Identify which techniques will be used to judge comprehensiveness.
   f.) Specify any additional completion criteria.
   g.) Specify techniques which are to be used to trace requirements.
   h.) Identify significant constraints on testing, such as test-item availability, testing-resource availability, and deadline.

7. Item Pass/Fail Criteria.
   Specify the criteria to be used to determine whether each test item has passed or failed testing.

8. Suspension Criteria and Resumption Requirements.
   a.) Specify criteria to be used to suspend the testing activity.
   b.) Specify testing activities which must be redone when testing is resumed.
   a.) Identify the deliverable documents: test plan, test design specifications, test case
       specifications, test procedure specifications, test item transmittal reports, test logs,
       test incident reports, test summary reports.
   b.) Identify test input and output data.
   c.) Identify test tools (optional).

10. Testing Tasks.
    a.) Identify tasks necessary to prepare for and perform testing.
    b.) Identify all task interdependencies.
    c.) Identify any special skills required.

    a.) Specify necessary and desired properties of the test environment: physical
        characteristics of the facilities including hardware, communications and system
        software, the mode of usage (i.e., stand-alone), and any other software or supplies
        needed.
    b.) Specify the level of security required.
    c.) Identify special test tools needed.
    d.) Identify any other testing needs.
    e.) Identify the source for all needs which are not currently available.

12. Responsibilities.
    a.) Identify groups responsible for managing, designing, preparing, executing,
        witnessing, checking and resolving.
    b.) Identify groups responsible for providing the test items identified in the Test Items
        Section.
    c.) Identify groups responsible for providing the environmental needs identified in the
        Environmental Needs Section

    a.) Specify staffing needs by skill level.
    b.) Identify training options for providing necessary skills.
   a.) Specify test milestones.
   b.) Specify all item transmittal events.
   c.) Estimate time required to do each testing task.
   d.) Schedule all testing tasks and test milestones.
   e.) For each testing resource, specify its periods of use.

15. Risks and Contingencies.
   a.) Identify the high-risk assumptions of the test plan.
   b.) Specify contingency plans for each.

16. Approvals
   a.) Specify the names and titles of all persons who must approve the plan.
   b.) Provide space for signatures and dates.

1.05 TEST PROCEDURE

A. Definition.

The Test Procedure is the document which specifies the steps used to analyze a software item, sub-system, or system in order to evaluate a set of features.

B. Outline.

1. Test case specification identifier.
2. Software item, sub-system, or system under test.
3. Dependencies (Other systems that must be present, working, and tested previously).
4. Initial Conditions.
5. Detailed procedure showing for each step:
   a.) Step Number.
   b.) User Action.
   c.) Expected Results.
   d.) Pass or Fail.
   e.) Discrepancy.
C. Sample Forms.

<table>
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<tr>
<th>TEST NAME</th>
<th>Test Record</th>
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<td>Test Procedure Name:</td>
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<tr>
<td>Test Results:</td>
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<td>Start Time:</td>
<td>End Time:</td>
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<tr>
<td>Hardware Under Test:</td>
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<td>Test Objective and Scope:</td>
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<td>Other Items:</td>
<td>Identification No.</td>
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<td>Test Setup and Initial Conditions Description:</td>
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<td>Special Test Conditions (if any):</td>
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<tr>
<td>Prerequisite Tests:</td>
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<tr>
<td>Discrepancy Summary (list step number where discrepancy occurred):</td>
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Test Engineer:  
Engineer’s Representative:  
Quality Assurance:
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<th>P</th>
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</tbody>
</table>

END OF TEST.
1.06 SUBMITTALS

A. Contractor shall submit Test Plan along with Final Design Review or 90 days prior to any test whichever comes first.

B. Test Procedures shall be submitted in draft format along with Test Plan. Actual test plans shall be submitted 30 days prior to the test

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 THE FOLLOWING CLASSES OF TESTS SHALL BE INCLUDED IN THE TEST PLAN AND PROCEDURES

A. Factory Test.

Prior to field installation, Contractor shall validate system functionality and design with a comprehensive Factory Test. Factory Test shall be performed in Puget Sound Metro area at Contractor’s facilities with at least one of every different piece of equipment supplied under this Agreement.

B. Field Validation Testing.

Contractor shall validate the operational readiness of equipment and test what can be tested prior to connecting various communications gear together. This is commonly called local testing because it will only test the equipment at one site. Testing of cables between two points shall also be considered Field Validation Testing.

C. Acceptance Testing.

Prior to Integrated Testing and connecting communications equipment to equipment supplied by others, Contractor shall test all functionality and connection systemwide across all communication systems. Only after Acceptance Testing has been satisfactorily performed shall Contractor be able to perform Reliability Testing or Integrated Testing.

D. Integrated Testing.

Prior to Integrated Testing and connecting communications equipment to equipment supplied by others, Contractor shall test all functionality and connection systemwide across all communication systems. Only after Acceptance Testing has been satisfactorily performed shall Contractor be able to perform Reliability Testing or Integrated Testing.

E. Reliability Testing.

After acceptance testing, Contractor may perform reliability testing as defined in Section 17030, Reliability Management Plan, for a period of one year.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01830
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes general requirements for an installation program. Specific elements of each system/sub-system are included under the specific Sections pertaining to each system/sub-system.

1.02 RELATED SECTIONS

A. Section 01330 — Submittals.

B. Section 01770 — Contract Closeout.

C. Section 01780 — Project Record Documents.

D. Section 01785 — Operations & Maintenance Manuals.

E. Section 17020 — Cutover of Existing System.

F. Section 17100 — Cable Network Overview.

1.03 DESCRIPTION

Contractor shall develop a comprehensive Installation and Commissioning Plan that shall clearly delineate the Contractor’s plan to achieve a validated design. Plan shall include but not be limited to:

1. General description of how Contractor is approaching Work with the intent on completion.
2. Site entrance acceptance checklists and procedures for site walkthroughs prior to installing equipment at a facility or in conduits.
3. Procedures to cutover existing and operational equipment.
4. Installation methods and procedures used by the Contractor.
5. Site exit acceptance checklist and procedures for site acceptance of site Work by Engineer.
6. Commissioning procedures for subsystems by location.

1.04 LOCATIONS/ DIVISION OF WORK

A. DSTT

Prerequisites for cutover.

B. Balance of System
1.05 SUBMITTALS

A. Contractor to submit Installation and Commissioning Plan along with Final Design Review submittal.

B. Contractor shall submit detailed site-specific procedures for each type of Work.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 01840
DIVISION 5

METALS
This page is intentionally blank.
PART 1 - GENERAL

1.01 SECTION INCLUDES

Section includes specifications for galvanizing where indicated for steel, iron or castings items.

1.02 REFERENCE STANDARDS

A. American Hot-Dip Galvanizers Association, Inc. (AHDGA).

AHDGA Inspection Manual for Hot-Dip Galvanized Products.

B. American Society for Testing and Material (ASTM).

1. ASTM A53/A53M Pipe, Steel, Black and Hot-Dipped Zinc-Coated, Welded and Seamless.

2. ASTM A123/A123M Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.


4. ASTM A153/A153M Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

5. ASTM A384 Safeguarding against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.

6. ASTM A385 Providing High-Quality Zinc Coatings (Hot Dip).

7. ASTM A563 Carbon and Alloy Steel Nuts.

8. ASTM B6 Zinc.

1.03 DEFINITIONS

A. Hot-Dip Galvanizing.

Dipping steel members and assemblies into molten zinc for lasting, or long-term corrosion protection. Resultant zinc coating fuses permanently with base steel material.

1.04 SUBMITTALS

A. Submit materials data as specified in Section 01330, Submittals.
B. Certification.

1. Furnish notarized certificates of compliance with ASTM and AASHTO requirements specified in this Section.

2. Each certificate shall be signed by the galvanizer and list a detailed description of all material and methods used.

3. Certification shall state that the galvanizing is in conformance with this Section.

C. Coordination Drawings: To safeguard against distortion, furnish to the galvanizer steel fabricator's shop drawings of non-standard fabrications, tubular fabrications, fabrications involving any dimension which exceeds the size of the galvanizer's kettle, large fabrications subject to warping during galvanizing, and fabrications involving materials of different thicknesses.

1.05 QUALITY CONTROL

A. Galvanizing Firm – Member of American Hot-Dip Galvanizers Association Inc. (AHDGA).

B. Inspection and Tests.

1. Inspections, test, and samples – Conform with ASTM Specifications and Standards.

2. Inspection rights and privileges, procedures, and acceptance or rejection of galvanized steel materials to conform with ASTM A123.

3. Inspection and test to include the following:

   a.) Visual examination of samples and finished products.

   b.) Tests to determine weight or mass of zinc coating per square foot of steel surface.

   c.) Tests to determine distribution and uniformity of zinc coating.

   d.) Tests to determine thread fittings of units, washers to bolts.

1.06 GALVANIZER'S STAMP

All galvanized material shall be marked with the galvanizer's stamp.

1.07 MOCK-UP AREAS

Where mock-up areas are indicated on the Contract Drawings, provide galvanized items in these areas before proceeding with the rest of the Work of this Section. Acceptable items in mock-up areas shall be incorporated into the Work, and shall remain as the quality and visual standard for the rest of the Work.

1.08 DELIVERY, STORAGE, AND HANDLING

Deliver, handle, and store in a manner that prevents damage to the item and its galvanizing.
PART 2 - PRODUCTS

2.01 GALVANIZING

A. Provide galvanizing after fabrication complying with ASTM A123 and A153. The galvanizing bath shall contain 0.05 to 0.09 percent nickel by weight.

B. Provide galvanizing repair materials where permitted and to the extent conforming to Section 05083, Factory-Applied Metal Coatings.

2.02 STEEL MATERIALS

A. Material for Galvanizing.

1. Geometrically suitable for galvanizing as specified in ASTM A384 and A385.

2. Steel materials suitable for galvanizing include structural shapes, pipe, sheet, fabrications, and assemblies.

B. Material chemically suitable for galvanizing. Verify with supplier or fabricator.

2.03 IRON AND STEEL HARDWARE

A. Bolts, nuts, washers, and items of iron and steel hardware furnished for galvanizing – Suitable for hot-dip galvanizing.

B. Inspection.

1. Inspect iron and steel hardware before galvanizing and verify suitability for galvanizing.

2. Replace items which are not suitable for galvanizing.

2.04 ZINC FOR GALVANIZING

Conform to ASTM B6, as specified in ASTM A123.

PART 3 - EXECUTION

3.01 GALVANIZING

A. Steel members, fabrications, and assemblies to be galvanized after fabrication.

1. Method – Hot-dip process in accordance with ASTM A123.

2. Weight of zinc coating – Conform to requirements of ASTM A153.


B. Safeguard against steel embrittlement in accordance with ASTM A143.
C. Safeguard against warpage or distortion of steel members in accordance with ASTM A383. Notify the Resident Engineer or its designee of potential warpage problems that require modification in design before proceeding with steel fabrications.

D. Finish and uniformity of zinc coating and adherence of coating – In accordance with ASTM A153.

3.02 TESTING

Submit test report for conformance with specified requirements.

3.03 PREPARATION OF STEEL MEMBERS

A. Galvanized members requiring shop fabrication shall be welded, drilled, and assembled, as applicable, prior to galvanizing.

B. Galvanized members that are to be field welded or that are to be shop welded to ungalvanized members where permitted shall be masked to a distance of one inch from the weld line prior to galvanizing.

C. All members to be galvanized shall be abrasively cleaned in accordance with SSPC SP6, Commercial Blast Cleaning.

3.04 SURFACE PREPARATION BEFORE GALVANIZING

A. Verify that all members have been abrasively cleaned as specified in Paragraph 3.01C above.

B. Pickle steel surfaces before hot-dip galvanizing in accordance with SSPC-SP8 - Pickling.

3.05 APPLICATION THICKNESS

A. Apply galvanizing in the weights and thicknesses specified in the applicable standards listed in Standard Specifications ASTM A123 and A153.

B. The indicated minimum thickness shall be the minimum measured at any point.

3.06 INSPECTION AND REPAIR

A. Contractor shall inspect galvanizing for full coverage and adhesion to steel. Grind rough areas to produce a uniform surface.

1. Repair minor defects and coat masked areas in accordance with ASTM A780, Repair of Hot Dipped Galvanizing.

2. Sprayed on zinc repairs will not be permitted.

3. Zinc-Based Solders and Wire—Clean to remove loose material and contaminates and heat to approximately 572°F. Apply zinc-alloy repair compound by spreading material over heated surface in accordance with compound manufacturer’s instructions. Remove repair compound residues with damp cloth or by rinsing with water.
B. Dry film thickness of applied repair materials – Not less than galvanized coating thickness required by ASTM A53, A123, or A153.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 05080
This page is intentionally blank.
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes specifications for shop-applied fluoropolymer coating systems for aluminum extrusions and panels, and for steel fabrications where identified in the Contract documents.

1.02 REFERENCE STANDARDS


8. ASTM D3363 Standard Test Method for Film Hardness by Pencil Test.


B. American Architectural Manufacturers Association (AAMA).

1.03 SUBMITTALS

A. General.

Refer to Section 01330, Submittals, for submittal procedures.

B. Qualifications Submittals (for each applicator).

1. Evidence that the applicator is an approved and authorized applicator of the coating formulator's products.

2. Certification that the applicator has been authorized to provide the coating formulator's warranty.

3. Evidence from the coating formulator that the proposed formulator is licensed by the polyvinylidene fluoride resin manufacturer.

4. Certified test results evidencing compliance of applied coatings with the application and testing requirements specified in this Section.

C. Literature and Instructions.

1. Descriptive and technical literature describing products proposed for use. Include, for each indicated substrate, the chemical and performance characteristics of cured fluoropolymer coating system.

2. Surface preparation requirements for the indicated substrates, and environmental and other requirements for successful application of the specified coatings.

D. Color Samples.

Match the colors specified in Color Schedule on 12-inch long sections of extrusions and 12-inch square heavy gage sheet metal, materials matching the indicated substrates, for Resident Engineer's review. Include additional samples for each indicated color demonstrating the color match of recommended field touchup materials.

E. Maintenance Information and Field Touchup Materials.

Manufacturer's recommended touchup and maintenance materials and procedures for field touchup of marred or damaged coatings using air-drying spray materials in matching colors.

1.04 SYSTEM DESCRIPTION

A. Fluoropolymer coatings are shop-applied thermo-cured color finish systems based on polyvinylidene fluoride resins, and applied to indicated materials and items after fabrication. Total coating system shall have dry film thickness of 1.6 mils minimum. Fluoropolymer coatings shall be applicator's standard 3-coat system as follows:

1. Corrosion-inhibitive primer, over appropriately cleaned or pretreated substrate with dry film thickness of 0.3 mil minimum.

2. Custom color coat with dry film thickness of 1.0 mil minimum.
3. Clear topcoat with dry film thickness of 0.3 mil minimum.

B. For both color coat and clear topcoat, a minimum of 70 percent of the total resin content of each formulation shall be polyvinylidene fluoride resin.

C. Provide coatings which match durability and other characteristics of field-tested coatings and are tested under weathering and exposure conditions cited in the performance criteria of AAMA 2604. Coatings shall meet the following requirements when tested:

1. Coatings shall exhibit no noticeable peel, blister, flake, chip, crack, check, or similar defect in the finish.

2. Coating colors shall exhibit no fading or other color change in excess of 5 NBS units.

3. Coatings shall meet or exceed all other performance criteria specified in this Section.

1.05 QUALITY CONTROL

A. Coating Applicator Qualifications.

Engage an experienced coating applicator that is licensed or approved by the fluoropolymer coating manufacturer. Applicator shall have demonstrated the ability to properly apply the coating and have quality control procedures firmly established in their shop. If requested by the Resident Engineer, coating applicator shall furnish test results of previously tested production specimens within the last 6 months showing conformance to AAMA 2604.

B. Single Source.

Use products of one manufacturer on each specific item (i.e. railings, windscreen framing, and canopy elements.) to ensure exact color match and finish appearance.

1.06 WARRANTY

A. Written warranty for 5-year period starting on date of substantial completion stating that shop applied coating will not blister, peel, crack, chalk, change color or have other forms of degradation during the warranty period.

B. In the event that coating failure occurs within the warranty period, replace item indicating coating failure including full cost of labor and materials for such replacement. Replacement items shall be new and finished with same type coating meeting the requirements of this Section. Replacement items shall match adjacent members.

C. Resident Engineer may, at his discretion, permit field repairs in lieu of replacement provided the coating failure is minor in scope and the field repair material and method employed match its adjacent member.
PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Finish coating system shall meet or exceed the performance requirements of AAMA 2604 as outlined below. Refer to AAMA 2604 and the cited ASTM test procedures for more complete information on testing and exposure requirements.

   Coatings shall have 25 to 40 percent reflective gloss when tested in accordance with ASTM D523.

2. Dry Film Thickness.
   1.6 mils minimum as measured by eddy current meter as defined in ASTM B244 or other equipment of equivalent precision.

3. Hardness.
   No rupture of coating film at F hardness minimum when tested by ASTM D3363.

4. Adhesion.
   No removal of coating film or blistering during dry, wet, or boiling water adhesion testing when tested in accordance with AAMA 2604: 7.4.1.

5. Impact Resistance.
   No removal of coating film when tested in accordance with AAMA 2604: 7.5.1.

6. Abrasion.
   Minimum abrasion coefficient value of 20, when tested in accordance with ASTM D968 and coefficient calculated in accordance with AAMA 905.2: 7.6.1.

7. Muriatic Acid Resistance.
   No blistering, and no visual change in appearance when tested in accordance with AAMA 605.2: 7.7.1.1.

   Mortar test patches shall dislodge easily from the coating film and any residue shall be removable with a damp cloth or with 10 percent muriatic acid solution. No loss of film adhesion or visual change in coating appearance after removal of test patches when tested in accordance with AAMA 2604: 7.7.2.1.

9. Nitric Acid Resistance.
   Maximum color change of 5 NBS units between tested and untested areas as calculated in accordance with ASTM D2244, when tested in accordance with AAMA 2604: 7.7.3.1.
10. Detergent Resistance.

    No loss of adhesion or blistering and no visual change in appearance when tested in accordance with AAMA 2604: 7.7.4.1.

11. Humidity Resistance.

    Formation of blisters not to exceed "Few" blisters size No. 8, as shown in Figure 4, in ASTM D714 when tested in accordance with ASTM D2247 and AAMA 2604: 7.8.1.1.


    Maximum undercut failure of 1/16 inch at scribed test lines and maximum film failure rate of 2 percent by area due to blistering or other film failures when tested in accordance with ASTM B117 and with AAMA 2604: 7.8.2.


    Maximum color change of 5 NBS units between tested and untested areas as calculated in accordance with ASTM D2244 after exposure testing in accordance with AAMA 2604: 7.9.1.1.


    Maximum chalking of No. 8 rating based on ASTM D4214 after exposure testing in accordance with AAMA 2604: 7.9.1.1.

15. Weathering Resistance-Gloss Retention.

    Minimum gloss retention of 30 percent when tested and calculated in accordance with ASTM D523 and AAMA 605.2: 7.9.1.4.2 after exposure testing in accordance with AAMA 2604: 7.9.1.1.


    Maximum erosion of 10 percent of dry film thickness as measured by eddy current meter as defined in ASTM B244 or other equipment or equivalent precision after exposure testing in accord with AAMA 2604: 7.9.1.1.

B. Minor film scratches and other blemishes in film surfaces that are repaired in accordance with recommended procedures and with recommended touchup materials shall meet or exceed the performance requirements outlined below:

1. Such repairs shall match the original finish for color and gloss.

2. Such repairs shall adhere to the original finish and exhibit no removal of coating film or blistering during dry adhesion testing when tested in accordance with AAMA 2604: 7.4.1.1.
PART 3 - EXECUTION

3.01 PREPARATION

A. Aluminum substrates shall be thoroughly cleaned and chemically etched and given the applicator's standard chromate conversion pretreatment prior to application of the thermocured prime coat.

B. Galvanized steel substrates shall be thoroughly cleaned and given the applicator's standard pretreatment prior to application of the thermocured prime coat.

3.02 APPLICATION

Apply the 3-coat fluoropolymer coating system to prepared substrates uniformly to comply with coating system formulator's recommendations. There shall be no unrepairable streaks, runs, sags, scratches, holidays, blisters, or similar imperfections visible in the dry film coating.

3.03 PROTECTION AND REPAIRS

A. Protect coatings for shipment and installation by application of strippable film or by packing finished items in suitable packings as necessary to protect the finish until placement or installation.

B. Protect coated items in final locations from damage.

C. Repairs of minor scratches or other blemishes due to shipping, handling, installation, or protection failure will be permitted and shall be made with the coating formulator's approved touchup materials and procedures. Remaining touchup materials shall be delivered to the Resident Engineer at project completion in containers appropriate for storage and clearly marked as to content by material and color.

D. Coated items damaged beyond repair shall be removed and shop-stripped and recoated with matching materials or be replaced with newly fabricated and coated items.

E. Make final touchup repairs and clean-coated surfaces just before substantial completion using methods that will not harm the finish.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 05083
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes specifications for welding of structural steel and miscellaneous metalwork, including sheet steel, as indicated. This Section also includes qualification of welders and welding procedures, inspections and tests of welds.

1.02 QUALITY CONTROL

A. Qualifications of Welders.

1. Welders, Welding operators, and tack welders shall be qualified in accordance with ANSI/AWS D1.1, Section 5, "Qualification."

2. For sheet steel, welders shall be qualified in accordance with ANSI/AWS D1.3, Section 6, "Qualification".

B. Qualification of Welding Procedures.

1. Welding procedures shall be prequalified or qualified accordance with ANSI/AWS D1.1, Section 5, "Qualification".

2. For sheet steel, proposed welding procedures shall be qualified in accordance with ANSI/AWS D1.3, Section 6, "Qualification". Prequalification is not applicable to sheet steel.

C. Qualifications of Welding Inspector.

Welds to be inspected by the Contractor shall be inspected and certified by a Contractor-employed AWS Certified Welding Inspector (CWI), certified in accordance with AWS QCI.

D. Qualification of Personnel Performing Nondestructive Testing.

Personnel performing nondestructive testing shall be qualified and certified in accordance with the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II may perform nondestructive testing.

E. Weldability of Steel.

For structural steel requiring impact test qualification and for corrosion-resistant structural steel, the weldability of the steel and the procedures for welding it shall be established, by qualification in accordance with ANSI/AWS D1.1, Section 5, to match the notch toughness and weathering characteristics of the base metal.
1.03 REFERENCE STANDARDS

A. American Society for Nondestructive Testing (ASNT).
   Recommended Practice No. SNT-TC-1A.

   2. ASTM E164  Practice for Ultrasonic Contact Examination of Weldments.
   4. ASTM E709  Guide for Magnetic Particle Examination.
   5. ASTM E1032  Method for Radiographic Examination of Weldments.

C. American Welding Society (AWS).
   1. ANSI/AWS A2.4  Standard Symbols for Welding, Brazing, and Nondestructive Examination.
   2. ANSI/AWS A3.0  Standard Welding Terms and Definitions.
   3. ANSI/AWS A5 Series  Filler Metal Specifications.
   5. ANSI/AWS D1.1  Structural Welding Code – Steel.
   7. AWS QCI  Standard for AWS Certification of Welding Inspectors.

1.04 SUBMITTALS

A. General.
   1. Refer to Section 01330, Submittals, and Section 01335, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.
   2. Submittals shall comply with AWS 2.4 and 3.0.

B. Welder Qualifications.
   1. Submit certified copies of qualification test records for each welder, welding operator, and tack welder to be employed in the Work.
   2. Comply with requirements of ANSI/AWS D1.1, Section 5, Parts A, C, D, and E.
3. Submit welders’ identification marks (I.D.) for each welder along with qualifications.

C. Welding Procedures.

1. Prior to commencement of welding, submit the procedure that will be used for qualifying welding procedures.

2. For procedures other than those prequalified in accordance with ANSI/AWS D1.1, submit a copy of procedure qualification test records in accordance with the qualification requirements of ANSI/AWS D1.1, Section 5, Parts A and B.

D. Welding Records and Data.

1. Retain all radiographs upon completion of fabrication.

2. Retain certifications that magnetic particle and dye-penetrant inspections have been satisfactorily completed.

3. Submit records of ultrasonic testing to the Resident Engineer upon completion.

4. If field welding is permitted, submit descriptive data for field welding equipment.

E. Mill Certificates.

Retain mill certificates and certified copy of reports for all analyses and tests required by referenced ASTM and AWS specifications.

PART 2 - PRODUCTS

2.01 WELDING ROD/ELECTRODES

A. Electrodes for structural plate, shapes, pipe, tubes, and bars shall conform with ANSI/AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform to ANSI/AWS D1.1, Table 4.1.1.

B. Electrodes for sheet steel shall conform to ANSI/AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform to ANSI/AWS D1.3, Table 5.1.

2.02 STUD SHEAR CONNECTORS

Only products of manufacturers qualified in accordance with ANSI/AWS D1.1, Appendix IX, will be accepted for this Work.

2.03 SHOP WELDING

A. Perform shop welding as indicated in accordance with ANSI/AWS D1.1, and ANSI/AWS D1.3, as applicable to the Work.
B. Welders shall mark adjacent to completed welds their welder I.D., using metal stamp, metal engraving, keel, paint stick, or other appropriate marking material.

C. Welding of stud shear connectors shall conform to ANSI/AWS D1.1, Section 7. “Stud Welding,” and the stud manufacturer’s instructions.

2.04 SHOP QUALITY CONTROL

A. Inspections and Tests by the Contractor.

1. Visual Inspection: All welds shall be visually examined in accordance with ANSI/AWS D1.1, Section 6 and 7.8, as applicable. Quality of welds and standards of acceptance shall be in accordance with ANSI/AWS D1.1, Sections 8.15.1, 9.25.1, and 10.17.1, as applicable.


   a.) Radiographic testing of welds shall conform to ANSI/AWS D1.1, Section 6, Parts A and B, and ASTM E94 and ASTM E1032, as applicable. Complete joint penetration groove welds shall be tested as follows:

      - One out of ten (10 percent) with thickness equal to or less than 3/4 inch.
      - One out of two (50 percent) with thickness greater than 3/4 inch and equal to or less than 1-1/2 inches.
      - 100 percent for thickness greater than 1-1/2 inches.


   a.) Ultrasonic testing of welds shall conform to ANSI/AWS D1.1, Section 6, Parts A and C, and ASTM E164, as applicable.

   b.) Complete joint penetration groove welds not accessible for radiographic testing shall be subjected to ultrasonic testing. The extent shall be the same as specified for radiographic testing.

5. Magnetic Particle Inspection.

   a.) Magnetic particle inspection of welds shall conform to ASTM E709. Complete and partial joint penetration groove welds and fillet welds shall be inspected as follows:

      - One out of five (20 percent) of complete joint penetration groove welds of tee and corner joints.
      - One out of ten (10 percent) of partial joint penetration groove welds and fillet welds.

Liquid dye penetrate inspection of welds shall conform to ASTM E165. Liquid penetrant inspection may be used for detecting discontinuities that are open to the surface.

7. Test Results.

Test result information shall be forwarded to the Resident Engineer immediately after test results are available stating the acceptance or rejection of fabricated components so that repairs and reinspection or testing may be performed as soon as possible.

8. Repairs.

Unacceptable welds shall be repaired in accordance with ANSI/AWS D1.1, Section 3.7. Repaired or corrected welds shall be reinspected or retested as specified for the original weld.

B. Shop Inspections and Tests by the Resident Engineer.

1. All welds are subject to inspections and tests by the Resident Engineer. Welds to be inspected and tested by the Resident Engineer will be selected at random.

2. The Resident Engineer will make test results available to the Contractor.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL

A. Inspections and Tests.

B. The Contractor shall perform tests of field welds as herein specified for shop welds.

C. The Resident Engineer will perform visual inspections of field welds as herein specified for shop welds.

D. Field Welding.

E. Field welding shall be performed as herein specified for shop welding.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 05090
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SECTION 05590
MISCELLANEOUS METAL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes specifications for metal fabrications and miscellaneous metalwork as indicated.

B. Metal fabrications and miscellaneous items and their related components which are to be provided under this Section include: steps; pipe and conduit sleeves; ladders; miscellaneous steel clips, angles, and brackets; and anchors, fasteners, and accessories as required to complete the Work.

1.02 REFERENCE STANDARDS


8. ASTM A143 Recommended Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.


11. ASTM A316 Specification for Acid Resistant Austenitic Stainless Steel.

12. ASTM A307 Standard Specification for Carbon Steel Bolts and studs, 60,000 PSI Tensile Strength.

13. ASTM A384 Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.

15. ASTM A500 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

16. ASTM A501 Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.

17. ASTM A536 Specifications for Ductile Iron Castings.


19. ASTM A668 Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use.


21. ASTM D2092 Standard Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting.

22. ASTM F436 Specification for Hardened Steel Washers.

B. National Association of Architectural Metal Manufacturers (NAAMM).

   NAAMM 531 Metal Bar Grating Manual.

C. Steel Structures Painting Council (SSPC).

   Steel Structures Painting Manual, Volume 2, "Systems and Specifications".

1.03 SUBMITTALS

A. General.

   Refer to Section 01330, Submittals, and Section 01335, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Shop Drawings.

   Submit fully detailed shop drawings of metal fabrications and miscellaneous metalwork showing sizes, details of fabrication and construction, methods of assembly, locations of hardware, anchors and accessories, and installation details.

C. Product Data.

   Submit manufacturers' product data of all manufactured items and products.
PART 2 - PRODUCTS

2.01 MATERIALS

A. Steel Materials.

1. Shapes: Standard structural sections, shapes, plates, and bars, as indicated, conform to ASTM A36. Bars conforming to ASTM A108 will be accepted.

2. Perforated Sheet: Perforated sheet supplied for acoustical enclosures shall be 16 AWG brushed stainless steel conforming to ASTM A304 with round hole patterns - 5/32 inch diameter and 3/16 inch staggered hole spacing. Open spacing shall be a minimum of 60 percent of total area.

B. Cover Plates

Blank cover plates as required for decommissioned phones in the DSTT shall be type 304 stainless steel, #10 AWG, #4 finish. Use vandal/tamper resistant screws.

C. Welding Rods/Electrodes.

Refer to Section 05090, Welding.

D. Forgings.

ASTM A668, of Class indicated or required.

E. Anchors and Bolts.

1. ASTM A307, A449, A563, and F436, as applicable.

2. Bolts and studs, nuts, and washers shall be stainless steel in accordance with ASTM A304.

F. Fasteners and Accessories.

1. Furnish anchors and fasteners, washers, straps, and accessories as required for a complete and finished installation.

2. Fasteners shall be 304 stainless steel. Machine screws shall be used wherever possible.

3. Fasteners and accessories designated for use in public spaces shall be hidden from view and require special vandal resistant access points.

G. Concrete and Masonry Anchors.

1. Where anchors are not cast into the concrete or masonry construction, provide galvanized expansion type anchors with matching galvanized steel bolts or studs with nuts, of sizes as indicated or required.

2. Provide washers under all bolt heads and nuts.
H. Metal Steps.

1. Provide metal steps where indicated, fabricated from checkered or diamond-pattern aluminum plate.

2. Metal steps shall be of sizes and plate or sheet thickness as indicated, and cut or formed to shape and configuration as indicated.

3. Steps shall be capable of supporting a uniform live load of 300 pounds per square foot and a concentrated load of 3,000 pounds.

I. Ladders.

Provide standard-manufactured or custom-fabricated steel ladders as required to meet the conditions indicated. Steel ladders shall be hot-dip galvanized after fabrication. Ladders may be anodized aluminum where not required to serve as a fire exit.

2.02 FABRICATION

A. Metalwork shall be fabricated by firms or shops experienced and skilled in the custom fabrication and construction of metal fabrications and miscellaneous metalwork. There shall be no exposed screws, bolts, and fasteners in the finished Work, except as indicated or required.

B. Welded connections shall be made in accordance with requirements of Section 05090, Welding. Welds where exposed to view shall be ground down and dressed smooth so that the shape and profile of the item welded is maintained.

C. Metal fabrications shall be prefabricated and preassembled in the factory or shop as far as practicable.

D. Form and fabricate the Work to meet installation conditions. Include anchors, fasteners, and accessories to secure the Work in place, as indicated.

E. Contractor may furnish standard manufactured products for components when applicable providing such products meet space limitations and installation conditions.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install metal fabrications and miscellaneous metalwork in accordance with the Contract Drawings and the shop drawings, using mechanics and workers skilled and experienced in the installation of the type of Work involved.

B. Install metal fabrications and miscellaneous metalwork with all accessories furnished by the fabricator as required for complete and finished installations.
C. Installation of metalwork shall be in accordance with approved shop drawings - true and horizontal, perpendicular, or at the required angle, as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

D. Field welding, where required, shall conform to requirements of Section 05090, Welding.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 05590
DIVISION 16

ELECTRICAL
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SECTION 16060
ELECTRICAL GROUNDING AND BONDING

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes the requirements for furnishing, installing, and testing complete grounding and bonding.

1.02 RELATED SECTIONS

A. Section 17140 – Backbone Cabling Requirements.

B. Section 17150 – Facility Cabling Requirements.

C. Section 17160 – Cabling Requirements.

D. Section 17630 – Communications Maintenance and Auxiliary Facilities.

E. Appendix G – Contract Data Requirements List.

1.03 REFERENCE STANDARDS

A. ANSI/TIA/EIA-607, Commercial Building Grounding and Bonding Requirements for Telecommunications.


D. ASTM D5-97, Standard Test Method for Penetration of Bituminous Materials

E. ASTM D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

F. ASTM D257-99, Standard Test Methods for DC Resistance or Conductance of Insulating Materials


I. NFPA 70, National Electrical Code.
1.04 SUBMITTALS

A. The following submittals shall be prepared and submitted as per Section 01330, Submittals and Appendix G, Contract Data Requirements List:

   a.) Shop Drawings.
      1.) Locations of ground rods, connectors, cables, etc., and details of connections, terminations and access points.
      2.) Manufacturer's catalog data for all proposed materials with installation recommendations.
      3.) Procedures and equipment for testing resistances and electrical continuity.

2. Certification.

Certified test reports verifying that ground resistance of each ground grid when installed and each ground bus when connected to the ground grid does not exceed specified values.


This document shall include each particular grounding location, include updated versions of the information submitted for the Detailed Design Document, and include the details of connections, terminations and access points.

PART 2 - PRODUCTS

2.01 GROUNDING CONDUCTORS

A. Grounding Electrode Conductors.

1. Insulated stranded copper conductor, or as shown on Contract Drawings, in accordance with Section 16120, Electrical Wires and Cables.

2. Size unless otherwise shown.

3. For use in connecting ground grid to Chassis Main Grounding Busbars (CMGB) and Telecommunications Main Grounding Busbars (TMGB): Bare No. 2 AWG or as shown on Contract Drawings.

4. For use in connecting ground grid to Chassis Grounding Busbars (CGB) and Telecommunications Grounding Busbars (TGB): Green insulated No. 6 AWG or as shown on drawings.

5. For other grounding electrode conductors: Green insulated No. 12 AWG or accordance with NEC Table 250-94.
   a.) Green insulated wire sized in accordance with NEC article 250-95, unless otherwise shown on Contract Drawings.
   b.) Equipment grounding insulated conductor: Green insulated single conductor or stranded copper No. 12 AWG as specified in Section 16120, Electrical Wires and Cables.

7. Static Dissipative Ground Strap.

Static Dissipative Ground Strap shall be used at communications cabinets and at racks to prevent equipment damage due to static discharge. Ground Straps connect to the nearest CGB in accordance with the manufacturer’s instructions using a minimum of #12 AWG green insulated copper wire.

B. Ground Rods

1. Ground rods shall be installed primarily by others. In the event that one needs to be supplied, the rod must meet the following specifications:
   a.) Ground rods shall be copper-clad steel, of the non-rusting type or approved equal. The rod shall be at least ten feet in length and at least 3/4 inch diameter.
   b.) Connections to ground rods shall be an exothermically welded or clamped using approved apparatus. Coat weld with coal tar epoxy.
   c.) Ground rod clamps shall be made of a cast bronze body with non-ferrous set screws. Attach using drill and tap connection. Coat with coal tar epoxy.

2.02 CHASSIS AND TELECOMMUNICATIONS GROUNDING BUSBARS

A. CMGB and TMGB.

1. Predrilled solid copper busbar provided with standard NEMA bolt hole sizing and spacing for the type of connectors to be used.

2. Sized in accordance with the immediate requirements of the application and with consideration for future growth (provide approximately 50 percent spare holes).

3. Minimum dimensions shall be ¼ inch thick and 4 inches wide and variable in lengths of 6” increments.

B. CGB and TGB located.

1. Predrilled solid copper busbar provided with standard NEMA bolt-hole sizing and spacing for the type of connectors to be used.

2. Sized in accordance with the immediate requirements of the application and with consideration for future growth (provide approximately 50 percent spare holes).
3. Minimum dimensions shall be ¼ inch thick and 2 inches wide and variable in length.

2.03 TERMINAL LUGS

A. For 4/0 AWG and smaller conductors.
   1. Copper compression terminal lugs.

B. For 250 MCM and larger.
   1. Long barrel, copper, double-compression terminal lugs.

2.04 EXOTHERMIC WELDS

A. Welding material shall consist of copper exothermic mixture employing tin-metal in an amount to effectively constitute 4.5 percent to 5.5 percent of the resulting weld metal. The resulting weld metal shall be of high electrical conductivity and shall have a minimum tensile strength of 39,000 pounds per square inch.

B. Coating Materials for Thermitite Welded Connections.

   1. Use black, rubber based compound coating materials, which are soft, permanently pliable, moldable, and un-backed, not less than 1/8 inch thick, with properties as follows:

   a.) Solids 100 percent.
   b.) Density 12.0 pounds per gallon minimum.
   c.) Penetration 90-130 ASTM D5.
   d.) Water Absorption 0.10 percent maximum ASTM D570.
   e.) Dielectric Strength 500 volts/mil ASTM D149.
   f.) Volume Resistivity 2,000 mega-ohms-inches ASTM D257.
      5,000 mega-ohms-cm ASTM D257.
   g.) Temperature -40 degrees F to +160 degrees F.
   h.) Chemical Resistance Melting point, none; flammability, slow burning (ASTM C653); resists alcohol, water, aqueous hydrochloride and sodium hydroxide; dissolved by carbon tetrachloride, naphtha gasoline, mineral, spirits, ketones, and benzene.
   i.) Highly cohesive and adheres strongly to metals and adhesive concrete and to itself.
2.05 GROUND CONNECTOR
   A. O-Z Gedney, Type KG or approved equal.
   B. Two-piece, designed for connecting grounding conductor to bus bar.
   C. Copper alloy body and silicon bronze bolt, nut and washer with interlocking clamp.
   D. Exothermic weld.
      1. Size and type per manufacturer's recommendations.

2.06 BUSBAR INSULATORS
   Fibrous glass reinforced polyester insulator with ½ inch diameter by two (2) inch length, threaded holes at both ends for CMGB, TMGB, CGB, and TGB installation.

2.07 COAL TAR EPOXY
   Polyamide cured coal tar epoxy, Dupont Corlar 823 CTE, Koppers Company No. 300M, PPG Industries 97-640 or 97-641 or approved equal, applied to a dry film thickness of 8 mils. per coat.

2.08 EPOXY RESIN ENCAPSULATION
   Two-component epoxy resin type with plastic snap mold, as manufactured by Duriron Company, 3-M Company or approved equal.

2.09 NO-OX-ID
   NO-OX-ID "A-SPECIAL"- non-oxidation compound or approved equal shall be used on all exposed copper or aluminum electrical installations to keep metals free from corrosion.

PART 3 - EXECUTION

3.01 GROUNDING
   A. Ground Connections.
      1. Weld buried ground connections exothermically, in accordance with manufacturer's recommendations, if not provided by others. Clean and coat with coal tar epoxy applied with a 32 mils dry film thickness using multiple coats. Allow drying between coats and before backfilling. Encapsulate with epoxy resin all buried ground connections of grounding electrode conductors running to ground buses.
      2. Use terminal lug to connect grounding conductor to equipment enclosure. Secure connector or terminal lug to the conductor so as to engage all strands equally by using tools and pressure recommended by the manufacturer.
      3. Exothermically weld connections for ground rods in manholes and handholes, or as shown.
      4. Splices in grounding conductors are not permitted.
B. Grounding Busbars.

1. Install separate CMGBs and TMGBs/CGBs and TGBs in locations as shown in Contract Drawings.

2. Mount TMGBs and CMGBs on insulators two (2) feet above finished floor using cap screws and expandable threaded anchors, unless shown otherwise in Contract Drawings.

3. Install TGBs and CGBs in the bottom of the cabinet on insulated spacers, which electrically isolate them from the cabinet.

4. Provide insulator support at each end of grounding busbars and at intervals not exceeding three (3) feet.

5. Bond the grounding electrode conductors to the CMGB using an approved Ground Connector.

C. Grounding of Separately Derived Ac Power System.

Bond the safety ground conductor (green wire) to the CMGB using a minimum of No. 6 AWG insulated stranded copper wire, as shown in Contract Drawings. For additional guidance, refer to the NEC.

D. Electronic Equipment Signal Grounding.

1. Where electronic equipment is provided with separate ‘Signal’ or ‘Telecommunications’ ground connections, a separate isolated TGB shall be provided in the equipment rack or enclosure. These connections shall be grounded to the TGB using a minimum of No. 6 AWG insulated stranded copper conductor.

2. Within the Communications House or other electronic equipment room, a separate TMGB shall be provided. All individual equipment rack or enclosure TGBs shall be grounded to the TMGB using a minimum of No. 6 AWG insulated stranded copper conductor.

3. The TMGB shall be grounded to the same point on the ground grid (or to the structural steel) as the CMGB using the same AWG grounding electrode conductor. Both grounding electrode conductors shall be insulated.

E. Cable Shield Grounding.

1. One end of all communication cable shields, including the armored jackets on the fiber cables, shall be grounded to the TMGB or TGB. Use the following guidelines to determine which end of the cable to ground:

   a.) When a cable goes between two Communications Houses, ground the shield at the southern most house.

   b.) When a cable goes between a Communications House and any other facility (TPSS, Communications Cabinets, etc.), ground the shield at the Communications House.
3.02 FIELD TESTING

A. Resistance to ground in stations shall not exceed five ohms. Resistance to ground for misc. cabinets and stand alone communications cabinets shall not exceed 10 ohms. Contractor shall use the IEEE-81 fall-off potential method of testing.

B. To meet resistance requirements, install additional ground rods. If resistance requirements can still not be met, install a sacrificial anode to be approved by the Engineer.

C. Conduct tests in presence of the Engineer.

D. Prepare and submit certifications as specified.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 16060
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SECTION 16075
ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 OVERVIEW

This Section is for the labeling and identification of electrical circuits, circuit breakers, electrical cable and conduit. Labeling of communications elements is specified in various Sections under 17000.

1.02 SECTION INCLUDES

A. Nameplates and tape labels.
B. Wire and cable markers.
C. Conduit color coding.

1.03 RELATED SECTIONS

A. Section 16120 – Electrical Wires and Cables.
B. Section 16610 – Static Uninterruptible Power Supplies.
C. Section 16615 – DC Rectifiers and Power Systems.

1.04 SUBMITTALS

A. Submit shop drawings under provisions of Section 01335, Shop Drawings, Product Data and Samples.
B. Include a schedule for nameplates and tape labels.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Nameplates.

Engraved three-layer laminated plastic, black letters on a white background.

B. Tape Labels.

Non-fading, printed adhesive labels, with 3/16 inch black letters on white background.

C. Wire and Cable Markers.

Non-fading, printed sleeve labels.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Degrease and clean surfaces to receive nameplates and tape labels.

B. Install nameplates and tape labels parallel to equipment lines.

C. Secure nameplates to equipment fronts using screws, rivets, or adhesive. Secure nameplate to inside face of recessed panelboard or cabinet doors in finished locations.

D. Use embossed tape only for identification of individual wiring devices and control device stations.

3.02 WIRE IDENTIFICATION

A. Provide wire markers on each conductor in panelboard, gutters, pull boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits, and with control wire number as indicated in Contract Drawings for control wiring.

B. Provide nameplates of minimum letter height as scheduled below.

1. Panelboards, Switchboards and Motor Control Centers: 1/4 inch; identify equipment designation. 1/8 inch; identify voltage rating and source.


4. Transformers: 1/4 inch; identify equipment designation. 1/8 inch; identify primary and secondary voltages, primary source, and secondary load and location.

3.03 CONDUIT COLOR CODING

A. Coordinate color of paint with Resident Engineer to identify conduit by system.

B. Medium-voltage Distribution System shall be yellow.

C. Low-voltage Distribution System shall be unpainted or black.

D. Fire Alarm System shall be red.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 16075
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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes specifications for electrical wire and cables. Communication wire and cable shall be specified under Section 17100, Cable Network Overview. Electrical wire and cable specified herein includes the following:

1. Low and medium voltage wires and cables.

2. Wiring connections and terminations.

1.02 REFERENCE STANDARDS

A. Association of American Railroads (AAR).
   AAR Signal Manual.

B. American National Standards Institute (ANSI).
   ANSI MC96.1 Temperature Measurement Thermocouples.

C. American Society for Testing and Materials (ASTM).
   1. ASTM B3 Specification for Soft or Annealed Copper Wire.
   2. ASTM B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   3. ASTM B33 Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.
   4. ASTM B172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors.

D. Institute of Electrical and Electronics Engineers (IEEE).
   IEEE 383 Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
E. National Electrical Manufacturers Association (NEMA).

NEMA WC70 Non-Shielded Power Cable 2000 V or Less.

F. National Fire Protection Association (NFPA).


1.03 SUBMITTALS

A. The following submittals shall be prepared and submitted as per Section 01330, Submittals and Appendix G, Contract Data Requirements List:

1. Submittal Requirements.

   a.) Before installation of wire and cable, submit the following information for each type and size of wire and cable:

      1.) Manufacturer of wire and cable, and certificate of compliance.

      2.) Number and size of strands composing each conductor.

      3.) Average overall diameter of finished wire and cable.

      4.) Minimum insulation resistance in megohms per 1000 feet at 30 degrees C ambient.

      5.) Jacket composition and thickness in mils.

      6.) Total number of conductors per cable.

      7.) Shield material (if any) and thickness.

      8.) Conductor resistance and reactance in ohms per 1000 feet at 25 degrees C ambient.

      9.) Conductor ampacity at 30 degrees C ambient for 600 V wire and cable, 20 degrees C ambient earth temperature, 100 percent load factor and conductor temperature of 90 degrees C for wire and cable rated 2 kV to 25 kV.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

B. Store wire and cable in secure and dry storage facility.
PART 2 - PRODUCTS

2.01 WIRE AND CABLE MARKINGS

Wire and cable markings shall be in accordance with applicable NEMA and National Electrical Code requirements.

2.02 600 VOLT SINGLE CONDUCTOR CABLE

A. Conductor Material.

ICEA stranded or solid copper meeting requirements of ASTM B3, soft drawn.

B. Conductor Type.


2. Size 10 AWG and Larger: Class B stranded.

3. Size 14 AWG and Larger.

   a.) All locations: Type XHHW, cross-linked polyethylene (XLPE) insulated in accordance with NEMA WC70.

   b.) Interior, Dry Locations Only: Type THHN or THWN, polyvinyl chloride (PVC) thermoplastic insulated in accordance with NEMA WC70. Cable shall be jacketed with clear polyamide nylon over the insulation.

4. Size 2/0 AWG and Larger: Type RHH or XHHW ethylene-propylene-rubber-insulated in accordance with NEMA WC70

C. Temperature Rating.

Temperature ratings of all cables shall be not less than 90°C.

D. Insulation Rating.

600 V.

2.03 MULTIPLE CONDUCTOR, LOW-VOLTAGE CABLE

A. Provide multiple conductor cable conforming to NEMA WC70, approved for use in cable tray, with the following additional requirements:

1. Number of Insulated Conductors.

   As indicated.

2. Provide multiple conductor cable for all power applications, except receptacles when installed in cable tray for sizes up to 4/0 AWG, as indicated.
3. Insulation.

   As specified above for single conductor cable.

4. Overall Covering.

   Cable shall be jacketed over the insulation.

5. Multiple conductor for control wire shall be minimum of 14 AWG stranded copper.

6. Insulation Rating.

   600 V.

B. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form using fillers which are compatible with other materials in the cable. The jacket used shall fit tightly to form a firm assembly.

2.04 FIXTURE WIRE

A. Provide fixture wire conforming to UL 62 and the following additional requirements:

1. Type.

   SF-2 silicone rubber insulated.

2. Conductor.

   Stranded copper conductor 16 AWG or larger as indicated.

2.05 BARE CONDUCTOR

   ASTM B3, Class B stranded, annealed soft-drawn copper conductor, unless otherwise indicated, size as indicated. Bare conductor shall be used for ground wire only.

2.06 COLOR CODING OF CONDUCTORS (600 V)

A. Individual conductors of multi-conductor cables shall be identified by means of solid colors, stripes, or printing, unless otherwise approved by the Resident Engineer.


   Cables shall be identified by printing on the jacket or by a printed marker tape under the jacket. Information shall include, but not be limited to, the number of conductors, conductor size, voltage rating, name of manufacturer, manufacturer’s type, and date of manufacture. This information shall appear at intervals of not more than 30 inches.
2. Footage Marker Tape.

Cables shall be provided with a footage marker tape under the jacket or by footage printing on the jacket.


Color coding of conductors for power cables shall be as follows:

<table>
<thead>
<tr>
<th>CONDUCTOR</th>
<th>480Y/277 V</th>
<th>208Y/120 V</th>
<th>-48/+24 VDC</th>
<th>24 VAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A</td>
<td>Brown</td>
<td>Black</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Phase B</td>
<td>Orange</td>
<td>Red</td>
<td>Red</td>
<td></td>
</tr>
<tr>
<td>Phase C</td>
<td>Yellow</td>
<td>Blue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>White</td>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Positive</td>
<td>Red</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td></td>
<td>Black</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Branch circuit phase conductors 10 AWG and smaller and all neutral and equipment conductors shall be solid color insulation or solid color coating.

C. Phase conductors having colored tracers shall have background color other than white or green.

D. Solid color coatings and tracers shall have a strongly adherent paint or dye not injurious to the insulation and which will not be obliterated by pulling into a conduit or raceway.

E. On-site coloring of ends of conductor may be permitted by the Resident Engineer upon receipt of satisfactory evidence that the Contractor is unable to order color coded wire and cable as specified. Provide certification from the cable manufacturer that the paint or dye proposed for field application is noninjurious to the insulation.

2.07 CONNECTORS AND INSULATING TAPES

A. Splice and Terminal Connectors.

1. Provide termination fittings listed for use with the cable furnished, NEMA standard.

2. Termination and splice fittings for No. 10 and smaller conductors shall be compression type or insulated expanding-wire type. Wire splices shall either be self-insulating or provided with an insulating cap or heat-shrink insulating sleeve.

3. Termination and splice fittings for No. 8 and larger conductors shall be tool-applied compression connectors of material and design compatible with the conductors for which they are used.

4. Terminal connectors for conductors size No. 4/0 and larger shall be long-barrel, double-compression type, and shall be furnished with two NEMA standard bolt holes in the tongue.
B. Insulating Material for Splices and Terminations.

1. Provide insulating material for splices and terminations of type accepted by the Resident Engineer for the particular use, location and voltage.

2. Plastic electrical insulating tape for general use shall be vinyl plastic with rubber based pressure sensitive adhesive, and shall be pliable at temperature of minus 18 degrees C to 105 degrees C. When tested in accordance with ASTM D3005, the tape shall have the following minimum properties:

   a.) Thickness: 7 mils.

   b.) Breaking Strength: 15 pounds per inch.

   c.) Elongation: 200 percent.

   d.) Dielectric Strength: 10 kV/mil.

   e.) Insulation Resistance (Direct method of electrolytic corrosion): 10 M-Ohm.

3. Rubber electrical insulating tape for protective overwrapping shall be silicone rubber with a silicone pressure-sensitive adhesive. When tested in accordance with ASTM D1000, the tape shall have the following minimum properties:

   a.) Elongation: 525 percent.

   b.) Dielectric Strength: 13 kV.

   c.) Insulation Resistance (Indirect Method of Electrolytic Corrosion): 10 M-Ohm.

4. Arcproof tape shall be flexible, conformable organic fabric, coated one side with a flame-retardant flexible elastomer, self-extinguishing, with the following minimum properties:

   a.) Thickness, ASTM D1000: 55 mils.

   b.) Tensile Strength, ASTM D1682: 50 pounds per inch.

   c.) Thermal Conductivity, ASTM D1518: 0.0478 BTU.

   d.) Electrical Arc Resistance: Withstand 200 A arc for 40 seconds.

5. Mark each tape package to indicate shelf-life expiration date.

2.08 CONDUCTOR BUNDLING STRAPS

A. Provide conductor bundling straps formed from self-extinguishing nylon having a temperature range of -40 degrees F to 185 degrees F.
B. Equip each strap with a locking hub or head with a stainless steel locking barb on one end and a taper on the other end.

C. Wire and cable ties for installation outdoors and in exposed locations shall be ultraviolet-resistant material.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Furnish wires and cables to the site in unbroken standard coils or reels to which shall be attached a tag bearing the manufacturer's name, trade name of the wire and listing information.

B. Provide wiring complete as indicated. Provide ample slack for field terminated wires and preformed cables with connections, including wires for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.

C. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the manufacturer.

D. Bundle cable and conductors neatly and securely with nylon straps located in branch circuit panelboards, cabinets, control boards, switchboards, and motor control centers. Use nylon bundling straps. Bundle power cables separately from control cables.

E. Install motor feeders, service connections, and extensions in accordance with the referenced codes. Install motor feeder in liquid-tight flexible conduit of 18 inches minimum length at motor conduit box.

F. For wire pulling, comply with the following:

1. Install wire and cable in conduit as indicated. Do not pull wires into conduit until conduits and outlets have been thoroughly cleaned and swabbed. Do not use block and tackle or other mechanical means for pulling conductors smaller than 2 AWG in raceways.

2. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire during the pulling of feeders. Use lubricant and installation procedure as recommended by the cable manufacturer.

3. Pulling tension shall not exceed manufacturer's recommendations. For conduit runs with three bends, and cable sized larger than 2 AWG, provide cable tension measuring equipment and record the highest cable tension. Notify Resident Engineer 48 hours prior to such pulling operations and adjust schedule as necessary to permit his observation.

4. Provide masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.

5. Multiple cables to be installed in a single conduit shall be pulled together.
G. Power and Control Cable Installation in Manholes and Pullboxes.

1. Cables shall be routed along the manhole or handhole walls providing the longest possible slack.

2. Cables shall be formed closely parallel to the walls, shall not interfere with duct entrances, and shall be supported on brackets and cable insulators, spaced at a maximum of 4 feet.

3. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, the existing locations of cables, cable supports, and grounding shall be modified as required to provide a properly arranged and supported installation.

H. Splices and Terminations.

1. Make wire and cable splices only in outlet, junction or pull boxes, or in equipment cabinets. Splices in multiconductor, medium-voltage cables shall be made in accordance with the cable and splice-kit manufacturers’ recommendations. Splices shall be insulated to a level equal to that of the cable.

2. Use splice and terminator installation tools and installation techniques recommended by the manufacturer.

3. Mechanical hand tools, with dies for each conductor size as recommended by the manufacturer, may be used on conductor sizes through #6 AWG.

4. For conductor sizes larger than #6 AWG, use hydraulic tools with hexagonal or circumferential dies as recommended by the manufacturer.

5. Use compression tools which will permanently imprint die information on the completed connection.

6. Wire and cable shall be continuous from power source to equipment. Where splices are required, they shall be made only in approved fittings or junction boxes and shall be subject to approval by the Resident Engineer. Follow manufacturer’s instructions in splicing wire and cable.

7. Fixture Wire

Make splices in lighting circuits with insulated crimp-type connectors.

8. Control Cables

Each wire held with screw-type terminals shall be terminated using insulated sleeve (nylon), ring-tongue-type or locking spade-type, crimp-on lugs.

9. Terminations

NO-OX-ID shall be liberally applied to all terminals to prevent corrosion.
3.02 IDENTIFICATION

A. Follow Section 16075, Electrical Identification with the following additions.

1. Provide nonmetallic fiberboard or plastic identification tags or pressure sensitive labels designed for fastening to cables, feeders, and power circuits in vaults, pull boxes, manholes, and switchboard rooms, and at all terminations of cable or wire.

2. Stamp or print tags or labels to correspond with markings on the Contract Drawings, or mark so that feeder or cable may be readily identified.

3. If suspended type identification tags are provided, attach the tags to slip-free plastic cable lacing units or to nylon bundling straps.

3.03 FIELD TESTING

A. Insulation Resistance Test.

1. Insulation resistance test shall be measured on all cables between conductor to grounded shield and shield to ground. Cable manufacturers recommended method and values shall be applied.

   a.) The test shall be made after cable installation, but before splicing or terminating.

   b.) If the splicing or terminating is not performed immediately after cable installation, second insulation resistance test shall be made just before splicing or terminating.

   c.) Each cable installation shall be tested after all splices and terminations are complete. No equipment shall be connected to the cable system during tests.

B. Cable Failure.

   If any field tests fail, the Contractor shall correct deficiency and retest. If the test fails again, the Contractor shall replace the entire cable segment at no additional cost to the Sound Transit.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 16120
SECTION 16130
ELECTRICAL RACEWAYS, BOXES AND CABINETS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Electrical conduit, raceways, boxes and cabinets shall be supplied by others except in communications areas and/or noted on Contract Drawings. Contractor to extend, as necessary, conduits or raceway supplied by others. Contractor to match conduit or raceway supplied by others when extended.

1. Electrical raceways including conduit, duct and cable tray.

2. Outlet, junction and pull boxes.

3. Electrical cabinets.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI).

   ANSI C80.1 Rigid Steel Conduit - Zinc Coated.


   2. A153/A153M-03 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

   3. National Electric Manufacturers Association (NEMA)FG-1-1993 Fiberglass Cable Tray Systems

   4. TC-2-2003: Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

   5. TC-3-1999: PVC Fittings for Use with Rigid PVC Conduit and Tubing

   6. TC-14-2002: Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

   7. VE-1-2002: Metal Cable Tray Systems

C. National Fire Protection Association (NFPA).

   1. NFPA 70: National Electric Code (NEC)

1.03 SUBMITTALS

A. The following submittals shall be prepared and submitted as per Section 01330, Submittals, and Appendix G, Contract Data Requirements List:

1. List of Materials.

Submit a list of materials proposed to use. Give name of manufacturer, brand name, and catalog number of each item. Submit the list complete at one time, with items arranged and identified in numerical sequence by specification section and article number.

2. Evidence of Conformance.

Where equipment or materials are specified to conform to the standards of organizations such as ANSI, ASTM and NEMA, submit evidence of conformance. The label or listing of the specified agency will be acceptable evidence. Instead of the label or listing, the Contractor may submit a written certificate from an approved, nationally recognized testing organization, stating that the items have been tested and that the units conform to the specified standard.

3. Shop Drawings.

Submit shop drawings showing the exact location and arrangement of conduits, cabinets, and pullboxes installed under this Contract. Submit drawings within ample time to prevent delays in the Work.

PART 2 - PRODUCTS

2.01 PVC CONDUIT

A. Provide heavy wall, high impact strength, rigid PVC conforming to the requirements of EPC-40-PVC conduit of NEMA TC 2 and fittings for EPC-40-PVC conduit of NEMA TC 3.

B. Epoxy Fiberglass Conduit and Fittings.

Provide standard-wall epoxy fiberglass electrical conduit conforming to the requirements of NEMA TC 14. Conduit joints and fittings may be tapered or untapered but shall all be of one type.

C. Conduit Expansion Fittings.

1. Provide factory-made expansion fittings where required for conduit expansion or seismic movement. If factory fittings are unavailable, fabricate expansion fittings from material similar to the type of conduit with which they are to be used.

2. Include a factory installed packing ring, designed to prevent the entrance of moisture, and a pressure ring.

3. Include a grounding ring or a grounding conductor for metallic expansion couplings.
4. Fittings shall maintain a constant inside diameter in every position and shall provide a smooth wireway for protection of wire insulation.

2.02 CONDUIT HANGERS

A. Hangers shall consist of two or more steel hanger rods, a steel horizontal member, U-bolts, clamps, and other attachments as necessary for securing hanger rods, and conduits.

B. Provide galvanized hanger rods not smaller than 3/8-inch diameter, threaded either full length or for a sufficient distance at each end to permit at least 1-1/2 inches of adjustment.

C. Provide horizontal member meeting the following requirements:

1. Standard structural steel shapes such as angles or channels, 1-1/2 by 1-1/2 inches or 1-5/8 by 1-5/8 inches, 12 gage, cold-formed, lipped channel, and designed to accept special spring-held hardened steel nuts for securing hanger rods and other attachments. Nuts and clamps shall be compatible with the channel.

2. Two or more channels may be welded together to form horizontal members of greater strength.

3. All members shall be hot-dip galvanized after fabrication in accordance with ASTM A123 or ASTM A153, as applicable.

D. Design of conduit hangers shall meet the following requirements:

1. Conduit hangers shall be capable of supporting a load equal to the sum of the weights of the conduits and wires, the weight of the hanger itself, plus 200 pounds.

2. The stress at the root of the thread of the hanger rods shall be not more than 9,475 PSI at design load.

3. Size the horizontal member such that the maximum stress will be not more than 12,650 PSI at design load.

4. Conduit support system shall be designed to withstand the seismic loads specified in the Washington State Building Code and the National Electrical Code.

2.03 INSERTS

A. Channel Inserts.

1. Fabricate from not less than 12 gage steel channel having an overall size of 1-5/8 by 1-5/8 inches with continuous 7/8-inch wide slot, in lengths as indicated. Galvanize after fabrication.

2. Inserts for embedding in concrete shall conform to the following requirements:

   a.) Fabricate from channels having a solid base.

   b.) Weld concrete anchors to the channel during fabrication and before coating.
c.) Clean and galvanize after fabrication.

d.) Provide assemblies with a minimum pull-out load rating of 2,000 pounds per linear foot uniformly distributed, with a safety factor of three.

e.) Furnish channel inserts for installation embedded in concrete with the channel interior completely filled with Styrofoam to prevent seepage of concrete into the channel during installation.

3. Inserts for surface mounting shall conform to the following requirements:

a.) Fabricate from channel having 3/8 inch by three inch slots on four-inch centers in the base.

b.) Galvanize, in accordance with ASTM A123 or ASTM A153, as applicable, inserts for surface mounting on concrete surfaces and for installation in damp or wet areas.

B. Spot Inserts for Embedding in Concrete.

1. Steel, galvanized after fabrication, in accordance with ASTM A153.

2. Design for a maximum loading of 800 pounds with a safety factor of three.

3. Knockout openings to accommodate either square or rectangular nuts.

2.04 OUTLET BOXES, JUNCTION AND PULL BOXES

A. Provide electrical boxes of the material, finish, type, and size indicated and as required for the location, kind of service, number of wires, and function.

B. Provide boxes complete with accessible covers designed for quick removal and suitable for the purpose for which they will be used, except that boxes in which, or on which, no devices or fixtures are to be installed shall be equipped with flat or raised blank covers as required. Ceiling fixture outlet boxes shall be equipped with 3/8-inch boltless fixture studs.

C. Boxes below 100 cubic inches in size shall be cast metal. Boxes over 100 cubic inches in size shall conform to the requirements for cabinets, except boxes in interface pull boxes shall be cast metal boxes with gasketed cast metal covers. Boxes for surface mounted wiring devices shall be NEMA Type FD.

D. Covers shall be of same thickness as boxes and shall be secured in position by means of No. 10-24 stainless steel machine screws. Arrange covers to be readily and conveniently removed.

E. Junction boxes shall be galvanized inside and outside. Where outlet boxes are used as junction boxes, they shall not be smaller than 4 inches square by 1-1/2 inches deep. Provide such boxes with flat blank covers.

F. Outlet boxes for exposed installation shall be cast metal, not smaller than 4 inches square by 2-1/8 inches deep. For embedded or concealed installation, use cast metal boxes approved for intended purpose.
G. Concealed, flush or surface-mounted switch boxes shall be not less than 4 inches square by 1-1/2 inches deep for two devices, unless otherwise indicated. Provide covers with openings of proper size and shape. Provide special boxes as required to suit the kind of service and location requirements.

H. Provide brackets, supports, hangers, fittings, bonding jumpers, and other installation accessories as required.

I. Provide neoprene gaskets 1/8-inch thick for boxes subjected to weather.

J. Provide each box with a grounding terminal.
   1. Provide grounding terminal of either a green-colored washer-in-head machine screw not smaller than No. 10-32 in a drilled, tapped, and threaded hole in the back of the box, or a grounding bushing with green-colored machine screw terminal attached to one of the conduits.
   3. Install grounding jumpers as specified in Section 16060, Electrical Grounding and Bonding.

K. All boxes for systems control and communications' applications shall conform with NEMA Type 4 and shall be provided with NEMA Type 4 labels.

2.05 METALLIC CABLE TRAYS

A. General.

Provide metallic cable tray systems conforming to NEMA VE 1, except for modifications indicated. Cable tray system shall be designed to withstand the seismic load specified in the California Building Code and the National Electrical Code.

B. Cable Tray System Components.

1. Provide components of hot-dip galvanized steel in accordance with ASTM A123, or stainless steel Type 304 or Type 316, as indicated.

2. Install bonding jumper at all cable tray connections.

C. Dimensions.

1. Straight sections and fittings shall have inside clear width as indicated, measured between the rails.

2. Width of tray shall be 6 inches minimum. Overall width shall not exceed inside width by more than 2-1/2 inches.

3. Loading depth of tray shall be 3 inches minimum. Inside nominal depth shall be 5 inches minimum. Overall tray depth shall be 6 inches.
D. Fabrication.

1. Provide straight sections and fittings consisting of stiffened channel rungs located between channel-shaped side rails having outward projecting flanges.

2. Rungs shall be positioned to provide a flat, cable support surface at least 1-1/8 inches wide, excluding corner radii, and shall be 0.060 inch thick. MIG-weld rungs to side rails and clean welds. Tray rungs shall be spaced 6 inches on center.

3. Provide straight-section side rails having a top flange not to exceed 1-1/4 inches wide and a minimum 3/8 inch vertical stiffening lip.

4. The radius of curved fittings shall be 24 inches minimum, unless otherwise approved by the Resident Engineer.

5. Where indicated, provide solid bottom type straight sections and fittings consisting of two-sided rails with a solid corrugated bottom welded to the side rails. Provide solid flanged covers to match solid bottom tray construction.

E. Performance Requirements.

1. The metallic cable tray system shall be capable of supporting a total cable load of 55 pounds per linear foot for cable tray of 30 inches wide or less and 88 pounds per linear foot for cable tray over 30 inches wide on a maximum span of 8 feet including a static concentrated load of 200 pounds as specified below, with a safety factor of two based on the destructive load, regardless of the type of splice plates or type of span, when tested in accordance with load test procedure specified in NEMA VE 1.

2. Straight sections and fittings shall not permanently deform under a 200 pound static concentrated load applied vertically along a four inch length for both of the following conditions.

   a.) Load applied to center of one tray section having specified cable load and support spacing. Load shall be applied at midpoint between supports over a splice connection.

   b.) Load applied to one rung of empty tray section having specified support spacing. Load shall be located at midpoint between side rails and supports.

F. Cable Tray Supports.

1. The cable tray system shall be supported at five-foot spans and shall be capable of carrying a working load of 100 pounds per linear foot, with a safety factor of 3.0 when loaded in accordance with NEMA VE 1, Section 3, and tested in accordance with NEMA VE 1, Section 4. All fittings, supports, and accessories shall be manufactured or fabricated in accordance with the cable tray manufacturer’s recommendations.

2. Cable tray supports fabricated from minimum 12 gage steel channel, 1-5/8 inches by 1-5/8 inches, with a continuous 7/8-inch wide slot, hot-dip galvanized after fabrication will be acceptable.
3. Provide assembled supports, fittings, brackets, and hardware to carry the loads as indicated with a factor of safety of three or greater.

4. Supports shall provide at least 1-1/8 inch bearing length for each rail and shall have provision for tray hold-down clamps and fasteners.

5. Anchorages and fastenings to underside of roof or ceiling require approval of the Resident Engineer before they may be used in the Work. Anchorages and fastening to pre-stressed girders, beams, and slabs will not be permitted.

2.06 FIBERGLASS CABLE TRAYS

Where the cable tray system is indicated or required to be fiberglass-reinforced plastic (FRP), provide such FRP cable tray system conforming to NEMA FG 1, except for modifications indicated. Use metallic hardware, units and bolts, if required. Conform to all requirements of the herein specified metallic cable trays as applicable to plastic systems. Provide special grounding and bonding in accordance with Section 16060, Electrical Wire and Grounging.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install electrical raceway, boxes and accessories in locations as indicated, rigid and secure, plumb and level, and in alignment with related and adjoining Work to provide a complete and operable system.

B. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the Work rigidly. Conform to Washington State Building Code requirements for Seismic Zone 3 location.

D. Control erection tolerance requirements so as to not impair the strength, safety, serviceability, or appearance of the installations. Determine exact locations of conduit. Route conduit parallel to building lines unless otherwise indicated.

E. The trade size, type, and general routing and location of conduits, raceways, and boxes shall be as indicated or specified.

F. Install exposed conduit so as to avoid conflicts with other Work. Install horizontal raceways close to the ceiling or ceiling beams, and above water or other piping wherever possible.

3.02 CONDUIT AND FITTINGS

A. Electrical Conduit - Installation Requirements.

1. Install conduit in accordance with National Electrical Code, NFPA 130, local codes and ordinances and as indicated. Prevent concrete and other materials from entering and obstructing the conduit, outlets, and pull and junction boxes. Do not use conduit smaller than 3/4-inch for exposed Work and 1 inch for embedded Work.
2. Unless otherwise indicated, install conduit runs with not more than three quarter bends, 270 degrees total, per run. Where more bends are required in a particular run, install pull boxes as required to facilitate pulling conductors even if not indicated.

3. Provide GRS or epoxy fiberglass conduit and accessories for all installations in tunnels, subway, and subway passenger stations including ventilation fans, lighting and sump pumps. Where conduits are embedded in concrete, provide PVC, PVC-coated rigid steel or epoxy fiberglass conduit.

4. Provide PVC-coated metallic conduit and adapter for the transition of a PVC conduit embedded in slab and the above-ground metallic conduit. Ensure that the above-ground PVC-coated metallic conduit is 2 feet minimum above ground.

5. Terminate metallic conduit installed for future extension with flush threaded couplings set to finished floor level or wall, unless otherwise indicated. Provide plug for open end. Extensions to existing Work shall match existing size.

6. Provide and install metallic numbering tags indicating the conduit number and circuit number on both ends of all conduit.

7. Properly support and anchor conduit to be embedded to maintain correct location and spacing and to prevent flotation during concreting operations. If necessary, provide suitable metal supports.

8. Install conduit so that moisture collecting in the conduit will be drained to the nearest outlet or pull box. Drill weepholes at the lowest points in each exposed conduit run. Install a "T" conduit with drain fitting at the lowest point.

9. Whenever exposed or buried conduit passes through an expansion or contraction joint in the structure, install the conduit at right angles to the joint, and provide an approved conduit expansion fitting at the joint. Paint the conduit with an approved bituminous compound for one foot on each side of the expansion couplings.

10. Provide expansion fittings in conduit runs where required to compensate for thermal expansion.

11. Rod and swab embedded conduit after installation to remove foreign matter. If obstructions are encountered which cannot be removed, or if conditions exist which may result in damage to wires and cables pulled through the conduit, install new conduit at no additional cost to Sound Transit.

12. After the conduit has been rodded and swabbed, install covers on boxes and protect conduit ends to prevent foreign material from entering the conduit.

13. Where conduit is exposed to different temperatures, seal the conduit to prevent condensation and passage of air from one area to the other.

14. Metallic conduits shall be electrically and mechanically continuous and connected to ground by bonding to the grounding system.

15. Apply conductive compound to the threads of threaded rigid conduit joints. Do not use compounds containing lead. Terminate the conduit in appropriate boxes at motors, switches, outlets, and junction points.
16. When field cutting of conduit is required, thread and ream the conduit to remove rough edges. Where a conduit enters a box or other fitting, provide a bushing to protect the wire from abrasion. Provide insulating bushings and double locknuts on ends of rigid conduits terminating at steel boxes, panel boards, cabinets, motor starting equipment, and similar enclosures.

17. Support individual horizontal conduits not larger than 1-1/2 inches in diameter by means of one-hole conduit straps with back spacers or individual conduit hangers.

18. Support individual horizontal conduits larger than 1-1/2 inches in diameter by individual hangers and forged steel conduit strap for vertical runs.

19. Space conduits installed against concrete surfaces 1/4 inch away from the surface by clamp backs or other approved means.

20. Hanger rods used in connection with spring-steel fasteners, clips and clamps shall be either 3/8-inch diameter galvanized steel rods or, if concealed above a suspended ceiling, galvanized perforated steel strapping. Do not use wire for support of conduit.

21. Support parallel conduits at the same elevation on multiple conduit hangers or channel inserts. Secure each conduit to the pipe hanger or channel insert member by a U-bolt, one-hole strap or other specially designed and approved fastener suitable for use with the pipe hangers or channel inserts.

22. Space supports not over ten feet on centers for vertical conduits spanning open areas. Securely anchor conduit at each end, and run so as not to interfere with the installation and operation of equipment at the location.

23. Support conduits and raceways above suspended ceilings from either the floor construction above or from the main ceiling support members, by using the applicable methods specified herein.

24. Install liquid-tight flexible metal conduit at structural construction joints, at motor connections and where required so that liquids tend to run off the surface and not drain toward fittings. Provide sufficient slack to reduce the effects of vibration. Running threads are not acceptable. Where necessary for connecting to rigid conduits, use conduit unions.

25. In areas of floating slabs, install horizontal runs of conduit beneath the floating slab. Conduit shall pass through the floating slab only where required to terminate in a vertical direction as indicated. Provide a sleeve with an all around 1/4-inch clearance between sleeve and vertical conduit riser. Fill the space around the conduit with rubber-base waterproofing compound.

26. Electrical metallic tubing (EMT) may be run exposed above 8 feet and concealed in walls and ceilings, where allowed. Do not install EMT in tunnels or below platform level or mounted to concrete surfaces in subway stations.

27. Tag unscheduled conduit in a manner acceptable to the Resident Engineer for indoor installations only. For exterior or potentially-wet areas provide GRS, epoxy fiberglass or PVC as appropriate.
28. Conduits for emergency loads (such as emergency lighting and fire alarm system) shall be run separately from "normal" load conduits and protected from physical damage or fires, and shall be GRS.

29. Seal conduits with watertight duct sealing system, where waterproofing is required.

B. Nonmetallic Conduit.

1. Embed in slabs and walls where indicated.

2. Cap or plug the ends of embedded conduit to prevent concrete and other materials from obstructing the conduit.

3. Sandpaper joints conduit to remove burrs, clean and dry the joints, and brush with solvent cement acceptable to the manufacturer before installing.

4. Support conduit to maintain the correct location and spacing during concreting operations and provide suitable plastic supports and spacers for conduit duct banks.

5. When nonmetallic electrical conduit stubbed up is to be connected to metallic conduit, use embedded metallic coupling flush with the floor or wall.

6. Other installation requirements shall be the same as for metallic electrical conduit.

C. Pull Cords.

1. Provide nylon pull cords of tensile strength not less than 240 pounds in each conduit and duct. Leave pull cords in ducts and conduit.

2. Splices in pull cords will not be permitted.

3. Leave ample slack length at each end of pull cords.

D. Filling of Openings.

1. Wherever slots, sleeves, or other openings are provided in floors and walls for the passage of raceways, conduits, and bus ducts, fill such openings as follows.

   a.) Provide fire-resistive filling material and installation for openings in conformance with applicable codes.

   b.) Where conduits passing through openings are exposed in finished rooms, use surface filling material that matches, and is flush with, the adjoining finished floor, ceiling, or wall.

E. Conduit Hangers.

1. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the jobsite to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.
2. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the Work rigidly. Conform to Washington State Building Code requirements for Seismic Zone 3 location.

3. Support parallel conduits at the same elevation on multiple conduit hangers or channel inserts. Secure each conduit to the hanger or channel insert member by U-bolt, one-hole strap, or other specially designed and approved fastener suitable for use with the hangers or channel inserts.

4. Space supports not over 10 feet on center for vertical conduits spanning open areas. Securely anchor conduit at each end, and run so as not to interfere with the installation and operation of equipment at the location.

5. Support conduits and raceways above suspended ceilings from either the floor construction above or from the main ceiling support members, by using the applicable methods specified herein.

3.03 INSERTS

A. Channel Inserts.

Install embedded channel inserts with the slotted face flush with the finished concrete surface.

B. Spot Inserts.

Install with the insert face flush with the finished concrete surface, firmly embedded, with no evidence of movement.

3.04 OUTLET, JUNCTION, AND PULL BOXES

A. Mount outlet, junction, and pull boxes so as to prevent moisture from entering or accumulating within the boxes. Do not use conduits entering the box as supports for the box.

B. Outlet Boxes.

1. Install as noted on Contract Drawings.

2. Unless otherwise indicated, flush mount outlet boxes with the front edges of the boxes or tile covers attached thereto flush with the finished wall or ceiling.

3. Mount boxes so that the long axis of the devices will be vertical, unless otherwise indicated.

4. Locate boxes and box knockouts in concrete so as not to interfere with the reinforcing steel.

5. Unless otherwise specified, provide boxes in tile walls and ceilings with tile covers. Do not install these covers until the finished tile line is determined for the particular location.

6. The mounting height indicated for a wall-mounted outlet box shall be construed to mean the height from the finished floor to the horizontal centerline of the cover plate.
7. Mount outlet boxes for switches and receptacles located on columns and pilasters so as not to interfere with installation of partitions.

8. Install boxes located near doors on the lock side, even where the symbols appear on the hinge side as indicated, unless other locations are approved by the Resident Engineer.

C. Junction and Pull Boxes.
   1. Install so that covers are readily accessible after completion of the installation.

   2. Do not install boxes above suspended ceilings, except where the ceiling is of the removable type or where definite provisions are made for access to each box.

D. Boxes Set in Concrete.

   2. Unused nailing holes or other holes in the side or bottom of the boxes shall be plugged or masked.

   3. After installation, clean boxes placed in concrete and provide covers to prevent entry of dirt and debris.

3.05 ELECTRICAL CABLE TRAYS

A. Install cable trays as indicated and in accordance with National Electrical Code, Article 318, using approved fittings and adequately supporting the complete system.

B. Provide antisway brackets on horizontal tray assemblies at 10 foot intervals.

C. Connect each isolated cable tray system or the entire tray system to the building equipment grounding system with a bare copper conductor in accordance with National Electrical Code.

D. Base size determination of grounding cable on the largest power and control conductor in the cable tray.

   1. Minimum size: 14 AWG.


PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 16130
SECTION 16610
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes specifications for three-phase, on-line, static-type, Uninterruptible Power Supply (UPS), complete with transient voltage surge suppression, input harmonics reduction, rectifier-charger, battery, battery disconnect device, inverter, and static bypass transfer switch.

1.02 REFERENCE STANDARDS

Applicable provisions of the following standards shall apply to the Work of this Section, except as modified herein, and are hereby made a part of these Specifications to the extent required.

A. American National Standards Institute (ANSI).

   ANSI C62.41 (IEEE 587) Recommended Practice on Surge Voltages in Low-Voltage Ac Power Circuits.

B. National Electrical Manufacturers Association (NEMA).

   1. NEMA PB-2-2001    Deadfront Distribution Switchboards
   2. NEMA PE-1     Uninterruptible Power Systems.
   3. NEMA 250    Enclosure for Electrical Equipment.

C. Underwriters Laboratories Inc. (UL).

   1. UL 1778        Uninterruptible Power Supply Equipment.
   2. UL 924A   Standard for Emergency Lighting and Power Equipment.

D. National Fire Protection Association (NFPA).

   1. NFPA 70  National Electrical Code.

E. Institute of Electrical and Electronic Engineers (IEEE).


G. Federal Communications Commission (FCC):

1. 47 CFR Part 15 Class A.

1.03 SUBMITTALS

A. The following submittals shall be prepared and submitted as per Section 01330, Submittals, and Appendix G, Contract Data Requirements List:

1. Product Data.

   Include data on features, components, ratings, and performance for each uninterruptible power supply component indicated.

2. Shop Drawings.

   Detail assemblies of equipment indicating dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels and battery arrangement.

3. Wiring Diagram.

   Detail internal and interconnecting wiring, power, signal, and control wiring. Differentiate between field-installed and factory-installed wiring and components.

4. Dimensioned Outline Drawings of Equipment Unit.

   Identify weight and center of gravity and locate and describe mounting and anchorage provisions for each individual cabinet or enclosure.

5. Detailed description of equipment anchoring devices on which the certification is based and their installation requirements.

6. Manufacturer Certificates.

   Signed by manufacturers certifying that they comply with requirements.

7. Qualification Data.

   For firms and persons specified in “Quality Assurance” Article.

8. Factory Test Reports.

   Comply with specified requirements.

9. Field Test Reports.

   Indicate test results compared with specified performance requirements and provide justification and resolution of differences if values do not agree.
10. Maintenance Data.

a.) For maintenance manuals specified in Division One, General Requirements, include the following:

1.) List of spare parts and replacement components recommended being stored at project site for ready access.

2.) Detailed operating instructions covering operation under both normal and abnormal conditions.

b.) Warranties.

Special warranties specified in this Section.

11. Manufacturer Seismic Qualification Certification

Submit certification that UPS equipment will withstand seismic forces per Uniform Building Code (UBC) for Washington State Seismic Zone 3 requirements.

1.04 QUALITY CONTROL

A. Source Limitations.

Obtain the UPS and associated components specified in this Section from a single manufacturer with responsibility for entire UPS installation.

B. Supplier shall have a local service organization with factory-trained technicians and local parts inventory, and shall be capable of providing training, parts and emergency maintenance and repairs for equipment at the Project site with eight hours maximum response time.

C. Installer Qualifications.

An experienced installer who is an authorized representative of UPS manufacturer for both installation and maintenance of units required for this Project for at least five years.

D. Listing and Labeling.

1. Provide electrical components, devices, and accessories that are Listed and Labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the Authority Having Jurisdiction, and marked for intended use for the location and environment in which they are installed.

2. The equipment shall also be labeled “Suitable for use on emergency system” per NEC 700-3.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.
B. Store equipment in spaces with environments controlled within manufacturer’s ambient temperature and humidity tolerances for non-operating equipment.

1.06 CAPACITY UPGRADE CAPABILITY

Selected systems shall be able to accept a field installed power upgrade to the next higher power rating without an increase in cabinet size.

1.07 EXTRA MATERIALS

A. Local field service organization shall stock extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Provide qualified service personnel available around-the-clock 365 days a year.

C. Provide toll free direct phone number.

D. Provide the following items:
   1. Fuses.
      One (1) for every 10 of each type and rating, but not less than one (1) of each.
   2. Cabinet Ventilation Filters.
      One (1) complete set.
   3. One (1) spare circuit board for each critical circuit.

1.08 DEFINITIONS

A. EMI is defined as electromagnetic interference.

B. LCD is defined as liquid-crystal display.

C. LED is defined as light-emitting diode.

D. THD is defined as total harmonic distortion.

E. UPS is defined as uninterruptible power supply.

1.09 WARRANTY

A. Warranties, General.

Special warranties specified in this Article shall be in addition to, and run concurrent with, other warranties made under requirements of these Specifications.
B. Special Battery Warranties.

Written warranty, signed by manufacturer and Installer agreeing to replace UPS system storage batteries that fail because of defects in materials or workmanship within specified warranty period.

C. Warranted Cycle Life for Nickel Cadmium Batteries (NiCo).

Equal to or greater than that represented in manufacturer's published table based on annual average battery temperature of 77° F.

D. Special UPS Warranties.

Written warranties, signed by manufacturer and Installer agreeing to replace components that fail in materials or workmanship within special warranty period.

E. Special Warranty Period.

Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers.

1. Subject to compliance with requirements, provide products by one of the following:

   a.) Solid-State Controls
   b.) Powerware.
   c.) Liebert Corporation.
   d.) American Power Conversion (APC).

2.02 FUNCTIONAL DESCRIPTION

A. Automatic operation includes the following:

1. Normal Conditions

   Supply the load with ac power flowing from the normal AC power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
2. Abnormal Supply Conditions.

If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter ac power output to the load without switching or disturbance.

3. If normal power fails, energy supplied by the battery through the inverter continues to supply-regulated ac power to the load without switching or disturbance.

4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.

5. If battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to a float-charge mode.

6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption of supply.

7. If a fault occurs in the system supplied by the UPS and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.

8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.

9. If battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following.

1. Turning the inverter off causes the load to be transferred by the static bypass transfer switch directly to the normal ac supply circuit without disturbance or interruption.

2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation.

1. Switch is interlocked so it cannot be operated unless static bypass transfer switch is in the bypass mode. Device provides manual selection between the following three conditions without interrupting supply to the load during switching:

   a.) Full Isolation.

   Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
b.) Maintenance Bypass.

Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.

c.) Normal.

Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and UPS rectifier-charger and inverter, or the battery and the inverter.

2.03 SERVICE CONDITIONS

A. Environmental Conditions.

1. UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance:

a.) Ambient Temperature for Electronic Components.

32 to 104 degrees F (zero to 40 degrees C).

b.) Ambient Temperature for Battery.

41 to 95 degrees F (five to 35 degrees C).

c.) Relative Humidity.

5 percent to 95 percent, noncondensing.

d.) Altitude.

Sea level to 500 feet.

2.04 PERFORMANCE REQUIREMENTS

A. Output Load Capacity.

100 kVA, 0.8 lagging power factor.

B. UPS shall perform as specified in this Article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:
1. Inverter is switched to battery source.

2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.

3. Steady-state input frequency deviates up to plus or minus five percent from nominal frequency.

4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of five percent of the fundamental value.

5. Output Frequency: 60 Hz plus/minus 0.5 percent over full range of input voltage, load and battery voltage.

6. Load is 50 percent unbalanced continuously.

C. Minimum Duration of Supply.

If/when the battery is sole energy source supplying UPS, duration of supply shall be 90 minutes for 75% of the maximum rated UPS load or 120 minutes for 150% of maximum calculated load, whichever is less.

D. Input Voltage Tolerance.

System steady state and transient output performance remains within specified tolerances when steady-state AC input voltage varies plus 10, minus 20 percent from nominal voltage.

E. Maximum Acoustical Noise.

<65 dBA measured one meter from the surface of the UPS.

F. Maximum Energizing Inrush Current.

Six times the full-load current.

G. Maximum Ac Output-Voltage Regulation for Loads up to 50 percent Unbalanced.

Plus or minus 2 percent over the full range of battery voltage.

H. Output Frequency.

60Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

I. Maximum Harmonic Content of Output-Voltage Waveform.

Five percent rms total and three percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.
J. Minimum Overload Capacity of UPS at Rated Voltage.

125 percent of full-load rating for 10 minutes without bypass source, and 150 percent for 30 seconds without bypass source.

K. Input Power Factor.

A minimum of 0.85 lagging when supply voltage and current are at nominal rated values and UPS is supplying rated full-load current.

L. EMI Emissions.

Comply with FCC Rules and Regulations, 47 CFR 15 for Class A equipment.

2.05 SYSTEM COMPONENTS, GENERAL

A. Electronic Equipment.

Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

B. Enclosure.

1. Comply with NEMA 250, Type 1, unless otherwise indicated.

   a.) The cabinet doors and louvers shall require tools for access.

   b.) Provide casters and leveling feet.

   c.) Front access only for servicing.

   d.) The overall enclosure width and depth shall not exceed the space allocated on the drawings.

C. Control Assemblies.

Mount on modular plug-ins, readily accessible for maintenance.

D. Surge Suppression.

1. Protect internal UPS components from surges that enter at each ac power input connection including main disconnect, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

   a.) Use factory-installed surge suppressors tested according to IEEE C62.41, Category B.

   b.) Additional Surge Protection: Protect internal UPS components from low frequency, high-energy voltage surges described in IEEE C62.41. Design the circuits.
connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.

E. Capacity Upgrade Capability.

Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.

F. Seismic-Restraint Design.

UPS assemblies, subassemblies, and components; and fastenings and supports, mounting, and anchorage devices for them, shall be designed and fabricated to withstand static and seismic zone three forces in any direction.

G. UPS Cabinet Ventilation.

Cooling of the UPS shall be by forced air. Low-velocity fans shall be used to minimize audible noise output. Fan power shall be provided by the UPS output.

H. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity.

Rated phase current times a multiple of 2.0, minimum.

2.06 RECTIFIER-CHARGER

A. Capacity.

Adequate to supply the inverter during full-rated output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

B. Output Ripple.

Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

C. Rectifier-Charger Control Circuits.

1. Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

2. Response Time.

Field adjustable for maximum compatibility with portable generator-set power source.

D. Battery Float-Charging Conditions.

Comply with battery manufacturer written instructions for battery terminal voltage and charging current required for maximum battery life.
2.07 INVERTER

A. Description.

1. Pulse-width modulated, with sinusoidal output.

2. Include a bypass phase synchronization window adjustment to optimize compatibility with portable engine-generator-set power source.

2.08 STATIC BYPASS TRANSFER SWITCH

A. Description.

1. Solid-state switching device providing uninterrupted transfer

2. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

B. Switch Rating.

Continuous duty at the rated full-load current of the UPS, minimum.

2.09 BATTERY

A. Description.

1. NiCd, pocket plate block battery, designed to sustain electrical loads for between 30 minutes to three hours or for "mixed" loads involving a mixture of high and low discharge rates.

2. Communications equipment can have variable discharges.

3. The typical discharge range is from 15 minutes to two hours with cell capacity of 600Ah.

4. Batteries shall be isolated compartment of UPS cabinet, and complete with battery disconnect switch.

2.10 UPS CONTROL AND INDICATION

A. Provide system power flow diagram on front of cabinet.

B. Description.

Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

C. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include an audible signal and a visual display.
D. Indications.

Plain-language messages on a digital LCD or LED.

E. Dry-form “C” contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

2.11 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description.

1. Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

   a.) Switch shall be interlocked to prevent interrupting power to the load when switching to the bypass mode.

   b.) Switch shall isolate other UPS components electrically to permit safe servicing.

B. Comply with NEMA PB 2 “Dead-Front Distribution Switchboards” and UL 891 “Dead-Front Switchboards”.

C. Switch Rating.

Continuous duty at rated full-load current of UPS.

D. Mounting Provision.

Internal to system cabinet or external wall mount.

E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by static bypass transfer switch. Lock is designed specifically for electrical component interlocking.

2.12 MONITORING BY REMOTE COMPUTER

A. Description.

1. Communication module in unit control panel shall provide capability for remote monitoring of status, parameters, and alarms. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
a.) LonWorks compatible network interface or other open systems interface approved by Resident Engineer.

b.) Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Design for Windows application in an IBM-compatible computer, which is not included in this Section.

2.13 BASIC BATTERY MONITORING

A. Battery Ground-Fault Detector.

Initiates visual and audible alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

B. Battery compartment smoke/high-temperature detector initiates a visual and audible alarm when smoke or a temperature greater than 75 degrees C occurs within the compartment.

C. Annunciation of Alarms.

At UPS control panel.

2.14 ADDITIONAL BATTERY MONITORING

A. Monitoring features and components shall include the following:

Factory-wired sensing leads to cell and battery terminals and cell temperature sensors. Provide fuses as required for proper protection of conductors.

B. Functional Performance.

1. Automatically measure and electronically record the following parameters on a routine schedule and during battery discharge events. During discharge events record measurements timed to the nearest second. Include measurements of the following parameters:

   a.) Total battery voltage and ambient temperature.

   b.) Individual cell voltage, impedance, and temperature; Measure battery and cell voltages and time to the nearest second during battery discharging events such as utility outages.

   c.) Individual cell electrolyte levels.

2.15 BATTERY CYCLE WARRANTY MONITORING

A. Description.

Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by a life-cycle warranty.
B. Basic Functional Performance.

Automatically measures and records each discharge event; classifies it according to duration category; and totals discharges according to warranty criteria displaying remaining warranted battery life on integral LCD.

C. Additional Monitoring Functions and Features shall include the following:

1. Measuring and Recording.

Total voltage at battery terminals, providing alarm for excursions outside the proper float voltage level.

2. Monitors.

Ambient temperature at battery and initiates an alarm if temperature deviates from normally acceptable range.


Provides access to monitored data using front panel display.

4. Alarm Contacts.

Arranged to provide local alarm for abnormal temperature, abnormal battery voltage, or temperature.

5. Memory.

Device stores recorded data in nonvolatile electronic memory.

6. RS-232 Port.

Permits downloading data to a portable personal computer.

7. Modem.

Makes measurements and recorded data accessible to remote personal computer via telephone line. Computer is not specified in this Section.

2.16 SOURCE QUALITY CONTROL

A. Factory test complete UPS, including battery, before shipment. Include the following tests:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.

2. Full-load test.
4. Overload test.
5. Power failure test.

B. Observation of Test.

Give 14 days advance notice of test and provide opportunity for Resident Engineer to observe tests.

C. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall supply and install one (1) 100 kVA UPS in the CCER at the O&M Facility meeting the requirements herein. In station facilities, UPS’s are supplied by others.

B. Examine elements and surfaces to receive equipment for compliance with installation tolerances and other conditions affecting performance, including, but not limited to, ambient temperature, cooling air circulation, contaminants and disassembly and maintenance space.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install system components on load distributing bases with maximum load not to exceed 100 lbs. per square foot.

B. Maintain minimum clearances and workspace at equipment according to manufacture’s written instructions and NFPA 70.

C. Connections.

1. Interconnect system components.
2. Make connections to supply and load circuits according to manufacturer’s wiring diagrams, unless otherwise indicated.
3.03 GROUNDING

A. Comply with Section 16060, Electrical Grounding and Bonding, for materials and installation requirements.

B. Comply with NFPA 70 for grounding and bonding requirements.

3.04 IDENTIFICATION

A. Identify components and wiring according to Section 16075, Electrical Identification.

B. Equipment shall be labeled “Suitable for use on emergency systems” per NEC 700-3.

C. Instructional signs.

Install approved legend where instructions or explanations are required for system of equipment operation.

3.05 BATTERY EQUALIZATION

Equalize charging of battery cells according to manufacturer’s written instructions. Record individual-cell voltages.

3.06 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service.

Engage the services of a factory-authorized service representative to supervise UPS installation, startup, and preliminary testing and adjustment and to participate in final tests, inspections, and adjustments.

B. Electrical Tests and Inspections.

1. Perform tests and inspections according to manufacturer’s written instructions and as listed below to demonstrate condition and performance of each component of the UPS:

   a.) Inspect interiors of enclosures, including the following:

      1.) Integrity of mechanical and electrical connections.

      2.) Component type and labeling verification.

      3.) Ratings of installed components.

2. Test manual and automatic operational features and system protective and alarm functions.

3. Test communication of status and alarms to remote monitoring equipment.
4. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for the unit’s rating. Use instruments calibrated, within the previous six months.

   a.) Simulate malfunctions to verify protective device operation.

   b.) Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.

   c.) Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.

   d.) Test output voltage under specified transient-load conditions.

   e.) Test efficiency at 50, 75, and 100 percent rated loads.

   f.) Test remote status and alarm panel functions.

   g.) Test battery-monitoring system functions.

   h.) Test resistance to ground of battery negative pole.

C. Seismic-restraint inspections shall include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.

2. Test mounting and anchorage devices.

3. Verify batteries are properly mounted and secured to battery racks.

D. Correct deficiencies until specified requirements are met.

E. Record of Inspections.

   1. Maintain and submit documentation of inspections, including references to manufacturers written instructions and inspection criteria.

   2. Include results of inspections.

3.07 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Sound Transit maintenance personnel to adjust, operate, and maintain the UPS.

   1. Train Sound Transit maintenance personnel in the procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division One, Operations and Maintenance Manuals.

3. Schedule training with Resident Engineer with at least seven days advance notice.

3.08 FUNCTIONAL PERFORMANCE TESTING

A. Monitoring and Testing Schedule.

1. Perform monitoring and testing in a single 10-day period.

a.) Schedule monitoring and testing activity with Resident Engineer. Provide at least seven days advance notice.

b.) Schedule monitoring and testing after Substantial Completion, when UPS in supplying power to its intended load.

B. Monitoring and Testing Instruments.

1. Three-phase, recording power monitors.

a.) Instruments shall provide continuous simultaneous monitoring of electrical parameters at input terminals of the UPS and at input terminals of a load served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus two percent for electrical parameters. Parameters to be monitored include the following:

1.) Current.
   - Each phase and neutral and grounding conductors.

2.) Voltage.
   - Phase to phase, phase to neutral, phase to ground, and neutral to ground.

3.) Frequency transients.

4.) Voltage swells and sags.

5.) Voltage impulses, phase-to-phase, phase-to-neutral, phase-to-ground, and neutral-to-ground.

6.) High-frequency noise.

7.) Radio-frequency interference.
8.) THD of the above currents and voltages.

9.) Harmonic content of currents and voltages above.

10.) Audible noise levels.

C. Monitoring and Testing Procedure.

1. Exploratory Period.

For approximately the first two days, make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these preliminary measurements with the objective of identifying optimum UPS, power system, load, and instrumentation set-up conditions for subsequent test and monitoring operations.

2. Remainder of Test Period.

a.) Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

1.) Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS with respect to values specified in Part 2 of this Section, and to highlight any need to adjust, repair, or modify the UPS or any distribution system or load component that may influence its performance or that may require better power quality.

2.) Perform load and UPS power source switching and operate the UPS on generator power during portions of the test period.

3.) Operate the UPS and UPS loads in each mode of operation permitted by UPS controls and by the power distribution system design.

4.) Create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients that can be performed using loads and devices available as part of the facility’s installed systems and equipment. Maintain normal operating loads in operation on system to maximum extent possible during tests.

5.) Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

D. Correlation with Specified UPS Monitoring Functions.

1. Obtain printout recordings of built-in monitoring functions specified for UPS and UPS components in this Section that are simultaneous with those made with portable instruments in this Article.
a.) Provide the temporary use of an appropriate personal computer and printer equipped with required connections and software for recording and printing if such units are not available on-site.

b.) Correlate printouts with recordings for monitoring performed according to this Article, and resolve and report any anomalies in and discrepancies between the two sets of records.

E. Documentation.

1. Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording.

2. Correlate simultaneous recordings made on UPS input and load circuits.

F. Analysis of Recorded Data and Report.

1. Review and analyze test observations and recorded data and submit a detailed written report. Include the following in final report:

   a.) Description of corrective actions performed during monitoring and survey Work and their results.

   b.) Recommendations for further action to provide optimum performance by the UPS

   c.) Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents

   d.) Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations

   e.) Recommendations for operating, adjusting, or revising UPS controls

   f.) Recommendation for alterations to the UPS installation

   g.) Recommendation for adjusting or revising generator-set or automatic transfer switch installations or their controls

   h.) Recommendations for power distribution system revisions

   i.) Recommendations for adjusting or revising electrical loads, or their connections or controls.

G. Interim and Final Reports.

Provide an interim report at the end of each test period and final comprehensive report at the end of the final test and analysis period.
3.09 OPERATION AND MAINTENANCE MANUALS

Provide Operation and Maintenance Manuals, as described in Section 01785, Operation and Maintenance Manuals.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 16610
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PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes specifications for dc power systems, complete with rectifiers, transient voltage surge suppression, input harmonics reduction, rectifier-charger, battery, battery disconnect device, and static bypass transfer switch.

1.02 REFERENCE STANDARDS

A. Applicable provisions of the following standards shall apply to the Work of this Section, except as modified herein, and are hereby made a part of these Specifications to the extent required:


   a.) NEMA PB-2 Dead-Front Distribution Switchboards.
   b.) NEMA PE-1 Uninterruptible Power Systems.
   c.) NEMA 250 Enclosure for Electrical Equipment.

3. Underwriters Laboratories Inc. (UL).

   a.) UL 1778 Uninterruptible Power Supply Equipment.
   b.) UL 891 Dead-Front Switchboards.
   c.) UL 924A Standard for Emergency Lighting and Power Equipment.
   d.) UL 1950 Safety of Information Technology Equipment, including Electric Business Equipment.


   a.) NFPA 70 National Electrical Code.
   b.) NFPA 75 Electronic Computer / Data Processing Equipment.
5. Institute of Electrical and Electronic Engineers (IEEE).


8. Network Equipment Building Standards (NEBS):
   a.) GR-63 Physical Protection.
   b.) GR-1089 Electromagnetic Compatibility and Electric Safety.

1.03 SUBMITTALS

A. The following submittals shall be prepared and submitted as per Section 01330, Submittals, and Appendix G, Contract Data Requirements List:

1. Product Data.

Include data on features, components, ratings, and performance for each type of dc power system component to be supplied.

2. Shop Drawings.

Detail assemblies of equipment indicating dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.

3. Wiring Diagram.

a.) Detail internal and interconnecting wiring, power, signal, and control wiring.

b.) Differentiate between field-installed and factory-installed wiring and components.

4. Dimensioned Outline Drawings of Equipment Unit.

Identify weight and center of gravity and locate and describe mounting and anchorage provisions for each individual cabinet or enclosure.

5. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

6. Manufacturer Certificates.

Signed by manufacturers certifying that they comply with requirements.
7. Qualification Data.

For firms and persons specified in Section 01450, Systems Quality Requirements.

8. Factory Test Reports.

Comply with specified requirements.

9. Field Test Reports.

Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

10. Maintenance Data.

a.) For maintenance manuals specified in Division One, General Requirements, include the following:

1.) List of recommended spare parts and replacement components to be stored at project site for ready access.

2.) Detailed operating instructions covering operation under both normal and abnormal conditions.

3.) Warranties.

- Special warranties specified in this Section.

11. Manufacturer Seismic Qualification Certification.

Submit certification that dc power system's equipment will withstand seismic forces per Uniform Building Code (UBC) for Washington State seismic zone four requirements.

1.04 QUALITY CONTROL

A. Source Limitations.

Obtain the dc power system and associated components specified in this Section from a single manufacturer with responsibility for entire dc power system installation.

B. Supplier shall have a local service organization with factory-trained technicians and local parts inventory, and shall be capable of providing training, parts and emergency maintenance and repairs for equipment at the Project site with eight hours maximum response time.

C. Installer Qualifications.

An experienced installer who is an authorized representative of a dc power system manufacturer for both installation and maintenance of units required for this Project for at least five years.
D. Listing and Labeling.

1. Provide electrical components, devices, and accessories that are Listed and Labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the Authority Having Jurisdiction, and marked for intended use for the location and environment in which they are installed.

2. The equipment shall also be labeled “Suitable for use on emergency system” per NEC 700-3.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.

B. Store equipment in spaces with environments controlled within manufacturer’s ambient temperature and humidity tolerances for non-operating equipment.

1.06 CAPACITY UPGRADE CAPABILITY

A. Selected systems shall be rack mounted system modular in design with hot swappable units of a nominal size (25 A or 50 A @ 48 Vdc).

B. Each nominal unit shall be ganged together with a common frame and back plane.

C. Contractor shall leave sufficient spare slots available to expand at least 33 percent at all stations and by at least 50 percent at the Operations and Maintenance Base with the future capability to add up to four (4) times its current capacity.

1.07 EXTRA MATERIALS

A. Overview.

1. Local field service organization shall stock extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

2. Provide qualified service personnel available around-the-clock 365 days a year.

B. Provide toll free direct phone number.

C. Fuses.

   One (1) for every ten (10) of each type and rating, but not less than one (1) of each.

D. Cabinet Ventilation Filters.

   One complete set.

E. One spare circuit board for each critical circuit.
1.08 DEFINITIONS

A. EMI shall be defined as electromagnetic interference.

B. LCD shall be defined as liquid-crystal display.

C. LED shall be defined as light-emitting diode.

D. THD shall be defined as total harmonic distortion.

E. dc power system shall be defined as 48 Vdc or 24 Vdc power supply.

1.09 WARRANTY

A. Warranties, General.

Special warranties specified in this Section shall be in addition to, and run concurrent with, other warranties made under requirements of these Specifications.

B. Special Battery Warranties.

Written warranty, signed by manufacturer and Installer agreeing to replace dc power system storage batteries that fail in materials or workmanship within specified warranty period.

C. Warranted Cycle Life for Batteries.

Equal to or greater than that represented in manufacturer’s published table based on annual average battery temperature of 77 degrees F.

D. Special dc Power System Warranties.

Written warranties, signed by manufacturer and Installer agreeing to replace components that fail in materials or workmanship within special warranty period.

E. Special Warranty Period.

Two years from date of Acceptance of Work.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products from a manufacturer who:

1. Has supplied this product in similar applications for at least 10 years, is in stable financial condition, and plans to be in the business of supplying product for at least 10 more years.

2. Complies with requirements in Section 01450, System Quality Requirements.
2.02 FUNCTIONAL DESCRIPTION

A. Automatic operation includes the following:

1. Normal Conditions.

   Supply the load with dc power flowing from the normal dc power input terminals, through the rectifier-charger, with the battery connected in parallel with the rectifier-charger output.

2. Abnormal Supply Conditions

   If normal dc supply deviates from specified and adjustable voltage, the battery supplies energy to maintain constant, regulated dc power output to the load without switching or disturbance.

3. If normal power fails, energy supplied by the battery through the rectifier-charger continues to supply-regulated dc power to the load without switching or disturbance.

4. When power is restored at the normal supply terminals of the system, the rectifier-charger supplies power to the load and simultaneously recharges the battery.

5. If battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to a float-charge mode.

6. If a fault occurs in the system supplied by the dc power system and current flows in excess of the overload rating of the dc power system, the automatic protection switch shall switch to the protect unit in the N+1 configuration.

7. When the fault has cleared, the automatic protection switch returns the load to the primary unit.

8. If battery is disconnected, the dc power system continues to supply power to the load with no degradation of its regulation of voltage of the output bus.

B. Manual operation includes the following:

1. Turning the primary rectifier unit off causes the load to be transferred by the automatic protection switch directly to the protect rectifier unit without disturbance or interruption.

2. Turning the rectifier on causes the static bypass transfer switch to transfer the load to the inverter.

2.03 SERVICE CONDITIONS

A. Environmental Conditions.

1. Dc power system shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.
a.) Ambient Temperature for Electronic Components: -29 to 149 degrees F.

b.) Ambient Temperature for Battery: 30 to 95 degrees F.

c.) Relative Humidity: 5 percent to 85 percent, noncondensing.

d.) Altitude: Sea level to 500 feet.

2.04 PERFORMANCE REQUIREMENTS

A. Output Load Capacity.

From 50 A to 4800 A.

B. Dc power system shall perform as specified in this Section while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.

2. Steady-state input frequency deviates up to plus or minus five percent from nominal frequency.

3. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of five percent of the fundamental value.

4. Output varies less than +/- 15 percent of rated output with no more than 0.1 V RMS distortions from non-dc source.

5. Load is 50 percent unbalanced continuously.

C. Minimum Duration of Supply.

If/when battery is sole energy source supplying dc power system, duration of supply shall be 120 minutes, for 75 percent of the maximum rated supply.

D. Input Voltage Tolerance.

System steady state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 20 percent from nominal voltage.

E. Maximum Acoustical Noise.

Less than 55 dBA measured one meter from the surface of the dc power system.

F. Maximum Energizing Inrush Current.

Six times the full-load current.
G. Maximum dc Output-Voltage Regulation plus or minus 5 percent over the full range of battery voltage.

H. Maximum Harmonic Content of Output-Voltage.
   One percent rms total for 100 percent rated load current with a load crest factor of 3.0.

I. Minimum Overload Capacity of dc Power System at Rated Voltage.
   125 percent of full-load rating for 10 minutes without bypass source, and 150 percent for 30 seconds without bypass source.

J. Input Power Factor.
   A minimum of 0.85 lagging when supply voltage and current are at nominal rated values and dc power system is supplying rated full-load current.

K. EMI Emissions.
   Comply with FCC Rules and Regulations, 47 CFR 15 for Class B equipment.

L. Safety.
   UL 1950, NEBS-GR-63 and NEBS-GR-1089

2.05 SYSTEM COMPONENTS, GENERAL

A. Electronic Equipment.
   Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

B. Enclosure.
   1. Comply with NEMA 250, Type 1, unless otherwise indicated.
      a.) The cabinet doors and louvers (if any) shall require tools for access.
      b.) Front access only for servicing.
      c.) The overall enclosure width and depth shall not exceed the space allocated on the drawings.

C. Control Assemblies.
   Mount on modular plug-ins, readily accessible for maintenance.
D. Surge Suppression.

1. Protect internal dc power system components from surges that enter at each ac power input connection including main disconnect, automatic protection switch, and maintenance bypass/isolation switch. Protect rectifier-charger, controls, and output components.

   Use factory-installed surge suppressors tested according to ANSI/IEEE C62.41, Category B.

E. Capacity Upgrade Capability.

Arrange wiring, controls, and modular component plug-in provisions to permit future at least 33 percent at all stations and by at least 50 percent at the Operations and Maintenance Base with the future capability to add up to four times its current capacity.

F. Seismic-Restraint Design.

Dc power system assemblies, subassemblies, and components; and fastenings and supports, mounting, and anchorage devices for them, shall be designed and fabricated to withstand static and seismic zone three forces in any direction.

G. Dc Power System Cabinet Ventilation.

Cooling of the dc power system shall be by forced air. Low-velocity fans shall be used to minimize audible noise output. Fan power shall be provided by the dc power system output.

H. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity.

   Rated phase current times a multiple of 2.0, minimum.

2.06 RECTIFIER-CHARGER

A. Capacity.

Combined modular units shall be adequate to supply the full-rated output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

B. Output Ripple.

   Limited by output filtration to less than 0.5 percent of rated voltage, peak to peak.

C. Rectifier-Charger Control Circuits.

1. Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

   a.) Response Time: Field adjustable for maximum compatibility with portable generator-set power source.
D. Battery Float-Charging Conditions.

Comply with battery manufacturer written instructions for battery terminal voltage and charging current required for maximum battery life.

2.07 AUTOMATIC TRANSFER SWITCH

A. Description.

Solid-state switching device providing uninterrupted transfer between the primary modular rectifier and the backup. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

B. Switch Rating.

Continuous duty at the rated full-load current of the dc power system, minimum.

2.08 BATTERY

A. Description.

1. NiCd, pocket plate block battery, designed to sustain electrical loads for between 30 minutes to three (3) hours or for “mixed” loads involving a mixture of high and low discharge rates. Communications equipment can have variable discharges. The typical discharge range is from 15 minutes to two hours with cell capacity of 600Ah.

2. Batteries shall be isolated from the dc power system cabinet, and complete with battery disconnect switch.

2.09 DC POWER SYSTEM CONTROL AND INDICATION

A. Provide system power flow diagram on front of cabinet.

1. Description

   Group displays, indications, and basic system controls on a common control panel on front of dc power system enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include an audible signal and a visual display.

C. Indications.

   Plain-language messages on a digital LCD or LED.

D. Dry-form “C” contacts shall be available for remote indication of the following conditions:

   1. Dc power system on battery.

   2. Dc power system on-line.
3. Dc power system load-on bypass.

4. Dc power system in alarm condition.

5. Dc power system off (maintenance bypass closed).

2.10 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description.

1. Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, and automatic protection switch.

   a.) Switch shall be interlocked to prevent interrupting power to the load when switching to the bypass mode.

   b.) Switch shall isolate other dc power system components electrically to permit safe servicing.

B. Comply with NEMA PB 2 “Dead-Front Distribution Switchboards” and UL 891 “Dead-Front Switchboards”.

C. Switch Rating.

   Continuous duty at rated full-load current of dc power system.

D. Mounting Provision.

   Internal to system cabinet or external wall mount.

E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the dc power system is bypassed by static bypass transfer switch. Lock is designed specifically for electrical component interlocking.

2.11 MONITORING BY REMOTE COMPUTER

A. Description.

1. Communication module in unit control panel shall provide capability for remote monitoring of status, parameters, and alarms. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

   a.) LonWorks compatible network interface or Resident Engineer approved open systems interface.

   b.) Software designed for control and monitoring of dc power system functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports.
2.12 BASIC BATTERY MONITORING

A. Battery Ground-Fault Detector.

Initiates visual and audible alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

B. Battery compartment smoke/high-temperature detector initiates a visual and audible alarm when smoke or a temperature greater than 75 degrees C occurs within the compartment.

C. Annunciation of Alarms.

At dc power system control panel.

2.13 ADDITIONAL BATTERY MONITORING

A. Monitoring features and components shall include the following:

Factory-wired sensing leads to cell and battery terminals and cell temperature sensors. Provide fuses as required for proper protection of conductors.

B. Functional Performance.

1. Automatically measure and electronically record the following parameters on a routine schedule and during battery discharge events. During discharge events record measurements timed to the nearest second. Include measurements of the following parameters:

a.) Total battery voltage and ambient temperature.

b.) Individual cell voltage, impedance, and temperature; Measure battery and cell voltages and time to the nearest second during battery discharging events such as utility outages.

c.) Individual cell electrolyte levels.

2.14 BATTERY CYCLE WARRANTY MONITORING

A. Description.

Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by a life-cycle warranty.

B. Basic functional Performance.

Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on integral LCD.
C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording.

   Total voltage at battery terminals, providing alarm for excursions outside the proper float voltage level.

2. Monitors.

   Ambient temperature at battery and initiates an alarm if temperature deviates from normally acceptable range.


   Provides access to monitored data using front panel display.

4. Alarm Contacts.

   Arranged to provide local alarm for abnormal temperature, abnormal battery voltage, or temperature.

5. Memory.

   Device stores recorded data in nonvolatile electronic memory.

6. RS-232 Port.

   Permits downloading data to a portable personal computer.

7. Modem.

   Makes measurements and recorded data accessible to remote personal computer via telephone line. Computer is not specified in this Section.

2.15 SOURCE QUALITY CONTROL

A. Factory test complete dc power system, including battery, before shipment. Include the following tests:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.

2. Full-load test.


4. Overload test.

5. Power failure test.
B. Observation of Test.

Record data from test and provide to Resident Engineer.

C. Report Test Results.

1. Include the following data:

   a.) Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.

   b.) List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.

   c.) List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall supply and install UPS and rectifiers meeting the requirements herein including one 50 kVA UPS in the CCER at the O&M Facility. Other units shall be supplied and installed as shown in Drawings. Sizes will vary with requirements.

B. Examine elements and surfaces to receive equipment for compliance with installation tolerances and other conditions affecting performance, including, but not limited to, ambient temperature, cooling air circulation, contaminants and disassembly and maintenance space.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install system components on a load distributing frame such that maximum floor load does not exceed 100 pounds per square foot.

B. Maintain minimum clearances and workspace at equipment according to manufacture’s written instructions and NFPA 70.

C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer’s wiring diagrams, unless otherwise indicated.

3.03 GROUNDING

A. Comply with Section 16060, Electrical Grounding and Bonding, for materials and installation requirements.

B. Comply with NFPA 70 for grounding and bonding requirements for Separately Derived Systems.
3.04 IDENTIFICATION

A. Identify components and wiring according to Section 16075, Electrical Identification.

B. Equipment shall be labeled “Suitable for use on emergency systems” per NEC 700-3.

C. Instructional Signs.

Install approved legend where instructions or explanations are required for system of equipment operation.

3.05 BATTERY EQUALIZATION

Equalize charging of battery cells according to manufacturer’s written instructions. Record individual-cell voltages.

3.06 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service.

1. Engage the services of a factory-authorized service representative to supervise dc power system

2. Installation, startup, and preliminary testing and adjustment and to participate in final tests, inspections, and adjustments.

B. Electrical Tests and Inspections.

1. Perform tests and inspections according to manufacturer’s written instructions and as listed below to demonstrate condition and performance of each component of the dc power system:

   a.) Inspect interiors of enclosures, including the following:

      1.) Integrity of mechanical and electrical connections.

            - Component type and labeling verification.

            - Ratings of installed components.

            - Test manual and automatic operational features and system protective and alarm functions.

      2.) Test communication of status and alarms to remote monitoring equipment.

      3.) Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for the unit’s rating. Use instruments calibrated, within the previous six (6) months.
Simulate malfunctions to verify protective device operation.

- Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.

- Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.

- Test output voltage under specified transient-load conditions.

- Test efficiency at 50, 75, and 100 percent rated loads.

- Test remote status and alarm panel functions.

- Test battery-monitoring system functions.

- Test resistance to ground of battery negative pole.

C. Seismic-restraint inspections shall include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.

2. Test mounting and anchorage devices.

3. Verify batteries are properly mounted and secured to battery racks.

D. Correct deficiencies until specified requirements are met.

E. Record of Inspections.

1. Maintain and submit documentation of inspections, including references to manufacturers written instructions and inspection criteria.

2. Include results of inspections.

3.07 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Sound Transit maintenance personnel to adjust, operate, and maintain the dc power system.

1. Train Sound Transit maintenance personnel in the procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.

2. Review data in maintenance manuals. Refer to Section 01785, Operation and Maintenance Manuals.

3. Schedule training with Resident Engineer with at least 30 days advance notice.
3.08 FUNCTIONAL PERFORMANCE TESTING

A. Monitoring and Testing Schedule.

1. Perform monitoring and testing in a single 10-day period.

   a.) Schedule monitoring and testing activity with Resident Engineer. Provide at least seven days advance notice.

   b.) Schedule monitoring and testing after Substantial Completion, when dc power system in supplying power to its intended load.

B. Monitoring and Testing Instruments

1. Recording Power Monitors.

   a.) Instruments shall provide continuous simultaneous monitoring of electrical parameters at input terminals of the dc power system and at input terminals of a load served by the dc power system. Instruments shall monitor, measure, and graph voltage current simultaneously and provide full-graphic recordings of the values of those parameters before and during power line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus two percent for electrical parameters. Parameters to be monitored include the following:

   1.) Current.

      - Each phase and neutral and grounding conductors.

   2.) Input Voltage.

      - Phase to phase, phase to neutral, phase to ground, and neutral to ground.

   3.) Output Voltage and Current.

   4.) Frequency transients.

   5.) Voltage swells and sags.

   6.) Input Voltage impulses, phase-to-phase, phase-to-neutral, phase-to-ground, and neutral-to-ground measuring output voltage and current.

   7.) High-frequency noise.

   8.) Radio-frequency interference.

   9.) THD of the above currents and voltages.
10.) Harmonic and transient content of currents and voltages above.

11.) Audible noise.

C. Monitoring and Testing Procedure.

1. Exploratory Period.

For approximately the first two days, make recordings at 10 percent or more of circuit locations and with the maximum range of parameter-threshold and sampling-interval settings. Make these preliminary measurements with the objective of identifying optimum dc power system, power system, load, and instrumentation set-up conditions for subsequent test and monitoring operations.

2. Remainder of Test Period.

a.) Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

1.) Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the dc power system with respect to values specified in Part 2 of this Section, and to highlight any need to adjust, repair, or modify the dc power system or any distribution system or load component that may influence its performance or that may require better power quality.

2.) Perform load and dc power system power source switching and operate the dc power system on generator power during portions of the test period.

3.) Operate the dc power system and dc power system loads in each mode of operation permitted by dc power system controls and by the power distribution system design.

4.) Create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients that can be performed using loads and devices available as part of the facility's installed systems and equipment. Maintain normal operating loads in operation on system to maximum extent possible during tests.

5.) Make adjustments and repairs to dc power system, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

D. Correlation with Specified Dc Power System Monitoring Functions.

1. Obtain printout recordings of built-in monitoring functions specified for dc power system and dc power system components in this Section that are simultaneous with those made with portable instruments in this Section.
a.) Provide the temporary use of an appropriate personal computer and printer equipped with required connections and software for recording and printing if such units are not available on-site.

b.) Correlate printouts with recordings for monitoring performed according to this Article and resolve and report any anomalies in and discrepancies between the two sets of records.

E. Documentation.

1. Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording.

2. Correlate simultaneous recordings made on dc power system input and load circuits.

F. Analysis of Recorded Data and Report.

1. Review and analyze test observations and recorded data and submit a detailed written report. Include the following in final report:

   a.) Description of corrective actions performed during monitoring and survey Work and their results.

   b.) Recommendations for further action to provide optimum performance by the dc Power System.

   c.) Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.

   d.) Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.

   e.) Recommendations for operating, adjusting, or revising dc power system controls.

   f.) Recommendation for alterations to the dc power system installation.

   g.) Recommendation for adjusting or revising generator-set or automatic transfer switch installations or their controls.

   h.) Recommendations for power distribution system revisions.

   i.) Recommendations for adjusting or revising electrical loads, or their connections or controls.

G. Interim and Final Reports.

Provide an interim report at the end of each test period and final comprehensive report at the end of the final test and analysis period.
3.09  OPERATION AND MAINTENANCE MANUALS

Provide Operation and Maintenance Manuals, as described in Section 01785, Operations and Maintenance Manuals.

PART 4 - MEASUREMENT AND PAYMENT

4.01  GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 16615
DIVISION 17
COMMUNICATIONS
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SECTION 17000
GENERAL COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section is provided to summarize and explain the intent of specifications that fall between the range of Sections 17000 and 17099.

1.02 RELATED SECTIONS

A. Section 17020 – Cutover of Existing System.
B. Section 17030 – Reliability Management Program.
C. Section 17040 – Technology Documentation.
D. Section 17050 – Configuration Management.
E. Section 17060 – Special Tools and Spare Parts.
F. Section 17070 – Human Factors Engineering and Ergonomics.
G. Section 17080 – System Support.
H. Section 17090 – Third Party Interfaces.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

The purpose of the range of Sections 17000 through 17099 is to identify special studies, elements of work or design programs that affect all portions of Work. Contractor shall take into consideration the criteria or the outcome of the specific studies defined in these Sections in all Work whether called out specifically or not.

3.02 INTEGRATED SYSTEM TESTING

After installation and the completion and acceptance by Resident Engineer of the field tests, assist Resident Engineer in performing the integrated system testing. Cooperate fully with Resident Engineer and the signals, traction power, vehicle, and civil line section contractors as required. Operate and maintain the communications systems until final acceptance by Resident Engineer. Correct any deficiencies found in the communications systems.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17000
SECTION 17010
INSTALLATION AND COMMISSIONING PLAN

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes general requirements for an installation program. Specific elements of each system/sub-system are included under the specific Sections pertaining to each system/sub-system.

1.02 RELATED SECTIONS

A. Section 17020 – Cutover of Existing System.

B. Section 17100 – Cable Network Overview.

1.03 DESCRIPTION

A. Contractor shall develop a comprehensive Installation and Commissioning Plan that shall clearly delineate the Contractor’s plan to achieve a validated design. Plan shall include but not be limited to:

1. General description of how Contractor is approaching Work with the intent on completion.

2. Site entrance acceptance checklists and procedures for site walkthroughs prior to installing equipment at a facility or in conduits.

3. Procedures to cutover existing and operational equipment.

4. Installation methods and procedures used by the Contractor.

5. Site exit acceptance checklist and procedures for site acceptance of site Work by Resident Engineer.

6. Commissioning procedures for System by Location.

1.04 LOCATIONS/ DIVISION OF WORK

A. DSTT.

Prerequisites for cutover.

B. Balance of System.

1.05 SUBMITTALS

A. Contractor to submit Installation and Commissioning Plan along with Final Design Review submittal.

B. Contractor shall submit detailed site-specific procedures for each type of Work.
PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17010
SECTION 17020
CUTOVER OF EXISTING SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes the requirements for ensuring cutover from the operating system that exists in the DSTT to a temporary state for construction of Phase One – Bus Only Operations, and cutover from Phase One to Phase Two – Full Bus/Rail Operations.

1.02 RELATED SECTIONS

A. Section 17130 – Exterior Communication Pathways.

B. Section 17140 – Backbone Cabling Requirements.

C. Section 17800 – Control System Overview.

D. Section 17840 – Central Control System.

1.03 REFERENCE STANDARDS

A. The following references shall be adhered to.

1. ANSI/TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.


7. TIA/EIA TSB-72 Centralized Optical Fiber Cabling Guidelines.

1.04 SUBMITTALS

A. DSTT Decommissioning Plan.

1. Contractor shall produce a comprehensive Decommissioning Plan no later than 60 days prior to Work that includes, but is not limited to:

a.) Identification & Protection of Systems to Remain.

1.) Clearly identify all circuits installed by KC Metro necessary to operate TPSS facilities at IDS, University, and Convention Place stations and communications facilities at Convention Place both on drawings and in the field.

2.) Design and install alternate fiber communication path from Convention Place Station to University Station in order to re-locate current cable from the construction zone. The cutover to this alternate fiber shall be done in non-revenue hours. No interruption of service in revenue hours shall occur.

3.) Establish protection and restoration plan in the event of Work in and around those circuits or other emergencies.

4.) Identify all contact persons with KC Metro, Sound Transit, and Contractor responsible and empowered to resolve issues with circuits.

b.) Decommissioning of Existing Systems.

1.) Clearly identify cables to cut and/or remove, equipment to be removed, and cabinets to be replaced.

2.) Establish plan and procedures to decommission circuits, remove power from equipment, and remove and turnover equipment and cabinets to be salvaged to KC Metro.

3.) Establish problem resolution committee with KC Metro, Resident Engineer, and C500 Contractor when decommissioning fire life safety circuits.

c.) Evaluation of Existing Cables and Equipment for Re-Use.

A significant amount of cable and equipment is scheduled for re-use in the DSTT. While some of these cables and some of the equipment have been previously evaluated for the purpose, it is Contractor’s responsibility to verify facts and guarantee the Work. As such, Contractor shall develop test plans and procedures to test according to industry standard practices and manufacturer recommendations in order to evaluate cables and equipment for re-use.

B. DSTT Fitness for Use Report.

1. Upon completion of testing of existing cables and equipment for re-use Contractor shall submit to Resident Engineer:
a.) Complete reports of all testing performed on existing cables and equipment.

b.) Evaluation report of fitness for re-use of cables and equipment.

c.) Recommendations on disposition of existing cables and equipment scheduled for re-use.

C. Designs and Construction Schedules.

As part of the normal design and construction process, Contractor shall submit preliminary designs, final designs, construction schedules, etc. that show in sufficient detail the design, schedule, and plan for Work in DSTT.

D. Phase One – Bus Only Operations.

1. Factory Acceptance Test.

Contractor shall perform Factory Acceptance Test according to these Specifications for all systems, subsystems, and software being supplied in Phase One.

2. Test and Acceptance Plan.

Contractor shall develop a comprehensive Test and Acceptance Plan for Phase One these Specifications.

E. Phase Two – Combined Bus/Rail Operations.

1. Acceptance Test.

a.) Contractor shall perform Acceptance Test according to these Specifications for all systems, subsystems, and software being supplied in Phase Two.

b.) Contractor shall develop and submit a plan for the conduct of this test, which shall include:

1.) Location of test.

2.) Hardware under test.

3.) Software under test.

4.) Any necessary workarounds to account for equipment or systems already installed in Phase One.

2. Test and Acceptance Plan.

Contractor shall develop a comprehensive Test and Acceptance Plan for Phase Two.
3. **Cutover Plan - Phase Two: Bus/Rail Operations.**

   a.) Contractor shall produce a comprehensive Cutover Plan 90 days prior to Work that includes, but is not limited to:

   1.) Clear identification of all circuits, equipment and cable that need to be modified to complete Phase Two installation both on drawings and in the field.

   2.) Schedule for upgrades to existing equipment supplied in Phase One.

   3.) Schedule of Work that may affect existing operations and arrange to perform such Work during non-revenue hours which clearly identifies dates and times where operating personnel or equipment may be perturbed and establishes procedures for ameliorating such perturbations.

   4.) Backup, Work around, and/or emergency restoration procedures for each section of Work that affects operations so that in the event of loss of communications functionality, operations are minimally affected.

   5.) Identification of all contact persons with KC Metro, Sound Transit, and Contractor responsible and empowered to resolve issues with circuits.

   6.) Regular meetings for this team and operations.

**PART 2 - PRODUCTS**

Contractor shall employ equipment and materials that meet these Specifications.

**PART 3 - EXECUTION**

3.01 **INSTALLATION GENERAL**

Contractor shall be responsible to adhere to these Specifications for all Work. Where existing systems and equipment are re-used, Contractor may apply for a deviation from these Specifications. Resident Engineer will allow all reasonable deviations for these Specifications where the performance of systems and equipment is unaffected.

3.02 **DOCUMENTATION**

Existing documentation for the DSTT may not be 100 percent accurate or complete. This does not alleviate Contractor from supplying documentation and ‘as-builts’ that meet these Specifications including those listed in Section 17930, Cable Management System, for existing cables that will be re-used. However, it is not Contractor’s responsibility to reproduce non-electronic documents in electronic format (other than scan/PDF format for backgrounds).
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17020
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SECTION 17030
RELIABILITY MANAGEMENT PROGRAM

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section specifies the Contract requirements for developing a comprehensive Reliability Management Program including but not limited to:

1. Develop a Quantified Risk Assessment (QRA) model of the Functional Availability of the Communications Systems.

2. Optimize design of Communications and Control Systems to minimize downtime and maximize Functional Availability.

3. Develop comprehensive test validating the Functional Availability and associated Communications and Control System design.

4. Submit comprehensive report on the Functional Availability and maintenance requirements of System.

5. Support requirements to Sound Transit comprehensive System Assurance Program.

1.02 REFERENCE STANDARDS


B. MIL Standards.


1.03 SUBMITTALS

A. Submittals shall be made according to Section 01330, Submittals, and the Appendix G, Contract Data Requirements List, for format, procedures, and schedule.

1. Resume for Manager of Reliability.

Contractor shall submit resume(s) of qualified person(s) for Manager of Reliability Management and other persons responsible to implement the program on behalf of Contractor to the Resident Engineer at the Post Award Meeting. Manager shall have at least 10 years prior experience implementing MIL-STD-882D, IEC 61508, and other similar programs on rail systems. Manager shall have demonstrated experience implementing such theoretical information into maintenance programs and developing procedures to test for effect.

3. Initial Theoretical Assessment of Functional Availability of the Communications and Control System Design.

4. Recommended Improvements.

5. Final Theoretical Functional Availability of the Communications and Control System Design.


7. Test Results.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

A. Functional Availability.

1. The statistical probability that a particular function is available for use. This includes the availability of both software and hardware required to make any particular function work. This concept is particularly important for the Communications and Control System on Link where many of the functions are dependent on software to work in some way, shape or form. Using a simplified OSI Seven Layer Model (shown below), one can see that traditional availability typically involves only layers one though four while Functional Availability takes into account all seven layers.

B. The intent of the Reliability Management Program is to develop, test and implement a means to objectively design for and subsequently measure of the Functional Availability of the Communications and Control System on Link. The methodology used shall be based upon modern quantitative risk assessment. The output from this program will be used to augment the design, test the system, input into the maintenance program for Link.
3.02 QRA MODEL OF THE FUNCTIONAL AVAILABILITY OF THE COMMUNICATIONS SYSTEMS

Contractor shall apply MIL-STD-882D to prepare a Functional Availability analysis for the complete Communications and Control System on Link. The exact methodology proposed by the Contractor shall be approved by Resident Engineer prior to beginning the analysis.

3.03 FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

A. Contractor shall perform a quantitative FMEA on the systems and software provided in this Contract. Contractor shall analyze each function defined in the Contract or in any design submittal as it relates to the overall Communications System reliability. The FMEA shall examine all the modes of potential failure of systems and software that could generate failures, their frequency, mean time to repair, and method to prevent failure or compensate. Results shall be recorded on a form similar to Table 2 and results submitted to Resident Engineer for approval.

B. Data Granularity.

1. Hardware.

Contractor shall use manufacturer provided information for hardware reliability both MTBF and MTTR. Such information shall be limited to the lowest replaceable unit – such as a line card, power supply, or backplane. A fuse shall be considered a replaceable unit if it can fail and remove a piece of equipment from service.

2. Software.

Contractor shall use testing and analysis to model software MTBF and MTTR. Industry packages for this type of analysis shall be those recommended by the Software Engineering Institute (SEI) such as SPIN, SMV or Bandera. Contractor shall obtain approval from Resident Engineer for any proposed analysis of software. Again, data used in Risk Summation shall be limited to the lowest replaceable unit. All types of software shall be analyzed in this analysis including COTS and custom.
3. Integrated Mode Failure.

Sound Transit recognizes that many integrated modes exist for failure with computer systems. Contractor shall provide best efforts to analyze this failure mode and further define this through testing.

4. Risk Summation.

Using fault tree analysis and the actual Link design, Contractor shall sum the probabilities of failure of each function identified in the Preliminary Design and subsequent design submittals so that each function in each instance shall have an availability defined from end to end of any particular function.

3.04 MINIMUM CRITERIA

A. Contractor’s design shall guarantee the following minimum functional availabilities for each class of function as follows:

TABLE 1
Minimum Functional Availabilities

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>DOWN TIME</th>
<th>MTTR</th>
<th>AVAILABILITY</th>
<th>FAILURE FREQ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency/FLS Function</td>
<td>1 hr/ 5 Years</td>
<td>2 hrs</td>
<td>0.99999</td>
<td>&lt; 1/ Year</td>
</tr>
<tr>
<td>Operations Function</td>
<td>1 hr/ 2 Years</td>
<td>2 hrs</td>
<td>0.999975</td>
<td>&lt; 1/ Year</td>
</tr>
<tr>
<td>Maintenance Function</td>
<td>4 hrs/ Year</td>
<td>2 hrs</td>
<td>0.9998</td>
<td>&lt; 2/ Year</td>
</tr>
<tr>
<td>Misc./ Other Function</td>
<td>8 hrs/ Year</td>
<td>2 hrs</td>
<td>0.9996</td>
<td>&lt; 3/ Year</td>
</tr>
</tbody>
</table>

1. Emergency or Fire Life Safety Functions are those having direct or indirect impact on the capability of fire, police, emergency services, or Link Staff to receive data or generally be informed about emergencies, communicate information and data amongst each other and the public during an emergency, and lastly to provide centralized remote control and operations of facilities on Link enabling people to save lives and property.

2. Operational Functions are those that enable centralized remote operations of trains throughout Link and the centralized operations of buses in the DSTT

3. Maintenance Functions are those that collect data for or provide communications to maintenance staff.

B. Final Design of the Communications System on Link will not be accepted or approved without demonstrating that the Contractor’s design shall meet these Criteria for Function Availability.
3.05 RELIABILITY BASED VALUE ENGINEERING

A. Contractor shall propose optimizations to the Design such that:

1. Minimum Criteria from Paragraph 3.04 above shall be met.

2. Any over engineered systems or subsystem can be redesigned for some savings to Sound Transit provided that both functions and minimal functional availability are still maintained.

B. Proposals with both cost and design suggestions for this Reliability Based Value Engineering shall be submitted to Resident Engineer along with Final Design Submittal. Sound Transit will not be obligated to accept any cost changes recommended by Contractor. Submittal of proposal with modifications shall not alleviate Contractor of the responsibility to meet minimum reliability requirements.

C. Cost Savings from Value Engineering shall be shared with Contractor as defined in General Provisions 4.12. Any savings identified shall be split evenly between the Contractor and Sound Transit.

3.06 FINAL THEORETICAL FUNCTIONAL AVAILABILITY FOR THE COMMUNICATION AND CONTROL SYSTEM DESIGN

In conjunction with Final Design submittal, Contractor shall submit final report detailing results of the Reliability Management Program to date including the availability of each function and estimated impact cost of communications maintenance. This shall include all approved changes in design from Contractor’s Reliability Based Value Engineering assessment.

3.07 RELIABILITY TEST PLAN AND PROCEDURES

Contractor shall develop a comprehensive test plan and procedures to test the Functional Availability of Communications and Control System. Test should, under actual operating conditions, test all functions for at least one year. Test plans and procedures shall be submitted 30 days prior to Factory Test.

3.08 RELIABILITY TEST

A. Contractor shall perform reliability tests as approved by Resident Engineer. All tests will require Resident Engineer witness and validate results.

B. Since the test for one year is the minimum criteria for Functional Availability of some functions, test shall be considered a failure should the Failure Frequency be exceeded. Should the test fail prior to completion, Contractor shall analyze failure, fix problem, and repeat test. Final payment for all unaccepted hardware and software shall be withheld until test is successful.

3.09 SUPPORT FOR SOUND TRANSIT’S SYSTEMS ASSURANCE PROGRAM

Sound Transit will be performing a Systems Assurance Program to determine the safety of Link. Contractor shall lend support to this effort as directed by Resident Engineer.
## TABLE 2
Modes and Effects Analysis

<table>
<thead>
<tr>
<th>Reference</th>
<th>Component</th>
<th>Failure Mode</th>
<th>Effect of Failure</th>
<th>Cause of Failure</th>
<th>Prevention/ Compensation</th>
<th>Remarks</th>
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</table>
3.10 RELIABILITY GUIDES AND TRAINING PROGRAM

A. Contractor shall develop a Reliability Measurement and Improvement Guide. This guide shall define Functional Availability, the development of parameters, means to measure Functional Availability and recommend ways to improve Functional Availability.

B. Contractor shall provide at least one class for 20 persons on how the Reliability Management Program works and how to measure and maintain Functional Availability throughout the life of Link.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17030
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SECTION 17040
TECHNOLOGY DOCUMENTATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

General information on the preparation and submission of the plan for documenting Work.

1.02 RELATED SECTIONS

A. Section 01330 – Submittals.

B. Section 01770 – Contract Closeout.

C. Section 01780 – Project Record Documents.

D. Section 01820 – Training Program.

1.03 TECHNOLOGY DOCUMENTATION PLAN

A. In general, the Technology Documentation Plan is to provide an order and logic to the various documents provided through the course of Work. The drawings provide an example ‘road map’ of document linkages. Contractor shall in its Plan ensure that this ‘road map’ is completed showing the various linkages in documents provided for ‘as-builts’ and records. All Technology Documentation shall be both in paper and electronic formats for all documents and plans. Contractor shall submit initial Plan for approval with Preliminary Engineering submittal.

1. Contents.

   a.) As a minimum, the following topics shall be covered:

      1.) Description of Plan.

      2.) Road Map.

      3.) Numbering systems and rules used including the following:

         - Sound Transit Equipment Numbering Standard.

         As shown on Drawing L00-0105, the Standard defines number of all equipment on Link. Contractor shall use this standard to create names for all communications equipment. These names shall be consistently used in the technology drawings and documents.

   b.) Sample documents for review of how system works.

   c.) Example of electronic documentation linkages and tracking.

   d.) Explanation of how Technology Plan links with Configuration Management Program.
e.) Procedure for Changes.

f.) Procedure for QA and Configuration Audits.

g.) Procedure for handing over program to Link.

PART 2 - PRODUCTS

2.01 BINDERS

A. Binders shall be designed for service in a maintenance shop environment. Covers shall be oil, water and wear-resistant.

B. Binders shall be white in color with text printed in black lettering. Graphics and Sound Transit’s logo shall be printed in color. Text and Sound Transit’s logo shall be printed on both spine and cover. All printing shall be silkscreen applied using wear resistant inks.

C. Binders rings shall be locking type and able to withstand 1000 openings and closings without failure or misalignment of rings.

2.02 DIVIDER PAGES

A. Divider pages shall be white with white tabs, 8.5” x 11”, 60# minimum, punched to fit in binders.

B. Tabs shall extend 3/8 inch from edge of divider page and be laser printed in black ink.

PART 3 - EXECUTION

Contractor shall deliver documents both hard and soft copies per Section 01330, Submittals.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17040
PART 1 - GENERAL

1.01 OVERVIEW

The Contractor shall have current internal Configuration Management (CfgM) operating procedures for the tasks specified herein, adequately disseminated, and adhered to by Contractor personnel assigned to Work. For new development items and modified items, all the provisions of this section apply. For unmodified, off-the-shelf items, only those sections specifically identified as applicable shall be adhered to.

1.02 RELATED SECTIONS

A. Section 17040 – Technology Documentation.

B. Section 17860 – Software Engineering Requirements.

1.03 REFERENCED SPECIFICATIONS

EIA-649 National Consensus Standard for Configuration Management.

1.04 SUBMITTALS

A. As part of the overall organization, Contractor shall designate a lead Configuration Management Specialist for the purpose of being the primary contact for the Contractor on Configuration Management issues.

B. Configuration Management Plan.

1. The Contractor shall prepare, provide and maintain a Contractor Configuration Management Plan. This plan shall include:

a.) Configuration management planning and management.

b.) Configuration identification.

c.) Configuration change management.

d.) Configuration status accounting.

e.) Configuration verification audits.

f.) Configuration management of digital data.

g.) Contractor/vendor configuration management.

h.) For unmodified items, the Contractor shall have current internal Configuration Management (CM) operating procedures for the applicable tasks specified herein, adequately disseminated, and adhered to by Contractor personnel assigned to the
Link Light Rail program. Draft plan shall be submitted along with the Conceptual Design Report.

C. The Contractor shall provide CfgM quality records for review at Contractor’s facility upon request. These quality records are documentation, which record and verify the results of a controlled process associated with the Contractor efforts to meet the requirements of this Specification. The following are CfgM quality records:

1. Change records.
2. Configuration audit reports.
4. Delivery records (Certification of Completion).
5. Drawings (drawings, parts lists, models, datasets, geometry).
6. Evidence of completion records.
7. Change incorporation scheduling records.
8. Management plans (Configuration management plan).
10. Variances (deviations).
11. Manufacturing, inspection, and test records.

For unmodified items, only 4 and 11 above applies.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 CONFIGURATION IDENTIFICATION

A. Configuration Item identification requirements are as follows:

1. Item Identification.

All deliverable items shall be uniquely marked and be consistent with the Contractor's internal procedures. Deliverable items and their subassemblies shall have permanent item identification applied. Identification shall consist of product identifiers and individual unit identifiers in accordance with EIA-649.
2. **Product Drawings.**

   The Contractor shall prepare and submit a set of product drawings in accordance with Section 01330, Submittals.

3. **Configuration Baseline.**

   The Contractor shall establish baselines for deliverable items, in accordance with the Contractor’s internal procedures, as an item proceeds in design from specification to delivered product. The Contractor shall generate configuration documentation for each baseline. This documentation shall include new development, modified, as well as unmodified COTS items.

4. For unmodified items, all deliverable items shall be uniquely marked and be consistent with the supplier’s internal procedures. Deliverable items and their subassemblies shall have permanent item identification applied.

### 3.02 CONFIGURATION CHANGE CONTROL

A. The Contractor, in accordance with the Contractor’s internal procedures meeting the requirements herein, shall conduct a configuration change control process. For unmodified items, the Contractor is not permitted to revise the design or process documentation of the product without prior authorization of Link.

1. **Contractor Change Proposals.**

   The Contractor shall prepare and submit Contractor Change Proposals (CCP) in accordance with Section 01330, Submittals. The Contractor shall implement changes as Major or Minor in accordance with the below subparagraphs.

2. **Major Changes.**

   a.) Prior to implementation by the Contractor, the buyer shall authorize all Major changes. Approved Major changes will have a mutually agreed-to retrofit plan established.

   b.) Major changes shall be changes that affect one or more of the following:

      1.) The Technical Specification for this Contract (including its appendices).

      2.) Cost or delivery schedule.

      3.) Interface control documentation.

      4.) Delivered configuration items.

      5.) New or revised requirements for Contractor identified support equipment or special tools.

      6.) Compatibility with Contractor identified support equipment or Sound Transit furnished equipment.
7.) Interchangeability (as applied to end items and to all subassemblies and parts of repairable end items, excluding the pieces and parts of non-repairable subassemblies) after Link acceptance of the configuration item.

8.) Configuration to the extent that retrofit action is required.

9.) Any other change not listed above which affects form, fit or function (as defined by EIA-649) of deliverable items after buyer acceptance of the configuration item.


Minor changes are all changes not classified as Major. The Contractor shall refer all Minor changes to buyer for concurrence with classification of the change. Implementation by the Contractor prior to Link concurrence that the change is Minor is done at risk on the part of the Contractor. Minor changes shall be submitted commencing with delivery to the buyer of the first configuration item.

3.03 DEVIATIONS

Requests for deviations from contract requirements shall be documented and submitted for buyer approval in accordance with EIA-649. The Contractor may disposition minor deviations with Link’s concurrence on a case by case basis.

3.04 CONFIGURATION STATUS ACCOUNTING

A. The Contractor shall establish and maintain a Configuration Status Accounting (CSA) system database for all deliverable hardware. The Contractor configuration status accounting system shall be capable of:

1. Providing the records necessary to verify that the "as designed" configuration equals the "as built" configuration.

2. Providing status of Major and Minor change processing from initiation through physical incorporation into the design drawings and hardware.

3. Providing the incorporation status of Major and Minor changes into the design drawings and hardware by unit serial number.

3.05 CONFIGURATION AUDITS

A. Functional Configuration Audits.

1. The Contractor and the buyer shall jointly conduct Functional Configuration Audits (FCAs) for new development and modified items.

2. FCAs shall be conducted following buyer approval of applicable acceptance test reports detailing the acceptance test and evaluation results.

3. The Contractor shall enter details of action items raised during a FCA into the Contractor's CSA System.
4. The Contractor shall participate in, and support the resolution of discrepancies identified during the conduct of a FCA.

5. Following each FCA, the Contractor shall prepare and deliver a Configuration Audit Summary Report in accordance with TBD.

B. Physical Configuration Audits.

1. The Contractor and the buyer shall jointly conduct Physical Configuration Audits (PCAs) in for new development and modified items.

2. The Contractor shall enter details of action items raised during a PCA into the Contractor's CSA System.

3. The Contractor shall participate in, and support resolution of discrepancies identified during the conduct of a PCA.

4. At the completion of each PCA, the Contractor shall prepare and deliver a Configuration Audit Summary Report in accordance with Section 01330, Submittals.

3.06 DELIVERY

A. The Contractor shall include in each shipment a Certificate of Conformance, signed by the Quality Manager or designee. Separate certificates will be supplied for each part number, if more than one part number applies. The certificate shall list the following, at a minimum, for the shipment:

1. Link purchase order number.

2. Part number.

3. Serial numbers.

4. Applicable top level specification(s) and drawing(s) with revision levels.

5. A listing of any existing non-conformances by unit (including a reference to Link approving paperwork.

   Contractor format will be acceptable. Link QA will review each Certificate of Conformance at the Contractor and provide concurrence, unless Link inspection is waived.

6. Nonconforming Units.

   If, during inspection or test, a unit is determined to be out of compliance to specification or subcontractor drawing requirements, and the subcontractor wishes to include the rejected unit as a deliverable unit without fully correcting the defect, Link shall be notified within four working days for concurrence. However, units, which do not meet interchangeability requirements, will not be considered for acceptance. The notification shall include, at a minimum, a clear description of the defect, the part number and serial number of the unit, and the suggested disposition with technical and cost/schedule justification. Unless approved in writing by Link, a rejected unit is not to be part of the...
procurement quantity. Rejected units may be resubmitted for Approval if the unit has been fully returned to compliance.

3.07 DATA MANAGEMENT

A. Data Management Planning.

1. The Contractor shall maintain a data management program and shall submit their existing Data Management Plan for Link review. Data Management may be included as a subsection of the Configuration Management Plan. This is intended to ensure that Link understands how the functional requirements are being met and that the interfaces are well organized. Contractors with data management systems in place that meet the requirements of EIA-649 are not required to submit their configuration management plan, but are required to submit a description of compliance.

2. The Contractor shall use a logical methodology for generating or acquiring, identifying, providing status, planning and controlling all technical and management data and related information. The methodology shall address:

   a.) On-time delivery of data.

   b.) Identification, marking and control of proprietary data.

   c.) Data quality.

   d.) Updates and corrections to submitted data.

   e.) Automation.

B. Deliveries.

For new development, modified, and unmodified items, the Contractor shall prepare data in accordance with Section 01330, Submittals. Specific deliverables that are required for review and approval depend on the maturity of the Contractors proposed design.

C. Data Accession List (DAL).

The purpose of the Data Accession List (DAL) is to provide an accession list, which is an index of data that may be available for request but is not deliverable to Link. It is a medium for identifying subcontractor internal data, which have been generated in compliance with the work effort. As a minimum, the DAL shall include the document number, revision, date, and title. The DAL provides only a listing of the data, and not the data itself. The Data Management organization is authorized to provide copies of the data listed on the DAL only upon receipt of a written Link subcontract management request. It is the responsibility of the subcontractor to notify the Data Management organization when releasing data defined as a DAL item, and to provide information (e.g., location, copies, etc.) of such data to Link upon request.

D. Records Retention.

The Contractor shall maintain all quality records for a minimum of two years after unit shipment. Records shall be readily available for review by Link, Link customers, or regulatory agencies. Written approval will be obtained from Link’s QA organization prior to destruction.
of records. The request for destruction approval will, at a minimum, reference the part numbers and serial numbers of the involved units.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17050
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SECTION 17060
SPECIAL TOOLS AND SPARE PARTS

PART 1 - GENERAL

1.01 OVERVIEW
Contractor shall supply Sound Transit with sufficient spares and special tools necessary to maintain the Communication and Control System as defined by this Agreement.

1.02 SECTION INCLUDES
Requirements for spare parts and special tools.

1.03 ABBREVIATIONS
Reference Appendix A, Glossary, for all abbreviations.

1.04 REFERENCED SPECIFICATIONS
Spare parts shall follow the same criteria as the original specification.

1.05 SUBMITTALS
Contractor shall submit list of recommended spare parts and special tools to the Resident Engineer 90 days prior to Acceptance Testing in each Phase of Work. List shall include make, model, and price. Resident Engineer will choose which spare parts and special tools to purchase.

PART 2 - PRODUCTS

2.01 GENERAL
A. Contractor shall submit spare parts of the exact make and model used in producing Work.

B. Special tools shall be specified in the manufacturer’s cut sheets and Contractor submittals.

PART 3 - EXECUTION

Once approved Contractor shall supply special tools and spare parts as per Section 01650, Product Delivery Requirements, or as directed by the Resident Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL
Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17060
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PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall perform a Human Factors Engineering and Ergonomics Study for the OCC based on the operational requirements described in these specifications. The result of the study shall be the primary factor in the design of the OCC and shall be used for the determination of furniture, equipment, and support facilities at the OCC and for equipment layout in the OCC.

1.02 SECTION INCLUDES

This Section includes the requirements for a Human Factors Engineering and Ergonomics Study.

1.03 RELATED SECTIONS

A. Section 17620 – Operation Control Center Facility Requirements.

B. Section 17625 – Operation Control Center Furniture.


1.04 REFERENCE STANDARDS

A. Occupational Safety & Health Administration (OSHA) Occupational Safety and Health Standards.


D. Americans with Disabilities Act (ADA).

1.05 SUBMITTALS

A. Conceptual Design Review

Contractor shall submit resumes of qualified persons performing this study for review. Persons performing the study shall have at least 10 years experience in control center ergonomic design and at least two (2) prior projects in rail transit.

B. Preliminary Design Review

Contractor shall submit the Human Factors Engineering and Ergonomics Study to Resident Engineer for approval prior to designing the OCC. Contractor shall demonstrate the results of the ergonomic study in the design of the OCC.
PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

A. The objective of the study is to ensure that the OCC functions effectively and efficiently in its control of the operations and maintenance of Link, and that it is a pleasant and ergonomically acceptable environment in which to work.

B. Contractor shall utilize human engineering and ergonomics experts to conduct the study. The Work shall be performed by qualified individuals in the human engineering and ergonomic profession with comparable experience in the evaluation and design of control rooms similar to the OCC in size and operating characteristics.

3.02 SCOPE OF STUDY

A. Contractor shall review ST operating and maintenance requirements to develop a full understanding of the Work processes to be conducted within the OCC. Contractor shall review the design of the OCC room and facilities to be built by others (Coordinate with Resident Engineer to obtain final C810 Final Design Documents).

B. The study shall identify human engineering and ergonomic design requirements, principles and practices to be applied for the OCC.

C. The study shall identify ergonomic risk conditions and provide solutions to control these risk conditions.

D. The OCC shall allow for various people including disabled personnel (e.g. wheelchair access) to operate the OCC equipment.

3.03 HUMAN FACTORS ENGINEERING AND ERGONOMICS STUDY REPORT

A. The result of the study shall be documented in a report subjected to approval by Resident Engineer.

B. The report shall include the following:

1. Summary of specific human engineering and ergonomic standards and guidelines that are applicable to the OCC.

2. Floor plans showing recommended OCC equipment layout.

3. Concept drawings showing consoles and human-machine equipment.

4. Design criteria for OCC equipment selection and placement for effective operations and maintenance.

5. Guidelines for environmental control including lighting.
6. Summary of ergonomic risk conditions and mitigating measures.

7. Summary of findings and recommendations.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17070
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SECTION 17075
TEST PLANS AND PROCEDURES

PART 1 - GENERAL

1.01 SECTION INCLUDES

General information on the preparation and submission of Test Plans and Test Procedures for the testing of each subsystem, system, and integration with other systems.

1.02 RELATED SECTIONS

Section 01330 - Submittals.

1.03 REFERENCED SPECIFICATIONS


1.04 TEST PLAN

A. Definition.

The Test Plan is a document describing the scope, approach, resources, and schedule of intended testing activities. It identifies test items, the features to be tested, the testing tasks, who will do each task, and any risks requiring contingency planning.

B. Outline.

1. Test Plan Identifier.

A unique identifier.

2. Introduction.

   a.) Summary of the items and features to be tested.
   
   b.) Need for and history of each item (optional).
   
   c.) References to related documents such as project authorization, project plan, QA plan, configuration management plan, relevant policies, relevant standards.
   
   d.) References to lower level test plans.

3. Test Items.

   a.) Test items and their version.
   
   b.) Characteristics of their transmittal media.
c.) References to related documents such as requirements specification, design specification, user’s guide, operations guide, and installation guide.

d.) References to bug reports related to test items.

e.) Items which are specifically not going to be tested (optional).

4. Features to be Tested by Contractor.

a.) All software features, hardware features and combinations of features to be tested.

b.) References to test-design specifications associated with each feature and combination of features.

5. Features to be Tested by Independent Testing Organization.

a.) Specific software and hardware features or standards that need to be met by code or industry practice.

6. Features Not to Be Tested.

a.) All features and significant combinations of features which will not be tested.

b.) The reasons these features won’t be tested.


a.) Overall approach to testing.

b.) For each major group of features of combinations of features, specify the approach.

c.) Specify major activities, techniques, and tools, which are to be used to test the groups.

d.) Specify a minimum degree of comprehensiveness required.

e.) Identify which techniques will be used to judge comprehensiveness.

f.) Specify any additional completion criteria.

g.) Specify techniques, which are to be used to trace requirements.

h.) Identify significant constraints on testing, such as test-item availability, testing-resource availability, and deadline.
8. Item Pass/Fail Criteria.

Specify the criteria to be used to determine whether each test item has passed or failed testing.


a.) Specify criteria to be used to suspend the testing activity.

b.) Specify testing activities, which must be redone when testing is resumed.

10. Test Deliverables.

a.) Identify the deliverable documents: test plan, test design specifications, test case specifications, test procedure specifications, test item transmittal reports, test logs, test incident reports, test summary reports.

b.) Identify test input and output data.

c.) Identify test tools (optional).


a.) Identify tasks necessary to prepare for and perform testing.

b.) Identify all task interdependencies.

c.) Identify any special skills required.


a.) Specify necessary and desired properties of the test environment: physical characteristics of the facilities including hardware, communications and system software, the mode of usage (i.e., stand-alone), and any other software or supplies needed.

b.) Specify the level of security required.

c.) Identify special test tools needed and calibration requirements of each.

d.) Identify any other testing needs.

e.) Identify the source for all needs which are not currently available.

13. Responsibilities.

a.) Identify groups responsible for managing, designing, preparing, executing, witnessing, checking and resolving.
b.) Identify groups responsible for managing the test tools and equipment and associated records (i.e. calibration records).

c.) Identify groups responsible for providing the test items identified in this Specification, Part 1, 1.04.3, Test Items.

d.) Identify groups responsible for providing the environmental needs identified in this Specification, Part 1, 1.04.12, Environmental Needs.


a.) Specify staffing needs by skill level.

b.) Identify training options for providing necessary skills.

c.) Specify approved independent testing facilities or organizations to be used on the job.

15. Schedule.

a.) Specify test milestones.

b.) Specify all item transmittal events.

c.) Estimate time required to do each testing task.

d.) Schedule all testing tasks and test milestones.

e.) For each testing resource, specify its periods of use.


a.) Identify the high-risk assumptions of the test plan.

b.) Specify contingency plans for each.

17. Approvals.

a.) Specify the names and titles of all persons who must approve the plan.

b.) Provide space for signatures and dates.
1.05 TEST PROCEDURE

A. Definition.

The Test Procedure is the document which specifies the steps used to analyze a software item, sub-system, or system in order to evaluate a set of features.

B. Outline.

1. Test case specification identifier.
2. Software item, sub-system, or system under test.
3. Dependencies (Other systems that must be present, working, and tested previously.
4. Initial Conditions.
5. Detailed procedure showing for each step:
   a.) Step Number.
   b.) User Action.
   c.) Expected Results.
   d.) Pass or Fail.
   e.) Discrepancy.

C. Sample Form:
<table>
<thead>
<tr>
<th>TEST NAME</th>
<th>Test Record</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Procedure Name:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Test Procedure Number:</strong></td>
<td><strong>Test Date:</strong></td>
</tr>
<tr>
<td><strong>Test Results:</strong></td>
<td><strong>Test Type:</strong></td>
</tr>
<tr>
<td><strong>Scheduled Test Duration:</strong></td>
<td><strong>Test Location:</strong></td>
</tr>
<tr>
<td><strong>Start Time:</strong></td>
<td><strong>End Time:</strong></td>
</tr>
<tr>
<td><strong>Hardware Under Test:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Software Under Test:</strong></td>
<td><strong>Release No.:</strong></td>
</tr>
<tr>
<td><strong>Test Objective and Scope:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Other Items:</strong></td>
<td><strong>Identification No.:</strong></td>
</tr>
<tr>
<td><strong>Test Setup and Initial Conditions Description:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Special Test Conditions (if any):</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Prerequisite Tests:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Discrepancy Summary (list step number where discrepancy occurred):</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Test Engineer:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Resident Engineer’s Representative:</strong></td>
<td></td>
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<tr>
<td><strong>Quality Assurance:</strong></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>Test Procedure Number</td>
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<tr>
<td>------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>1</td>
<td>Test 1</td>
</tr>
<tr>
<td>1.1</td>
<td>Step 1</td>
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<tr>
<td>1.2</td>
<td>Step 2</td>
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<td></td>
<td>1.n</td>
</tr>
<tr>
<td>2</td>
<td>Test 2</td>
</tr>
<tr>
<td>2.1</td>
<td>Step 1</td>
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<td>2.2</td>
<td>Step 2</td>
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<td>2.n</td>
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<tr>
<td>3</td>
<td>Test 3</td>
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<td>N</td>
</tr>
</tbody>
</table>

END OF TEST.
1.06 SUBMITTALS

A. Contractor shall submit Test Plan along with Final Design Review or 90 days prior to any test whichever comes first.

B. Test Procedures shall be submitted in draft format along with Test Plan. Actual test plans shall be submitted 30 days prior to the test.

C. Test Results shall be submitted for Approval within 10-days of completion of Test unless stated otherwise in Specifications or agreed to by Engineer.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 TESTING

A. The following classes of tests shall be included in the Test Plan and Procedures.

1. Factory Test

Prior to field installation, Contractor shall validate system functionality and design with a comprehensive factory test. Factory testing shall be performed in Puget Sound Metro area at Contractor’s facilities with at least one of every different piece of equipment supplied under this Agreement.

2. Field Validation Testing.

Contractor shall validate the operational readiness of equipment and test what can be tested prior to connecting various communications gear together. This is commonly called local testing because it will only test the equipment at one site. Testing of cables between two points shall also be considered field validation testing.


Prior to Integrated Testing and connecting communications equipment to equipment supplied by others, Contractor shall test all functionality and connection systemwide across all communication systems. Only after acceptance testing has been satisfactorily performed shall Contractor be able to being reliability testing or integrated testing.

4. Integrated Testing.

a.) Prior to pre-revenue operations, the complete Link System shall undergo integrated testing. Contractor shall support this test with sufficient technical personnel. Actual testing shall be performed by others. Contractor’s personnel shall consist of at least, but not be limited by:

1.) One person, who is fully knowledgeable on the comprehensive Communications Systems operation and generally knowledgeable on setup of specific equipment, on site at all times during integrated testing.
2.) Technical resources available to diagnose specific abnormalities and trouble shoot problems with the Communications Systems within 24 hours of notification by Resident Engineer

b.) Forces used for integrated testing shall not be considered System Support and shall not submit for payment under Section 17080, Project Record Documents.

5. Reliability Testing.

After acceptance testing, Contractor shall engage in reliability testing as defined in Section 17030, Reliability Management Program, for a period of not less than one year

PART 4 - MEASUREMENT AND PAYMENT

4.01 SUMMARY

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17075
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PART 1 - GENERAL

1.01 SECTION INCLUDES

This section includes the provisions for system engineering and technical support after Acceptance of Work by Sound Transit.

1.02 RELATED SECTIONS

Section 00300 – Special Provisions.

1.03 REFERENCE STANDARDS

Not Used.

1.04 NOTED RESTRICTIONS

System Support shall apply only to technical support after acceptance of Work. Engineering, other technical support, or training required prior to acceptance shall be governed by other provisions.

1.05 QUALITY CONTROL

All project quality standards, procedures and processes shall apply to work under this Section.

1.06 SUBMITTALS

A. Contractor shall submit System Support Plan 90 days prior to Acceptance of Work. Support plan shall detail:

1. Staff or group responsible for system support.
2. Response times of support personnel (two (2) days maximum).
3. Contingency plan for key personnel.
4. Contact names and numbers.
5. Resumes of all key and personnel expected.
6. Policies for professionalism and staff conduct.
1.07 DELIVERABLES

Not Used.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

Upon written request by Sound Transit, Contractor shall supply engineering and/or technical support personnel for any and all Work performed and accepted by Sound Transit. Support is intended to supplement Sound Transit’s staff in the performance of their duties, make minor modifications or changes outside the contract scope, provide additional hands-on training, and/or help engineering staff design for additional integration work.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

A. No equipment, material, or manuals shall be included with this support. All administrative overhead, travel, and other direct or indirect costs shall be included. Task shall not extend beyond two (2) years or 2750 hours whichever occurs first.

B. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17080
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes information relating to the interfaces that require coordination between C803 and parties other than Sound Transit.

1.02 RELATED SECTIONS

A. Section 17020 – Cutover of Existing System.

B. Appendix E – C802/C803 Data Interface.

1.03 REFERENCE STANDARDS

Not Used.

1.04 NOTED RESTRICTIONS

Contractor shall work diligently and professionally with all designated interfaces. At no time shall Contractor proceed with any work outside the scope of this Contract without written instruction from Resident Engineer, even if additional work resolves Contractor’s or interface’s issue. Any change or Work that deviates from Work specified by these Specifications and Contract Drawings arising out of coordination with any third party shall constitute a change and shall be governed by the provisions outlined in these Specifications.

1.05 QUALITY CONTROL

Contractor shall follow all quality control procedures identified in these Specifications in all work defined by or through any and all interfaces with third parties.

1.06 SUBMITTALS

A. Meeting Minutes.

Contractor shall maintain meeting minutes of all items discussed in Third Party Meetings. Contractor shall have written acknowledgement of receipt and agreement to meeting minutes by all attendees prior to final issuance. All finalized meeting minutes shall be submitted to Resident Engineer for review and record. Meeting minutes shall be submitted to engineer within 15 working days of meeting date.

B. Interface Drawings.

Contractor shall maintain an updated set of interface drawings at all times on the Jobsite. Proposed changes to interfaces after approval of Final Design shall be submitted to Resident Engineer for approval within 72 hours of notification of change.
C. Use Cases.

Contractor shall maintain an updated set of use cases at all times on the Jobsite. Proposed changes to use cases after approval of Final Design shall be submitted to Resident Engineer for approval within 72 hours of notification of change.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

A. The following list represents an attempt to define the interfaces with which Contractor shall be expected to interface. It is by no means complete. Resident Engineer shall define additional interfaces with Work, as it deems necessary to complete Work.

1. Design Interfaces.

   a.) Throughout the design phase and into construction Contractor shall interface with the other systems contracts including, but not limited to:

      1.) C802 – Signals.

      2.) C807 – Traction Power.

      3.) P809 – Fare Collection/Smart Card.

      4.) P814 – Management Information Systems.

      5.) Various electrical and mechanical interfaces provided for under the civil line section contracts: C500/520, C700, C810, C710, C735, and C755.

      6.) Sounder CCTV/PA/VMS communications system.

      7.) Sound Transit IS and Phone Networks.

      8.) KCM Existing Equipment in tunnels, MIS network and Phone Networks.

   b.) Design interfaces shall verify and validate the interface drawings, supplement them with additional information including that about protocols and data formatting, and coordinate during construction for a seamless flow of information and control between elements in the different contracts or owners.

   c.) Contractor shall coordinate with all others to establish and maintain a points database which details all data points exchanged. This shall include the protocol for exchange; the names of the points; if binary, the meaning of the point in both true and false states; if analog, the range of the point in raw counts and/or engineering
units; and any other information necessary to the supply of the functions of these Specifications.

d.) Contractor shall anticipate there to be one or more meetings with each party required to coordinate and exchange information. Contractor shall utilize all reasonable means to attend meetings with personnel that are capable of understanding the issues under discussion and with ability and authority to make decisions.

e.) Throughout the course of design exchanges it may become necessary to share proprietary information. Contractor may request non-disclosure agreements so that proprietary or trade secretive information is not used in appropriately. However, should Contractor fail to provide information about interfaces in a timely manner, Contractor shall be subject to liquidated damages as noted in the Special Conditions.

B. Construction Interfaces.

1. During the course of installation of Work, Contractor shall be limited in access to jobsite by work performed by others. To assist coordination of all the various contractor’s work, each civil line section contractor can be expected to hold one or more regular meetings. Resident Engineer shall inform Contractor of when and how to attend these meetings. Contractor shall complete the following:

a.) Develop work plans for each section of Work with detailed list of activities and schedule of work. This shall be continually updated as information is known and should correspond to actual dates of access or Work.

b.) Attend and participate, by coordinating work schedules in meetings, at least 4 weeks prior to start of installation in, on or around work being performed on each line section or at the direction of the Resident Engineer.

C. Performing Work outside Sound Transit Property.

1. The following segments of Work are performed, in whole or part, outside of the Link Project boundaries:

a.) Connection to the KCRS Zone Controller.

b.) Connection to Union Station for Sounder and Sound Transit connections.

c.) Connection to DSTT Control Center.

2. For all work outside these boundaries, Contractor shall be responsible to coordinate Work with building owner’s representative, City representative or other owner as required to approve and perform Work. Contractor shall be responsible to obtain any and all permits. Sound Transit shall pay for permits, leases or access fees per the Special Conditions.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17090
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes an overview of the design goals and cabling requirements for this Contract.

1.02 RELATED SECTIONS

A. Section 17105 – Grounding and Bonding of Cables.

B. Section 17110 – Main Distribution Frames, Intermediate Frames, Cross Connects Points, Fiber Distribution and Service Entrances.

C. Section 17120 – Interior Communication Pathways.

D. Section 17130 – Exterior Communication Pathways.

E. Section 17140 – Backbone Cabling Requirements.

F. Section 17150 – Facility Cabling Requirements.

G. Section 17170 – Testing Identification and Administration.

1.03 REFERENCE STANDARDS

A. The following references shall be adhered to:

1. ANSI/TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.


7. TIA/EIA TSB-72 Centralized Optical Fiber Cabling Guidelines.

9. NFPA 130  Standard for Fixed Guideway Transit and Passenger Rail Systems

10. NEC 100.

11. NEC 250 Part C and NEC 250-90.

PART 2 - PRODUCTS

2.01 GENERAL

Rail transit environment is a harsh location for equipment and cabling. Cable plant and equipment shall be designed to withstand the environment for more than 30 years without fail. As with most cable plant environments physical damage tends to be the common mode of failure. However, unlike non-transit environments damage does not come from misc. construction or ‘back hoe fade’, it comes from damage from continued thermal expansion and contraction, from damage by maintenance personnel while maintaining other Works (pulling or stepping on cables), from excess water intrusion (especially in DSTT), and rodents. Contractor shall take these things into consideration along with while designing, purchasing, and installing cable plant on Link.

2.02 DESIGN PARAMETERS

A. The cable plant has been broken into two distinct parts local and systemwide cable plant.

1. Local Cable Plant refers to all cable plant starting in the Communications Room or Cabinet and extending throughout a station or facility. It may be worthwhile to note that this has nothing to do with Inside Plant cables which are generally located in environmentally controlled areas. Many of the stations are exposed to the elements and therefore are in fact outside but the cable plant is local.

a.) Local Cable Plant.

1.) Copper Cable.

- Insulation shall be capable of being submerged or intermittently submerged for at least 10 years and shall meet both IEEE 383 vertical flame test and LZH (low smoke zero halogen) jacketing such as a cross-linked polyethylene.

- Contractor shall strictly follow the equipment manufacturer’s recommendations and design parameters when designing or installing cable runs.

- When copper cable is used to extend an Ethernet network or carry IP based signaling, Contractor shall use Cat 6 wiring when at all feasible.

2.) Fiber Cable.

- Insulation shall be capable of being submerged or intermittently submerged for at least 10 years and shall meet both IEEE 383 vertical flame test and LZH (low smoke zero halogen) jacketing such as a cross-linked polyethylene.
- Contractor shall strictly follow the equipment manufacturers recommendations and design parameters when designing or installing cable runs.

- Fiber cable construction shall be tight buffer, air core with water absorbing polymer tape.

- Fibers shall be either single or multimode depending strictly on the optimal design for the application.

2. Systemwide Cable Plant.

   a.) Systemwide Cable Plant refers to all cable plant extending between two or more stations. An example of this is the 24 Fiber cable running in a collapsed ring around Link.

   1.) Systemwide Cable Plant shall be fiber cable

      - Insulation shall be capable of being submerged or intermittently submerged for at least 10 years and shall meet both IEEE 383 vertical flame test and LZH (low smoke zero halogen) jacketing such as a cross-linked polyethylene.

      - Contractor shall strictly follow the equipment manufacturer's recommendations and design parameters when designing or installing cable runs.

      - Fiber cable construction shall be of loose tube, gel filled design similar to PE-90 with exceptions noted above.

PART 3 - EXECUTION

3.01 INSTALLATION GENERAL

   A. Install communications cables and connectors in accordance with recognized industry installation practices and industry standard requirements.

   B. Coordinate with general Contractors regarding data raceways/pathways and cable supports provided by others as necessary to interface installation of cables.

3.02 INSIDE PLANT CABLING

   A. Facilities Provided by Others.

      In general, conduits and cable trays will be provided by others outside of the communications specific rooms. Contractor may have to extend conduits or cable trays up to 25' within a specific room to meet its needs.

   B. Contractor's Responsibility to Verify.

      Contractor shall verify conduits and trays provided by others prior to start of installation.
C. Cable runs.

Unless otherwise agreed to in writing, Contractor shall not splice or break cables or wires mid-span. If cable fails or is damaged, Contractor shall remove and replace entire cable or wire span.

3.03 OUTSIDE PLANT CABLING

A. Facilities Provided by Others.

1. In general, conduits and cable trays will be provided by others outside of the communications specific rooms. Contractor may have to extend conduits or cable trays up to 25' within a specific room to meet its needs. This shall include inner-ducts placed in signals and communications duct bank.

2. A noted exception to the supply of inner-duct is the DSTT where none is provided.

B. Contractor’s Responsibility to Verify.

Contractor shall verify conduits and trays provided by others are properly constructed and prepared for cable installation prior to start of installation.

C. Cable runs.

1. Unless otherwise agreed to in writing or indicated on Drawings, Contractor shall not splice or break cables or wires mid-span. If cable fails or is damaged, Contractor shall remove and replace entire cable or wire span.

2. Contractor shall where inner-ducts are supplied pneumatically blow cables in place. 50' slack coils shall be placed approximately every 1000' in manholes provided.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17100
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes the requirements for furnishing, installing, and testing complete grounding and bonding of the communications cables.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.
B. Section 17140 – Backbone Cabling Requirements.
C. Section 17150 – Facility Cabling Requirements.
D. Section 17630 – Communications Facilities Requirements.

1.03 REFERENCE STANDARDS

A. The following references shall be adhered to:

1. ANSI/TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.
5. NFPA 70 National Electrical Code.
6. NEC 100.
1.04 SUBMITTALS


1. Shop Drawings.

Locations of cable ground on all shielded cables.

2. Certification.

Certified test reports verifying that ground resistance of each connection to the cable shield does not exceed five ohms to ground using the IEEE 81.2 fall-off potential method of testing.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GROUNDING

A. Ground Connections to Cable Shields.

B. Use NO-OX-ID to ensure proper connection to ground and that connection doesn’t corrode.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17105
SECTION 17110
MAIN DISTRIBUTION FRAMES, INTERMEDIATE FRAMES, CROSS CONNECTS POINTS, FIBER DISTRIBUTION AND SERVICE ENTRANCES

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes furnishing and installing Main Distribution Frames, Intermediate Frames, Cross Connects Points, Fiber Distribution and Service Entrances.

1.02 RELATED SECTIONS

A. Section 17105 – Grounding and Bonding of Cables.
B. Section 17120 – Interior Communication Pathways.
C. Section 17130 – Exterior Communication Pathways.
D. Section 17140 – Backbone Cabling Requirements.
E. Section 17150 – Facility Cabling Requirements.
F. Section 17170 – Testing, Identification and Administration.
G. Section 17630 – Communications Facilities Requirements.

1.03 REFERENCE STANDARDS

B. ANSI/TIA/EIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces.
D. ANSI/TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.
E. NEC 800-30 Protective Devices.
F. NFPA 70 National Electrical Code.
G. UL497 Protectors for Paired Conductor Communication Circuits.
H. UL969 Marking and Labeling Systems.
1.04 QUALITY CONTROL

The quality of the installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with these Specifications and workmanship standards and practices.

1.05 SUBMITTALS

A. Performance data and descriptions of all products shall be submitted as part of the Detail Design Review submittal package for each subsystem in which they are used. Additionally include: manufacturer model number, UL listing or rating, critical dimensions and mounting arrangement, and replacement parts list.

B. Samples of products shall be submitted upon request.

PART 2 - PRODUCTS

2.01 TAGGING FOR ALL CABLES, WIRES AND EQUIPMENT

A. Cables and Wires.

1. Both ends of each cable shall be tagged where cables and wires terminate on terminals, punch-down blocks, connectors, etc. Communications cable identifiers shall comply with TIA/EIA-606 and Sound Transit Methods.

2. Cable function, designation, and termination location shall be shown.

3. Sleeve type non-metal tags shall be used where cable diameter permits.

4. Flat plastic tags shall be used for other cables.

   a.) A single hole in the tag shall be provided for attachment with a dielectric tie.

   b.) Permanent lettering shall be used.

B. Equipment.

1. Label with unique identifiers, all terminal blocks, card cages, circuit cards, punch-down blocks, jack fields, etc. Communications equipment identifiers shall comply with TIA/EIA-606 and Sound Transit Procedure.

2. Permanent lettering scheme shall be utilized.

3. Labels shall be attached with a non-drying adhesive.
2.02 COPPER CAT 6 PUNCH-DOWN BLOCKS

A. Type.

1. Blocks shall be 110 Cat 6 Type 50-pair punch-down blocks, or approved equivalent. Blocks shall be configured with two columns of 25 pairs of two termination clips. Clips shall accept #20 AWG through #26 AWG insulated wire, and #18 AWG and #19 AWG bare wire.

2. Clips shall be pre-wired to an Amphenol type RJ21X connector socket, or approved equal.

3. Blocks shall be equipped with a base, standoff bracket, cover, and bridging clips.

B. Base.

1. The base shall be impact resistant plastic.

2. Molded fanning strips shall be provided on each side of the split blocks.

3. Permanent numbering shall be applied to the fanning strips.

4. A standoff of 50 mm (2 in.) from the mounting surface shall be provided.

5. A removable cover with circuit designations permanently applied shall be provided.

6. Connector retention screws shall be provided.

2.03 COPPER CAT 6 TWENTY-FIVE PAIR CONNECTORS

A. Type.

1. Connectors shall be Amphenol-type RJ21X and shall be 110 Cat 6 rated, or approved equal, with a self-extinguishing thermoplastic housing.

2. A slide on cover shall protect the connector contacts.

3. Retention screws shall be provided.

4. Connectors shall be non-reversible and shall be compatible in design and type (male/female) with the associated receptacles.

B. Connector Contacts.

1. Two rows of 25 contacts shall be provided.

2. Contacts shall be insulation displacement type, designed to accept #22 AWG and #24 AWG wire.
2.04 COPPER TELCO AND SITE CONNECTORIZED PROTECTED ENTRANCE TERMINALS

A. Design.

1. Protected entrance terminals shall be used at the input for all signal circuits using metal cable and entering/exiting the facility (e.g. Communications Room). Connectorized protected entrance terminals shall be used in all applications unless specifically stated otherwise in these Specification or in the Contract Drawings.

2. Protected entrance terminals shall have a field splice line side connection stub pre-wired to three element (five pin) protector sockets. The equipment side of the protectors shall be connected via RJ21 connectors.

3. Blocks shall be 110 Cat 6 rated or approved equivalent.

4. Protected entrance terminals shall include an integral splice chamber.

5. Protected entrance terminals shall be provided in 25, 50, and 100 pair sizes as per the application shown on the approved drawings.

B. Protector Sockets.

Protector sockets shall be UL standard five pin sockets, with two-position (normal and detent) design. In the detent position, the protector shall be retained, the line side shall be disconnected, and the equipment side shall be protected. When fully inserted, the line and equipment side have the tip and ring pair shall be protected.

2.05 COPPER CAT 6 MULTI-PAIR PROTECTED TERMINAL BLOCKS

A. Design.

1. Protected terminal blocks shall be used at the input for all signal circuits using metal cable and entering/exiting the facility (e.g. Communications Room).

   a.) Multi-pair protected terminal blocks shall be utilized for applications requiring non-connectorized 25 pair or less terminal blocks, as specified in the Contract Drawings. Blocks shall be 110 Cat 6 rated or approved equivalent.

   b.) Types and pair counts for terminal blocks shall be as shown on the approved drawings.

   c.) Terminal blocks shall consist of pairs of brass binding posts imbedded in high impact resistant polyurethane.

   d.) Binding posts shall be pre-wired to two-element protector sockets. The ground of all protector sockets shall be wired to a common ground terminal.
2.06 MULTI-PAIR TERMINAL BLOCKS (NON-PROTECTED)

A. Types and pair counts for terminal blocks shall be as shown on the approved drawings. Blocks shall be 110 Cat 6 rated or approved equivalent.

B. Terminal blocks shall consist of pairs of brass binding posts imbedded in high impact resistant polyurethane.

C. Binding posts shall be equipped with two brass nuts and washers. Binding posts shall be sized to accept a minimum of three #19 AWG conductors.

2.07 PROTECTOR MODULES

A. Three Element (5-Pin) Protectors.

1. Protectors shall be solid-state modules with fuses or heat coils specifically designed for lightning protection.

   a.) Modules shall plug into 5-pin protected entrance terminal sockets.

   b.) Each module shall protect both halves of a pair.

   c.) Protector modules shall be UL 497 listed for Primary protection.

   d.) Modules shall have 2 ns to 5 ns response time.

   e.) Modules shall protect for voltages over 230 V(dc).

   f.) Modules shall protect for currents over 80 A.

B. Two Element Protectors.

1. Protectors shall be solid-state modules with fuses or heat coils specifically designed for lightning protection.

   a.) Modules shall plug or screw into protected terminal blocks.

   b.) Protector modules shall be UL 497 listed for Primary protection.

   c.) Modules shall have 2 ns to 5 ns response time.

   d.) Modules shall protect for voltages over 230 V(dc).

   e.) Modules shall protect for currents over 80 A.
2.08 MAIN DISTRIBUTION FRAME

A. Each Main Distribution Frame (MDF) rack shall consist of a jumper trough, support frame, and 10 cross-connect modules. Split 100-pair and connectorized 200-pair modules shall be utilized.

B. Each MDF support frame shall be fabricated of cold rolled steel with welded construction. It shall be equipped with support arms for mounting 10 cross-connect modules, as well as jumper wire retainers and a ground bar.

C. The MDF support frame shall be made rigid by securing it to the concrete floor by securing overhead or providing additional bracing.

D. Each split 100-pair cross-connect module shall consist of four split 25-pair connectorized punch-down blocks installed on a mounting block. Each 200-pair cross-connect module shall consist of four 50-pair connectorized blocks installed on a mounting block.

1. The cross-connect module-mounting block shall be equipped with a hinged, latching front cover and shall be equipped with all hardware for mounting on the support frame. The inside of each cover shall be marked with cable pair designations identifying all circuits that terminate on the module.

2. Each punch-down block shall consist of two rows of 50 two-termination clips, imbedded in an impact resistant molded plastic base.

   a.) The termination clips shall accept #20 AWG through #26 AWG insulated conductors and #18 AWG and #19 AWG bare conductors. Each two-termination clip shall be pre-wired to one conductor of a 25-pair Amphenol-type RJ21X connector socket, or approved equal.

   b.) Each connector socket shall provide positive contact electrical connections and shall be equipped with a means for physically attaching the connector to the socket (flexible tie down strip or other technique).

   c.) The base of each punch-down block shall have a 25-pair plastic fanning strip on each side of the split block. Each fanning strip shall be permanently marked so as to identify the pair number (1 through 25) terminated on the adjacent clip.

2.09 LOCAL DISTRIBUTION FRAMES IN STATION COMMUNICATIONS CABINETS

A. An LDF shall be provided at each Communications Room or Cabinet. Each LDF shall consist of the following equipment:

1. A minimum of one 100-pair connectorized protected entrance terminals, as described in (TBD). Each contained within a separate enclosure. Enclosure shall have a fully removable cover in order to provide access to protected terminal blocks.

2. A minimum of four 110 Type CAT 6 50-pair connectorized terminal blocks (as described in Article 2.02) utilizing 25 pair connectors per Article 2.04, shall be provided as cross-connects.
3. Multi-pair protected terminal blocks (as described in Article 2.06) designed for a minimum of 36-pairs of PA speaker connections, as shown in Contract Drawings.

2.10 MULTI-PAIR DISCONNECT MODULE TERMINAL BLOCKS

A. Design.

Multi-pair disconnect module terminal blocks shall be 110 Type CAT 6 Rated or approved equal. Terminal blocks shall provide normally closed two-piece (line side and equipment side) insulation displacement contacts in 8 and 50 pair modules, as per the application shown on the approved drawings. Disconnection of the line side from the equipment side shall be by insertion of a disconnect plug.

B. Performance.

1. Contacts shall accept #20 through #26 AWG insulated conductors.
2. Contact resistance shall be less than $1 \times 10^{-3}$ ohms.
3. Insulation resistance shall be greater than $50 \times 10^{12}$ ohms.
4. Wire retention force shall be greater than or equal to 75 percent of wire breaking force.

2.11 DIGITAL PATCH PANEL

A. Design.

1. Digital patch panel shall be provided for data patching between communications equipment. Panel shall meet the following specifications:

   a.) Patching capability to 13 MHZ between communications line and equipment.
   b.) RS-232 compatible through standard DB25 “D” connectors.
   c.) DTE, DCE, and monitor jacks for each communications channel.
   d.) Card Cage to fit EIA RS-310C 19” rack and be designed to hold 18 modules. Modules shall be supplied as required.
   e.) Five 6-foot patch cords per 18-module unit.

2.12 FIBER PATCH PANEL

A. Design

1. Fiber patch panels shall be provided for termination and patching of all fiber.
   a.) High Density 12 or 24 fiber configuration.
b.) “SC” style connectors unless otherwise noted in Contract Drawings.

c.) Attenuation 0.4 dB or less.

d.) Fiber and cable management for easy access.

2.13 OPTICAL FIBER PATCH CORDS AND PIGTAILS

A. Patch cords and pigtails shall be cable assemblies consisting of flexible optical fiber cable with SC compatible connectors. Patch cords shall be complete factory fabricated assemblies from manufacturer's standard product lines. Fiber optic jumper cables shall meet the following requirements:

1. Patch Cord Assemblies.

   a.) The cable construction shall allow a small bend radius for installation in space constrained areas. The cable shall contain a dielectric strength member and a protective outer jacket.

   b.) The Patch Cord shall comply with the requirements of TIA/EIA-568-A.

2. Connectors.

   a.) Two duplex connectors shall be provided on Patch cords.

   b.) One duplex connector shall be provided on pigtails, with the other end prepared for splicing.

3. Fiber Cable.

   a.) Patch cords and pigtails shall utilize a two-fiber zipcord type jacketed cable, in lengths required to meet minimum bend radius while connected and routed through cable management hardware but no less than six feet in length. The cable jacket color shall be orange for multi-mode and yellow for single mode cable. The fiber core size shall also be identified on the outer jacket.

   b.) The optical fiber shall meet the same characteristic requirements of the distribution panel terminated cable to which it mates.

   c.) Tensile strength of the jacketed cable shall be greater than or equal to 20 lbs.

4. Performance

   a.) Both multimode and single mode patch cords shall meet the specific performance requirements listed in Section 17140, Backbone Cabling Requirements, and 17150, Facility Cabling Requirements.
PART 3 - EXECUTION

3.01 TAGS

A. All tags shall be installed so that they are clearly legible in the normal position. Nomenclature on tags, as installed shall not read upside down.

B. All terminal block and apparatus tags shall be mounted such that removal of outside wiring from the unit shall not require or cause removal of the tag.

3.02 TWENTY – FIVE PAIR CONNECTORS

A. Cable Attachment Tool.

Twenty-five pair connectors that are attached to cables in the field shall be made-up utilizing a connector attachment tool approved by the manufacturer.

B. Testing.

All 25 pair connectors that are attached in the field shall be tested, utilizing an approved tester that detects opens, shorts and crosses. Color code shall also be verified.

3.03 TERMINAL BLOCKS

A. All connections to terminal blocks shall be made in accordance with the approved connection details. Twisted pair jumper wire shall be utilized for cross-connections.

B. All wiring on terminal blocks shall be neatly bundled, and restrained to facilitate tracing wires by pulling.

C. Tags and labels shall be utilized to identify the terminal block designation and the pair number terminated on each terminal.

D. Protected terminal blocks shall be grounded with #6 AWG minimum ground wire.

E. All protector modules shall be tested prior to installation on terminal blocks.

3.04 DISTRIBUTION FRAME INSTALLATION

A. Mounting.

Local Distribution Frames and miscellaneous equipment enclosures shall be mounted against walls within the Equipment Room/Cabinets, and other facilities as shown in the Contract Drawings, in locations as approved by Sound Transit. Hardware used for attachment to walls shall be appropriate for the wall material and enclosure load.

B. Wiring.

1. The main/local distribution frame shall be wired in accordance with the approved cross-connect drawings.
2. Tags and labels shall be utilized to identify the cross-connect module designation and the pair number terminated on each quick-clip. All tag and label designations shall be transferred to the as-built drawings.

3. Cables and cross-connect wiring shall be neatly bundled and restrained using dielectric ties in order to facilitate tracing wires by pulling.

4. Distribution frame racks and protected terminal block ground wires shall be grounded CMGB (or earth ground bus-bar) with #6 AWG minimum ground wire.

3.05 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment. Any deviation from stated specifications will be reported to Resident Engineer immediately.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17110
PART 1 - GENERAL

1.01 OVERVIEW

Contractor, in general, shall only supply interior communication pathways within communication rooms at each station and the Operation and Maintenance Facility. Extensions of up to 25 feet to conduit provided by others shall be accommodated by Contractor. Cable trays shall be installed by Contractor as shown on Drawings.

1.02 SECTION INCLUDES

A. This Section includes the requirements for furnishing, installing and testing complete conduit and inner duct systems.

B. This Section includes the requirements for providing overhead cable trays within the Central Communications Equipment Room and Communication Houses.

C. This Section includes the requirements for providing cable racks and supports in manholes and pull-boxes.

1.03 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 17130 – Exterior Communication Pathways.

C. Section 17150 – Facility Cabling Requirements.

D. Section 17170 – Cable Testing, Identification and Administration.

E. Section 17630 – Communications Facilities Requirements.

1.04 REFERENCE STANDARDS


B. ANSI/TIA/EIA 569-A, 607.

C. NEBS GR-63 Physical Protection.

D. NEMA FB1, TC6, VE 1, and VE 2.

E. NFPA 70, 70B.

F. UL 1, 6, 514A, 514B, 514C, 651, 910, and 1666.
1.05 QUALITY CONTROL

Contractor's materials, design, installation, and testing shall comply with the latest version of all referenced standards and codes, as applicable, as well as codes and regulations of the jurisdictional authorities. Select a firm regularly engaged in the manufacture of conduit, conduit fittings, connectors, and accessories of the type specified herein indicating conformance and compliance with these Specifications.

1.06 SUBMITTALS


The Contractor shall submit product information for each type of conduit to be used. Identify dimensions, material, parts lists, finishes and hardware.


1. The Contractor shall submit the Central Communications Equipment Room and Communication Houses Cable Tray Product Data and Layouts. The Contractor shall include the following:

   a.) Drawings of cable tray and accessories including clamps, brackets, hanger rods, splice plate connectors, expansion joint assemblies, and fittings, showing accurately scaled components.

   b.) Manufacturer's catalog data for all proposed materials with installation recommendations.

C. Final Design Document.

The Contractor shall submit each particular subsystem or location to be installed, including updated versions of the information submitted for the detailed design documents. Submit the details of connections, terminations and access points.

D. Factory Acceptance Test Procedure.

1. 30 days prior to the Factory Acceptance Test and before any field installation, Contractor shall submit the final Factory Acceptance Test procedure. This procedure shall include detailed procedures and forms for performing Factory Acceptance Tests of the Backbone cabling. It is expected that the test will be performed at the Contractor's facilities under supervision of Sound Transit Resident Engineer.

2. Factory tests shall be performed in accordance with EIA/TIA-455-A.

E. Final Acceptance (Site) Test Procedure.

30 days prior to the Final Acceptance Test, Contractor shall submit test reports verifying conduit and cable tray grounding and continuity per the requirements of Section 16060, Electrical Grounding and Bonding.
F. Final PVC Conduit Acceptance Test Procedure.

30 days prior to the Final Acceptance Test, Contractor shall submit test reports verifying PVC conduit Air pressure tests. For PVC conduits greater than 3” diameter the minimum rating shall be no less than 300psi.

G. Test Results.

Submit test reports verifying compliance with testing requirements, per the requirements of Section 17170, Cable Testing, Identification and Administration.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish and install conduit for all power, and communications cabling within the Central Communication Equipment Room, Communication Houses at stations, and Communications Cabinets, including interfaces to the Combined System Duct (CSD), unless specified or indicated otherwise.

B. Do not use conduit smaller than 19 mm (3/4 inch) in diameter for interior Work and not smaller than 25 mm (1 inch) in diameter for exterior Work, unless shown otherwise on the Contract Drawings.

C. Polyvinyl Chloride (PVC)

Polyvinyl chloride material is prohibited from use inside Communications Houses and the Operations and Maintenance Facility unless embedded in concrete.

2.02 GALVANIZED RIGID STEEL CONDUIT AND FITTINGS

A. Manufacture galvanized rigid steel conduit in accordance with UL 6.

B. Apply protective coating and threading complying with ANSI C80.1. Hot-dip galvanize externally and internally after fabrication in accordance with ASTM A123 as applicable.

C. Hot-dip galvanize the male threads of conduit and fittings in a manner to keep the threads clear of excess zinc. Provide zinc coating for conduit accessories such as lock nuts, bushings and connectors.

D. Touch up galvanized coating with cold galvanizing compounds for all ferrous and non-ferrous surfaces; ASTM A780 where the original galvanized coating on conduit or galvanized steel has been damaged.

2.03 RIGID STEEL PLASTIC COATED CONDUIT AND FITTINGS

A. Use galvanized rigid conduit and fittings.

B. Apply external and internal coatings of polyvinyl chloride. Apply all coatings under factory conditions using heat. Use cold liquid PVC materials only for field applications to small areas where the factory-applied coating has been damaged during installation.
C. Apply factory coatings of PVC with thickness not less than 1 mm (40 mils, 0.040 inch) to exterior surfaces, and not less than 0.5 mm (20 mils, 0.020 inch) to interior surfaces. Apply PVC coating to all exterior and interior surfaces of conduit and fittings except threaded areas, which must be free of PVC. At all female threaded areas of fittings (including both ends of couplings) provide a skirt of PVC 1 mm (40 mils, 0.040 inch thick) extending beyond the steel far enough to completely cover the exposed male threads of the mating conduit.

2.04 NON-METALLIC RIGID CONDUIT AND FITTINGS

A. Furnish non-metallic rigid conduit and fittings fabricated from polyvinyl chloride (PVC). Provide sunlight-resistant, PVC, with impact strength conforming to the requirements of ASTM D256, NEMA TC6, and ASTM F512.

B. Fabricate rigid, non-metallic, fiberglass reinforced epoxy (FRE) type conduit as indicated. Provide each conduit length with an expanded coupling with integral gaskets for a watertight seal when the coupling is mated to the joining conduit end. Make joint watertight without the use of lubricants or adhesives.

C. Provide non-metallic rigid conduit and fittings conforming to UL 514 and UL 651.

D. Provide end bells, flexible couplings, and expansion joints as necessary.

E. Use fitted plastic couplings to ensure a watertight joint.

2.05 ELECTRICAL METALLIC TUBING AND FITTINGS

A. Manufacture electrical metallic tubing from galvanized steel in accordance with ANSI C-80.3.

B. Fittings and conduit bodies shall be steel compression type in accordance with ANSI/NEMA FB1. Do not use setscrew type fittings.

2.06 LIQUID-TIGHT FLEXIBLE STEEL CONDUIT AND FITTINGS

A. Provide liquid-tight flexible conduit UL listed with galvanized steel core and thermoplastic cover conforming to UL1 and being UL listed, where indicated. Do not use flexible steel conduit other than watertight type.

B. Provide fittings and conduit bodies suitable for watertight flexible steel conduit and in accordance with ANSI/NEMA FB1.

2.07 CONDUIT FITTINGS AND ACCESSORIES

A. Provide conduit connector fittings conforming to UL 514, material similar to that of conduit with which they are to be used, with the following additional requirements:

1. For enclosures, cabinets, boxes, and gutters, which are subject to moisture or dirt: Tapped conduit hub.

2. For enclosures having punched or formed knockout for conduit entry: Watertight hub fitting with gasket, nylon insulated throat, and locknut.

B. Thread all conduit couplings on both ends. Do not use slip-on couplings.
C. Provide malleable iron union couplings for joining rigid conduit at intermediate runs, threaded watertight to permit completing conduit run when neither conduit can be turned and to permit breaking the conduit run at the union.

D. Fabricate bushings of the same material with which the bushings are to be used. Provide insulated bushings 32 mm (1-1/4 inches) and larger with 150°C (300°F) temperature rating. Install insulated grounding bushings in conduits to protect wires inside boxes except where the protective shoulder is provided as part of the conduit thread connection.

E. Equip metal fittings with bonding jumper cable where required to provide electrical continuity.

F. Provide expansion fittings with both expansion and deflection types on all conduits crossing expansion joints. Fabricate conduit expansion fittings from material similar to that of conduit with which coupling is to be used, having factory installed packing ring and pressure ring to prevent entrance of moisture. Equip metallic couplings with grounding ring.

G. Provide sealing fittings that are watertight, malleable iron cadmium plated, and with pouring spout perpendicular to the conduit. Provide vertical seals complete with drain seals.

2.08 CABLE TRAYS

A. Furnish and install cable tray systems designed to withstand a Seismic Zone 3 earthquake, unless specified otherwise.

B. Cable trays shall be of open ladder type, aluminum, or other suitable material commercially available and providing support spacing and strength of material characteristics equal to or greater than the aluminum.

C. The aluminum ladder type cable tray shall meet the following requirements:
   1. Ladder rung spacing shall be approximately 150 mm (6 inches).
   2. Standard tray length shall be a minimum of 3.6 m (12 feet).
   3. Top and bottom flange section shall each be a minimum of 25 mm (1 inch).
   4. Height of rail shall be approximately 152 mm (6 inches).
   5. Rung thickness shall be a minimum of 1.5 mm (.06 inches).
   6. Rung top width shall be approximately 25 mm (1 inch).

D. Loading Capacities.
   1. Cable trays shall be capable of carrying a uniformly distributed load of 22 kg/m (50 lbs./ft.) on a 2.5 m (8 ft.) support span with a safety factor of 1.5 when supported as a simple span and tested per NEMA VE1-4.01. In addition to the uniformly distributed load, the cable tray shall support 90 kg (200 lbs.) concentrated load at mid-point of span and the centerline of the tray. Load and safety factors specified are applicable to both the side rails and rung capacities.
   2. Cable tray shall be made to manufacturing tolerances as specified by NEMA.
E. Each cable tray shall be designed and fabricated with sufficient capacity to provide 50 percent of the cross-sectional area as free air space after the full number of cables and wires are installed. Corners shall have a minimum radius of 300 mm (12 inches), for either horizontal or vertical turns. Sufficient overhead space must be available after installation to permit wires and cables to be inspected.

F. Where practical, the tray shall be constructed in straight sections joined with approved couplers. Electrical continuity of the tray shall be maintained across sections by bonding straps.

G. Using the manufacturer's standard, the tray shall be laid out using a minimum number of sections, but providing maximum continuous runs without gaps.

H. All fittings, supports, and accessories shall be furnished in accordance with the manufacturer's recommendations.

I. To the extent practical, cable trays shall be supported by cantilever type brackets in order that the cables can be laid into the tray without pulling.

J. Where the width of the tray, or the loading of cables is such that cantilever supports are impractical, other suspension methods may be used if approved by Sound Transit, but such application shall be kept to a minimum.

K. At least three supports shall be provided for each length of tray. Supports shall be evenly spaced insofar as possible. In no case shall the spacing between adjacent supports exceed 1500 mm (5 feet).

L. To prevent injury to cables, metal edges shall not protrude and sharp corners shall not exist in the completed layout.

M. If the Contractor's system requires separation of types wires and media in the cable trays for electrical interference protection, these barriers shall be provided where specifications cannot be met.

2.09 POWER CABLE SUPPORTS

A. Furnish and install Power cable tray systems designed to withstand a Seismic Zone 3 earthquake, unless specified otherwise.

B. Cable trays shall be of J-Hook stand-off of ladder rack type, Aluminum, or other suitable material commercially available and providing support spacing and strength of material characteristics equal to or greater than Aluminum.

PART 3 - EXECUTION

3.01 GENERAL

A. Furnish and install all electrical materials, equipment, and accessories as indicated on the Contract Drawings. They shall be rigid and secure, plumb and level, and in alignment with related and adjoining Work to provide a complete and operable system. Electrical materials shall not be welded for attachment or support.
B. Furnish and install anchor bolts and anchorage items as required, performing field checks to ensure correct placement.

C. Furnish and install supporting members, fasteners, framing, hangers, bracing, brackets, straps, bolts and angles as required to set and connect the Work rigidly.

D. In areas where water incursion is possible, Contractor shall install devices that will minimize this.

3.02 FACTORY TESTING

Manufacturer shall provide test reports witnessed by an independent testing laboratory of the "worst case" loading conditions outlined in these technical specifications and performed in accordance with the latest revision of NEMA VE-1.

3.03 DELIVERY, STORAGE AND HANDLING

A. Deliver conduit, boxes, cable tray systems and components carefully to avoid breakage, denting and scoring finishes. Do not install damaged equipment.

B. Store materials in original cartons and in clean dry space; protect from weather and construction traffic.

3.04 CONDUIT AND FITTINGS INSTALLATION

A. General.

1. Examine carefully all conduits and fittings before installing. Set aside all pieces with splits, breaks, blisters, or defects and remove from the worksite.

2. Use rigid steel metal conduit for all exposed installations in housings and rooms, unless indicated or specified otherwise. Install exposed conduit parallel with or at right angles to the building walls in accordance with NEC.

3. Use liquid-tight flexible metal conduit for final connection to rotating and/or vibrating equipment and as permitted by NEC. Install a green insulated wire in flexible conduits for grounding purposes. Provide flexible conduit no longer than 900 mm (36 inches), except from outlet box to recessed lighting fixtures, provide flexible conduit no longer than 1800 mm (6 feet) from outlet box to recessed lighting fixture. Do not use flexible conduit to aid in the final positioning of panels, back boxes and terminal cabinets.

4. Make all conduit bends in accordance with NEC, with not more than two 90° bends between conduit ends or pull boxes. Where conduits contain fiber optic cables, 90° bends are not to be used. Ensure that conduit bends meet the minimum bend radius requirements.

5. Mechanically connect together all metal conduits, fittings, boxes, cabinets, and raceways to form an effective continuous electrical path for grounding purposes.

6. After the conduit has been rodded and swabbed, repack boxes and protect conduit ends to prevent any foreign material from entering the conduit.
B. Cutting.

1. Cut off square all field-cut conduit without restriction to the conduit openings. After conduit is cut and threaded, ream conduit to remove all burrs and sharp edges and then clean thoroughly. Make all joints waterproof by the application of a suitable corrosion-resistant sealer to the threads immediately before assembly.

2. Cut off square non-metallic conduit without restriction to the conduit openings. Trim all cut ends inside and out to remove rough edges and then clean thoroughly. Install all joints completely sealed and watertight.

C. Mandrel.

1. For each completed run of conduit, pull a flexible mandrel through the conduit at a speed not greater than 460 mm (1-1/2 feet) per second prior to installation of cable. Use mandrel size not less than that indicated in Table 1. If the mandrel does not pass through the conduit, remove the obstruction or replace the clogged conduit with new conduit.

2. For all conduits mandreled, complete and submit to Sound Transit, the Conduit Mandrel Report and Station Conduit Mandrel Report.

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<thead>
<tr>
<th>CONDUIT SIZE</th>
<th>MANDREL DIAMETER SIZE</th>
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<td>mm (inches)</td>
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</table>

D. Tagging.

Provide metallic numbering tags indicating the conduit number on the ends of conduit. Uniquely identify power and communications conduit.

E. Boxes.

Securely fasten each conduit entering a non-threaded metal box with two locknuts and a bushing. Retain bushing caps, where required, in place until just before conductors are installed. Secure continuous ground by bonding as required. Thread free ends of spare conduits and install couplings and plugs.
F. Pull Rope.

In each conduit, install a pull rope or cable having a minimum tensile strength of 225 kg (500 pounds). Double back 600 mm (2 feet) of pull rope at each termination. Do not use nylon rope for pulling wires.

G. Fittings.

1. Install expansion and deflection fittings as required on all conduits crossing expansion and contraction joints.

2. Install sealing fittings on all conduits and cables penetrating fire rated walls, floors, partitions, and ceilings to insure that the fire rating is maintained. All cable entrance openings in equipment enclosures, cabinets, cases, houses, rooms and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compounds for rooms, houses, walls, or other partitions shall be fire retardant per ASTM E814. All spare conduits shall be sealed or plugged in an approved manner.

3. Apply electrically conductive pipe joint compound to male threads prior to assembly of metallic conduits.

4. Where metal conduit runs exceed 150 m (500 feet), provide insulated couplings at intervals of 150 m (500 feet) or less, to minimize stray current effects.

H. Finishing.

1. After sanding, apply joint solvent cement to the male end of all PVC conduits prior to inserting in coupling. Furnish solvent cement of type as recommended by the conduit manufacturer.

2. Where conduit enters pad-mounted cabinets, Communications Houses/Rooms, or other facility directly through the floor slab, fill conduit opening with an approved duct sealant in order to prevent moisture from entering the entrance case.

3.05 CABLE TRAY INSTALLATION

A. Installation.

1. Comply with NFPA 70B.

2. Install cable trays in accordance with equipment manufacturer’s instructions, and with recognized industry practices to ensure that cable tray equipment comply with requirements of NEC Article 318, applicable portions of NFPA 70B, and NEMA VE2 for general cable tray installation guidelines.

3. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.

4. Cable tray fitting supports shall be located such that they meet the strength requirements of straight sections. Install fitting supports per NEMA VE2 guidelines, or in accordance with manufacturer’s instructions.
B. Attachment.

Each cable tray section shall be attached to the ceilings utilizing expansion fasteners appropriate for the ceiling material. Fasteners shall be rated for a pull-out load equal to at least 150 percent of the maximum rated load for each cable tray section.

C. Grounding.

Cable tray shall be grounded to the Equipment Room and Communications Room CMGB utilizing #6 AWG minimum ground wire, per Section 16060. In Communications Houses/Rooms, ground the tray to the Signal ground plate. Electrical continuity of the cable tray shall be maintained between sections utilizing #6 AWG minimum ground wire and attachment hardware, as recommended by the manufacturer.

D. Installation of Cable.

Cables shall be laid into the tray, rather than pulled, wherever possible, so as to eliminate twisting. Cables shall be attached to the tray utilizing dielectric Velcro type ties so as to maintain straight runs and adequate separation of cables. Cables carrying AC and DC power shall be separated from fiber, audio and data cables. Separation of Copper Media and Fiber in the run is required.

3.06 FIELD TESTING

A. The quality of the installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with these technical specifications.

B. Test cable trays to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance, in accordance with NFPA 70B, Chapter 20 (2002 edition), for testing and test methods. Submit grounding tests results per the requirements of Section 16060, Electrical Grounding and Bonding.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17120
PART 1 - GENERAL

1.01 OVERVIEW

In general, exterior communications pathways are provided by others. This Section is provided to cover any potential changes that may arise.

1.02 SECTION INCLUDES

This Section specifies the construction of new ducts, conduits, manholes, and hand-holes for communications facilities as shown in Contract Drawings.

1.03 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.
B. Section 17120 – Interior Communication Pathways.
C. Section 17150 – Facility Cabling Requirements.

1.04 REFERENCE STANDARDS

A. AASHTO Standards.
B. ANSI: C80.1.
D. FS: TT-P-0035.

1.05 SUBMITTALS

A. Detailed Design Document -Submit the following for approval:
   1. Shop Drawings.
   2. Drawings for each cast-in-place manhole.
      a.) Drawings for each size and configuration of pre-cast manhole and handhole with details of accessories and joints.
      b.) Diagrams showing dimensioned locations for openings and knockout panels for duct penetrations of manhole walls.
3. Documentation.

Submit calculations to demonstrate compliance with required load-bearing capacity, certified by a Professional Engineer registered in the State of Washington.

**PART 2 - PRODUCTS**

2.01 CONDUIT AND FITTINGS

A. PVC conduit and fittings shall be per ASTM F512; modulus of elasticity, 500,000 psi.

1. Concrete encased: Type EB-20.

2. Direct burial: Type DB-120.

B. Galvanized rigid steel conduit and fittings per ANSI C80.1, as specified in Section 17120, Interior Communication Pathways.

C. Non-conductive pipe and/or duct bank equivalent to items A, B.

D. Spacers: As recommended by conduit manufacturer, or as noted.

E. End Bells: Flared, smooth-surfaced fittings of same material as conduit; if of different material, including adapter for connection to conduit.

2.02 AGGREGATE

Aggregate for Sub-grade Foundation where required: ASTM C33, coarse aggregate No. 4 and No. 67.

2.03 CHANNEL INSERTS

Size as shown, 12-gauge minimum thickness, with 7/8-inch slot; surface-mounted; slotted-base channel with 9/16-inch by 3/16-inch nominal mounting slots on 8 inch centers, hot-dip galvanized after fabrication.

2.04 CABLE PULLING IRON

Fabricated of plain steel reinforcement bar, ASTM A615, Grade 60; welded; size as shown. Hot-dip galvanized after fabrication, ASTM A386.

2.05 CASTINGS

A. Handhole Frame and Cover: Steel, ASTM A36; size as shown.

B. Manhole Frame and Cover:

1. Cast iron, ASTM A48, Class 30, sized as shown.

2. Utility company manhole: Furnished by the utility.
2.06 MANHOLE STEPS

A. Unless otherwise shown, either:
   1. ASTM A48, cast iron, Class 30A.
   2. Molded rubber or plastic on cast-iron or reinforcing steel core.

2.07 HANDHOLES AND MANHOLES

A. Unless otherwise shown, Contractor's option of either cast-in-place or pre-cast.
   1. Cast-in-place concrete: As shown and specified.
   2. Pre-cast concrete.
      a.) Shape shown.
      b.) Designed for AASHTO H20-44 truck loading.
      c.) Manhole: Include lifting rings, manhole steps pulling irons, sump, hole through floor for ground rod, and seal or sealant for sealing joints between sections, pre-cast extensions included where required by Utility. Contractor shall also provide tamper resistant bolts to secure covers on manholes and hand-holes.

2.08 GROUNDING

As specified in Section 16060, Electrical Grounding and Bonding, or National Electric Code as applicable.

2.09 WARNING TAPES

A. Polyethylene tape, 8 mil thick and a minimum of 6 inches wide.

B. Provide warning labels on 3 foot centers and colored as follows:
   1. For communication ducts, conduit, or cable.
      Orange tape with black printed labeling: "Warning - Communication Duct".
   2. For electrical ducts, piping or cable, red tape with black printed labeling.
      "Warning - Buried Electrical Cable".
PART 3 - EXECUTION

3.01 EXCAVATING AND BACKFILLING

A. Excavating and Backfilling.
   As directed by the Resident Engineer.

B. Ducts and Manholes Installed on Backfill Over Subway Structure.
   1. Place and compact backfill up to grade shown for ducts and manholes; compact as directed by the Resident Engineer, ensure the manhole sets level.
   2. Schedule completion of backfilling to allow sufficient time for installation of ducts and manholes.

C. Where shown for sub-grade foundation, use layers of coarse aggregate ASTM C33, No. 56.

3.02 PAVEMENTS, SIDEWALKS, CURBS, AND GUTTERS

A. Remove pavements, sidewalks, curbs, and gutters where necessitated by construction of ducts and manholes.

B. On completion of distribution systems construction, replace pavements, sidewalks, curbs, and gutters.

3.03 PLACING DUCTS

A. Depending on encasement necessary for duct formation, place conduits on spacers and, where required, construct concrete base prior to placing bottom tier of conduits.

B. Lay conduits using spacers to provide tier spacing as shown. For utility company facilities, use spacers recommended by that utility company.

C. Make tight conduit joints by complying with recommendations of conduit manufacturer, using coupling jointing compound or solvent cement.

D. Use non-metallic conduit, unless otherwise shown.

E. Where required, properly place and consolidate concrete around conduits in accordance with the appropriate Sound Transit Standard Specification, Cast-In-Place Concrete. The Sound Transit Standard Specification will be provided by the Resident Engineer, if appropriate.

F. Where shown, install reinforcing steel in encasement in accordance with the appropriate Sound Transit Standard Specification, Concrete Reinforcement. The Sound Transit Standard Specification will be provided by the Resident Engineer, if appropriate.

G. Clear conduit by rod and pull an approved test mandrel from structure to structure.

H. In conduits equal to or greater than 3” install appropriate number of 1” inter-liners with pull-ropes for the future. In all conduits leave approved nylon or polyester pull line in each conduit, tagged to identify the conduits point of origin, contents, and final destination.
3.04 INSTALLATION OF WARNING TAPES

After placing a minimum 18 inches of backfill over the duct, conduits, or cables, place the appropriate warning tapes above and parallel to the centerline of the duct for the entire length of the duct trench.

3.05 CONSTRUCTION OF MANHOLES AND HANDHOLES

A. Cast-in-Place.

1. Provide drainage facilities for manholes and hand-holes as required.

2. Erect formwork in accordance with the appropriate Sound Transit Standard Specification, Concrete Formwork.

3. Place reinforcing in accordance with approved shop drawings.

4. Provide for location of duct entrances and inserts in walls as required.

5. Place concrete as specified in the appropriate Sound Transit Standard Specification, Cast-In-Place Concrete. The Sound Transit Standard Specification will be provided by the Resident Engineer, if appropriate.

6. Install conduits of material shown.

7. Install end bells on conduits where ducts terminate in manhole and hand-holes.

8. Build duct formation into walls of manholes and hand-holes and seal around opening.

9. If location of manholes or handhole openings will be obstructed inform Resident Engineer immediately.

10. Install frame and cover, adjust to finished grade by using pre-cast neck extenders, grout and, if necessary, brick chimney.

11. Seal conduit openings with approved conduit plugs.

12. Install cable pulling irons and steps as required.

13. Install ground rods as required. If soil conditions prevent driving rod to required depth, install alternative grounding system as approved.


15. Paint interior of manhole or handhole, except floor, with two coats of masonry paint, 10 mils minimum total dry film thickness.
B. Pre-cast.

1. Provide drainage facilities where required.

2. Install conduits of material shown.

3. Install end bells on conduits where ducts terminate in manhole and hand-holes.

4. Build duct formation into walls of manholes and hand-holes and seal around opening.

5. If location of manholes or hand-holes openings will be obstructed inform the Resident Engineer immediately.

6. Install frame and cover, adjust to finished grade by using pre-cast neck extenders, grout and, if necessary, brick chimney.

7. Seal conduit openings with approved conduit plugs.

8. Install cable pulling irons and steps.

9. Install ground rods as required. If soil conditions prevent driving rod to required depth, install alternative grounding system as approved.

10. When installing sections of pre-cast manholes, prevent damage to joints seals.


3.06 SPlicing

A. Furnish reinforcing bars in full lengths as shown in the Contract Drawings and approved shop drawings.

B. Unless otherwise shown, lap reinforcement using lap lengths in accordance with ACI 318.

C. Do not splice bars at locations other than those shown in Contract Drawings and approved shop drawings unless approved in writing.

D. Make mechanical or welded splices only when specified or shown, or approved in writing by the Resident Engineer. Splices shall be installed by approved manufacturer procedures.

E. After installing mechanical connections on epoxy coated bars, all coating damages shall be repaired. All parts of mechanical connections used on epoxy-coated bars shall be coated with same material used for repair of coating damages.

3.07 FIELD TESTING

A. The quality of the installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with these technical specifications.
B. Test PVC conduits and fitting greater than three inch diameter to a minimum of 300psi pneumatic test. Failures to meet the above standard shall be repaired or replaced at no expense to Sound Transit.

3.08 CLEAN-UP

Remove debris from manholes and hand-holes and ensure complete installation is left in neat and finished condition.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17130
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SECTION 17140
BACKBONE CABELING REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

The Contractor shall design, furnish and install a complete fiber optic backbone cable as shown on the Contract Drawings.

1.02 RELATED SECTIONS

A. Section 17050 – Configuration Management.

B. Section 17105 – Grounding and Bonding of Cables.

C. Section 17170 – Cable Testing, Identification and Administration.

D. Section 17500 – Cable Transmission System/WAN Overview.

E. Section 17510 – Communication System Backbone Equipment.

F. Section 17930 – Cable Management System.

1.03 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:

1. ANSITIA/EIA-455 Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components.

2. ANSITIA/EIA-568 Commercial Building Telecommunications Cabling Standard.

3. ANSITIA/EIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces.

4. ANSI/TIA/EIA-598 Optical Fiber Color Coding.


6. ANSI/TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.


8. NEC 800-30 Protective Devices.

10. UL910
Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air.

1.04 QUALITY CONTROL

A. Qualifications.

1. All cable manufacturers shall be approved by Sound Transit. The Contractor shall provide all data required for Sound Transit evaluation and shall make the arrangements for any required demonstrations and tests.

2. Qualifications shall be based on the following criteria:

a.) Past Performance and Experience.

   The cable manufacturers must demonstrate previous successful experience in supplying wire and cable specified herein. A list of such installations shall be provided for each cable manufacturer to be considered.

b.) Quality Assurance Program.

   The manufacturers of cables, in accordance with the requirements of these technical specifications, is required to have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance. Sound Transit reserves the right to audit the manufacturer’s facilities for conformance to the Contract. This may include, but is not limited to first article inspections, source inspections, and on-site surveys. Such compliance shall promote a thoroughly tested cable that will render long service life to the user. Prime concern must be focused on the necessary formal assurance requirements to insure that cable failure cannot be attributed to actions or lack of actions by the manufacturer.

c.) Technical Data.

   The Contractor shall provide full technical data that demonstrates compliance with the requirements of these technical specifications for each specified cable type the Contractor plans to supply.

d.) Demonstration Tests.

   The Contractor shall make arrangements with the prospective cable manufacturers to perform demonstration tests as required by Sound Transit.

e.) Sample Specimens.

   The Contractor shall, if requested, furnish to Sound Transit within 20 days after the Notice-to-Proceed, sample specimens in 1200 mm (4 ft.) lengths similar to that which the manufacturers proposes to furnish for each type cable specified herein. The sample specimens shall remain the property of Sound Transit.
f.) The manufacturers shall certify compliance with the following warranty prior to selection.

1.) The manufacturers warrant that the design, material, and workmanship incorporated in each item of cable shall be of the highest grade and consistent with the established, and generally accepted, standards for aerial and underground cable for transit applications; and that each such item and every part and component thereof shall comply with these Specifications.

2.) The manufacturers agree that this warranty shall commence with the acceptance of each item of the cable, whether the defect be patent or latent, and shall continue for a period of 8 years after initial satisfactory operation of the item or 10 years after acceptance of the item, whichever is shorter.

B. After Selection.

1. The Contractor shall monitor the manufacturers of the cable to assure that the approved Quality Assurance Program is being closely adhered to and that the wire and cable is being manufactured in accordance with these Technical Specifications and the approved submittals.

2. Each finished cable shall be traceable to the test date on file for each step in its manufacturing process.

3. Inspection.

a.) Sound Transit shall have the right to make such inspection and tests as necessary to determine if the cable meets the requirements of these technical specifications. Sound Transit shall have the right to reject cable that is defective in any respect.

b.) Sound Transit shall be given 15 days advance notice of the date the cable will be ready for final testing so that Sound Transit may witness the tests, if it so elects.

c.) Physical tests shall be made on samples selected at random at the place of production. Each test sample shall be taken from the accessible end of different reels. Each reel selected and the corresponding sample shall be identified. The number and lengths of samples shall be as specified under the individual tests. All applicable tests for the cable materials and cable construction specified shall be performed.

d.) Certified test reports shall be furnished for the finished cables no later than the time of shipment. Each test document shall, in addition to the test results, indicate the date the tests were performed and the signature of the manufacturer's authorized representative.

e.) Sound Transit reserves the right to conduct those tests to provide further satisfaction that the cable is manufactured in accordance with the requirements of these technical specifications.
1.05 SUBMITTALS


The Contractor shall submit complete technical data for the proposed cable. The data submitted shall demonstrate compliance with all optical and mechanical properties specified herein. The Contractor shall submit information for each proposed manufacturer describing his experience in manufacturing optical cable for rapid transit and railroad applications and his quality assurance program and warranty.


1. The Contractor shall submit the following to the Resident Engineer for approval.

a.) Cable test and inspection reports for tests and inspections required and described by these Specifications.

b.) Test reports of cable tests conducted in the field in accordance with approved testing procedures. Information to be supplied by certified cable test reports shall include the following:

1.) Report number.

2.) Date and location of test.

3.) Description of test and test conditions.

4.) Complete cable or wire description.

5.) Lot, batch, or reel identification number.

6.) Quantitative test results.

7.) Summary of the test results.

8.) Information on the components of the cable tested to include batch numbers and physical and electrical properties.

c.) Procedure for terminating cable within the Fiber Distribution Panel (FDP), including fusion splicing of pigtails.

d.) Fusion splice equipment description.

e.) Splice and termination testing procedure.

f.) The Contractor shall submit for approval of the projected loads and optical loss budget calculations.
C. Final Design Document

1. The Contractor shall submit the following information for each segment of cable to be installed:

   a.) Pulling layout including distances and tension calculations, for each section of installation.

   b.) Pulling equipment and tension monitoring devices.

   c.) Chronological plan for installing cable, including estimated time for each pull and plan for protecting cable on-reel and in slack loops during installation.

   d.) The manufacturer shall supply instructions for splicing. The instructions shall be forwarded with the certified test results for each reel of cable. The instructions shall specify the exact nature of splicing materials to be employed, and the manner they are to be spliced.

   e.) Sound Transit reserves the right to request additional submittals than those described herein at no additional cost to the Contract.

D. Factory Acceptance Test Procedure

1. 30 days prior to the Factory Acceptance Test and before any field installation, Contractor shall submit the final Factory Acceptance Test procedure. This procedure shall include detailed procedures and forms for performing Factory Acceptance Tests of the Backbone cabling. It is expected that the test will be performed at the Contractor’s facilities under supervision of Sound Transit.

2. Factory tests shall be performed in accordance with EIA/TIA-455-A.

E. Final Acceptance (Site) Test Procedure.

30 days prior to the Final Acceptance Test, Contractor shall submit the final test procedure for the test.

F. Test Results.

   Test Reports. Submit test reports verifying compliance with testing requirements, per the requirements of Section 17170, Cable Testing, Identification and Administration.

1.06 DELIVERABLES

As specified in these Specifications.
PART 2 - PRODUCTS

2.01 FIBER BACKBONE OUTSIDE PLANT

A. General.

All outside plant FO cable shall be certified to meet the following: EIA 455-13, EIA 455-25A, EIA 455-41, EIA 455-47B, EIA 455-59, EIA 455-61, EIA 455-88, EIA 455-91, and EIA 455-104A.

B. Construction.

1. The cable shall have a double jacket with steel tape armor applied between the jackets. Cable shall be rodent proof.

2. The cable shall be designed for direct buried installation.

3. The cable shall be of loose tube design, with fibers evenly distributed among the buffer tubes.

4. Each fiber shall consist of a central glass optical fiber surrounded by a primary polymer buffer with a secondary hard elastomeric polymer buffer up to 900 \( \mu m \). Non-elastomeric (PVC) materials are not allowed.

5. Each buffered fiber to be color-coded so as to provide unique and permanently visible identification. Color-coding shall be in accordance with EIA/TIA-598.

6. A kevlar strength member shall be central to the cable core.

7. Flame-retardant Cable filling to prevent moisture entry shall be applied within the buffer tubes and within the binder.

8. A binder of kevlar shall be applied over the cable core.

9. An inner jacket of polyethylene or similar material shall be applied over the binder.

10. Corrugated, plastic coated, steel tape armor shall be applied over the inner jacket.

11. The outer jacket shall be polyethylene or similar material approved by the Resident Engineer.

12. All fibers must be usable fibers and meet the following requirements:

   a.) Fiber and cable protective coverings shall be continuous with no factory splices.

   b.) All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet optical, mechanical and environmental requirements of this specification.

   c.) All optical fibers shall be proof tested by the manufacturer at a minimum of 100,000 PSI.
13. The outer surface of the jacket of each shipping length of cable shall be permanently identified by printing on the outer surface of the jacket at intervals of five feet or less. Information is to include count of fibers, fiber type and size, cumulative footage markers, manufacturer's designation and manufacturer's name.


1. Glass Composition: SiO2, which may include small amounts of Ge, F, or P to control the index of refraction or to assist in fiber manufacture.

2. Operational Wavelength: 1,310 nm and 1,550 nm.


4. Optical Attenuation: @ 1,310 nm: 0.35 dB/km @ 20°C.

5. Fiber Macrobend: Attenuation per 100 turns of fiber 75 mm in diameter shall not exceed 0.50 db at 1550 nm including intrinsic attenuation of the 77.4 feet of fiber.

6. Attenuation Uniformity: No point discontinuities greater than 0.2 dB at either 1,300 nm or 1,550 nm.

7. Optical Dispersion: @ 1,300 nm: 3.5 to 4.5 ps/nm-km.

8. Max. Dispersion Slope: \( \leq 0.093 \text{ ps/(km-nm}^2\text{)} \) over the wave length range of 1285 to 1570.

9. Zero Dispersion Wavelength: 1,300 to 1,324 nm.

10. Fiber Core Diameter: 9.0 um nominal + 0.5 um.


13. Cladding Noncircularity: \( \leq 1 \text{ percent.} \)

14. Core/Cladding Concentricity: < 0.8 um.

15. Spot Size: 9.8 um.

16. Refractive Index Difference: 0.3+ 0.5 percent.

D. Mechanical Specifications
1. Crush Resistance: 10,000 N/m, (678lbs/ft) length of cable.

2. Cable Outside Diameter: 15.1mm (0.59") nominal.

3. Minimum Bending Radius
   a.) Installation: 20 x Diameter.
   b.) Static: 15 X Diameter.

4. Temperature
   a.) Operational: -30° C to + 60° C.
   b.) Storage: -40° C to + 60° C (on reel).

5. Humidity: 0 to 100 percent, inclusive.

6. Tensile Strength:
   a.) Installation: 2,700 N (600 lbf).
   b.) Static: 600 N (135 lbf).

2.02 FIBER SLACK ENCLOSURES (FSE)

A. Enclosure.
   1. Enclosures shall be NEMA-3R type with hinged cover.
   2. Enclosures shall lock with hasp and padlock, keyed as directed by the Resident Engineer.
   3. Enclosures shall be sized for 300’ of cable slack.

B. Hardware.
   1. Hooks shall be provided to hold cable slack, with coils of appropriate bend radius.
   2. Ties to restrain cable shall be utilized.

2.03 FIBER DISTRIBUTION PANELS (FDP)

A. Enclosure.
   1. The enclosure shall house the splice shelf and connector sleeve panels for all optical connections but as a minimum shall provide 72 connections Single Mode Fiber Distribution Panels.
2. All outside plant (OSP) cable jackets and central strength members shall be secured to the enclosure for strain relief.

3. Distribution Panels. Distribution panels shall be a complete system of components by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Patch panels shall be 19-inch rack mounted panels. Patch panels shall provide strain relief for cables. Panels shall be labeled with alphanumeric x-y coordinates and shall be provided with labeling space. The patch panel shall accommodate the future installation of SC, ST, FC, D4, or MIC (FDDI), type connector modules. Each module shall provide six connector sleeves.

B. Splice Shelf

1. The splice shelf shall accept slide in/out splice trays for a maximum number of connectors and for the fiber types to be installed.

2. Each splice tray shall restrain and protect fusion or mechanical splices.

C. Connector Sleeve.

1. Connector sleeves shall be the SC type. The connector sleeve shall meet TIA/EIA-568-A requirements when connecting mated pairs.

2. The fiber distribution panels shall be fully populated with connector sleeves.

3. Dust Caps shall be provided for all sleeves.

4. Loss across connection shall not exceed the following, with optical attenuators removed:

   a.) Single Mode .6 db.

   b.) Multi-Mode .75 db.

5. The FDP sleeves shall be capable of accepting optical attenuators as required for maintaining the Optical Loss budget.

D. Slack Retention.

1. Slack in pigtails and patch cords shall be neatly coiled and retained such that the minimum bending radius shall not be exceeded.

2. Slack shall be sufficient for accessing splice shelves and connectors.

2.04 FIBER CONNECTORS

A. Connectors shall be SC type.

B. Optical parameters of the connectors shall meet the requirements of TIA/EIA-568-A.
2.05 OPTICAL FIBER PATCH CORDS AND PIGTAILS

A. Patch cords and pigtails shall be cable assemblies consisting of flexible optical fiber cable with SC compatible connectors. Patch cords shall be complete factory fabricated assemblies from manufacturer's standard product lines. Fiber optic jumper cables shall meet the following requirements:

1. Patch Cord Assemblies.
   a.) The cable construction shall allow a small bend radius for installation in space constrained areas. The cable shall contain a dielectric strength member and a protective outer jacket.
   b.) The Patch Cord shall comply with the requirements of TIA/EIA-568-A.

2. Connectors.
   a.) Two duplex connectors shall be provided on Patch cords.
   b.) One duplex connector shall be provided on pigtails, with the other end prepared for splicing.

3. Fiber Cable.
   a.) Patch cords and pigtails shall utilize a two-fiber zipcord type jacketed cable, in lengths required to meet minimum bend radius while connected and routed through cable management hardware but no less than six feet in length. The cable jacket color shall be orange for multi-mode and yellow for single mode cable. The fiber core size shall also be identified on the outer jacket.
   b.) The optical fiber shall meet the same characteristic requirements of the distribution panel terminated cable to which it mates.
   c.) Tensile strength of the jacketed cable shall be greater than or equal to 20 lbs.

2.06 INNER DUCT

A. Inner duct shall have the following characteristics:

1. Corrugated semi-ridged constructions of flame retardant PVC or FCP material and shall meet the following flammability requirements:
   a.) OSP, inside building horizontal, and inside building riser inner duct shall meet the UL 1666 flame test.
   b.) Inner duct installed in any air plenum environment shall meet UL-910 (NFPA 262-1990).

2. Compatible with the fiber optic cable installed within.
3. Inner diameter of no less than 1.25" and no more than 2.0".

4. Couplers, if used, shall not reduce the inside diameter of the inner duct.

5. All unused inner duct shall be preinstalled with lubricated pull tape or line.

PART 3 - EXECUTION

3.01 GENERAL

Unless specified or approved otherwise, provide cable as indicated in the Contract Drawings.

3.02 PREPARATION

A. The Contractor shall give Sound Transit 48 hours notice prior to installing cables.

B. In certain types of installation where the cable cannot be constrained, ample cable slack shall be provided for additional flexibility due to vibration of such equipment.

C. Cables shall not be bent to a radius less than twelve (12) times the diameter of the cable or the manufacturers’ recommended minimum bending radius, during installation or as finally installed.

D. All cables shall be tagged at their termination points. In addition, all cables shall be tagged within Communications Houses/Rooms, manholes, handholes, housings, etc. and on each side of any barrier the cable passes through. Cables shall also be tagged at aerial exits from conduit risers.

E. All cable entrance openings shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit or pipe. All spare conduits shall be sealed or plugged in an approved manner. Cable openings within the substation floors and/or walls shall be sealed with an approved fire sealant.

F. Where cables leave conduits, the ends of the conduit shall be fitted with end bells to prevent damage to the cable.

G. Cable connections and splices shall be made in strict accordance with the manufacturer’s instructions.

H. Contractor shall provide service loops sufficient for the maintenance and free movement of attached electrical equipment.

3.03 FACTORY TESTING

A. All optical cable tests shall be accomplished in accordance with the approved plan:

   1. Cable shall be tested on-reel prior to shipment.

   2. End to end loss shall be recorded for each fiber at 1,310 and 1,550 nm for single mode and 850 and 1310 for multi-mode.
3. OTDR with hardcopy record shall be provided for each fiber, at 1,300 nm.

4. Optical dispersion shall be tested for each fiber.

5. Certified copies of tests results shall be submitted to the Resident Engineer.

3.04 DELIVERY, STORAGE AND HANDLING

A. Packing - Cable shall be shipped on non-returnable wooden reels. The diameter of the drum shall be at least 20 times the diameter of the cable. Cable shall be shipped on reels substantial to withstand reasonable handling and shall be so designed that the inner end of the cable be accessible, but protected from injury. All ends of the cable shall be sealed to prevent entrance of moisture and securely fastened to prevent them from becoming loose during transit.

B. Marking - Each reel shall contain on the outside flange, the following information:

1. Manufacturer's name.
2. Contract name and number.
3. Cable identification number.
4. Cable length.
5. Date of manufacture.
6. Copy of the factory test results.

3.05 INSTALLATION

A. All optical cable installation shall be accomplished in accordance with the approved Installation Plan:

1. All fiber optic cable shall be installed in inner duct. The inner duct shall be installed without coils or twists.

2. Pull locations shall be selected to protect the cable on the reel and in slack loops. The Contractor shall be responsible for protecting cable after working hours where cable installation is not completed during a single shift. Cables damaged due to Contractor's neglect while installing cable shall be replaced by the Contractor at no additional cost to Sound Transit.

3. Pull lengths shall be designed to allow a 20 percent margin in cable tensile strength. The Contractor shall not exceed the lesser of 80 percent of the cable's maximum tensile rating or 600 lbs during installation. No residual tension shall remain on the cable after installation except that due to the cable's weight in the vertical rise.

4. If a winch or pulling machine is used during installation, a dynamometer shall be used to monitor the tension on the cable. The dynamometer shall be certified as calibrated and shall hold the peak value of the cable pull. The peak value shall be recorded and forwarded to the Resident Engineer as part of the installation test data submittals.
5. The maximum vertical rise shall be defined as the distance over which the cable is self-supporting. Cable strain relief shall be used at the top of each vertical rise and no less than every time that 80 percent of vertical rise rating of the cable is exceeded.

6. The Contractor shall not exceed the cable's minimum bend radius for cable under tension or long-term installation/storage.

7. Continuity of cable shall be maintained between termination or splice locations shown on the Contract Drawings. Additional splices will not be allowed without the prior written approval of the Resident Engineer.

8. The Contractor shall notify the Resident Engineer in writing at least 48 hours in advance of installation of each section of optical cable.

9. All cable entrance openings in equipment enclosures, houses, rooms and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compounds for rooms, houses, walls, or other partitions shall be fire retardant per ASTM E-814. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in an approved manner.

B. Termination.

1. Slack in FSEs shall be carefully coiled in order to avoid violating the short and long-term minimum bend radius. The Contractor shall supply a minimum of 10 meters of slack at each termination of the cable inside the FSE.

2. Slack in FDPs shall be restrained and shall be sufficient for strain relief.

3. The central strength member of cable shall be attached to the FDP. The outer jacket of cable shall be attached to the FDP with a cable clamp.

4. All fiber optic splices shall be fusion splices. The Contractor shall perform splicing at fiber slack enclosures only for the purposes of passing an optical connection through a Communications House. Fusion splicing shall be performed by qualified personnel utilizing a splicer equipped with Local Injection and Detection (LID) to optimize splices. The loss across each spliced fiber shall be less than or equal to 0.3 dB.

5. All optical terminations shall be field or factory terminated. The use of pigtail assemblies shall not be permitted.

6. The Contractor shall notify the Resident Engineer in writing at least 72 hours in advance of terminating each section of optical cable.

7. Where armored cable is utilized, the armor shall be grounded to the communications room ground bus at one termination location.

3.06 INNER DUCT INSTALLATION

A. General.

Install inner duct in each conduit as indicated on the Contract Drawings. Where multiple inner ducts are required in one conduit, pull all at the same time.
B. Pull Rope.

In each inner duct, install a pull rope or cable having a minimum tensile strength of 225 kg (500 pounds). Double back 600 mm (2 feet) of pull rope at each termination. Do not use nylon rope for pulling wires.

3.07 FIELD TESTING

A. Tests shall be performed after installation is complete.

B. Twenty-four hour advance notice to the Resident Engineer shall be provided.

C. Optical attenuation from FDP to FDP shall be recorded.

D. Optical Time Domain Reflectometer (OTDR) records including hardcopy and 3.5" floppy disk or CD-ROM softcopy, for both directions of transmission shall be furnished to Sound Transit.

E. All fibers shall be tested.

1. OTDR tests shall be performed utilizing a pulse suppressor such that the FDP termination shall be shown.

2. The loss across each connector and splice shall be shown.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17140
SECTION 17150
FACILITY CABLING REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section specifies furnishing and installing all internal, riser and distribution wires and cable, cable connectors, physical connections in this Contract for inter-room and in-building cabling requirements.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 17050 – Configuration Management.

C. Section 17105 – Grounding and Bonding of Cables.

D. Section 17110 – Main Distribution Frames, Intermediate Frames, Cross Connect Points, Fiber Distribution and Service Entrances.

E. Section 17120 – Interior Communication Pathways.

F. Section 17130 – Exterior Communication Pathways.

G. Section 17140 – Backbone Cabling Requirements.

H. Section 17150 – Facility Cabling Requirements.

I. Section 17170 – Cable Testing, Identification and Administration.

J. Section 17180 – Cable Plant Maintenance Manuals and Training.

K. Section 17190 – Spares, Special Materials, Support and Warranty.

L. Section 17310 – PABX.

M. Section 17500 – Cable Transmission System/WAN Overview.

N. Section 17510 – Communication System Backbone Equipment.

O. Section 17930 – Cable Management System.
1.03 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section as well as any local and/or Sound Transit requirements and guidelines not stated below.

1. ANSITIA/EIA-568 Commercial Building Telecommunications Cabling Standard.

2. ANSITIA/EIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces.


4. ANSI/TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.


6. NEC 800-30 Protective Devices.

7. NFPA 70 National Electrical Code.


10. UL910 Test for Flame Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air.

1.04 CITED STANDARDS

A. All Work shall conform to the requirements of the Federal, State, and Local Electrical and Telecommunications Regulations.

B. Work shall meet or exceed the standards and procedures of the following:


3. Telecommunications Industries Association (TIA).

4. Electronic Industries Association (EIA).


6. Institute of Electrical and Electronics Engineers (IEEE).

7. Underwriters Laboratories (UL).
11. Occupational Safety and Health Administration (OSHA).

C. In the event of conflicts, the more stringent provisions shall apply.

1.05 QUALITY CONTROL

A. All wire and cable manufacturers, quoted products and installation vendors shall be approved by the Resident Engineer. Contractor shall provide all data required for the Resident Engineer evaluation and shall make the arrangements for any required demonstrations and tests.

B. Qualifications shall be based on the following criteria:

1. Past Performance and Experience.

   The cable manufacturers must demonstrate previous successful experience in supplying wire and cable specified herein. A list of three such installations of similar size and scope shall be provided for each cable manufacturer to be considered.

2. Quality Assurance Program

   The manufacturers of cables, in accordance with the requirements of these technical specifications, is required to have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance. The Resident Engineer reserves the right to audit the manufacturer's facilities for conformance to the Contract. This may include, but is not limited to first article inspections, source inspections, and on-site surveys. Such compliance shall promote a thoroughly tested cable that will render long service life to the user. Prime concern must be focused on the necessary formal assurance requirements to insure that the manufacturer cannot attribute cable failure to actions or lack of actions.

3. Technical Data.

   Contractor shall provide full technical data that demonstrates compliance with the requirements of these Specifications for each specified cable type Contractor plans to supply (i.e. White Papers, Certifications).

Contractor shall make arrangements with the prospective cable manufacturers to perform demonstration tests as required by the Resident Engineer.

5. Sample Specimens.

The Contractor shall, if requested, furnish to the Resident Engineer within 20 days after the Notice-to-Proceed, sample specimens in 1200 mm (4 ft.) lengths identical to that which the manufacturers proposes to furnish for each type cable specified herein including connectors and peripherals. The sample specimens shall remain the property of Sound Transit.

1.06 SUBMITTALS


1. Contractor shall submit complete technical data for the cable and ancillary devices he proposes to furnish. The data submitted shall demonstrate compliance with all optical and mechanical properties specified herein.

2. Contractor shall submit information for each proposed manufacturer describing his experience in manufacturing copper, network and optical cable for rapid transit and railroad applications and quality assurance program and warranty.


1. Contractor shall submit the following to the Resident Engineer for approval.

   a.) Cable test and inspection reports for tests and inspections required and described by these Specifications.

   b.) Test reports of cable tests conducted in the field in accordance with approved testing procedures. Information to be supplied by certified cable test reports shall include the following:

      1.) Report Number.

      2.) Date and location of test.

      3.) Description of test and test conditions.

      4.) Complete cable or wire description.

      5.) Lot, batch, or reel identification number.

      6.) Quantitative test results.

      7.) Summary of the test results.
8.) Information on the components of the cable tested to include batch numbers and physical and electrical properties.

9.) Copper phone and network cable splice and termination testing procedure.

10.) Contractor shall submit for approval of the projected loads and optical loss budget calculations.

C. Final Design Document.

1. Contractor shall submit the following information for each segment of cable to be installed:

a.) Pulling layout including distances and tension calculations, for each section of installation.

b.) Pulling equipment and tension monitoring devices.

c.) Chronological plan for installing cable, including estimated time for each pull and plan for protecting cable on-reel and in slack loops during installation.

d.) The manufacturer shall supply instructions for splicing. The instructions shall be forwarded with the certified test results for each reel of cable. The instructions shall specify the exact nature of splicing materials to be employed, and the manner they are to be spliced.

e.) The Resident Engineer reserves the right to request additional submittals than those described herein at no additional cost to Sound Transit.

PART 2 - PRODUCTS

2.01 GENERAL

A. In building systems wiring will be installed per BICSI standards and as shown on the drawings.

B. Material and workmanship shall be of the highest quality assuring durability for minimum life expectancy of 40 years. Wire and cable shall be suitable for use in the environment to be encountered on a transit signal system, and shall be certified for continuous operation at 75 degrees C in wet or dry locations with no conductor failing in continuity or with loss of insulation to cross or ground less than one (1) meg-ohm.

C. All copper or fiber cabling within a facility shall be plenum rated unless otherwise noted.

2.02 STATION CCTV CABLING

A. Terminations of the RG-59 or RG-11 coaxial will be on a patch panel mounted on a 19-inch rack for video terminations.
B. Follow stated guidelines for Coax Camera Cabling:

1. If cable run <250m  Recommendation is to RG59.
2. If cable run >250m and <500m  Recommendation is to RG59 with amplification or RG11.
3. If cable run >500m and <1.5km Recommendation is to RG11 with amplification 70.

C. Contractor may utilize other means of carrying video signals than coax cabling. Contractor shall follow the termination methods and cabling requirements recommended by the manufacturer.

D. Camera Connectors dependent on model of camera.

2.03 STATION PUBLIC ADDRESS/VMS WIRING

A. PA and VMS shall be considered evacuation notification devices and shall require 2 hour rated cable per NFPA 72.

B. Contractor shall provide loudspeaker wiring in accordance with Section 17710, Public Address System, and with Contract Drawings.

C. Loudspeaker cables shall be shielded twisted pairs, 14 AWG stranded, minimum. Local distribution cables for the PA system shall be placed in separate conduit or raceways from low-level voice and data circuits.

D. Loudspeaker wiring shall be provided for connection of speakers at all stations.

2.04 ETEL-PET (EMERGENCY TELEPHONE SYSTEM) DIGITAL

A. In a copper application, Contractor shall provide 110/RJ45 connections through the use of industry standard connectors. The number of available ports is specific to the project application.

B. Contractor provides cable management for individual Category 6 4-pair cables, which will be terminated on industry standard connectors.

C. Contractor provides wire management for slack storage and routing for 24 copper cable pairs within the unit.

D. Slack storage configuration must be arranged so copper pairs are provided with no less than a 1.5-inch bend radius.

2.05 PABX STATION WIRING (DIGITAL AND ANALOG SETS)

A. Local inside facility distribution of low-level (analog) voice circuits shall, at a minimum, be by standard category 5e or better telephone cable.

B. Wire conductors shall be composed of soft or annealed copper, meeting insulating, sensitivity and elongation requirements. Joints made in conductors during manufacture may be welded or brazed using silver alloy solder and non-acid flux.
C. Insulated conductors shall be in twisted pairs. Each pair shall be individually colored. The average length of pair twist shall not exceed 6 inches. To minimize noise and cross talk, each pair of a 12-pair cable shall have a different average length of twist from any other pair in the cable.

D. All cables shall be sized for design requirements plus 50 percent pair counts.

E. Inside wire (wiring run within any building) from telephone terminals to telephone instruments shall be 22 AWG or 24 AWG and have a characteristic impedance of 105 ohms ±15 percent. Cable shall be low smoke Teflon.

F. All main riser cables shall be 22 AWG and shall meet REA Specifications PE-22 or PE-89. All cables shall be at least 12 pairs.

G. All main and riser cables shall be shielded.

H. REA Specification PE-39 cables shall not be used as a substitute for PE-22 or PE-89 cables.

2.06 INSIDE PLANT FIBER CABLES

A. Inside plant cables shall be used for installation in building cable trays, conduit and open-air systems or other areas where temperature and humidity are controlled and where cable is not exposed to potential water and pest damage. Cable shall be of tight buffer-breakout design having elastomeric-coated tight buffer fibers individually encased in aramid yarn and a sub-cable jacket, aramid yarn strength member, and flame retardant exterior jacket. Flame retardant jacketing shall exhibit low smoke, low halogen emission, and low toxicity properties when exposed to severe heat or flames.

B. Sub-cables.

Shall be a breakout design such that each individual fiber shall be physically and environmentally protected should the outer cable jacket be removed. Individual glass fibers shall be coated with acrylate fiber coating, a 900-micron diameter elastomeric tight buffer coating, individual aramid strength member, and outer elastomeric sub-cable jacket.

C. Color Code.

Individual fibers in each sub-cable, the elastomeric tight buffer material, and each individual sub-cable shall be color coded per EIA/TIA 598.

D. Cabling.

Sub-cables shall be encased in aramid strength member and exterior flame retardant jacket. Exterior jacket shall meet or exceed IEEE 383-flame test, NES 711 smoke index, NES 713 toxicity index, and MIL-C-24643 acid gas test. Jacketing material shall be an UV resistant and not promote the growth of fungus. Cable shall be free of metal locational or protective elements.

E. Rip Cord.

A ripcord of different color than the aramid yarn shall be pulled in longitudinally under the outer jacket.
F. Cable Print.

1. Outer jacket shall be marked with the following information:
   a.) Cable Manufacturer.
   b.) Number of Fibers.
   c.) Fiber Type (SM or MM).
   d.) Halogen Free, Low Smoke.
   e.) Date Coded (MMYY).
   f.) Sequential Marking (a mark every foot or meter).
   g.) Marking shall be of contrasting color to outer jacket and shall be indented into outer jacket.

G. Performance Requirements.

Cables shall be tested to insure compliance to UL OFNR cables, Bellcore GR-20 and EIA-455 for mechanical strength/resistance.

H. Possible Substitutions.

Super Absorbent Polymer materials in both sub-cable and cable assembly may be substituted for individual 900 micron elastomeric tight buffer material provided all other cable requirements are met.

2.07 GLASS FIBERS FOR COMMUNICATIONS

A. Single Mode Fiber.

1. Single mode fibers shall Corning SMF-28e or equal as follows:
   a.) Fiber Core Diameter 8.2 – 8.8 Microns.
   b.) Fiber Diameter 125 Microns.
   c.) Fiber Type Step index.
   d.) Attenuation < 0.35 dB/km @ 1310 nm < 0.25 dB/km @ 1550 nm.
   e.) Cutoff Wavelength < 1260 nm.
f.) Zero Dispersion Wavelength \( 1302 < L_0 < 1322 \text{ nm} \).
g.) Zero Dispersion Slope \(< 0.092 \text{ ps/nm}^2\text{km}.\)
h.) Environmental Induced Attenuation \(< 0.05 \text{ dB} @ 1310,1550.\)

For water immersion 23 + 2C.
For humidity cycling 98 percent RH.
For Temp. Dependence –60C to +85C.

i.) Proof Test Stress > 100 kpsi.

j.) Coating Diameter 245 + 5 Microns.

B. Multi Mode Fiber.

1. Multi mode fibers shall Corning 62.5/125 fiber or equal as follows:

a.) Fiber Core Diameter 62.5 + 3.0 Microns.
b.) Fiber Diameter 125 Microns.
c.) Fiber Type Step index.
d.) Attenuation \(< 3.0 \text{ dB/km} @ 850 \text{ nm}\)
\(< 0.70 \text{ dB/km} @ 1300 \text{ nm}.\)
e.) Zero Dispersion Wavelength \( 1332 < L_0 < 1354 \text{ nm} \).
f.) Zero Dispersion Slope \(< 0.097 \text{ ps/nm}^2\text{km}.\)
g.) Environmental Induced Attenuation \(< 0.20 \text{ dB} @ 850, 1300.\)

For water immersion 23 + 2C.
For humidity cycling 98 percent RH.
For Temp. Dependence –60C to +85C.

h.) Proof Test Stress > 100 kpsi.
i.) Coating Diameter 245 + 5 Microns.
2.08 IDENTIFICATION TAGS

A. Description.

Heat-shrinkable radiation cross-linked, thermally stabilized, flame-retarded modified polyolefin sleeves. Markers shall be recognized to UL Standard 224.

B. Sleeves shall be smear resistant prior to shrinking and achieve mark permanency when shrunk without the need for permatizing equipment. Sleeves shall achieve mark permanency when standard ballpoint pens or high-carbon content fabric ribbons are used. The markers shall be flattened and mounted on a carrier suitable for use with typewriters or printers. Markers shall be resistant to common industrial fluids including Freon TF, isopropyl alcohol, and Ethylene Glycol.

Markers shall be compatible with an integrated hardware and software system allowing high speed, automated, set or batch, wire-list printing. System shall allow external data to be imported from mainframe computers. System shall be compatible with panel and wraparound markers as specified in this Section.

PART 3 - EXECUTION

3.01 COPPER CABLE INSTALLATION REQUIREMENTS

A. Installation shall conform to with REA TECM Parts 641, 635, and 644, and TIA/EIA 568-A and TIA/EIA-569.

B. Cables shall be inspected by Contractor at time of delivery to the construction site to assure that no damage was done in shipping and that the specified cable was received. Every reel shall be inspected by Contractor for physical damage such as nails driven into reels to secure shipping blocks, lagging, or reel covering missing and cable and seals missing or damaged. A copy of these inspection and inventory reports shall be submitted to the Resident Engineer. Contractor, at no cost to Sound Transit, shall replace all damaged or rejected cable promptly.

C. Wires and cables shall be stored on solid surfaces, which shall adequately support the cable reels, but which shall be well drained and not allow accumulation of liquids, oils, or chemicals.

D. The cable reels shall be aligned and protection provided so as not to allow the reel flanges to damage other reels. Adequate aisles and barricades shall provide accessibility but prevent construction equipment from damaging the cable reels.

E. Cable ends shall be resealed promptly when a length is cut from the reel. Cable reels shall be properly handled, i.e., by using a sling and spreader attached to a shaft through the reel hubs, or by cradling both flanges between lift truck forks. The reels shall not be lifted by the top reel flange or dropped from any height. Lift truck forks shall not touch cable surfaces on the reel. Reels shall always be rolled in the direction opposite the cable wind on the reel. Reels shall not be laid flat.

F. Contractor shall verify that the installation design is correct and adequate for the cables to be installed. Contractor shall assure that conduit size, conduit fill, conduit bend radii, manhole spacing, manhole size, raceways, ducts, and associated hardware are proper for the intended installation.
G. Contractor shall be responsible for verifying the required cable length for each cable run prior to installation. Civil stationing appearing on referenced drawings may be used for defining locations and estimating cable lengths. However, no existing drawings shall be used to determine final lengths and cuts. Actual lengths shall be determined by making on-site inspections and measurements.

H. Wires and cables shall be continuous without splices between junction boxes, terminals, pull boxes, manholes and hand holes. Cables shall not be bent to a radius less than 10 times the diameter of the cable or less than the manufacturers' recommended minimum bending radius, whichever is greater, during installation or as finally installed.

I. Develop a written cable installation procedure and check-off list for approval prior to cable installation. This procedure shall be prepared based on Contractor’s review of the conduit plans, and field site survey and shall include a cable plan and installation information for each cable pull. The installation plan shall include proper procedures for feeding cable into conduit, to maintain proper bend radii, and to minimize friction.

J. Contractor shall give the Resident Engineer 24 hours notice prior to installing cables.

K. Install cable per the approved installation and cable plan. Contractor shall provide any installation hardware necessary to route, support, terminate, or protect any cable installation.

L. Provide additional conduit as required to access equipment enclosures or apparatus.

M. The Contractor shall provide sufficient slack in cable conductors at all terminating points to enable three re-terminations of the conductors without re-servicing or re-pot heading the cable.

N. In certain types of installation, the cable cannot be constrained; therefore, ample cable slack shall be provided for additional flexibility due to vibration of such equipment.

O. Tags to identify cables shall be of plastic material. Tags shall be lettered to correspond with the cable destination and number of pairs in the cable.

P. All cables shall be terminated in order according to the color code. Individual cable pairs shall be identified at each cable termination with plastic tags as specified in Section 17170, Public Address System. All spare pairs in each cable shall be terminated and identified.

Q. All cable entrance openings in equipment enclosures, houses, rooms and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compounds for rooms, houses, walls, or other partitions shall be fire retardant per ASTM E-814. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in an approved manner.

R. A suitable lubricating medium, harmless to the cable jacket, shall be used when pulling cables into conduit, pipe, or duct bank.

S. Where cable transfers from trays or troughs to conduit the ends of the conduit shall be fitted with plastic end bells to prevent damage to the cable.
T. Wherever cables are terminated the outer sheath of the cable shall be carefully removed to the point of cable entrance. At the end of the cable sheath or covering, two layers of plastic electrical tape shall be applied.

3.02 INSTALLATION

A. Installation in Trays or Troughs.
   1. Routing of new wires and cables in the West Lake Station and other communications houses shall be within Contractor-furnished cable trays.
   2. Cable installed in trays or troughs shall be laid loosely, neatly and with a minimum of crossovers, and not pulled into place. They shall have a minimum amount of crossover and shall not be pulled tightly around bends. Dividers shall segregate Cables of different media types.
   3. Cabling between racks or cabinets shall be routed via the overhead cable trays, with 1 foot of slack between the cable tray and each rack to which the cable is connected. Cables shall be secured to the last strap of the cable tray before transitioning to equipment racks or cabinets.
   4. Where transfers of cable from trays to conduit occur, conduit ends shall be fitted with plastic end bells to prevent damage to cable.
   5. Cable identification tags shall be installed every three feet along the run of cable.

B. Installation in Conduit or Pipe.
   1. Contractor shall have all communications conduits, including Sound Transit furnished conduits inspected, mandrel, swabbed, and cleaned prior to cable installation. Manholes shall be cleaned and the location of pulling eyes shall be determined.
   2. Contractor-furnished conduits shall have a clean, smooth concentric interior surface.
   3. Crossover of cables shall be avoided when cables are pulled into conduits. Care shall be taken not to have the conductors pulled tight or kinked in conduit fittings or boxes. All cables to be installed in a single conduit shall be pulled and installed simultaneously.

C. Special Protection.
   1. The Contractor shall provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. Cables damaged due to Contractor's actions shall be replaced or repaired at Contractor's expense at Resident Engineer's discretion.

D. Multi-Pair Cables.
   1. Multi-pair cables shall be continuous without splices, between termination locations. Termination locations shall be located within communication interface cabinets and wayside equipment enclosures, as shown on the Contract Drawings. No terminations of any kind shall be acceptable at locations other than approved equipment enclosures, except as may be approved by the Resident Engineer.
2. The shield of each section of communication cable shall be electrically continuous between terminations on terminal blocks. Each section of communications cable shall have its shield grounded at the terminal block location at one end of the cable section only. The shield shall be grounded with the use of tin plated brass shield connectors and #6 AWG insulated ground wire, in a manner as recommended by the cable manufacturer. The ground wire shall be connected to the terminal block housing ground grid.

3. Pairs shall be maintained intact, and shall terminate in Telecommunications Industry Standard color code. Cable pairs from different cables and binder groups shall not occupy the same line terminal block.

3.03 SPLICING

A. Wires and cables shall be continuous between terminals. Splices will only be allowed with the expressed written permission of the Resident Engineer and only at the locations specified, and then only when there are no practical alternatives. All splices shall be shown on the track and cable plans, and only those splices shown on the approved track and cable plans will be allowed. If allowed, splices shall be made only in readily accessible junction boxes or approved enclosures.

B. The cable manufacturers’ methods, recommendations, materials, and techniques for splicing shall be strictly followed.

C. To minimize mechanical stress at splicing locations, cables shall be trained into final position observing minimum bending radii of the cable of not less than ten (10) times the diameter of the cable.

D. In multiple-conductor splicing, the conductors of one cable shall match the conductors of the other cable being spliced. (i.e. Strait Splice).

E. If splices are not made immediately after installation, ends of cable shall be sealed as recommended by the manufacturer to prevent entrance of moisture.

F. Cleanliness and freedom from contamination shall be strictly observed with respect to splicing materials and joint construction.

G. Only experienced splicers shall be used and a list of employees and certifications of experience will be provided. All necessary tools, protection, and provisions for proper splicing conditions shall be provided.

H. Splices for express signal wire and cable shall conform to all sound standards. Splices will not be permitted in signal wires or cables. Wires and cables shall be continuous between all designed termination points. If the signal wire or cable cannot be installed continuously between designed termination points, Contractor shall install an intermediate relay case for termination at no additional cost.

3.04 TERMINATIONS

A. Cables shall be trained into final position while observing minimum bending radii. Slack shall be provided at all terminals in an amount sufficient for two re-terminations or 50 feet whichever is more.
B. Wire and cables where connected directly to equipment shall be of sufficient length to allow access for removal and inspection of equipment. Wires and cables shall be continuous, without splices, between terminals within a housing and enclosure or piece of equipment.

C. Termination Work shall be conducted under clean and dry conditions.

D. For stranded copper wire, compression-type, insulated terminals in accordance with the wire and cable manufacturers’ recommendations shall be used. The terminals shall be installed only with tools and techniques recommended by the terminal manufacturer. Solid wire shall be terminated to wire eyes.

E. Wires and cables shall be terminated at terminal blocks. Compression-type insulated terminal connections to terminal blocks shall use a single washer on top of the terminal. Wire eyes require two washers for one eye, three washers for two eyes. Connections shall be completed with double nuts torque to the rated value of the nut.

3.05 FIBER CABLE INSTALLATION REQUIREMENTS

A. In general, the installer shall follow the cable manufacturer’s recommended installation practices. Cable damaged to the point the manufacturer will not honor the warranty shall be replaced. Beyond this, Contractor shall abide by the following:

1. Fiber Splicing.

   a.) Fibers shall be fusion spliced only (no mechanical splices) with the following performance requirements:

   b.) Attenuation Due to Splice: 0.1dB @ 850, 1300, 1310, and/or 1550 nm.

   c.) Regardless of splice loss attenuation, splicing of two dissimilar fibers shall not be permitted. For example: Contractor shall not be allowed to splice single mode and multi-mode fiber together.

   d.) Individual splices shall be protected by a reinforced heat shrink sleeve.

   e.) Heat shrink sleeves shall be affixed to splice tray with appropriate dimensions for fiber loops as may be required.

   f.) Splice trays shall be firmly mounted into outdoor rated splice enclosure or into cabinet mounted splice enclosure as shown on installation drawings.

   g.) Design shall ensure splice remains moisture free for an indefinite period of time. When splice is located in airtight enclosure, water-absorbing material such as desiccant gel shall be added to absorb any potential condensation.

   h.) Splices shall, without exception, be located within either an OSP Fiber Splice Case or and ISP Fiber Splice Enclosure. Fiber splices shall be designed and maintained as re-enterable splices. No gel type encapsulants shall be permitted. If required, dry type encapsulant shall be used.
2. OSP Fiber Splice Cases (used in indoor applications).

   a.) Outside Plant Fiber splice cases are used in all outdoor, uncontrolled environments, or building entrances. Uncontrolled environments shall mean any location in which temperature and humidity are not artificially regulated, where relative humidity can exceed 50 percent, or where liquid may come into contact with the fiber cable core.

   b.) Unless in a repair situation or otherwise directed, OSP Fiber splice cases shall not be placed into manholes, cable trays, conduit paths, or in ladder tray. Under normal conditions, Splice Cases shall be placed at least 6 inches above top of rail in a NEMA 4 weather and vandal resistant cabinet sized to hold splice case and a 50’ cable slack coil.

   c.) Splice case shall be of cylindrical design having two points of entry (one in each end of the cylinder) for up to four (4) cables in each point. Entry points shall be of a flexible compression type fitting having a single compression gasket between two type 304 stainless steel plates. Splice case shall be able to withstand submersion up to a depth of 10’ for a period of 10 days without leaking. Splice case shall be able to withstand three (3) repeat blows of 1000N without failure or leakage via submersion test.

   d.) Splice cases shall be filled with dry-type encapsulant to prevent water incursion.

   e.) Sufficient hardware shall be supplied with splice case such that splices and trays do not move relative to the case itself.

3. ISP Fiber Splice Enclosures.

   a.) Inside Plant Fiber splice enclosures are used in indoor environmentally controlled spaces for Inside Plant Cables. Environmentally controlled shall mean any location in which temperature and humidity are artificially regulated, where relative humidity cannot exceed 50 percent, and where no liquid may come into contact with the fiber cable core.

   1.) Splice enclosures shall be wall or 19” rack mounted enclosures large enough to house the internal splice trays and some cable dressing. 50’ slack coils associated with splice shall be located near the splice.

   2.) Splice enclosures shall be NEMA 3 rated.

4. Fiber Terminations.

   a.) Fibers shall be terminated using only factory polished pre-connectorized pig-tails fusion spliced to the OSP or ISP cable.

   1.) Connectors shall be Telcordia 326 compliant ‘SC’ type meeting the following performance requirements:

   b.) Insertion Loss < 0.20 dB.
c.) Return Loss < -55.0 dB.

d.) Fiber type and specifications must match those fibers contained in fiber cable that is being terminated.

5. Installation Methods.

a.) At all times Contractor shall use the least damaging installation method to install cables in order to ensure maximum cable life and maintainability. Preferred methods shall include:

1.) Use of inner duct.

Contractor where specified and where practical use inner duct within larger ducts to optimize conduit usage and prevent damage to cable both in current installation and in future installations. It is recommended that the Contractor use smooth-wall/ribbed inner-duct to reduce friction. Pneumatic couplers should be used to take advantage of cable blowing installation methods.

2.) Cable Blowing.

The preferred method of installing fiber cable in ducts shall be blowing.

3.) Cable Laying.

In cable trough Contractor shall use cable laying techniques to reduce stress. Cables shall not be pulled through cable trays.

4.) Cable Pulling.

Due to the potential for stress damage Contractor shall continuously monitor stress placed upon the cable with dynamometer or equivalent. Data from the monitoring shall be submitted with the cable test results.

5.) Slack Cable.

Every 1000 LF of cable length a 50-foot slack coil of cable shall be placed in an optimal location to provide maintenance with sufficient slack to splice with. Additional 50-foot slack coils shall be placed at either end of the cable.
3.06 DELIVERY, STORAGE AND HANDLING

A. Packing.

Cable shall be shipped on non-returnable wooden reels. The diameter of the drum shall be at least 20 times the diameter of the cable. Cable shall be shipped on reels substantial to withstand reasonable handling and shall be so designed that the inner end of the cable be accessible, but protected from injury. All ends of the cable shall be sealed to prevent entrance of moisture and securely fastened to prevent them from becoming loose during transit.

B. Marking.

1. Each reel shall contain on the outside flange, the following information:
   a.) Manufacturer's name.
   b.) Contract name and number.
   c.) Cable identification number.
   d.) Cable length.
   e.) Date of manufacture

3.07 CABLE IDENTIFICATION

A. All cables shall be tagged at their termination points. In addition, all cables shall be tagged within Communications Houses/Rooms, manholes, hand-holes, housings, etc. and on each side of any barrier the cable passes through. Cables shall also be tagged at aerial exits from conduit risers.

Identification Tags shall comply with 2.08 above.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17150
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SECTION 17170
CABLE TESTING, IDENTIFICATION AND ADMINISTRATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes the requirement for testing, identifying and documenting the cable plant. Contractor is reminded that only upon completion of Work in this Section shall it be paid for furnishing, install, and testing each cable.

1.02 RELATED SECTIONS

Section 17090 – Third Party Interfaces.

1.03 REFERENCE STANDARDS


C. EIA-709.3 - Free Topology Twisted-Pair Channel Specification.


1.04 NOTED RESTRICTIONS

Not Used.

1.05 QUALITY CONTROL

A. Contractor shall follow project quality guidelines.

B. Contractor shall test and verify that all of the physical and optical/electrical properties of cable and equipment supplied and installed meet the original manufacturer’s specification and expected profile for each test performed in this Section. To verify this, Contractor shall supply evidence of that fact and sign paperwork to reflect this work.

C. Optical splice loss shall be less than 0.1 dB at all measured frequencies.

D. Optical terminations shall be less than 0.25 dB insertion loss and less than –50 dB return loss at all measured frequencies.
1.06 SUBMITTALS

A. Test Plan and Procedures.

1. Along with the Final Design Submittal, Contractor shall submit a draft Test Plan and Procedures for the Cable Plant. It shall include, but not be limited to:

   a.) Pre-installation walk-through and verification of site conditions.

   b.) Receipt and validation of manufacturer’s test and QC documentation.

   c.) Installation inspection testing.

      1.) Monitoring maximum tension loads.

      2.) Visual inspection of installation.

   d.) General testing of fiber cables.

      1.) Grading of all terminations by TIA/EIA-455-57B.

      2.) End-to-end bi-directional power meter test at 1310 and 1550 nm.

      3.) Bi-directional OTDR test at 1310 and 1550.

   4.) Calculation of the following:

      - Optical loss budget.

      - Return loss.

      - Splice loss.

      - Termination loss.

      - Physical distance to all fiber features correlated with actual track positioning.

   e.) Special testing of main ring fibers.

      1.) Contractor shall perform the following additional tests on the 24F ring that connects all OC-12 nodes.

         - Optical Spectrum Analysis.

         - Range: 1250-1650 nm.

         - Resolution: +/- 0.033 nm.
- Accuracy: +/- 0.015 nm.
- Power accuracy: 0.4 dB.

f.) Chromatic Dispersion Analysis.

1.) Range 1250 – 1650 nm.
   - Wavelength accuracy: 0.1 nm.
   - Dispersion accuracy: 1.6 ps/nm.

g.) Polarization Mode Dispersion Analysis both 1st and 2nd order.

1.) Range: 0 – 115 ps.
2.) Accuracy: +/- (0.020 +/- 2 percent of PMD).

h.) General Testing of Copper Cables including the following:

1.) Cable exterior jacket insulation resistance.
2.) Cable shield resistance to ground.
3.) Other cable characteristics such as cross-talk, inductive coupling, etc., or other notable feature specified by the manufacturer.
4.) Termination points for connectivity, mis-terminations, etc.

i.) Special testing for Coax cables.

Contractor shall TDR all coax cables and identify all notable features.

j.) Post installation survey and labeling of cables.

k.) Procedures to verify documentation both as-built drawings and recording cable in Cable Management System.

l.) Submittal of Test Results to Resident Engineer.

PART 2 - PRODUCTS

Not Used.
PART 3 - EXECUTION

3.01 GENERAL

Contractor shall execute the Approved Test Plan and Procedures.

3.02 PRE INSTALLATION

A. Contractor shall coordinate with others supplying conduits, cable trays, or other wireway/termination points. Prior to hand over of cableways and termination points, Contractor will have an opportunity to walkthrough and inspect work performed by others. Contractor may generate punch list for submittal to Resident Engineer.

B. Upon completion of punch list items, Contractor accepts work by others.

3.03 FACTORY TESTING

Contractor shall collect and submit for approval actual factory test results performed on cables.

3.04 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for delivery, storage, and handling of cables.

3.05 INSTALLATION

A. Contractor shall monitor and record maximum pulling tension applied to each cable installed.

B. Cable labels and submit results to Resident Engineer.

3.06 FIELD TESTING

A. Field testing shall include a visual inspection with Resident Engineer to verify proper installation methods were applied including the following:

1. Cable matches specs and terminations are per the drawing.

2. Cable is free of rips, tears, kinks, or other potentially damaging anomaly.

3. Wire/Cable Labels are both installed at both ends and at each access point and accurate.

4. Cable is secured/racked properly.

5. Cableway/wireways are plugged and/or firestop added between rooms as required.

6. As-built drawings are accurate and complete.

7. Cables are documented in Cable Management System.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17170
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PART 1 - GENERAL

1.01 OVERVIEW

This Section contains the Contractor’s requirements for the development of a maintenance manual and training program necessary to train Sound Transit to maintain the communications cable plant.

1.02 RELATED SECTIONS

A. Section 01785 – Operations and Maintenance Manuals.

B. Section 01820 – Training Program.

1.03 REFERENCE STANDARDS

A. TIA/EIA-568-B.

B. EIA-709.3.

1.04 NOTED RESTRICTIONS

Not Used.

1.05 QUALITY CONTROL

Contractor shall follow project quality guidelines.

1.06 SUBMITTALS

A. Contractor shall submit maintenance manuals and training program drafts along with the Final Design Submittal.

B. Final version of maintenance manual and training program shall be submitted 30 days prior to acceptance of any section of cable plant.

1.07 DELIVERABLES

A. Maintenance Manual shall cover the following topics at a minimum:

1. Testing fiber cables.

   a.) Optical Power Loss.

   b.) Insertion Loss.

   c.) Optical Return Loss.
d.) Splice Loss.

e.) Connector Loss.

f.) Bi-directional OTDR analysis at 1310, 1550 and 1625 nm.

g.) Optical Spectrum Analysis from 1250nm to 1650nm.

2. Trouble shooting fiber cable.

a.) Physical inspections.

b.) Identification of installation mis-alignments (fiber splice and termination mismatches).

c.) Identification of microbends, bubbles, or other manufacturing anomalies.

d.) Location of mechanical problems: breaks, bends or crush points.

e.) Monitoring for cable deterioration.

3. Fiber Cable Repair.

a.) Re-splicing fibers.

b.) Installing 1000’ fiber patch kit.

4. Documenting Fiber Cables.

a.) Using cable management programs.

b.) Documenting and tracking fiber cable performance over time.

5. Testing Copper cables.

a.) Compliance with industry standards

b.) Insulation Resistance.

6. Trouble shooting copper cable.

a.) Physical inspections.

b.) Identification of installation mis-alignments on terminations or pair switches.

c.) Identification of intermittent failures.
d.) Location of mechanical problems: breaks, bends or crush points using TDR.

e.) Monitoring for cable deterioration.

7. Copper Cable Repair.

a.) Re-splicing cables.

b.) Installing new and re-terminating.

8. Documenting Copper Cables.

a.) Using cable management programs.

b.) Documenting and tracking copper cable performance over time.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 TRAINING PROGRAM

Contractor shall develop train course outline and quick reference sheet per Section 01820, Training Program. Training Program shall train at least 4 classes of 5 persons each on how to maintain the cable plant per the Maintenance Manual. Training shall be strictly hands on using actual materials and test equipment supplied for this purpose. Training shall be for a minimum of 40 hours per class covering all of the material in the maintenance manual.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17180
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SECTION 17190
CABLE PLANT SPARES AND SPECIAL TOOLS

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes the requirements for supply of spares and special tools for the cable plant section of Work.

1.02 RELATED SECTIONS

A. Section 17140 – Backbone Cabling Requirements.

B. Section 17150 – Facility Cabling Requirements.

1.03 REFERENCE STANDARDS

Not Used.

1.04 CITED STANDARDS

Not Used.

1.05 NOTED RESTRICTIONS

Not Used.

1.06 QUALITY CONTROL

Contractor shall follow Quality Control standard established in this Agreement.

1.07 SUBMITTALS

A. In addition to the provisions of Sections 17140, Backbone Cabling Requirements, and 17150, Facility Cabling Requirements, Contractor shall prepare a recommended patch and repair kit for each of the various OSP cables supplied including, but not limited to, the following types of materials:

1. 1000 LF of Cable.

2. Two (2) splice cases including splice trays, sleeves, and dry fill material.

3. Manhole racking equipment.

4. Labels, signs, and other misc. materials and instructions.

1.08 DELIVERABLES

Included in Sections 17140, Backbone Cabling Requirements and 17150, Facility Cabling Requirements.
PART 2 - PRODUCTS

Included in Sections 17140, Backbone Cabling Requirements and 17150, Facility Cabling Requirements.

PART 3 - EXECUTION

Included in Sections 17140, Backbone Cabling Requirements and 17150, Facility Cabling Requirements.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17190
PART 1 - GENERAL

1.01 OVERVIEW

The Office Services Network (OSN) is the set of Ethernet LAN’s in the O&M Facility and in the passenger stations designated for general computing. The OSN also supplies Ethernet connectivity for the PABX phones in the passenger stations. The OSN is a separate network from the Control System Network in order to isolate the CCS and allow it to be exclusively for control functions. The intent is for the CCS to maintain a high level of availability unaffected by OSN problems due to hardware or software failure and security issues.

1.02 SECTION INCLUDES

A. This Section contains functional and design requirements for:

1. Ethernet Networking within the O&M Facility within and outside of the OCC.
2. Ethernet Networking for PABX phones in Passenger Stations.

1.03 RELATED SECTIONS

A. Section 17040 – Technology Documentation.
B. Section 17090 – Third Party Interfaces.
C. Section 17170 – Cable Testing, Identification and Administration.
D. Section 17500 – Cable Transmission System/WAN Overview.
E. Section 17800 – Control System Overview.
F. Section 17801 – Control System Network.
G. Section 17930 – Cable Management System.

1.04 REFERENCE STANDARDS

A. BICSI.

Telecommunications Distribution Methods Manual (TDMM).
B. TIA/EIA.

1. TIA/EIA-455 Fiber Optic Test Standards.
2. TIA/EIA-526 Optical Fiber Systems Test Procedures.
5. TIA/EIA-606 Administration Standard for Telecommunications Infrastructure of Commercial Buildings.
6. TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.
7. TIA/EIA-758 Customer Owned Outside Plant.

1.05 SYSTEM DESCRIPTION

A. Functional Requirements.

1. The OSN is the cable, connecting hardware and active components necessary to provide a unified Ethernet network to all locations within Link and to selected third parties. The network infrastructure shall be designed to support the known present, and reasonably certain future requirements. TIA/EIA-568-A provides the standards to be applied when designing and installing the OSN.

a.) O&M Facility OSN Network.

1.) Provide Category 6 cabling for Ethernet connectivity to all OSN nodes in the O&M Facility as shown in the Contract Drawings.

2.) Centralize the OSN in the Communications Equipment Room in a star network topology. Provide sufficient equipment racks for mounting all servers, switches, patch panels, and other equipment.

3.) Connect and configure the network firewall specified in Section 17801, Control System Network to allow access to the CSN by certain OSN computers. Only OSN computers physically located within the OCC shall have access to the CSN.

4.) Provide and configure a secure wide area network link to the Sound Transit LAN in the Union Station building.

5.) Power OSN equipment within the OCC and CCER by the same UPS system supplying other critical OCC systems. Outside of the OCC, OSN equipment shall be powered from non-UPS station power.
b.) Station OSN Ethernet Network.

1.) Provide a shared 10 Mbps Ethernet connection from the OSN Station Network Switch to all PABX phones and maintenance ports as shown in the Contract Drawings.

2.) Provide access to the shared 10 Mbps Ethernet connection for one network maintenance port on the communications terminal board in the Communications Cabinet. Clearly label this port to distinguish it from the CSN maintenance port.

c.) Signal House OSN Ethernet Network.

1.) Provide access to the shared 10 Mbps Ethernet connection for one PABX phone on the communications terminal board in the Signal House.

2.) Provide access to the shared 10 Mbps Ethernet connection for one network maintenance port on the communications terminal board in the Signal House. Clearly label this port to distinguish it from the CSN maintenance port.

d.) Traction Power Substation OSN Ethernet Network.

1.) Provide access to the shared 10 Mbps Ethernet connection for one PABX phone on the communications terminal board in the Signal House.

2.) Provide access to the shared 10 Mbps Ethernet connection for one network maintenance port on the communications terminal board in the Signal House. Clearly label this port to distinguish it from the CSN maintenance port.

e.) WAN Connection.

All OSN LANs shall be connected to form a system wide network through the SONET Add Drop Multiplexors (ADM). Each OSN Ethernet switch shall connect at 10Mbps to the ADM at that location. See Section 17500, Cable Transmission System/WAN Overview.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Resident Engineer. These submittals are subject to Resident Engineer approval.


   a.) Contractor shall submit the following information prior to Conceptual Design Review per the schedule and requirements set in Section 01330, Submittals.

   1.) Schematic block diagrams including all active components for all OSN locations. These conceptual drawings shall be used to illustrate the intent of the OSN infrastructure design.
2.) Detailed description of OSN design.

2. Preliminary Design Review.

a.) Contractor shall submit the following information prior to OSN Preliminary Design Review per the schedule and requirements set in Section 01330, Submittals.

1.) Updated schematic block diagrams.

2.) Installation drawings showing the actual installer how the network is to be installed. Installation drawings shall, at a minimum, show pathway locations and routing, configuration of telecommunications spaces including backboard and equipment rack configurations, and wiring details including identifier assignments.

3.) Detailed list and description of all equipment intended for use.

4.) Updated detailed description of OSN design.

5.) Request for deviations and exceptions from these Specifications.

3. Final Design Review.

a.) Contractor shall submit the following information prior to OSN Final Design Review, per the schedule and requirements set in Section 01330, Submittals.

1.) Final Schematic Block Diagrams.

2.) Final Installation Drawings.

3.) Final list and description of all equipment and components.

4.) Field installation details for all types of components.

5.) Rack/elevation drawings.

6.) Sample test procedures for all equipment and cable testing.


a.) Prior to Final Acceptance Testing, according to the project schedule guidelines set in Section 01330, Submittals, Contractor shall submit final versions of the following:

1.) User Manuals.

2.) Maintenance Manuals.
3.) Completed test results for all equipment and cable testing.

4.) Training Manuals.

5. Training.

Training for the OSN shall be included with the training provided for the CSN as described in Section 17801, Control System Network.


Prior to the Final Acceptance Test, according to the project schedule guidelines set in Section 01330, Submittals, Contractor shall submit the final test procedure for all testing.

7. Test Results.

Prior to acceptance of the OSN, all test results shall be submitted. Test results are subject to inspection by Resident Engineer.

8. As-Builts.

Prior to acceptance of the OSN, Contractor shall submit all as-builts. As-builts are subject to inspection by Resident Engineer. As-built drawings shall graphically document the installed network infrastructure through floor plan, elevation, and detail drawings in Section 17930, Cable Management System. The identifiers for major infrastructure components shall be recorded. The pathways, spaces, and wiring portions of the infrastructure each may have separate drawings if warranted by the complexity of the installation, or the scale of the drawings. Drawings shall be in the latest AutoCAD format on a CD and in printed form.

**PART 2 - PRODUCTS**

A. Ethernet Switches.

1. Ethernet switches shall be provided for OSN network requirements within the OCC and CCER and at all OSN locations.

   a.) Sized for designed OSN requirements plus 25 percent spare at each location.

   b.) Compliant with all referenced standards including IEEE 802.3.

   c.) Ports shall be configurable for 10, 100, or 1000 Mbps Ethernet auto sensing and auto negotiating.

   d.) Integrated inline power to IP phones for a single wire to the phone.

   e.) Fully supported Simple Network Management Protocol (SNMP).

   f.) Password protected administration interface.
g.) Local in-band management through EIA-232 interface.

h.) Remote out-of-band management through SNMP or Telnet client.

i.) Onboard hardware diagnostics and LEDs indicating successful completion or failure of power-up diagnostics; link good LEDs for each Ethernet port.

2. Except for the Ethernet Switches, the OSN shall use the same equipment racks, grounding and bonding, and network infrastructure in place for the CSN. Refer to Section 17801, Control System Network, for all CSN network design requirements.

PART 3 - EXECUTION

3.01 OVERVIEW

A. The OSN network infrastructure shall be designed and installed in accordance with applicable codes and industry standards. The various components of the structured cabling system shall be installed strictly in accordance with the manufacturer’s instructions and procedures.

B. All design and installation requirements specified in Section 17801, Control System Network, for the CSN shall apply identically to the OSN.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17200
PART 1 - GENERAL

1.01 OVERVIEW

A. The Sound Transit Communications Voice Systems provide both emergency and non-emergency voice communication throughout the Link system for employees, patrons, maintenance personnel, and emergency service personnel. The Voice Systems also provide services associated with voice communication such as voice mail, telephone PABX services, and recording of emergency voice communications. The Voice Systems on Link are comprised of the following subsystems:

1. Non-emergency phone network comprised of the Digital IP telephone network (as part of the Office Services Network) at stations.

2. The digital telephone network at the central control center and the O&M facility.

3. The Emergency telephone network (comprised of the Emergency Telephone (ETEL) network.

4. Passenger Emergency Telephone (PET) network.

1.02 SECTION INCLUDES

This Section describes the overview of voice systems for Sound Transit Link Communications.

1.03 RELATED SECTIONS

A. Section 17310 – PABX.

B. Section 17320 – Telephone Sets, Faxes and Modems.

C. Section 17330 – Voice Mail System.

D. Section 17360 – Emergency Phone System.

E. Section 17365 – Passenger Emergency Telephones.

F. Section 17520 – Voice Circuits.

G. Section 17550 – Leased Lines.

H. Section 17560 – Quality of Service Requirements.

I. Section 17730 – Integrated Communications Controller.
1.04 SYSTEM INTERFACES

A. The Voice System provides voice communications within the Sound Transit Communications system, as well as communications with external organizations such as King County Metro, the Sound Transit Information Technology (IT) department, and to the public telephone company local and long distance providers. These interfaces are described in Sections 17310, PABX, 17550, Leased Lines, and 17090, Third Party Interfaces.

1. The Link Communications System interface with King County Metro provides coordination between KC Metro and Sound Transit Communications Operations and Maintenance personnel; as well as general communication between Link and King County Metro.

2. The Link Communication System interface with Sound Transit IT provides communications throughout the Sound Transit organization. This interface also provides primary access to Sound Transit IT’s long distance service with Washington State, and provides Sound Transit IT with a redundant long distance path through Link.

3. A secondary Communication System interface with Washington State will provide redundant long distance services to Link and other Sound Transit personnel.

4. These interfaces are described in Section 17310, PABX, and in Section 17550, Leased Lines.

B. Internal to Link Communications, the Voice System interfaces with the following internal systems:

1. Field Control System.

2. Central Control System.

3. PA System.

4. CCTV System (for Emergency Telephones and Passenger Emergency Telephones).

5. Integrated Communications Controller (for Emergency Telephones and Passenger Emergency Telephones).

6. Communications System Backbone Network.

1.05 VOICE SYSTEM COMPONENTS

A. PABX.

1. The PABX switches both analog and digital calls. The PABX also provides all voice services. The PABX provides a T1 interface to King County Metro, an interconnect with the Sound Transit PABX, an interface with Washington State for long distance service, and an interface with a local phone service provider. See Section 17310, PABX, for a description and detailed requirements for the Sound Transit PABX.
B. The Voice System is made up of both an emergency voice network that includes both the Emergency Telephones (ETELs) and the Passenger Emergency Telephones (PETs), and a non-emergency voice network that includes the digital IP phone network at the stations and at the OCC and the O&M facility.


   a.) The Emergency Voice Network is made up of Emergency Telephones for Sound Transit and emergency personnel and Passenger Emergency Telephones for Sound Transit patrons. Emergency phones are IP-based emergency telephones located at Sound Transit Link stations and in the tunnels. Emergency phone traffic is transmitted over the Fiber Optic Communications Backbone with the highest priority traffic, and switched via the PABX and controlled via the Integrated Communications Controller. The Integrated Communications Controller requirements are described in Section 17730, Integrated Communications Controller.

   b.) Both types of emergency phones interface with the CCTV system such that when an emergency phone is taken off hook or the push-to-talk is activated, the associated CCTV camera is turned on and panned to focus on that emergency phone. Emergency Telephone and Passenger Emergency Phone requirements are described in Sections 17360, Emergency Phone System and 17365, Passenger Emergency Phones, respectively.


   The Non-emergency voice network provides non-emergency voice connectivity to Sound Transit personnel at the stations and at the OCC and at the O&M Facility. Note that pay phones will be provided under a separate Contract for Sound Transit patrons. At the stations, non-emergency IP phones will be provided and connected via the Office Services Network. At the CCER and the O&M Facility, analog phones will be provided and connected throughout the facility. Telephone sets, faxes and modem requirements are described in Section 17320, Telephone Sets. Voice mail requirements are described in Section 17330, Voice Mail System.

**PART 2 - PRODUCTS**

Not Used.

**PART 3 - EXECUTION**

Not Used.

**PART 4 - MEASUREMENT AND PAYMENT**

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

**END OF SECTION 17300**
PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall provide a Central Private Automatic Branch Exchange (PABX) as part of the Communications System that provides voice communications throughout the O&M facility as well as throughout Link. The PABX shall provide both digital and analog switching, where analog phones are to be used at the O&M Facility and digital IP phones are to be used along the wayside and at the stations.

1.02 SECTION INCLUDES

This Section includes the requirements for furnishing, installing and testing a PABX at the Operations and Maintenance (O&M) Facility. The PABX shall be compatible with and shall connect with at a minimum the PABXs located at King County Metro and Union Station as Specified in Section 17550, Leased Lines, and with telephones specified in Section 17320, Telephone Sets.

1.03 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 16120 – Electrical Wires and Cables.

C. Section 17030 – Reliability Management Program.

D. Section 17040 – Technology Documentation.

E. Section 17050 – Configuration Management.

F. Section 17060 – Special Tools and Spare Parts.

G. Section 17070 – Human Factors Engineering and Ergonomics.

H. Section 17150 – Facility Cabling Requirements.

I. Section 17320 – Telephone Sets.

J. Section 17330 – Voice Mail System.

K. Section 17360 – Emergency Phone System.

L. Section 17365 – Passenger Emergency Telephones.

M. Section 17370 – Voice System Testing, Identification and Administration.

N. Section 17380 – Voice System Training, Manuals, Special Tools and Spare Parts.
0. Section 17390 – Voice System Support and Warranty.

P. Section 17510 – Communication System BackBone Equipment.

Q. Section 17550 – Leased Lines.

R. Section 17740 – Master Clock System.

S. Section 17800 – Control System Overview.

T. Section 17801 – Control System Network.

U. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:


3. ATIS T1.101 Synchronization Interface for Digital Network, for Telecommunications.


6. IEEE 802 Local and Metropolitan Area Networks.


10. NEMA Enclosures for Electrical Equipment up to 1000 Volts.


15. TIA/EIA/IS-968  Connection of Terminal Equipment to the Telephone Network.


20. UL 50  Standards for Safety for Enclosures of Electrical Equipment.

1.05 QUALITY CONTROL

Quality control shall be as specified in this document. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Resident Engineer. These submittals are subject to Resident Engineer approval.


a.) The Contractor shall submit the following information prior to PABX Conceptual Design Review per the schedule and requirements set in Section 01330, Submittals.

1.) Description of PABX functions.

2.) Display layouts showing the location and type of PABX equipment.

3.) Display layouts showing the terminal equipment.

4.) Preliminary list of equipment.

5.) Deviations and exceptions from these Specifications.

6.) Numbering Plan and requirements for routing features.

7.) Interface diagrams, descriptions and Use Cases for PABX integration with other PABXs (e.g. King County Metro and Sound Transit at Union Station).

8.) Voice and data features for specified user types.
2. Preliminary Design Review.

   a.) Contractor shall submit the following minimum information prior to PABX Preliminary Design Review, per the schedule and requirements set in Section 01330, Submittals.

   1.) Layout of PABX and associated PABX equipment.

   2.) Detailed list and description of all equipment intended for use.

   3.) Draft description of PABX design, operations and maintenance to include:

      - Results of telephone review to match telephone equipment with employees.

      - Draft definition of class of service, determination of feature buttons.

      - Draft definition of hunt groups, call pick-up and dial intercom groups.

   4.) An activation plan, outlining the proposed sequence in which PABX interfaces will be connected.

3. Final Design Review.

   a.) Contractor shall submit the following minimum information prior to PABX Final Design Review, per the schedule and requirements set in Section 01330, Submittals

   1.) Detailed description of PABX design, operations and maintenance to include:

      - Final design schematics for the PABX.

      - Final list and description of all equipment used for PABX.

      - Results of telephone review to match telephone equipment with employees.

      - Final definition of class of service, determination of feature buttons.

      - Final definition of hunt groups, call pick-up, and dial intercom groups.

      - Installation Manual and field installation details as required.

      - User and Maintenance Manuals.

      - Test Plans, including Factory and Field Tests.

      - Activation Plan for connection of PABX interfaces.


Contractor shall submit Factory Test Procedures as indicated in Section 01330, Submittals and 17050, Configuration Management.

5. Installation Drawings.

Contractor shall submit Installation Drawings as indicated in Section 01330, Submittals and Section 17050, Configuration Management.

6. Test Procedures.

Contractor shall submit Test Procedures as indicated in Section 01330, Submittals, and Section 01452, Contractor Construction Control Requirements.

7. Final User Documents.

a.) Prior to Final Acceptance Testing according to the project schedule guidelines, Contractor shall submit final versions of the following:

1.) User Guides for PABX Operation and Feature Use.

2.) Maintenance and Service Manuals.

3.) Training Plan.

4.) Training Manuals.

b.) It is expected that Contractor shall supply the manufacturer’s standard manuals for operations, maintenance and training of the PABX. Specific features particular to and used by Sound Transit shall be identified and given special attention in the training plan. Supplementary materials shall be provided as operational and maintenance reference guides specific to Sound Transit.

8. Training.

a.) After Factory Test and before Final Acceptance Testing, Contractor shall provide the following:

1.) Courses to train administrators in specific areas such as network management, PABX management, cost management, facilities management, call accounting, voice mail and alarm monitoring.

2.) Comprehensive courses to train those people who will train the end users.

9. Final Acceptance (Site) Test Procedure.

Prior to the Final Acceptance Test according to the project schedule guidelines set in Section 01770, Contract Closeout, Contractor shall submit the final test procedures for all testing.
10. Test Results.

Prior to acceptance of the PABX, all test results must be submitted. Test Results are subject to inspection by Resident Engineer.

11. As-Builts.

Prior to acceptance of the PABX, all as-built documentation (hardware and software) must be approved by Resident Engineer. As-built documentation shall be sufficient to re-install and configure equipment exactly as built by Contractor, including field modifications and labeling, without the aid of engineering or design support.

PART 2 - PRODUCTS

2.01 GENERAL

Contractor shall furnish and install a PABX in the CCER at the O&M Facility.

2.02 EQUIPMENT RELIABILITY

A. Notwithstanding the requirements of Section 01330, Submittals, the following shall apply:

1. The MTBF for the networked PABX in the installed environment shall be greater than 40,000 hours.

2. Latency Error Budget.

Packet transit times, including voice encoding and decoding, for both network and/or PSTN, shall be less than 150 milliseconds, per ITU-T Recommendation G.114.

3. Completed Call Test.

During factory testing, a completed call test shall be made. There shall be no more than two in 10,000 locally originating and incoming calls misdirected, unsuccessfully terminated, prematurely disconnected or otherwise failing as a result of equipment malfunction and/or equipment deficiencies. This test shall be made with a load box with no less than 10 lines access and 10 subscriber numbers for completion, or equivalent, with no other traffic in the PABX. If there is a failure in the equipment during this test, the cause shall be repaired and the test restarted at zero calls.

2.03 PABX

A. Equipment Design.

1. The PABX shall be of digital solid-state, modular design, utilizing the latest hardware and software technologies available at the time of manufacture. The PABX and accessories shall provide, but not be limited to the following:

a.) Stored Program Control (SPC), computerized digital switching system, with a battery backed non-volatile RAM for customer data.
b.) Capability to interface with all Public Switched Telephone Network (PSTN) signals and protocols.

c.) ISDN, Centrex, long distance trunk routing, and Direct Inward Dial capability.

d.) Private Network Services such as numbering, centralized service attendant, call transfer, and DID.

e.) Utilize both telephony and Internet Protocol (IP) signaling for maximum efficiency.

f.) Operate from 120 VAC, 60 Hz power or 48Vdc.

g.) Have a wired capacity of at least 20 percent in excess of specified equipped capacity.

h.) Have expansion capacity of at least 300 percent of base installed under this Contract.

2. Switching Capacity.

a.) Minimum required number of supported analog telephones: 196.

b.) Minimum required number of supported digital Voice over Internet Protocol (VoIP) telephones: 100.

c.) Minimum required number of Digital Access Lines (T-1): four (4).

3. Supported Analog Trunk Types:

a.) Loop or Ground Start Central Office (CO).

b.) Two (2) or four (4) wire E&M.

c.) Direct Inward Dial (DID).

d.) Paging.

4. Supported Digital Trunk Types:

a.) T-1.

b.) VoIP.

c.) ISDN-PRI.

d.) ISDN-BRI.
5. **PABX Interfaces.**

   a.) Design, integration and testing interfaces between the PABX and other subsystems and Work are as follows:

   1.) PABX phone network for O&M Facility (Analog).

   2.) OS Network for connectivity of wayside PABX phones (10 Base T).

   3.) Voice Mail.

6. **T-1 line to King County Metro PABX via SONET.**

   a.) Contractor shall design PABX with the capability for 5-digit dialing across the King County Metro PABX switch for designated users/phone numbers.

   b.) Contractor shall design PABX such that all services and features described in this Section and determined by Resident Engineer are available across the King County Metro PABX. Resident Engineer will provide Contractor with King County Metro PABX manufacturer, model and configuration information.

7. **T-1 Line to Sound Transit Union Station PABX via SONET (Union Station PABX Switch is NEC NEAX 2400 IPX).**

   a.) Contractor shall design PABX with the capability for 5-digit dialing across the King County Metro PABX switch for designated users/phone numbers.

   b.) Contractor shall design PABX such that all services and features described in this Section and determined by Resident Engineer are available across the King County Metro PABX.

   c.) **Long Distance Requirements.**

      Contractor shall use the Washington State Long Distance service via Sound Transit’s existing switch and service.

   d.) **External T-1 to Washington State Long Distance service, as a redundant service along with Sound Transit’s existing service.**

   e.) **External DID Lines to 3rd party service provider for local service to be determined by Resident Engineer.**

   f.) **911 Emergency Requirements.**

      1.) Contractor shall deliver the capability for the PABX to determine the physical location of each phone initiating a call.

      2.) For 911 calls, Contractor shall ensure every 911 call is routed to the appropriate 911 Jurisdiction, based on the location of the phone initiating the call.
g.) Integrated Communications Controller Switch. PA at the O&M Facility shall be operable from any PABX extension in the O&M Facility.

h.) Data Switching Capacity. V.90 support with up to 53 kb/s Asynchronous downstream and 33.6 kb/s upstream; 64 kb/s Synchronous.

i.) Network Management System (NMS) for PABX administration and maintenance, and capable of displaying and printing traffic information, performance of software adds, moves, and changes, traffic reports and diagnostics. In general, NMS shall have all features available for remote maintenance and administration that are available locally.

j.) PABX shall get all timing and synchronization information from the Master Clock System described in Section 17740, Master Clock System.

8. IP Trunk Features.

a.) Interface:

1.) Network Interface: 10/100 Base T (IEEE 802.3), RJ-45.

2.) Ethernet: Half-Duplex.

b.) Codec Types:

1.) G.711 Encoding/Decoding (64 kb/s).

2.) G.723.1 Compression Encoding/Decoding (5.3 to 6.3 kb/s).


c.) Fax: Group 3 and T.38.

9. Required PABX Features.

a.) The following features must be provided:

1.) Answer Supervision.

The PABX must return answer supervision signals to the public network when calls are:

- Answered by the called telephone.

- Routed to a recorded announcement.

- Routed to a dial prompt.
2.) Documentation showing compliance with applicable FCC regulations shall be submitted.

3.) Authorization Codes.

The PABX shall provide capability to allow users to override a PABX station Class of Service by dialing a valid authorization code in order to place outgoing calls from a restricted telephone.

4.) Automatic Route Selection.

The PABX shall provide automatic routing of calls over alternative facilities with optimization based on the number dialed. The PABX should be programmable to route calls over first available trunk facilities in a specified sequence for least cost routing.

5.) Busy Out.

The PABX shall prevent a telephone which is left off-hook from tying up common equipment in the PABX.

6.) Call Accounting (Station Message Detail Recording (SMDR) Output).

- The PABX shall provide, a data stream which will provide calling details on all incoming, outgoing, and internal calls.

- The Station Message Detail Recording (SMDR) call record shall include the calling extension, and the dialed telephone number. The SMDR record shall identify the specific trunk that carried the call and the length of time that the trunk was held to the nearest 1/10th minute.

7.) Call Forwarding.

Any extension shall be capable of being automatically routed to other destinations based on the source of the call. At minimum, the term “other destinations” shall mean the following:

- Any other destination in the PABX.

- Any telephone number outside the PABX.

- Any attendant console in the PABX.

- Any specific voice mailbox.

- No destination, giving the caller a busy tone if the extension is busy or ringing if the extension is available.

The PABX shall automatically route calls from a busy extension to other destinations.
The identification of the originally called extension shall be fully operational at each advancement of forwarding, including for alphanumeric display and for answer by the voice message box assigned to the originally called extension.

The PABX shall automatically route calls from a busy extension to other destinations. Based on extension software definition, the PABX may forward internal calls only, or external calls only, or internal and external both, or present the caller with a busy tone.

The PABX shall forward calls to other destinations depending on whether the call source is internal or external.

The PABX shall automatically route calls to other destinations after the originally called extension rings for a programmable period without answer. Based on extension software definition, the PABX may forward internal calls only, or external calls only, or internal and external both, or present the caller with a busy tone.

Timing parameters for Forward-No Answer shall be controlled by extension software definition, not simply as a PABX parameter which applies to all extensions.

The PABX shall allow the telephone user to program any extension to forward all calls to another destination. Call forward variables shall override previous programming for call forward-busy and call forward-ring-no answer.

Where several extensions in a hunting arrangement appear on more than one telephone in a group, one controlling extension shall be able to invoke call forwarding variable for all instruments. It shall not be necessary to forward from each instrument in the group to activate the feature.

8.) Call Hold.

The PABX shall allow a telephone user to hold any call in progress without the need to depress the switch-hook, without the need for any mechanical hold arrangements and without the need to distinguish internal and external calls.

9.) Call Transfer.

The PABX shall allow each telephone set to transfer an established connection without distinction between internal and external connections to any non-restricted telephone set within the PABX or any trunk. The user will not have to depress the switch-hook.

10.) Caller ID.

The PABX shall provide the capability for the call recipient to view the caller's telephone number before answering the call.

- Class of Service.
- The PABX shall contain the following telephone set classes of service which must be software controlled:

   Internal calling only.

   Internal calls and specified (in software tables) prefixes.

   Internal, local and specified (in software tables) external prefixes and area codes.

   Unlimited access.

11.) Direct Inward Dial (DID).

- The PABX shall allow incoming calls from the public network (not FX or WATS) to be completed to specific telephone without attendant assistance.

- DID calls to DID-restricted telephone lines shall be routed to an attendant or recorded announcement, depending on the option selected.

- The PABX shall have the ability to forward DID calls to another telephone set if the DID telephone dialed is busy or does not answer.

- The telephone forwarded to shall be given an indication of forwarded DID calls received at the telephone so that forwarded DID calls are distinguished from other calls forwarded or transferred to the telephone.

- Calls received on DID extensions shall be able to hunt to and from another DID extensions and/or non-DID extensions.

- Calls made to DID numbers that do not exist or are not assigned shall be routed to reception or an intercept answering machine.

- When a DID call is received, the PABX shall release that DID number back to the Central Office so that subsequent calls from the CO to that same DID number can be received while the first call is still in progress.

- The PABX shall include any equipment necessary to transfer the DID trunks out of the PABX to analog single-line telephones in the event of PABX failure or commercial power failure. This shall be provided on all DID trunks.

10. Dialing.

a.) The PABX shall provide the capability of dialing both external and internal users. The PABX shall provide, at a minimum, the following convenience dialing features.

1.) External Dialing.
The PABX shall be capable of providing connectivity for internal users to dial externally by pressing one digit prior to dialing the phone number to reach an outside line.

2.) Internal Dialing.

The PABX shall be capable of providing 5-digit extension dialing to all internal users and to Resident Engineer designated users from the King County Metro PABX switch and the Sound Transit Union Station PABX switch.

11. Distinctive Ring.

Distinctive/Discriminating Ringing. The PABX shall provide separate ringing tones for internal calls, incoming internal calls, intercom calls, and special purpose calls as necessary.

12. Intercept.

The PABX shall provide Intercept service, which allows for the automatic re-routing of calls that cannot be completed because of equipment, imposed restrictions, or dialing irregularities. Intercept calls are routed to the attendant, a tone, or an announcement.

13. Hunting.

a.) The PABX shall provide the following types of hunting. This service applies to calls to a busy extension and is not in lieu of the specifications of Call Forward busy.

1.) Circular.

2.) Terminal.

3.) Secretarial.

14. Last Number Redialing.

The PABX must automatically store the last number that was dialed, whether the call rings, is busy or answered. The number can then be redialed by pressing a button or dialing a code.

15. Line Selection.

The PABX shall allow a user to select any line available to that user to connect to that line.


The PABX shall provide the capability for a message waiting indication. The user will know that a message is waiting if either the telephone set lamp flashes or a stuttered dial tone is heard on off-hook. The user can then retrieve the message by dialing the message-center directly or by retrieving his or her voice mail, as appropriate. Once all new messages have been retrieved, the Message Waiting indication is deactivated.
17. Memory Protection.

Volatile memory, generic and customer PABX attributes software shall be preserved in case of commercial power failure. Memory must be restored automatically via non-volatile memory when power is restored.

18. Multi-Line Calling.

Contractor shall provide a PABX that supports multi-line calling.


Universal Dialing Plan. The PABX shall include a Universal Dialing Plan such that user dialing at all locations in the PABX for interoffice, local and long distance dialing will use the same codes and access techniques.

20. Recorded Announcements.

a.) Call Delay Recorded Announcement.

1.) The PABX shall provide for Call-Delay Recorded Announcements. Each time a new call is placed in an incoming-call queue, the current waiting time of the oldest enqueued call is calculated. Based on this waiting time, the new call will receive one of the following treatments:

- If the waiting time is less than a user-specified threshold, the caller hears ringback tone until the actual waiting time exceeds the threshold. The caller then receives a recorded announcement advising of the delay.

- If the waiting time is greater than or equal to the specified threshold, the caller immediately hears the recorded announcement.

2.) In either case, second and third recorded announcements may follow later, and silence, music, or ringing may follow each announcement.

3.) When the user becomes available, the call is immediately presented to the agent.

b.) Forced Announcements for New and Overflowed Calls.

The PABX shall provide the capability of Forced Recorded Announcements for New and Overflowed Calls such that all incoming calls are directed to a recorded message which may be a verbal announcement, music, or a combination of both.


The PABX shall allow telephone set traffic and feature usage statistics to be read from the PABX by a distant terminal.
22. Self Diagnostics and Fault Isolation.

The PABX must have the capability to allow the controlling computer(s) to test itself and the rest of the PABX, including trunks. If a fault is found, the PABX should disable that portion of the PABX and display an alarm.

23. Speed Dial.

The PABX shall have the capability for the user to program their phone to dial frequently called internal and external telephone numbers on a speed dial list with only two or three keystrokes. The PABX shall support both Individual Speed Dialing, where an individual programs his or her frequently called numbers, and Group Speed Dialing, where frequently dialed numbers are available to everyone in a specified group.


Contractor shall provide a PABX that has the capability of switching calls internally to any user within Sound Transit and to Resident Engineer-designated users within King County Metro.

25. Timing and Synchronization.

Contractor shall provide the PABX with timing and synchronization information provided by the Master Clock system, described in Section 17740, Master Clock System.


The PABX shall provide Voice Mail capability as defined in Section 17330, Voice Mail System.

2.04 MAIN DISTRIBUTION FRAME (MDF)

The MDF shall provide for cross-connection for all cables to the PABX. MDF is specified in Section 17110, Main Distribution Frames, Intermediate Frames, Cross Connects Points, Fiber Distribution and Service Entrances.

2.05 OTHER EQUIPMENT

Contractor shall provide all equipment and do all Work to make the PABX fully functional.

PART 3 - EXECUTION

3.01 GENERAL

A. Contractor shall assemble all equipment and materials to form a complete functioning PABX and perform factory tests prior to delivery to site.

B. Material and equipment shall be delivered as completely assembled within shipping and handling limitations, ready for installation or storage.

C. Equipment in storage before shipment and during installation shall be protected from physical damage and from the environment.
D. After the installation of the equipment, Contractor shall perform field tests and provide technical consultation regarding equipment provided.

3.02 PREPARATION

Contractor shall perform pre-installation inspection of Work by others. Contractor shall prepare a written report of deficiencies and issue this report to Resident Engineer as per Section 01650, Product Delivery Requirements.

3.03 FACTORY TESTING

A. A completed call test described earlier in this Section 2.02 shall be made. If there is a failure in the equipment during this test, the cause shall be repaired and the test restarted at zero calls.

B. Input and output signal levels at all PABX interfaces.

3.04 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage, and handling of equipment.

3.05 INSTALLATION

A. Contractor shall submit installation drawings prior to installation of the PABX equipment at any Sound Transit station, per the schedule and requirement guidelines set in Section 01650, Product Delivery Requirements. Contractor shall proceed with the installation only after the approval of installation drawings.

B. Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

C. Contractor will provide their proposed detailed implementation plan to Resident Engineer with their proposal response. The implementation plan will include a milestone of dates and activities that will be mutually agreed upon after Contract award.

D. Contractor shall write, issue and manage all necessary orders to the local telephone utility and any other carriers including new or re-terminated trunk orders, data circuits, disconnects and referrals of existing services as necessary, and any other necessary trunking and related orders. Such orders shall be reviewed by Resident Engineer prior to issue.

E. Resident Engineer will have the right with five (5) days written notice to connect the PABX to any equipment manufactured or supplied by others that is compatible with PABX. Such equipment includes, but is not limited to, peripheral equipment, other computers, communications equipment, terminal devices, and the like. Resident Engineer may require that Contractor supply the specifications for the interface and supervise the connection. If such a connection is likely to interfere in any way with the operation of the PABX, Contractor shall notify Resident Engineer at least five days prior to any such connection.
3.06 FIELD TESTING

A. Field Tests shall be conducted in compliance with Resident Engineer-approved plans and procedures.

Field acceptance tests shall consist of exercising each system function through its required operations, under simulated conditions, to prove that the installation complies with specified requirements.

B. Contractor shall:

1. Furnish certified test reports for field acceptance tests.

2. Provide equipment and apparatus required for the tests.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17310
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SECTION 17320
TELEPHONE SETS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Contractor shall provide telephone sets in the O&M facility, and digital IP telephone sets at
the stations as described in this Section.

B. This Section includes the requirements required to design, furnish and install PABX
telephone sets (both analog and digital) and shall be compatible with and connect to the
PABX specified in Section 17310, PABX.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 16120 – Electrical Wires and Cables.

C. Section 17030 – Reliability Management Program.

D. Section 17040 – Technology Documentation.

E. Section 17050 – Configuration Management.

F. Section 17060 – Special Tools and Spare Parts.

G. Section 17070 – Human Factors Engineering and Ergonomics.

H. Section 17080 – System Support.

I. Section 17150 – Facility Cabling Requirements.

J. Section 17310 – PABX.

K. Section 17330 – Voice Mail System.

L. Section 17370 – Voice System Testing, Identification and Administration.

M. Section 17380 – Voice System Training, Manuals, Special Tools and Spare Parts.

N. Section 17390 – Voice System Support and Warranty.
1.03 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:

5. 47 CFR 68.218(b)(1) Connection of Terminal Equipment to the Telephone Network,
7. IEEE 802 Local and Metropolitan Area Networks.

1.04 QUALITY CONTROL

Contractor shall adhere to quality control requirements specified elsewhere in this document. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations.
1.05 SUBMITTALS

A. Contractor shall provide the following submittals for review by Resident Engineer. These submittals are subject to Resident Engineer approval.

   a.) Contractor shall submit the following information prior to the Voice Systems Conceptual Design Review, per the schedule and requirements set in Section 01330, Submittals.
      1.) Description of the PABX telephone functions.
      2.) Display layouts showing the location and type of PABX telephone equipment.
      3.) Preliminary list of equipment.
      4.) Deviations and exceptions from these Specifications.

2. Preliminary Design Review.
   a.) Contractor shall submit the following minimum information prior to the Voice Systems Preliminary Design Review per the schedule and requirements set in Section 01330, Submittals.
      1.) Layout of associated PABX phone equipment at each station and at OCC and Equipment Room.
      2.) Detailed list and description of all equipment intended for use.

3. Final Design Review.
   a.) Contractor shall submit the following minimum information prior to the Voice Systems Final Design Review per the schedule and requirements set in Section 01330, Submittals.
      1.) Installation manual and field installation details as required.
      2.) User and Maintenance manuals.
      3.) Test Plans, including Factory and Field tests.

   Contractor shall submit Factory Test Procedures.
5. Installation Drawings and Test Procedures.

Contractor shall submit Installation Drawings and Test Procedures.


a.) Prior to Final Acceptance Testing per the schedule and requirements set in Section 01330, Submittals, Contractor shall submit final versions of the following:

1.) User Manuals.

2.) Maintenance Manuals.

3.) Training Plan.

4.) Training Manuals.

7. Training.

After Factory Test and before Final Acceptance Testing, Contractor shall train up to 100 persons on the use of the PABX phones.

8. Final Acceptance (Site) Test Procedure.

Prior to the Final Acceptance Test, per the schedule and requirements, Contractor shall submit the final test procedure for the test.

9. Test Results and As-Builts.

Prior to acceptance of the PABX phones, all test results and as-builts shall be submitted. Results and as-builts are subject to inspection.

PART 2 - PRODUCTS

2.01 GENERAL

A. Required PABX Station Equipment.

1. All PABX phones shall generate Dual Tone Multi Frequency (DTMF) for internal and external calls.

2. All PABX phones shall generate DTMF during any and all dialing conditions, including, but not limited to, during conference calls and call transfer, in the use of single button dialing, and station and system speed dial.

3. PABX phones shall conform to all FCC rules and regulations, including, and without limitation, applicable FCC regulations regarding hearing compatibility.

4. All PABX phones shall have message waiting capability and each telephone shall be equipped with an integrated visual message-waiting indicator.
5. All PABX phones shall be equipped with standard modular RJ-type jacks at both ends of their mounting cords and their handset cords.

6. PABX phones which utilize hookswitch flash for feature access shall be equipped with a special, fully integrated TAP or FLASH button to perform hookswitch flash.

7. All multi-line phones shall have a hold button.

8. All PABX phone features of the system shall be accessible from the dial pad as well as feature buttons.

B. Contractor shall provide PABX phones, at the following locations (as indicated on drawings):

1. Central Communications Equipment Room.
2. Operations Control Center.
3. Offices.
4. Reception Areas.
5. Conference Rooms.
6. File Storage Rooms.
7. First Aid Rooms.
8. Lobbies.
9. Lunch Rooms.
10. Major Equipment Rooms including: electrical, mechanical, communications, train signaling, traction power, and UPS.
12. Select Maintenance Shop Facilities.

2.02 PABX DIGITAL PHONES (IP PHONES)

A. Digital telephone handset, headset and handsfree telephone audio performance requirements for digital wireline telephones shall be compatible with the parameters specified in ANSI/TIA/EIA-810-A.

B. Technical Requirements.

1. Type: Shore Gear AP100, AP110, IP100, or approved equal.

2. Display.

   a.) Alpha-numeric visual display.
b.) Capable of displaying a minimum two lines with at least 16 characters each.

   a.) 12 button minimum.
   b.) Capable of generating appropriate DTMF tones.


8. Ethernet Requirements: 10 Base-T Ethernet/ 100 Base-T Fast Ethernet, auto-sensing.

   a.) Signaling Transport Protocol: H.323 and RFC793.
   b.) Media Transport Protocol: UDP (RFC768) and RTP (RFC1889).

10. Host Configuration: DHCP.


C. User Features:

1. Originate and accept calls.

2. Caller ID (address and name).

3. Call Transfer.

4. Call forward on all calls.

5. Call forward on no reply.

6. Call forward on busy.

7. Call Hold.


10. Last number redial.
11. Personal speed dial.

12. Multi-line calling.

13. Hands free answering.

14. Distinctive ringing

PART 3 - EXECUTION

3.01 GENERAL

A. Contractor shall provide all equipment and do all Work to make the PABX phones fully functional.

1. Contractor shall assemble all equipment and materials to form a complete functioning system and perform factory tests prior to shipment.

2. Material and equipment shall be delivered as completely assembled within shipping and handling limitations, ready for installation or storage.

3. Equipment in storage before shipment and during installation shall be protected from physical damage and from the environment.

4. After the installation of the equipment, Contractor shall perform field tests and provide technical consultation regarding equipment provided.

3.02 PREPARATION

Contractor shall perform pre-installation inspection of Work by others. Contractor shall prepare a written report of deficiencies and issue this report to Resident Engineer as per Section 01650, Product Delivery Requirements.

3.03 FACTORY TESTING

A. Tests shall be conducted in compliance with approved plans and procedures, and shall be performed prior to shipment.

B. Contractor shall submit for approval certified manufacturer test reports at the time of delivery.

C. Resident Engineer may witness factory testing.

3.04 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment.

3.05 INSTALLATION

A. Contractor shall submit installation drawings prior to installation of PABX phones at any station, according to the schedule and requirements guidelines set in Section 01330, Submittals. Contractor shall proceed with the installation only after the approval of installation drawings.
B. Contractor shall follow manufacturer's recommended installation practices, Contract Specifications and Contract Drawings during construction.

3.06 FIELD TESTING

A. The Contractor shall perform tests for all telephone connections. The Contractor shall verify:

1. All telephone instruments and jacks shall indicate assigned PABX extension.

2. PABX recognizes on/off hook status of assigned extensions.

3. PABX provides dial tone to assigned extensions, when off-hook.

4. PABX correctly interprets dialed digits correctly.

5. All telephone instruments ring when dialed.

B. Contractor shall submit for approval certified test reports at the time of delivery.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17320
PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall provide a Voice Mail System as part of the overall Voice Systems.

1.02 SECTION INCLUDES

This Section includes the requirements required for furnishing, installing and testing a Voice Mail System at the Operations and Maintenance Facility.

1.03 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding Requirements.

B. Section 16120 – Electrical Wires and Cables.

C. Section 17030 – Reliability Management Program.

D. Section 17040 – Technology Documentation.

E. Section 17050 – Configuration Management.

F. Section 17060 – Special Tools and Spare Parts.

G. Section 17070 – Human Factors Engineering and Ergonomics.

H. Section 17150 – Facility Cabling Requirements.

I. Section 17310 – PABX.

J. Section 17320 – Telephone Sets.

K. Section 17370 – Voice System Testing, Identification and Administration.

L. Section 17380 – Voice System Training, Manuals, Special Tools and Spare Parts.

M. Section 17390 – Voice System Support and Warranty.

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:


2. 47 CFR Part 68   Connection of Terminal Equipment to the Telephone Network.

4. NEMA  Enclosures for Electrical Equipment up to 1000 Volts.


6. UL 50  Standards for Safety for Enclosures of Electrical Equipment.

1.05 QUALITY CONTROL

As specified in this document, equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Resident Engineer. These submittals are subject to Resident Engineer approval.


a.) Contractor shall submit the following information prior to PABX Conceptual Design Review, per the schedule and requirements.

1.) Description of Voice Mail functions.

2.) Display layouts showing the location and type of Voice Mail equipment.

3.) Preliminary list of equipment.

4.) Deviations and exceptions from these Specifications.

2. Preliminary Design Review.

a.) Contractor shall submit the following minimum information prior to PABX System Preliminary Design Review, per the schedule and requirements set in Section 01330, Submittals.

1.) Layout of Voice Mail equipment.

2.) Detailed list and description of all equipment intended for use.

3.) Draft description of Voice Mail system design, operations and maintenance.

3. Final Design Review.

a.) Contractor shall submit the following minimum information prior to PABX System Final Design Review, per the schedule and requirements set in Section 01330, Submittals.
1.) Detailed description of Voice Mail System design, operations and maintenance to include:

   - Description and purpose of proposed test and diagnostic equipment.
   - Final design schematics for the Voice Mail System.
   - Final list and description of all equipment used for Voice Mail System.
   - Installation manual and field installation details as required.
   - User and Maintenance manuals.
   - Test Plans, including Factory and Field tests.


   Contractor shall submit Factory Test Procedures.

5. Installation Drawings.

   Contractor shall submit Installation Drawings.

6. Test Procedures.

   Contractor shall submit Test Procedures.

7. Final User Documents.

   a.) Prior to Final Acceptance Testing per the schedule and requirements set in Section 17030, Reliability Management Program, Contractor shall submit final versions of the following:

      1.) User Manuals.
      2.) Maintenance Manuals.
      3.) Training Plan.
      4.) Training Manuals.

8. Training.

   After Factory Test and before Final Acceptance Testing, Contractor shall train up to 100 persons on the use of the Voice Mail System.
9. Final Acceptance (Site) Test Procedure.

Prior to the Final Acceptance Test per the schedule and requirements set in Section 01330, Submittals, Contractor shall submit the final test procedure for the test.

10. Test Results.

Prior to acceptance of the System, all test results shall be submitted. Test results are subject to Resident Engineer inspection.

11. As-Builts.

Prior to acceptance of the System, all as-builts shall be submitted. As-builts are subject to Resident Engineer inspection.

PART 2 - PRODUCTS

2.01 GENERAL

The Contractor shall provide an integrated voice mail and automated attendant answering peripheral compatible with the PABX specified in Section 17310, Exterior Communication Pathways.

2.02 VOICE MAIL

A. Voice Mail Features.

1. The voice mail equipment shall provide the following:

   a.) System Features.

      1.) Message waiting lamp activation.
      2.) Call forward to voice mailbox.
      3.) Greeting, system and individual.
      4.) Check for message receipt.
      5.) Remote access to mailbox and feature changes.
      6.) 24-hour internal or external access.
      7.) Name/extension identification.
      8.) Record a conversation.
      9.) Security codes.
10.) Voice prompt support.

11.) Visitor/guest mailboxes.

12.) General delivery mailbox.

13.) Group messaging.

b.) Message Recording Features.

1.) Cancel message.

2.) Edit.

3.) Message length, programmable.

4.) Review.

c.) Message Retrieval Features.

1.) Backup five seconds.

2.) Listen.

3.) Check time, date.

4.) Delete.

5.) Save.

6.) Forward to another mailbox.

7.) Skip to next message.

8.) New and saved message queue.

d.) Message Notification Features.

1.) Message waiting light activation/deactivation.

2.) Number of voice messages waiting.

3.) Cellular telephone notification.

4.) Pager notification.
e.) Automated Answering Features.

1.) Announcement/greeting with selectable options.

2.) Answer delay, programmable.

3.) Automatic call transfer to mailbox greeting.

4.) Password protection.

5.) Rotary mailbox.

f.) Capacities.

1.) Voice channels: 24.

2.) Maximum mailboxes: 400.

3.) Voice storage: 200 hours.

4.) Total number of calls supported during peak usage hour: 1440 calls.

PART 3 - EXECUTION

3.01 GENERAL

A. Contractor shall assemble all equipment and materials to form a complete functioning system and perform factory tests prior to shipment.

B. Material and equipment shall be delivered as completely assembled within shipping and handling limitations, ready for installation or storage.

C. Equipment in storage before shipment and during installation shall be protected from physical damage and from the environment.

D. After the installation of the equipment, Contractor shall perform field tests and provide technical consultation regarding equipment provided.

3.02 PREPARATION

Contractor shall perform pre-installation inspection of work by others. Contractor shall prepare a written report of deficiencies and issue this report to Resident Engineer.

3.03 FACTORY TESTING

A. Tests shall be conducted in compliance with approved plans and procedures, and shall be performed prior to shipment.
B. Contractor shall submit certified test reports at the time of delivery.

3.04 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for all delivery, storage, and handling of equipment.

3.05 INSTALLATION

A. Contractor shall submit installation drawings prior to installation of the Voice Mail System per the schedule and requirements guidelines set in Section 01650, Product Delivery Requirements. Contractor shall proceed with the installation only after the approval of installation drawings.

B. Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

C. Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

3.06 FIELD TESTING

A. Field acceptance tests shall consist of exercising each system function through its required operations, under simulated conditions, to prove that the installation complies with specified requirements.

B. Contractor shall submit certified reports for field acceptance tests, and provide equipment and apparatus required for the tests.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.
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SECTION 17350
PASSENGER INFORMATION PHONES

Passenger Information Phones will not be delivered in this Contract. This section is for reference only.

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SECTION 17360
EMERGENCY PHONE SYSTEM

PART 1 - GENERAL

1.01 OVERVIEW

The Emergency Phone (ETEL) System is a secondary means of providing voice communications between and amongst Staff, Emergency Services and other persons in the various non-public areas of stations and grade separated sections of track way per NFPA 130 and as required by the local jurisdiction having authority. Although the ETEL System is a secondary form of communications, its primary use is for communications during emergencies when all other forms of communications have failed. As such, the ETEL System and its components shall be considered safety critical.

1.02 SECTION INCLUDES

This Section include the requirements relating to the design, furnish and installation of the ETEL System.

1.03 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.
B. Section 16120 – Electrical Wires and Cables.
C. Section 17030 – Reliability Management Program.
D. Section 17040 – Technology Documentation.
E. Section 17050 – Configuration Management.
F. Section 17060 – Special Tools and Spare Parts.
G. Section 17070 – Human Factors Engineering and Ergonomics.
H. Section 17140 – Backbone Cabling Requirements.
I. Section 17150 – Facility Cabling Requirements.
J. Section 17370 – Voice System Testing, Identification and Administration.
K. Section 17380 – Voice System Training, Manuals, Special Tools and Spare Parts.
L. Section 17390 – Voice System Support and Warranty.
M. Section 17510 – Communication System Backbone Equipment.
N. Section 17520 – Voice Circuits.
O. Section 17560 – Quality of Service Requirements.
P. Section 17730 – Integrated Communications Controller.

Q. Section 17740 – Master Clock System.

R. Section 17800 – Control System Overview.

S. Section 17801 – Control System Network

T. Section 17910 – Communications Network Management.

U. Appendix F – Control System Functions (Use Cases).

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:


6. NEMA Enclosures for Electrical Equipment up to 1000 Volts.

7. UL 50 Standards for Safety for Enclosures of Electrical Equipment.

8. IEEE 802 Local and Metropolitan Area Networks.


10. ADA Americans with Disabilities Act.

1.05 QUALITY CONTROL

Contractor shall adhere to quality control guidelines as specified in this Section and as referenced elsewhere.
1.06 SUBMITTALS

A. Submittals for the ETEL System shall be as follows:


Contractor shall submit a brief design document describing the operation of the ETEL System including a block diagram of the system, a list of anticipated equipment, and a list of any exceptions to design requirements Contractor desires to put forward for approval.

2. Preliminary Design Review.

   a.) Contractor shall submit a detailed document including but not limited to the following documentation:

      1.) Product specifications of equipment for intended use.

      2.) Draft Use Case documents for all user and systems interfaces.

      3.) Draft Software Requirements Specification.

      4.) Draft system schematics.

      5.) Draft System Safety Analysis as per IEC 61508


   a.) Contractor shall submit a final version of the software requirements including but not limited to:

      1.) Use Case documents for all user and systems interfaces.

      2.) Full UML design implementation of System.

4. Final Design Review.

   a.) Contractor shall submit a final document for approval before release for construction. This document shall include but not be limited to:

      1.) Final verbal description of operations of the ETEL System.

      2.) Final product specification sheets.

      3.) Detailed schematics of the ETEL System.

      4.) Pre-verification version of System Safety Analysis.
5.) Installation manual and field installation details as required.

6.) Draft User and Maintenance manuals.

7.) Test Plans, including Factory and Field tests.


5. Factory Acceptance Test Procedure.

Prior to the Factory Acceptance Test and before any field installation, Contractor shall submit the final Factory Acceptance Test procedure. This procedure shall include detailed procedures and forms for performing Factory Acceptance Tests necessary to verify each and every function and failure mode of the ETEL System. It is expected that the test will be performed at the Contractor’s facilities under supervision of Resident Engineer.


a.) Prior to Final Acceptance Testing, Contractor shall submit final versions of the following:

1.) User Manuals.

2.) Maintenance Manuals.

3.) Training Plan.

4.) Training Manuals.

7. Training.

After Factory Test and before Final Acceptance Testing, Contractor shall train up to 40 persons on the use of the ETEL System per the approved Training Plan and Manual.

8. Final Acceptance (Site) Test Procedure.

Prior to the Final Acceptance Test, Contractor shall submit the final test procedure for the test.

9. Test Results and As-Builts.

Prior to acceptance of the System, all test results and as-builts must be submitted. Results and as-builts are subject to inspection.
PART 2 - PRODUCTS

2.01 GENERAL

Contractor shall deliver an ETEL System at all stations and designated areas that provides highly reliable voice communication between Sound Transit staff and emergency personnel during critical and emergency situations.

2.02 EQUIPMENT RELIABILITY

A. All equipment that supports the end-to-end ETEL system (to include ETEL sets and the ETEL network and network equipment) shall be selected and configured to provide maximum reliability. This includes designing reliability and sparing (hot swappable where possible), selecting high MTBF equipment, implementing Quality of Service techniques and designing the system for maximum maintainability.

B. Overall reliability shall support Section 17030, Reliability Management Program.

2.03 INTEGRITY OF OPERATION

Contractor shall provide an ETEL system for maximum integrity of operation. Emergency voice traffic shall be intelligible with no lost data or gaps in conversation, and shall be real-time.

2.04 ETEL PHONES

A. Physical Requirements.

1. Enclosure shall be similar in design to that shown in the Contract Drawings and suitable for the environment intended: weather resistant (NEMA 3R), water and corrosion (NEMA 4X or similar), fire retardant with a 30 minute rating, and impact and vandal resistant.

2. Exterior of enclosure shall be Pantone Color: Canary Yellow, with black lettering spelling “EMERGENCY”.

3. A beacon shall be mounted as shown in Drawings. Beacon shall have a MTBF of 50,000 hours.

4. Contractor shall provide a Text Display as part of the ETEL telephone set. Text Display shall be backlit, and shall be in a minimum of size 14 font, clearly legible as approved by Resident Engineer. Text Display shall show the states of the ETEL to include the following.

   a.) Call initiated.

   b.) Connection made with OCC Operator.

   c.) Call terminated (nominal state).

   d.) Current Time and Date.

   e.) All written text shall be accompanied by Braille translation as required by ADA.
5. Interior cover of enclosure shall have site-specific map and directions of use.

6. Latching mechanism shall be easily accessible, easy to open manually without aid, and corrosive resistant to prevent seizing of mechanical parts.

7. Door mechanism shall be spring loaded to maintain a fully open or fully closed position when open or closed respectively. Door hinge shall not be exposed when fully closed.

8. Keypad shall be a sealed metallic type.

9. All features shall be designed for heavy-duty use. Products shall incorporate features such as armored handset cords resistant to 500 lbs. of pull strength and metallic – chrome plated non-movable magnetic type hook switch.

10. Display to be fully visible in a 0.0 lux environment without external illumination from a distance of five feet. Display shall have at least two (2) lines of 20 text characters.

11. Speaker shall be outdoor rated and suitable for the environment intended.

12. All materials shall be fastened with tamper resistant hardware.

13. Door shall be capable of locking with either fireman’s key or Sound Transit provided key.

B. Electrical Requirements

1. Unit shall accept source power of 120 Vac/60 Hz + 10 percent, 220 Vac/50 Hz + 10 percent or 240 Vac/60 Hz + 10 percent variation in voltage and line frequency.

2. Unit shall have optional two (2) hour battery backup where UPS power is not available.

3. Communications to/from the unit shall be over either 10-Base-F or 10-Base-T circuits.

4. Fiber Optic transceivers shall accept ‘SC’ type connectors with 1310 nm single mode fiber.

5. All connectors into and out of each unit shall be IP-67 rated.

6. Speaker shall have minimum rating: Power = 6 W, Sensitivity = 95 dB (SPL), Response 400 Hz to 5000 Hz.

7. Audio amplifier shall have minimum rating: Power = 10 W RMS, Response 300 Hz to 6500 Hz. Output power shall be adjustable remotely via any ETEL Console.

8. Speaker and lighted sign shall be connected in such a way that loss of either device during a fire or for reasons of vandalism shall not disable phone functions.

9. Communications protocol shall be H.323 (version 2 or later) compliant voice over IP (VoIP) utilizing RTP and IP multicasting.

10. Each ETEL shall be individually addressable.
11. ETEL shall be capable of positively self-reporting device status by either change of state method or by a programmed sequence.

12. ETEL shall be capable of reporting the following states at a minimum:

a.) Power Failure.

b.) Battery Failure.

c.) Transmit loss of signal.

d.) Receive loss of signal.

e.) Bit Error Rate in excess of threshold.

f.) Speaker/Amplifier Failure.

g.) Sign Failure.

h.) Handset Failure.

i.) Handset ‘Off-hook’.

j.) Auxiliary Headset Active.

C. Operational Requirements.

In general, the ETEL phone shall operate as a party line phone system for up to seven (7) users on a specific circuit with the ability to page over non-operating ETEL phones anywhere on the network. Specific details regarding the operational requirements of the ETEL phone are covered in Appendix F, Control System Functions (Use Cases).

2.05 ETEL CONSOLE

A. ETEL system shall be designed to run on either integrated communications controller (Section 17730, Integrated Communications Controller) or a stand alone system as noted here.

B. The ETEL Console is largely a software program that shall be designed to operate on a standard PC type computer. Various windows or screens shall show status of active ETEL party line calls and their participants. Up to three (3) active operators and three (3) active ETEL party line calls shall be able to function via a single ETEL Console simultaneously.

1. The ETEL Console shall have the following call functional capabilities:

a.) Receive and initiate calls similar to ETEL Phone.

b.) Page via ETEL paging system similar to ETEL Phone.
c.) Patch ETEL calls with other phone systems connected.

d.) Replay recorded calls via FCS recording.

2. ETEL Console shall have the following maintenance and diagnostic capabilities at a minimum:

a.) Receive status of all ETEL Network and Phone change of status events.

b.) Be able view and configure all ETEL Network and Phone parameters including packet routing, user groups, and QoS parameters.

c.) Be able to view the unique device part numbers within network.

3. ETEL Console shall maintain system wide user privileges to limit access rights to the Console users.

2.06 ETEL NETWORK

A. ETEL Network shall be a flexible, self-healing network made up of function-dedicated devices, shared non-dedicated devices, and system interfaces that deliver value added services to the ETEL System. In order to keep the ETEL System usable and maintainable well into the future, a full-featured graphical software package shall be provided to assist in configuring and optimizing the network.

1. Network Topology.

a.) Nodes.

1.) The Network shall be broken up into Nodes consisting of one or more ETEL Phones or consoles and a single router type device (with optional redundant router) per node. ETEL Phones can connect to this Router either via direct hardwire connection or via another TCP/IP network using H.323/RTP.

2.) Functionally, nodes interface with all other systems or devices via the Router. Nodes shall interface with the following at a minimum:

- Other Nodes via a managed TCP/IP H.323 or by connecting the two ETEL phone node configurations for the passage of data and voice information.

- Traditional analog telephone circuits for integration with legacy ETEL Systems and integration with multipurpose communication consoles, and external third party conferencing.

- FCS System via TCP/IP for operational information, data logging, and voice recording.

- Network Management System via TCP/IP for maintenance information.
- External Master Clock source via TCP/IP or other serial channel for accurate
time stamping of data and voice recordings.

2. Network Configuration and Logic.

a.) When two or more Nodes are combined they shall form a network with at least two
connections per Node to other Nodes. Network shall be physically configurable in
any manner. Specific design topology of the Network shall optimize capacity,
reliability and throughput of information.

b.) Network logic and ‘intelligence’ shall be distributed and located at the lowest
reasonable level of the ETEL System.

c.) Network shall be self-healing, meaning that calls shall dynamically reroute to achieve
and subsequently maintain open communications between all call participants.
Parameters for function relating to self-healing shall be user configurable.

3. Supporting Interfaces.

a.) FCS/CCS/NMS.

In order to supply Staff and Emergency Services personnel with adequate
information to make informed decisions during emergencies, graphical information
about the specific ETEL location shall be deemed necessary. As such, a real time
data link shall be required between FCS and the ETEL System to support real time
graphics in the CCS/NMS systems. Such screens shall be available to operators
located at any graphics enabled control point (such as an EMP or control center).

b.) PABX/Analog Phone Switch.

For improved coordination with outside agencies and the consolidation of
communications elements at control centers, it is desirous to tie the ETEL System
into a PABX or analog phone switch from which an independent communications
console shall command the ETEL System. The communication console shall require
all the same information as a standard ETEL Phone. A single console shall accept up
to three ETEL conference lines simultaneously. This PABX or analog phone switch
shall have 6 DID lines for dedicated connection to external organizations.

c.) FCS Event Recording and Correlation, Voice Recording and Playback.

A single system wide event and voice recorder shall handle all data and voice
recording requirements of the ETEL System. ETEL Consoles shall be able to
playback voice recordings only. Full correlation of data events, voice recordings and
video data shall take place from the CCS system.
PART 3 - EXECUTION

3.01 GENERAL

Contractor shall furnish, test and install a fully functional highly reliable ETEL system at all designated locations.

3.02 FACTORY TESTING

Contractor shall test all ETEL equipment, including all spares. Contractor shall perform end-to-end system testing on one full ETEL node configuration prior to delivery to the field.

3.03 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for all delivery, storage, and handling of equipment.

3.04 INSTALLATION

Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

3.05 FIELD TESTING

A. Contractor shall test every field installation of the ETEL system to ensure it complies with these specifications to include reliability and integrity of operation requirements.

B. Contractor shall test making ETEL calls while the system is at full capacity to ensure integrity and reliability.

C. All circuits are free from static or other interference and have a clear signal as determined by Resident Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17360
SECTION 17365
PASSENGER EMERGENCY TELEPHONES

PART 1 - GENERAL

1.01 OVERVIEW

The Passenger Emergency Telephone (PET) System is the primary means for Link patrons to notify Sound Transit Operations and emergency responders of an event in and around the public areas of stations. PET devices shall be considered ‘pull station’ devices per NFPA 72. Because of the safety related nature of the PET, the PET System and its components shall be considered safety critical.

1.02 SECTION INCLUDES

This Section includes the requirements relating to the design, furnish and installation of the PET System.

A. Section 16060 – Electrical Grounding and Bonding.
B. Section 17030 – Reliability Management Program.
C. Section 17040 – Technology Documentation.
D. Section 17050 – Configuration Management.
E. Section 17060 – Special Tools and Spare Parts.
F. Section 17070 – Human Factors Engineering and Ergonomics.
G. Section 17150 – Facility Cabling Requirements.
H. Section 17370 – Voice System Testing, Identification and Administration.
I. Section 17380 – Voice System Training, Manuals, Special Tools and Spare Parts.
J. Section 17390 – Voice System Support and Warranty.
K. Section 17510 – Communications System Backbone Equipment.
L. Section 17520 – Voice Circuits.
M. Section 17560 – Quality of Service Requirements.
N. Section 17730 – Integrated Communication Controller.
O. Section 17740 – Master Clock System.
P. Section 17800 – Control System Overview.
Q. Section 17801 – Control System Network.
R. Section 17910 – Communications Network Management.

S. Appendix F – Control System Functions (Use Cases).

1.03 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:


7. NEMA Enclosures for Electrical Equipment up to 1000 Volts.

8. UL 50 Standards for Safety for Enclosures of Electrical Equipment.

9. IEEE 802 Local and Metropolitan Area Networks.


11. ADA Americans with Disabilities Act.

1.04 QUALITY CONTROL

Contractor shall adhere to quality control guidelines as specified in this document and as referenced elsewhere.

1.05 SUBMITTALS

A. Submittals for the PET System shall be as follows:


    a.) Contractor shall submit a brief design document verbally describing the operation of the PET System also containing a block diagram of the system, a list of anticipated equipment, and a list of any exceptions to design requirements Contractor desires to put forward for approval.
2. Detailed Design Review.

a.) Contractor shall submit a detailed document including but not limited to the following documentation:

1.) Product specifications of equipment for intended use.

2.) Draft Use Case documents for all user and systems interfaces.

3.) Draft Software Requirements Specification.

4.) Draft system schematics.

5.) Draft System Safety Analysis as per IEC 61508.


a.) Contractor shall submit a final version of the software requirements including but not limited to:

1.) Use Case documents for all user and systems interfaces.

2.) Full UML design implementation of System.

4. Final Design Review.

a.) Contractor shall submit a final document for Resident Engineer approval before release for construction. This document shall include but not be limited to:

1.) Final verbal description of operations of the PET System.

2.) Final product specification sheets.

3.) Detailed schematics of the PET System.

4.) Pre-verification version of System Safety Analysis.

5.) Installation manual and field installation details as required.

6.) Draft User and Maintenance manuals.

7.) Test Plans, including Factory and Field tests.

5. Factory Acceptance Test Procedure.

   a.) Prior to the Factory Acceptance Test and before any field installation, Contractor shall submit the final Factory Acceptance Test procedure. This procedure shall include detailed procedures and forms for performing Factory Acceptance Tests necessary to verify each and every function and failure mode of the PET System. It is expected that the test will be performed at the Contractor’s facilities under supervision of Resident Engineer.


   a.) Prior to Final Acceptance Testing, Contractor shall submit final versions of the following:

      1.) User Manuals.
      2.) Maintenance Manuals.
      3.) Training Plan.
      4.) Training Manuals.

7. Training.

   After Factory Test and before Final Acceptance Testing, Contractor shall train up to 40 persons on the use of the PET System per the approved Plan and Manual.

8. Final Acceptance (Site) Test Procedure.

   Prior to the Final Acceptance Test, Contractor shall submit the final test procedure for the test.

9. Test Results.

   Prior to acceptance of the System, all test results shall be submitted. Test Results are subject to inspection.

10. As-Built.

    Prior to acceptance of the System, all as-built documentation shall be submitted. All as-built documentation is subject to inspection.

PART 2 - PRODUCTS

2.01 GENERAL

Contractor shall deliver a PET System at all stations and designated areas that provides highly reliable communications between Sound Transit passengers and Sound Transit Operations and emergency personnel during a critical or emergency situation.
2.02 EQUIPMENT RELIABILITY

A. All equipment that supports the end-to-end PET system shall be selected and configured to provide maximum reliability. This includes designing reliability and sparing (hot swappable where possible), selecting high MTBF equipment, implementing Quality of Service techniques and designing the system for maximum maintainability.

B. Overall reliability shall support Section 17030, Reliability Management Program.

2.03 INTEGRITY OF OPERATION

Contractor shall provide a PET System for maximum integrity of operations. Emergency voice traffic shall be intelligible with no lost data or gaps in conversation, and shall be real-time with no noticeable delay.

2.04 PET PHONES

A. Physical Requirements.

1. Enclosure shall be similar in design to that shown in the Contract Drawings and suitable for the environment intended: weather resistant, water and moisture resistant per NEMA 4X & IP 67, fire retardant with a 30 minute rating, and impact and vandal resistant.

2. Exterior of enclosure shall be Pantone Color: True Red (PMS 199C). All text shall be in either raised or recessed lettering white in color.

3. All written text shall be accompanied by Braille translation as required by ADA.

4. PET shall be a ‘hands-free’ operating device without cords or keypads.

5. Display to be fully visible in a 0.0 lux environment without external illumination from a distance of five feet. Display shall have at least two lines of 20 text characters.

6. Contractor shall provide two distinct light indicators with the PETs. One shall indicate that the phone is connected with an operator at the Control Center. The other light indicator shall indicate that help is on the way.

B. Electrical Requirements.

1. Unit shall accept source power of 120 Vac/60 Hz + 10 percent, 220 Vac/50 Hz + 10 percent or 240 Vac/60 Hz + 10 percent variation in voltage and line frequency.

2. Unit shall have optional two (2) hour battery backup where UPS power is not available.

3. Communications to/from the unit shall be over either 10-Base-T or 10-Base-F circuits.

4. All connectors into and out of unit shall be IP 67 rated.

5. Exterior devices shall be connected in such a way that loss of a device during a fire or for reasons of vandalism shall not disable other phone functions.
6. Communications protocol shall be H.323 (version 2 or later) compliant voice over IP (VoIP) utilizing RTP and IP multicasting.

7. Each PET shall be individually addressable.

8. PET shall be capable of positively self-reporting device status by either change of state method or by a programmed sequence.

9. PET shall be capable of reporting the following states at a minimum:
   a.) Power Failure.
   b.) Battery Failure.
   c.) Vandalism or tampering with device.
   d.) Transmit loss of signal.
   e.) Receive loss of signal.
   f.) Bit Error Rate in excess of threshold.
   g.) LED message failure.
   h.) Optional Sign Failure.
   i.) Handset ‘Off-hook’.

C. Operational Requirements.

D. In general, the PET phone shall operate as a direct ring-down phone system between the user and the OCC (with the emergency responder on scene in the loop if applicable). Specific details regarding the operational requirements of the PET are covered in Appendix F, Control System Functions (Use Cases).

2.05 PET CONSOLE

A. The PET System shall be configured to operate from integrated communications controller, Section 17730, Integrated Communications Center, or a stand alone console as noted here.

B. The PET Console shall be designed to operate on a standard PC type computer. Various windows or screens shall show status of active PET calls and their participants. Up to three (3) active operators and three (3) active PET line calls shall be able to function via a single PET Console simultaneously.

1. The PET Console shall have the following call functional capabilities:
   a.) Receive and initiate PET calls.
b.) Patch PET calls with other phone systems connected.

c.) Replay recorded PET calls via FCS recording.

d.) Indicate to patrons via the PET Indicator Light that help is on the way. Contractor shall provide a button on the PET console for an operator to click or push to communicate to patrons on a PET call that help is on the way.

2. PET Console shall have the following maintenance and diagnostic capabilities at a minimum:

a.) Receive status of all PET Network and Phone change of status events.

b.) Be able to view and configure all PET Network and Phone parameters including packet routing, user groups, and QoS parameters.

c.) Be able to view the unique device part numbers within network.

d.) PET Console shall maintain system wide user privileges to limit access rights to the Console users.

2.06 PET NETWORK

A. PET Network shall be a flexible, self-healing network made up of function-dedicated devices, shared non-dedicated devices, and system interfaces that deliver value added services to the PET System. In order to keep the PET System usable and maintainable well into the future, a full-featured graphical software package shall be provided to assist in configuring and optimizing the network.

1. Network Topology.

a.) Nodes.

1.) The Network shall be broken up into Nodes consisting of one or more PET Phones or consoles and a single router type device (with optional redundant router) per node. PET Phones can connect to this Router either via direct hardwire connection or via another TCP/IP network using H.323/RTP.

2.) Functionally, nodes interface with all other systems or devices via the Router. Nodes shall interface with the following at a minimum:

- Other Nodes via a managed TCP/IP H.323 or by connecting the two PET phone node configurations for the passage of data and voice information.

- Traditional analog telephone circuits for integration with legacy phone systems and integration with multipurpose communication consoles and external third party conferencing.

- FCS System via TCP/IP for operational information, data logging, and voice recording.
- CCTV network and control for operating PTZ units and focusing cameras on appropriate PET device for viewing by CCTV operator.

- Network Management System via TCP/IP for maintenance information.

- External Master Clock source via TCP/IP or other serial channel for accurate time stamping of data and voice recordings.

2. Network Configuration and Logic.

a.) When two or more Nodes are combined they shall form a network with at least two connections per Node to other Nodes. Network shall be physically configurable in any manner. Specific design topology of the Network shall optimize capacity, reliability and throughput of information.

b.) Network logic and ‘intelligence’ shall be distributed and located at the lowest reasonable level of the PET System.

c.) Network shall be self-healing, meaning that calls shall dynamically reroute to achieve and subsequently maintain open communications between all call participants. Parameters for function relating to self-healing shall be user configurable.

3. Supporting Interfaces.

a.) FCS/CCS/NMS.

In order to supply Sound Transit Staff and Emergency Services personnel with adequate information to make informed decisions during emergencies, graphical information about the specific PET location shall be deemed necessary. As such, a real time data link shall be required between FCS and the PET System to support real time graphics in the CCS/NMS systems. Such screens shall be available to operators located at any graphics enabled control point (such as an EMP or control center).

b.) PABX/Analog Phone Switch.

For improved coordination with outside agencies and the consolidation of communications elements at control centers, it is desirable to tie the PET System into a PABX or analog phone switch from which an independent communications console shall command the PET System. The communication console shall visibly display all the information required to operate the PET System. A single console shall accept up to three PET lines simultaneously. This PABX or analog phone switch shall have 6 DID lines for dedicated connection to external organizations.

c.) FCS Event Recording and Correlation, Voice Recording and Playback.

A single system wide event and voice recorder shall handle all data and voice recording requirements of the PET System. PET Consoles shall be able to playback voice recordings only. Full correlation of data events, voice recordings and video data shall take place from the FCS system.
d.) CCTV System.

The CCTV system shall be notified any time a PET unit is ‘activated’ or taken off hook by a user. Upon activation of function by CCS the assigned camera shall zoom to a preset viewing position. After the camera is in position, the image shall be available to the CCTV operator in the OCC or to whatever position is assuming those duties, through a simple user operation. Image shall be presented in a format 200 percent larger than nominal default CCTV window size, and window with PET CCTV image shall be front and center of display. PET CCTV window shall be able to be reduced or closed by an operator after executing.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall furnish, test and install a fully functional highly reliable PET system at all designated locations.

3.02 FACTORY TESTING

Contractor shall test all PET equipment, including all spares. Contractor shall perform end-to-end system testing on one full PET node configuration prior to delivery to the field.

3.03 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for all delivery, storage, and handling of equipment.

3.04 INSTALLATION

Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

3.05 FIELD TESTING

A. Contractor shall test every field installation of the PET system to ensure it complies with these specifications to include reliability and integrity of operation requirements.

B. Contractor shall test making PET calls while the system is at full capacity to ensure integrity and reliability.

C. Contractor shall test the PET/FCS/CCTV integration described in this Section.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17365
SECTION 17370
VOICE SYSTEM TESTING, IDENTIFICATION AND ADMINISTRATION

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall perform component, function and system testing for the Sound Transit Voice Systems described in Sections 17300 through 17365. Contractor shall label and identify all PABX, phone and associated equipment consistent with the overall system identification scheme. Additionally, contractor shall perform all administration tasks in support of the design, development, installation, testing and acceptance of the Sound Transit Voice Systems.

1.02 SECTION INCLUDES

This Section includes the requirements for testing, identification and administration for the Voice Systems to include the PABX and PABX components (telephone sets, faxes, modems and voice mail system), the Emergency Phone System and the Passenger Emergency Telephone System throughout the Sound Transit Communications System.

1.03 RELATED SECTIONS

A. Section 17030 – Reliability Management Program.
B. Section 17050 – Configuration Management.
C. Section 17300 – Voice System Overview.
D. Section 17310 – PABX.
E. Section 17320 – Telephone Sets.
F. Section 17330 – Voice Mail System.
G. Section 17360 – Emergency Phone System.
H. Section 17365 – Passenger Emergency Telephones.
I. Section 17380 – Voice System Training, Manuals, Special Tools and Spare Parts.
J. Section 17390 – Voice System Support and Warranty.
K. Section 17520 – Voice Circuits.
L. Section 17560 – Quality of Service Requirements.
1.04 REFERENCE STANDARDS

A. Contractor shall adhere to the following references:

3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.
4. OSHA Occupational Health and Safety Administration.
5. ADA Americans with Disabilities Act.

1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.06 SUBMITTALS

Contractor shall submit the following as part of the Voice Systems delivery:

A. Testing Submittals.

1. Factory Testing.

Contractor shall submit documentation necessary to plan, perform, and execute all factory testing for the Phone System. Contractor may submit multiple phone system test submittals broken out by component (e.g., PABX testing, analog and IP phone testing, emergency phone testing) as appropriate based on scheduling of test and delivery of each component.

a.) Test Plan and Procedures.

1.) Draft

- Contractor shall submit a Draft Test Plan and Draft Test Procedures 60 days prior to the start of Factory Test. Draft Test Plan shall include all components to be tested and a draft Verification Matrix that includes each requirement (functional, performance), the test intended to verify that requirement, and the method of testing (e.g. Inspection, Testing, Simulation, or Modeling).

- Draft Test Procedures shall include each factory test to be performed and the test procedures required to perform that test. Test procedures shall assume the appropriate background (e.g. MS Windows or phone technician skills) required to perform that test or operation, but shall be detailed such that anyone with the appropriate background could step in and perform the test with only the procedures.
Draft Plan and Procedures shall include all testing required for the Phone System. Where information is missing or incomplete, Contractor shall include the section heading or a placeholder for the information that is missing.

2.) Final.

Contractor shall submit a final Factory Test Plan and Factory Test Procedures for the Voice System prior to the start of Factory Testing.

b.) Test Report.

Contractor shall submit a Test Report after Factory Testing that details the test conditions (location, date, time, equipment used, equipment simulated, etc.), the tests performed, which, if any, tests failed, why the tests failed, and what actions are required to resolve any issues from Factory Test.

2. Field Testing.

a.) Test Plan and Procedures.

1.) Draft.

- Contractor shall submit a System Draft Test Plan and System Draft Test Procedures for the Phone Systems prior to the Field Testing. System Draft Test Plan shall include testing required to verify all requirements specified in Sections 17310 through 17365. Contractor shall provide a Verification Matrix that includes, at a minimum, each requirement to be verified, the test used to verify the requirement, the method of testing (e.g. Inspection, Test, Simulation, or Modeling).

- System Draft Test Procedures shall include each system field test to be performed and the test procedures required to perform that test. Test procedures shall assume the appropriate background (e.g. MS Windows or phone technician skills) required to perform that test or operation, but shall be detailed such that anyone with the appropriate background could step in and perform the test with only the procedures.

- Draft Plan and Procedures shall include all testing required for the Phone System. Where information is missing or incomplete, Contractor shall include the section heading or a placeholder for the information that is missing.

2.) Final.

- Contractor shall submit a final Field Test Plan and Field Test Procedures for the ST Voice System prior to the start of Field Testing.

- Contractor shall indicate in the Test Plan any requirements that will not be verified by field testing on equipment to be used in operations. Contractor shall also indicate any equipment that is not tested in field system testing.
Contractor shall gain approval from Resident Engineer for these exceptions before testing is to begin.

3.) Test Reports and Results.

- Contractor shall submit a Test Report for each test conducted that includes the test conditions (location, date, time, equipment used, equipment simulated, etc.), equipment tested, requirements tested, and test results. For any tests that failed, contractor shall indicate why the test failed, and any actions necessary either to correct the system problem and retest, or to verify the requirement via some other means. Contractor shall submit Test Results to Resident Engineer and shall gain Resident Engineer Approval for any follow-on actions as a result of testing.

B. Identification Submittals.

1. Identification Scheme.

Contractor shall submit the labeling or identification scheme for all phone system equipment and associated cabling.

C. List of Phone System Equipment.

Contractor shall include a list of all equipment delivered (including spare equipment). Contractor shall list all equipment by Identification Name, type of equipment, model number, version number, software or firmware running on equipment and version of software or firmware, location, warranty information, and any other information required to identify the phone system equipment.

1.07 TESTING

A. Contractor shall test the Voice System in accordance with Section 17030, Reliability Management Program.

1. Contractor shall perform Factory Testing on the Voice System. In Factory Testing, Contractor shall verify that every piece of equipment to be installed works according to these specifications, and Contractor shall verify that the integrated Voice System works with a minimum of one of each type of equipment.

2. Contractor shall provide Field Testing after all equipment for that Phase of Installation has been installed and configured. Field Testing is the final testing for the installed equipment. Every piece of equipment that is installed, and every piece of spare equipment identified as part of the Voice System shall be tested in Field Testing. Likewise, every requirement for the voice system shall be tested and verified to the Resident Engineer’s approval. The successful completion of all Field Testing is required for Final System Acceptance.

3. Installation and Field Testing shall occur in two phases, as described in Section 01110, Summary of Work.

4. As part of factory and field testing, Contractor shall verification of the following, at a minimum.
a.) PABX. Contractor shall test the PABX switch and associated equipment to verify all requirements specified in Section 17310, PABX. Specifically Contractor shall verify the following:

1.) All voice services described in Section 17310, PABX.

2.) All performance specifications for IP phone connections (end to end latency of no more than 150 milliseconds).

3.) PABX interfaces with KC Metro and ST Union Station, including 5-digit dialing across the leased line and extended services across both interfaced PABX systems.

b.) Contractor shall verify all analog and IP digital phone sets are capable of the services specified in Section 17310, PABX.

c.) Voice Mail. Contractor shall verify the voice mail requirements specified in Section 17330, Voice Mail System.

d.) ETEL. Contractor shall verify all of the Emergency Phone requirements specified in Section 17360, Emergency Phone System. Specifically, Contractor shall verify the following:

1.) All circuits are free from static or other interference and have a clear signal as determined by Resident Engineer.

2.) Resident Engineer shall be the final approval on ETEL performance, clarity, and intelligibility under varying network conditions (e.g. peak and non-peak operations, loaded and non-loaded network conditions).

3.) ETEL delivered features and locations meet NFPA 72 and NFPA 130 requirements.

e.) PET. Contractor shall verify all of the Passenger Emergency Telephone requirements specified in Section 17365, Passenger Emergency Telephones. Specifically, Contractor shall verify the following:

1.) All circuits are free from static or other interference and have a clear signal as determined by Resident Engineer.

2.) Resident Engineer shall be the final approval on PET performance, clarity, and intelligibility under varying network connections (e.g. peak and non-peak operations, loaded and non-loaded conditions).

3.) Contractor shall verify for Resident Engineer approval that PETs are intelligible with varying ambient noise conditions and at various stations and wayside locations (e.g. empty tunnel station, full tunnel station, various station locations where PETs are to be located). Contractor shall verify both the intelligibility of the PET speaker at the PET location, and the intelligibility of the PET user by the operator at the Operations Control Center.
4.) Contractor shall verify the PET/CCS/CCTV interface such that when a PET is taken off hook, CCS generates an alarm and a CCTV camera is panned to focus on that PET. The operator may then select that video feed to view that PET from the alarm or through a simple command on the CCS GUI.

5.) Contractor shall verify ADA compliance of the PETs.

6.) PET delivered features and locations meet NFPA 72 and NFPA 130 requirements.

f.) Contractor shall verify voice performance requirements as described in Section 17520, Voice Circuits, and in 17560, Quality of Service Requirements. Contractor shall demonstrate intelligibility of all IP phones to Resident Engineer for approval, and shall verify QoS priority requirements for ETEL phones and PET phones as described in Section 17560, Quality of Service Requirements.

1.08 IDENTIFICATION

A. Contractor shall provide unique identification of all equipment provided as part of the Communications Voice System.

B. Contractor shall label all equipment and cabling associated with the Voice Systems as follows.

1. Cable labeling requirements are specified in Section 17170, Cable Testing, Identification and Administration.

2. All PABX equipment, cards and ports shall be uniquely labeled. All analog and IP phone sets, fax machines and modems shall be uniquely labeled. All spares parts and components shall be uniquely labeled consistent with their like parts and components.

3. All equipment, card, and port labeling shall follow a logic that is based on type of equipment and equipment location. Resident Engineer shall approve of identification plan prior to any labeling of equipment.

4. All labeling shall be permanent in such a way as to withstand handling and changes in temperature and ambient conditions.

5. All equipment labels shall be consistent with those in the test reports and as-built documentation.

1.09 ADMINISTRATION

Contractor shall provide project administration as specified in this document for the Communications Voice System.

PART 2 - PRODUCTS

Not Used.
PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17370
PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall perform component, function and system testing for the Sound Transit Voice Systems described in Sections 17300 through 17365. Contractor shall label and identify all PABX, phone and associated equipment consistent with the overall system identification scheme. Additionally, contractor shall perform all administration tasks in support of the design, development, installation, testing and acceptance of the Sound Transit Voice Systems.

1.02 SECTION INCLUDES

This Section includes the requirements for testing, identification and administration for the Voice Systems to include the PABX and PABX components (telephone sets, faxes, modems and voice mail system), the Emergency Phone System and the Passenger Emergency Telephone System throughout the Sound Transit Communications System.

1.03 RELATED SECTIONS

A. Section 17030 – Reliability Management Program.
B. Section 17050 – Configuration Management.
C. Section 17300 – Voice System Overview.
D. Section 17310 – PABX.
E. Section 17320 – Telephone Sets.
F. Section 17330 – Voice Mail System.
G. Section 17360 – Emergency Phone System.
H. Section 17365 – Passenger Emergency Telephones.
I. Section 17380 – Voice System Training, Manuals, Special Tools and Spare Parts.
J. Section 17390 – Voice System Support and Warranty.
K. Section 17520 – Voice Circuits.
L. Section 17560 – Quality of Service Requirements.
1.04 REFERENCE STANDARDS

A. Contractor shall adhere to the following references:

3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.
4. OSHA Occupational Health and Safety Administration.
5. ADA Americans with Disabilities Act.

1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.06 SUBMITTALS

Contractor shall submit the following as part of the Voice Systems delivery:

A. Testing Submittals.

1. Factory Testing.

Contractor shall submit documentation necessary to plan, perform, and execute all factory testing for the Phone System. Contractor may submit multiple phone system test submittals broken out by component (e.g., PABX testing, analog and IP phone testing, emergency phone testing) as appropriate based on scheduling of test and delivery of each component.

a.) Test Plan and Procedures.

1.) Draft

- Contractor shall submit a Draft Test Plan and Draft Test Procedures 60 days prior to the start of Factory Test. Draft Test Plan shall include all components to be tested and a draft Verification Matrix that includes each requirement (functional, performance), the test intended to verify that requirement, and the method of testing (e.g. Inspection, Testing, Simulation, or Modeling).

- Draft Test Procedures shall include each factory test to be performed and the test procedures required to perform that test. Test procedures shall assume the appropriate background (e.g. MS Windows or phone technician skills) required to perform that test or operation, but shall be detailed such that anyone with the appropriate background could step in and perform the test with only the procedures.
Draft Plan and Procedures shall include all testing required for the Phone System. Where information is missing or incomplete, Contractor shall include the section heading or a placeholder for the information that is missing.

2.) Final.

Contractor shall submit a final Factory Test Plan and Factory Test Procedures for the Voice System prior to the start of Factory Testing.

b.) Test Report.

Contractor shall submit a Test Report after Factory Testing that details the test conditions (location, date, time, equipment used, equipment simulated, etc.), the tests performed, which, if any, tests failed, why the tests failed, and what actions are required to resolve any issues from Factory Test.

2. Field Testing.

a.) Test Plan and Procedures.

1.) Draft.

- Contractor shall submit a System Draft Test Plan and System Draft Test Procedures for the Phone Systems prior to the Field Testing. System Draft Test Plan shall include testing required to verify all requirements specified in Sections 17310 through 17365. Contractor shall provide a Verification Matrix that includes, at a minimum, each requirement to be verified, the test used to verify the requirement, the method of testing (e.g. Inspection, Test, Simulation, or Modeling).

- System Draft Test Procedures shall include each system field test to be performed and the test procedures required to perform that test. Test procedures shall assume the appropriate background (e.g. MS Windows or phone technician skills) required to perform that test or operation, but shall be detailed such that anyone with the appropriate background could step in and perform the test with only the procedures.

- Draft Plan and Procedures shall include all testing required for the Phone System. Where information is missing or incomplete, Contractor shall include the section heading or a placeholder for the information that is missing.

2.) Final.

- Contractor shall submit a final Field Test Plan and Field Test Procedures for the ST Voice System prior to the start of Field Testing.

- Contractor shall indicate in the Test Plan any requirements that will not be verified by field testing on equipment to be used in operations. Contractor shall also indicate any equipment that is not tested in field system testing.
Contractor shall gain approval from Resident Engineer for these exceptions before testing is to begin.

3.) Test Reports and Results.

- Contractor shall submit a Test Report for each test conducted that includes the test conditions (location, date, time, equipment used, equipment simulated, etc.), equipment tested, requirements tested, and test results. For any tests that failed, contractor shall indicate why the test failed, and any actions necessary either to correct the system problem and retest, or to verify the requirement via some other means. Contractor shall submit Test Results to Resident Engineer and shall gain Resident Engineer Approval for any follow-on actions as a result of testing.

B. Identification Submittals.

1. Identification Scheme.

Contractor shall submit the labeling or identification scheme for all phone system equipment and associated cabling.

C. List of Phone System Equipment.

Contractor shall include a list of all equipment delivered (including spare equipment). Contractor shall list all equipment by Identification Name, type of equipment, model number, version number, software or firmware running on equipment and version of software or firmware, location, warranty information, and any other information required to identify the phone system equipment.

1.07 TESTING

A. Contractor shall test the Voice System in accordance with Section 17030, Reliability Management Program.

1. Contractor shall perform Factory Testing on the Voice System. In Factory Testing, Contractor shall verify that every piece of equipment to be installed works according to these specifications, and Contractor shall verify that the integrated Voice System works with a minimum of one of each type of equipment.

2. Contractor shall provide Field Testing after all equipment for that Phase of Installation has been installed and configured. Field Testing is the final testing for the installed equipment. Every piece of equipment that is installed, and every piece of spare equipment identified as part of the Voice System shall be tested in Field Testing. Likewise, every requirement for the voice system shall be tested and verified to the Resident Engineer’s approval. The successful completion of all Field Testing is required for Final System Acceptance.

3. Installation and Field Testing shall occur in two phases, as described in Section 01110, Summary of Work.

4. As part of factory and field testing, Contractor shall verification of the following, at a minimum.
a.) PABX. Contractor shall test the PABX switch and associated equipment to verify all requirements specified in Section 17310, PABX. Specifically Contractor shall verify the following:

1.) All voice services described in Section 17310, PABX.

2.) All performance specifications for IP phone connections (end to end latency of no more than 150 milliseconds).

3.) PABX interfaces with KC Metro and ST Union Station, including 5-digit dialing across the leased line and extended services across both interfaced PABX systems.

b.) Contractor shall verify all analog and IP digital phone sets are capable of the services specified in Section 17310, PABX.

c.) Voice Mail. Contractor shall verify the voice mail requirements specified in Section 17330, Voice Mail System.

d.) ETEL. Contractor shall verify all of the Emergency Phone requirements specified in Section 17360, Emergency Phone System. Specifically, Contractor shall verify the following:

1.) All circuits are free from static or other interference and have a clear signal as determined by Resident Engineer.

2.) Resident Engineer shall be the final approval on ETEL performance, clarity, and intelligibility under varying network conditions (e.g. peak and non-peak operations, loaded and non-loaded network conditions).

3.) ETEL delivered features and locations meet NFPA 72 and NFPA 130 requirements.

e.) PET. Contractor shall verify all of the Passenger Emergency Telephone requirements specified in Section 17365, Passenger Emergency Telephones. Specifically, Contractor shall verify the following.

1.) All circuits are free from static or other interference and have a clear signal as determined by Resident Engineer.

2.) Resident Engineer shall be the final approval on PET performance, clarity, and intelligibility under varying network connections (e.g. peak and non-peak operations, loaded and non-loaded conditions).

3.) Contractor shall verify for Resident Engineer approval that PETs are intelligible with varying ambient noise conditions and at various stations and wayside locations (e.g. empty tunnel station, full tunnel station, various station locations where PETs are to be located). Contractor shall verify both the intelligibility of the PET speaker at the PET location, and the intelligibility of the PET user by the operator at the Operations Control Center.
4.) Contractor shall verify the PET/CCS/CCTV interface such that when a PET is taken off hook, CCS generates an alarm and a CCTV camera is panned to focus on that PET. The operator may then select that video feed to view that PET from the alarm or through a simple command on the CCS GUI.

5.) Contractor shall verify ADA compliance of the PETs.

6.) PET delivered features and locations meet NFPA 72 and NFPA 130 requirements.

f.) Contractor shall verify voice performance requirements as described in Section 17520, Voice Circuits, and in 17560, Quality of Service Requirements. Contractor shall demonstrate intelligibility of all IP phones to Resident Engineer for approval, and shall verify QoS priority requirements for ETEL phones and PET phones as described in Section 17560, Quality of Service Requirements.

1.08 IDENTIFICATION

A. Contractor shall provide unique identification of all equipment provided as part of the Communications Voice System.

B. Contractor shall label all equipment and cabling associated with the Voice Systems as follows.

1. Cable labeling requirements are specified in Section 17170, Cable Testing, Identification and Administration.

2. All PABX equipment, cards and ports shall be uniquely labeled. All analog and IP phone sets, fax machines and modems shall be uniquely labeled. All spares parts and components shall be uniquely labeled consistent with their like parts and components.

3. All equipment, card, and port labeling shall follow a logic that is based on type of equipment and equipment location. Resident Engineer shall approve of identification plan prior to any labeling of equipment.

4. All labeling shall be permanent in such a way as to withstand handling and changes in temperature and ambient conditions.

5. All equipment labels shall be consistent with those in the test reports and as-built documentation.

1.09 ADMINISTRATION

Contractor shall provide project administration as specified in this document for the Communications Voice System.

PART 2 - PRODUCTS

Not Used.
PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17370
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PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall furnish all training, manuals, special tools and spare parts required for the operations and maintenance of the Voice System. The goal of providing training, manuals, documentation, special tools and spare parts is so that at time of System Acceptance, Sound Transit is fully equipped to operate, maintain and resolve all issues associated with the delivered system.

1.02 SECTION INCLUDES

This Section includes the requirements for training, manuals, special tools and spare parts for the Voice Systems that provide emergency and non-emergency voice communications throughout Link and with external organizations.

1.03 RELATED SECTIONS

A. Section 17030 – Reliability Management Program.
B. Section 17060 – Special Tools and Spare Parts.
C. Section 17300 – Voice System Overview.
D. Section 17310 – PABX.
E. Section 17320 – Telephone Sets.
F. Section 17330 – Voice Mail System.
G. Section 17360 – Emergency Phone System.
H. Section 17365 – Passenger Emergency Telephone.
I. Section 17370 – Voice System Testing, Identification and Administration.
J. Section 17390 – Voice System Support and Warranty.
K. Section 17520 – Voice Circuits.

1.04 REFERENCE STANDARDS

A. Contractor shall adhere to the following references:

3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.

4. OSHA Occupational Health and Safety Administration.

5. ADA Americans with Disabilities Act.

1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.06 SUBMITTALS

A. Contractor shall submit the following as part of the Voice Systems delivery.

1. Training Plan.

a.) Contractor shall provide a training plan that includes all vendor training required by user and maintenance personnel and a schedule for when that training needs to occur relative to the project delivery schedule.

b.) Contractor shall list all prerequisite training or knowledge required in order to participate in the Voice System training.

c.) Contractor shall also provide as part of the Training Plan a description of proficiency assessments for each class to assess how well the users and maintainers mastered the material.

d.) Contractor shall include a schedule of manufacturer, vendor, and contractor provided training for both users and maintainers of the voice system. All training shall be scheduled to be completed no more than 30 days prior to system acceptance.

e.) Contractor shall provide, as part of the training plan, a list of all required and recommended vendor and manufacturer training. Contractor shall also provide a list of all Contractor training that is required. Contractor shall provide with this list a brief description of what material each class is intended to cover, and how long the class lasts.

2. Contractor shall deliver all training materials used for training which shall include Presentation Slides, Training Notes, and Handouts, training software, and a video of each training class.

B. Manuals.

1. Manufacturer's Manuals.

Contractor shall provide all Manufacturer’s User and Maintenance Manuals for every type of equipment in the Voice System to include the PABX, the analog phones, the digital IP phones and the Voice Mail service. Contractor shall submit any other Manufacturer manuals or documentation that would aid Sound Transit in operating or maintaining the Voice Systems.
2. Contractor’s Manuals.

Contractor shall submit User and Maintenance Manuals for Voice Systems equipment and software developed by Contractor to include ETELs and PETs.

C. Documentation.

1. Manufacturer’s Documentation.

Contractor shall submit all Manufacturer documentation in addition to the user and maintenance manuals described earlier required for installation, operations, maintenance and management of the Voice Systems.

2. Contractor’s Documentation.

Contractor shall provide all design, test and installation documentation for the Voice Systems. This includes, but is not limited to, all design documents and drawings, installation documentation and drawings, as-built documents and drawings, test reports, documentation of configuration and software delivered. A list of any open discrepancy reports or issues at each design review, test review and at acceptance shall be submitted as well.

D. List of Special Tools.

Contractor shall submit a list of all special tools required for test, operation, maintenance, or troubleshooting recommended by Contractor and submitted for approval by Resident Engineer.

E. List of Spare Parts.

Contractor shall submit a list of all recommended spare parts and components for the Voice System for Resident Engineer approval. This shall include PABX and PABX components, telephone sets, ETEL and PET sets, light bulbs, power supplies, etc. Contractor shall assume in general sparing of 10 percent of number of operational parts, or one part, whichever is greater.

1.07 TRAINING

A. Contractor shall provide training to cover the following areas of Voice System operation, maintenance, and troubleshooting:

1. User Training.

a.) PABX Analog Phones.

Contractor shall provide training classes for use of the PABX Analog Phones. Contractor shall provide the Manufacturer Manuals as well as specific training such as how to use the phones, how to set up voice mail, how to administer and access the voice mail system, and how to operate the phone services such as call forwarding, hold, and conference calling.
b.) IP Phones.

Contractor shall provide training classes for use of the PABX IP Phones for ST Communications Operations and Maintenance personnel. Contractor shall provide the Manufacturer Manuals as well as specific training such as how to use the phones, how to set up voice mail, how to administer and access the voice mail system, and how to operate the phone services such as call forwarding, hold, and conference calling.

c.) ETELs.

Contractor shall provide training classes for 40 users on the use of the ETEL phones. Contractor shall instruct users on how to make a call, how to end a call, and how to read the visual indications.

d.) PETs.

PET phones are intended for public use and are therefore assumed to be accompanied with any required signage or documentation, and are assumed to not require any user training or documentation.


a.) PABX.

Contractor shall provide Manufacturer training classes, or shall schedule ST personnel to attend Manufacturer training on the PABX. Training shall include instruction on loading, configuring, troubleshooting, and maintaining the PABX, as well as instruction connecting new phone extensions, setting up leased lines, and changing services. Specific procedures on troubleshooting common problems and troubleshooting techniques shall be trained. Training shall also cover all maintenance of the PABX including training with specific delivered maintenance procedures.

b.) PABX Analog Phone.

Contractor shall provide Manufacturer training on installing new phones (as part of PABX training).

c.) PABX IP Digital Phone.

Contractor shall provide Manufacturer training on installing new phones (as part of PABX training).

d.) Voice Mail.

Contractor shall provide ST Maintenance Staff with Manufacturer training on the Voice Mail system, to include instruction on how to set up voice mail, how to change greeting, how to set up temporary greetings, how to save messages, and how to delete messages.
e.) ETEls/PETs.

Contractor shall provide training classes for ST Maintenance staff on how to install ETEls/PETs, how to troubleshoot ETEls/PETs problems both on the hardware level and on the software level, and how to maintain ETEls/PETs hardware and software.

B. Contractor shall provide training classes for ST Maintenance staff on how to install ETEls/PETs, how to troubleshoot ETEls/PETs problems both on the hardware level and on the software level, and how to maintain ETE/PE hardware and software (to include replacing ETEls/PET components such as light bulbs).

1.08 MANUALS

A. Contractor shall provide the following manuals for using and maintaining the Voice Systems. Manuals shall be professionally bound.

1. User Manuals.

a.) PABX Analog Phone.

Contractor shall provide 50 hard copies of the Manufacturer manual for the Analog phones (should include Voice Mail). Contractor shall provide one soft copy of the Manufacturer’s Manual in a format that is not modifiable, such as pdf.

b.) PABX Digital Phone.

Contractor shall provide 50 hard copies of the Manufacturer manual for the Analog phones. Contractor shall provide one soft copy of the Manufacturer’s Manual on CD or floppy disk. Soft copy shall be in pdf format, such that it cannot be edited or modified.

c.) Voice Mail.

Contractor shall provide 50 hard copies of the Manufacturer manual for the Voice Mail System. Contractor shall provide one soft copy of the Manufacturer’s Manual on CD or floppy disk. Soft copy shall be in pdf format such that it cannot be edited or modified.

d.) ETEL.

Contractor shall provide 40 hard copies of ETEL User Manuals. Contractor shall provide two soft copies of the User’s Manual on CD or Floppy Disk, one in pdf format that is not able to be modified and one in MS Word format that is able to be modified, saved and printed.

e.) PET.

No user manuals are required.

a.) Contractor shall provide Manufacturer Maintenance Manuals for the PABX to include maintenance procedures for both the Analog and the Digital IP Phones. Contractor shall include in the Maintenance Manual detailed procedures for installing the PABX, adding lines and extensions, configuring services, adding and configuring leased lines, troubleshooting and maintaining the PABX.

b.) Contractor shall provide Maintenance Manuals for the ETELs and the PETs. Contractor shall include written descriptions and procedures for adding ETEL hardware, installing the ETEL controller, media converter and any other associated hardware, installing the ETEL software, maintaining the ETEL hardware and software, and troubleshooting the ETEL hardware and software.

c.) As part of Maintenance Documentation Contractor shall also provide copies of schematics, rack drawings, plan drawings, installation drawings as part of the Maintenance Manuals such that Maintenance personnel can install and connect all Voice Systems Equipment.

1.09 SPECIAL TOOLS

A. Contractor shall furnish all special tools required to test, install and troubleshoot the Voice Systems.

B. Contractor shall provide a list of all special tools required to test, install, and troubleshoot the Voice Systems to Resident Engineer for approval.

C. Contractor shall furnish all special tools approved by Resident Engineer. Contractor shall ensure all special tools function correctly at the time of contract approval. Should any tool be found to be defective or not properly functioning, Contractor shall replace the tool at no cost to Sound Transit.

1.10 SPARE PARTS

A. Contractor shall provide sufficient spare Voice System parts and components to allow replacement of any malfunctioning part to meet MTTR requirements that cannot be met by simple troubleshooting.

B. Contractor shall provide a list of all recommended Spare Parts based on the following.

1. Actual delivered system design.

2. Number of each type of phone installed.

3. Relative criticality of component or phone.

4. Manufacturer recommendations.

5. Sound Transit general sparing guidelines described in Section 17060, Special Tools and Spare Parts.
C. Contractor shall submit a draft of this list of Spare Parts for Resident Engineer Approval as part of the Preliminary Design Review, and a final Spares List as part of the Final Design documentation.

1. Contractor shall furnish and configure (where appropriate) all spare parts and components along with furnished operational parts and components.

D. Contractor shall test all spare parts and components along with all system parts and components as part of Voice System Factory Testing.

E. Contractor shall replace any spare parts that fail prior to final system acceptance at no cost to Sound Transit. Should any operational part fail prior to final system acceptance and a spare part used to replace the operational part, the spare part shall be replaced at no additional cost to Sound Transit.

F. All spare parts shall be of identical make, model and version as the operational part that it is a spare for, unless directed otherwise by Resident Engineer.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17380
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PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall provide support and warranty of the Sound Transit Voice System such that the Voice System will be supported during the time of delivery through a year after the final acceptance of the final phase of the ST Communications System.

1.02 SECTION INCLUDES

This Section includes requirements for the support and warranty of the Sound Transit Voice System.

1.03 RELATED SECTIONS

A. Section 17080 – System Support.
B. Section 17300 – Voice System Overview.
C. Section 17310 – PABX.
D. Section 17320 – Telephone Sets, Faxes and Modems.
E. Section 17330 – Voice Mail System.
F. Section 17360 – Emergency Phone System.
G. Section 17365 – Passenger Emergency Telephones.
H. Section 17370 – Voice System Testing, Identification and Administration.
I. Section 17380 – Voice System Training, Manuals, Special Tools and Spare Parts.
J. Section 17520 – Voice Circuits.

1.04 REFERENCE STANDARDS

B. NFPA 130 Standards for Fixed Guideway Transit Systems.
C. UL 50 Standards for Safety for Enclosures of Electrical Equipment.
D. OSHA Occupational Health and Safety Administration.
E. ADA Americans with Disabilities Act.
1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.06 SUBMITTALS

A. Contractor shall submit the following as part of the Support and Warranty delivery of the Voice Systems. See Section 17080, System Support, for overall System Support and Warranty requirements.

1. Contractor shall submit copies of all Manufacturer support and warranty agreements for all equipment delivered at System Acceptance for Phase I and for all equipment delivered at System Acceptance for Phase II. Contractor shall provide the contact information for all Voice System Manufacturers in accordance with delivered support and warranty agreements.

2. Contractor shall deliver the Configuration Management documentation of the system at the time of final delivery (Phase II), including hardware make and model, version number, software version number, software patch number, etc.

3. Contractor shall submit a complete list of all problems encountered during installation and field testing, when they occurred, and how they were corrected. Contractor shall deliver a complete list of all open problems, bugs, and requirements not met at the time of System Acceptance at Phase I and at Phase II.

1.07 SUPPORT

A. Contractor shall provide voice system support for all software and hardware from the beginning of acceptance of Phase I to a year after the acceptance of Phase II. Contractor support for voice systems shall be primarily supplemented by manufacturer support, with the exception of the Emergency Phone System and Passenger Emergency Telephone System.

1. For the PABX, Contractor shall provide a maintenance agreement for a level of support that meets the following requirements:

a.) Manufacturer support shall be available 24 hours a day, seven days a week.

b.) Manufacturer Support shall respond to a problem within four (4) hours during normal business hours defined here as 9 am to 5 pm Monday through Friday, Pacific time, and shall respond to a problem within 8 hours at all other times.

2. For the Analog and Digital IP phones and for the Voice Mail System, Contractor shall provide a maintenance agreement for a level of support that meets the following requirements.

a.) Manufacturer support shall be available Monday through Friday from 9 am to 5 pm Pacific time.

b.) Manufacturer Support shall respond to a problem within four (4) hours during the period of availability as described above.
3. For the ETEL and PET phones, Contractor shall provide a maintenance agreement for a level of support that meets the following requirements:

   a.) Manufacturer support shall be available 24 hours a day, seven days a week.

   b.) Manufacturer Support shall respond to a problem within four (4) hours during normal business hours defined here as 9 am to 5 pm Monday through Friday, Pacific time, and shall respond to a problem within 8 hours at all other times.

1.08 WARRANTY

   A. Contractor shall provide a warranty for the Voice System that covers the repair or replacement of all equipment and software through a period from factory testing through one year after final acceptance of Phase II of the Voice System at no additional cost to Sound Transit. Contractor shall ensure that all manufacturer warrantees cover support and replacement during this period. Where any Manufacturer warrantees cover less than this period or do not cover this period, Contractor shall provide the warranty for this equipment.

   B. Any upgrades or fixes to Voice System hardware and software shall be made with Resident Engineer approval, at no additional cost to Sound Transit.

PART 2 - PRODUCTS

   Not Used.

PART 3 - EXECUTION

   Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

   Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17390
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SECTION 17400
RADIO SYSTEM OVERVIEW

PART 1 - GENERAL

1.01 OVERVIEW

This Section includes a high-level overview of the Two-Way Radio System for Sound Transit’s Link light rail operations. Radio communications for Sound Transit will be provided over the existing King County Regional 800 MHz Trunked Radio System (“KCRS”). The light rail system will require communications along the entire Sound Transit Link light rail alignment from South 154th Street in Tukwila to the Convention Place Station in Downtown Seattle, including two tunnel segments: the existing Downtown Seattle Transit Tunnel (“DSTT”) and a new light rail tunnel to be constructed under Beacon Hill.

1.02 RELATED SECTIONS

A. Section 17410 – KCRS and King County Metro Radio System Interface Requirements.

B. Section 17420 – Tunnel Radio System.

C. Section 17430 – Base Stations and Controllers.

D. Section 17440 – Portable and Mobile Radios.

E. Section 17450 – Mobile Data Requirements.

F. Section 17460 – Software and Supplies.

G. Section 17470 – Radio System Testing, Identification, and Administration.


I. Section 17490 – Tunnel Radio Systems Support and Warranty.

1.03 SOUND TRANSIT TWO-WAY RADIO SYSTEM OVERVIEW

A. The Sound Transit Link two-way radio system will operate over the existing King County Regional 800 MHz Trunked Radio System (“KCRS”), using Motorola mobile radios, portable radios, and control stations configured for operation on the KCRS, which is a Motorola Smartzone analog trunked radio system now being upgraded to Version 4.1.

1. Mobile and portable radios for the Sound Transit two-way radio system will be provided by others and under a separate contract, and are not the responsibility of the Contractor in this Specification.

2. The existing above-ground repeater sites in the KCRS will provide coverage to the portions of the ST alignment that are above ground, while a new Tunnel Radio System (described in Section 17420, Tunnel Radio System) will be implemented to provide coverage in the two tunnel segments (DSTT and Beacon Hill).
3. The Tunnel Radio System will provide radio communications for Sound Transit trains, and public safety agencies (Seattle Police, King County Metro Transit Police, Seattle Fire, and EMS) in the DSTT over the KCRS 800 MHz system and for Sound Transit trains and public safety agencies in a new tunnel to be constructed under Beacon Hill in Seattle over the KCRS 800 MHz radio system. King County Metro Transit buses in the existing DSTT (Downtown Seattle Transit Tunnel) will communicate over a new 700 MHz radio system to be implemented by King County Metro (“KCM”) under a separate contract. The Tunnel Radio System will provide coverage in the tunnel bore segments and in all public and all habitable ancillary spaces in the stations in both tunnels.

4. The Tunnel Radio System will be fed by a new 10-channel 800 MHz dual-redundant base station repeater site on the KCRS connected via redundant path RF-over-fiber links to RF distribution hubs located at University Station in the DSTT and at the Beacon Hill Station in the Beacon Hill Tunnel. The passive components of the Tunnel Radio System (transmission lines, power dividers and combiners, antennas, etc.) shall be designed to accommodate a future 700 MHz public safety band radio system to be supplied by King County Metro (under a separate contract) in the DSTT only. The RF distribution hubs will feed 800 MHz signals from the KCRS to hybrid radiating cable/distributed antenna systems in each tunnel bore. The distribution systems shall be configured to allow the addition of 700 MHz operation in the future.

5. Sound Transit will operate with a total of 10 talkgroups on the KCRS, as follows:

<table>
<thead>
<tr>
<th>Talk Group</th>
<th>Talk Groups Required in DSTT and Beacon Hill Tunnels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Main Line Operations 1</td>
<td>X</td>
</tr>
<tr>
<td>2 Main Line Operations 2</td>
<td>X</td>
</tr>
<tr>
<td>3 DSTT Operations</td>
<td>X</td>
</tr>
<tr>
<td>4 Yard Operations</td>
<td></td>
</tr>
<tr>
<td>5 Maintenance 1</td>
<td>X</td>
</tr>
<tr>
<td>6 Maintenance 2</td>
<td></td>
</tr>
<tr>
<td>7 DSTT Maintenance</td>
<td>X</td>
</tr>
<tr>
<td>8 Fare Inspection</td>
<td>X</td>
</tr>
<tr>
<td>9 Security 1</td>
<td>X</td>
</tr>
<tr>
<td>10 Security 2</td>
<td>X</td>
</tr>
</tbody>
</table>

X – Talk group required in tunnels

6. The interface between the Sound Transit radio console equipment and the King County Regional 800 MHz Trunked Radio System will be provided by a system of 10 (ten) 800 MHz control stations (one control station per Sound Transit talkgroup). The control stations and associated equipment used for this interface will be the responsibility of the C803 Contractor, as described in detail in Section 17410, KCRS and King County Metro Radio System Interface Requirements.

7. The KCRS and repeater site used to feed the Tunnel Radio System will be provided by others under separate contracts, and is not the responsibility of the C803 Contractor.
8. The Tunnel Radio System will include two conventional 800 MHz repeaters in each tunnel operating on ITAC interoperability channels to provide backup communications in the tunnels in the event of the complete failure of one or both of the base station repeater sites or failure of one or both of the fiber links between the base station repeater sites and the tunnel segments. One repeater will provide backup communications for public safety users. The other repeater will provide backup communications for ST users. The ST conventional repeater will be linked to the ST control center via a dedicated four (4) wire E&M link, over the ST communications backbone system.

B. King County Regional 800 MHz Trunked Radio System Overview.

1. [NOTE: The overview of the King County Regional 800 MHz Trunked Radio System contained in this Section is provided for background and reference only. The C803 Contractor will have no responsibility for installation, testing, or maintenance of the KCRS base station equipment described here or elsewhere in Sections 17420, Tunnel Radio System and 17430, Base Stations and Controllers. The equipment required to provide the RF interface between the Tunnel Radio System and the KCRS dual-redundant base station equipment, the 700 MHz control station interface to the KCM radio system and the 800 MHz control station equipment to provide the interface between the Sound Transit radio console equipment and the KCRS 800 MHz system will be provided under this Specification, as described in Sections 17410, KCRS and King County Metro Radio System Interface Requirements and 17420, Tunnel Radio System.

2. The following description of the King County regional 800 MHz trunked radio system has been taken from the King County Regional 800 MHz Trunked Radio System Information Sheet (updated March 2001), prepared by the King County Emergency Management Division of the King County Department of Information and Administrative Services, and from the King County Comprehensive Radio Plan, dated March 1998.

a.) Background.

1.) The King County Regional 800 MHz trunked radio system was approved by voters in an election held on September 15, 1992. King County voters authorized a special levy to be assessed for a period of three consecutive years to finance the development of an 800 MHz trunked radio system, including compatible mobile and portable radios, base stations, a microwave transmission network, network controllers and other related equipment. The levy was collected in 1993, 1994 and 1995 at a rate not to exceed $.16 per $1000 of assessed valuation, for a total amount of $57,016,764. Although portions of the system and some users were on the air in 1996, the addition of those users was part of the 'implementation' phase for the system. December 1997 is considered to be the end of the 1st year of the 15-year life cycle assumed in the system design.

2.) The primary purpose of the system is to provide emergency radio communications services for all the police, fire, emergency medical services, public school districts and public hospitals within King County. The secondary purpose of the system is to provide, to the extent possible within the constraints of available funding and limited spectrum availability, sufficient capacity within the system to service other public agencies with emergency response duties.

3.) The regional system consists of several subsystems joined together by electronic switching equipment to provide highly reliable region-wide communications. Each subsystem has been implemented by a subregional system management
group, also called a subregion, that owns and manages portions of the system. Subregions include: The City of Seattle, Valley Communications Center, Eastside Public Safety Communications Agency (EPSCA), and King County. The governing body for the EPSCA Subregion includes the cities of Bellevue, Kirkland, Redmond, Mercer Island and Issaquah. The governing body for the Valley Communications Subregion includes the cities of Auburn, Kent, Renton, and Tukwila.

4.) The Regional Communications Board provides central coordination for the regional system. This Regional Communications Board is a joint board, and consists of one representative from each subregion and an at-large member who represents the interests of system users who do not have a voting representative on the governing body of any subregion. Each member of the Board has equal voting authority. Decisions concerning network design require unanimous approval by the Board.

b.) System Design.

1.) The Subregions have worked cooperatively through the Regional Communications Board to implement a design for the entire county-wide system that is able to meet performance needs within the limited number of frequencies and available funding. Some of the major design considerations are related to coverage, performance standards, and the sheer number of diverse government users within King County.

2.) A majority of King County’s population lies in a region that is within 140km of the Canadian border. Treaties between the US and Canada allow agencies in these border areas to only have clear use of about 1/2 of the available 800 MHz spectrum. All other spectrum utilization needs to be on a non-interference basis to the neighboring country. Given the unique terrain and topography of the Puget Sound region, the design of the system needed to carefully plan spectrum utilization so that capacity needs could be met without causing interference problems to our Canadian neighbors.

3.) King County covers approximately 2,200 square miles. Almost 90 percent of the almost 1.7 million population live in the western half of the county. The eastern portion of the county reaches to the crest of the Cascade Mountains, where radio coverage is more difficult to provide. This area is sparsely populated but has several major transportation corridors that have heavy commercial and recreational use.

4.) The large number of separate governments within King County include 38 cities, 24 fire districts, the Port of Seattle, 4 hospital districts, 20 school districts, and 43 water and sewer districts. There are a total of 68 separate public safety agencies delivering police, fire and EMS services to our citizens. Over the years these agencies had developed a collection of over 100 separate VHF, UHF and 800 MHz radio systems.

5.) The levy-funded 800 MHz radio system has been designed with the capacity to meet the diverse needs of these users with one compatible radio network. This network has sufficient capacity to meet the growth needs of our region; it provides the coverage capabilities essential to public safety services that many of the older systems lack; it has a high likelihood of surviving a natural disaster for the delivery of reliable service; and it provides for direct communications between
jurisdictions to better meet mutual response needs during single incidents or during a disaster.

6.) The 800 MHz regional system has been designed to provide a very high grade of service (One percent blocked calls, maximum blocking delay of one second during the peak busy hour) when loaded with a maximum of 15,000 mobile and portable radios. The system will ultimately be loaded with between 12,000 and 13,000 radios when all users planning to migrate to the system are incorporated. The present loading is approximately 12,500 units, approximately divided between 33 percent portable radios and 67 percent mobile radios. Traffic and usage statistics for the system are constantly measured and monitored to assure that adequate capacity is maintained as system loading and use changes.

7.) The county-wide network is essentially configured as three subsystems that work through common network controller equipment. Subsystems include the City of Seattle subsystem, the EPSCA subsystem, and the subsystem that was jointly developed by King County and Valley Communications Center. By connecting all sites within the subsystems to common network controller equipment, it is possible to implement talkgroups on the system that have seamless coverage over the entire county. A system topology diagram and a site map for the system are shown below.

8.) The system has been designed for portable grade coverage wherever possible and the system loading is patterned so that all areas of the county experience relatively similar system capacity access. The overall county-wide system has been designed with sufficient frequency capacity to include most, if not all, general government users within King County.

9.) The regional system currently uses analog audio technology rather than digital audio technology. Analog technology for 800 MHz trunking is proven and reliable, and provides better audio quality with fewer sites when compared to a digital trunking system. Further, an industry standard is not yet fully developed for digital trunking technology for public safety communications systems. At the time system design decisions were being made (and in some respects even to this day) investment in public safety digital trunking infrastructure involves some risk of selecting technology that may not be supported into the future as final standards emerge. Because digital technology does appear to be the direction for communications in the future, however, the system uses, to the extent possible with today’s technology, infrastructure equipment that can be migrated to digital technology in the future when the need exists, when the costs are more reasonable, and when the technology is stable.

10.) The system topology and site map exhibits shown in the following two pages show the overall configuration of the King County Regional 800 MHz Trunked Radio System. These drawings are provided for reference only to provide an understanding of the overall system of which the ST Tunnel Radio System will be a part.

11.) The two base station sites shown in the System Topology block diagram as “Metro Tunnel North” and “Metro Tunnel South” will be replaced by the dual-redundant fiber-fed repeater site described in this Specification, as part of the new Tunnel Radio System implementation. Design, installation, testing, and maintenance of this new base station site will be handled under a separate contract, and will not be the responsibility of the Sound Transit Link C803 Contractor.
Figure 1 - King County Regional 800 MHz Trunked Radio System - Basic System Topology (For Reference Only)
Figure 2 – King County Regional 800 MHz Trunked Radio System – Site Map (SHOWN FOR REFERENCE ONLY)
C. Sound Transit Tunnel Radio System Overview.

1. The subsystems described in Sections 17410, KCRS and King County Metro Radio System Interface Requirements and 17420, Tunnel Radio System include a radio frequency distribution system consisting of RF/Fiber conversion equipment at the Sound Transit Operations and Maintenance Center RF Headend and at the two RF Distribution Hub locations at University Station and Beacon Hill Station; downlink power dividing equipment; uplink power combining equipment; and BDA (bi-directional amplifier) equipment designed to feed 800 MHz signals to the two distributive antenna systems (DAS) described in the next paragraph. All fiber links used in this distribution system will consist of continuous fusion spliced fiber runs terminated at the radio system demarcation point with FC/APC connectors. Each hub location will be provided with main and backup diverse route fiber feeds, with switching at both the headend and hub locations to select either the main or the backup fiber feed.

2. Dark single-mode fiber for the fiber interconnects between the Tunnel Radio System Headend at the ST O&M Facility and the Distribution Hubs at University Station and Beacon Hill Station will be provided by the C803 Contractor as part of the ST communications backbone system under Sections 17100, Cable Network Overview and 17140, Backbone Cabling Requirements. The demarcation points for the fiber interconnect system described in Sections 17410, KCRS and King County Metro Radio System and 17420, Tunnel Radio System will be the connectors on the fiber termination modules at the ST Operations and Maintenance Center, the University Station hub site, and the Beacon Hill hub site.

3. This Specification (Section 17420, Tunnel Radio System) also includes subsections describing new distributive antenna systems (DAS) in the Downtown Seattle Transit Tunnel (“DSTT”) and in the Beacon Hill Tunnel, which are to be used by the Sound Transit Link light rail trains. The fiber distribution system described above will provide the interconnection between the 800 MHz RF base station equipment at the Sound Transit Operations and Maintenance Center and the distributive antenna systems located in the two tunnels.

4. The base station equipment, associated transmitter combining and receiver multicoupling equipment, and the dual-redundant base station switching equipment at the ST Operations and Maintenance Center headend, will be provided by others and under a separate contract. The demarcation point for the interconnection between that base station equipment and the RF/Fiber interconnect system described in this specification will be the output connector of the redundant transmitter combiner switch for the downlink path and the input to the redundant receiver switch for the uplink path, as shown in the drawings.

5. The Tunnel Radio System Distribution Hubs and Distributive Antenna Systems in both tunnels are described in detail in Section 17420, Tunnel Radio System. The interface requirements for the base station repeater site for the 700 MHz control station interface used to provide interoperability between the ST 800 MHz system and the new KCM 700MHz system in the DSTT, and the control station interface between the ST radio console and the KCRS are described in detail in Section 17410, KCRS and King County Metro Radio System Interface Requirements.

6. A high-level system diagram showing the configuration of the Tunnel Radio System is shown in Drawing L00-R100 – TUNNEL RADIO SYSTEM - SYSTEM OVERVIEW, attached to this Specification.
PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17400
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SECTION 17410
KCRS AND KING COUNTY METRO RADIO SYSTEM INTERFACE REQUIREMENTS

PART 1 - GENERAL

1.01 OVERVIEW

A. Contractor shall design, furnish, and install all necessary fiber-optic equipment, power dividers and combiners, fiber optic switches, interconnecting cabling, other devices and software to completely implement the King County Regional 800 MHz Trunked Radio System ("KCRS") headend repeater base station repeater interface for a new fiber-fed 800 MHz Tunnel Radio System and associated FCS monitoring equipment described in Sections 17420, Tunnel Radio System, and 17802, Field Control System, of this Specification and in the attached Contract Drawings. An overview of the KCRS is contained in Section 17400, Radio System Overview.

B. Contractor shall also design, furnish and install equipment necessary to implement the 800 MHz control station interface between the Sound Transit radio dispatch console at the ST O&M central control facility and the KCRS, as well as all equipment necessary to implement the 700 MHz control station interface between the Tunnel Radio System and the King County Metro ("KCM") radio system in the Downtown Seattle Transit Tunnel ("DSTT"), as described herein and in the attached Contract Drawings.

1.02 SECTION INCLUDES

A. This Section includes the requirements for furnishing, installing, and testing the interface equipment required to connect a dedicated 800 MHz base station repeater site to a new Tunnel Radio System to provide radio communications for both Sound Transit and for public safety agencies in the existing Downtown Seattle Transit Tunnel ("DSTT") and in the new Sound Transit Link Beacon Hill Tunnel. The Tunnel Radio System is described in Section 17420, Tunnel Radio System, of this Specification. The Tunnel Radio System will provide coverage both in the tunnel segments and in all public and ancillary habitable spaces in the stations in both tunnels. The system will have two RF distribution Hubs located at University Station in the DSTT and in Beacon Hill Station in the Beacon Hill Tunnel. These Hubs will be fed via an analog RF-over-fiber link from the King County Regional 800 MHz Trunked Radio System ("KCRS") system base station headend at the Sound Transit Operations and Maintenance Facility (O&M). This Section also includes the requirements for furnishing, installing and testing a transmitter combiner system, a receiver multicoupler system, a transmitting antenna system, and a receiving antenna system for 10 (ten) 800 MHz control stations at the Sound Transit O&M Facility. The control stations will provide a direct RF interface between the Sound Transit Link control center radio console equipment and the King County Regional 800 MHz Trunked Radio System ("KCRS"). Each control station will be dedicated to a single Sound Transit talkgroup on the KCRS, for a total of ten (10) talkgroups.

B. Requirements for four (4) 700 MHz control stations used to provide shared talkgroups between the KCRS and the new King County Metro (KCM) 700 MHz transit radio system in the DSTT, and to be installed at the University Station Distribution Hub in the DSTT, are also described in this Section with additional installation and configuration details in Section 17420, Tunnel Radio System.
1.03 RELATED SECTIONS

A. Section 16610 – Static Uninterruptible Power Supply.

B. Section 16615 – Dc Rectifiers and Power Systems.

C. Section 17400 – Radio System Overview.

D. Section 17420 – Tunnel Radio System.

E. Section 17430 – Base Stations and Controllers.

F. Section 17440 – Portable and Mobile Radios.

G. Section 17450 – Mobile Data Requirements.

H. Section 17460 – Software and Supplies.

I. Section 17470 – Radio System Testing, Identification and Administration.


K. Section 17490 – Tunnel Radio System Support and Warranty.

1.04 RELATED WORK BY OTHER CONTRACTORS

The base station repeater equipment to be located at the Sound Transit O&M Center will be provided under a separate contract. The demarcation line between base station equipment and the Tunnel Radio System Interface equipment covered by these specifications is the single RF output from the repeater base station transmitter redundant combiner switch on the transmit (downlink) side of the Tunnel Radio System and the input to the repeater base station redundant receiver multicoupler switch on the receive (uplink) side of the Tunnel Radio System. This demarcation line for the ST O&M Facility base station repeater site is shown in Drawings M01-R101 - O&M CONTROL CENTER RF/FIBER HEADEND DISTRIBUTION SYSTEM AND KCRS BASE STATION INTERFACE BLOCK DIAGRAM.

1.05 REFERENCE STANDARDS

A. Without limiting the generality of other requirements of this Specification, all work specified herein shall conform to or exceed the applicable requirements of the referenced Standards; provided, that wherever the provisions of said publications are in conflict with the requirements specified herein, the more stringent requirements shall apply unless in conflict with the equipment manufacturer’s written recommendations:

1. NFPA 70 (National Electrical Code) Sections 100-300 and Section 800.


4. Uniform Building Code, including the seismic requirements of Section 2312, for Earthquake Zone 3.

5. EIA Standards EIA 232-C, EIA 485.

6. TIA/EIA 603-1 – Land mobile FM or PM communications equipment measurement and performance.


8. Codes and Standards of good practice issued by the following organizations:
   a.) National Electric Manufacturers Association (NEMA).
   b.) Underwriters Laboratories (UL).
   c.) National Fire Protection Association (NFPA).
   d.) Publication No. 70, National Electrical Code.
   e.) Occupational Safety Health Administration (OSHA) Standard.

1.06 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Codes and local regulations.

1.07 SCOPE OF WORK FOR KCRS AND KCM BASE STATION INTERFACE EQUIPMENT

A. Tunnel Radio System Headend at ST O&M Facility.

1. Provide and install downlink and uplink power dividing/power combining equipment to distribute RF signals from the King County Regional 800 MHz Trunked Radio System (“KC RS”) dual-redundant repeater site at the ST Operations and Maintenance Facility to the RF-fiber links to the Distribution Hub locations at University Station and Beacon Hill Station.

2. Provide and install equipment required for redundant path RF-over-fiber optic links from the King County Regional 800 MHz Trunked Radio System (“KC RS”) base station equipment at Sound Transit Operations and Maintenance Facility to the University Station and Beacon Hill Station RF Distribution Hubs. The KC RS is an existing local government 800 MHz trunked radio system that will provide coverage for Sound Transit Link light rail vehicles throughout King County. This system will also provide public safety (police, fire and EMS) coverage in the existing Downtown Seattle Transit Tunnel (“DSTT”) and in the new Beacon Hill light rail tunnel. The KC RS 800 MHz trunked radio system will use U.S. Canada Treaty Zone channels (U.S. Secondary/Canadian Primary
channels) selected from the 800 MHz SMR band (809.7625-813..9875/854.7625-858.9875 MHz) for coverage in the tunnels. The ITAC repeaters used for backup communications in the both tunnels will operate in the NPSPAC public safety band (821-824/866-869 MHz).

a.) Dark fiber for the RF-over-Fiber links will be provided per the requirements shown in Sections 17100, Cable Network Overview and 17140, Backbone Cabling Requirements. This Section covers only RF-fiber interface and interconnection equipment up to the fiber demarcation point at the Headend and Hub locations.

3. Interfaces to ST Field Control System.

a.) Provide and install interface equipment to the Field Control System (described in Section 17802, Field Control System) for alarms and status indications from the RF/Fiber transceivers and fiber switches shall be provided via normally-closed direct contact closures, with the closed condition representing normal operation and the open condition representing an alarm condition. The required alarms, status indications, and analog monitoring functions for the fiber equipment at the OMF headend site are shown in the list below.

1.) RF Fiber Transceivers.
   - Laser Monitor Output (analog voltage output).
   - Laser Status Alarm Output.
   - Temperature Alarm.
   - Optical Monitor (analog voltage output).
   - Optical Alarm.

2.) Fiber Main/Backup Path Switches.
   - Active Path Indication (Path 1 Active/Path 2 Active).

4. The King County Regional 800 MHz Trunked Radio System (“KCRS”) dual-redundant 800 MHz repeater site equipment up to and including the main/backup repeater site switching equipment shown in the Contract Drawings is shown for reference only. This equipment, up to the demarcation line between the base station equipment and the distribution system interface equipment, will be provided under a separate contract and is not the responsibility of the C803 Contractor.

B. ITAC Backup Control Stations in DSTT and Beacon Hill Tunnel and Microwave Radio Links to ST Control Center Radio Console.

1. In the event of a complete failure of the fiber links between the system Headend and the DSTT and Beacon Hill Tunnel Hub locations, two 800 MHz repeaters located at each Hub and operating on ITAC channels in the NPSPAC band shall provide backup communication within the tunnel itself. One repeater will operate in stand-alone mode to provide public safety communications within the tunnel. The other repeater will be linked via a 4-wire E & M wireline circuit to the radio console at ST Central Control to provide...
emergency backup communications between the train controller and the trains in the
tunnel segment (DSTT or Beacon Hill) served by each backup repeater. Requirements
for the E&M circuits and associated channel bank equipment are described below.

2. The ITAC repeaters will be provided by others under a separate contract. The
demarcation line between these base station repeaters and the equipment to be provided
by the Contractor for the Tunnel Radio System is shown in Drawing L00-R105 - TUNNEL
RADIO SYSTEM - CONTRACT DEMARCATION BLOCK DIAGRAM.

C. Control Stations and Control Station Antenna System at ST Link O&M Center.

1. Provide and install ten (10) 800 MHz trunked control stations to provide RF access to the
KCRS for the radio console at the ST Control Center. Each control station shall be
configured to operate on a single dedicated talkgroup on the KCRS 800 MHz system.
The control stations shall be configured to provide direct audio and control links to the ST
radio console equipment in the ST Central Control facility via a four (4)-wire E & M
interface with an M lead. The following Sound Transit talkgroups shall be implemented
via the dedicated control stations:

<table>
<thead>
<tr>
<th>Talk Group</th>
<th>Talk Groups Required in DSTT and Beacon Hill Tunnels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1       Main Line Operations 1</td>
<td>X</td>
</tr>
<tr>
<td>2       Main Line Operations 2</td>
<td>X</td>
</tr>
<tr>
<td>3       DSTT Operations</td>
<td>X</td>
</tr>
<tr>
<td>4       Yard Operations</td>
<td></td>
</tr>
<tr>
<td>5       Maintenance 1</td>
<td>X</td>
</tr>
<tr>
<td>6       Maintenance 2</td>
<td></td>
</tr>
<tr>
<td>7       DSTT Maintenance</td>
<td>X</td>
</tr>
<tr>
<td>8       Fare Inspection</td>
<td>X</td>
</tr>
<tr>
<td>9       Security 1</td>
<td>X</td>
</tr>
<tr>
<td>10      Security 2</td>
<td>X</td>
</tr>
<tr>
<td>X – Talk group required in tunnels</td>
<td></td>
</tr>
</tbody>
</table>

2. Control station transmitter combining/receiver multicoupling equipment and antenna
equipment shall be provided to allow all ten (10) 800 MHz control stations to operate over
a single transmit antenna and a single receive antenna; the typical configuration for the
transmitter combining and receiver multicoupling equipment is shown in Drawing M01-
R103. The transmitter combiner/receiver multicoupler system shall be designed (in
conjunction with sufficient transmit/receive antenna separation) to allow any control
station transmitter (or transmitters) to operate without degrading the receiver sensitivity or
performance of any other control station receiver (or receivers) operating simultaneously
with the control station transmitter(s).

a.) The transmit and receive antennas for the control station interface shall be mounted
on the roof of the OMF building, as shown in the Contract Drawings. Contractor shall
provide TVSS (Transient Voltage Surge Suppression) systems for the RF
transmission lines used to connect the control station interface transmitter combiner
to the TX antenna and the control station interface receiver multicoupler to the RX
antenna, as shown in the Contract Drawings. These systems shall, to the extent possible, be located at the point of entry into the OMF Central Communications Equipment Room and shall be connected to the equipment room ground system using an entry port panel designed to support the devices and to provide a low impedance connection to the equipment room ground system. The entry panel shall be attached directly to the equipment room ground system so as to minimize the impedance of the panel-to-ground path at RF frequencies.

D. Redundant Fiber Path Requirements – KCRS Base Station to Distribution Hubs.

1. Each RF Distribution Hub (University Station and Beacon Hill Station) shall be connected to the KCRS Radio System repeater site Headend (at the ST Operations and Maintenance Facility “OMF”) via redundant diverse route single mode continuous fiber links. Each fiber link shall be configured to provide main and backup operation, with the main link as the default path, and with automatic switching to the backup link in the event of failure of the main link.

2. Dark fiber for these links will be provided as part of the Sound Transit communications backbone system, as described in Sections 17100, Cable Network Overview and 17140, Backbone Cabling Requirements. The demarcation point for the interface between the RF-fiber links and the single mode fiber links shall be the connectors on the fiber termination modules at the ST Operations and Maintenance Facility, the University Station Hub, and the Beacon Hill Tunnel.

E. Station and Tunnel Distributive Antenna Systems (DAS).

Requirements for the DSTT and Beacon Hill 800 MHz Distributive Antenna Systems are included in Section 17420, Tunnel Radio System.

F. Frequency Bands.

1. The Headend-to-Hub and Hub-to-Headend RF/fiber links described in this Section and the Distribution Hubs and the Distributive Antenna Systems in both tunnel segments described in Section 17420, Tunnel Radio System, shall be designed to carry the following frequency bands:

<table>
<thead>
<tr>
<th>Frequency Band</th>
<th>Uplink Passbands</th>
<th>Downlink Passbands</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 MHz SMR Band</td>
<td>809.7625-813.9875 MHz</td>
<td>854.7625-858.9875 MHz</td>
</tr>
<tr>
<td>800 MHz NPSPAC Band</td>
<td>821-824 MHz</td>
<td>866-869 MHz</td>
</tr>
</tbody>
</table>

2. These systems shall be designed to carry the 700 MHz band (764-776 MHz/894-806 MHz) in the future by modifying or adding RF/Fiber and BDA components only. All other parts of the system shall be configured to cover the entire band from 764 to 869 MHz without degradation of system performance.

G. Interoperability Requirements and 700 MHz Control Stations.

1. The RF distribution and DAS systems described in Section 17420, Tunnel Radio System, are intended to provide both light rail and public safety communications in the tunnels. Interoperability between Sound Transit and public safety agencies operating in the tunnels will be provided via dedicated shared interoperability talkgroups on the existing...
King County 800 MHz Trunked Radio system and the new King County Metro Transit 700 MHz System.

2. Contractor shall provide and install 4 (four) dedicated 700 MHz control stations for the KCM radio system interface, as described below. The control stations shall be configured as shown in the Contract Drawings.

3. The dedicated 700 MHz RF trunked control stations and associated equipment are required for the talkgroup interface between the ST Tunnel Radio System and the King County Metro (KCM) RF distribution system in the DSTT. This interface will be provided by 3 (three) dedicated 700 MHz RF trunked control stations located in the TC/C Room in the University Station. Three of the control stations will be used to provide 3 (three) shared talkgroups between the KRCS Regional 800 MHz Trunked Radio System (used for communications with ST personnel and trains in the DSTT) and the proposed new King County Metro 700 MHz trunked radio system (used for communications with KCM personnel and buses in the DSTT). The fourth control station will be used as a backup for the shared talkgroup used for communication between the DSTT controller at the DSTT dispatch control center and buses and trains in the DSTT. This fourth control station shall be configured to allow the tunnel controller to use it in place of the primary control station via a switch or selector at the console in the DSTT control center in the event of the failure of the control station normally used to provide communications over this talkgroup.

4. Each control station shall be assigned to a single (shared) talkgroup on the KCM 700 MHz radio system (actual talkgroup assignments and names remain to be determined). It shall be the responsibility of the Contractor to have the control stations programmed for operation on the appropriate talkgroups on the new KCM 700 MHz system by the appropriate technical personnel at King County Metro.

5. Each 700 MHz control station shall be connected to the Sound Transit radio console at the ST O&M Center via a dedicated DS0 4-wire E&M circuit. The fiber path for the DS0 links will be provided via channel banks and ST Communications Backbone system, as described in Section 17500, Cable Transmission System Support and Warranty.

6. The Contractor shall provide, install and configure the channel bank equipment required to provide the interfaces between the fiber backbone system and the dedicated 4-Wire E & M DS0 circuits at the Headend in the Central Communications Equipment Room at the ST O&M Facility Headend, in the University Station Distribution Hub in the University Station TC/C Room, and at the Beacon Hill Station Distribution Hub in the Beacon Hill Station Communications Equipment Room. (Channel bank requirements are indicated below.) One E&M control circuit shall be provided for each 700 MHz control station in the DSTT and for each ST 800 MHz backup repeater (See Section 1.06.B above), one in the University Station TCC Room and the other in the Beacon Hill Communications Equipment Room. Contractor shall also provide the necessary connections between these 4-wire E&M circuits and their associated control stations and repeaters.

7. Contractor shall provide and install transmitter combiner and receiver multicoupler equipment required to combine the three (3) 700 MHz control stations into a single transmit antenna and a single receive antenna mounted in the DSTT so as to provide an RF link between the Sound Transit Tunnel Radio System and the RF distribution system provided by KCM as part of the KCM 700 MHz system in the DSTT. The control stations and their associated antennas are to be located at the University Station inside the DSTT in order to limit radiation of the control channel signals into the above-ground portion of the KCM system and to limit traffic on these shared talkgroups to the KCM base station repeater site used to feed the KCM RF distribution system in the DSTT.
8. Final configuration and layout of the KCM tunnel RF distribution system remains to be determined. Based on the actual configuration of the KCM tunnel radio distribution system, Contractor shall select antenna locations for the control station transmit and receive antennas and set control station transmit power levels to provide adequate coupling of the control station signals into the KCM RF distribution system in the DSTT, and to simultaneously avoid overload of any KCM RF distribution system components by strong signals from the 700 MHz control stations.

H. Backup Power Requirements.

Provide and Install equipment required to allow all Tunnel Radio System Headend equipment at the ST O&M Facility to operate from the backup power systems provided at the system Headend communications room. Both 48 Vdc battery backup and 120 Vac UPS backup power systems will be provided as part of the ST communications backbone system (See Section 16610, Static Uninterruptible Power Supply and 16615, Dc Rectifiers and Power System) in the ST Central Control communications room. It shall be the responsibility of Contractor to provide an appropriate interface to these systems, including Dc-to-Dc converters or other equipment required to provide an appropriate interface between the backup power supplied under this Contract and the equipment used in the Tunnel Radio System Headend and 800 MHz Radio System/Console control station interface.

I. Tunnel Radio System Conceptual Design Drawings.

The Contract Drawings show an overview of the system, and high-level schematic details of the Headend dual-redundant base station interface, and the RF-fiber link equipment configuration at the Headend and Hub locations, and a high-level conceptual design for the hybrid radiating cable/distributed antenna distributive antenna system.


K. Block diagrams of the required system interfaces described in the Specification are contained in the Contract Drawings. Tunnel Radio System Detailed Design Drawings — ST O&M Tunnel Radio System Headend. The Contract Drawings show details of the ST O&M Facility 800 MHz Base Station Interface equipment layout and configuration, the equipment configuration for ST O&M Facility 800 MHz control station interface to the KCRS, the equipment configuration for the 700 MHz control station to the KCM 700 MHz radio system, and typical equipment configurations at the ST O&M Facility base station headend location.

1.08 SUBMITTALS

A. See Section 01330, Submittals, for general submittal requirements.


a.) Contractor shall submit the following information prior to Tunnel Radio System Conceptual Design Review:

A brief design document verbally describing the functions and operation of the KCRS system headend interfaces and the radio console/control station interface to the KCRS, including block diagrams of the system similar to the block diagrams shown in the drawings, a list of anticipated equipment, and a list of any exceptions to the design requirements Contractor desires to put forward for approval.
2. Preliminary Design Review.

   a.) Contractor shall submit the following minimum information prior to Tunnel Radio System Preliminary Design Review:

   1.) A detailed document including but not limited to the following documentation:

      - Product specifications of equipment for intended use.

      - Draft RF system schematics, showing the complete system configuration, including all signal paths and system components, system component gains and losses, normal signal levels, noise levels, and intermodulation levels at each active RF stage input (amplifiers and RF-fiber links) and output throughout the system, and cumulative, end-to-end uplink signal, noise, and intermodulation levels based on the uplink and downlink input signal levels shown in the link budgets and system block diagrams contained in the Specification.

      - Draft schematic diagrams of the configuration of equipment to perform the monitoring and control functions described in this specification, including all proposed interfaces to the Communications Field Control System described in Section 17802, Field Control System.

3. Intermediate Design Review.

   a.) Contractor shall submit the following minimum information prior to Tunnel Radio System Intermediate Design Review:

   1.) Preliminary layout of antenna transmission lines, proposed antenna locations for the radio console/control station interface TX and RX antennas on the ST O&M Facility roof, power dividers and combiners, transmitter combiner and receiver multicoupler equipment in equipment cabinets, rack-mounted control stations, and other associated equipment to be mounted in cabinets and at the ST O&M Facility headend.

   2.) Detailed list and description of all equipment intended for use.

   3.) Draft Use Case documents for all user and systems interfaces.

   4.) Draft description of KCRS base station interface, the KCRS control station interface and the KCM 700 MHz control station interface design, operations and maintenance.

4. Final Design Review.

   a.) Contractor shall submit the following minimum information prior to the Tunnel Radio System Final Design Review:

   1.) A complete list of the specific components to be provided to install the interface and interconnect system(s) shown in the Specification documents, corresponding
to each component shown in the Specification block and level diagrams and the Specification Equipment List. The Contractor shall submit detailed descriptions of each major component, separate from the device's specification sheet. The description shall address the device's features, whether the device can be dc powered from a standby battery system or requires continuous ac power, and its function within the system. Specification sheets for each device shall be included in the documentation submitted under this Section.

2.) A complete set of Block and Level system diagrams for the KCRS base station interface, the KCRS console/control station interface and the KCM 700 MHz Control Station Interface at the University Station Distribution Hub, similar to those shown in the Specification, showing at a minimum the following information:

- The complete system configuration for each interface/interconnect subsystem, including all signal paths and system components, system component gains and losses, and normal signal levels based on the uplink and downlink input signal levels shown in the link budgets and system block diagrams shown in the Specification.

- Nominal gain, noise figure, and Output Third Order Intercept for all amplifiers and other system gain blocks [e.g. receiver multicoupler amplifier(s)].

- Calculated signal power levels (dBm), composite noise power levels [dBm in a 12.6 kHz ENBW (Equivalent Noise Bandwidth) channel], carrier-to-noise (C/N) ratios (dB), and 3rd order intermodulation power levels (dBm and dBc - dB relative to the desired carrier level) at critical points in the system uplink path. At a minimum, these shall be shown at the output connectors of the fiber optic links at the KCRS base station headend location at the OMF, and at the output of the uplink power combiner that feeds the KCRS 800 MHz system dual-redundant base station site. Signal levels shall be based on the nominal “normal” uplink signal levels shown at the last tunnel BDA input in the uplink signal paths. Noise power levels and carrier-to-noise ratios shall be based on the calculated cascade noise power at the output of each uplink fiber optic-RF receiver at the OMF headend site, based on the uplink BDA gain and noise figure values and the fiber optic link net gain and fiber optic/RF receiver output noise power used in the Contractor's system design. These signal, noise and intermodulation product levels shall be shown on system block and level diagrams and in sample calculations similar to those shown in Appendix K, Radio Calculations, of this Specification.

- The link budgets shall demonstrate that the Contractor’s proposed Tunnel Radio System will provide an uplink carrier-to-noise (C/N) ratio of at least 29.2 dB (19 dB for uplink DAQ 3.0 performance in a Rayleigh fading environment plus 10.2 dB for lognormal fading caused by location variability) at the output of the four-way combiner used to feed the KCRS dual redundant base station site at the OMF, assuming a composite noise power at the output of the OMF 4-way combiner 3 dB higher than the value shown for the Contractor’s system design for the DSTT and Beacon Hill Tunnel segments. The additional 3 dB margin is required to allow for future system expansion up to two additional Distribution Hubs in a north tunnel extension of the ST alignment from the current terminus of the DSTT Stub Tunnel at Pine Street.
- Intermodulation calculations shall be based on the worst-case “strong” 2-
  component signal levels at the last uplink BDA input in each uplink signal
  chain (BDA #1 through BDA #4 at the University Distribution Hub and at the
  Beacon Hill Distribution Hub), based on two portable radios spaced 3 feet
  from the distributed antenna with the least uplink line loss to the BDA.
  (These are the same BDA input levels described in Section 3.03 below, Field
  Testing). Worst-case uplink IM product power levels shall also be shown at
  the input to the RF-fiber transmitter at each Distribution Hub.

- The uplink amplifier AGC circuits in the BDAs used in the Tunnel Radio
  System shall be adjusted to limit the maximum uplink signal levels under
  these worst case “strong” signal conditions to power levels that produce a
  minimum carrier-to-intermodulation (C/IM) ratio of 29.2 dB at the uplink
  output of each BDA and at the output of the uplink fiber-RF receivers at the
  end of the fiber links from the Distribution Hubs to the OMF headend.

- Calculated IM power levels shall be shown in a format similar to the link
  budget block diagrams and sample calculations contained in Appendix K,
  Radio Calculations, of the Specification.

3.) An itemized list of the costs of providing adjustments for all site conditions
    affecting the proposed installation and the costs for providing these adjustments,
    as described in Section 17420, Tunnel Radio System.

4.) An itemized list of specialized test equipment, other instrumentation, items, and
    material required for maintenance and repair of the proposed KCRS base station
    interface, the KCRS console/control station interface, and the KCM 700 MHz
    control station interface system, including a description and the purpose of each
    item of proposed test and diagnostic equipment. Proposed test equipment shall
    be included as an optional item in the Proposal Price List.

5.) Final design schematics and cable and antenna layout drawings for the KCRS
    base station interface, the KCRS console/control station interface, and the KCM
    700 MHz control station interface system.

6.) A document describing the procedure required to obtain new equipment or
    replacement service parts and/or components from the manufacturer in both a
    routine manner and on a rush order basis (next-day delivery), if necessary to
    effect an emergency repair in the field. The Contractor shall also describe the
    degree of depot support to be supplied for board level repair; and the ability and
    procedure to temporarily replace (loan) any particular board during the time that
    the defective board is being repaired.

7.) A list of locally owned or affiliated service locations (i.e. within the
    Seattle/Bellevue/Tacoma/Everett urbanized area). The Contractor shall also
    provide a telephone number of a technical service center for 24 hour fixed
    equipment technical assistance.

8.) A guarantee of the availability of each system component, as well as all
    necessary software, documentation, product support, and other components
    necessary for system expansion, or their functionally equivalent replacements,
    for at least eight years from the date of acceptance.
9.) Written certification from the manufacturers of major items of electronic equipment and software that the manufacturers will support their products for not less than eight years after final system acceptance. Support shall include all equipment, software, documentation, parts, technical assistance, repair, customer service, and any other items necessary for continuing full operation of the Tunnel Radio System/KCRS base station interface system, the KCRS console/control station interface system, and the 700 MHz KCM interface system. Equipment items or software no longer in production shall be replaceable by functionally equivalent items or software.

10.) A recommended, itemized list of the types and quantities of spare equipment, cards, individual parts and components, and any other items that are deemed necessary for proper maintenance and service of the KCRS base station interface, the KCRS console/control station interface, and the 700 MHz KCM system interface. This list shall include any applicable portions of the spare parts itemized in Section 17480, Radio Systems Training, Manuals, Documentation, Special Tools and Spare Parts, of this Specification, as well as any additional spare parts recommended for proper system maintenance by the Contractor. The Contractor shall furnish this list as part of the Proposal Price List and Price Catalog.

11.) The Contractor shall grant the Sound Transit rights to interface to any component provided as part of the Contractor’s KCRS base station interface, the KCRS console/control station interface, and the KCM 700 MHz control station interface systems.

12.) Proposed Factory Acceptance Test Procedure.

13.) 30 days prior to the Factory Acceptance Test and before any field installation, Contractor shall submit the final Factory Acceptance Test procedure for the KCRS console/control station interface, and the KCM 700MHz control station interface. This procedure shall include detailed procedures and forms for performing Factory Acceptance Tests necessary to verify the performance of all active components in the system interfaces, including RF/fiber optic links, control stations, power dividers and combiners, fiber switches, and all interface equipment required for the Health and Status monitoring system described in this specification. It is expected that the test will be performed at the Contractor’s facilities and will be observed by Sound Transit representatives.


Contractor shall submit a report to Sound Transit at the completion of Factory Tests documenting the results of all measurements described in this Section. Documentation shall consist of original test data sheets and other documentation provided by the equipment manufacturers performing the tests. The documentation shall include a diagram or description showing the test measurement configuration and indicating the test equipment used to make the measurements. Equipment descriptions shall include the most recent calibration date for each piece of test equipment used in the tests.


The Requirements for the Field Testing Measurement Report for the KCRS base station repeater site interface equipment is described in Section 17420, Tunnel Radio Systems,
which describes the Field Test Measurement Report Requirements for the complete Tunnel Radio System.

PART 2 - PRODUCTS

2.01 GENERAL

The product specifications shown below call out the specific components used in the RF Distribution System conceptual design described in this Specification. Substitute, equivalent, or “or-equal” items may be used whenever specified herein as long as the overall system performance shown in the design documents is maintained, and the resulting system passes all applicable acceptance tests. Whenever it is indicated in the Contract Drawings or specified in the Specification that a substitute "or-equivalent" item of material or equipment may be furnished or used by Contractor if acceptable to the Resident Engineer, the “or-equivalent” item shall provide the same overall system performance and general suitability as the specified item. No component substitutions will be allowed without specific written approval of Sound Transit or its engineers. Any substitutions must comply with the requirements of these Specifications.

2.02 ST O&M FACILITY AND KING COUNTY METRO BASE STATION HEADEND COMPONENT AND EQUIPMENT REQUIREMENTS

A. ST Base Station Headend 4-Way 800 MHz Power Dividers/Combiners.

1. Contractor shall provide 4-way power dividers/combiners as shown in the Contract Drawings. These power dividers have been specifically selected to provide minimal downlink insertion loss and to minimize passive intermodulation. These power dividers/combiners shall be Kathrein/Scala IPD4-HLN or approved equivalent.

   a.) Electrical Requirements.
      
   1.) Frequency Range: 764 MHz – 869 MHz (minimum).
   
   2.) Impedance: 50 Ohms.
   
   3.) Insertion Loss: 0.05 dB (maximum).
   
   4.) VSWR: 1.25:1 (maximum).
   
   5.) Maximum Input Power: 100 Watts.
   

   b.) Mechanical Requirements.
      
   1.) RF Connectors: N female.
   
   2.) Dimensions (maximum): 7" x 2" x 2".
B. Fiber-Optic Transceivers.

Headend-to-Hub Fiber Optic Transceivers (ST Operations & Maintenance Facility Base Station Headend).

1. Contractor shall supply Fiber Optic Transceivers as shown in the Contract Drawings. Two versions of these shall be supplied: Headend-to-Hub units shall be installed at the base station headend site (ST O&M Facility base station headend). Hub-to-Headend units shall be installed at the two RF Distribution Hubs at University Station and Beacon Hill Station. (Only the Headend-to-Hub units are described in this Section; the Hub-to-Headend units are described in Section 17420, Tunnel Radio System.) Headend-to-Hub units shall be configured for 1.5 µm TX and 1.3 µm RX. These shall be Fiber-Span ac 1223W-1.5H2 units or engineer-approved equivalent. Headend units shall be supplied with two transceivers per 1 RU shelf. Headend units shall be supplied with a 120 Vac power supply.

a.) Electrical Requirements.

1.) Power: With Ac Power Supply: 120 Vac.

2.) With dc Power Plant and dc-to-dc Converters: +5 Vdc @ 1200 mA, -5 Vdc @ 1000 mA and +12 Vdc @ 150 mA.

3.) Optical Output Power (typical): 4 mW.

4.) Wavelength peak (typical): 1550 nm.

5.) Frequency Response, 50 to 1000 MHz: ±1.5 dB.

6.) Input and Output VSWR (maximum) 2.0:1.

   - Spur Free Dynamic Range (minimum - with 5 dB optical loss): 100 dB.
   - Link RF Gain (minimum with 5 dB optical loss): -12 dB.
   - Output Noise Floor: -138 dBm/Hz (maximum @ 5 dBo) over operating temperature.
   - Third Order Intercept Point (minimum @ 5 dBo): +30 dBm to 40° C, +29 dBm 40° to 70° C.

b.) Monitor and Alarm Output Requirements.

1.) Laser Monitor Output (0.1 Vdc = 10 mA).

2.) Laser Status Alarm Output (Open collector, 20 mA).

3.) Temperature Alarm (Open collector, 20 mA).
4.) Optical Monitor (1 Vdc = 1 mW).

5.) Optical Alarm (Open collector, 20 mA).

6.) Optical Alarm LED.

7.) Temperature Alarm LED.

8.) Laser Alarm LED.

c.) Mechanical and Environmental Requirements.

1.) RF Connectors: SMA female.

2.) Fiber Optic Connector: FC/APC.

3.) Operating Temperature: -30° to 70° C.

4.) Fiber optic loop switches.

C. Fiber Optic Jumpers.

FC/APC to FC/APC Jumpers (Patch Cords).

1. Contractor shall provide single mode fiber optic jumpers (patch cords) terminated with FC/APC connectors on each end. These jumpers shall be CSP 486-550-017 or approved equivalent. These jumpers are to provide:

   a.) Bi-directional connections between the main/backup fiber optic switches at each Hub Location (University Station TC/C Room and Beacon Hill Station Communications Equipment Room) and the fiber termination modules provided by the Sound Transit Communications backbone system at each Hub Location for the fiber links to the ST O&M Facility Headend location - four jumpers at each Hub location for uplink and downlink main and backup paths.

   b.) Bi-directional connections between the fiber termination modules provided by the Sound Transit Communications backbone system the ST O&M Facility Headend Location and the main/backup fiber optic switches at the Headend Location - 8 jumpers at the Headend location.

   c.) Fiber Type: 900 µm Single Mode Simplex, Riser Rated.

   d.) Connectors: Angled Polish, FC/APC at each end.

2. Manufacturing and Testing: Manufactured and assembled in a controlled factory environment and 100 percent tested for total optical transmission loss and optical return loss.
3. Jumper Lengths:
   a.) 3 meters (10 feet), 5 meters (17 feet), or 10 meters (33 feet) at Hub Locations, depending upon distance between Fiber/RF Equipment Cabinets and ST Fiber Termination Panels.
   b.) 3 meters (10 feet), 5 meters (17 feet), or 10 meters (33 feet) at Headend Locations, depending upon distance between ST Fiber Termination Panels and Headend Fiber/RF Equipment Cabinets.
   c.) Optical Loss: 0.75 dBo (maximum).
   d.) Optical Return Loss: 65 dB (minimum).

D. Fiber Optic Main/Backup Switches.

1. Fiber optic main/backup switches shall be used at the ST O&M and KCM base station headends to switch to the backup fiber path in the event of failure of the main fiber path. These switches shall be Force, Inc. Model TB 5615B, or approved equivalent. The specifications for these switches are as follows:
   a.) Optical Insertion Loss: 2.0 dB
   b.) Backreflection Tolerance: -50 dB
   c.) Operating Wavelength: 1200 to 1610 nm
   d.) Optical Input Range: +20 dBm
   e.) Optical Trip Threshold/Meter Range: -35 +20 dBm
   f.) Optical Switch Speed: 15 ms.
   g.) Power Supply Voltage: 85 to 264 Vac
   h.) Power Supply Frequency 47 to 63 Hz

1 Optical insertion loss is the total maximum loss of both the optical switch and optical couplers without the loss associated with the rear panel optical ports.
2 To reduce backreflections, all fiber connections shall be FC/APC type, SC/APC type, or fusion spliced.
3 This assumes that the internal optical power meters are calibrated at 1550 nm, and that measurements of 1310 nm light will be about 1.5 dB lower than the actual level. The absolute power readings provided by the internal meters shall vary by no more than ± 1.5 dB over the full wavelength range of 1200 nm to 1610 nm.
4 The optical trip threshold shall be adjustable to any value between -35 and +20 dBm.
5. The rear panel power module shall accept voltage levels from 85 to 264 Vac at 47 to 63 Hz.

2. Environmental Characteristics.

   a.) Operating Temperature Range: +10 to +40 °C

   b.) Storage Temperature Range: –40 to +80 °C

   c.) Humidity: 5 to 90 percent

   d.) Physical Characteristics.

   e.) Weight: 6 lbs, 2.2 kg.

   f.) Dimensions: 19.0 x 1.72 x 14.2 in. 7 482.6 x 43.7 x 360.7 mm 7

6. Humidity is RH non-condensing.

7. Dimensions include mounting flanges.

2.03  800 MHZ CONTROL STATION TX AND RX ANTENNAS

A. 800 MHz Log Periodic Directional Antennas.

1. Contractor shall provide 800 MHz log periodic directional as shown in the Contract Drawings. These antennas shall be Kathrein/Scala Model LP10-900 or approved equivalent.

   a.) Electrical Requirements.

      1.) Frequency Range: 790 MHz to 960 MHz.

      2.) Gain: 10.0 dBi.

      3.) VSWR: less than 1.4:1 over frequency range.

      4.) Front to Back Ratio: >30 dB.

      5.) 3 dB Horizontal Beamwidth: 51°.

      6.) 3 dB Vertical Beamwidth: 45°.

      7.) Maximum Input Power: 500 Watts.

      8.) Impedance: 50 Ohms.
b.) Mechanical Requirements.

1.) RF Connectors: N female.

2.) Dimensions: 31" x 12" x 6.5".
   785 x 300 x 155 mm.

3.) Equivalent Flat Plate Area: 2.6 ft\(^2\) (0.24 m\(^2\)).

4.) Wind Survival Rating: 120 mph (200 kph).

2.04 700 MHZ CONTROL STATION TX AND RX ANTENNAS

See Section 17420, Tunnel Radio System, 2.09B.

2.05 RF TRANSMISSION LINES

A. Contractor shall provide RF transmission lines that interconnect all of the various components of this system, as follows:

1. Control Station TX and RX Antenna Transmission Lines.

   a.) Contractor shall provide RF transmission lines for interconnection of the ST O&M Facility base station headend-to-KCRS control station interface TX and RX antennas and the control station transmitter combiner and receiver multicoupler systems.

   b.) These transmission lines shall be fabricated from Times Microwave LMR-1200-DB Watertight cable or engineer-approved equivalent with Type N male connectors, unless otherwise indicated in the Contract Drawings. Control station TX and RX antenna transmission lines shall be 100 percent sweep-tested for attenuation and VSWR.

1.) Electrical Requirements.

   - Attenuation (maximum): 450 MHz - 1.7 dB/100 ft; 900 MHz - 2.5 dB/100 ft; 2000 MHz - 3.9 dB/100 ft (measured at 25° C with VSWR 1:1).

   - Average Power (minimum): 450 MHz - 1.35 kW; 900 MHz - 0.93 kW; 2000 MHz - 0.59 kW (VSWR 1:1 40° C with 100° C inner conductor).

   - Shielding Effectiveness: >90 dB.

   - Impedance: 50 Ohms.

2.) Mechanical and Environmental Requirements.

   - RF Connectors: N male (silver plated brass with gold inner conductor)

   - Outside Dimensions: Nominally 1.2 inches.
- Minimum Bend Radius: 6.5 inches.
- Jacket: Black Polyethylene

2.06 RF TRANSMISSION LINE TRANSIENT VOLTAGE SURGE SUPPRESSORS

A. Contractor shall provide and install RF Transmission Line TVSS (Transient Voltage Surge Suppressor) devices in the TX and RX transmission line feeds for the 800 MHz control station interface system at the OMF. These devices shall be PolyPhaser Model IS-CT50HN-B or approved equivalent.

1. Electrical Requirements.
   a.) In Line Insertion Loss – 0.1 dB (maximum).
   b.) Maximum Composite RF Power (806-869 MHz): 750 Watts.
   c.) VSWR – 1.1:1 (maximum).
   d.) Impedance: 50 Ohms.
   e.) Surge Power Rating (minimum) – 20 KA.
   f.) Surge Energy Rating (minimum) 138 joules.
   g.) Turn On Voltage – 1200 Vdc.

2. Mechanical Requirements.
   a.) RF Connectors: N male (silver plated brass with gold inner conductor).
   b.) Temperature: Operating Range: 0°C to +50°C
      Storage: -40°C to +65°C
   c.) Humidity: 5 percent to 95 percent non-condensing.
   d.) Altitude: up to 15,000 ft. (4,267 meters).

2.07 HEADEND EQUIPMENT CABINET RF JUMPERS

A. Contractor shall provide and install RF jumper cables for the Headend equipment cabinets, as shown in the Contract Drawings. All jumpers used in the Headend Equipment cabinets shall use 3/8” superflexible foam dielectric coaxial cable (Times Microwave Systems LMR-400-FR or engineer approved equivalent) terminated with factory-installed Type N male or Type SMA male connectors, as required for the various interconnections shown in the Contract Drawings (Type N male connectors power dividers, directional couplers and filters,
SMA connectors for attenuators, and RF/fiber transceivers). Jumpers shall be 100 percent factory sweep-tested for attenuation and VSWR.

1. Electrical Requirements.
   a.) Attenuation (maximum): 450 MHz - 1.7 dB/100 ft; 900 MHz - 2.5 dB/100 ft; 2000 MHz - 3.9 dB/100 ft (measured at 25° C with VSWR 1:1).
   b.) Average Power (minimum): 450 MHz - 1.35 kW; 900 MHz - 0.93 kW; 2000 MHz - 0.59 kW (VSWR 1:1 @ 40° C with 100° C inner conductor).
   c.) Shielding Effectiveness: >90 dB.
   d.) Impedance: 50 Ohms.

2. Mechanical Requirements.
   a.) RF Connectors: N male (silver plated brass with gold inner conductor) or SMA Male (gold plated).
   b.) Outside Dimensions: Nominally ½ inch.
   c.) Minimum Bend Radius: 1.5 inches.
   d.) Jacket: Non-Halogen FR; UL/NEC CATVR rated; listed CMR/MPR (PCC-FT4).

2.08 RF CONNECTORS

All RF connectors shall be N or SMA type connectors. RF connectors shall not be manufactured from ferrous materials (nickel and stainless steel) or have non-soldered contacts of dissimilar metals. Connectors shall have silver plated bodies with gold plated inner conductors.

2.09 RF ATTENUATORS

A. Fixed Attenuators.

1. Contractor shall provide and install fixed RF attenuators as shown in the Contract Drawings. These attenuators shall be Pasternak Enterprises attenuators as specified below, or engineer-approved equivalent.

   a.) 1 Watt Fixed Attenuators (Pasternak Enterprises PE7002-X, where X indicates the attenuation value required in the Contract Drawings, or approved equivalent.)

      1.) Electrical Requirements.

         - Frequency Range: dc to 2000 MHz.
         - Impedance: 50 Ohms.
- Average Power Handling Capability: 1 Watt (+30 dBm).

- Accuracy: dc-1000 MHz, ±0.6 dB; 1000-2000 MHz, ±1 dB.

- VSWR: >dc to 1000 MHz, 1.3:1 (maximum); 1000—2000 MHz 1.5:1 (maximum).

2.) Mechanical Requirements.

Connectors: Type N Male to Type N Female.

b.) 10 Watt Fixed Attenuators (Pasternak Enterprises PE7010-X, where X indicates the attenuation value required in the Contract Drawings, or approved equivalent.)

1.) Electrical Requirements.

- Frequency Range: dc to 2000 MHz.

- Impedance: 50 Ohms.

- Average Power Handling Capability: 10 Watts (+40 dBm).

- Accuracy: dc-1000 MHz, ±0.6 dB.

- 1000-2000 MHz, ±1 dB.

- VSWR: >dc to 1000 MHz, 1.3:1 (maximum).

- 1000—2000 MHz 1.6:1 (maximum).

2.) Mechanical Requirements.

Connectors: Type N Male to Type N Female.

2.10 800 MHZ VARIABLE STEP RF ATTENUATORS

A. Contractor shall provide variable step attenuators for use at the ST O&M Facility base station headend. These attenuators shall be used as the O&M Headend RF-fiber optic link input attenuators, as shown in the Contract Drawings. These shall be Alan Industries, Inc. 50SV10 units or approved equivalent.

1. Electrical Requirements.

a.) Frequency Range: dc - 1500 MHz (minimum).

b.) Attenuator Range: 0 - 10 dB (1.0 dB steps).

c.) Accuracy: ±0.3 dB

d.) Impedance: 50 Ohms.
e.) Insertion Loss: 0.2 dB (minimum).

f.) VSWR: 1.4:1 (maximum).

g.) Average Power: 1.0 Watt (250 Watts Peak).

2. Mechanical Requirements.

a.) RF Connectors: SMA female.

b.) Nominal Dimensions: 1.30 inch Diameter (excluding connectors) X 1.63” Length.

2.11 EQUIPMENT ENCLOSURES

A. Headend RF/Fiber/Control Station Cabinets.

1. Contractor shall supply and install equipment cabinets for the RF-fiber link, fiber switch, base station interface, control stations and associated equipment at the ST O&M Facility base station. Equipment cabinets shall be standard self-supporting units 7' high and nominal 24" in width, with steel construction. Specific requirements for these cabinets are described in the list below.

a.) 86" (2200 mm) H X 24" (600 mm) W X 28.5" (700 mm) D EIA Lockable Equipment Cabinet for Fiber Optic, Power Divider/Combiner, Hub BDA, and Associated Equipment.

b.) Vented Front door with acrylic insert and heavy duty locking handle.

c.) Vented rear door with heavy duty locking handle.

d.) Quick release side panels with keylocks.

e.) Cable entry top with 4-4" fans and 4 - 2" cable entry holes.

f.) 3 pairs of vertical grid straps for cabinet side panel equipment support.

g.) 2 pairs of rack angles for mounting 19" equipment, tapped to 10-32.

h.) 1 set of leveling feet and base angles with 3/4" holes for floor attachment.

i.) Jet-black textured finish.

2. Cabinets spacing shall allow full and unobstructed access to the front and rear faces of installed equipment whenever possible.

3. Equipment cabinets shall be designed to allow rigid base attachments to the floor to prevent equipment from being displaced, and shall be attached to the Headend equipment room floor using concrete anchors, unless other attachment methods are
specified by Sound Transit for the specific Headend equipment room. Hilti Kwik Bolt II, Raw Stud, Sanko anchors or approved equal shall be used to attach the cabinets to the floor in each Headend equipment room. Expansion anchors shall be installed using manufacturer’s recommended hardware and procedures.

4. The cabinets shall have a lockable door both front and back. No roller caster base cabinets or racks are permitted.

5. Contractor shall perform a heat load analysis for each cabinet to determine if additional ventilation or cooling, beyond that provided by the fans listed above, is necessary.

2.12 800 MHZ TRUNKED CONTROL STATIONS

A. Contractor shall supply and install 800 MHz trunked control stations at the ST O&M Facility base station headend to provide a direct RF interface between the ST Central Control radio console and the King County Regional 800 MHz Trunked Radio System (“KCRS”). The control stations shall be Motorola Astro Digital Spectra W4 radios configured for control station operation. The control stations shall be compatible with the Motorola Smartzone 800 MHz trunked radio system used by KCRS (Smartzone Version 3.0, to be upgraded to Version 4.1).

1. Features and Technical Specifications.

a.) All control stations shall meet the following requirements:

1.) Control stations shall have a minimum power output of 15 watts, and shall be rated for 10 percent transmit, 10 percent receive, and 80 percent standby.

2.) Control Stations shall be equipped with a handset with PTT switch (for testing purposes), integral speaker, microphone, volume control, and provisions for adding a desktop microphone.

3.) All control stations shall operate from 120 Vac unless otherwise noted.

4.) Control stations shall be fully operational and maintain all settings previously in effect following restoration of 120 Vac power.

5.) Control stations shall be capable of operating in trunked mode on a Motorola Smartzone (Version 4.1) trunked radio system.

2. Control Station Technical Features.

a.) Transmitters and receivers shall be capable of operating on existing 25 kHz channels (20K0 emission designator) and 12.5 kHz channels (11K3 emission designator) through software or firmware changes. No hardware changes shall be required to change between bandwidths.

b.) The receiver selectivity and transmitter voice frequency response, deviation, and transmit power shall be automatically controlled by an internal microprocessor, based on the transmit and receive frequency selection. It shall not be necessary to program these parameters for each radio frequency.
c.) Radios shall incorporate carrier squelch as well as EIA standard analog Continuous Tone Controlled Squelch System (CTCSS) and Digital Coded Squelch formats. All radios shall be equipped for "AND" squelch operation.

d.) Radios shall be provided in a rack-mount configuration, designed to minimize occupied space for multiple control stations in a single cabinet.

e.) The radio personality shall be capable of being reprogrammed in the field using a portable computer. The connection shall be accessible without requiring the removal of equipment from its mounting bracket or from the equipment rack.

f.) Coded squelch encode and decode tones shall be channel-slaved, and the radio shall be capable of operating with encode tones that are different from the receiver decode tone. A monitor switch shall be provided to enable or disable the coded squelch function for maintenance.

g.) Radios shall be housed in rugged cases, with all points of access gasketed and sealed against dust. No internal ventilation shall be required. Cable connectors shall be securely attached to unit.

h.) Metering of all essential circuits shall be possible while the radio is installed and operating, and may be accomplished through software control.

i.) Time-out Timer: A time-out timer shall turn off the transmitter after a time interval (adjustable up to three minutes) of continuous transmit, generate an alert tone on the radio speaker, and reset upon release of the PTT switch. It shall be possible to completely disable the timeout timer.

j.) Control station radios shall be capable of "cloning" radio personality (without individual ID numbers) to minimize future reprogramming costs.

k.) PTT ID: Radios shall be capable of generating individual identification numbers that are transmitted with every PTT.

l.) Each control station radio shall be equipped with an eight (8) character alphanumeric display to allow the user to assign a descriptive name to each operating condition. Displays shall be clearly labeled and visible in a brightly lit equipment room, with variable brightness. The display shall either be backlit or vacuum florescent for visibility in a darkened room.

m.) 128 Channels: Radios and the associated control head shall be capable of a minimum 128-channel operation.

n.) The interface between each control station and the Sound Transit radio console shall be 4-wire E & M with an M lead.
Table 2.11 – A Control Station Transmitter Technical Specifications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Required Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>851-869 MHz</td>
</tr>
<tr>
<td>Maximum Frequency Separation, no degradation</td>
<td>Full Bandsplit</td>
</tr>
<tr>
<td>Programmable channel steps</td>
<td>12.5/25 kHz</td>
</tr>
<tr>
<td>Minimum Power output (EIA Intermittent)</td>
<td>15 W</td>
</tr>
<tr>
<td>Emission designators</td>
<td>20K0 and 11K3</td>
</tr>
<tr>
<td>Spurious and harmonic emissions</td>
<td>-85 dB</td>
</tr>
</tbody>
</table>

Table 2.11 – B Control Station Receiver Technical Specifications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Required Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>806-824 MHz</td>
</tr>
<tr>
<td>Maximum Frequency Separation, no degradation</td>
<td>Full Bandsplit</td>
</tr>
<tr>
<td>Channel spacing</td>
<td>12.5/25 kHz</td>
</tr>
<tr>
<td>Sensitivity, 12 dB SINAD</td>
<td>0.25 µV</td>
</tr>
<tr>
<td>Selectivity, EIA: 25 kHz</td>
<td>-80 dB</td>
</tr>
<tr>
<td>Selectivity, EIA: 12.5 kHz</td>
<td>-65 dB</td>
</tr>
<tr>
<td>Intermodulation Rejection</td>
<td>-80 dB</td>
</tr>
<tr>
<td>Spurious and image rejection</td>
<td>-83 dB</td>
</tr>
<tr>
<td>Speaker input power, (minimum)</td>
<td>5 W</td>
</tr>
</tbody>
</table>

2.13 700 MHZ TRUNKED CONTROL STATIONS

A. Contractor shall supply and install three (3) 700 MHz trunked control stations at the University Station Communications Room in the DSTT to provide a direct RF interface between the ST Tunnel Radio System and the King County Metro ("KCM") RF distribution system in the DSTT. The KCM 700 MHz System type has not yet been determined; however, the system will be either a Motorola Smartzone Version 6 12.5 kHz channel FDMA system or a MA-Com digital TDMA system.

B. The Contractor shall submit two add/alternate options for the 700 MHz control stations. One option shall provide control stations compatible with a Motorola 700 MHz Smartzone Version 6 digital 700 MHz system, and the other option shall provide control stations compatible with a MA-Com 700 MHz digital TDMA system.

1. Features and Technical Specifications.

a.) All 700 MHz control stations shall meet the following requirements:

1.) Control stations shall have a minimum power output of 15 watts, and shall be rated for ten (10) percent transmit, ten (10) percent receive, and 80 percent standby.

2.) Remotes shall be equipped with a handset with PTT switch (for testing purposes), integral speaker, microphone, volume control, and provisions for adding a desktop microphone.

3.) All control stations shall operate from 120 Vac unless otherwise noted.
4.) Control stations shall be fully operational and maintain all settings previously in effect following restoration of 120 Vac power.

2. Control Station Technical Features.

a.) Transmitters and receivers shall be capable of operating on existing 25 kHz FDMA channels (20K0 emission designator) and 12.5 kHz FDMA channels (11K3 emission designator), or on TDMA channels providing equivalent voice-channel efficiency (one voice channel per 12.5 kHz of occupied bandwidth) through software or firmware changes. No hardware changes shall be required to change between bandwidths.

b.) The receiver selectivity and transmitter voice frequency response, deviation, and transmit power shall be automatically controlled by an internal microprocessor, based on the transmission and receive frequency selection. It shall not be necessary to program these parameters for each radio frequency.

c.) Radios shall incorporate carrier squelch as well as EIA standard analog Continuous Tone Controlled Squelch System (CTCSS) and Digital Coded Squelch formats. All radios shall be equipped for "AND" squelch operation.

d.) Radios shall be provided in a rack-mount configuration, designed to minimize occupied space for multiple control stations in a single cabinet.

e.) The radio personality shall be capable of being reprogrammed in the field using a portable computer. The connection shall be accessible without requiring the removal of equipment from its mounting bracket or from the equipment rack.

f.) Coded squelch encode and decode tones shall be channel-slaved, and the radio shall be capable of operating with encode tones that are different from the receiver decode tone. A monitor switch shall be provided to enable or disable the coded squelch function for maintenance.

g.) Radios shall be housed in rugged cases, with all points of access gasketed and sealed against dust. No internal ventilation shall be required. Cable connectors shall be securely attached to unit.

h.) Metering of all essential circuits shall be possible while the radio is installed and operating, and may be accomplished through software control.

i.) Time-out Timer: A time-out timer shall turn off the transmitter after a time interval (adjustable up to three (3) minutes) of continuous transmit, generate an alert tone on the radio speaker, and reset upon release of the PTT switch. It shall be possible to completely disable the timeout timer.

j.) Control station radios shall be capable of "cloning" radio personality (without individual ID numbers) to minimize future reprogramming costs.

k.) PTT ID: Radios shall be capable of generating individual identification numbers that are transmitted with every PTT.
l.) Each control station radio shall be equipped with an 8-character alphanumeric display to allow the user to assign a descriptive name to each operating condition. Displays shall be clearly labeled and visible in a brightly lit equipment room, with variable brightness. The display shall either be backlit or vacuum florescent for visibility in a darkened room.

m.) 128 Channels: Radios and the associated control head shall be capable of a minimum 128-channel operation.

n.) The control stations shall be provided with a wireline control interface. The interface between each control station and the Sound Transit radio console shall be 4-wire E & M with an M lead.

Table 2.12 – A Control Station Transmitter Technical Specifications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Required Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>764-776 MHz</td>
</tr>
<tr>
<td>Maximum Frequency Separation, no degradation</td>
<td>Full Bandsplit</td>
</tr>
<tr>
<td>Programmable channel steps</td>
<td>12.5/25 kHz (FDMA); 12.5 kHz (TDMA)</td>
</tr>
<tr>
<td>Minimum Power output (EIA Intermittent)</td>
<td>15 W</td>
</tr>
<tr>
<td>Emission designators (digital)</td>
<td>11K3 (FDMA), or 11K3FID (TDMA)</td>
</tr>
<tr>
<td>Spurious and harmonic emissions</td>
<td>-85 dB</td>
</tr>
</tbody>
</table>

Table 2.12 – B Control Station Receiver Technical Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Required Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>794-806 MHz</td>
</tr>
<tr>
<td>Maximum Frequency Separation, no degradation</td>
<td>Full Bandsplit</td>
</tr>
<tr>
<td>Channel spacing</td>
<td>12.5/25 kHz</td>
</tr>
<tr>
<td>Sensitivity (minimum), (1 percent BER )</td>
<td>0.56 µV; -112 dBm</td>
</tr>
<tr>
<td>Selectivity, EIA: 25 kHz (FDMA)</td>
<td>-80 dB</td>
</tr>
<tr>
<td>Selectivity, EIA: 12.5 kHz (FDMA, TDMA)</td>
<td>-65 dB</td>
</tr>
<tr>
<td>Intermodulation Rejection (minimum)</td>
<td>-65 dB</td>
</tr>
<tr>
<td>Spurious and image rejection (minimum)</td>
<td>-70 dB</td>
</tr>
<tr>
<td>Speaker output power, (minimum)</td>
<td>5 W</td>
</tr>
</tbody>
</table>

2.14 CHANNEL BANKS FOR CONTROL STATION AND BACKUP BASE STATION CONTROL LINKS

A. Contractor shall provide and install channel banks to provide a DS0 level interface between the 700 MHz control stations and the ST Communications Backbone described in Section 17500, Cable Transmission System/WAN Overview. The channel banks shall be used to implement 4-wire E&M audio and control links between the ST radio system console and the four (4) 700 MHz control stations located in the University Station TCC Room, and the ST ITAC backup repeaters located at the University Station TCC Room and at the Beacon Hill Station Communications Room, as described in Sections 1.06 B and 1.06 C above. The channel bank equipment shall be Adtran Total Access 1500 and 750 Narrowband Multiservice Access Platform chassis (or approved equivalent.) The 1500 series model at the ST O&M Facility Central Communications Equipment Room shall populated with eight (8) Adtran Single E&M/TO Single Access Modules (Adtran 1180402L1 or approved equivalent),
the 750 series chassis at the University Station TCC Room shall be populated with six (6) Adtran Single E&M/TO Single Access Modules (or approved equivalent), and the 750 series chassis at the Beacon Hill Station Communications Room shall be populated with two (2) Adtran Single E&M/TO Single Access Modules (or approved equivalent). Each chassis shall be provided with a single Power Supply (PSU), a Line Interface Unit (LIU), a System Controller Unit (SCU) (headend chassis only), and a 120 Vac power supply.

1. Network Interfaces.

a.) ST O&M Facility Central Communications Equipment Room.

1.) Transport: DS1.

2.) Capacity: 1 to 4 T1 plus 1 protect T1.

3.) Line Rate: 1.544 Mbps ±75 bps.

4.) Physical Interface: Wire wrap.

5.) Framing: D4 (SF)/ESF; TR-08.

6.) Line Code: AMI/B8ZS.

7.) Input Signal: 0 to –36 dB.

8.) DSO Assignment: User-selectable.

9.) T1 Transmit Timing: Loop, local, external.

10.) TR-08 Support (ST O&M Headend): Single Party Ringing (SPR) and Universal VoiceGrade (UVG) analog ports supported with FXS Modules. CLASS® services supported with FXS modules.

b.) University Station and Beacon Hill Station.

1.) Transport: DS1.

2.) Line Rate: 1.544 Mbps ±75 bps.

3.) TR-08 Support: Conforms with TR-TY-000008.

4.) TR-08 Mode 1, Unconcentrated.

5.) SLC96® framing with alarm reporting/monitoring.

6.) Automatically configures to ORB-13 or ORB-16 alarm messaging formats.
7.) Single Party Ringing (SPR) and Universal Voice Grade (UVG) analog ports supported with FXS Modules. CLASS® services supported with FXS modules.

2. Testing and Troubleshooting.
   a.) ST O&M Facility.
      1.) Local: Payload and line loopback.
      2.) Remote: Payload and line loopback.
   b.) University Station and Beacon Hill Station.
      1.) Local: Payload and line loopback; CSU loopback.
      2.) Remote: Payload and line loopback; CSU loopback.
   c.) Network Interface Test Jacks.
      1.) Bantam Jacks: RXMON (headend and remote chassis); TXMON (headend chassis only).

3. Performance Monitoring.
   a.) Error Counts: ES, SES, UAS, percent, AS, percent, EFSEC, alarms and error rates.
   b.) Reports: NI Information stored for last 24 hours (in 15-minute increments).

4. Electrical.
   a.) dc Power –40 to +56 Vdc.
   b.) (Appropriate Ac Power Supply supplied for 120 Vac 60 Hz operation).
   c.) Connections: Screw terminals (A and B feed).

5. Regulatory Standards.
   a.) NEBS Level 3.
   b.) UL 1950.
   c.) FCC Part 15 (Class A) and Part 68.

   a.) Craft Interface: Accessible from front of SCU.
b.) Electrical Interface: EIA-232, PC serial port, or modem.

c.) Physical connector: DB-9 front.

d.) 10Base T Port.

e.) SNMP/Telnet.

f.) S.25.

g.) TL1.

7. Mechanical.

a.) Dimensions: 3.5 inches H X 23 inches W X 11 inches D.

b.) Weight: 12 lbs (chassis only).

c.) Configured for 19": EIA Rack Mount (University Station and Beacon Hill).

d.) Configured for 24": EIA Rack Mount (ST O&M Headend).

PART 3 - EXECUTION

3.01 FACTORY TESTING – KCRS BASE STATION INTERFACE EQUIPMENT

A. Fiber Optic Cable Factory Tests.

1. All fiber optic jumper cables shall be swept for Optical Return Loss and Attenuation over the nominal operating frequency range of the jumpers with factory installed FC/APC connectors.

2. The results of these tests shall be provided in either graphical or tabular form in the Factory Test Report.

B. 700/800 MHz Power Divider/Power Combiner Factory Tests.

1. The 700/800 MHz Power Dividers and Power Combiners used for the interface between the base station equipment and the RF over fiber link equipment at the ST O&M Facility shall be swept for amplitude response and return loss (VSWR) over the 764-869 MHz band at both the common input port and at each output port (or at each input port and the common output port for power combiners) through port and the coupled port. Common input-to-output port loss for each output port shall be measured for power dividers and input-to-common output port loss for each output port shall be measured for power combiners, over the same frequency range.

2. The results of these measurements shall be provided in both graphical (network analyzer plots) and tabular form in the Factory Test Report.
C. RF Transmission Line Factory Tests.

1. All RF pre-assembled transmission lines and jumpers to be used at the ST O&M Facility Tunnel Radio System Headend shall be swept for VSWR and Attenuation over the frequency range of 764 - 869 MHz, using factory-installed connectors.

2. The results of these tests shall be provided in either graphical or tabular form in the Factory Test Report.

D. Fiber Optic Switch Factory Tests.

1. All fiber optic jumper cables shall be swept for Optical Return Loss and Attenuation over the nominal operating frequency range of the switches, with factory installed FC/APC connectors.

2. The results of these tests shall be provided in either graphical or tabular form in the Factory Test Report.

E. RF/Fiber Optic Link Factory Tests.

1. RF/Fiber optic transceivers shall be tested for total system RF loss (RF input to RF output) with transceivers connected on the bench with 5 dB of optical loss.

2. Transmitter input 3rd Order Intercept (in dBm) and Receiver Noise (in dBm/Hz) shall be measured for each unit with transceivers connected with 5 dB of optical loss.

3. Written documentation of these test measurements shall be included in the Factory Test Measurement report submitted to Sound Transit, as described in this Section and in Section 17470, Radio System Testing, Identification and Administration.

F. Equipment Configuration at Factory Test.

1. During the factory tests, all Headend and Distribution Hub fiber optic equipment, RF BDA equipment and other RF distribution equipment up to and including the Distribution Hub BDAs, shall be set up in the same configuration that will be used at the designated installation site. Optical attenuators may be used to provide RF fiber link system attenuation equivalent to the attenuation that will occur due to actual fiber losses between the Headend site and the DSTT and Beacon Hill Distribution Hub sites. Sub-systems shall be tested in the staging area in such a manner as to minimize the actual installation time in the field. An example of the system as-built documentation shall be available at the time of system demonstration.

2. See Section 17470, Radio System Testing, Identification and Administration, for specific factory test requirements for Distribution Hub and Distributive Antenna System (DAS) equipment.
3.02 FACTORY TESTING – KCRS 800 MHZ CONTROL STATIONS, KCM 700 MHZ CONTROL STATIONS, TRANSMITTER COMBINER/RECEIVER MULTICOUPLER, AND CONTROL STATION ANTENNA EQUIPMENT

A. Transmitter Combiner Factory Tests.

1. The transmitter combiner for the ST O&M Facility control station interface to the KCRS and the transmitter combiner for the 700 MHz control stations in the DSTT shall be swept VSWR and Attenuation over the frequency range of 851 - 869 MHz (ST O&M 800 MHz interface) or 764 – 776 (700 MHz control stations), from each transmitter input port to the common antenna output port. Transmitter-to-transmitter isolation shall be measured from each transmitter input port to all other transmitter input ports. Antenna-to-transmitter isolation shall be measured from the antenna output port to each transmitter input port.

2. Written documentation of these test measurements shall be included in the Factory Test Measurement report submitted to Sound Transit, as described in this Section and in Section 17470, Radio System Testing, Identification and Administration.

B. 700 & 800 MHz Receiver Multicoupler Factory Tests.

1. The receiver multicoupler for the ST O&M Facility control station interface to the KCRS and the receiver multicoupler for the 700 MHz control stations in the DSTT shall be swept VSWR and Attenuation (or Gain, if the multicoupler amplifier is set to provide net gain through the multicoupler system) over the frequency range from 806 - 824 MHz for the 800 MHz control stations and 794 – 806 MHz for the 700 MHz control stations, from each receiver multicoupler input port to its associated control station antenna port. Transmitter-to-receiver multicoupler isolation shall be measured from each control station input port to all other receiver multicoupler input ports. Transmit antenna-to-receiver multicoupler isolation shall be measured from the transmitter combiner antenna output port to each receiver multicoupler input port.

2. Written documentation of these test measurements shall be included in the Factory Test Measurement report submitted to Sound Transit, as described in this Section and in Section 17470, Radio System Testing, Identification and Administration.

C. Antenna Factory Tests.

1. The control station interface 800 MHz log periodic transmit and receive antennas at the O&M Facility shall be swept for return loss (VSWR) over the frequency range of 806 – 869 MHz, and the 700 MHz control station transmit and receive antennas used in the DSTT shall be swept for return loss (VSWR) over the frequency range of 764-806 MHz.

2. The results of these measurements shall be provided in both graphical (network analyzer plots) and tabular form in the Factory Test Report. Measured horizontal plane and vertical plane antenna patterns shall be provided for each antenna as part of the Factory Test Report.

D. RF Transmission Line Factory Tests.

1. All RF pre-assembled transmission lines and jumpers to be used as part of the ST O&M Facility control station interface to the KCRS shall be swept for VSWR and Attenuation over the frequency range of 806-869 MHz, using factory-installed connectors.
2. All RF pre-assembled transmission lines and jumpers to be used as part of the DSTT 700 MHz control station interface to the KCM tunnel radio distribution system shall be swept for VSWR and Attenuation over the frequency range of 764-806 MHz, using factory-installed connectors.

3. The results of these tests shall be provided in either graphical or tabular form in the Factory Test Report.

E. 800 and 700 MHz Control Station Factory Tests.

1. All 800 MHz control stations to be used for the ST O&M Facility console-to-KCRS interface and the 700 MHz control stations to be used for the interface to the KCM RF distribution system in the DSTT shall be tested at the factory.

2. Transmitter power output for each RF channel to be used in the system, for each control station transmitter.

3. Receiver sensitivity tests for each control station receiver.

4. Audio level tests at the outputs of receivers.

5. The results of these tests shall be provided in the Factory Test Report.

3.03 FIELD TESTING

Field Testing for the KCRS base station repeater site equipment is described in Section 17420, Tunnel Radio System, which describes the required field and acceptance testing for the complete Tunnel Radio System.

3.04 CABLE, WIRE, TRANSMISSION LINE, AND FIBER LABELING

All labeling of cables, wires, transmission lines, and fiber and fiber jumpers shall comply with the requirements of Section 17470, Radio System Testing, Identification and Administration. Label format, composition, and installation shall comply with the requirements of Section 17170, Cable Testing, Identification and Administration, which describes general overall Cable Testing, Identification, and Administration requirements.

3.05 EQUIPMENT NAMEPLATES

A. All equipment nameplates shall comply with the requirements of Section 17470.

B. Nameplate format, composition, and installation shall comply with the requirements of Section 17170, Cable Testing, Identification and Administration, which describes general overall Cable Testing, Identification, and Administration requirements.

3.06 PREPARATION

A. Contractor shall be responsible for all preparation work required for installation of all Tunnel Radio System base station interface components in the ST O&M Facility, including core drilling for cable penetrations in locations where required penetration sleeves are not already provided by the Sound Transit Civil or Electrical Contractor.
B. The Contract Drawings indicate the general arrangement of circuits, conduit runs, equipment cabinets, antennas, transmission line runs, fiber termination panels, and other work. Information shown on the Contract Drawings is schematic; however, reconfiguration or rerouting will not be permitted without specific acceptance. In cases of conflict between specifications and Contract Drawings, the specification shall have precedence. Data presented on the Contract Drawings is as accurate as planning can determine, but accuracy is not guaranteed and field verification of all dimensions, locations, levels, etc., to suit field conditions is required. Review all, Civil, Structural and Mechanical and Electrical/RF System Drawings and all specifications and adjust all work to conform to all conditions shown therein.

3.07 DELIVERY, STORAGE, AND HANDLING

See Section 17470, Radio System Testing, Identification and Administration, for delivery, storage, and handling requirements for the Tunnel Radio System base station interface components and materials.

3.08 INSTALLATION

A. Control Station Antenna Mounting at Sound Transit O&M Facility.

1. As shown in the Contract Drawings, the transmit and receive antennas for the control stations at the ST O&M Facility will be located on opposite ends of the Maintenance Facility Building, with a minimum horizontal separation of 250 feet (in order to provide isolation between the control stations transmitters and receivers). Both the transmit and receive antennas shall be broadband log periodic 800 MHz antennas with a nominal gain of 10.0 dBi (See Section 2.03 for detailed antenna specifications). Both the transmit antenna and the receive antenna shall be vertically polarized, and each antenna shall be installed with the antenna pattern maximum lobe oriented toward the City of Seattle subsystem repeater site on the Bank of America Tower (formerly the Columbia Center).

2. Control stations and associated transmitter combining/receiver multicoupling equipment shall be rack-mounted in enclosed EIA cabinets located in the Sound Transit Control Center communications equipment room at the O&M Facility, as shown in the Contract Drawings.

3. The equipment configuration shown in the Contract Drawings is typical. Equipment cabinets, antenna transmission lines, antennas, and radiating cable may be relocated within reasonable limits as necessary to avoid conflicts with other equipment mounted in the O&M Center Roof and in the Control Center Communications Room.

3.09 DOCUMENTATION AND PROJECT RECORD DRAWINGS

A. Documentation.

Documentation supplied for the KCRS base station interface equipment shall include: final system description; block and level diagrams; installation and shop drawings; contractor test reports; system performance verification reports; all manufacturer’s manuals for all components and any additional documentation required to include as a minimum: schematics, parts lists, component layouts, installation and replacement instructions, setup procedures, test methods, and operating instructions.
B. Manuals.

1. Contractor shall provide the Sound Transit the following sets of operational, maintenance and service manuals, 30 days prior to the start of acceptance tests:

   a.) Three (3) user operational manual sets. Each set shall include one (1) user operational manual for each type of equipment, with the entire set bound together as a master manual.

      1.) Operational manuals shall include a troubleshooting guide containing simple step-by-step procedures to determine if operation in a backup mode is necessary and to change to a backup mode of operation if required, as well as simple step-by-step operational procedures describing how to respond to common failure modes. The procedures in the troubleshooting guide shall be written to assist an operator to determine a work-around solution for a particular failure without assistance, if possible, or to determine who to call for assistance if a work-around solution is not possible.

      2.) A draft version of the troubleshooting guide shall be approved by an authorized representative of the Sound Transit before the final version of the guide is provided by the Vendor.

   b.) Three (3) bound sets of all necessary installation and service manuals for each type of equipment supplied, regardless of whether it is manufactured by the Vendor or another supplier. Service manuals shall include details on hardware and software operation. Service manuals shall contain sufficient information to allow a competent service technician to service the equipment down to the component level.

   c.) Three (3) parts manuals for each piece of equipment.

   d.) Three (3) operational and programming manuals for all software supplied for the system. Software manuals shall include flow charts and shall employ standard language. Any proprietary restrictions on software documentation shall be identified and described in the documentation.

2. Manuals shall be professionally bound. Fold-out schematic diagram sheets or other pages that require folding shall be a continuous sheet of paper without splices. Sound Transit shall be granted, in writing, the rights to reproduce all materials supplied under this contract for its own future needs.

C. Operation and Maintenance Data.

1. Contractor shall provide the following operation and maintenance information for the entire Headend/Hub/DAS system:

   a.) System Block and Level Diagrams.

      Contractor shall provide complete high level system overview diagrams and complete system block and level diagrams showing all system gains, losses, and level and/or attenuator settings. Diagrams shall include RF signal levels at headend base station repeater system inputs and outputs, uplink and downlink input and sample ports,
based on the measurements performed during the Field Acceptance Tests described above. System levels documented shall include measured composite uplink noise in the 806-824 MHz band at the output side of the Headend power combiners used to connect the Tunnel Radio System to the KCRS and repeater site base stations receiver multicouplers.

b.) Proof-of-Performance Outline and System Adjustment Procedures.

Contractor shall provide detailed system adjustment procedures, including a detailed step-by-step written procedure for initial system setup and proof-of-performance tests required to demonstrate correct system performance. Proof-of-performance tests described in the procedure shall be equivalent to those indicated in this Specification, at a minimum.

c.) Recommended System Maintenance and Troubleshooting Procedures.

1.) Contractor shall provide documentation of normal system maintenance requirements, including any system components that need regular checking and/or long-term observation and performance logging. Any system trends that may indicate changes in the system that will eventually require adjustment or replacement of system components must be included.

2.) Contractor shall also provide written step-by-step troubleshooting procedures to be employed if all or part of the system fails.

D. All of the documentation described above shall be incorporated into and used in the system training described in Section 17480, Radio System Training, Manuals, Special Tools and Spare Parts.

3.10 FINAL ACCEPTANCE

Final acceptance of the system shall consist of successful completion of all acceptance tests, submittal by Contractor of all as-built drawings, test results, manuals, and other documentation, completion of Contractor-provided training, correction of all deficiencies, and final clean-up of installation sites.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17410
SECTION 17420
TUNNEL RADIO SYSTEM

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall design, furnish, and install all necessary fiber-optic equipment, amplifiers, antennas, devices, interconnecting cabling, and software to completely implement the fiber-fed 800 MHz Tunnel Radio Distributed Antenna System (DAS) and associated Field Control System interfaces described in this specification and in the attached Contract Drawings.

1.02 SECTION INCLUDES

This Section includes the requirements for furnishing, installing, and testing a Tunnel Radio System to provide radio communications for both Sound Transit and for public safety agencies in the DSTT (Downtown Seattle Transit Tunnel) and in the Beacon Hill Tunnel. The Tunnel Radio System will provide coverage both in the tunnel segments and in all public and ancillary spaces in the stations in both tunnels. The system will have two RF distribution Hubs located at University Station in the DSTT and in Beacon Hill Station in the Beacon Hill Tunnel. These Hubs will be fed via an analog RF-over-fiber link from the system Headend at the Sound Transit Operations and Maintenance Facility (OMF). Also included are the interoperability requirements for 700 MHz radio system supplied by King County Metro (KCM) for bus operation in the DSTT.

1.03 RELATED SECTIONS

A. Section 16610 – Static Uninterruptible Power Supply.
B. Section 16615 – Dc Rectifiers and Power Plant.
C. Section 17400 – Radio System Overview.
D. Section 17410 – KCRS and King County Metro Radio System Interface Requirements.
E. Section 17430 – Base Stations and Controllers.
F. Section 17440 – Portable and Mobile Radios.
G. Section 17450 – Mobile Data Requirements.
H. Section 17460 – Software and Supplies.
I. Section 17470 – Radio System Testing, Identification and Administration.
K. Section 17490 – Tunnel Radio System Support and Warranty.
1.04 REFERENCE STANDARDS

A. Without limiting the generality of other requirements of this Specification, all work specified herein shall conform to or exceed the applicable requirements of the referenced Standards; provided, that wherever the provisions of said publications are in conflict with the requirements specified herein, the more stringent requirements shall apply unless in conflict with the equipment manufacturer’s written recommendations:

1. NFPA 70 (National Electrical Code) Sections 100-300 and Section 800.


4. Uniform Building Code, including the seismic requirements of Section 2312, for Earthquake Zone 3.

5. EIA Standards RS 232-C, RS 485.

6. TIA/EIA 136, Rev B; TIA/EIA-95-B.

7. TIA/EIA 603-1 – Land mobile FM or PM communications equipment measurement and performance.


9. Codes and Standards of good practice issued by the following organizations:
   a.) National Electric Manufacturers Association (NEMA).
   b.) Underwriters Laboratories (UL).
   c.) National Fire Protection Association (NFPA).
   d.) Publication No. 70, National Electrical Code.
   e.) Occupational Safety Health Administration (OSHA) Standard.

1.05 QUALITY CONTROL

Quality Control shall be as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations.
1.06 SUBMITTALS

A. This Specification describes a system design which an engineering study and local experience has determined to be practical. The Contractor is required to submit a proposal which meets or exceeds the requirements herein.

B. See Section 01330, Submittals, for detailed Submittal requirements.


   a.) Contractor shall submit the following information for the Tunnel Radio System Conceptual Design Review (See Section 01330, Submittals, for general Design Review submittal requirements and schedules):

       A brief design document verbally describing the functions and operation of the Tunnel Radio System, including block diagrams of the system similar to the block diagrams shown in the Contract Drawings, a list of anticipated equipment, and a list of any exceptions to the design requirements Contractor desires to put forward for approval.

2. Preliminary Design Review.

   a.) Contractor shall submit the following minimum information for the Tunnel Radio System Preliminary Design Review (See Section 01330, Submittals, for general Design Review requirements and schedules):

       1.) A detailed document including but not limited to the following documentation:

           - Detailed list and description of all equipment intended for use.

           - Product specifications of equipment intended for use.

           - Draft RF system schematics, showing the complete system configuration, including all signal paths and system components, system component gains and losses, normal signal levels, noise levels, and intermodulation levels at each active RF stage input (amplifiers and RF-fiber links) and output throughout the system, and cumulative, end-to-end uplink signal, noise, and intermodulation levels based on the uplink and downlink input signal levels shown in the link budgets and system block diagrams contained in these Specifications.

           - Draft schematic diagrams of the configuration of equipment to perform the monitoring and control functions required for interfaces to the Field Control System described in Section 17802, Field Control System.

           - Draft description of Tunnel Radio System design, operations and maintenance.

3. Intermediate Design Review.

   a.) Contractor shall submit the following minimum information for the Tunnel Radio System Intermediate Design Review (See Section 01330, Submittals, for general Design Review submittal requirements and schedules):
1.) Preliminary layout of Tunnel Radio System RF transmission lines, power dividers and combiners, radiating cable, distributed antennas, bi-directional amplifiers, and associated Tunnel Radio System equipment in the DSTT and the Beacon Hill tunnel, at each station, in the Distribution Hub equipment rooms, and at the O&M Facility headend.

2.) Predicted system RF coverage in all required coverage areas in the DSTT and in the Beacon Hill Tunnel, based on the Contractor’s proposed system design. Predicted coverage shall be shown on plan view drawings of each level in each tunnel, and shall show all equipment rooms, stairwells, and other habitable spaces (including coverage in all elevators in the Beacon Hill Tunnel). Contractor shall include a complete description of the RF propagation model used to generate the predictions and all assumptions and input parameters used in the model.

3.) Draft Use Case documents for Tunnel Radio system failure and backup modes.

4. Final Design Review.

a.) Contractor shall submit the following minimum information for Tunnel Radio System Final Design Review (See Section 01330, Submittals, for general Design Review submittal requirements and schedules):

1.) A complete list of the specific components to be provided to install the system described in the Specification documents, corresponding to each component shown in the Specification block and level diagrams and the Specification Equipment List, based on the actual system components used in the Contractor’s system design. The Contractor shall submit detailed descriptions of each major component, separate from the device's specification sheet. The description shall address the device’s features, whether the device can be dc powered from a standby battery system or requires continuous ac power, and its function within the system. Specification sheets of each device shall be included in the documentation submitted under this Section.

2.) A complete set of Block and Level system diagrams, similar to those shown in these Specifications, showing at a minimum the following information:

- The complete system configuration, including all signal paths and system components, system component gains and losses, and normal signal levels based on the uplink and downlink input signal levels shown in the link budgets and system block diagrams shown in these Specifications.

- Nominal gain, noise figure, and Output Third Order Intercept for all amplifiers and other system gain blocks (e.g. 800 MHz BDA units and RF-fiber link transmitters and receivers).

- Calculated signal power levels (dBm), composite noise power levels [dBm in a 12.6 kHz ENBW (Equivalent Noise Bandwidth) channel], carrier-to-noise (C/N) ratios (dB), and 3rd order intermodulation power levels (dBm and dBc - dB relative to the desired carrier level) at critical points in the system uplink path. At a minimum, these shall be shown at the BDA outputs at each of the RF Distribution Hub locations, at the RF input and output connectors of the fiber optic links between the Distribution Hub locations and the OMF.
Headend location, and at the output of the uplink power combiner that feeds the KCRS 800 MHz system dual-redundant base station site.

- Signal levels shall be based on the nominal “normal” uplink signal levels shown at the last tunnel BDA input in the uplink signal paths. Noise power levels and carrier-to-noise ratios shall be based on the calculated cascade noise power at the output of each uplink fiber optic-RF receiver at the OMF headend site, based on the uplink BDA gain and noise figure values and the fiber optic link net gain and fiber optic/RF receiver output noise power used in the Contractor’s system design. These signal, noise and intermodulation product levels shall be shown on system block and level diagrams and in sample calculations similar to those shown in Appendix K, Radio Calculations of this Specification.

- The link budgets shall demonstrate that the Contractor’s proposed Tunnel Radio System will provide an uplink carrier-to-noise (C/N) ratio of at least 29.2 dB (19 dB for uplink DAQ 3.0 performance in a Rayleigh fading environment plus 10.2 dB for lognormal fading caused by location variability) at the output of the four-way combiner used to feed the KCRS dual redundant base station site at the OMF, assuming a composite noise power at the output of the OMF 4-way combiner 3 dB higher than the value shown for the Contractor’s system design for the DSTTT and Beacon Hill Tunnel segments. The additional 3 dB margin is required to allow for future system expansion to up to two additional Distribution Hubs in a north tunnel extension of the ST alignment from the current terminus of the DSTTT Stub Tunnel at Pine Street, as described in Section 1.09B below.

- Intermodulation calculations shall be based on the worst-case “strong” 2-component signal levels at the last uplink BDA input in each uplink signal chain (BDA #1 through BDA #4 at the University Distribution Hub and at the Beacon Hill Distribution Hub), based on two portable radios spaced 3 feet from the distributed antenna with the least uplink line loss to the BDA. (These are the same BDA input levels described in Section 3.03 below, Field Testing). Worst-case uplink IM product power levels shall also be shown at the input to the RF-fiber transmitter at each Distribution Hub.

- The uplink amplifier AGC circuits in the BDAs used in the Tunnel Radio System shall be adjusted to limit the maximum uplink signal levels under these worst case “strong” signal conditions to power levels that produce a minimum carrier-to-intermodulation (C/IM) ratio of 29.2 dB at the uplink output of each BDA and at the output of the uplink fiber-RF receivers at the end of the fiber links from the Distribution Hubs to the OMF headend.

- Calculated IM power levels shall be shown in a format similar to the link budget block diagrams and sample calculations contained in Appendix K, Radio Calculations, of the Specification.

3.) An itemized list of the costs of providing adjustments for all site conditions affecting the proposed installation and the costs for providing these adjustments, as described below.

4.) An itemized list of specialized test equipment, other instrumentation, items, and material required for maintenance and repair of the proposed Tunnel Radio System, including a description and the purpose of each item of proposed test
and diagnostic equipment. Proposed test equipment shall be included as an optional item in the Proposal Price List.

5.) Final design schematics and Distributive Antenna System cable and antenna layout drawings for the Tunnel Radio System.

6.) A document describing the procedure required to obtain new equipment or replacement service parts and/or components from the manufacturer in both a routine manner and on a rush order basis (next-day delivery), if necessary to effect an emergency repair in the field. The Contractor shall also describe the degree of depot support to be supplied for board level repair; and the ability and procedure to temporarily replace (loan) any particular board during the time that the defective board is being repaired.

7.) A list of locally owned or affiliated service locations. The Contractor shall also provide a telephone number of a technical service center for 24 hour fixed equipment technical assistance.

8.) A guarantee of the availability of each system component, as well as all necessary software, documentation, product support, and other components necessary for system expansion, or their functionally equivalent replacements, for at least eight years from the date of acceptance.

9.) Written certification from the manufacturers of major items of electronic equipment and software that the manufacturers will support their products for not less than eight years after final system acceptance. Support shall include all equipment, software, documentation, parts, technical assistance, repair, customer service, and any other items necessary for continuing full operation of the Tunnel Radio System. Equipment items or software no longer in production shall be replaceable by functionally equivalent items or software.

10.) A description of the feasibility, development plans, and hardware or software changes required to expand the Tunnel Radio System to additional tunnel segments. The Contractor shall describe any limits (for example, limits imposed by cumulative system noise or intermodulation) to the number of additional tunnel segments that could be incorporated into the Tunnel Radio System. Expansion shall not require the replacement or major modification of electronic equipment supplied under this contract.

11.) A recommended, itemized list of the types and quantities of spare equipment, cards, individual parts and components, and any other items that are deemed necessary for proper maintenance and service of the radio system. This list shall include the spare parts itemized in Section 17480, Radio Systems Training, Manual, Documentation, Special Tools and Spare Test, of this Specification, as well as any additional spare parts recommended for proper system maintenance by the Contractor. The Contractor shall furnish this list as part of the Proposal Price List and Price Catalog.

12.) The Contractor shall grant Sound Transit rights to interface to any component provided as part of the Contractor’s Tunnel Radio System.

Thirty days prior to the Factory Acceptance Test and before any field installation, Contractor shall submit the final Factory Acceptance Test procedure. This procedure shall include detailed procedures and forms for performing Factory Acceptance Tests necessary to verify the performance of all active components in the tunnel radio system, including RF/fiber optic links, bi-directional amplifiers, bi-directional amplifiers, and all interface equipment required to connect to the Field Control System described in this specification. It is expected that the test will be performed at the Contractor’s facilities in the Seattle area under the supervision of Sound Transit. Factory test requirements are described in Section 17470, Radio System Testing, Identification and Administration.


a.) Prior to Final Acceptance Testing, contractor shall submit final versions of the following items, using the schedule and procedures set out in Section 01330, Submittals:

1.) User Manuals.

2.) Maintenance Manuals.

3.) Training Plan.

4.) Training Manuals.

b.) Prior to the Factory Acceptance Test and before any field installation, Contractor shall submit the final Factory Acceptance Test procedure, as specified in Section 01330, Submittals. This procedure shall include detailed procedures and forms for performing Factory Acceptance Tests necessary to verify the performance of all active components in the tunnel radio system, including RF/fiber optic links, bi-directional amplifiers, and all interface equipment required to interconnect to the Field Control System described in this Specification. Factory Test Acceptance requirements are shown in Section 17470, Radio System Testing, Identification and Administration. It is expected that the test will be performed at the Contractor’s on-site facilities and will be observed by representatives of Sound Transit.

1.07 SOUND TRANSIT TUNNEL RADIO SYSTEM OVERVIEW

A. The subsystems described in this Specification include a radio frequency distribution system consisting of RF/Fiber conversion equipment at the Sound Transit Operations and Maintenance Facility RF Headend and at the two RF Distribution Hub locations at University Station and Beacon Hill Station, downlink power dividing equipment, uplink power combining equipment, and BDA (bi-directional amplifier) equipment designed to feed the two distributive antenna systems (DAS) described in the next paragraph. All fiber links used in this distribution system shall consist of continuous fusion spliced fiber runs terminated at the demarcation point with FC/APC connectors. Each hub location shall be provided with dual-redundant diverse route fiber feeds, with switching at both the headend and hub locations to automatically select either the main of the backup fiber feed.

B. The Headend-to-Hub fiber itself is not part of this Section, and will be provided as part of the ST communications backbone system under Sections 17100, Cable Network Overview and 17140, Facility Cabling Requirements. The demarcation points for the fiber interconnect
system described in this Specification will be the connectors on the fiber termination modules at the OMF Facility, at the University Station RF distribution hub site, and at the Beacon Hill RF distribution hub site.

C. This Specification also includes subsections describing new distributive antenna systems (DAS) in the Downtown Seattle Transit Tunnel ("DSTT") and in the Beacon Hill Tunnel. The fiber distribution system described above shall provide the interconnection between the RF base station equipment at the Sound Transit O&M Facility and the distributive antenna systems located in the two tunnels.

D. The base station equipment, associated transmitter combining and receiver multicoupling equipment, and dual-redundant base station switches at the O&M Facility headend will be provided by others under a separate contract.

E. The demarcation point for the interconnection between the ST O&M Facility base station facility equipment and the RF/Fiber interconnect system described in this Specification shall be the output connector of the redundant transmitter combiner switch at the ST repeater base station site for the downlink path and the input to the redundant receiver switch at the ST repeater base station facility for the uplink path, as shown in Drawing M01-R101.

F. In order to provide shared voice talkgroups between the KCRS 800 MHz system used by the ST trains in the DSTT and the new King County Metro ("KCM") 700 MHz system used by Metro buses in the DSTT, and to allow communications between the DSTT bus/rail controller and the Metro buses and ST trains that will operate in that tunnel, three (3) 700 MHz control stations will be installed at the University Station Distribution Hub and will be coupled via antennas in the tunnel into the KCM 700 MHz RF distribution system in the DSTT. The requirements for these 700 MHz control stations and their interface to the ST Central Control facility at the ST OMF are described in detail in Section 17410, KCRS and King County Metro Radio System Interface Requirements.

1.08 SCOPE OF WORK FOR TUNNEL RADIO SYSTEM

A. Provide a new Tunnel Radio System for initial line segment tunnels, as described below.

1. New tunnel segment.
   a.) Beacon Hill Tunnel.

   1.) Provide and install fiber-fed RF Distribution Hub at Beacon Hill Station and radiating cable/distributive antenna system to cover Beacon Hill Station and Beacon Hill Tunnel segment, as shown in the Contract Drawings. The Tunnel Radio System in Beacon Hill Tunnel will provide Sound Transit and Public Safety coverage over the King County 800 MHz Regional Trunked Radio system ("KCRS"). Existing Tunnel Segment - Existing DSTT (Downtown Seattle Transit Tunnel) Convention Place Station to International Station.

   - Provide and install fiber-fed RF Distribution Hub at University Station and radiating cable/distributive antenna system to cover Convention Place Station (including the Pine Street Stub Tunnel), Westlake Station, University Station, Pioneer Square Station, International Station and all intervening tunnel segments in the DSTT, as shown in the Contract Drawings. The Tunnel Radio System in the DSTT will provide Sound Transit and Public Safety coverage over the King County 800 MHz Regional Trunked Radio system ("KCRS").
- Provide and install uplink and downlink RF power combining and dividing equipment for the interface between the RF-fiber links, Distributive Antenna System, and the ITAC public safety conventional base station repeaters (described below) and the DAS at the University Station RF Distribution Hub and the Beacon Hill Station RF Distribution Hub.

- Provide and install a new Distributive Antenna System ("DAS") to carry public safety and ST radio traffic in the DSTT. The Distributive Antenna System shall be configured with both radiating cable and discrete distributed antennas, and shall be connected to the University Station Distribution Hub equipment, as shown in the Contract Drawings and as described in this specification.

2. Tunnel Radio System Headend at ST O&M Facility.

a.) Provide and install downlink and uplink power dividing/power combining equipment to distribute RF signals from the King County Regional 800 MHz Trunked Radio System ("KCRS") dual-redundant repeater site at the ST Operations and Maintenance Facility to the RF-fiber links to the Hub locations at University Station and Beacon Hill Station.

b.) Provide and install equipment required for RF-over-fiber optic from the King County Regional 800 MHz Trunked Radio System ("KCRS") dual-redundant repeater site at the ST Operations and Maintenance Facility to the University Station and Beacon Hill Station RF Distribution Hubs.

c.) Dark fiber for these links will be provided per the requirements shown in Section 17100, Cable Network Overview and 17140, Backbone Cabling Requirements. This Specification Section covers only RF-fiber interface and interconnection equipment up to the fiber demarcation points at the Headend and Hub locations.

d.) The KCRS dual-redundant 800 MHz repeater site equipment up to and including the main/backup repeater site switching equipment shown in the Contract Drawings will be provided under a separate contract and is not the responsibility of Contractor.

3. Tunnel Radio System RF Distribution Hubs, Backup Repeaters and Shared Talkgroup Control Stations.

a.) University Station (DSTT).

Provide and install Distribution Hub to feed distributive antenna system and interface to two ITAC 800 MHz conventional repeaters for backup public safety and ST communications in the DSTT.

b.) Provide and install three (3) 700 MHz control stations at the University Station Distribution Hub. Control Stations shall be coupled via antennas in the tunnel into the King County Metro (KCM) 700 MHz RF distribution system in the DSTT. The requirements for these 700 MHz control stations and their interface to the ST Central Control facility at the ST OMF Center are described in detail in Section 17410, KCRS and King County Metro Radio System Interface Requirements.
c.) Beacon Hill Station.

Provide and install Distribution Hub to feed distributive antenna system and interface to two ITAC 800 MHz conventional repeaters for backup public safety and backup ST communications in the Beacon Hill Tunnel.

d.) Distribution Hubs shall include RF-fiber equipment, 800 MHz bi-directional amplifiers (BDAs), and the uplink and downlink RF power dividing/combining equipment required to feed the distributive antenna system ("DAS") at each Hub, the backup ITAC repeaters at each Hub, and the 700 MHz shared talkgroup control stations at the University Station Hub.


a.) Provide and install 800 MHz bi-directional amplifiers at the University Station RF Distribution Hub, in the Westlake Station TCC Room, in the Pioneer Square Station TCC Room, in the International Station TCC Room, and in the DSTT tunnel segment between University Station and Pioneer Square Station, as shown in the Contract Drawings.

b.) Provide and install 800 MHz bi-directional amplifiers at the Beacon Hill Station RF Distribution Hub and in the Beacon Hill tunnel segments, as shown in the Contract Drawings.

5. Redundant Fiber Path Requirements.

a.) Each RF Distribution Hub (University Station and Beacon Hill Station) shall be connected to the KCRS repeater site Headend (ST Operations and Maintenance Facility) via redundant diverse route single mode fiber links. Each fiber link shall be configured to provide main and backup operation, with the main link as the default path, and with automatic switching to the backup link in the event of failure of the main link.

b.) Dark fiber for these links will be provided as part of the Sound Transit communications backbone system, as described in Sections 17100 Cable Network Overview and 17140, Backbone Cabling Requirements. The demarcation point for the interface between the RF-fiber links and the single mode fiber shall be the connectors on the fiber termination modules at the ST Operations and Maintenance Facility (OMF), the University Station Hub, and the Beacon Hill Tunnel.


a.) Both the DSTT and Beacon Hill Tunnel distributive antenna systems shall be configured as hybrid systems using radiating cable in the tunnel segments and discrete distributed antennas in the stations and associated ancillary habitable spaces, such as equipment rooms, emergency exit passageways, stairwells, and elevators (coverage inside elevators is not required in the DSTT; it is required in the Beacon Hill Station). The system shall be capable of future expansion to cover the 700 MHz public safety band by adding 700 MHz BDA equipment to the system supplied under this contract. All passive system components shall be capable of operation with no degradation in performance over the entire range of the 700 and 800 MHz bands (764 – 869 MHz).
b.) Provide and install a Distributive Antenna Systems (DAS) consisting of radiating mode leaky cable, distributed antennas, and bi-directional amplifiers ("BDAs") in the Beacon Hill tunnel and station and in the DSTT tunnel and stations. The DAS in each tunnel shall provide 800 MHz coverage in all public station areas, all tunnel segments, and in all ancillary habitable spaces in the stations, shafts, and headhouses, as shown in the Contract Drawings. The system shall be capable of future expansion to cover the 700 MHz public safety band by adding 700 MHz BDA equipment to the existing system. All passive system components shall be capable of operation with no degradation in performance over the entire range of the 700 and 800 MHz bands (764 – 869 MHz).

c.) DSTT.

In the DSTT, radiating mode cable, coaxial cable, and distributed antennas will be installed in the tunnel segments, in the stations, and in the equipment rooms, and in the tunnel entryways, as shown in the Contract Drawings. This system shall be configured as a single cable, bi-directional single-band (800 MHz) system, as shown in the Contract Drawings. The system shall be capable of future expansion to cover the 700 MHz public safety band by adding 700 MHz BDA equipment to the existing system. All passive system components shall be capable of operation with no degradation in performance over the entire range of the 700 and 800 MHz bands (764 – 869 MHz).

d.) Beacon Hill Tunnel.

In the Beacon Hill Tunnel, radiating mode cable, coaxial cable, and distributed antennas will be installed in the tunnel segments, in the stations, and in the east and west main shafts and headhouses, as shown in the Contract Drawings. This system shall also be configured as a single cable, bi-directional single-band (800 MHz) system, as shown in the Contract Drawings.

7. Frequency Bands.

a.) The Head end-to-Hub RF/fiber links, the Distribution Hubs, and the Distributive Antenna Systems in both tunnel segments shall be designed to carry the following segment of the 800 MHz frequency band:

<table>
<thead>
<tr>
<th>Frequency Band</th>
<th>Uplink Passbands</th>
<th>Downlink Passbands</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 MHz SMR Band</td>
<td>809.7625-813.9875 MHz</td>
<td>854.7625-858.9875 MHz</td>
</tr>
<tr>
<td>800 MHz NPSPAC Band</td>
<td>821-824 MHz</td>
<td>866-869 MHz</td>
</tr>
</tbody>
</table>

b.) These systems shall be designed to carry the 700 MHz band (764-776/894-806 MHz) in the future by modifying or adding RF/Fiber and BDA components only.

c.) All other parts of the system shall be configured to cover the entire band from 764 – 869 MHz without degradation of system performance.

a.) The fiber-fed radiating cable and distributive antenna system (DAS) shall meet or exceed the system Coverage Performance Criterion (CPC), as defined in Section 17470, Radio System Testing, Identification and Administration, of these Specifications, at 95 percent of the locations in the following areas:

1.) DSTT and Beacon Hill Tunnels.

2.) Onboard trains operating in the DSTT and in the Beacon Hill Tunnel.

3.) Stations, elevators (Beacon Hill Station only), stairwells, ventilation shafts, equipment rooms and all other habitable ancillary spaces in the DSTT stations and the Beacon Hill station, as shown in the Contract Drawings.


Interoperability between Sound Transit and KCM operating in the DSTT will be provided via dedicated shared interoperability talkgroups on the King County Regional 800 MHz Trunked Radio system and the KCM 700 MHz Transit Radio System. These talkgroups will operate transparently over both systems, using system channel resources from each system within the system passbands specified above. KCM/ST Safety interoperability talkgroups will operate via dedicated 700 MHz control stations in the DSTT, as described in above. Other than the equipment required to meet this interoperability requirement, Contractor shall provide no active equipment for 700 MHz.


a.) In the event of a complete failure of the fiber links between the system Headend and the DSTT and Beacon Hill Tunnel Hub locations, two 800 MHz repeaters located at each Distribution Hub and operating on ITAC channels in the NPSPAC 800 MHz band will provide backup communication within the tunnel itself. Each repeater at each Hub shall be configured for stand-alone operation, to allow direct communication among users of portable and mobile radios inside each tunnel. One repeater will be used for public safety communications, while the other repeater will be used for communications among ST train operators and ST personnel in the each tunnel. The ST repeater shall also be provided with an E & M control link to the ST control center, as described in Section 17410, KCRS and King County Metro Radio System Interface Requirements.

b.) The ITAC Repeaters will be provided by others under a separate contract.

c.) Contractor shall provide and install all transmitter combiners, receiver multicouplers, attenuators, and other equipment required to provide the RF interface between the ITAC repeaters and the Distributive Antenna System at each Hub, as shown in the Contract Drawings.


Provide and Install equipment required to allow all Tunnel Radio System equipment to operate from the backup power systems provided at the system Headend communications room, the Distribution Hub equipment rooms, and the bi-directional amplifier locations in each tunnel segment. 48 Vdc battery backup and 120 Vac UPS
backup power systems will be provided as part of Work (See Sections 16610, Static Uninterruptible Power Supply and 16615, Dc Rectifiers and Power Systems) in the OMF Communications Equipment Room and the Beacon Hill Station Communications Room. 48 Vdc and 120 Vac UPS power will be provided by others in the DSTT TC/C Rooms. 120 Vac power with UPS backup for the BDAs in the University-to-Pioneer tunnel segment cross passage in the DSTT and in the west and first east cross passages in the Beacon Hill Tunnel will be provided by others. It shall be the responsibility of Contractor to provide an appropriate interface to these systems, including dc-to-dc converters or other equipment required to provide an appropriate interface between the primary and/or backup power systems and the equipment used in the Tunnel Radio System.


The Contract Drawings show an overview of the Tunnel Radio System, high-level schematic details of the Headend dual-redundant base station interface, and the RF-fiber link equipment configuration at the Headend and Hub locations, and a high –level conceptual design for the hybrid radiating cable/distributed antenna distributive antenna system:


The Contract Drawings show details of the conceptual design radiating cable/distributed antenna layout for the distributive antenna systems in the DSTT and in the Beacon Hill Tunnel, block diagrams of the Distribution Hubs and the Distributive Antenna Systems in the DSTT and in the Beacon Hill Tunnel, as well as typical equipment configurations at the University Station and Beacon Hill Station Distribution Hubs.

B. Contractor’s Design Responsibility.

Notwithstanding the detailed information contained in this Specification, it is the responsibility of the Contractor to supply a fully functional Tunnel Radio Distributive Antenna System connected to the OMF Headend site, as described in this Section and Section 17410, KCRS and King County Metro System Radio System Interface Requirements.:

1.09 SYSTEM CONFIGURATION

A. The following sections describe the system configuration, equipment, RF Distribution Hub and Tunnel BDA equipment enclosure locations, antenna location and mounting details, and other pertinent requirements for the new Sound Transit Link Tunnel Radio Fiber-Fed Distributive Antenna System (“DAS”). Contractor shall configure the DAS as shown in the system diagrams unless the Engineer has approved an alternate configuration, in accordance with the requirements of this Specification.

B. The Headend Combiner/RF/Fiber Distribution System design and the Distributive Antenna System (“DAS”) design shown in this Specification are based on “hub-and spoke” fiber-fed, band-specific BDA (Bi-directional Amplifier) technology, with a single headend base station location feeding multiple hub locations. Each hub feeds, in turn, a separate hybrid distributive antenna system (“DAS”) consisting of coupled mode (“leaky cable”) and/or radiating mode radiating cable runs, discrete distributed antennas, and 800 MHz bi-directional amplifiers, as shown in the Contract Drawings. The purpose of the distributive antenna system is to provide 800 MHz radio frequency coverage within the tunnels, stations and associated ancillary habitable spaces for both Sound Transit and Public Safety portable and mobile radios. The system must be capable of providing 700 MHz public safety band (764-776 MHz/894-806MHz) coverage in the future by addition or modification of BDA and RF/Fiber equipment. The passive portions of the DAS, with the exception of band specific filters, shall be
broadband and shall be capable of operation in full compliance with these Specifications over the frequency range from 764 – 869 MHz.

The Tunnel Radio System described in this Specification shall be designed and configured to allow expansion of the system to an additional north tunnel extension of the ST alignment by adding up to two Distribution Hubs, in addition to the DSTT and Beacon Hill Distribution Hubs described in this Specification, while maintaining all of the downlink and uplink coverage and system performance requirements shown in this Specification, including uplink carrier-to-noise (C/N) ratio and uplink carrier-to-intermodulation (C/IM) requirements.

C. Each hub location also incorporates two conventional 800 MHz base station repeaters and the interface equipment required to couple the downlink signals from these repeaters into the distributive antenna system and the uplink signals from the DAS into the repeaters. The base station repeaters will be installed under a separate contract; the demarcation points for the stand-alone repeater interface equipment shown in this Specification are the repeater transmitter RF output connectors and the repeater receiver RF input connectors.

1. DSTT and Beacon Hill Tunnel Bi-directional Amplifiers (“BDAs”).

a.) The bi-directional Amplifiers (“BDAs”) that are part of each RF distribution Hub and the distributive antenna systems in the DSTT shall be TX RX Systems Model 61-89A-06-OLC-XX units (or engineer-approved equivalent) configured to pass the following frequency band:

1.) 800 MHz SMR Band (ST/Public Safety users): 809.7625-813.9875 MHz uplink; 854.7525-858.9875 MHz downlink.

2.) 800 MHz NPSPAC Band (ST/Public Safety users/ITAC Repeaters): 821-824 MHz uplink; 866-869 MHz downlink.

b.) Four 800 MHz BDAs at the University Station RF Distribution Hub will drive the hybrid radiating cable/discrete antenna distributive antenna systems associated with the University Station Hub location, as shown in the Contract Drawings.

c.) Four 800 MHz BDAs at the Beacon Hill Station RF Distribution Hub will drive the hybrid radiating cable/discrete antenna distributive antenna systems associated with the Beacon Hill Station Hub location, as shown in the Contract Drawings.

d.) Combining of 800 MHZ band segment BDA inputs and outputs at the BDA connection to the distributive antenna system or radiating cable shall be accomplished using a critical length cable harness or other techniques that do not introduce significant additional RF signal attenuation in either band segment passband compared to the signal attenuation at the same point in a single band-segment BDA.

2. Automatic Output Level Control.

a.) Both uplink and downlink bi-directional amplifier chains shall employ an output automatic level control that automatically adjusts the total composite output power of each amplifier chain such that levels of the spurious and intermodulation products produced in the amplifiers meet the limits imposed by §90.219 and §90.210 of the FCC’s Rules. The amplifier’s output level control circuit shall be provided with a calibrated control voltage output monitor point that indicates the total amount of gain
reduction adjustment occurring during normal operation. Calibration sheets for each BDA shall be provided that indicates the gain reduction, in dB, indicated by the full range of control voltage values available at the monitor point.

b.) Uplink BDA Automatic Level Control circuits in the BDAs shall be adjusted to limit the maximum uplink signal levels under these worst case "strong" signal conditions to power levels that produce a minimum carrier-to-intermodulation (C/IM) ratio of 29.2 dB at the uplink output of each BDA and at the output of the uplink fiber-RF receivers at the end of the fiber links from the Distribution Hubs to the OMF headend.

3. BDA RF, Voltage, Current and Temperature Sample System.

a.) 800 MHz BDAs shall be equipped with an output RF power sampling system that provides a 4-20voltage or current sample output corresponding to the total composite RF power at the output stage of each of the BDA downlink amplifier chains. This dc sample voltage will be used to provide remote monitoring of RF power levels in the downlink side of the BDAs via the Field Control System. The sample system shall provide a suitable dc output (0-5 Vdc or 4-20 ma) that indicates total composite power levels over the range expected for a single 800 MHz channel up to a total of 10 (ten) 800 MHz channels simultaneously passing through the downlink side of the each BDA. The dc voltage or sample shall be converted to a 0-5 Vdc or 4-20 ma output to allow remote monitoring via the ST Field Control System described in Section 17802, Field Control System.

b.) Each BDA shall also be equipped with circuitry to monitor uplink and downlink amplifier power supply voltage and current. Voltage and current samples shall be converted to a 0-5 Vdc or 4-20 ma output suitable for monitoring via the ST Field Control System described in Section 17802, Field Control System.

c.) Each 800 MHz BDA shall be equipped with circuitry to monitor temperature inside the BDA enclosure. Multiple BDAs in the same enclosure shall be monitored using a single common temperature monitor. Temperature samples shall be converted to a 0-5 Vdc or 4-20 ma output suitable for monitoring via the ST Field Control system described in Section 17802, Field Control System.

d.) Contract Drawing L00-D305 shows the typical configuration of the interface between the RF downlink power, Supply Voltage and Current, and Temperature sample systems and the ST Field Control System.

e.) Calibration curves or tables, showing the relationship between the actual sampled RF power, Supply Voltage, Supply Current, and Temperature and the voltage and current values supplied to the Field Control System shall be provided for each BDA.

4. BDA Equipment Enclosures.

a.) The RF/fiber equipment and associated interface equipment at the Headend (ST Link O&M Facility) and the bi-directional amplifiers and associated monitoring equipment at the Hub location in Westlake Station and Beacon Hill Station shall be rack-mounted in enclosed EIA cabinets located in the equipment rooms in those stations. The specific locations of these cabinets at the Distribution Hub in the University Station equipment room are shown in the detailed room configuration Contract Drawings (See Contract Drawings). Detailed specifications for these cabinets are shown below.
b.) The bi-directional amplifiers and associated monitoring equipment at the tunnel BDA locations in the DSTT and in the Beacon Hill Tunnel shall be mounted in wall-mount equipment cabinets hinged to allow access to both the front and the rear of the enclosed equipment. The specific locations of these cabinets are shown in the detailed tunnel configuration Contract Drawings. Detailed specifications for these cabinets are shown below.

5. Radiating and Coupled Mode Slotted Coaxial Cables.

Radiating mode slotted coaxial cable shall be used in both tunnel segments (DSTT and Beacon Hill Tunnel) covered by the Tunnel Radio System.

6. DSTT and Beacon Hill Tunnel Radiating Mode Cable.

a.) The radiating cable portion of the hybrid distributive antenna system in the DSTT and Beacon Hill Tunnel segments shall use Andrew RTC6-C-1RN Radiax® 1-1/4” radiating mode radiating cable (or approved equivalent). The location and configuration of this radiating cable is shown in the Contract Drawings.

b.) Additional 7/8” inch radiating mode cable shall be used to provide coverage in the east and west shaft stairwells and the west emergency access ladders in the Beacon Hill Station and in the stairwell of the Pine Street Stub Tunnel vent shaft. These radiating mode cables shall be Andrew RTC5-C-1RN Radiax® radiating mode cable (or approved equivalent).

7. Beacon Hill Tunnel Coupled Mode Cable.

Several runs of ½” coupled mode radiating cable shall be used to feed discrete distributed antennas in the Beacon Hill Station, as shown in the Contract Drawings. These coupled mode radiating cables shall be Andrew RXL4-1-RN Radiax® coupled mode cable (or approved equivalent). Plenum rated 1/2 “ coupled mode radiating cable shall be used in the east and west plenum spaces on the roof level of University Station in the DSTT, as shown in the Contract Drawings. These coupled mode radiating cables shall be Andrew RXP4-1 (or approved equivalent).

8. Discrete Distributed Antennas.

a.) The discrete distributed antenna network used to provide coverage in each of the DSTT and Beacon Hill stations shall be fed via low insertion loss power dividers inserted in the tunnel side of each Distribution Hub, as shown in the block diagrams in the Contract Drawings.

b.) The locations of specific discrete antennas shown in the Contract Drawings is typical, and antenna locations may be selected to avoid conflicts with conduits, HVAC vents, lighting fixtures, and other obstructions.

9. Link Budgets and System Block and Level Diagrams.

a.) The link budgets and the system block and level diagrams contained in this Specification (Appendix K, Radio Calculations) show both the uplink and downlink design capacity assumptions and the design uplink and downlink signal levels underlying the overall conceptual design assumed in these Specifications.
b.) The link budgets show calculated uplink and downlink signal levels, calculated uplink cascade noise and intermodulation levels, and calculated carrier-to-noise (C/N) and carrier-to-intermodulation (C/IM) ratios at each BDA, at representative distributed antennas, and at the Tunnel Radio System Headend.

c.) The uplink and downlink link budgets and their underlying assumptions are described in the introductory text in Appendix K, Radio Calculations, and are described in Tables 1 through 8 and Link Budget Calculation Sheets 1 through 25 of Appendix K, Radio Calculations.

10. RF Distribution Hub Locations.

a.) RF distribution hubs that feed the hybrid radiating cable/distributed antenna systems in each tunnel are located as follows:

1.) University Station TC/C Room in the DSTT.

2.) Beacon Hill Station Communications Equipment Room, Transfer Level, near the center of the Beacon Hill Tunnel.

b.) The hubs provide the signal combining, amplification, and RF-to-fiber conversion functions required to distribute the signals from the tunnel distribution systems to the 800 MHz base station headend at the ST Operations and Maintenance Facility and vice versa. They also provide the interfaces between the ITAC backup repeaters and the distributive antenna systems in the DSTT and the Beacon Hill Tunnel and the interfaces between the 700 MHz KCRS/KCM shared talkgroup control stations and the distributive antenna system in the DSTT.

c.) The configurations of the University Station Distribution Hub and the Beacon Hill Distribution Hub are shown in the Contract Drawing.

11. Headend Locations.

a.) The Beacon Hill Distribution Hub is connected to the headend combining system at the following system headend location:

Sound Transit Operations & Maintenance Facility (the Specific location and configuration of this equipment in the Central Communications Equipment Room is shown in the Contract Drawings). The Tunnel Radio System interface to the 800 MHz base station equipment at this headend location is also shown in the Contract Drawings.

b.) The University Station Distribution Hub is connected to the headend combining system at the following system headend location:

Sound Transit Operations & Maintenance Facility [800 MHz] (the Specific location and configuration of this equipment in the Central Communications Equipment Room is shown in Contract Drawings. The Tunnel Radio System interface to the 800 MHz base station equipment at this headend location is also shown in the Contract Drawings.)

Backup power for the KCRS dual-redundant repeater base station equipment, RF/fiber interface, transceivers, switches, and monitoring equipment at the Operations and Maintenance Facility Headend site will be provided by the Sound Transit backup power systems described in Sections 16610, Static Uninterruptible Power Supply and 16615, Dc Rectifiers and Power Systems. Both 120 Vac UPS backup power and 48 Vdc backup power will be provided at this site. It shall be the responsibility of the Contractor to configure and connect all active Headend equipment provided under Section 17410, KCRS and King County Metro Radio System Interface Requirements, for operation with either ac or dc backup power at the Headend site, as described in Sections 16610, Static Uninterruptible Power Supply and 16615, Dc Rectifiers and Power Systems.


Backup power for the KCRS stand-alone repeaters, RF/fiber transceivers and switches, BDAs, and associated monitoring equipment at the University Station and Beacon Hill Distribution Hub sites will be provided by others. Both 120 Vac UPS backup power and 48 Vdc backup power shall be provided at these sites. It shall be the responsibility of Contractor to configure and connect all active Hub RF/fiber and path switching equipment, 800 MHz stand-alone repeater equipment, BDAs, and associated monitoring equipment provided under Section 17420, Tunnel Radio System, for operation with either ac or dc backup power at these Hub sites, as described in Sections 16610, Static Uninterruptible Power Supply and 16615, Dc Rectifiers and Power Systems.


Backup power for the BDAs and associated monitoring equipment located in the cross passages in the DSTT and Beacon Hill tunnels segments are provided by others. 120 Vac power with UPS backup will be provided at these locations. It shall be the responsibility of Contractor to configure and connect all active BDA equipment and associated monitoring equipment provided under Section 17420, Tunnel Radio Systems, for operation with the ac power systems at these tunnel BDA locations.

15. Interfaces to ST Field Control System.

a.) A monitor interface to the Field Control System for each BDA shall be included in the overall system design. The Field Control System interface shall be designed to monitor power supply voltage and current at each RF Distribution Hub BDA and tunnel BDA, for both downlink and uplink amplifiers, as well as composite RF signal levels at each Hub downlink port; and temperature in each Hub and tunnel equipment cabinet. The Field Control System interface shall be configured to provide 4-20 mA or 0-5 Vdc sample outputs and normally closed (open on fault) alarm contacts to the ST Field Control system described in Section 17802, Field Control System.

b.) Alarms and status indications from the RF/Fiber transceivers, and fiber switches shall be provided via normally-closed direct contact closures, with the closed condition representing normal operation and the open condition representing an alarm condition. The required alarms and status indications for each RF Distribution Hub are shown in the list below.
1.) RF Fiber Transceivers.
   - Laser Monitor Output (analog voltage output).
   - Laser Status Alarm Output.
   - Temperature Alarm.
   - Optical Monitor (analog voltage output).
   - Optical Alarm.

2.) Fiber Main/Backup Path Switches.
   - Active Path Indication (Path 1 Active/Path 2 Active)

c.) Contractor shall provide a list of the functions, monitored parameter ranges, and human-machine interface software parameters, ranges, and alarm limits for the BDA voltage, current, RF downlink power, and temperature samples provided by the BDA Field Control System interface.

16. BDA Cabinet Typical Equipment Configuration.

a.) Drawing L00-R206 shows the typical configuration of equipment in the BDA equipment cabinets located at the Westlake Station, University Station, Pioneer Square Station, International Station, and Beacon Hill station TCC equipment rooms, respectively. The equipment housed in each enclosure is shown in the RF system block diagrams shown in the Contract Drawings. Details of the Field Control Interfaces for the BDAs in each tunnel are shown in the Contract Drawings.

b.) The wall-mount tunnel BDA equipment enclosures are dual-hinged NEMA 12 units, designed to open from rear as well as the front, to allow access to cabling and the back side of equipment modules at the rear of the cabinet [Hoffman EWM362225 units or engineer-approved equivalent, modified from the standard Hoffman unit to provide for a NEMA12 rating and a solid steel front door]. Detailed specifications for these enclosures are shown in Section 2.15A below. The enclosures are wall mounted in the DSTT and in the Beacon Hill Tunnel crossover passages, as shown in the Contract Drawings.

1.10 SYSTEM BLOCK AND LEVEL DIAGRAMS AND LINK BUDGETS

A. System block diagrams showing the configuration of both uplink and downlink Hub Equipment and Distribution Hub and Tunnel BDA equipment are shown in Contract Drawings.

The signal, noise, and intermodulation levels shown in the block diagrams are taken from the pertinent link budgets shown in Appendix K, Radio Calculations.

B. Link Budget Block Diagrams 1 through 25 in Appendix K, Radio Calculations, show the uplink and downlink link budgets assumed for the Headend-University Hub subsystem and for the Headend-Beacon Hill Hub subsystem. Tables 1 through 8 of Appendix K, Radio Calculations, show the assumptions underlying the Link Budget Block Diagrams and sample calculations for representative segments of the Distributive Antenna Systems in the DSTT.
and the Beacon Hill Tunnel. The performance of the components shown in the link is based on the product specifications listed in Section 17420, Tunnel Radio System.

C. The System Block and Level Diagrams shown in the Contract Drawings and Link Budget Block Diagrams shown in Appendix K, Radio Calculations, provide one component of the system performance requirements that must be verified during the system Acceptance Tests described in Section 17470, Radio System Testing, Identification and Administration. As described below, any alternate system configuration proposed by the Contractor must be approved by Sound Transit and must comply with all of the system performance requirements shown in this Section and the acceptance test requirements of Section 17470, Radio System Testing, Identification and Administration.

1.11 DESIGN APPROACH - USE OF EQUIVALENT COMPONENTS OR ALTERNATE SYSTEM CONFIGURATION

A. The Contract, if awarded, will be on the basis of materials and equipment described in the Contract Drawings or specified in these Specifications without consideration of possible substitute, equivalent or "or-equal" items. Substitute, equivalent, or "or-equal" items may be used whenever specified herein as long as the overall system performance shown in the design documents is maintained, and the resulting system passes all applicable acceptance tests. Whenever it is indicated in the Contract Drawings or specified in these Specifications that a substitute or "or-equal" item of material or equipment may be furnished or used by the Contractor if acceptable to the Engineer, the "or-equal" item shall provide the same overall system performance and general suitability as the specified item. No component substitutions will be allowed without specific written approval of the Engineer.

B. Any two or more components performing the same function in the system shall be provided by the same manufacturer and shall have the same model number, unless a different manufacturer and/or a different model number are specifically identified in this Specification.

1. Alternate Equipment and/or System Configurations.

a.) Contractor may provide alternate equipment or modify the specific configuration of portions of the system described herein (e.g. specific Hub and/or Tunnel BDA configuration and/or performance, amplifier gain settings, use of fiber distribution from the two Hub locations to distributed antenna locations in the stations rather than distribution via RF cables, etc.) in response to any part of these Specifications. However, Contractor must demonstrate that such modifications or alternate products provide a superior compromise between performance and cost while still meeting the specified functional requirements herein, and that such modifications will provide a system with equivalent or better uplink and downlink end-to-end performance to the system design shown herein.

b.) Such demonstration shall include detailed block and level diagrams and system performance calculations, including calculations of cumulative cascade uplink noise and uplink intermodulation performance at the ST Operations and Maintenance Facility headend as well as downlink received signal power calculations. These calculations shall be based on the assumed uplink and downlink distribution system losses; uplink and downlink transmitter and receiver coupling systems; fiber optic link losses, noise, and intermodulation characteristics; and main headend combiner characteristics shown in the Contractor's version of the system link budgets shown in Link Budget Block Diagrams 1 through 25 of Appendix K; Radio Calculations, and on the distributive antenna system distribution losses shown in the Contractor's version of Tables 1 through 8 of Appendix K, Radio Calculations, and in the complete set of block and level diagrams for both tunnels shown in the Contract Drawings.
2. Approval of Alternate Equipment configurations.

Sound Transit must specifically approve any such modifications or alternate equipment or system configurations, as described in this Specification.

PART 2 - PRODUCTS

2.01 GENERAL

The product specifications shown below call out the specific components used in the Tunnel Radio System conceptual design described in this Specification. Substitute, equivalent, or “or-equal” items may be used whenever specified herein as long as the overall system performance shown in the design documents is maintained, and the resulting system passes all applicable acceptance tests. Whenever it is indicated in the Contract Drawings or specified in these Specifications that a substitute “or-equivalent” item of material or equipment may be furnished or used by Contractor if acceptable to the Engineer, the “or-equivalent” item shall provide the same overall system performance and general suitability as the specified item. No component substitutions will be allowed without specific written approval of Sound Transit or the Engineer. Any substitutions must comply with the requirements of these Specifications.

2.02 TUNNEL RADIO COMPONENT AND EQUIPMENT REQUIREMENTS

A. Distribution Hub Equipment Cabinet RF Jumpers.

1. Contractor shall provide and install RF jumper cables for the Hub equipment cabinets, as shown in the Contract Drawings. All jumpers used in the Hub Equipment cabinets shall use 0.590” superflexible foam dielectric coaxial cable (Times Microwave Systems LMR-600-FR or Engineer approved equivalent) terminated with factory-installed Type N male or Type SMA male connectors, as required for the various interconnections shown in the Contract Drawings (Type N male connectors for power dividers, directional couplers and filters, SMA connectors for attenuators, and RF/fiber transceivers). Jumpers shall be 100 percent factory sweep-tested for attenuation and VSWR.

a.) Electrical Requirements.

1.) Attenuation (maximum): 450 MHz - 1.7 dB/100 ft; 900 MHz - 2.5 dB/100 ft; 2000 MHz - 3.9 dB/100 ft (measured at 25° C with VSWR 1:1).

2.) Average Power (minimum): 450 MHz - 1.35 kW; 900 MHz - 0.93 kW; 2000 MHz - 0.59 kW (VSWR 1:1 @ 40° C with 100° C inner conductor).

3.) Shielding Effectiveness: >90 dB.

4.) Impedance: 50 Ohms.

b.) Mechanical Requirements.

1.) RF Connectors: N male (silver plated brass with gold inner conductor) or SMA Male (gold plated).
2.) Outside Dimensions: Nominally 0.590 inches.

3.) Minimum Bend Radius: 1.5 inches.

4.) Jacket: Non-Halogen FR; UL/NEC CATVR rated; listed CMR/MPR (PCC-FT4).

2.03 RF CONNECTORS

All RF connectors shall be N or SMA type connectors. RF connectors shall not be manufactured from ferrous materials (nickel and stainless steel) or have non-soldered contacts of dissimilar metals. Connectors shall have silver plated bodies with gold plated inner conductors.

2.04 RF POWER DIVIDERS/COMBINERS

Power divider/combiners shall be designed to minimize downlink insertion loss and passive intermodulation

A. Antenna System 2-Way Power Dividers/Combiners.

1. Contractor shall provide 2-way power dividers/combiners as shown in the Contract Drawings. These power dividers/combiners shall be Kathrein/Scala IPD2-HLN or approved equivalent.

a.) Electrical Requirements.

1.) Frequency Range: 764 MHz - 869 MHz (minimum).

2.) Impedance: 50 Ohms.

3.) Insertion Loss: 0.05 dB (maximum).

4.) VSWR: 1.25: 1 (maximum).

5.) Maximum Input Power: 100 Watts.

6.) Power Dividing/Combining Ratios: 50 percent/50 percent.

90 percent/10 percent.

80 percent/20 percent.

60 percent/40 percent.

70 percent/30 percent.

(As required as shown in the Contract Drawings).
b.) Mechanical Requirements.

1.) RF Connectors: N female.
2.) Dimensions (maximum): 7" x 2" x 2".

B. 3-Way Power Dividers/Combiners.

1. Contractor shall provide 3-way power dividers/combiners as shown in the drawings. These power dividers/combiners shall be Kathrein/Scala IPD3-HLN or approved equivalent.

a.) Electrical Requirements.

1.) Frequency Range: 764 MHz - 869 MHz (minimum).
2.) Impedance: 50 Ohms.
3.) Insertion Loss: 0.05 dB (maximum).
4.) VSWR: 1.25: 1 (maximum).
5.) Maximum Input Power: 100 Watts.
6.) Power Dividing/Combining Ratios: 33 percent/33 percent/33 percent. 40 percent/20 percent/40 percent. 80 percent/10 percent/10 percent (As required as shown in the Contract Drawings).

b.) Mechanical Requirements.

1.) RF Connectors: N female.
2.) Dimensions (maximum): 7" x 2" x 2".
C. 4-Way Power Dividers/Combiners.

1. Contractor shall provide 4-way power dividers/combiners as shown in the Contract Drawings. These power dividers/combiners shall be Kathrein/Scala IPD4-HLN or approved equivalent.

a.) Electrical Requirements.

1.) Frequency Range: 764 MHz – 869 MHz (minimum).

2.) Impedance: 50 Ohms.

3.) Insertion Loss: 0.05 dB (maximum).

4.) VSWR: 1.25:1 (maximum).

5.) Maximum Input Power: 100 Watts.

6.) Power Dividing/Combining Ratios:

<table>
<thead>
<tr>
<th>Ratios</th>
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<tbody>
<tr>
<td>25 percent/25 percent</td>
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<tr>
<td>25 percent/25 percent</td>
</tr>
<tr>
<td>70 percent/10 percent</td>
</tr>
<tr>
<td>10 percent/10 percent</td>
</tr>
</tbody>
</table>

(As required as shown in the Contract Drawings).

7.) Mechanical Requirements.

- RF Connectors: N female.

- Dimensions (maximum): 7" x 2" x 2".

2.05 FIBER-OPTIC TRANSCEIVERS

A. Hub-to-Headend and Headend-to-Hub Fiber Optic Transceivers (ST Operations & Maintenance Facility Headend, Metro Control Center Headend, University Station Hub, Beacon Hill Station Hub.)
1. Contractor shall supply Fiber Optic Transceivers as shown in the Contract Drawings. Two versions of these shall be supplied. For the Headend-to-Hub units shall be configured for 1.5 µm TX and 1.3 µm RX and shall be Fiber-Span AC 1223W-1.5H2 units or engineer-approved equivalent, as shown in Section 17410, KCRS and King County Metro Radio System Interface Requirements. The Hub-to-Headend units shall be configured for 1.3 µm TX and 1.5 µm RX. These shall be Fiber-Span AC 1223W-1.3H2 units or engineer-approved equivalent. Headend units shall be supplied with two transceivers per 1 RU shelf. Hub units shall be supplied with a single transceiver per 1 RU shelf. Both Headend and Hub units shall be supplied with a 120 Vac power supply.

a.) Electrical Requirements.

1.) Power: With Ac Power Supply: 120 Vac.

2.) With Dc Power Plant and Dc-to-Dc Converters
   +5 Vdc @ 1200 mA, -5 Vdc @ 1000 mA and +12 Vdc @ 150 mA.

3.) Optical Output Power (typical): 4 mW.

4.) Wavelength peak (typical): 1310 nm.

5.) Frequency Response, 50 to 1000 MHz: ±1.5 dB.

6.) Input and Output VSWR (maximum) 2.0:1.

7.) Spur Free Dynamic Range (minimum - with 5 dB optical loss): 100 dB.

8.) Link RF Gain (minimum with 5 dB optical loss): -12 dB.

9.) Output Noise Floor: -138 dBm/Hz (maximum @ 5 dBo) over operating temperature.

10.) Third Order Intercept Point (minimum @ 5 dBo): +30 dBm to 40° C, +29 dBm 40° to 70° C.

b.) Monitor and Alarm Output Requirements.

1.) Laser Monitor Output (0.1 Vdc = 10 mA).

2.) Laser Status Alarm Output (Open collector, 20 mA).

3.) Temperature Alarm (Open collector, 20 mA).

4.) Optical Monitor (1 Vdc = 1 mW).

5.) Optical Alarm (Open collector, 20 mA).
6.) Optical Alarm LED.

7.) Temperature Alarm LED.

8.) Laser Alarm LED.

c.) Mechanical and Environmental Requirements.

1.) RF Connectors: SMA female.

2.) Fiber Optic Connector: FC/APC.

3.) Operating Temperature: -30° to 70° C.

2.06 FIBER OPTIC JUMPERS

A. FC/APC to FC/APC Jumpers (Patch Cords).

1. Contractor shall provide single mode fiber optic jumpers (patch cords) terminated with FC/APC connectors on each end. These jumpers shall be CSP 486-550-017 or approved equivalent. These jumpers are to provide:

a.) Bi-directional connections between the RF/Fiber transceivers at each Hub Location (Westlake Station and Beacon Hill Station) and the fiber termination modules provided by the Sound Transit Communications backbone system at each Hub Location for the fiber links to the ST O&M Facility Headend location - 4 jumpers at each Hub location for uplink and downlink main and backup paths.

b.) Bi-directional connections between the fiber termination modules provided by the Sound Transit Communications backbone system the ST O&M Facility Headend Location and the RF/Fiber transceivers at the Headend Location - 8 jumpers at the Headend location.

2. Fiber Type.

900 µm Single Mode Simplex, Riser Rated.

3. Connectors.

Angled Polish, FC/APC at each end.


Manufactured and assembled in a controlled factory environment and 100 percent tested for total optical transmission loss and optical return loss.
5. Jumper Lengths.

   a.) 3 meters (10 feet), 5 meters (17 feet), or 10 meters (33 feet) at Hub Locations, depending upon distance between RF Equipment Cabinets and ST Fiber Termination Panels.

   b.) 3 meters (10 feet), 5 meters (17 feet), or 10 meters (33 feet) at Headend Locations, depending upon distance between ST Fiber Termination Panels and Headend Equipment Cabinets.

6. Optical Loss is 0.75 dBo (maximum).

7. Optical Return Loss is 65 dB (minimum).

2.07 FIBER OPTIC MAIN/BACKUP SWITCHES

A. Fiber optic main/backup switches shall be used at the ST O&M base station headends to switch to the backup fiber path in the event of failure of the main fiber path. These switches shall be Force, Inc. Model TB 5615B, or approved equivalent. The specifications for these switches are as follows:

1. Optical Insertion Loss: 2.0 dB

2. Backreflection Tolerance: -50 dB

3. Operating Wavelength: 1200 to 1610 nm

4. Optical Input Range: +20 dBm

5. Optical Trip Threshold/Meter Range: -35 to +20 dBm

6. Optical Switch Speed: 15 ms.

7. Power Supply Voltage: 85 to 264 Vac

8. Power Supply Frequency: 47 to 63 Hz

---

1 Optical insertion loss is the total maximum loss of both the optical switch and optical couplers without the loss associated with the rear panel optical ports.

2 To reduce back reflections, all fiber connections shall be FC/APC type, SC/APC type or fusion spliced.

3 This assumes that the internal optical power meters are calibrated at 1550 nm, and that measurements of 1310 nm light will be about 1.5 dB lower than the actual level. The absolute power readings provided by the internal meters shall vary by no more than ± 1.5 dB over the full wavelength range of 1200 nm to 1610 nm.

4 The optical trip threshold shall be adjustable to any value between -35 and +20 dBm.
The rear panel power module shall accept voltage levels from 85 to 264 Vac at 47 to 63 Hz.

   a.) Operating Temperature Range: +10 to +40 °C.
   b.) Storage Temperature Range: -40 to +80 °C.
   c.) Humidity: 5 to 90 percent.
   d.) Physical Characteristics.
      1.) Weight: 6 lbs, 2.2 kg.
      2.) Dimensions: 19.0 x 1.72 x 14.2 in. 7
                     482.6 x 43.7 x 360.7 mm 7

   6 Humidity is RH non-condensing.
   7 Dimensions include mounting flanges.

2.08 800 MHZ (NPSPAC & SMR BAND) BI-DIRECTIONAL AMPLIFIERS

A. The bi-directional amplifiers (BDAs) used in the Tunnel Radio System shall be TX RX Systems model 61-89A-06-OLC-XX (or Engineer approved equivalent) units configured to allow mounting in the tunnel BDA cabinets and to allow rack mounting at the Hub locations at University Station and Beacon Hill Station. The BDAs shall have the following specifications:

1. Frequency Ranges.
   a.) 821-824 MHz uplink/866-869 MHz Downlink (NPSPAC band).
   b.) 809.7625-813.9875 MHz uplink/854.7625-858.9875 MHz downlink (SMR band).
   c.) Minimum Guardband 42 MHz between uplink & downlink.

2. Passbands.
   Pass Bandwidth (3 dB Points) 3 MHz (NPSPAC).
   4.23 MHz (SMR Band).

3. Minimum Notch Depth @ 825 & 870 MHz 35 dB.

4. Output Level Control (OLC)
   Preset to limit composite output power such that spurious and intermodulation product levels comply with limits imposed by §90.219 and §90.210 of the FCC’s Rules.
5. Maximum Gain +84 dB typical (with OLC inactivated and without gain set pads).


7. Gain Adjustment Range 0, -3, -6, and -9 dB.

8. 1 dB Compression Point +34 dBm (minimum).

9. Output Third-Order Intercept +44 dBm (minimum).

10. Local Output RF Sampler -50 dB coupled RF sample.

11. Custom Output RF Directional Detectors (for remote downlink monitoring).

   RF monitor via FCS Directional coupler with precision detector or other sampling equipment to allow calibrated dc sample (0-5 Vdc or 4-20 ma) corresponding to composite RF power to be inserted in downlink (866-869 MHz and 854.7625-858.9875 MHz ) amplifier paths between last amplifier stage and output filter.

12. System Noise Figure +6.5 dB (maximum – without gain set pads).

13. Temperature Range -30° to +60° C.


15. VSWR 2.0:1 (maximum).

16. Input/Output Connectors Type N Female.

17. Standard RF Sample Port Connectors BNC Female.


   SMA Female (SMA Male to spade lug jumper to be provided to interface to RF voltage sample converter)

19. Electrical.

   a.) Ac Power Input 100-120 / 200-240 Vac, 50/60 Hz.

   b.) Dc Backup Input Voltage 24-28 Vdc.

   c.) Unit Current Draw 3.0 Amps dc / <1.5 Amps ac.
20. Mounting.

a.) Mounted on a steel panel suitable for mounting in tunnel BDA cabinets; 19” EIA rack mounting for RF Distribution Hub locations (University Station and Beacon Hill Station).

1.) Nominal Dimensions 30” X 20” X 8” (762 X 508 X 203 cm) – Internal.

2.) Net Weight 100 lb (44 kg) (approximate).


The nominal BDA output power per 800 MHz channel (with OLC enabled) is shown in the following table:

<table>
<thead>
<tr>
<th>Number of Channels in Passband</th>
<th>Maximum Power per Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>24.7 dBm (295 mW)</td>
</tr>
<tr>
<td>4</td>
<td>20.0 dBm (100 mW)</td>
</tr>
<tr>
<td>6</td>
<td>17.3 dBm (53.7 mW)</td>
</tr>
<tr>
<td>8</td>
<td>15.5 dBm (53.7 mW)</td>
</tr>
<tr>
<td>10</td>
<td>14.1 dBm (25.7 mW)</td>
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<tr>
<td>20</td>
<td>9.8 dBm (9.6 mW)</td>
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<tr>
<td>30</td>
<td>7.3 dBm (5.4 mW)</td>
</tr>
<tr>
<td>40</td>
<td>5.6 dBm (3.7 mW)</td>
</tr>
<tr>
<td>50</td>
<td>4.3 dBm (2.7 mW)</td>
</tr>
</tbody>
</table>

NOTE: The Sound Transit Tunnel Radio System base station repeater site will be configured for 10-channel operation.


2.09 ANTENNAS

A. 700/800 MHz Omni Directional Antennas.

1. Contractor shall provide 800 MHz Ceiling Mount Low Profile Omnidirectional Antennas as shown in the Contract Drawings. These shall be Astron model PCNLP-08V1 or approved equivalent, modified to cover the frequency range specified below.
a.) Electrical Requirements.

1.) Frequency Range: 764 MHz to 869 MHz.

2.) VSWR: less than 1.5:1.

3.) Polarization: Vertical.

4.) Maximum Input Power: 50 Watts.

5.) Impedance: 50 Ohms.

b.) Mechanical Requirements.

1.) RF Connector: N female.

2.) Mount: Ceiling Mounted False Speaker Baffle with ML195 pigtail.


4.) Antenna Pigtail Cable Length: 12" (maximum).

5.) Color: White.

B. Ceiling Mount Antenna Supports for Suspended ceilings.

1. Suspended Ceiling Tile Bridges.

a.) Contractor shall provide and install Atlas/Soundolier 81-8R Series tile bridges (or approved equivalent) to prevent ceiling tile sag in suspended ceiling installations of antenna assemblies. The 81-8R distributes the assembly weight to overhead T-Bar support members.

b.) The 81-8R is designed to mount 8" loudspeakers and has a round cut-out that suits baffles mounting the industry standard Atlas/Soundolier 95 Series enclosures. All tile bridges shall be constructed of 24-gauge CRS with an electro galvanized rust-resistant finish.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>CUTOUT DIAMETER</th>
<th>LENGTH</th>
<th>WIDTH</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>81-8R</td>
<td>10-3/4&quot; (273 mm)</td>
<td>23-5/8&quot; (600 mm)</td>
<td>14-18&quot; (359 mm)</td>
<td>2.0 lbs (9 kg)</td>
</tr>
</tbody>
</table>
3. **Recessed Ceiling Enclosures.**
   
a.) The metal protective enclosures to be provided and installed by the Contractor shall be Atlas/Soundolier Model 95-8 or approved equivalent. The enclosure shall have four 8–32 J-Clips installed on the mounting flange and shall be equipped conduit 1-1/2” knockouts or smaller knockouts that can be enlarged to accommodate 1-1/2” EMT conduit. It shall be of welded CRS construction, and shall have a painted finish.

b.) For applications requiring UL standard 1480 rating and/or UL file S 1824 plenum rating, protective enclosure shall be Atlas/Soundolier Model U95-8 or approved equivalent.

2.10 **RADIATING CABLE**

A. Contractor shall provide radiating mode RF radiating cable as part of the distributive antenna system in the tunnel segments in the DSTT and in the Beacon Hill Tunnel, as shown in the Contract Drawings. These Specifications for the radiating cable shall be as follows:

1. **DSTT and Beacon Hill Tunnel Segments.**
   
a.) The radiating mode radiating cable to be installed in the DSTT tunnel segments and in the Beacon Hill Tunnel segments shall be Andrew RTC6-C-1-RN Radiax® (or approved equivalent) with Type N female connectors, unless otherwise indicated in the Contract Drawings.

b.) Radiating cable transmission line segments in the DSTT and the Beacon Hill Tunnel shall be 100 percent sweep-tested for attenuation and VSWR after installation and prior to their interconnection to the rest of the system.

c.) **Electrical Requirements.**

1.) **Attenuation (maximum):** 450 MHz – 0.67 dB/100 ft; 900 MHz – 1.33 dB/100 ft; (measured per IEC 1196-4 Standard).

2.) **Median Coupling Loss** 900 MHz – 62 dB @ 6 ft ±5 dB; (measured per IEC 1196-4 Standard).

3.) **Impedance:** 50 Ohms.

4.) **Velocity Factor:** 89 percent.

5.) **VSWR:** 1.3:1 (typical).
d.) Mechanical and Environmental Requirements.

1.) RF Connectors: N Female (silver plated brass with gold inner conductor).

2.) Outside Dimensions: Nominally 1-1/4” – 1.54 inches maximum.

3.) Minimum Bending Radius: 15 inches.

4.) Cable Weight, lb/ft: 0.53 (maximum).

5.) Jacket: Non-Halogen Fire Retardant; UL/NEC VW1/CATVX rated; IEC 332-1 rated.

2. Pine Street Stub Tunnel Ventilation Shaft Stairwell and Beacon Hill Station East and West Ventilation Shafts.

a.) The radiating mode radiating cable to be installed in the Pine Street Stub Tunnel Ventilation Shaft Stairwell and Beacon Hill Station East and West Ventilation Shaft stairwells and West Ventilation Shaft emergency access rooms shall be Andrew RTC5-C-1-RN Radiax® (or approved equivalent) with Type N female connectors, unless otherwise indicated in the Contract Drawings. Radiating cable transmission line segments in Pine Street Stub Tunnel Ventilation Shaft Stairwell and Beacon Hill Station East and West Ventilation Shafts shall be 100 percent sweep-tested for attenuation and VSWR after installation and prior to their interconnection to the rest of the system.

b.) Electrical Requirements.

1.) Attenuation (maximum): 450 MHz – 1.00 dB/100 ft; 900 MHz – 1.60 dB/100 ft; (measured per IEC 1196-4 Standard).

2.) Median Coupling Loss 900 MHz – 63 dB @ 6 ft ±5 dB; (measured per IEC 1196-4 Standard).

3.) Impedance: 50 Ohms.

4.) Velocity Factor: 89 percent.

5.) VSWR: 1.3:1 (typical).

c.) Mechanical and Environmental Requirements.

1.) RF Connectors: N Female (silver plated brass with gold inner conductor).

2.) Outside Dimensions: Nominally 7/9” – 1.07 inches maximum.

3.) Minimum Bending Radius: 10 inches.
4.) Cable Weight, lb/ft: 0.41 (maximum).

5.) Jacket: Non-Halogen Fire Retardant; UL/NEC VW1/CATVX rated; IEC 332-1 rated.

B. Contractor shall provide ½” coupled mode RF radiating cable as part of the distributive antenna system in the tunnel segments in the DSTT and in the Beacon Hill Tunnel, as shown in the Contract Drawings. These Specifications for the radiating cable shall be as follows:

1. 1/2” coupled mode radiating cable in Beacon Hill Station and DSTT.

   a.) The coupled mode radiating cable to be installed in the in the Beacon Hill Station and in the DSTT shall be Andrew RXL4-1RN Radiax® (or approved equivalent) with Type N female connectors, unless otherwise indicated in the Contract Drawings.

   b.) Radiating cable transmission line segments in the Beacon Hill Station BDA#4/Platform to Transfer Level Emergency Stairwell Feeds shall be 100 percent sweep-tested for attenuation and VSWR after installation and prior to their interconnection to the rest of the system.

   c.) Electrical Requirements.

      1.) Attenuation (maximum): 450 MHz – 0.67 dB/100 ft; 900 MHz – 1.33 dB/100 ft; (measured per IEC 1196-4 Standard).

      2.) Median Coupling Loss 900 MHz – 62 dB @ 6 ft ±5 dB; (measured per IEC 1196-4 Standard).

      3.) Impedance: 50 Ohms.

      4.) Velocity Factor: 89 percent.

      5.) VSWR: 1.3:1 (typical).

   d.) Mechanical and Environmental Requirements.

      1.) RF Connectors: N Female (silver plated brass with gold inner conductor).

      2.) Outside Dimensions: Nominally 1-1/4” – 1.54 inches maximum.

      3.) Minimum Bending Radius: 15 inches.

      4.) Cable Weight, lb/ft: 0.53 (maximum).

      5.) Jacket: Non-Halogen Fire Retardant; UL/NEC VW1/CATVX rated; IEC 332-1 rated.

C. Contractor shall provide ½” coupled mode plenum rated RF radiating cable as part of the distributive antenna system in the east and west plenums on the roof level of University
Station in the DSTT and in the Beacon Hill Tunnel, as shown in the Contract Drawings.
These Specifications for the radiating cable shall be as follows:

1. University Station Roof Level East and West Plenums.

   a.) The coupled mode radiating cable to be installed in the University Station Roof Level East and West Plenum feeds shall be Andrew RXP4-1 Radiax® (or approved equivalent) with Type N female connectors, unless otherwise indicated in the Contract Drawings.

   b.) Radiating cable transmission line segments in the University Station Roof Level East and West Plenum feeds shall be 100 percent sweep-tested for attenuation and VSWR after installation and prior to their interconnection to the rest of the system.

   c.) Electrical Requirements.

       1.) Attenuation (maximum): 450 MHz – 0.67 dB/100 ft; 900 MHz – 1.33 dB/100 ft; (measured per IEC 1196-4 Standard).

       2.) Median Coupling Loss 900 MHz – 62 dB @ 6 ft ±5 dB; (measured per IEC 1196-4 Standard).

       3.) Impedance: 50 Ohms.

       4.) Velocity Factor: 89 percent.

       5.) VSWR: 1.3:1 (typical).

   d.) Mechanical and Environmental Requirements.

       1.) RF Connectors: N Female (silver plated brass with gold inner conductor).

       2.) Outside Dimensions: Nominally 1-1/4” – 1.54 inches maximum.

       3.) Minimum Bending Radius: 15 inches.

       4.) Cable Weight, lb/ft: 0.53 (maximum).

       5.) Jacket: Non-Halogen Fire Retardant; UL/NEC VW1/CATVX rated; IEC 332-1 rated.

2.11 RF TRANSMISSION LINES

A. Contractor shall provide RF transmission lines that interconnect all of the various components of this system, as follows:
1. Discrete Distributed Antenna 0.590” Transmission Lines.

a.) Contractor shall provide 0.590” RF transmission lines for interconnection of the discrete antennas used for station coverage and the RF feeds from the RF distribution hub bi-directional amplifiers (BDAs), as shown in the Contract Drawings.

b.) These transmission lines shall be fabricated from Times Microwave LMR-600-FR or Engineer-approved equivalent with Type N male connectors, unless otherwise indicated in the Contract Drawings. BDA/antenna transmission lines shall be 100 percent sweep-tested for attenuation and VSWR.

c.) Electrical Requirements.

1.) Attenuation (maximum): 450 MHz - 1.7 dB/100 ft; 900 MHz - 2.5 dB/100 ft; 2000 MHz - 3.9 dB/100 ft (measured at 25° C with VSWR 1:1).

2.) Average Power (minimum): 450 MHz - 1.35 kW; 900 MHz - 0.93 kW; 2000 MHz - 0.59 kW (VSWR 1:1 40° C with 100° C inner conductor).

3.) Shielding Effectiveness: >90 dB.

4.) Impedance: 50 Ohms.

d.) Mechanical and Environmental Requirements.

1.) RF Connectors: N male (silver plated brass with gold inner conductor) or SMA Male (gold plated).

2.) Outside Dimensions: Nominally ½ inch.

3.) Minimum Bend Radius (for less than 1 Ohm Impedance Change): 1.5 inches.

4.) Jacket: Non-Halogen FR; UL/NEC CATVR rated; listed CMR/MPR (PCC-FT4).

2. Discrete Distributed Antenna 1.20” Transmission Lines.

a.) Contractor shall provide 1.20” RF transmission lines for interconnection of the discrete antennas used for station coverage and the RF feeds from the RF distribution hub bi-directional amplifiers (BDAs), as shown in the Contract Drawings.

b.) These transmission lines shall be fabricated from Times Microwave LMR-1200-FR or engineer-approved equivalent with Type N male connectors, unless otherwise indicated in the Contract Drawings. BDA/antenna transmission lines shall be 100 percent sweep-tested for attenuation and VSWR.
c.) Electrical Requirements.

1.) Attenuation (maximum): 450 MHz – 0.864 dB/100 ft; 900 MHz – 1.27 dB/100 ft; 2000 MHz – 1.99 dB/100 ft (measured at 25° C with VSWR 1:1).

2.) Shielding Effectiveness: >90 dB.

3.) Impedance: 50 Ohms.

d.) Mechanical and Environmental Requirements.

1.) RF Connectors: N male (silver plated brass with gold inner conductor) or SMA Male (gold plated).

2.) Outside Dimensions: Nominally 1.2 inches.

3.) Minimum Bend Radius (for less than 1 Ohm Impedance Change): 6.5 inches.

4.) Jacket: Non-Halogen FR; UL/NEC CATVR rated; listed CMR/MPR (PCC-FT4).

3. Hub and Tunnel BDA Equipment Cabinet RF Jumper Cables.

a.) Contractor shall provide and install RF jumper cables from the BDA equipment enclosures to radiating cable feed points at each BDA, as shown in the Contract Drawings. All jumpers used in the remote BDA cabinets shall use 0.590” superflexible foam dielectric coaxial cable (Times Microwave Systems LMR-600-FR or engineer approved equivalent) with factory-installed Type N male connectors, unless otherwise indicated in the Contract Drawings. Jumpers shall be 100 percent factory-tested for attenuation and VSWR.

b.) Electrical Requirements.

1.) Attenuation (maximum): 450 MHz - 1.7 dB/100 ft; 900 MHz - 2.5 dB/100 ft; 2000 MHz - 3.9 dB/100 ft (measured at 25° C with VSWR 1:1).

2.) Average Power (minimum): 450 MHz - 1.35 kW; 900 MHz - 0.93 kW; 2000 MHz - 0.59 kW (VSWR 1:1 @ 40° C with 100° C inner conductor).

3.) Shielding Effectiveness: >90 dB.

4.) Impedance: 50 Ohms.

c.) Mechanical and Environmental Requirements.

1.) RF Connectors: N male (silver plated brass with gold inner conductor).

2.) Outside Dimensions: Nominally ½ inch.
3.) Minimum Bend Radius: 1.5 inches.

4.) Jacket: Non-Halogen FR; UL/NEC CATVR rated; listed CMR/MPR (PCC-FT4).

2.12 RF ATTENUATORS

A. Fixed Attenuators.

1. Contractor shall provide and install fixed RF attenuators as shown in the drawings. These attenuators shall be Pasternak Enterprises attenuators as specified below, or Engineer-approved equivalent).

   a.) One (1) Watt Fixed Attenuators (Pasternak Enterprises PE7002-X, where X indicates the attenuation value required in the Contract Drawings, or approved equivalent.)

      1.) Electrical Requirements.

         - Frequency Range: Dc to 2000 MHz.
         - Impedance: 50 Ohms.
         - Average Power Handling Capability: 1 Watt (+30 dBm).
         - Accuracy: Dc-1000 MHz, ±0.6 dB.
                     1000-2000 MHz, ±1 dB.
         - VSWR: >Dc to 1000 MHz, 1.3:1 (maximum).
                    1000—2000 MHz 1.5:1 (maximum).

      2.) Mechanical Requirements.

         - Connectors: Type N Male to Type N Female.

   b.) 10 Watt Fixed Attenuators (Pasternak Enterprises PE7010-X, where X indicates the attenuation value required in the Contract Drawings, or approved equivalent).

      1.) Electrical Requirements.

         - Frequency Range: Dc to 2000 MHz.
         - Impedance: 50 Ohms.
         - Average Power Handling Capability: 10 Watts (+40 dBm).
         - Accuracy: Dc-1000 MHz, ±0.6 dB.
                     1000-2000 MHz, ±1 dB.
         - VSWR: >Dc to 1000 MHz, 1.3:1 (maximum).
                    1000—2000 MHz 1.6:1 (maximum).
2.) Mechanical Requirements

- Connectors: Type N Male to Type N Female.

B. 800 MHz (450-1500 MHz) Variable Step RF Attenuators.

1. Contractor shall provide variable step attenuators for use as the Distribution Hub Equipment Cabinet 700 & 800 MHz uplink and downlink amplifier input attenuators, as shown in the Contract Drawings. These shall be Alan Industries, Inc. 50SV10 units or approved equivalent.

a.) Electrical Requirements.

1.) Frequency Range: Dc - 1500 MHz (minimum).

2.) Attenuator Range: 0 - 10 dB (1.0 dB steps).

3.) Accuracy: ±0.3 dB.

4.) Impedance: 50 Ohms.

5.) Insertion Loss: 0.2 dB (maximum).

6.) VSWR: 1.4:1 (maximum).

7.) Average Power: 1.0 Watt (250 Watts Peak).

b.) Mechanical Requirements.

1.) RF Connectors: SMA female.

2.) Nominal Dimensions: 1.30 Diameter (excluding connectors) X 1.63” Length.

2.13 RF TERMINATIONS

A. N Male Precision RF Terminations.

1. Contractor shall provide N Male precision RF terminations for the ends of the radiating cable segments in the Westlake-to-Convention Place Tunnel and the Beacon Hill Tunnel, as shown in the Contract Drawings. These terminations shall be Pasternak Enterprises Model No. PE6009 or engineer-approved equivalent.
a.) Electrical Requirements.

1.) Impedance: 50 Ohms.

2.) Power Handling Capacity: 2 Watts.

3.) Frequency Range: Dc to 18 GHz.

4.) Maximum VSWR: 1.30:1.

b.) Mechanical Requirements.

c.) Connector Style: N Male (without chain).

2.14 EQUIPMENT ENCLOSURES

A. Tunnel BDA Wall Mounted Cabinets.

1. Equipment Cabinets

a.) Equipment cabinets shall be wall-mounted units nominally 36” high with an inside nominal width of 19”. Units shall be double-hinged to allow access to both the front and the back of equipment mounted inside the cabinet.

1.) Front rack-mounting flanges shall be equipped with universal 10-32 thread panel mounting holes at 3/8”, 5/8” and 1/2” spacing. Equipment cabinets shall be designed to allow rigid base attachments to the floor and back panel attachments to the wall to prevent equipment from being displaced. Each cabinet shall be provided with a factory-installed padlock hasp and a Best padlock capable of using a core provided by the Sound Transit locksmith.

2.) Cabinets shall be Hoffman EWM362225 (800/900 MHz Cabinets) or EWM482225 (Cellular/PCS Cabinets) units or approved equivalent, modified from the standard Hoffman unit to provide for a NEMA12 rating and a solid steel front door.

3.) Contractor shall perform a heat load analysis for each cabinet to assure that operating temperature specifications for the equipment the in cabinet will not be exceeded, assuming a maximum ambient temperature of 85° F (29° C).

B. Hub RF/Fiber/BDA Equipment Cabinets.

1. Contractor shall supply and install equipment cabinets for the RF fiber, headend combining and RF distribution, heath and status monitoring system, and backup UPS equipment at the Tower 1 Headend – Equipment cabinets shall be standard self-supporting units 7’ high and nominal 24” in width, with steel construction. Specific requirements for these cabinets are described in the list below:
a.) 86" (2200 mm) H X 24" (600 mm) W X 28.5" (700 mm) D EIA Lockable Equipment Cabinet for Fiber Optic, Power Divider/Combiner, Hub BDA, and Associated Equipment.

b.) Vented Front door with acrylic insert and heavy duty locking handle.

c.) Vented rear door with heavy duty locking handle.

d.) Quick release side panels with keylocks.

e.) Cable entry top with 4-4" fans and 4 - 2" cable entry holes.

f.) 3 pairs of vertical grid straps for cabinet side panel equipment support.

g.) 2 pairs of rack angles for mounting 19" equipment, tapped to 10-32.

h.) 1 set of leveling feet and base angles with 3/4" holes for floor attachment.

i.) Jet-black textured finish.

j.) Cabinets spacing shall allow full and unobstructed access to the front and rear faces of installed equipment whenever possible.

2. Equipment cabinets shall be designed to allow rigid base attachments to the floor to prevent equipment from being displaced, and shall be attached to the Hub equipment room floor using concrete anchors, unless other attachment methods are specified by Sound Transit for specific Hub equipment rooms. The Hilti Kwik Bolt II, Raw Stud, Sanko or approved equal shall be used. Install expansion anchors using manufacturers suggested hardware and procedures.

3. The cabinets shall have a lockable door both front and back. No roller caster base cabinets or racks are permitted.

4. Contractor shall perform a heat load analysis for each cabinet to determine if additional ventilation or cooling, beyond that provided by the fans listed above, is necessary.

PART 3 - EXECUTION

A. Contractor shall provide all labor, materials, appliances, tools, equipment, facilities, transportation, and services necessary for or incidental to performing all operations of the Work of this Specification, complete, as specified herein. It is the intent of this Specification to provide for a complete, integrated, working system. Inadvertent omission of any necessary items of work, material, or equipment shall not negate the Contractor's responsibility to provide those items. Work includes, but is not necessarily limited to, the following:

1. Furnish and install all necessary fiber-optic equipment, amplifiers, antennas, devices, interconnecting cabling, and software to completely implement the fiber-fed 800 MHz Tunnel Radio System and associated Field Control System interfaces described in these Specifications and in Contract Drawings. This includes electrical connection to service and emergency power supplies, physical installation and integration of the DAS system with the KCRS dual redundant base station repeater equipment, interconnection of the
Headend equipment to the RF Distribution Hub equipment via RF-over-fiber links, final system adjustment, and acceptance testing of the new Tunnel Radio System.

a.) Equipment Installation and Interconnection.

Install all equipment cabinets and equipment required for the Tunnel Radio System Headend and Distribution Hubs, and for the DSTT and Beacon Hill distributive antenna systems. Install all fiber optic jumper cables, RF cables, and ac and dc power cables required to interconnect the ST O&M Facility 800 MHz repeater base station Headend to the two Distribution Hubs at University Station and Beacon Hill Station and to connect the Distribution Hubs to the DSTT and Beacon Hill distributive antenna systems. Install all necessary conduit required to provide RF connections from Hubs to distributed antenna locations and to provide connections to Hub cabinets from the demarcation points on the main Sound Transit backbone fiber distribution system. The backbone fiber will be provided separately as described in Section 17140, Backbone Cabling Requirements. The demarcation point between the Sound Transit fiber links and the Tunnel Radio System Headend and Hub fiber/RF equipment will be the FC/APC connectors on the Sound Transit fiber interconnection modules at the Headend and Hub Equipment locations.

b.) Coordination.

Coordinate installation details and schedules with Sound Transit representatives and with site owner/managers as directed by Engineer (e.g. King County Metro).

c.) Equipment Adjustment.

Adjust amplifiers and other equipment; test each item of equipment and all features of the overall system for proper and optimal functioning after installation.

d.) Acceptance Testing.

Perform factory testing, end-to-end system tests, and other component and system tests as described in Section 17470, Radio System Testing, Identification and Administration, to verify proper installation and operation of headend, fiber, distribution hub, and DAS equipment, and to verify specified performance.

e.) Field Control System Interface.

Provide and install components required to interface to the Field Control System for Hub and tunnel BDAs, fiber optic link equipment (transceivers and main/backup switches), shared talkgroup control stations, and stand-alone ITAC 800 MHz repeaters and associated equipment, that will allow Sound Transit personnel to check the status and condition of any monitored component in the system from the ST Central Control center. Configure hardware to operate with the FCS as described Section 17802, Field Control System.

f.) Documentation.

Support the entire system with engineering documentation as specified herein and in Section 17480, Radio Systems Training, Manuals, Documentation, Special Tools and Spare Parts.
g.) Training.

Provide adequate maintenance and operational training to key Sound Transit personnel as detailed in Section 17480, Radio System Training, Manuals, Documentation, Special Tools and Spare Parts.

h.) Spare Parts.

Provide an adequate inventory of spare parts, as detailed in Section 17480, Radio System Training, Manuals, Documentation, Special Tools and Spare Parts.

i.) Compliance with Rules and Standards.

Ensure that the equipment, materials and installation comply with all applicable FCC rules and regulations, with the provisions of the NEC and all City of Seattle and Sound Transit electrical, fire, and building codes, and with City of Seattle and Sound Transit seismic standards.

3.02 INSTALLATION CONDITIONS AND REQUIREMENTS

A. Contractor shall be familiar with the existing system, sites, and equipment and installation conditions and requirements. Verbal statements by or opinions of Sound Transit representatives relating to the existing system, site conditions, and installation conditions and requirements will not be considered binding.

B. The Contract Drawings indicate the general arrangement of circuits, conduit runs, equipment cabinets, antennas, transmission line runs, fiber termination panels, and other work. Information shown on the Contract Drawings is schematic; however, reconfiguration will not be permitted without specific acceptance. In cases of conflict between specifications and Contract Drawings, these Specifications shall have precedence. Data presented on the Contract Drawings is as accurate as planning can determine, but accuracy is not guaranteed and field verification of all dimensions, locations, levels, etc., to suit field conditions is required. Contractor shall review all Contract and Reference Drawings, and Specification and adjust all work to conform to all conditions shown therein.

3.03 QUALITY OF WORK

A. All equipment, material and articles incorporated in the work covered by this contract are to be new and of the most suitable grade for the purpose intended. All work under this contract shall be performed in a skillful and workmanlike manner.

B. Engineer shall have the right to reject any equipment based on an integral part that he or she deems to be substandard.

C. All cabling shall be appropriately labeled and shall be installed in a neat orderly workman-like manner.

D. All modules and control panels shall use heavy material and shall be supported sufficiently to allow no deflection of module or panel surfaces when controls are operated by personnel in a stressful operating environment. A guideline here is that a panel shall deflect no more than 1/16 of an inch when pressed in its center or weakest point with a force of twenty five pounds perpendicular to the panel surface.
E. Motherboards shall be supported so that inserting or removing modules shall not cause damaging deflection of the board.

F. All surfaces and edges shall be deburred and finished. No sharp edges shall be allowed whether internally or externally on frames or modules.

G. All controls shall operate in a smooth and positive manner, without backlash and without undue restrictions on freedom of movement.

H. Only parts known for long-term reliability shall be utilized. Sound Transit shall have the right to reject any equipment based on an integral part that it deems to be substandard.

I. Modules shall be constructed to prevent the possibility of damage during normal insertion, removal, and storage. Transformers shall not be supported by circuit boards.

J. If custom modifications to commercially available equipment are made to meet the requirements of this specification, then such modified equipment shall have a finished appearance consistent with the appearance of the rest of the facility. No evidence of custom changes or additions shall be detectable from the operating panel appearance.

K. Any new components added to front or rear panels shall have appropriate nomenclature added of matching font style and quality as the standard nomenclature. Custom fabricated panels shall have matching finishes and nomenclature of matching font style and quality as the remainder of the unit.

3.04 EQUIPMENT ENCLOSURE AND ANTENNA LOCATIONS

The tunnel BDA and antenna locations shown in this Specification have been selected so as to avoid, as much as possible, physical conflicts with other equipment in the tunnels and crossovers. However, the Contractor shall field verify the actual locations to assure that the remote BDA fiber termination boxes, equipment cabinets, wire ways, and antennas can be mounted as shown in the Contract Drawings at each location.

3.05 WIRING AND WIRING PRACTICES

A. Wires and cables shall be installed according to the following:

1. All conductors shall be copper, of not less than 98 percent conductivity. Aluminum conductors are not permitted.

2. Conductors shall be continuous between terminals, without splices.

3. Conductor gauge, insulation, and shielding shall be adequate for the intended purpose.

4. Cable and wire shall be run neatly, with adequate lacing or clamping.

5. Consistent color-coding shall be used throughout.

6. All applications requiring physical movement and flexing shall use stranded conductors.

7. Eye-type, crimped or soldered lugs shall be used with stranded wires terminated on screw-type terminals. Connections shall be made only with crimping tools that meet the
connector manufacturer's specifications and have been adjusted in accordance with the crimping tool manufacturer's requirements.

8. Shielded wiring, or other means of signal isolation, shall be used wherever necessary to avoid cross-talk, hum, pops, clicks, and other forms of interference. The Contractor shall provide an interference-free system.

9. Unless installed in conduit, wiring within console cabinets, beneath raised floors, and from outlet boxes to free-standing or desk-mounted equipment shall be neatly installed, bundled with appropriate tie-wrap devices, and tied to supports if practicable.

10. Dispatch center signal and control wiring, and connection of devices referenced in these Specifications, shall be installed in conduits or concealed, and shall be included as part of the work to be performed by the Contractor. Wiring shall be accessible for maintenance. At remote sites and equipment rooms, open cabling is permitted on cable racks provided that the wiring is neatly tied.

11. Interconnect cabling used within consoles, equipment cabinets, or in areas where the wiring will not be installed in metallic conduit, shall be insulated with heat-resistant material to minimize pyrolysis and/or fire hazard.

12. Cable and wiring penetrations through metal cabinets shall be insulated with dielectric grommets.

13. Cable and wiring installed in modular furniture shall be run in the trays or channels designed for the purpose.

14. Extra wiring necessary for equipment movement shall be neatly coiled, tied, and concealed.

15. Wiring in dropped ceiling areas shall not lie on top of light fixtures or ceiling tiles.

16. Cable penetrations through building outside walls shall be thoroughly packed and waterproofed.

17. Any cable passages from one fire-rated area to another shall be packed with approved sealant to preserve fire-rating integrity.

18. Cables, wiring forms, and other interconnecting equipment shall be identified by permanent labels, tags, or other appropriate means. Marking shall clearly indicate the function or source. Cables shall be identified at both ends with indications of the source and destination of that cable run. The cable identification shall agree with the wiring and interconnect diagrams.

19. The following are soldering requirements:

   a.) Solder shall be rosin-core, 60 percent tin, 40 percent lead. Acid core or corrosive fluxes are not permitted.

   b.) A temperature-controlled soldering iron or hot-air soldering device shall be used; soldering guns are not permitted. Soldered connections are subject to inspection and approval by Sound Transit.
c.) Solder penetration and solidification of stranded wire beyond the insulation is not permitted.

d.) Exposed stranded, soldered wire between the solder joint and the insulation shall not be larger than the nominal conductor diameter.

e.) Solder joints shall be smooth and shiny, without excessive amounts of solder, solder drips or appendages. "Cold" or fractured solder joints are not permitted.

B. Terminal Boards.

1. Only 66-type punch blocks shall be used. The blocks shall be mounted on a designated wall within the equipment room. With the exception of digital signals, all signal, communications, control, and other circuits shall be terminated on new or existing 66-type punch blocks.

2. An adequate number of 66 type telephone-type punch blocks, cable guides, and other necessary hardware shall be provided as required for a neat and workmanlike installation.

3. All multi-conductor cabling shall be color-coded for identification of conductors in conformance with EIA standards. Cabling color coding shall be consistent on all console positions.

3.06 ANTENNA INSTALLATION

Antenna Mounting in Stations and Radiating Cable Mounting in Tunnels.

The equipment configuration shown in the Contract Drawings is typical. Equipment cabinets, antenna transmission lines, antennas, and radiating cable may be relocated within reasonable limits as necessary to avoid conflicts with light fixtures, loudspeakers, and other equipment mounted in the stations and tunnels.

3.07 FINAL ACCEPTANCE

Final acceptance of the system shall consist of successful completion of all acceptance tests, submittal by Contractor of all as-built drawings, test results, manuals, and other documentation, completion of Contractor-provided training, correction of all deficiencies, and final clean-up of installation sites.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17420
SECTION 17430  
BASE STATIONS AND CONTROLLERS  

PART 1 - GENERAL  

1.01 OVERVIEW  

A. This Section is provided for reference only; others will perform the Work covered by this Section under separate contracts.  

B. The King County Regional 800 MHz Trunked Radio System ("KCRS") base station repeater site that will be used to feed the Tunnel Radio System described in Section 17420, Tunnel Radio, will be a dual-redundant (main/backup) 10-channel stand-alone repeater site located at the Sound Transit Operations and Maintenance Facility (OMF).  

C. The KCRS transmitter combiners, receiver multicouplers, base station repeater main/backup site switching equipment, backup power supply equipment, and the fiber or microwave links between the repeater sites and their respective system audio switches and zone controllers will be provided by others under a separate contract.  

D. Tunnel Radio System interface requirements for both base station repeater sites are contained in Section 17410, KCRS and King County Metro Radio System Interface Requirements.  

1.02 SECTION INCLUDES  

A. This Section includes requirements for base stations and related repeater site equipment used to feed the Tunnel Radio System that is part of the Two-Way Radio System for Sound Transit’s Link light rail operations. Radio communications for Sound Transit will be provided over the existing King County Regional 800 MHz Trunked Radio System (“KCRS”). The light rail system will require communications along the entire Sound Transit Link light rail alignment from South 154th Street in Tukwila to the Convention Place Station in Downtown Seattle, including two tunnel segments: the existing Downtown Seattle Transit Tunnel (“DSTT”) and a new light rail tunnel to be constructed under Beacon Hill.  

B. This Section includes requirements and specifications for base stations, transmitter combiners and receiver multicouplers, dual-redundant (main/backup) repeater site switching equipment, channel banks, and other equipment required to provide the voice, data and control interconnect between the KCRS base station at the Sound Transit Operations and Maintenance Facility and the KCRS Smartzone audio switch and zone controller.  

1.03 RELATED SECTIONS  

A. Section 17400 – Radio System Overview.  

B. Section 17410 – KCRS and King County Metro Radio System Interface Requirements.  

C. Section 17420 – Tunnel Radio System.  

D. Section 17440 – Portable and Mobile Radios.  

E. Section 17450 – Mobile Data Requirements.
F. Section 17460 – Software and Supplies.

G. Section 17470 – Radio System Testing, Identification and Administration.


**PART 2 - PRODUCTS**

Not Used.

**PART 3 - EXECUTION**

Not Used.

**PART 4 - MEASUREMENT AND PAYMENT**

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17430
PART 1 - GENERAL

1.01 OVERVIEW

A. This Section is provided for reference only; others will perform the Work covered by this Section.

B. Radio communications for Sound Transit will be provided over the existing King County Regional 800 MHz Trunked Radio System ("KCRS"). The light rail system will require communications along the entire Sound Transit Link light rail alignment from South 154th Street in Tukwila to the Convention Place Station in Downtown Seattle, including two tunnel segments: the existing Downtown Seattle Transit Tunnel ("DSTT") and a new light rail tunnel to be constructed under Beacon Hill.

C. Mobile radios, portable radios, and control stations used by Sound Transit will operate over the KCRS via 10 talkgroups dedicated to Sound Transit operations.

1.02 SECTION INCLUDES

This Section includes requirements for portable and mobile radios that will be used on the Two-Way Radio System for Sound Transit’s Link light rail operations. Radio communications for Sound Transit will be provided over the existing King County Regional 800 MHz Trunked Radio System ("KCRS"). The light rail system will require communications along the entire Sound Transit Link light rail alignment from South 154th Street in Tukwila to the Convention Place Station in Downtown Seattle, including two tunnel segments: the existing Downtown Seattle Transit Tunnel ("DSTT") and a new light rail tunnel to be constructed under Beacon Hill. This Section is included primarily for reference.

1.03 RELATED SECTIONS

A. Section 17400 – Radio System Overview.

B. Section 17410 – KCRS and King County Metro Radio System Interface Requirements.

C. Section 17420 – Tunnel Radio System.

D. Section 17430 – Base Stations and Controllers.

E. Section 17450 – Mobile Data Requirements.

F. Section 17460 – Software and Supplies.

G. Section 17470 – Radio System Testing, Identification and Administration.

H. Section 17480 – Radio System Training, Manuals, Documentation, Special Tools and Spare Parts.

I. Section 17490 – Tunnel Radio Systems Support and Warranty.
PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17440
SECTION 17450
MOBILE DATA REQUIREMENTS

PART 1 - GENERAL

1.01 OVERVIEW

A. This Section is provided for reference only; others will perform the Work covered by this Section under separate contracts.

B. Radio communications for Sound Transit will be provided over the existing King County Regional 800 MHz Trunked Radio System ("KCRS"). The light rail system will require communications along the entire Sound Transit Link light rail alignment from South 154th Street in Tukwila to the Convention Place Station in Downtown Seattle, including two tunnel segments: the existing Downtown Seattle Transit Tunnel ("DSTT") and a new light rail tunnel to be constructed under Beacon Hill.

C. Mobile radios, portable radios, and control stations used by Sound Transit will operate over the KCRS via ten talkgroups dedicated to Sound Transit operations.

D. Mobile data equipment and associated accessories and equipment will be provided by others under a separate contract.

1.02 SECTION INCLUDES

A. This Section includes requirements for mobile data equipment to be used in Sound Transit’s Link light rail operations. Voice radio communications, and limited short-message mobile data communications for Sound Transit will be provided over the existing King County Regional 800 MHz Trunked Radio System ("KCRS"). The light rail system will require communications along the entire Sound Transit Link light rail alignment from South 154th Street in Tukwila to the Convention Place Station in Downtown Seattle, including two tunnel segments: the existing Downtown Seattle Transit Tunnel ("DSTT") and a new light rail tunnel to be constructed under Beacon Hill.

B. This Section includes requirements and specifications for all mobile data equipment and associated accessories and equipment to be used for the Sound Transit Link Light Rail System, including mobile data equipment used to provide limited short-message data communications over the King County Regional 800 MHz Trunked Radio System.

1.03 RELATED SECTIONS

A. Section 17400 – Radio System Overview.

B. Section 17410 – KCRS and King County Metro Radio System Interface Requirements.

C. Section 17420 – Tunnel Radio System.

D. Section 17430 – Base Stations and Controllers.

E. Section 17440 – Portable and Mobile Radios.

F. Section 17460 – Software and Supplies.
G.  Section 17470 – Radio System Testing, Identification and Administration.


I.  Section 17490 – Tunnel Radio System Support & Warranty.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17450
PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall furnish all system software and firmware required to operate the Tunnel Radio System described in Section 17420, Tunnel Radio System, and the KCRS and King County Metro base station interface equipment and Sound Transit control station RF interface equipment described in Section 17410, KCRS and King County Metro Radio System Interface Requirements.

1.02 SECTION INCLUDES

This Section includes the requirements for system support and all warranty maintenance and repairs required to operate the Tunnel Radio System described in Section 17420, Tunnel Radio System, and the KCRS and Sound Transit control station RF interface equipment described in Section 17410, KCRS and King County Metro Radio System Interface Requirements, for the duration of the warranty period specified in Section 17080, System Support.

1.03 RELATED SECTIONS

A. Section 17400 – Radio System Overview.
B. Section 17410 – KCRS and King County Metro Radio System Interface Requirements.
C. Section 17420 – Tunnel Radio System.
D. Section 17430 – Base Stations and Controllers.
E. Section 17440 – Portable and Mobile Radios.
F. Section 17450 – Mobile Data Requirements.
G. Section 17460 – Software and Supplies.
H. Section 17470 – Radio System Testing, Identification and Administration.
I. Section 17480 – Radio System Training, Manuals, Documentation, Special Tools, & Spare Parts.
J. Section 17490 – Tunnel Radio System Support and Warranty.

1.04 RELATED WORK BY OTHER CONTRACTORS

Not Applicable.
1.05 REFERENCE STANDARDS

A. Without limiting the generality of other requirements of this Specification, all Work specified herein shall conform to or exceed the applicable requirements of the referenced Standards. Provided that wherever the provisions of said publications are in conflict with the requirements specified herein, the more stringent requirements shall apply unless in conflict with the equipment manufacturer’s written recommendations:

1. NFPA 70 (National Electrical Code) Sections 100-300 and Section 800.


4. Uniform Building Code, including the seismic requirements for Earthquake Zone 3.

5. EIA Standards EIA 232-C, EIA 485.

6. TIA/EIA 136, Rev B; TIA/EIA-95-B.

7. TIA/EIA 603-1 – Land mobile FM or PM communications equipment measurement and performance.


9. Codes and Standards of good practice issued by the following organizations:
   a.) National Electric Manufacturers Association (NEMA).
   b.) Underwriters Laboratories (UL).
   c.) National Fire Protection Association (NFPA).
   d.) Publication No. 70, National Electrical Code.
   e.) Occupational Safety Health Administration (OSHA) Standard.

1.06 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.
1.07 SOFTWARE AND FIRMWARE

A. Contractor shall furnish all system software and firmware required to operate all components of the Tunnel Radio System described in Section 17420, Tunnel Radio System and Sound Transit control station RF interface equipment described in Section 17410, KCRS and King County Metro Radio System Interface Requirements.

1. Software and Firmware Versions

   System software and firmware shall be the latest version available for each piece of equipment at the time of system acceptance by Sound Transit.

2. Control Station Software

   Software and firmware for the 800 MHz control stations used in the RF console/KCRS over-the-air interface shall be the latest available version compatible with the KCRS Motorola Smartzone 4.1 trunked radio system.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17460
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PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall design, furnish, and install all necessary fiber-optic equipment, amplifiers, antennas, devices, interconnecting cabling, and software to completely implement the fiber-fed 800 MHz Tunnel Radio DAS (Distributive Antenna System) and associated Health and Status monitoring system described in this specification and in the attached Contract Drawings.

1.02 SECTION INCLUDES

This Section includes the requirements for factory and field testing and equipment and conductor identification for a Tunnel Radio System to provide radio communications for both Sound Transit and for public safety agencies in the DSTT (Downtown Seattle Transit Tunnel) and in the Beacon Hill Tunnel. The Tunnel Radio System will provide coverage both in the tunnel segments and in all public and ancillary spaces in the stations in both tunnels. The system will have two RF distribution Hubs located at University Station in the DSTT and in Beacon Hill Station in the Beacon Hill Tunnel. These Hubs will be fed via analog RF-over-fiber links from the system Headend at the Sound Transit Operations and Maintenance Facility (OMF) for the KCRS (King County 800 MHz Trunked Radio System).

Testing of the 700 MHz control stations used for interoperability with the KCM 700 MHz radio system shall be conducted under a separate contract.

1.03 RELATED SECTIONS

A. Section 17400 – Radio System Overview.
B. Section 17410 – KCRS and King County Metro Radio System Interface Requirements.
C. Section 17420 – Tunnel Radio System.
D. Section 17430 – Base Stations and Controllers.
E. Section 17440 – Portable and Mobile Radios.
F. Section 17450 – Mobile Data Requirements.
G. Section 17460 – Software and Supplies.
I. Section 17490 – Tunnel Radio System Support and Warranty.
1.04 RELATED WORK DESCRIBED IN OTHER SECTIONS

Coordination by the Contractor of the field testing for the Field Equipment Control System and field testing of the Tunnel Radio System will be required to provide for testing of the interfaces between the Tunnel Radio System Health and Status Monitoring Sub-system and the Field Equipment Control System (See Section 17802, Field Control System).

1.05 REFERENCE STANDARDS

A. Without limiting the generality of other requirements of this Specification, all Work specified herein shall conform to or exceed the applicable requirements of the referenced Standards; provided, that wherever the provisions of said publications are in conflict with the requirements specified herein, the more stringent requirements shall apply unless in conflict with the equipment manufacturer’s written recommendations:

1. NFPA 70 (National Electrical Code) Sections 100-300 and Section 800.


4. Uniform Building Code, including the seismic requirements of Section 2312, for Earthquake Zone 3.

5. EIA Standards EIA 222-C, EIA 485.

6. TIA/EIA 136, Rev B; TIA/EIA-95-B.

7. TIA/EIA 603-1 – Land mobile FM or PM communications equipment measurement and performance.


9. Codes and Standards of good practice issued by the following organizations:

   a.) National Electric Manufacturers Association (NEMA).

   b.) Underwriters Laboratories (UL).

   c.) National Fire Protection Association (NFPA).

   d.) Publication No. 70, National Electrical Code.

   e.) Occupational Safety Health Administration (OSHA) Standard.

1.06 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Codes and local regulations.

1.07 SUBMITTALS

A. See Section 01330, Submittals, for detailed general submittal requirements.


      Contractor shall submit a report to Sound Transit at the completion of Factory Tests documenting the results of all measurements described in this Section. Documentation shall consist of original test data sheets and other documentation provided by the equipment manufacturers performing the tests. The documentation shall include a diagram or description showing the test measurement configuration and indicating the test equipment used to make the measurements. Equipment descriptions shall include the most recent calibration date for each piece of test equipment used in the tests.


      Contractor shall submit a report to Sound Transit at the completion of Field Tests documenting the results of all measurements described in this Section, including the Coverage Acceptance Tests. Documentation shall consist of original test data sheets and other documentation generated from the tests, as described below. The documentation shall include a diagram or description showing the test measurement configuration and indicating the test equipment used to make the measurements. Equipment descriptions shall include the most recent calibration date for each piece of test equipment used in the tests.

   3. Submit test plans and test procedures for Factory Test and Field Test.

PART 2 - PRODUCTS

2.01 CABLE, WIRE, TRANSMISSION LINE, AND FIBER LABELING

A. For wire/cables/fibers smaller than #4 AWG use manufacturer's standard vinyl-cloth self-adhesive cable/conductor markers of wrap-around type, either pre-numbered plastic coated type, or write-on type with clear plastic self-adhesive cover flap are to be used and numbered to show circuit identification. Labels on “write-on” cable markers shall use machine-generated type with a minimum ten (10)-point sans-serif font; typed label shall be protected by clear self-adhesive cover flap. Clear heat-shrink tubing shall be installed over “wrap around “ labels to prevent the label from peeling off of the cable.

B. For cables #4 AWG and larger heat shrink sleeving shall be used for phase or polarity color-coding and for numbered markers to show circuit identification.

C. The application of cable/conductor identification, with circuit number, on each wire/cable/fiber in each box/enclosure/cabinet is required. The identification shall match the marking system used in fiber termination patch panels, panelboards, shop drawings, and contract documents.
D. All antenna and radiating cable transmission lines shall be labeled with cable identification tags at each connector. Labels at the Distribution Hub Communications Room shall denote the antenna or radiating cable location fed by the cable, measured cable run loss (in dB), and VSWR at installation. Radiating cables in the tunnels and station areas shall be labeled with the same information. Labels shall be permanent and not hand written, as described above.

E. Cable label information shall directly correlate to system documentation/drawings that define or depict the interconnecting cables (i.e. cable label text shall match drawing text). A spare set of cable labels shall be provided with the site documentation package.

F. Label format, composition, and installation shall comply with the requirements of Section 17170.

2.02 EQUIPMENT CONNECTOR, SWITCH AND CONTROL LABELING

Numbers, lettering and wording as required or as recommended by manufacturer or as required for proper identification and operation/maintenance of the systems and equipment described in this Specification shall be used. All front or rear panel input and output connectors, switches, controls, etc. shall be identified, and panel labels shall match block and circuit diagram terminology and numbering shown in the contract documents and shop drawings to simplify system maintenance and troubleshooting. Gothic sans serif letters shall be provided. Lettering on rack and cabinet panels shall be applied using silk-screening or other techniques that provide a permanent, durable label that will not be affected by changes in temperature or by minor abrasions under normal use. Label format, composition, and installation shall comply with the requirements of Section 17170, Cable Testing, Identification and Administration.

2.03 EQUIPMENT NAMEPLATES

Each major equipment item (BDAs, fiber transceivers, fiber switches, power dividers, antennas, etc.) shall be identified with a nameplate that corresponds to the callout name (and/or number) shown in the as built drawings and in the system block and level diagrams and system schematic diagrams. Nameplate format, composition, and installation shall comply with the requirements of Section 17170, Cable Testing, Identification and Administration.

PART 3 - EXECUTION

3.01 PREPARATION

A. Contractor shall be responsible for all preparation work required for installation of all Tunnel Radio System components in the ST O&M Facility, in the DSTT, and in the Beacon Hill Tunnel, including core drilling for cable penetrations in locations where required penetration sleeves are not already provided by the Sound Transit Civil or Electrical Contractor.

B. The Contract Drawings indicate the general arrangement of circuits, conduit runs, equipment cabinets, antennas, transmission line runs, fiber termination panels, and other Work. Information shown on the Contract Drawings is schematic; however, reconfiguration or rerouting will not be permitted without specific acceptance. In cases of conflict between specifications and Contract Drawings, the specification shall have precedence. Data presented on the Contract Drawings is as accurate as planning can determine, but accuracy is not guaranteed and field verification of all dimensions, locations, levels, etc., to suit field conditions is required. Review all Civil, Structural and Mechanical and Electrical/RF System Contract Drawings and all specifications and adjust all Work to conform to all conditions shown therein.
3.02 FACTORY TESTING – TUNNEL RADIO SYSTEM

A. RF/Fiber Optic Link Factory Tests.

1. RF/Fiber optic transceivers shall be tested for total system RF loss (RF input to RF output) with transceivers connected on the bench with five 5 dB of optical loss.

2. Transmitter input 3rd Order Intercept (in dBm) and Receiver Noise (in dBm/Hz) shall be measured for each unit with transceivers connected with 5 dB of optical loss.

3. Written documentation of these test measurements shall be included in the Factory Test Measurement report submitted to Sound Transit, as described in Section 17470, Radio System Testing, Identification and Administration.

B. 800 MHz Bi-directional Amplifier Factory Tests.

1. Each BDA shall be swept (806-824 MHz uplink/851-869 MHz downlink) for amplitude response, gain and return loss (VSWR) for both the uplink and downlink paths, and the network analyzer plots generated by these tests shall be provided as part of the Factory Test Report. A data sheet for each amplifier shall also be provided listing (at a minimum) the following information:

   a.) Measured Output 3rd Order Intercept for uplink and downlink paths (dBm).

   b.) Measured Maximum two (2) Channel Output Power in dBm (with Output Level Control enabled).

   c.) Output Level Control voltage at maximum two (2) channel output power (Volts DC).

   d.) Level of 3rd Order Intermodulation products for two (2) channels at maximum output power (dBm).

   e.) Measured system Noise Figure (dB) without gain reduction pads.

   f.) Isolation (dB) between uplink and downlink paths.

C. RF Transmission Line Factory Tests.

1. All RF pre-assembled transmission lines and jumpers shall be swept for VSWR and Attenuation over the frequency range of 764-869 MHz, with connectors installed at the factory.

2. The results of these tests shall be provided in either graphical or tabular form in the Factory Test Report.

D. Radiating Cable Factory Tests.

1. All pre-assembled radiating cable transmission lines shall be swept for VSWR and Attenuation over the frequency range of 764-869 MHz with connectors installed at the factory.
2. The results of these tests shall be provided in either graphical or tabular form in the Factory Test Report.

E. Fiber Optic Cable Factory Tests.

1. All fiber optic jumper cables shall be swept for Optical Return Loss and Attenuation over the nominal operating frequency range of the jumpers with factory installed FC/APC connectors.

2. The results of these tests shall be provided in either graphical or tabular form in the Factory Test Report.

F. 700/800 MHz Hybrid Coupler Factory Tests.

1. 700/800 MHz Hybrid Couplers shall be swept for amplitude response and return loss (VSWR) over the 764-869 MHz band at both the in-line through port and the coupled port. Coupled port loss and in-line insertion loss shall also be measured for these units over the same frequency range.

2. The results of these measurements shall be provided in both graphical (network analyzer plots) and tabular form in the Factory Test Report.

G. 700/800 MHz Power Divider/Power Combiner Factory Tests.

1. 700/800 MHz Power Dividers and Power Combiners shall be swept for amplitude response and return loss (VSWR) over the 764-869 MHz band at both the common input port and at each output port (or at each input port and the common output port for power combiners) through port and the coupled port. Common input-to-output port loss for each output port shall be measured for power dividers and input-to-common output port loss for each output port shall be measured for power combiners, over the same frequency range.

2. The results of these measurements shall be provided in both graphical (network analyzer plots) and tabular form in the Factory Test Report.

H. Antenna Factory Tests.

1. All 700/800 MHz antennas shall be swept for return loss (VSWR) over the frequency range of 764-869 MHz.

2. The results of these measurements shall be provided in both graphical (network analyzer plots) and tabular form in the Factory Test Report.

I. Fiber Optic Switch Factory Tests.

1. All fiber optic jumper cables shall be swept for Optical Return Loss and Attenuation over the nominal operating frequency range of the switches, with factory installed FC/APC connectors.

2. The results of these tests shall be provided in either graphical or tabular form in the Factory Test Report.
J. Equipment Configuration at Factory Test.

During the factory tests, all Headend and Distribution Hub fiber optic equipment, RF BDA equipment and other RF distribution equipment up to and including the Distribution Hub BDAs, shall be set up in the same configuration that will be used at the designated installation site. Optical attenuators may be used to provide RF fiber link system attenuation equivalent to the attenuation that will occur due to actual fiber losses between the Headend site and the DSTT and Beacon Hill Distribution Hub sites. Sub-systems shall be tested in the staging area in such a manner as to minimize the actual installation time in the field. An example of the system as-built documentation shall be available at the time of system demonstration.

3.03 DELIVERY, STORAGE, AND HANDLING

A. The Contractor shall be responsible for coordinating, unloading, inspecting, accepting and storing all material deliveries for the Tunnel Radio System. Sound Transit personnel shall be excluded from performing any of these activities.

B. All claims necessary as a result of damage or loss during shipment shall be the responsibility of the Contractor.

C. All stored materials and equipment for the Tunnel Radio System shall remain the responsibility of the Contractor until they are installed and the entire Tunnel Radio system is tested and accepted by Sound Transit.

D. Major system equipment items and materials shall be delivered to the project staging facility agreed upon by the Contractor and Sound Transit.

3.04 INSTALLATION

A. Antenna Mounting in Stations and Radiating Cable Mounting in Tunnels.

1. The equipment configuration shown in the Contract Drawings is typical. Equipment cabinets, antenna transmission lines, antennas, and radiating cable may be relocated within reasonable limits as necessary to avoid conflicts with light fixtures, loudspeakers, and other equipment mounted in the tunnels.

2. The distributed antennas must be mounted at the vertical elevations above floor level shown in Contract Drawings to provide isolation from strong signals generated by two (2)-Watt 700/800 MHz and in the immediate vicinity of the distributed antennas.

B. Transmission Lines.

1. An appropriate coaxial cable cable-cutting tool (for example, Andrew “EASIAX” Model 222951 or Times “EZ” connector strip tool Model ST-1700) shall be used to terminate all cables. Replacement blades shall be those recommended and provided by the tool manufacturer.

2. All antenna and radiating cable transmission lines shall be labeled with cable identification tags at each connector. Labels at the Distribution Hub Communications Room shall denote the antenna or radiating cable location fed by the cable, measured cable run loss (in dB), and VSWR at installation. Radiating cables in the tunnels and station areas shall be labeled with the same information. Labels shall be permanent and
not hand written, as described in Section Part 2 – above. The manufacturers’ minimum bending radius shall not be exceeded during installation.

3. Transmission lines shall be installed in cable trays where available, and in all other locations shall be secured through standard cable hangers attached to channel supports or "Unistrut" as appropriate. All cables shall be dressed appropriately, and run parallel to each other.

4. Radiating cable shall be mounted using standard self-locking hangers designed specifically for use with leaky or radiating cable. Hangers shall provide the optimum spacing between the cable and the mounting surface (wall, ceiling, cable tray, etc.) recommended by the cable manufacturer (typically 85 mm [3.35"]). Hangers shall be attached directly to walls and ceilings using self-tapping concrete anchors or to channel supports or "Unistrut" as appropriate. Radiating cable runs along cable trays shall be mounted below the cable tray, using appropriate hangers for optimum spacing, as described above.

5. Hanger spacing for radiating cable shall be six (6) feet (minimum) in the station areas and in the DSTT tunnel segments, and three (3) feet (minimum) in the Beacon Hill Tunnel segments.

6. Wall, floor and ceiling feed-through sleeves shall be sized for the correct cable OD and for compliance with NEC and other applicable local wiring codes. All feed-through sleeves shall be fire-stopped per the requirements of NEC and Sections.

### 3.05 FIELD TESTING

**A. RF/Fiber Optic System Installation Tests.**

1. After installation of single mode fiber links, the following tests shall be performed and documented for each main and backup fiber (from input FC/APC connector to output FC/APC connector):
   
a.) Optical Return Loss (dB).

b.) Total Optical Loss (dB).

2. After installation of RF/fiber optic equipment, the following tests shall be performed and documented for each RF/fiber optic link (from RF input to RF output):

   a.) Swept Return Loss (764-869 MHz) [dB].

   b.) Total RF Loss (dB).

   c.) Composite Noise at receiver RF output with transmitter RF input terminated in 50 Ohms (dBm/Hz).

3. Two-tone Intermodulation Product Levels at receiver RF output and two 800 MHz signals 4 dB below the 1 dB compression point for the RF/fiber optic transmitter each at transmitter RF input. The test signals shall be separated in frequency far enough to allow clear resolution of the 2A-B and 2B-A mix products resulting from the test. Both the
levels of the test signals and the levels of the resulting intermodulation products shall be shown in the test results.

4. The results of these tests shall be provided in either graphical or tabular form in the Field Test Report.

B. 800 MHz Bi-directional Amplifier Installation Tests.

1. Following installation of all 800 MHz Bi-Directional amplifiers, all tests listed in Section 3.02.B above shall be performed to demonstrate that each BDA is adjusted and is performing as shown in the Factory Tests.

2. The results of these tests shall be provided in either graphical or tabular form in the Field Test Report.

C. RF Transmission Line Installation Tests.

1. All installed coaxial cable transmission lines shall be swept for VSWR (return loss) and Attenuation over the frequency range of 764-869 MHz with connectors installed at the factory. Each coaxial cable segment shall be tested with a TDR (Time Domain Reflectometer) to demonstrate that there are no significant discontinuities or “impedance bumps” in the line segment. VSWR (return loss) tests shall be performed from each end of each cable segment with the opposite end terminated with a 50-ohm load. Attenuation and TDR tests may be performed from one end only.

2. All installed coaxial cable segments shall comply with the manufacturer’s VSWR and Attenuation specifications.

3. The results of these tests shall be provided in either graphical or tabular form in the Field Test Report. The printed TDR graphs for each test shall be included in the Field Test Report.

D. Radiating Cable Transmission Line Installation Tests.

1. All installed radiating cable transmission lines shall be swept for VSWR (return loss) and Attenuation over the frequency range of 764-869 MHz with connectors installed at the factory. Each radiating cable segment shall be tested with a TDR (Time Domain Reflectometer) to demonstrate that there are no significant discontinuities or “impedance bumps” in the line segment. VSWR tests shall be performed from each end of each cable segment with the opposite end terminated with a 50-ohm load. Attenuation and TDR tests may be performed from one end only.

2. All installed radiating cable segments shall comply with the manufacturer’s VSWR and Attenuation specifications.

3. The results of these tests shall be provided in either graphical or tabular form in the Field Test Report. The printed TDR graphs for each test shall be included in the Field Test Report.
E. On-Site Acceptance Tests.

1. Contractor shall perform acceptance testing to demonstrate that the DAS meets or exceeds the system requirements. Acceptance testing shall include functional testing and coverage testing.

2. The on-site acceptance tests, to be witnessed by Sound Transit, shall demonstrate and verify the following:

   a.) All fixed equipment, software, and other items have been supplied and installed in compliance with the contract conditions.

   b.) All equipment, software, and other items, perform in accordance with the technical specifications.

   c.) The system and all its components perform in compliance with the system design and contract requirements; all features are operational; and the system is ready for operational usage with full traffic load. This shall include tests of all failure modes, and operation under failure of primary power sources.

   d.) Documentation of on-site acceptance tests shall include a report on the specific measurements of equipment functional performance at each fixed equipment site (Headend, Hub and BDA sites), as well as the results of coverage tests in all required mobile and portable coverage areas.

   e.) The system functional measurements shall include at a minimum for both 800 MHz frequency band segments (809.7625-813.9875 MHz and 821-824 MHz uplink; 854.7625-858.9875 and 866-869 MHz downlink) used in the Tunnel Radio System:

      1.) 800 MHz Uplink System Noise at Headend Fiber Link RF Uplink Output, measured at the input to the receiver multicoupler at the KCRS base station at the ST O&M Facility.

      2.) 800 MHz Uplink System Single Channel Carrier Level from a test portable radio located in the tunnel at the most distant extension of the radiating cable from each Hub (this measurement shall be made with the portable radio operating inside an ST light rail vehicle). This measurement shall be made at the input to the receiver multicoupler at the KCRS base station at the ST O&M Facility. The transmitter output power of the portable radio shall be measured and documented as part of this measurement.

      3.) 800 MHz Uplink System Single Channel Carrier Level from a test portable radio located as far as from the worst-case distributed antenna (i.e. the antenna that shows the lowest predicted downlink signal level at a portable radio in the Contractors Final Design Review Link Budget Calculations) for each Distribution Hub (this measurement shall be made with the portable radio carried at belt level by test personnel). This measurement shall be made at the input to the receiver multicoupler at the KCRS base station at the ST O&M Facility. The transmitter output power of the portable radio shall be measured and documented as part of this measurement.
4.) 800 MHz Uplink System Carrier-to-Noise Ratio at Headend Fiber Link RF Uplink Output, measured at the input to the receiver multicoupler at the KCRS base station at the ST O&M Facility, for both tunnel in-vehicle and distributed antenna uplink signal measurements described above. (This is the ratio between the Uplink System Single Channel Carrier Level and the Uplink System Noise at the input to the receiver multicoupler for each uplink signal measurement.) This test shall demonstrate that the Contractor’s Tunnel Radio System meets the uplink carrier-to-noise requirements specified in Sections 17410, KCRS and King County Metro Radio System Interface Requirements, and 17420, Tunnel Radio System.

5.) 800 MHz Uplink Amplifier 1 dB Compression Point (for each uplink amplifier in the system).

6.) 800 MHz Downlink Input Power to each Discrete Antenna (for each station location) with the system driven by a test signal from the KCRS base station repeater site or an equivalent signal generated using other test equipment as a source, operating at the nominal base station power per channel at the OMF headend fiber optic interface downlink input that will be used for regular operation of the system.

7.) 800 MHz Downlink Input Power to the input connector of each radiating cable run with the system driven by a test signal from the KCRS base station repeater site or an equivalent signal generated using other test equipment as a source, operating at the nominal base station power per channel at the OMF headend fiber optic interface downlink input that will be used for regular operation of the system.

8.) 800 MHz Downlink 1 dB Compression Point (for each downlink amplifier) with the system driven by a test signal from the KCRS base station repeater site or an equivalent signal generated using other test equipment as a source, operating at the nominal base station power per channel at the OMF headend fiber optic interface downlink input that will be used for regular operation of the system.

9.) 800 MHz Downlink Composite Output Power for 2 channels (for each downlink amplifier) with the system driven by a test signal from the KCRS base station repeater site or an equivalent signal generated using other test equipment as a source, operating at the nominal base station power per channel at the OMF headend fiber optic interface downlink input that will be used for regular operation of the system.

F. Coverage Acceptance Tests.

1. The objective of the coverage test measurements is to demonstrate a 95 percent service area reliability with a 90 percent confidence level and a ten (10) percent confidence interval. In other words, the objective is 90 percent confidence that the true value of service area reliability falls between 90 percent and 100 percent. To achieve this objective, Contractor shall perform coverage tests in the stations and associated habitable spaces in the following manner:

a.) Create a uniform grid with 50 foot centers over each coverage area of interest. The grid shall include all platform areas, equipment rooms, communication rooms, entry and other stairwells, and other ancillary spaces in the DSTT and the Beacon Hill...
Tunnel. In the Beacon Hill Station, measurement areas shall include both platforms, both emergency cross-passages, and all corridor and room areas on all levels of the East Shaft/Headhouse and West Shaft/Headhouse structures. Requirements for measurements in tunnel segments are described below.

1.) At the first grid point, take at least 50 measurements each (in dBm) of two test frequencies, one in the 800 MHz SMR downlink band (854.7625-858.9875 MHz) and one in the 800 MHz NPSPAC downlink band (866-869 MHz), over a distance of 29\(\lambda\) to 50\(\lambda\) (40\(\lambda\) preferred), where \(\lambda\) is the radio carrier wavelength (1.22 feet at 806 MHz).

2.) Arithmetically average the dBm values of these measurements to obtain the local mean received signal power for the grid point and apply the result, \(S_{\text{avg}}\), to the grid point.

3.) Repeat Steps two (2) and three (3) for each grid point.

4.) Calculate the service area reliability for each station (all levels included) and tunnel segment:

\[
\text{Service Area Reliability (\%)} = \frac{T_p}{T_t} \times 100\%
\]

\(T_p\) is the total number of grid points passed (i.e., \(S_{\text{avg}} > -94.8\) dBm).
\(T_t\) is the total number of grid points measured.

b.) In order for the service area to meet the coverage requirements, the measured service area reliability shall be greater than or equal to 95 percent in each complete station (including all ancillary habitable spaces), and no two adjacent measurement grid points shall be allowed to fail (i.e. to show a measured local mean power below the Channel Performance Criterion (CPC) of \(-94.8\) dBm for a portable radio with a quarter wave antenna at belt level).

c.) The 95 percent service area reliability requirement described above shall apply to each station (including ancillary habitable spaces) individually, and shall be analyzed separately from the service area reliability requirements for other stations.

d.) Measurements shall be made using mobile equipment suitably mounted to allow the test measurement setup to be moved through the required test areas (station platforms, equipment rooms, etc) as close to a uniform rate of speed as possible. Post processing of the measured data may be used to obtain equivalent portable radio talk-out performance. The specific performance degradation factor used to account for the difference between the antenna system losses for the test measurement setup and for portable radios carried at belt level shall be approved by ST.

e.) Measured test data and reference parameters shall be provided in tabular form (Excel), and the final test results shall be provided in both a table and on plan view drawings of the DSTT and the Beacon Hill Tunnel, including all levels of the Shaft/Headhouse and the East Shaft/Headhouse structures at Beacon Hill and all
areas of the Platform, Mezzanine, and Roof levels (where applicable) of the stations in the DSTT.

f.) The Contractor shall request the approval of ST to waive tests in any areas that are not reasonably accessible. The details of the Coverage Acceptance Test Plan, including grid points to be included in the tests and measurement collection locations and routes shall be approved by ST prior to the commencement of the Coverage Acceptance Tests.

G. Coverage Tests in Rail Vehicles in the Tunnels.

1. In the tunnel segments, measurements shall be made on board an ST light rail vehicle with the receiving antenna height 2.0 meters above the vehicle floor level. These measurements shall be made continuously at a minimum sample rate of 200 samples per second for each frequency measured (one 800 MHz SMR band test frequency and one 800 MHz NPSPAC band test frequency); that is, alternating 800 MHz SMR and 800 MHz NPSPAC samples every 2.5 milliseconds. The raw sample data shall be stored in a log file in ASCII format, with markers in each log file to indicate the beginning and the end of each tunnel segment. The dBm values of these logged samples shall be averaged over 50 foot intervals for the length of the tunnel segment by dividing the total number of samples contained in the sample log file into segments equal to the total tunnel length in feet/50 and averaging the dBm values in each segment to provide a local mean received power value for each 50 foot segment of the tunnel. The Acceptance Test Measurement Report shall include the raw data ASCII log files in electronic form as an attachment. The average values described above shall be shown in both tabular form and graphical form with the distance in feet from the start of the tunnel on the x-axis and the measured average power in dBm on the y-axis.

2. This measurement technique assumes that the light rail vehicle travels at constant speed through the tunnel. Although this assumption is not strictly correct, especially at the beginning and the end of each tunnel segment, the technique described above is adequate to provide a reasonable and statistically valid representation of the mean received signal power for each 50-foot segment of the tunnel.

3. The service area reliability for each tunnel segment shall be calculated as described in Section 3.05 F.1.a) 4) above.

4. In order for the service area to meet the coverage requirements, the measured service area reliability shall be greater than or equal to 95 percent in each tunnel segment, and no two adjacent measurement segments shall be allowed to fail (i.e. to show a measured local mean power below the Channel Performance Criterion (CPC) of –92.8 dB for a portable radio with a quarter wave antenna at belt level.

5. The 95 percent service area reliability requirement described above shall apply to each tunnel segment individually, and shall be analyzed separately from the service area reliability requirements for station areas outside the tunnel segments.
H. DAQ (Delivered Audio Quality) Tests.

1. DAQ Testing and Evaluation.

a.) The purpose of this test is the determination of Delivered Audio Quality of not less than DAQ 3.4, as described in Table A-1 of EIA TSB-88A\(^1\). This level describes a signal which approximates an equivalent intelligibility of 20 dB SINAD for a stationary receiver. This applies to both talk-out and talk-back paths, for both portable and mobile radios.

b.) DAQ shall be evaluated by logging the voice quality of predetermined test calls at specific individual test locations using the DAQ score as defined in the following Table:

<table>
<thead>
<tr>
<th>DAQ (Delivered Audio Quality)</th>
<th>Subjective Performance Description</th>
<th>SINAD Equivalent Intelligibly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unusable, Speech present but unreadable</td>
<td>&lt;8</td>
</tr>
<tr>
<td>2</td>
<td>Understandable with considerable effort. Frequent repetition due to noise/distortion.</td>
<td>12 dB</td>
</tr>
<tr>
<td>3</td>
<td>Speech understandable with slight effort. Occasional recitation required due to noise/distortion</td>
<td>17 dB</td>
</tr>
<tr>
<td>3.4</td>
<td>Speech understandable, without repetition. Some noise/distortion.</td>
<td>20 dB</td>
</tr>
<tr>
<td>4</td>
<td>Speech easily understood. Occasional noise/distortion.</td>
<td>25 dB</td>
</tr>
<tr>
<td>4.5</td>
<td>Speech easily understood. Infrequent noise/distortion.</td>
<td>30 dB</td>
</tr>
<tr>
<td>5</td>
<td>Speech easily understood.</td>
<td>&gt;33 dB</td>
</tr>
</tbody>
</table>

c.) Ninety-five percent (95 percent) of test locations in each station and in each tunnel segment must pass. DAQ testing shall be performed using portable radios of the type to be used on the KCRS (800 MHz) radio system, equipped with the antenna type to be used in normal operation. Locations that are found to have a poor DAQ score because of low signal strength (i.e. grid locations that do not pass the minimum CPC requirement) will not be counted. This is a voice quality test.

d.) For DAQ tests, an acceptable test is defined as the establishment of two-way voice communications between mobile/portable units and the repeater station after the first operation of the push-to-talk switch, and maintenance of that communications path for not less than four (4) seconds. For an 800 MHz analog trunked repeater the test requires that the trunked system control channel has sufficient field strength and other transmission characteristics to be operable between the mobile/portable unit and the repeater station, that appropriate data interchange has taken place, that the system has assigned the mobile/portable unit to a voice channel, that the mobile/portable unit has switched to the assigned voice channel, and that the voice channel is operable and meets the specified requirement.

e.) DAQ tests at each location shall include both talk-out and talk-back tests. Talk-out tests shall measure DAQ for transmissions from a console through the Tunnel Radio

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System to field test locations. Talk-out tests shall be made with the receiving antenna at two meters above local ground level. Talk-back tests shall measure DAQ for transmissions from a transmitter equivalent to a typical portable radio, as provided under this Specification, used at head-level, through the Tunnel Radio System, to a console.

f.) A radio call shall be made at a random location within each cell. Scheduling of these tests and/or assignment of a dedicated talkgroup for the tests shall be coordinated with KCRS. The proposed testing methodology must include one point for each of the measurement grid points described above.

g.) The test plan shall ensure that the tests at each test site use a random sampling of all installed trunked RF channels for voice transmission, and a random sampling of all RF channels assignable to control channel operation.

h.) Up to three representatives of Sound Transit shall be invited to observe these tests. One representative from ST and one Contractor representative shall provide results for each test. Test results shall be averaged between the value provided by the ST representative and the value provided by the Contractor representative.

i.) In cases of marginal readings or disagreement, and at the option of Sound Transit, the DAQ tests shall be reviewed by a five-member test team, comprised of no more than two representatives of the Contractor. Test results shall be based on the median DAQ scoring of the five members.

j.) Sound Transit reserves the right to modify this test plan for voice trunks on the KCRS (800 MHz) system.

I. Operational Acceptance Test.

1. During this test, no adjustments, modifications, or substitutions are to be made to the fixed equipment by Contractor, except by approval of the designated representative of Sound Transit.

2. The Vendor shall notify Sound Transit of any failure or degradation of the system or its components.

3. The operational test period shall be 30 calendar days after full system turn-up. Any periods of major system failure or significant degradation shall restart the operational test period. Major system failures shall include any failure of the RF/Fiber links, main/backup fiber switches, the passive portion of the distributive antenna system (including radiating cable in the tunnels), or unidirectional or bidirectional amplifiers. No more than five (5) such individual failures shall be allowed during the operational test period.

4. Operational Acceptance Test results (including any failures) shall be documented and certified by Contractor.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17470
PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall furnish all system documentation, manuals, and other materials necessary for training ST personnel on the maintenance and repair of the Tunnel Radio System. Contractor shall provide training classes as specified in this Section. Contractor shall provide special tools and spare parts required for maintenance of the Tunnel Radio System described in Section 17420, Tunnel Radio System.

1.02 SECTION INCLUDES

This Section includes the requirements for training, training manuals, system documentation, special tools and spare parts for the Tunnel Radio System that will provide radio communications for both Sound Transit and for public safety agencies in the Downtown Seattle Transit Tunnel ("DSTT") and in the Beacon Hill Tunnel. The Tunnel Radio System, which will provide coverage both in the tunnel segments and in all public and ancillary spaces in the stations in both tunnels, is described in detail in Section 17420, Tunnel Radio System.

1.03 RELATED SECTIONS

A. Section 17400 – Radio Systems Overview.

B. Section 17410 – KCRS and King County Metro Radio System Interface Requirements.

C. Section 17420 – Tunnel Radio System.

D. Section 17430 – Base Stations and Controllers.

E. Section 17440 – Portable and Mobile Radios.

F. Section 17450 – Mobile Data Requirements.

G. Section 17460 – Software and Supplies.


I. Section 17490 – Tunnel Radio System Support & Warranty.

1.04 RELATED WORK BY OTHER CONTRACTORS

Not Applicable.
1.05 REFERENCE STANDARDS

A. Without limiting the generality of other requirements of this Specification, all Work specified herein shall conform to or exceed the applicable requirements of the referenced Standards; provided, that wherever the provisions of said publications are in conflict with the requirements specified herein, the more stringent requirements shall apply unless in conflict with the equipment manufacturer’s written recommendations:

1. NFPA 70 (National Electrical Code) Sections 100-300 and Section 800.


4. Uniform Building Code, including the seismic requirements of Section 2312, for Earthquake Zone 3.

5. EIA Standards RS 232-C, RS 485.

6. TIA/EIA 136, Rev B; TIA/EIA-95-B.

7. TIA/EIA 603-1 – Land mobile FM or PM communications equipment measurement and performance.


9. Codes and Standards of good practice issued by the following organizations:

   a.) National Electric Manufacturers Association (NEMA).

   b.) Underwriters Laboratories (UL).

   c.) National Fire Protection Association (NFPA).

   d.) Publication No. 70, National Electrical Code.

   e.) Occupational Safety Health Administration (OSHA) Standard.

1.06 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.07 SUBMITTALS

A. This Specification describes a system design which an engineering study and local experience has determined to be practical. The Bidder is required to submit a proposal which meets or exceeds the requirements herein.

B. See Section 01330, Submittals, for detailed general submittal requirements.

1.08 TRAINING

A. Contractor shall provide training to cover the following areas of system operation, maintenance, and troubleshooting.

1. Review of overall system design and configuration to allow Sound Transit personnel to become familiar with the layout of the system and the location of system equipment. Training materials shall include complete high level system overview diagrams and complete system block and level diagrams showing all system gains, losses, and level and/or attenuator settings. Diagrams shall include signal levels for all bands at headend uplink and downlink output and input ports, distribution hub BDA uplink and downlink sample ports, and BDA output ports, at each antenna in the DSTT and Beacon Hill distributive antenna systems, at the input connector to each section of radiating cable in the tunnel segments and at the input and output sample ports of each tunnel BDA, based on the measurements performed during the Acceptance Tests described in Section 17470, Radio System Testing, Identification and Administration.

2. System maintenance requirements, including any system components that need regular checking and/or long-term observation and performance logging. Any system trends that may indicate changes in the system that will eventually require adjustment or replacement of system components.

3. Detailed system adjustment procedures, including a detailed step-by-step written procedure for initial system setup and proof-of-performance tests required to demonstrate correct system performance. Proof-of-performance tests described in the procedure shall be equivalent to those shown in Section 17470, Radio System Testing, Identification and Administration, at a minimum.

4. Training on the use of the BDA and fiber-optic link Health and Status Monitoring sub-system, including a description of all status and alarm functions, review of “normal” operating ranges for dynamic parameters monitored by the system (DC supply voltage, DC supply current, forward RF composite power, etc.). Maintenance and troubleshooting of any monitor system interface hardware shall also be covered.

5. Step-by-Step troubleshooting procedures to be employed if all or part of the system fails.
B. Contractor shall provide a minimum of 24 hours of training, scheduled to allow participation by personnel on two different shifts, to cover the material described above.

1.09 DOCUMENTATION AND PROJECT RECORD DRAWINGS

A. Documentation supplied for the Tunnel Radio System shall include: final system description; block and level diagrams; installation and shop drawings; contractor test reports; system performance verification reports; all manufacturer’s manuals for all components and any additional documentation required to include as a minimum: schematics, parts lists, component layouts, installation and replacement instructions, setup procedures, test methods, and operating instructions.

1. FCS Sub-System Interface System Manual.

a.) Contractor shall provide a complete system manual for the BDA and fiber optic link FCS Interface systems, describing both the hardware configuration and the software interface, if any, used to provide inputs to the ST Field Control System (“FCS”). Documentation shall include a description all functions of the monitoring systems, all status and alarm functions, review of “normal” operating ranges for dynamic parameters monitored by the system (DC supply voltage, DC supply current, forward RF composite power, etc.). Maintenance and troubleshooting procedures for the monitor system hardware (and software, if applicable) shall also be included in the documentation.

2. Additional Manuals.

a.) Contractor shall provide the Sound Transit the following sets of operational, maintenance and service manuals, 30 days prior to the start of acceptance tests:

1.) Three (3) user operational manual sets. Each set shall include one user operational manual for each type of equipment (e.g. bi-directional amplifiers, 800 MHz control stations, 700 MHz control stations, fiber optic switches, fiber optic transceivers, transmitter combiners and receiver multicouplers, etc.) with the entire set bound together as a master manual.

- Operational manuals shall include a troubleshooting guide containing simple step-by-step procedures to determine if operation in a backup mode is necessary and to change to a backup mode of operation if required, as well as simple step-by-step operational procedures describing how to respond to common failure modes. The procedures in the troubleshooting guide shall be written to assist an operator to determine a work-around solution for a particular failure without assistance, if possible, or to determine who to call for assistance if a work-around solution is not possible.

- A draft version of the troubleshooting guide shall be approved by an authorized representative of Sound Transit before the final version of the guide is provided by the Contractor.

2.) Three (3) bound sets of all necessary installation and service manuals for each type of equipment supplied, regardless of whether it is manufactured by the Contractor or by another supplier. Service manuals shall include details
on hardware and software operation. Service manuals shall contain sufficient information to allow a competent service technician to service the equipment down to the component level.

3.) Three (3) parts manuals for each piece of equipment.

4.) Three (3) operational and programming manuals for any and all software supplied for the system. Software manuals shall include flow charts and shall employ standard language. Any proprietary restrictions on software documentation shall be identified and described in the documentation.

b.) Manuals shall be professionally bound. Fold-out schematic diagram sheets or other pages that require折叠 shall be a continuous sheet of paper without splices. Sound Transit shall be granted, in writing, the rights to reproduce all materials supplied under this contract for its own future needs.

B. Operation and Maintenance Data.

Contractor shall provide the following operation and maintenance information for the entire Headend/Hub/DAS system:

1. System Block and Level Diagrams.

Contractor shall provide complete high level system overview diagrams and complete system block and level diagrams showing all system gains, losses, and level and/or attenuator settings. Diagrams shall include signal levels at headend uplink and downlink input and sample ports, hub equipment rack uplink and downlink sample ports, and BDA downlink sample ports, based on the measurements performed during the Acceptance Tests described in Section 17470, Radio System Testing, Identification and Administration. System levels documented shall include measured composite uplink noise in the 821-824 MHz band and in the 809.7625-813.9875MHz band at the output side of the Headend power combiners used to connect the Tunnel Radio System to the KCRS repeater site base stations.

2. System Dc Power Supply Data, Operating Parameters, and FCS Interface Sub-system Documentation.

Contractor shall provide complete documentation of the configuration and operation of the FCS Interface system, including all functions of the monitoring and logging software, description of all status and alarm functions, review of "normal" operating ranges for dynamic parameters monitored by the system (Dc supply voltage, Dc supply current, forward RF composite power, etc.), Maintenance and troubleshooting of the FCS interface system hardware and software shall also be covered by the documentation. DC power supply documentation shall include calculated heat load data and cooling requirements for all DC power supplies and for all OMF Headend rooms, Distribution Hub equipment rooms, and remote BDA cabinets.


Contractor shall provide detailed system adjustment procedures, including a detailed step-by-step written procedure for initial system setup and proof-of-performance tests.
required to demonstrate correct system performance. Proof-of-performance tests described in the procedure shall be equivalent to those shown in Section 17470, Radio System Testing, Identification and Administration, of this Specification, at a minimum.

4. Recommended System Maintenance and Troubleshooting Procedures.

a.) Contractor shall provide documentation of normal system maintenance requirements, including any system components that need regular checking and/or long-term observation and performance logging. Any system trends that may indicate changes in the system that will eventually require adjustment or replacement of system components shall be included.

b.) Contractor shall also provide written step-by-step troubleshooting procedures to be employed if all or part of the system fails.

C. All of the documentation described above in Section 1.09 shall be incorporated into and used in the system training described in Section 1.08 above.

1.10 SPECIAL TOOLS

Contractor shall provide Sound Transit with a recommended list of any special tools or test equipment required for ongoing maintenance and repair of the Tunnel Radio System.

1.11 SPARE PARTS

A. Contractor shall provide sufficient spare system components to allow rapid replacement of failed major or minor components by the Contractor or by ST personnel. Components used before the system Acceptance Tests are completed and signed off by ST will be considered normal system components, not spares. Contractor must provide a full complement of spares as of the date the 30-day field acceptance test period is completed and has been signed off by ST. Additional spares must be provided within 24 hours when needed, and must be delivered in new and unopened boxes.

B. Any two or more spare components performing the same function in the system shall be provided by the same manufacturer and shall have the same model number as the original components they are meant to replace, unless a different manufacturer and/or a different model number are specifically identified by the Contractor and approved by Sound Transit.

C. Contractor shall provide the following specific spare parts for the Tunnel Radio System, based on the system conceptual design shown in the Specification, at a minimum:

1. Active Component Spares.

a.) Fiber Optic Links from ST O&M Headend to DSTT and Beacon Hill Tunnel Distribution Hubs.

   1.) Fiber Optic Transceivers with High Dynamic Range Transmitters (Hub Transceivers) – two (2).
2.) Fiber Optic Transceivers with Normal Dynamic Range Transmitters (Headend Transceivers) – two (2).

3.) Fiber Optic Main/Backup Fiber Switches – two (2).

b.) Bi-Directional Amplifiers.

1.) 800 MHz BDAs – four (4) uplink and four (4) downlink amplifier modules; two (2) power supplies.

2. Passive Component Spares.

a.) Fiber Optic Cable Jumpers.

1.) FC/APC or SC/APC fiber optic jumper cables – ten (10).

b.) RF Cable Jumpers.

1.) 0.590" 3-foot coaxial cable jumpers – ten (10).

2.) 0.590" 6-foot coaxial cable jumpers – ten (10).

c.) RF Power Dividers.

1.) 2-Way Power Dividers (90 percent/10 percent) – six (6).

2.) 2-Way Power Dividers (50 percent/50 percent) – six (6).

3.) 2-Way Power Dividers (30 percent/70 percent) – four (4).

4.) 2-Way Power Dividers (40 percent/60 percent) – one (1).

5.) 2-Way Power Dividers (20 percent/80 percent) – one (1).

6.) 3-Way Power Dividers (33 percent/33 percent/33 percent) – six (6).

7.) 3-Way Power Dividers (40 percent/20 percent/40 percent) – two (2).

8.) 3-Way Power Dividers (80 percent/10 percent/10 percent) – one (1).

9.) 4-Way Power Dividers (25 percent/25 percent/25 percent/25 percent) – six (6).

10.) 4-Way Power Dividers (10 percent/10 percent/10 percent/70 percent) – two (2).

D. Contractor shall provide Sound Transit with specific recommendations for changes to the list shown above and/or additional recommended spare parts requirements, based on Contractor’s specific system design and Contractor’s experience with systems similar to the Tunnel Radio System.
PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17480
SECTION 17490
TUNNEL RADIO SYSTEM SUPPORT AND WARRANTY

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall furnish all system support and all warranty maintenance and repairs required to operate the Tunnel Radio System described in Section 17420, Tunnel Radio System, the KCRS base station interface equipment, and the Sound Transit control station RF interface equipment described in Section 17410, KCRS and King County Metro Radio System Interface Requirements, for the duration of the warranty period specified in Section 17080, System Support. Contractor shall provide the specific warranty and support provisions for the Tunnel Radio System, including base station and control station interfaces, as specified in this Section.

1.02 SECTION INCLUDES

This Section includes the requirements for system support and all warranty maintenance and repairs required to operate the Tunnel Radio System described in Section 17420, Tunnel Radio System and the KCRS base station interface equipment and Sound Transit control station RF interface equipment described in Section 17410, KCRS and King County Metro Radio System Interface Requirements, for the duration of the warranty period specified in Section 17080, System Support.

1.03 RELATED SECTIONS

A. Section 17400 – Radio Systems Overview.

B. Section 17410 – KCRS and KC Metro Radio System Interface Requirements.

C. Section 17420 – Tunnel Radio System.

D. Section 17430 – Base Stations and Controllers.

E. Section 17440 – Portable and Mobile Radios.

F. Section 17450 – Mobile Data Requirements.

G. Section 17460 – Software and Supplies.

H. Section 17470 – Radio System Testing, Identification and Administration.

I. Section 17480 – Radio System Training, Manuals, Documentation, Special Tools and Spare Parts.

1.04 RELATED WORK BY OTHER CONTRACTORS

Not Applicable.
1.05 REFERENCE STANDARDS

A. Without limiting the generality of other requirements of this Specification, all warranty-related work specified herein shall conform to or exceed the applicable requirements of the referenced Standards; provided that wherever the provisions of said publications are in conflict with the requirements specified herein, the more stringent requirements shall apply unless in conflict with the equipment manufacturer’s written recommendations:

1. NFPA 70 (National Electrical Code) Sections 100-300 and Section 800.


4. Uniform Building Code, including the seismic requirements of Section 2312, for Earthquake Zone 3.

5. EIA Standards EIA 232-C, EIA 485.

6. TIA/EIA 136, Rev B; TIA/EIA-95-B.

7. TIA/EIA 603-1 – Land mobile FM or PM communications equipment measurement and performance.


9. Codes and Standards of good practice issued by the following organizations:
   a.) National Electric Manufacturers Association (NEMA).
   b.) Underwriters Laboratories (UL).
   c.) National Fire Protection Association (NFPA).
   d.) Publication No. 70, National Electrical Code.
   e.) Occupational Safety Health Administration (OSHA) Standard.

1.06 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations.
1.07 WARRANTY

A. The Contractor shall provide a one-year (minimum) warranty on all Tunnel Radio System components (including base station interface and control station interface components), including parts, labor, hardware, and software, as described in detail in Section 17080, System Support. The warranty period shall start at the time of Final System Acceptance.

B. Except as otherwise expressly provided in this Contract, the Contractor shall remedy at his own expense any failure of the Work for a period of one year, including the equipment, to conform to Contract Specifications and any defect of material, workmanship or design in the Work, but excluding any defect of any design furnished by Sound Transit under the Contract, provided that the Contracting Officer or the Authorized Representative give the Contractor notice of any such failure of defect promptly after discovery but not later than one year after final acceptance of the Work, except that in the case of defects or failures in a part of the Work of which Sound Transit takes possession prior to final acceptance, such notice shall be given not later than one year from the date Sound Transit takes such possession.

C. The Contractor, at his own expense shall also remedy damage to equipment, the site, or the buildings or the contents thereof, which is the result of any failure or defect, and restore any Work damaged in fulfilling the terms of this article.

D. Should the Contractor fail to remedy any such failure or defect within a reasonable time after receipt of notice thereof, Sound Transit shall have the right to replace, repair or otherwise remedy such failure or defect at the Contractor's expense. This warranty shall not delay final acceptance of or final payment for the Contract Work.

1. Subcontractors', Manufacturers' and Suppliers' Warranties.

a.) All subcontractors', manufacturers' and suppliers' warranties and guaranties, expressed or implied, with respect to any part of the Work and any material used in the Tunnel Radio System and associated system interfaces shall be deemed obtained, and shall be enforced, by the Contractor as the agent and for the benefit of Sound Transit without the necessity of separate transfer or assignment thereof, provided that, if directed by Sound Transit, the Contractor shall require such subcontractors, manufacturers and suppliers to execute such warranties and guarantees in writing to Sound Transit.

b.) Any Work repaired or replaced pursuant to this article shall also be subject to the provisions of this article to the same extent as Work originally performed. The rights and remedies of Sound Transit provided in this article are in addition to and do not limit any rights afforded to Sound Transit by any other article of this contract.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 MAINTENANCE UNTIL ACCEPTANCE

During the acceptance testing period, the Contractor shall provide replacement parts, materials, and experienced personnel to service the Tunnel Radio System equipment at the Sound Transit facilities or fixed equipment sites. A two-hour response time is required for all major failures of
fixed-end equipment, i.e., within two working hours after notification of a major equipment failure, a qualified technician shall be on the scene working on the problem. Sound Transit, Sound Transit Security personnel, the Seattle Police and Fire Departments Police Departments, and other public safety agencies that will use the Tunnel Radio System operate 24 hours a day, 7 days a week.

3.02 PARTS AND DEPOT SUPPORT

The Contractor shall provide a written procedure to obtain new equipment or replacement service parts and/or components from the manufacturer in both a routine manner and on a rush order basis (next-day delivery), if necessary to effect an emergency repair in the field. The Contractor shall also describe in writing the degree of depot support to be supplied for board level repair, and the ability and procedure to temporarily replace (loan) any particular board during the time that the defective board is being repaired.

3.03 LIST OF SERVICE LOCATIONS

The Contractor shall provide a list of locally owned or affiliated service locations, as well as the response times that these affiliated service locations will provide for repair of the Tunnel Radio System. The Contractor shall also provide a telephone number of a technical service center for 24 hour fixed equipment technical assistance.

3.04 EQUIPMENT AVAILABILITY GUARANTEE

The Contractor shall guarantee the availability of each system component, as well as all necessary software, documentation, product support, and other components necessary for system expansion, or their functionally equivalent replacements, for at least eight years from the date of acceptance of the Tunnel Radio System.

3.05 REPAIR PARTS AVAILABILITY GUARANTEE

The Contractor shall provide written certification from the manufacturers of major items of electronic equipment and software that the manufacturers will support their products for not less than eight years after final Tunnel Radio System acceptance. Support shall include all equipment, software, documentation, parts, technical assistance, repair, customer service, and any other items necessary for continuing full operation of the Tunnel Radio System, base station interfaces and control station console interfaces. Equipment items or software no longer in production shall be replaceable by functionally equivalent items or software.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17490
SECTION 17500
CABLE TRANSMISSION SYSTEM/WAN OVERVIEW

PART 1 - GENERAL

1.01 OVERVIEW

The Communications System Cable Transmission System/Wide Area Network provides timely reliable and accurate operations and maintenance video, voice, and data communications data between Central Control and the Sound Transit stations. The Backbone Network is made up of a single bi-directional fiber optic OC-12 SONET Ring. This ring provides connectivity for ‘large node’ Sound Transit stations. The ‘small node’ stations are connected to the larger SONET nodes via Ethernet switches equipped with Spanning Tree Protocol (STP) functionality. The Contract Drawings show how the backbone is configured to provide redundant high-bandwidth connectivity to each station and to the O&M Facility. The Wide Area Network equipment is specifically the ethernet switches and SONET multiplexors that connect the application hardware to the fiber cable Backbone. The data and quality of service requirements define and distinguish the various types of logical circuits that are transmitted over the Backbone. The quality of service implementation also provides prioritization of critical data, as well as network management and monitoring to ensure proper communications of all data throughout the system.

1.02 SECTION INCLUDES

This Section describes the overview of Cable Transmission System/WAN for Sound Transit Link Communications.

1.03 RELATED SECTIONS

A. Section 17510 – Communication System Backbone Equipment.

B. Section 17520 – Voice Circuits.

C. Section 17530 – Video Circuits.

D. Section 17540 – Data Circuits.

E. Section 17550 – Leased Lines.

F. Section 17560 – Quality of Service Requirements.

G. Section 17570 – WAN System Testing, Identification and Administration.

H. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.

I. Section 17590 – Cable Transmission System/WAN Support and Warranty.

1.04 SYSTEM INTERFACES

A. The Backbone provides the communication path for all Sound Transit Communications operational data. As such, this piece of the system interfaces with all elements of the Sound Transit Communications System in providing a secure, reliable, high-performance link. Specifically, the Backbone interfaces with the following Sound Transit Communication
subsystems. The Office Services Network interfaces with non-operational Sound Transit organizations. This Local Area Network provides the interface for the operational backbone with the non-operational administrative network.

1. Field Control System.
2. Central Control System.
3. PA/VMS System.
4. CCTV System.
5. Phone Systems.
7. Office Services Network.
8. Radio System.

1.05 WIDE AREA NETWORK COMPONENTS

A. The Backbone is organized into the following components:

1. Backbone Equipment.

   a.) The Backbone is made up of SONET Add Drop Multiplexors (ADMs) at selected stations and at the Central Control Equipment Room. These multiplexors provide the OC-12 drop that provides connectivity to the backbone. These ADMs provide Ethernet connection for each logical network that runs over the system (FCS and CCS, PA/VMS, CCTV, phone, management). The ADMs provide network drops at selected stations. Ethernet Network Switches are also provided at these stations and at Central Control Equipment Room to route each type of traffic to its appropriate network device. For the stations that do not have ADMs, known as ‘small nodes’, Ethernet switches with STP functionality shall be provided that connect to the appropriate Ethernet switch at the neighboring larger station. E.g., the OSN Ethernet switch at a small node (such as Lander Station) shall connect over the backbone to the OSN Ethernet switches at the neighboring SONET Node stations. Spanning Tree Protocol enables redundancy such that the failure of any node shall only affect that node’s application traffic. These Ethernet Switches provide network services; most important of these is Quality of Service, which prioritizes the various network traffic to enable high priority emergency traffic to have required available bandwidth.

   b.) In addition to the network ADMs and switches, the Backbone Equipment includes a Storage Area Network for all archived and operational data. The Storage Area Network is made up of Storage Devices sized to store 30 days of archived compressed video data. The Storage Devices are designed to meet the storage and retrieval requirements set in Section 17751, Security and Surveillance Systems Overview. In addition to the storage devices, a removable storage device is provided for storage and retrieval of any CCTV Incident as required.
c.) Section 17510, Communication System Backbone Equipment, describes the requirements for the backbone ADMs and Ethernet switches, as well as the requirements for the Storage Devices.

B. The Backbone is made up of four distinct types of circuits: voice, video, data, and leased circuits.

1. Voice Circuits.

   The Backbone provides adequate and prioritized bandwidth for all voice traffic. This includes high priority circuits for emergency voice traffic (for both ETELs and PETs) and lower priority circuits for non-emergency voice traffic (non-emergency phones at the stations and at the O&M Facility). Emergency phones are IP-based emergency telephones located at Sound Transit Link stations and in the tunnels. Emergency phone traffic is controlled via the Integrated Communications Controller, and is switched via an integrated IP Emergency phone solution. For specific requirements for Emergency Telephones and Passenger Emergency Telephones, see Sections 17360, Emergency Phone System and 17365, Passenger Emergency Telephones. The Integrated Communications Controller requirements are described in Section 17730, Integrated Communications Controller. (Also see Section 17310, PABX, for PABX requirements.)

2. Video Circuits.

   The Backbone provides bandwidth for all operational and archive video data. The design of the CCTV system provides operational data for up to 16 cameras of live feed to the Operations Control Center. It also provides continuous compressed video data from all cameras for storage of the most recent 30 days at a central storage repository located at the O&M Facility. Thus the live feed data must have allocated prioritized bandwidth in order for CCTV operators to view the selected video data real-time at a resolution high enough to distinguish people and movement without skips or pauses in the video. The data for archiving may be at a lower resolution and greater compression rate, and may be sent over the network at a lower priority.

3. Data Circuits.

   The Backbone also provides circuits for data to include clock data, PA/VMS data, FCS data and network maintenance and management data. Clock and FCS data are considered highest priority though they are not expected to take up much bandwidth. In addition to this data, non-emergency operational PA/VMS data is transported over data circuits, as is network management and maintenance data. Section 17540, Data Circuits, addresses data circuit requirements.

4. Leased Circuits.

   The Sound Transit Communication System interfaces with external components via several leased lines connected to the PABX. These leased lines are connected to King County Metro to provide voice communication and services, to Sound Transit to provide connection throughout the Sound Transit organization as well as to provide redundant connections for long distance services, and to local and long distance service providers. Section 17550, Leased Lines, describes the requirements for leased lines.
C. Quality of Service.

Quality of Service (QoS) is critical for operations of the Backbone. Quality of Service defines priority requirements and latency requirements for each type of traffic such that the network will operate properly to allow data to reach the proper applications when needed for all emergency, operations and maintenance purposes. Quality of Service requirements are defined in Section 17560, Quality of Service Requirements.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17500
SECTION 17510
COMMUNICATION SYSTEM BACKBONE EQUIPMENT

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall provide equipment to support Backbone capable of providing data communications for Sound Transit Communications applications to include FCS, PA/VMS, CCTV, timing data, Emergency and Non-emergency phones, and management data. Contractor shall provide equipment capable of both providing adequate bandwidth and adequate quality of service appropriate for each application.

1.02 SECTION INCLUDES

A. This Section consists of requirements relating to the design, furnish and installation of the Backbone Equipment. This Section includes the equipment required to support the Backbone, the network equipment required to interface to the subsystems at the Central Control Center and the stations, and the equipment required to store, archive and retrieve all operational and configuration data.

B. This Section also includes the requirements relating to Storage Devices that allow CCTV controllers to store and retrieve compressed stored video data, and data files. The Storage Area Network shall be designed with additional redundancy for those files specified as critical.

1.03 RELATED SECTIONS

1. Section 17030 – Reliability Management Program.
2. Section 17040 – Technology Documentation.
3. Section 17050 – Configuration Management.
5. Section 17140 – Backbone Cabling Requirements.
7. Section 17520 – Voice Circuits.
8. Section 17530 – Video Circuits.
10. Section 17550 – Leased Lines.
11. Section 17560 – Quality of Service Requirements.
13. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.


15. Section 17730 – Integrated Communications Controller.

16. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS


B. ANSI T1.102-1993 (R1999), Telecommunications - Digital Hierarchy - Electrical Interfaces.

C. ANSI T1.102.01-1996 (R2001), Telecommunications - Digital Hierarchy - VT1.5 Electrical Interface.


E. ANSI T1.105.01-2000, Telecommunications- Synchronous Optical Network (SONET) Automatic Protection Switching.

F. ANSI T1-105.02-2001, Telecommunications- Synchronous Optical Network (SONET)- Payload Mappings.

G. ANSI T1.105.03-1994, Telecommunications -Synchronous Optical Network (SONET)- Jitter at Network Interfaces with supplements 105.03a and 105.03b.


L. ANSI T1.105.08-2001, Directory Service for Telecommunications Management Network (TMN) and Synchronous Optical Network (SONET).

M. ANSI T1.105.09-1996 (R2002), Telecommunications-Synchronous Optical Network (SONET)- timing and Synchronization.

N. ANSI T1.106 and ANSI T1.117-1991 (R1997), Digital Hierarchy Optical Interface Specifications (Short Reach).
O. ANSI/EIA/TIA-232, Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

P. ANSI/TIA/EIA-310-D, Cabinets, Racks, Panels, and Associated Equipment.


R. IEEE 802.1p, Local and Metropolitan Area Networks (Prioritization).

S. IEEE 802.1Q, Local and Metropolitan Area Networks (VLAN Tagging).

T. IEEE 802.3, Local and Metropolitan Area Networks.

U. IEEE 802.17, Resilient Packet Rings.


BB. Telcordia GR-1042-CORE, Generic Requirements for Operations Interfaces Using OSI Tools - Information Model Overview: Synchronous Optical Network (SONET) Transport Information Model.


DD. Telcordia TR-NWT-000418, Generic Reliability Assurance Requirements for Fiber Optic Transport Systems.

EE. Telcordia TR-NWT-00496, SONET Add-Drop Multiplex Equipment (SONET ADM) Generic Criteria.


GG. NFPA 72 National Fire Alarm Code.
1.05 QUALITY CONTROL

A. Manufacturer Qualifications.

Contractor shall submit the proposed manufacturer of the backbone optical multiplexer equipment for Engineer's approval. Acceptability of the manufacturer will be based on the manufacturer's experience and the following data:

1. Reliability of equipment as measured against Bellcore TR-NWT-000418, Generic Reliability Assurance Requirements for Fiber Optic Transport Systems.

2. Compatibility with other standards compliant equipment.

3. Technology and capability of the proposed equipment.

4. Contractor's design and installation shall comply with all applicable Standards and Codes as listed herein.

B. All equipment furnished under this Section shall be UL listed.

C. All grounding shall be in accordance with local standards, and specification Section 16060, except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.

1.06 SUBMITTALS

A. Preliminary Design Review.

1. Contractor shall submit the following prior to the PDR:

a.) A functional block diagram of the entire Backbone Equipment.

b.) Preliminary optical loss calculations for each span of the Backbone respectively. Calculations shall show the total anticipated optical loss in dB between locations and the gain margin in dB above the level required for the BER performance specified herein.

c.) Typical layouts for the Central Communications Equipment Room and Fiber optic Nodes.

d.) Rack layouts for each location.

e.) Cross-Connect Details for each location.

f.) DACS configuration showing mapping of DS0 channels from input to output.

g.) Detailed functional description.

h.) Site Work Plans for Work to be conducted at existing locations.
i.) Manufacturers data sheets and other descriptive information sufficient to determine compliance with these Specifications for the following equipment:

1.) SONET OC-12 Add Drop Multiplexers.

2.) CCER Network Switches.

3.) Station Network Switches.

4.) Digital Access Cross Connect (DACS).

5.) T-1 Optical Modem.

6.) Storage Devices/Storage Area Network.

B. Final Design Review.

1. Contractor shall submit the following prior to the FDR:

   a.) Assembly drawings, installation drawings, and parts list.

   b.) Factory test procedures.

   c.) Installation and test procedures.

   d.) Final optical loss calculations for each span of the Backbone respectively. Calculations shall provide final figures for calculations initially submitted in the PDR.

C. Test Procedures and Results.

1. Contractor shall submit draft and final plan and procedures for performing the factory and field tests required as described in Part 3 of this Section. Submitted Test Plans and Procedures shall follow the specifications in Sections 01450, Systems Quality Requirements and 17030, Reliability Management Program.

2. Contractor shall submit complete test results after completing each test, according to the schedule guidelines set in the Contract.

1.07 DELIVERABLES

In addition to the Submittals described above, Contractor shall deliver fully functioning Backbone Equipment in accordance with these specifications, as well as user and maintenance documentation supporting the delivered Backbone Equipment. Included with this equipment is the highly reliable storage equipment required to store and retrieve all designated video data.
PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall supply the hardware and firmware required to provide highly available communications between Sound Transit station facilities and the Central Control System. This backbone shall be the primary communications backbone for all Operations-related voice, data and video traffic.

B. Backbone Network Equipment shall be sized such that the maximum peak anticipated bandwidth required in 2020 shall not exceed 30 percent of the rated capacity of the Network and of the Network Equipment. The bandwidth required in 2020 shall be extrapolated from the anticipated system expansion described in the Link Environmental Impact Statement. Contractor shall design the Communications System Backbone Equipment such that it can be easily upgraded to accommodate future increased bandwidth requirements, such as moving from OC-12 to OC-48.

C. The storage equipment shall be sized such that the maximum anticipated saved video data in 2020 shall not exceed 60 percent of the storage capacity of the system.

2.02 EQUIPMENT RELIABILITY

The backbone shall be designed for the highest reasonable availability per IEC 61508 (SIL 2) and/or NEBS Level Three. Overall system shall be rate by MIL-STD-882D. This includes designing redundancy and sparing (hot-swappable where possible), selecting high MTBF equipment, implementing Quality of Service techniques, implementing IEEE 802.17 RPR, and designing the system for maximum maintainability.

2.03 SONET ADD-DROP MULTIPLEXERS

A. Configuration.

1. The Fiber Optic multiplexing equipment shall include OC-12 Add/Drop Ring nodes with internal multiplexing facilities at select Sound Transit stations according to the Contract drawings, and as follows.

   a.) The following stations shall include OC-12 Add/Drop Ring nodes:

      1.) Westlake Station

      2.) University Station.

      3.) Pioneer Square.

      4.) International District Station.

      5.) Beacon Hill.

      6.) McClellan.
7.) S. 154th Street.

b.) These node multiplexers shall provide interfaces to the OC-12 Backbone Network and to the Station Network Switches at OC-12 data rates.

2. The following stations are considered 'Small Nodes'. They shall be connected to neighboring stations via Ethernet Switches equipped with Spanning Tree Protocol (STP) functionality. Each functional network (e.g. OSN, TVM, and CSN) shall have its own Ethernet Switch that connects to the corresponding application switch at the neighboring station. The following stations shall have this configuration. See Contract Drawings for additional description of this configuration.

a.) Lander Station.

b.) Edmunds Station.

c.) Othello Station.

d.) Henderson Street.

3. CCER/OCC

The Central Communications Equipment Room shall connect to the Backbone Equipment via an OC-12 node ADM with the following interfaces, at a minimum.

a.) One 10BaseT Interface for the OS Network Connection.

b.) One 10BaseT Interface for the Fare Collection Hub and Fare Collection Equipment.

4. OC-12 SONET ADMs shall be able to identify the DS1 circuits within the OC-12 digital bitstream and "drop" or "insert" DS1 circuits associated with the site.

5. Fiber distribution panels at each end of each link shall permit the appropriate optical fibers to be terminated.

6. SONET ADMs shall have primary and redundant power feeds, connected to -48 VDC power supply redundant bus fuse panels. The fuse panels shall be serviced from redundant load sharing -48 VDC power supplies using a dual breaker feed.

7. SONET ADMs shall provide sectionalized protection for a service fiber span. Transfer of the fiber optic traffic from a faulted service fiber path to the protection fiber path shall be automatic.

8. An ADM shall have the capability of being added to or deleted from a ring, without causing more than one protection switch activation for the addition or deletion of the ADM.
B. Optical Interface Requirements.

1. OC-12 line rate: 622.080 Mbps.
3. Bit error rate (BER): <10^-9
4. Line code: Scrambled NRZ.
6. Optical transmitters: InGaAsP Laser, MLM or SLM Structure.
7. Optical receivers: InGaAsP PIN.
8. Protection: Two-way loop configuration with automatic network reconfiguration.
9. Restoration of service: 60 ms.

C. OC-12 Low Speed Interface Requirements. All OC-12 SONET ADMs shall have the following low speed/DS-1 interface requirements:

1. Number of DS1s: Capable of 336 per OC-12 multiplexer shelf.
2. Line code: User selectable to be bipolar 8 zero substitution (B8ZS) or alternate mark inversion (AMI).
3. Line impedance: 100 ohms +5 percent, balanced.

D. Network Synchronization.

1. All SONET network elements shall be integrated into the synchronization hierarchy as described and specified in ANSI T1.101.
2. All other SONET ADMs shall be loop timed off the Stratum 1 local oscillator at the OCC, as per the Section 17740, Master Clock System.

E. Operations and Maintenance Requirements.

1. Alarms and indications:
   a.) SONET ADM shelves shall have face plate LEDs to indicate an alarm or failure condition.
   b.) SONET contact closure alarms (major, minor, critical and power alarms) shall be provided locally at the equipment location to the associated Control System PLC. Alarm contact ratings sufficient to interface to the local Control System PLC’s sensing circuit. Alarms shall indicate the following conditions:
1.) Critical alarm: service affecting; thresholds are user selectable via a software command.

2.) Major alarm: one or more lines out of service.

3.) Minor alarm: a potential loss of service or maintainability.

4.) Power alarm: one or both -48 VDC fuse panel feed failures.

c.) Failure States. Failure states shall include Loss of Signal (LOS), Loss of Frame (LOF), Loss of Pointer (LOP), Loss of Synchronization, and equipment failures. As a minimum, equipment failures to be detected shall be:

1.) Fuse or power circuit failures.
   - Synchronization equipment failure.
   - Protection switching equipment failure.
   - CPU failure.
   - Local nonvolatile backup memory failure.
   - OC-12 termination equipment failure (optical detector and light source).

2. Maintenance and Control.

a.) Any SONET ADM shall provide remote access capability to all SONET nodes.

b.) SONET ADMs shall have a user panel permitting interaction with the system using push buttons and LED displays, without the need for a terminal or computer interface. The user panel shall permit the user to read system alarms and status, and execute basic system control functions, at the multiplexer or at any remote multiplexer on the ring interconnected via a SONET Data Communications Channel (DCC).

c.) SONET ADMs shall have two EIA-232-E interface ports for specialized maintenance and administrative activities. A front access port shall be configured as a data circuit-terminating equipment (DCE) for direct terminal access. A rear access port shall be configured as data terminal equipment (DTE) to allow a permanent modem connection without requiring a null modem.

d.) Installation and distribution of updated software to other nodes over the SONET network (in service) shall be possible by a laptop computer located at any node.

e.) SONET ADMs shall be manageable by the Network Management System, as specified in Section 17910, Cable Plant Spares and Special Tools.
3. Other Operations and Maintenance Requirements.

   a.) SONET ADMs shall provide built in test signal generation, such that no external test equipment or terminal is needed for routine installation, start-up, or repair.

   b.) SONET ADMs shall continuously monitor all facilities connected to it and report alarmed conditions as they occur and as they clear (i.e., when maintenance and service limits are exceeded and when they return to normal).

   c.) The basic software for SONET ADMs shall include the following maintenance and operations capabilities.

      1.) Local alarms.

      2.) Local protection switching.

4. Local diagnostics.

5. Signal monitoring.

6. Maintenance history.

F. All external connections shall be made by means of connectors attached to a wiring harness or cable. The connectors shall be keyed to preclude improper hookups. All wires to and from the connectors shall be color-coded and/or appropriately marked. All necessary connectors, cable harnesses and accessories shall be provided with the equipment.

G. Identification and Labeling.

SONET ADMs shall be uniquely identifiable in Common Language Equipment Identification (CLEI) code. Every circuit pack shall be identifiable with a CLEI code, a bar code, and a functional designation.

H. Vendor.

SONET OC-12 ADM requirements may be met by Nortel Optiplex Metro 3500 or equal product identified by Contractor and approved by Engineer. The Ethernet switches that are used at the stations for OSN, TVM and CSN may be Garrettcom switched, or approved equal.

2.04 CENTRAL COMMUNICATIONS SWITCH

A. Contractor shall provide a single NEBS Level 3 switch at the CCER with a minimum of 64 Gbits per second switching throughput and (48) 100 BaseT/F connections to connect from the Communications Backbone ADM and the CCER subsystem equipment. Switch shall be a Riverstone RS-8600 or approved equal.
B. The Central Communications Switch shall support the following:

1. QoS (comply with IEEE 802.1u).
2. Security access control on a per-port basis.
3. Support user authentication and data encryption.
4. Support the following protocols.
   a.) SNMP v3.
   b.) TCP/IP.
   c.) Telnet.
   d.) TFTP.

C. The Central Communications Switch shall support IPv6 and Resilient Packet Ring (RPR).

D. The Central Communications Switch shall be manageable and configurable per the requirements set in Section 17910, Communications Network Management. This includes the following requirements.

1. Switch configuration shall be downloadable from the System Manager console.
2. Switch shall have the capability of upgrading version of software through standard TCP/IP protocol-like TFTP, and shall use flash memory for image storage.
3. Switch shall support spanning tree algorithm.
4. Switch shall support debugging and diagnostics from Telnet and out-of-band terminals.
5. Switch shall support the capability of local configuration through a serial port.
6. Switch management software shall display all routing tables.
7. Switch management software shall display ARP cache.
8. Switch management software shall display traffic statistics.

E. The Central Communications Switch shall support the following routing protocol requirements:

1. Switch shall support the Routing Information Protocol (RIP) including support for Split Horizon with Poisoned Reverse.
2. Switch shall support Open Shortest Path First (OSPF) Version 2 routing protocol.
3. Switch shall support static routes.
4. Switch shall be configurable to support forwarding of Bootstrap Protocol (BOOTP) packets.

5. Switch shall be configurable to support or not support Proxy ARP on an interface-by-interface basis.

6. Switch shall support Point-to-Point Protocol (PPP) for IP communication over serial links for both synchronous and asynchronous links.

7. Switch shall be configurable to have more than one simultaneous IP subnet number per Ethernet interface.

F. Backplane and any other common bus shall have an MTBF of at least 150,000 hours.

G. Redundancy shall be provided and configured for all types of cards and power supplies such that the switch shall automatically recover from any card or power supply failure.

H. Each module of the central switch including the management and controller modules shall be hot swappable.

I. Central Communications Switch shall have visual indicators for the following:

1. Power is on.

2. For each communications port.
   a.) Link is established and cables are connected.
   b.) Data is detected.

2.05 STATION NETWORK SWITCH

A. Each station shall have a network switch that connects the Backbone ADM with the station subsystem equipment.

B. Contractor shall provide a Station Network Switch with the following minimum features.

1. Station Network Switch shall support forwarding speeds of up to 400 kpps and a backplane bandwidth of 16 GB.

2. Station Network Switch shall include a minimum of 48 10 BaseT connections and one OC-12.

3. QoS (comply with IEEE 802.1u).

4. Security access control on a per-port basis.

5. Support user authentication and data encryption.

6. Support the following protocols:
7. Station Network switch shall support at a minimum Fast Ethernet and Gigabit Ethernet.

8. Station Network Switch shall include Multi-protocol support.

9. Station Network Switch shall be Scalable and Re-deployable.

C. Above requirements may be met by Riverstone RS-3000 or equal product identified by Contractor and approved by Engineer.

PART 3 - EXECUTION

3.01 GENERAL

This Section describes the preparation, testing, installation and acceptance of the Communication System Backbone Equipment.

3.02 PREPARATION

Engineer will schedule design reviews with Contractor. The design reviews shall encompass Contractor submittals for the Preliminary and Final Design.

3.03 FACTORY TESTING

A. SONET Backbone Equipment.

Factory testing shall be performed after all wiring is complete within each rack.


Contractor shall temporarily connect the optical multiplexers from each pair of adjacent nodes and perform the following tests:

a.) Verify BER and margin in Optical signal.

b.) Verify BER in each DS-1.

c.) Verify BER in data channels.

d.) Verify voice channel continuity.
2. Alarms.

With full power to the Backbone Equipment rack, Contractor shall perform the following tests:

a.) Verify optical switching from main to standby connections.

b.) Verify DS-1 input switching.

c.) Verify major and minor alarms operation.

B. Storage Devices.

1. Contractor shall verify in the factory the capability of storing, archiving, querying and retrieving the various types of operational data to include video, voice, operational data (e.g. alarms, logs), user data, and configuration data.

2. Contractor shall verify in the factory the capability of storing to CD (or approved removable media) video data.

3.04 DELIVERY, STORAGE AND HANDLING

Contractor shall be responsible for delivery, storage and handling of all equipment.

3.05 INSTALLATION

A. Factory Installation.

1. Contractor shall mount all equipment within cabinets and racks.

2. Contractor shall label all connections.

   a.) Contractor shall transfer labels to as-builts.

   b.) Contractor shall label all circuit cards.

3. Contractor shall dress all cross-connections with dielectric cable ties.

B. Field Installation.

1. Equipment may be installed in cabinets and racks prior to shipment.

   a.) Cabinets shall be installed and securely bolted to the floor.

   b.) Cabling shall be secured to racks and cable trays.
2. Equipment in Communications Equipment Rooms.

   a.) Contractor shall inspect power, ground, cable entrances, cable trays and other facilities and report any deficiencies to Engineer.

   b.) Contractor shall bolt all cabinets to the floor in the approved arrangement.

   c.) Contractor shall install all cables and secure to trays and cabinets with dielectric ties.

3. All cables shall be routed in cable tray between racks.

3.06 FIELD TESTING

A. Backbone Equipment.

1. Phased Tests. Field testing shall be performed in coordination with installation. Field testing shall be performed in a phased approach grouped by station nodes to ensure each node operates according to these Specifications. This phased approach shall be described in the Test Plan and Test Procedures for this subsystem.


   a.) Contractor shall verify that office battery has been applied to the shelves.

   b.) Contractor shall check all ADM module switch settings.

   c.) Contractor shall test ADM with OC-12 looped back as applicable.

   d.) Contractor shall test end-to-end OC-12 ADM UPSR setup as applicable.

   e.) Contractor shall test all DS1 transmission paths.


   a.) BER and optical margin, for the normal and standby transmitters and receivers shall be measured.

   b.) BER in DS1 channels, with normal and standby interfaces shall be measured.

   c.) BER in data channels shall be measured, end-to-end and with remote end loop back.

   d.) Transmission levels in voice channels shall be set and recorded.

4. Functional Verification.

   a.) Alarms shall be forced to verify proper operation of LEDs and output contacts.
b.) Protection Switching shall be forced for all optical interfaces, high-speed multiplexer sections and low speed inputs.

c.) Remote diagnostic capabilities shall be verified.

B. Network Storage Capability.

Contractor shall verify storage, query and retrieval capability of all Operations data as specified in this Section, at all Control Centers and at each station.

PART 4 - MEASUREMENT AND PAYMENT

4.01 SUMMARY

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17510
PART 1 - GENERAL

1.01 OVERVIEW

A. This Section describes the Voice Circuits within the Backbone that provide voice communications throughout the Sound Transit Communications Systems. Specifically Voice Circuits include standard IP phone circuits at the stations and emergency phone circuits at the stations and central locations. Circuits that include Public Address are described in Section 17540, Data Circuits. Radio circuits are described in Section 17400, Radio System Overview.

B. Qualities of Service considerations are critical to the success of Voice over IP (VoIP) applications. Packets must be delivered and assembled immediately and without significant error or dropped packets in order for real-time conversations to be understandable. Quality of Service is addressed in Section 17560, Quality of Service Requirements.

1.02 SECTION INCLUDES

This Section includes a description and specification of the voice circuits throughout the Sound Transit Communications Systems. Specific priority and quality of service specifications are described in Section 17560, Quality of Service Requirements.

1.03 RELATED SECTIONS

A. Section 16120 – Electrical Wires and Cables.

B. Section 16610 – Static Uninterruptible Power Supply.

C. Section 17030 – Reliability Management Program.

D. Section 17040 – Technology Documentation.

E. Section 17050 – Configuration Management.

F. Section 17140 – Backbone Cabling Requirements.

G. Section 17150 – Facility Cabling Requirements.

H. Section 17310 – PABX.

I. Section 17320 – Telephone Sets.

J. Section 17330 – Voice Mail System.

K. Section 17360 – Emergency Phone System.

L. Section 17365 – Passenger Emergency Telephones.
M. Section 17510 – Communication System Backbone Equipment.

N. Section 17530 – Video Circuits.

O. Section 17540 – Data Circuits.

P. Section 17550 – Leased Lines.

Q. Section 17560 – Quality of Service Requirements.

R. Section 17570 – WAS System Testing, Identification and Administration.

S. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.

T. Section 17590 – Cable Transmission System/WAN Support and Warranty.

U. Section 17730 – Integrated Communications Controller.

V. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. The following References shall be adhered to in the performance of this Section:

1. IEEE 802 Local and Metropolitan Area Networks.


5. TIA/EIA/IS-811 Performance and Interoperability Requirements for Voice-over IP (VoIP) Feature Telephones.

1.05 VOICE CIRCUIT COMPONENTS

A. The Sound Transit Voice Circuits are made up of emergency voice circuits for ETELs and PETs, and non-emergency voice circuits for non-emergency station phones.

B. For all Voice Circuits, Contractor shall provide appropriate bandwidth, priority, and circuit features (e.g. priority, dejitter buffering, Type of Service (ToS), Weighted Fair Queuing (WFO), Random Early Detection (RED), Weighted RED (WRED), Resource Reservation Protocol (RSVP), and any other features recommended by Contractor and approved by Engineer) to provide toll quality voice for all operational phones.

C. Contractor shall verify all IP voice circuits have a Mean Opinion Score between four and five.

D. Contractor shall verify for all Voice Circuits that transmission/delivery delay for all IP voice circuits is below 150 milliseconds. This delay requirement includes Propagation Delay (the time it takes the packets to be transmitted over the physical link), Serialization Delay (the time
it takes to place bits from the transmission buffer to the transmission media), Processing Delay (the time it takes to code, compress, decompress and decode the voice data; this depends on the algorithm used), and any variable delays such as queuing delays.

E. Contractor shall simulate voice circuits during design phase and shall present Engineer with IP voice quality samples of the proposed design for Engineer approval before implementation.

F. Contractor shall allocate appropriate bandwidth for all voice circuits, and shall prioritize the voice circuits as follows:

1. Emergency Voice Circuits.

   a.) Contractor shall ensure appropriate bandwidth is allocated for ETELs and PETs.

   b.) Contractor shall provide approximately 10.112 Mbps for ETELs and approximately 3.2 Mbps for PETs. Contractor shall provide updated capacity and bandwidth analysis to Engineer for approval, as part of voice circuit design, based on final number of phones and anticipated bandwidth.

   c.) Contractor shall design voice circuits and overall network to ensure ETEL and PET voice traffic has the highest priority over the network, from end to end. Contractor shall also use error detection and correction techniques to ensure ETEL and PET traffic is highly accurate (to the MOS requirements stated above).


   a.) Contractor shall ensure appropriate bandwidth is allocated for non-emergency station and wayside phones.

   b.) Contractor shall provide approximately 6.748 Mbps for non-emergency station and wayside phones. Contractor shall provide updated capacity and bandwidth analysis to Engineer for approval, as part of voice circuit design.

   c.) Contractor shall design voice circuits and overall network to ensure non-emergency voice traffic has appropriate priority in order to meet the delay and accuracy requirements described earlier in this Section.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17520
SECTION 17530
VIDEO CIRCUITS

PART 1 - GENERAL

1.01 OVERVIEW

A. This Section describes the Video Circuits within the Backbone that provide video recorded at the stations and throughout the system to central for viewing and archiving. Video Circuits include both those circuits that provide live video feed to the OCC and those circuits that provide stored video to the devices located in the CCER.

B. Appropriate bandwidth and priority allocation is critical in order for video to be able to be viewed real-time, without delays, skips, and lost feed. Therefore the Video Circuits must be appropriately sized and allocated to accommodate the expected video volume, without wasting bandwidth that is needed for other systems. Additionally, Video Circuits must be monitored such that any dropped video feeds are detected and alarmed, and lost video is minimized.

1.02 SECTION INCLUDES

This Section includes a description and specification of the Video Circuits throughout the Sound Transit Communications system. Specific priority and quality of service specifications are described in Section 17560, Quality of Service Requirements.

1.03 RELATED SECTIONS

A. Section 16120 – Electrical Wires and Cables.

B. Section 17030 – Reliability Management Program.

C. Section 17040 – Technology Documentation.

D. Section 17050 – Configuration Management.

E. Section 17140 – Backbone Cabling Requirements.

F. Section 17150 – Facility Cabling Requirements.

G. Section 17510 – Communication System Backbone Equipment.

H. Section 17520 – Voice Circuits.

I. Section 17560 – Quality of Service Requirements.

J. Section 17570 – WAN System Testing, Identification and Administration.

K. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.

L. Section 17590 – Cable Transmission System/WAN Support and Warranty.
M. Section 17730 – Integrated Communications Controller.

N. Section 17751 – CCTV.

O. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. The following References shall be adhered to in the performance of this Section:

1. IEEE 802. Local and Metropolitan Area Networks.


1.05 VIDEO CIRCUIT COMPONENTS

A. Sound Transit Communication Video Circuits are comprised of two main categories: live video feed from selected cameras viewed at the OCC, and stored video feed collected from all cameras and stored at the central storage devices.

1. Live Operational Video Feed.

a.) The Sound Transit Communication System video circuit shall provide live video from Sound Transit station and central cameras to the central CCTV system for viewing by Sound Transit Communications operators. Operators may select up to 16 cameras to view simultaneously. In certain instances such as a Ticket Vending Machine intrusion alarm, or a Passenger Emergency Phone off-hook alarm, the CCS system will alarm the operator, and that operator may select the alarmed video feed on the CCTV display, as one of the 16 video feeds.

b.) Contractor shall provide a video circuit to accommodate up to 16 camera feeds, originating from anywhere in the system over the backbone network.

c.) The circuit shall be sized and prioritized such that each video feed shall be viewed with a maximum of 200 ms of delay from when it was recorded and sent.

d.) The video circuit shall be appropriately sized to allow real-time video with minimal dropped frames and maximum quality.

e.) Bandwidth Allocation.

1.) Up to 100 Mbps shall be allocated for live video feed.

2.) Assuming 16 video feeds, using MPEG 4 technology at 750 kbps and full frame (30 frames per second), 12 Mbps would be needed to transmit live video feed. Contractor shall develop a video circuit solution based on the requirements.
specified in this Section and in Section 17751,CCTV, and shall submit the solution design to Engineer for approval.

3.) Specifically, Contractor shall present the video quality (frames per second, compression technology used, expected quality with peak network congestion) to Engineer for approval, as part of the CCTV design submittals. Part of this submittal shall include a demonstration of the video given this design. The goal shall be for Contractor to provide video circuits such that the video displayed meets the latency requirements, has no dropped frames due to network congestion, and is of a quality such that people can be seen and identified, train numbers can be identified, and incidents can be viewed. Engineer shall provide the final approval for video quality based on video circuits provided.

2. Transport of Storage Video.

a.) The Sound Transit Communication Video Circuit shall also accommodate video traffic for storage at OCC.

b.) While this video is not considered high priority data, bandwidth shall be adequate to accommodate this steady stream of data with no backlog.

c.) This data shall be compressed at a minimum of one frame per second (one tenth of full frame) using MPEG 4 compression, or Engineer-approved equal compression technology.

d.) Bandwidth allocation.

  1.) Single shared OC.3 shall be allocated for video traffic.

  2.) No more than 65.888 Mbps shall be allocated for archive data.

  3.) Contractor shall provide a recommendation to Engineer for approval before developing the final video circuit design as part of the CCTV design submittals. Contractor’s complete analysis shall be provided to Engineer along with Contractor’s recommendation.

  4.) Assuming MPEG 4 compression with a nominal video data rate of 750 kbps at full frame (30 frames per second), and assuming approximately 250 cameras, 6.25 Mbps minimum bandwidth would be required for stored data.

  5.) Contractor shall provide Engineer with several video quality options and a recommended solution for approval before final design of the CCTV system and of the video circuits.

PART 2 - PRODUCTS

Not Used.
PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17530
PART 1 - GENERAL

1.01 OVERVIEW

A. This Section describes the Data Circuits within the Backbone that provide all non-voice, non-video data. Data Circuits provide communications for Timing Data, FCS Data, PA/VMS Data and Maintenance and Management Data.

B. Implementation of VLANs and Quality of Service, as well as appropriate allocation of bandwidth is critical to segment and prioritize the various types of data traffic to provide each application with the data it requires in order to operate successfully.

1.02 SECTION INCLUDES

This Section includes a description and specification of the data circuits throughout the Sound Transit Communications System. Specific priority and quality of service specifications are described in Section 17560, Quality of Service Requirements.

1.03 RELATED SECTIONS

A. Section 16120 – Electrical Wires and Cables.
B. Section 17030 – Reliability Management Program.
C. Section 17040 – Technology Documentation.
D. Section 17050 – Configuration Management.
E. Section 17140 – Backbone Cabling Requirements.
F. Section 17150 – Facility Cabling Requirements.
G. Section 17510 – Communication System Backbone Equipment
H. Section 17520 – Voice Circuits.
I. Section 17530 – Video Circuits.
J. Section 17550 – Leased Lines.
K. Section 17560 – Quality of Service Requirements.
L. Section 17570 – WAN System Testing, Identification and Administration.
M. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.
N. Section 17590 – Cable Transmission System/WAN Support and Warranty.
O. Section 17710 – Public Address System.

P. Section 17720 – Variable Message Signs.

Q. Section 17730 – Integrated Communications Controller.

R. Section 17740 – Master Clock System.

S. Section 17801 – Control System Network.

T. Section 17802 – Field Control System.

U. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. The following References shall be adhered to in the performance of this Section:

1. IEEE 802 Local and Metropolitan Area Networks.


1.05 DATA CIRCUIT COMPONENTS

A. The Data Circuits in this Section are those circuits over the Backbone. They include the timing, FCS, PA/VMS, and maintenance and management data.

1. Timing Data.

   a.) Contractor shall provide high priority data circuits as part of Backbone for timing data. It is critical that this traffic be transported real-time with the highest priority and data integrity, as timing data is used by all systems to provide timing and synchronization.

   b.) The timing data is quite small, but must take highest priority such that when the backbone is fully loaded the timing and synchronous data shall always have bandwidth allocated to it.

   c.) Contractor shall allocate a maximum of 1 Mbps for timing data. It is expected that the actual timing data bandwidth will be smaller than this.

   d.) Contractor shall implement timing data circuits such that the maximum delay incurred by the communications path is 0.01 second.

   e.) Contractor shall configure the backbone such that timing data is Priority 1 (see Section 17560, Quality of Service Requirements, for descriptions of priority levels).
2. FCS Data.

   a.) Contractor shall provide data circuits allocated for Field Control System data. FCS data that goes over the backbone network consists of signal processor data, bus detection data, and Lonworks data.

   b.) Contractor may allocate up to 34.3 Mbps for FCS data.

   c.) Current design of FCS Data requires approximately 5.555 Mbps bandwidth. Contractor shall ensure the data circuits shall be designed to provide highly reliable, available, and accurate communications for FCS data.

   d.) Contractor shall implement FCS data circuits such that the maximum delay incurred by the communications path is 0.01 second.

   e.) Contractor shall configure the backbone such that FCS Data is Priority 1 (see Section 17560, Quality of Service Requirements, for descriptions of priority levels).

3. PA/VMS Data.

   a.) Contractor shall allocate 3.2 Mbps for Public Address and Visual Message System data.

   b.) Contractor shall implement PA/VMS data circuits such that the maximum delay incurred by the communications path is 0.03 seconds.

   c.) Contractor shall configure the backbone such that PA/VMS data is Priority 3 (see Section 17560, Quality of Service Requirements, for descriptions of priority levels).

4. Maintenance and Management Data.

   a.) Contractor shall allocate bandwidth for network management and maintenance. This includes all network status messages (e.g. pings, status updates), as well as remote commands and configuration that occurs over the backbone to station switches and network devices.

   b.) Contractor shall allocate one Mbps for maintenance and management data circuits. It is expected that the actual maintenance and management data bandwidth will be smaller than this.

   c.) Contractor shall implement maintenance and management circuits such that the maximum delay incurred by the communications path is 0.03 seconds.

   d.) Contractor shall configure the Backbone such that maintenance and management data is Priority 3 (see Section 17560, Quality of Service Requirements, for descriptions of priority levels).
PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17540
SECTION 17550
LEASED LINES

PART 1 - GENERAL

1.01 OVERVIEW

A. This Section describes the Leased Lines required to interface the Sound Transit Communications System with external organizations, specifically Sound Transit IT, King County Metro, and local and long distance service providers.

B. Contractor shall coordinate with Sound Transit and local telephone service providers to establish the following leased lines for the Communications System:

1. Connection to ST at Union Station – T-1 (voice) plus 10Mb (data).
2. Connection to KCM (location TBD) – T-1 (voice) plus 10Mb (data).
4. Approximately 6 DID lines to Qwest.

C. Contractor shall perform the following to support Sound Transit in the negotiation of leased line agreements:

1. Determine and specify the technical characteristic of the leased lines to be compatible with the Communications System.
2. Recommend the level of service to be provided for each leased line. The acceptable downtime for any failed lease line shall be less than 24 hours.
3. Specify the Meet Point requirements for each leased line.
4. Identify potential competitive local exchanges (CLEC).

D. Once service agreements are in place, Contractor shall coordinate with telephone service providers for the installation and testing of the leased lines. The Contractor shall complete the installation from the point-of-presence to the Communications System and shall perform full end-to-end testing.

1.02 SECTION INCLUDES

This Section includes a description and specification of the leased lines required for the Communications Systems.

1.03 RELATED SECTIONS

A. Section 16120 – Electrical Wires and Cables.

B. Section 17030 – Reliability Management Program.
C. Section 17040 – Technology Documentation.

D. Section 17050 – Configuration Management.

E. Section 17080 – System Support.

F. Section 17140 – Backbone Cabling Requirements.

G. Section 17150 – Facility Cabling Requirements.

H. Section 17310 – PABX.

I. Section 17510 – Communication System Backbone Equipment.

J. Section 17520 – Voice Circuits.

K. Section 17540 – Data Circuits.

L. Section 17560 – Quality of Service Requirements.

M. Section 17570 – WAN System Testing, Identification and Administration.

N. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.

O. Section 17590 – Cable Transmission System/WAN Support and Warranty.

P. Section 17730 – Integrated Communications Controller.

Q. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:


4. ADA Americans with Disabilities Act.

1.05 QUALITY CONTROL

Quality Control is as specified in this document. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations.

1.06 SUBMITTALS

A. Contractor shall submit a document for Resident Engineer approval describing the requirements and recommendations for the various leased lines to include the following
information. Contractor shall specify those specifications that are required for the leased lines to operate with the Communications System, and those specifications that are recommended.

1. Technical characteristic requirements and recommendations.

2. Level of service requirements and recommendations for each leased line.

3. Meet Point requirements.

4. Potential CLECs, along with any information or recommendation that would distinguish one carrier from another.

5. Contractor shall submit copies of all leased line agreements.


7. Contractor shall submit all leased line Test Plans and Procedures.

8. Contractor shall submit As-Built documentation after final installation and test of the leased lines.

1.07 DELIVERABLES

Contractor shall deliver all leased line agreements and shall ensure successful installation and operation of all leased lines described in this Section.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Contractor shall be responsible for the full installation of all leased lines that meet the requirements specified here and in the Contractor’s study. Contractor shall be responsible for installation from point-of-presence to the Communications System PABX.

B. Contractor shall ensure lease agreements meet the requirements specified here and in the Contractor’s study.

3.02 FIELD TESTING

A. Contractor shall perform full end-to-end testing of all leased lines. Contractor shall verify the following as part of the end-to-end testing:

1. Trunk connection with Sound Transit IT is in place, with all required features and services.

2. PABX is properly configured for all interface features and interfaces for all leased lines.
3. KC Metro leased line is in place; calls can be transferred back and forth and users can extension-dial from the Sound Transit Communications operational system to King County operational system.

4. Long distance service leased lines are in place and long distance service agreements are in place.

5. Local service (Qwest) leased lines are in place and local service agreements are in place.

B. Contractor shall submit all test results and copies of all agreements to Resident Engineer for approval.

PART 4 - MEASUREMENT AND PAYMENT

4.01 SUMMARY

Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the bid schedule, or incidental to the work.

END OF SECTION 17550
PART 1 - GENERAL

1.01 OVERVIEW

Quality of Service (QoS) shall be implemented into the Backbone Equipment in order to provide secure, predictable, measurable and guaranteed services to operational applications by managing delay, delay variation (jitter), bandwidth and packet loss in the Communications Network.

1.02 SECTION INCLUDES

This Section includes the requirements for designing, developing, implementing and testing Quality of Service in the Communications Backbone Equipment.

1.03 RELATED SECTIONS

A. Section 16120 – Electrical Wires and Cables.
B. Section 16610 – Static Uninterruptible Power Supplies.
C. Section 17000 – General Communications Requirements.
D. Section 17030 – Reliability Management Program.
E. Section 17040 – Technology Documentation.
F. Section 17050 – Configuration Management.
G. Section 17080 – System Support.
H. Section 17310 – PABX.
I. Section 17320 – Telephone Sets.
J. Section 17360 – Emergency Phone System.
K. Section 17365 – Passenger Emergency Telephones.
L. Section 17510 – Communication System Backbone Equipment.
M. Section 17520 – Voice Circuits.
N. Section 17530 – Video Circuits.
O. Section 17540 – Data Circuits.
P. Section 17550 – Leased Lines.
Q. Section 17570 – WAN System Testing, Identification and Administration.
R. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.
S. Section 17590 – Cable Transmission System/WAN Support and Warranty.
T. Section 17730 – Integrated Communications Controller.
U. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

NFPA 70 National Electric Code.

1.05 QUALITY CONTROL

As specified in this document, equipment installation shall conform to all applicable National Electrical Code, and local regulations.

1.06 SUBMITTALS

A. Contractor shall submit the following prior to the Preliminary Design Review:

1. Description of the Quality of Service implementation, identifying all types of data, estimated bandwidth, priority, latency requirements, and scheme or method of implementing Quality of Service plan.

2. Description of all software or tools required to implement Quality of Service, as well as description of how software and tools will be configured.

3. Identification of all equipment interfaces where QoS will be implemented.

B. Contractor shall submit the following prior to the Final Design Review:

1. Final detailed QoS Implementation Plan.

2. Final list and specifications of all software, tools and configurations required to implement the QoS Plan.

3. Deliverables.

4. In addition to Submittals described above, Contractor shall deliver a Communications and Control System that implements the Quality of Service requirements detailed in this Section over all devices in these Specifications.

PART 2 - PRODUCTS

Not Used.
PART 3 - EXECUTION

3.01 GENERAL

A. Contractor shall implement Quality of Service for the various types of data over the Backbone.

B. Contractor shall provide end-to-end QoS. Contractor shall submit for Resident Engineer approval all devices that do not meet QoS requirements, and shall demonstrate how Quality of Service requirements will be met with these exceptions.

C. Quality of Service shall meet the following requirements:

1. Priority.

   Data shall be prioritized such that critical operational data and emergency data have priority and allocated bandwidth on the Backbone Equipment. Priority shall be assigned as follows. Levels are assigned to indicate order of priority with 1 being highest priority.

   a.) Level 1 Priority.

      1.) Timing/Synchronization data.

      2.) Operational CCS and FCS data (e.g., status, alarms, control commands, etc.).

      3.) ETEL and PET Voice Data.

   b.) Level 2 Priority.

      PA/VMS Voice and Message data.

   c.) Level 3 Priority.

      1.) Operational CCTV Video data.

      2.) Digital PABX phone data.

      3.) Network Management and Maintenance data.

   d.) Level 4 Priority.

      1.) Compressed CCTV Video data for storage and archival.

      2.) Other data for storage/archive (e.g. logs, configuration data).
2. Latency.

a.) Operational and non-operational data being transmitted over the Backbone shall have the following latency requirements:

1.) Timing and synchronization data shall be available to all network equipment across the Backbone within +/- 0.01 second.

2.) Operational FCS data shall be available to the OCC with a latency of +/- 0.03 second.

3.) Voice data shall have the following latencies, depending on what type of voice data is being sent.
   - ETEL: +/- 0.01 second.
   - PET: +/- 0.01 second.
   - PA: +/- 0.03 second.
   - PIP: +/- 0.03 second.
   - Digital PABX Phone: +/- 0.03 second.

4.) Other operational data (e.g. VMS) shall have +/- 0.05 second maximum latency.

5.) Operational video shall have +/- 0.05 second maximum latency.

6.) Non-operational archived video: No latency requirements for non-operational data.


a.) All data transmitted over the Communications Backbone shall have the following maximum bandwidth allocations. The bandwidth allocations below are assumed to be future maximum bandwidth allocations, incorporating known and estimated future stations and traffic.

1.) Timing and Synchronization: 10 Mbps maximum.

2.) Operational FCS Data for all stations: 34.304 Mbps maximum.

3.) Voice data shall have the following maximum bandwidth allocations for all stations, depending on type of voice data:
   - ETEL: 10.112 Mbps.
   - PET: 3.2 Mbps.
- PA: 3.2 Mbps.
- PIP: 6.4 Mbps.
- Digital PABX Phone: 6.748 Mbps.

4.) CCTV Operational Video: 100 Mbps for all stations.

5.) CCTV Non-Operational Compressed Stored Video: 65.888 Mbps for all stations.

3.02 PREPARATION

The Contracting Officer will schedule design reviews with the Contractor. The design reviews shall encompass the Contractor submittals for the Preliminary and Final Design.

3.03 FACTORY TESTING

QoS shall be tested in the factory using actual Communications Backbone Equipment and data, where possible.

3.04 FIELD TESTING

A. Field Tests shall be conducted in compliance with Resident Engineer-approved plans and procedures.

1. Field acceptance tests shall consist of exercising each system function through its required operations, under simulated conditions, to prove that the installation complies with specified requirements.

2. Contractor shall:
   
   a.) Submit certified test reports for field acceptance tests.
   
   b.) Provide equipment and apparatus required for the tests.

B. Contractor shall verify Quality of Service of all data according to the specifications above.

PART 4 - MEASUREMENT AND PAYMENT

4.01 SUMMARY

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17560
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SECTION 17570
WAN SYSTEMS TESTING, IDENTIFICATION AND ADMINISTRATION

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall perform component, function and system testing for the Sound Transit WAN System described in Sections 17500 through 17560. Contractor shall label and identify all Communications System Backbone Equipment and other associated equipment consistent with the overall system identification scheme. Additionally, Contractor shall perform all administration tasks in support of the design, development, installation, testing and acceptance of the Sound Transit WAN Systems.

1.02 SECTION INCLUDES

This Section includes the requirements for testing, identification and administration for the WAN System to include the Communication System Backbone Equipment (ADMs and Ethernet Switches), the Central Storage Devices and the voice, video, data and leased line circuits.

1.03 RELATED SECTIONS

A. Section 17500 – Cable Transmission System/WAN Overview.
B. Section 17510 – Communication System Backbone Equipment.
C. Section 17520 – Voice Circuits.
D. Section 17530 – Video Circuits.
E. Section 17540 – Data Circuits.
F. Section 17550 – Leased Lines.
G. Section 17560 – Quality of Service Requirements.
H. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.
I. Section 17590 – Cable Transmission System/WAN Support and Warranty.
J. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. Contractor shall adhere to the following references:

3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.
4. OSHA  Occupational Health and Safety Administration.
5. ADA  Americans with Disabilities Act.

1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.06 SUBMITTALS

Contractor shall submit the following as part of the WAN System delivery:

A. Testing Submittals.

1. Factory Testing.

   Contractor shall submit documentation necessary to plan, perform, and execute all factory testing for the WAN System. Contractor may submit multiple WAN Communications System test submittals broken out by component (e.g., ADM backbone testing, Ethernet Switch testing for Central Control and for each station, storage device testing, and voice, video and data circuit performance testing) as appropriate based on scheduling of test and delivery of each component.

   a.) Test Plan and Procedures.

      1.) Draft.

      - Contractor shall submit a Draft Test Plan and Draft Test Procedures 60 days prior to the start of Factory Testing. Draft Test Plan shall include all components to be tested and a draft Verification Matrix that includes each requirement (functional and performance), the test intended to verify that requirement, and the method of testing (e.g. Inspection, Testing, Simulation, or Modeling).

      - Draft Test Procedures shall include each factory test to be performed and the test procedures required to perform that test. Test procedures shall assume the appropriate background (e.g. MS Windows or network technician skills) required to perform that test or operation, but shall be detailed such that anyone with the appropriate background could step in and perform the test with only the procedures.

      - Draft Test Plan and Procedures shall include all testing required for the WAN System. Where information is missing or incomplete, Contractor shall include the Section heading or a placeholder for the information that is missing.

      2.) Final.

      Contractor shall submit a final Factory Test Plan and Factory Test Procedures for the ST WAN System prior to the start of Factory Testing.
b.) Test Report.

Contractor shall submit a Test Report after Factory Testing that details the test conditions (location, date, time, equipment used, equipment simulated, etc.), the tests performed, which if any tests failed, why the tests failed, and what actions are required and/or recommended to resolve any issues from Factory Test.

c.) Test Measurements.

Contractor shall submit a report to Sound Transit at the completion of Factory Tests documenting the results of all measurements of voice, video and data circuit performance described in Sections 17520, Voice Circuits, 17530, Video Circuits, 17540, Data Circuits and 17560, Quality of Service Requirements. Documentation shall consist of original test data sheets and other documentation provided. The documentation shall include a diagram or description showing the test measurement configuration and indicating the test equipment and software used to make the measurements.

2. Field Testing.

a.) Test Plan and Procedures.

1.) Draft.

- Contractor shall submit a Field Draft Test Plan and Field Draft Test Procedures for the ST WAN System 60 days prior to the start of Field Testing, per the schedule. Field Draft Test Plan shall include testing required to verify all requirements specified in Sections 17510 through 17560. Contractor shall provide a Verification Matrix that includes, at a minimum, each requirement to be verified, the test used to verify the requirement, and the method of testing (e.g. Inspection, Test, Simulation, or Modeling).

- Field Draft Test Procedures shall include each system field test to be performed and the test procedures required to perform that test. Test procedures shall assume the appropriate background (e.g. MS Windows, engineering technician, basic network understanding) required to perform that test or operation, but shall be detailed such that anyone with the appropriate background could step in and perform the test with only the procedures.

- Draft Plan and Procedures shall include all testing required to verify the successful verification of the WAN System. Where information is missing or incomplete, Contractor shall include the Section heading or a placeholder for the information that is missing.

2.) Final.

- Contractor shall submit a final Field Test Plan and Field Test Procedures for the ST WAN System prior to the start of Field Testing, as indicated in Section 01330, Submittals.
- Contractor shall indicate in the Test Plan any requirements that will not be verified by field testing on actual equipment to be used in operations. Contractor shall also indicate any equipment that is to be provided for operations (including spares) that is not tested in field system testing. Contractor shall gain approval from Engineer for these exceptions before testing is to begin.

b.) Test Reports and Results

Contractor shall submit a Test Report for each test conducted that includes the test conditions (location, date, time, equipment used, equipment simulated, etc.), equipment tested, requirements tested, and test results. For any tests that failed, Contractor shall indicate why the test failed, and any actions necessary either to correct the system problem and retest, or to verify the requirement via some other means. Contractor shall submit Test Results to Engineer and shall gain Engineer Approval for any follow-on actions as a result of testing.

c.) Test Measurements

Contractor shall submit a report to Sound Transit at the completion of Field Tests documenting the results of all measurements of voice, video and data circuit performance described in Sections 17520, Voice Circuits, 17530, Video Circuits, 17540, Data Circuits and 17560, Quality of Service Requirements. Documentation shall consist of original test data sheets and other documentation provided. The documentation shall include a diagram or description showing the test measurement configuration and indicating the test equipment and software used to make the measurements.

B. Identification Submittals.

1. Identification Scheme.

Contractor shall submit the labeling or identification scheme for all WAN system equipment, components, and associated cabling.

2. List of WAN System Equipment.

Contractor shall include a list of all equipment delivered (including spare equipment). Contractor shall list all equipment by Identification Name, type of equipment, model number, version number, software or firmware running on equipment and version of software or firmware, location, warranty information, and any other information required to identify the WAN system equipment.

1.07 TESTING

A. Contractor shall test the WAN System in accordance with Section 17030, Reliability Management Program.

1. Contractor shall perform Factory Testing on the ST WAN. In Factory Testing, Contractor shall verify that every piece of equipment to be installed including spares works according to these specifications, and Contractor shall verify that the integrated WAN System works with a minimum of one of each type of equipment.
2. Contractor shall provide Field Testing after all equipment for each respective Phase of Installation has been installed and configured. Field Testing is the final testing for the installed equipment. Every piece of equipment that is installed, and every piece of spare equipment identified as part of the ST WAN System shall be tested in Field Testing. Likewise, every requirement for the WAN system shall be tested and verified to the Engineer’s approval. The successful completion of all Field Testing is required for Final System Acceptance.

3. Installation and Field Testing shall occur in two phases, as described in Section 01110, Summary of Work.

4. Contractor shall include testing of the following, at a minimum:
   
   a.) Communications Systems Backbone Equipment. Contractor shall test the ADMs, and Ethernet switches and associated equipment to verify all requirements specified in Sections 17520, Voice Circuits, 17530, Video Circuits and 17540, Data Circuits. Specifically, Contractor shall verify the following:

   1.) SONET Add Drop Multiplexer (ADM).

       - All ports and all cards function properly.
       - All power supplies operate properly.
       - Failover and Backup capabilities are configured and function properly.
       - SONET ADMs can connect with all other WAN devices over the WAN.
       - Data is properly segmented and prioritized using QoS.
       - RPR is configured and operating properly.

   2.) Ethernet Switch.

       - All ports and all cards function properly.
       - All power supplies operate properly.
       - Failover and Backup capabilities are configured and function properly.
       - Ethernet switches can connect with all other IP devices over the WAN and with all local devices over the local area network.
       - Data is properly segmented and prioritized using QoS over all devices in the wide area network.
       - VLANs are configured and operate properly over the wide area network.

5. Voice Circuits. Contractor shall verify all voice circuit requirements as described in Sections 17520, Voice Circuits and 17560, Quality of Service Requirements. Specifically, Contractor shall verify the following:
a.) Contractor shall verify IP phone calls (including non-emergency IP phones, ETELs and PETs) are intelligible and end to end voice delay is less than 150 milliseconds.

b.) All circuits are free from static or other interference and have a clear signal as determined by Engineer.

c.) Engineer shall be the final approval on non-emergency and emergency IP phone performance, clarity, and intelligibility under varying network conditions (e.g. peak and non-peak operations, loaded and non-loaded network conditions.)

6. Video Circuits. Contractor shall verify the video circuit requirements specified in Section 17530, Video Circuits and 17560, Quality of Service Requirements. Specifically Contractor shall verify the following.

a.) Operational video is transferred over the WAN real-time and the video circuits are monitored for drops and missed packets.

b.) Video quality is as specified in Sections 17751, CCTV and 17530, Video Circuits. Engineer shall be the final approval on video quality for the following:

1.) Operational "real time" video.

2.) Short term (72 hour) storage "full frame" (e.g., 30 frames per second).

3.) Long term (30 days) storage.

7. Data Circuits. Contractor shall verify all of the data circuits and data Quality of Service requirements as specified in Section 17540, Data Circuits and 17560, Quality of Service Requirements. Specifically, Contractor shall segregation and prioritization of the different types of data described in Section 17540, Data Circuits, specifically timing data, FCS data, PA/VMS data, and maintenance and management data.

8. Leased Lines. Contractor shall verify the leased line requirements for voice and data leased lines with KC Metro PABX, ST Union Station PABX, and local and long distance service providers. Contractor shall test that all services between the KC Metro and ST Union Station PABXs are available (such as 5-digit dialing across the phone switches and call forwarding). Contractor shall verify by test and by lease agreement that long distance and local phone services are installed and meet these specifications. Contractor shall provide final leased line design and requirements to be approved by Engineer. Contractor shall test and verify the final leased line design and requirements that Contractor has developed.

9. Quality of Service.

a.) Contractor shall verify Quality of Service requirements described in Section 17560, Quality of Service Requirements.

b.) Contractor shall test and verify priority and latency requirements for all ST Communications data as described in Sections 17510 to 17560.
1.08 IDENTIFICATION

A. Contractor shall provide unique identification of all equipment and components provided as part of the ST Communications WAN System.

B. Contractor shall uniquely label all equipment, components and cabling associated with the ST WAN Systems as follows.

1. Cable labeling requirements are specified in Section 17170, Cable Testing, Identification and Administration.

2. All ADMs and Ethernet Switch equipment, cards and ports shall be uniquely labeled. All Storage Devices shall be uniquely labeled. All spare parts and components shall be uniquely labeled consistent with their like parts and components.

3. All equipment, card, and port labeling shall follow a logic that is based on type of equipment and equipment location. Engineer shall approve of identification plan prior to any labeling of equipment.

4. All labeling shall be permanent in such a way as to withstand handling and changes in temperature and ambient conditions.

5. All equipment labels shall be consistent with those in the test reports and as-built documentation.

1.09 ADMINISTRATION

Contractor shall provide project administration as specified in this document for the ST Communications WAN System.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17570
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SECTION 17580
CABLE TRANSMISSION TRAINING, MANUALS, SPECIAL TOOLS AND SPARE PARTS

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall furnish all training, manuals, special tools and spare parts required for the operations and maintenance of the WAN System. The goal of providing training, manuals, documentation, special tools and spare parts is so that at time of System Acceptance, Sound Transit is fully equipped to operate, maintain and resolve all issues associated with the delivered system.

1.02 SECTION INCLUDES

This Section includes the requirements for training, manuals, special tools and spare parts for the WAN System that provide emergency and non-emergency operational communications throughout the Sound Transit System and with external organizations.

1.03 RELATED SECTIONS

A. Section 17140 – Backbone Cabling Requirements.
B. Section 17500 – Cable Transmission System/WAN Overview.
C. Section 17510 – Communication System Backbone Equipment.
D. Section 17520 – Voice Circuits.
E. Section 17530 – Video Circuits.
F. Section 17540 – Data Circuits.
G. Section 17550 – Leased Lines.
H. Section 17560 – Quality of Service Requirements.
I. Section 17570 – WAN System Testing, Identification and Administration.
J. Section 17590 – Cable Transmission System/WAN Support and Warranty.
K. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. Contractor shall adhere to the following references:

3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.
4. OSHA Occupational Health and Safety Administration.
5. ADA Americans with Disabilities Act.

1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.06 SUBMITTALS

A. Contractor shall submit the following as part of the WAN System delivery.

1. Training Plan.
   a.) Contractor shall provide a training plan that includes all vendor training required by user and maintenance personnel and a schedule for when that training needs to occur relative to the project delivery schedule.
   b.) Contractor shall list all prerequisite training or knowledge required in order to participate in the WAN System training.
   c.) Contractor shall also provide as part of the Training Plan a description of proficiency assessments for each class to assess how well the Maintenance personnel has mastered the material.
   d.) Contractor shall include, as part of the Training Plan, a schedule of manufacturer, vendor, and contractor provided training for ST Maintenance personnel for the WAN system. All training shall be scheduled to be completed no more than 30 days prior to system acceptance.
   e.) Contractor shall provide, as part of the training plan, a list of all required and recommended Vendor and Manufacturer training. Contractor shall also provide a list of all Contractor training that is required. Contractor shall provide with this list a brief description of what material each class is intended to cover, and how long each class lasts.
   f.) Contractor shall deliver all training materials used to train including Presentation Slides, Training Notes, and Handouts, training software, and a video of each training class.

2. Manuals.
   a.) Manufacturer’s Manuals.

Contractor shall provide all Manufacturer’s Configuration and Maintenance Manuals for every type of equipment in the WAN System to include the SONET ADMs, the Ethernet Switches, Storage Devices and Removable Media Storage Devices.
Contractor shall also provide any other associated Manufacturer’s Configuration and Administration Manuals required for configuring, troubleshooting, and maintaining all network equipment to meet Quality of Service requirements described in these Specifications.

b.) Contractor’s Manuals.

Contractor shall submit additional Contractor Maintenance Manuals that include the specific configuration, maintenance and troubleshooting information and instruction for the WAN System design. Contractor shall augment the Manufacturer Administration and Maintenance manuals with specific instruction related to the configuration of WAN System. Such manuals shall include specific configuration, backup/restore and maintenance procedures for the switches and ADMs, operation and maintenance of the Storage devices specific to the CCTV video that is stored on these devices, and any other instruction specific to the WAN System.

3. Documentation.

a.) Manufacturer’s Documentation.

Contractor shall submit all Manufacturer documentation in addition to the user and maintenance manuals described earlier that are required for installation, operation, maintenance and management of the WAN System.

b.) Contractor’s Documentation.

Contractor shall provide all design, test, installation, maintenance and troubleshooting documentation for the WAN System. This includes, but is not limited to, all design documents and drawings, installation documentation and drawings, as-built documents and drawings, test reports, documentation of configuration and software delivered. A list of any open discrepancy reports or issues at each design review, test review and at acceptance shall be submitted as well.

4. List of Special Tools.

Contractor shall submit a list of all special tools required for test, operation, maintenance, or troubleshooting recommended by Contractor and submitted for approval by Resident Engineer. Contractor shall include any tools required for factory testing to verify network requirements prior to full system installation.

5. List of Spare Parts.

Contractor shall submit a list of all recommended spare parts and components for the WAN System for Resident Engineer approval. This shall include ADM cards, power supplies, chassis, and ADM components, Ethernet cards, power supplies, chassis and Ethernet Switch components, Storage Devices, and any other components required for the WAN operations and maintenance. Contractor shall assume in general sparing of 10 percent of number of operational parts or one part, whichever is greater.
1.07 TRAINING

A. Contractor shall provide training to cover the following areas of WAN System operation, maintenance, and troubleshooting:

1. Administration and Maintenance Training.

a.) SONET ADM.

Contractor shall provide Manufacturer training classes for installation, configuration, administration, maintenance, backup/restore and troubleshooting of the SONET ADM. Contractor shall provide the Manufacturer Manuals as well as specific training such as how to install the ADM, how to backup and restore the ADM, how to configure the ADM specific to Contractor’s design, and how to troubleshoot the ADM.

b.) Ethernet Switches.

Contractor shall provide Manufacturer training classes for installation, configuration, administration, maintenance, backup/restore and troubleshooting of the Ethernet Switches. Contractor shall provide the Manufacturer Manuals as well as specific training such as how to install the switches, how to backup and restore the switches, how to configure the switches specific to Contractor’s design, and how to troubleshoot the switches.

c.) Storage Devices.

Contractor shall provide Manufacturer training classes for use of the delivered storage devices and removable storage devices. Contractor shall train ST Maintenance staff on how to install and configure the Storage Devices, how to troubleshoot the Storage Devices, how to maintain the storage devices, and how to archive off storage if required.

d.) Network Design/QoS.

Contractor shall provide Manufacturer training classes specific to configuring and modifying Quality of Service settings on all WAN devices. Contractor shall include this training with the NMS training, described in Section 17910, Communications Network Management, to configure QoS parameters and to monitor actual network traffic. Contractor shall train maintenance personnel to monitor performance and adjust QoS parameters accordingly to meet overall system network goals. Should Manufacturer training classes not meet these specific requirements, Contractor shall supplement Manufacturer training to meet these training requirements.

e.) Contractor shall train maintenance personnel on possible modifications to the network design based on possible future modifications to the system (e.g. addition of stations, addition of cameras, and addition of phones). Should Manufacturer training classes not meet these specific requirements, Contractor shall supplement Manufacturer training to meet these training requirements.

f.) Contractor shall provide an assessment in the form of a test or network design problem of how well the personnel trained have mastered the material for each
training class. Contractor shall provide assessment results to Resident Engineer for
final approval that all required personnel have been adequately trained.
Manufacturer training exams and assessments that are given as part of Manufacturer
training classes shall be used where appropriate.

1.08 MANUALS

A. Contractor shall provide all required manuals for using and maintaining the WAN System.

B. Manuals shall be professionally bound.

C. Contractor shall be responsible for providing any upgraded manuals and documentation
through the end of the Warranty Period at no additional cost to Sound Transit, as described in
Section 17590, Cable Transmission System/WAN Support and Warranty.

D. Manuals.

1. SONET ADM.

a.) Contractor shall provide 40 hard copies of the Manufacturer User, Administration and
Maintenance Manuals for the SONET ADM. Contractor shall provide one soft copy
of the Manufacturer’s Manual in a format that is not modifiable, such as pdf.
Maintenance Manuals shall include detailed procedures for the SONET ADM that
include the following.

1.) Connecting various types of network devices.

2.) Configuring the ADMs to communicate with the various network devices
described in these Specifications and shown in the Contract Drawings.

3.) Configuring RPR on the ADM.

4.) Configuring QoS.

5.) Backing up and restoring, rebooting the ADM.

6.) Troubleshooting and maintaining the ADM.

2. Ethernet Switch.

a.) Contractor shall provide 40 hard copies of the Manufacturer User, Administration and
Maintenance Manuals for the Ethernet Switch. Contractor shall provide one soft copy
of the Manufacturer’s Manual in a format that is not modifiable, such as pdf.
Maintenance Manuals shall include detailed procedures for the SONET ADM that
include the following at a minimum.

1.) Connecting various types of network devices.

2.) Configuring the Ethernet switches to communicate with the various network
devices described in these specifications and shown in the Contract Drawings.
3.) Configuring QoS.

4.) Backing up and restoring, rebooting the ADM.

5.) Troubleshooting and maintaining the ADM.

3. Storage Device.

Contractor shall provide 40 hard copies of the Manufacturer User, Administration and Maintenance Manuals for the Storage Device. Contractor shall provide one soft copy of the Manufacturer’s Manual in a format that is not modifiable, such as pdf.

4. Removable Media Storage Devices.

Contractor shall provide 40 hard copies of Manufacturer User, Administration, and Maintenance Manuals for the Removable Media Storage Devices. Contractor shall provide one soft copy of the User’s Manual in .pdf format or equal that is not able to be modified.

E. As part of Maintenance Documentation Contractor shall also provide copies of schematics, rack drawings, plan drawings, installation drawings as part of the Maintenance Manuals such that Maintenance personnel can install and connect all WAN System Equipment.

1.09 SPECIAL TOOLS

A. Contractor shall furnish all special tools required to test, install and troubleshoot the WAN System and WAN System Devices.

B. Contractor shall provide a list of all special tools required to test, install, and troubleshoot the WAN System to Resident Engineer for approval.

C. Contractor shall furnish all special tools approved by Resident Engineer. Contractor shall ensure all special tools function correctly at the time of contract approval. Should any tool be found to be defective or not properly functioning, Contractor shall replace the tool at no cost to Sound Transit.

1.10 SPARE PARTS

A. Contractor shall provide sufficient spare WAN system parts and components to allow replacement of any malfunctioning part to meet MTTR requirements that cannot be met by simple troubleshooting.

B. Contractor shall provide a list of all recommended Spare Parts based on the following:

1. Actual delivered system design.

2. Number of ADMs and Ethernet Switches required in the system design, as well as number of ports of ADM and Ethernet Switch used (for each station and for Central Control).
3. Reliability of each part and component (ADM, Ethernet Switch, ADM and switch replaceable components such as cards and power supplies).

4. Manufacturer recommendations.

5. Sound Transit general sparing guidelines described in Section 17060, Special Tools and Spare Parts.

6. Contractor shall include spare ports and spare cards as part of Sparing Plan for the ADMs and Ethernet Switches.

C. Contractor shall submit a draft of this list of Spare Parts for Resident Engineer Approval as part of the Preliminary Design Review, and a final Spares List as part of the Final Design documentation.

D. Contractor shall furnish and configure (where appropriate) all spare parts and components along with furnished operational parts and components.

E. Contractor shall test all spare parts and components along with all system parts and components as part of WAN System Factory Testing.

F. Contractor shall replace any spare parts that fail prior to final system acceptance at no cost to Sound Transit. Should any operational part fail prior to final system acceptance and a spare part used to replace the operational part, the spare part shall be replaced at no additional cost to Sound Transit.

G. All spare parts shall be of identical make, model and version as the operational part that it is a spare for, unless directed otherwise by Resident Engineer.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 SUMMARY

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17580
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SECTION 17590
CABLE TRANSMISSION SYSTEM/WAN SUPPORT AND WARRANTY

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Contractor shall provide support and warranty of the WAN System such that the WAN System will be supported during the time of delivery through a year after the final acceptance of the final phase of the ST Communications System.

B. This Section includes requirements for the support and warranty of the Sound Transit WAN System.

1.02 RELATED SECTIONS

A. Section 17080 – Warranty and System Support.

B. Section 17500 – Cable Transmission System/WAN Overview.

C. Section 17510 – Communication System Backbone Equipment.

D. Section 17520 – Voice Circuits.

E. Section 17530 – Video Circuits.

F. Section 17540 – Data Circuits.

G. Section 17550 – Leased Lines.

H. Section 17560 – Quality of Service Requirements.

I. Section 17570 – WAN System Testing, Identification and Administration.

J. Section 17580 – Cable Transmission Training, Manuals, Special Tools and Spare Parts.

1.03 REFERENCE STANDARDS

A. Contractor shall adhere to the following references:


3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.

4. OSHA Occupational Health and Safety Administration.

5. ADA Americans with Disabilities Act.
1.04 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.05 SUBMITTALS

A. Contractor shall submit the following as part of the Support and Warranty delivery of the Communication System Wide Area Network. See Section 17080, System Support, for overall System Support and Warranty requirements.

1. Contractor shall submit copies of all Manufacturer support and warranty agreements for all equipment delivered at System Acceptance for Phase I and for all equipment delivered at System Acceptance for Phase II. Contractor shall provide the contact information for all Communication System Backbone Equipment Manufacturers, in accordance with delivered support and warranty agreements.

2. Contractor shall deliver the complete Configuration Management of the system at the time of final delivery (Phase II), including hardware make and model, version number, firmware version number, firmware patch number, and including copies of all configurations and scripts for all backbone equipment and storage equipment.

3. Contractor shall submit a complete list of all problems encountered during installation and field testing, when they occurred, and how they were corrected. Contractor shall deliver a complete list of all open problems, bugs, and requirements not met at the time of System Acceptance at Phase I and at System Acceptance at Phase II.

1.06 SUPPORT

A. Contractor shall provide backbone network system support for all software and hardware from the beginning of acceptance of Phase I to a year after the acceptance of Phase II. Contractor support for WAN/Backbone systems shall consist of Contractor support for the WAN, and shall be supplemented by Manufacturer Support for the Backbone Equipment and Storage Device Equipment.

1. For the Backbone Equipment (ADM, Ethernet Switches, Storage Devices, and associated equipment) Contractor shall provide a maintenance agreement for a level of support that meets the following requirements.

a.) Contractor.

   1.) Contractor support shall be available 24 hours a day, 7 days a week.

   2.) Contractor shall respond to a problem within 1 hour during normal business hours defined here as 9 am to 5 pm Monday through Friday, Pacific time, and shall respond to a problem within 4 hours at all other times.
b.) Manufacturer.

1.) For issues requiring Manufacturer Support, Contractor shall provide a Manufacturer Support Agreement that provides Manufacturer support be available 24 hours a day, 7 days a week.

2.) Manufacturer shall respond to a problem within 1 hour during normal business hours defined here as 9 am to 5 pm Monday through Friday, Pacific time, and shall respond to a problem within 4 hours at all other times.

1.07 WARRANTY

A. Contractor shall provide a warranty for the WAN System that covers the repair or replacement of all equipment, software and firmware through a period from factory testing through one year after final acceptance of Phase II of the WAN System at no additional cost to Sound Transit. Contractor shall ensure that all manufacturer warranties cover support, repair, and replacement of equipment and equipment components during this period. Where any Manufacturer warranties cover less than this period or do not cover this period, Contractor shall provide the full warranty for this equipment.

B. Any upgrades or fixes to WAN System hardware and software shall be made with Resident Engineer approval, at no additional cost to Sound Transit.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17590
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SECTION 17600
ARCHITECTURAL, MECHANICAL AND ELECTRICAL REQUIREMENTS OVERVIEW

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes the explanation of Sections 17600 though 17699.

1.02 RELATED SECTIONS

A. Section 17610 – Communications Facilities, Panels and Enclosures.

B. Section 17620 – Operations Control Center Facility Requirements.

C. Section 17625 – Operations Control Center Furniture.

D. Section 17630 – Communications Facilities Requirements.

E. Section 17635 – Communications Furniture.

F. Section 17640 – Interfaces Design for Civil, Electrical, Mechanical and Architectural Elements.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

Sections 17600 through 17699 are intended to guide the Contractor in building out the non-electronic or cable portions of Work. This includes the design and construction of the Communications Rooms in stations and the Operations Control Center (OCC) with respect to room finishes, and it includes the design and construction requirements for communications cabinets and the like that will get installed in rooms or on pads provided by others.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17600
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SECTION 17610
COMMUNICATIONS FACILITIES, PANELS AND ENCLOSURES

PART 1 - GENERAL

1.01 OVERVIEW

A. Communications Cabinets as located on Contract Drawings for housing all communications equipment where a communications room is not available at a station.

B. Communications Distribution Cabinets as located on Contract Drawings, and at other locations as required for splices, taps, equipment connections and compliance with regulatory requirements. Communications Distribution Cabinets shall house any combination of communication equipment.

C. Racks as located on Contract Drawings for mounting all communication equipment in communication rooms and TC/C rooms. At Signal Houses equipment racks, ground bars, cable trays and ground cable will be furnished and installed by the Signal Contractor.

1.02 RELATED SECTIONS

A. Section 01330 – Submittals.

B. Appendix B – Communications Equipment List.

1.03 REFERENCE STANDARDS

A. ANSI.


2. ANSI/EIA-310-D, “Cabinets, Racks, Panels, and Associated Equipment”.

B. Bellcore.


C. BICSI Telecommunications Distribution Methods Manual (TDMM).


E. NEMA (National Electrical Manufacturers Association).

NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

F. TIA/EIA.

1. TIA/EIA-569-A: Commercial Building Standard for Telecommunications Pathways and Spaces.

1.04 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals are subject to Engineer approval.

1. Preliminary Design Review.

   a.) Contractor shall submit the following information prior to Preliminary Design Review per the schedule and requirements set in Section 01330, Submittals.

       Manufacturer's catalog data for all proposed materials with installation recommendations.

2. Intermediate Design Review.

   a.) Contractor shall submit the following information prior to FCS Intermediate Design Review per the schedule and requirements set in Section 01330, Submittals.

       1.) Manufacturer's Installation Instructions including application conditions and limitations of use. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

       2.) Drawings showing the installation details of the racks and cabinets.

       3.) Complete installation drawings and procedures as well as inspection procedures.

3. Final User Documents.

   a.) Prior to Final Acceptance Testing, according to the project schedule guidelines set in Section 01330, Submittals, Contractor shall submit final versions of the following:

       1.) Detailed drawings of connections to building grounds and station platform utility pad grounds showing routing of ground wires and mechanical details of connections.

       2.) Parts list of all items and accessories supplied for all cabinets and racks.

       3.) Test reports verifying ground grid resistance does not exceed specified values for each communications equipment location.

1.05 QUALITY ASSURANCE

Products shall be manufactured and used in accordance with the following requirements or standards: Federal Communications Commission (FCC), National Electrical Code (NEC), Underwriters’ Laboratories (UL), Department of Labor – Occupational Safety and Health Administration (OSHA) and all applicable federal, state and local requirements.
1.06 COORDINATION

Coordinate mounting heights, orientation and locations of all enclosures with the appropriate site electrical contractor.

1.07 WARRANTY

All cabinets and racks shall be free from defects in workmanship and material and shall be guaranteed to function in the installed environment. The Contractor without charge shall make any repairs, adjustments or replacements made necessary by such defects during the first full year from the time of acceptance of the project by Sound Transit.

PART 2 - PRODUCTS

2.01 COMMUNICATION CABINETS

A. Equipment cabinets are above ground, pad mounted enclosures sized to house telecommunications equipment ranging from active electronic and optical systems to passive mechanical cross-connect and splicing fields. These cabinets shall provide mechanical and environmental protection for the equipment contained within, allow craftsperson work activities and discourage access by unauthorized persons.

B. Means shall be provided to control internal temperature and humidity of these cabinets. Cabinets shall be designed to withstand Puget Sound area climatic conditions.

C. All communication cabinets shall be rated NEMA 4X.

D. Enclosures shall be nominally sized at 62 inches high by 76 inches wide by 36 inches deep. Four adjustable 19” EA racks shall provide a minimum of 160 inches of useable mounting area.

E. Electromagnetic Interference (EMI).

1. Cabinets shall be designed for EMI shielding with the following features:

   a.) Continuously welded seams.
   
   b.) Gasketed front and rear doors.
   
   c.) Screened ventilation openings.
   
   d.) Tested per Mil Std. 285.

F. Finish.

1. Cabinet shall be painted (including any cutouts) as follows:

   a.) Pre-treated with iron phosphate
b.) Finish coated with 100 percent solid thermosetting polyester to a minimum 5-mil thickness.

c.) Interior white color.

d.) Exterior color shall be coordinated with Engineer.

G. Sliding battery drawer with containment tray shall hold up to twelve 12V 100 amp style batteries.

H. Equipment compartment shall be air conditioned.

I. Separate compartments for battery, fiber entry, electrical, air conditioning, and equipment racks.

J. Safety and Reliability.

1. The cabinet shall be free of defects, such as sharp edges or burrs that could present a safety hazard to personnel involved in their assembly, installation, use or maintenance.

2. Product integrity shall be maintained and there shall be no deviations from physical criteria that may or will adversely affect the product with respect to safety, reliability, interchangeability, life, performance and operation, and maintenance.

K. Electrical.

1. Cabinets shall be designed to accept station normal power, 120 VAC, single phase 40A service to power UPS, which powers the electronic equipment in the racks, in accord with details shown on Contract Drawings.

2. A decal showing an electrical schematic of the power wiring shall be affixed to the inside surface of the cabinet.

3. A 120 VAC Auxiliary Power Strip (UL listed) equipped with ground fault interrupter (GFI) protection shall be provided and wired to the Station Electrical Cabinet 120 VAC, single-phase, 20A breaker.

L. Grounding and Bonding.

1. Cabinets shall include, for each rack, two (2) electrically isolated grounding buss bars located at the bottom of the rack in accordance with Section 16060, Electrical Grounding and Bonding.

2. Contractor shall meet additional grounding requirements outlined in Section 16060, Electrical Grounding and Bonding, and on Contract Drawings.

M. Cabinet Interface with Concrete Pad.

1. All cabinets shall have a hole pattern on a flat horizontal surface on the base of the cabinet for anchoring to station utility pads. The hole pattern shall permit lateral relocation of the fasteners to avoid interference with imbedded rebar. Access to the
anchoring hardware is required for verification that hardware continues to meet torque requirements.

2. Racks shall be secured on foundation using Hilti Model HSLB M12-25 Expansion Anchor or approved equal, as necessary to comply with seismic zone 3.

N. Doors.

1. Cabinet doors shall be equipped with a device that restrains the doors in the open position.

2. The door restraints shall be self activating when the doors are opened and shall be released manually to close the doors.

3. The door restraints shall be capable of resisting the opening and closing forces resulting from wind gusts without mechanical damage or loss of function.

4. Cabinet shall be equipped with forced entry resistant doors with a three-point lock. The door handle shall accept a padlock.

5. The locking device shall be properly sealed to prevent water intrusion into the cabinet. All keys shall be alike and master keys shall be provided to the Resident Engineer.

6. Door seals and gaskets shall be designed to seal effectively against water intrusion, dust, debris and insects.

7. The adhesives used on seals and gaskets shall maintain satisfactory adhesive qualities and function after exposure to all temperature, humidity, water exposures outlined in the contract documents.

8. Seals and gaskets shall be made of a material that has aging characteristics of being highly resistant to heat, ozone and ultraviolet light. Seal material shall also be tear resistant, have low compression set in the designed use, and be resistant to such chemical sprays, such as insecticides and repellants.

O. Screens.

1. Cabinet cooling systems, using outside air, should be designed to eliminate the need for replaceable air filters.

2. Screens shall be provided to minimize the entrance of dust debris and insects into the cabinet.

3. Screened areas shall be covered by louvers or other means to inhibit the entrance of horizontally driven rain.

4. Cabinet shall be designed to effectively drain moisture that may enter through screens.

P. Acoustical Noise Suppression.

Cabinets shall suppress acoustical noise to a level of 60 dBA at a distance of 5 feet from the cabinet during times of maximum noise generation within the cabinet.
Q. Lifting Details.
   1. Cabinets shall be provided with a means such as eyebolts for attaching hoisting lines.
   2. Eyebolts used for lifting shall not protrude through the cabinet housing and into the interior of the cabinet.

R. Condensation.
   1. Cabinets shall be designed and shall include facilities to prevent condensation within the cabinet.
   2. Instructions and procedures shall be provided to prevent the formation and condensation on installed telecommunications equipment prior to turn-up and when the equipment is in operation.

S. Documentation.
   1. Documentation shall be provided with the cabinet, providing the following as a minimum:
      a.) Installation procedures.
      b.) Maintenance and repair procedures.
      c.) Safety instructions.
   2. Cabinets shall be provided with decal(s) on the door interior containing information on the equipment system, internal cabling and powering schematics.
   3. Cabinets shall be provided with a data pocket on the inside of the front door able to hold several 9” x 12” laminated sheets.

T. Designed to comply with Bellcore TA-NWT-000487.

U. UL Listed.

2.02 COMMUNICATION DISTRIBUTION CABINETS

A. Communication Distribution Cabinets shall be NEMA rated for the installation environment. If the cabinet is exposed to outdoor weather or within three feet of water it shall have a NEMA 4X designation. All other enclosures shall have a NEMA 12 designation.

B. Enclosures shall be sized for ample space of all components with room for 25 percent expansion.

C. Fabricated from 16 gauge steel, continuously welded seams.

D. External mounting feet top and bottom for wall mounted units.

E. Free standing units shall be securely anchored to the floor.
F. Cabinets shall include either a metal back panel for mounting equipment or shall include 19 inch rack mounting rails.

G. Doors shall seal with closed cell oil-resistant neoprene gasket.

H. All cabinets shall have hinged doors and keyed lock.

I. Communication Distribution Cabinets shall be properly grounded. Material and installation shall comply with National Electrical Contractors Association's "Standard of Installation" pertaining to the installation, grounding and bonding of circuits and equipment.

J. UL 50 Listed for Type 4X / Type 12.

2.03 Equipment Racks.

A. Welded steel frame equipment racks shall be used for mounting all communications equipment in communications rooms, TC/C rooms and in the CCER.

B. Rack framework shall be 11 gauge ASTM A570 steel.

C. All racks shall be sized for standard 19 inch equipment widths.

D. Racks shall be painted ANSI 61 gray.

E. Tapped mounting channels shall be completely adjustable.

F. Louvered top panel and ventilation fan to provide air flow of 500 SCFM minimum.

G. Racks outside of the CCER shall be enclosed with lockable doors. Side panels shall be removable.

H. Racks shall be designed to accept station normal power, 120 VAC, single phase 40A service to power UPS, which powers the electronic equipment in the racks.

I. Equipment Rack Interface with Floor.

1. All equipment racks shall have a hole pattern on a flat horizontal surface on the base of the rack for anchoring to building floors. The hole pattern shall permit lateral relocation of the fasteners to avoid interference with imbedded rebar. Access to the anchoring hardware is required for verification that hardware continues to meet torque requirements.

2. Racks shall be secured on foundation using Hilti Model HSLB M12-25 Expansion Anchor or approved, rated for seismic zone 4.

J. Include shelves, brackets, leveling casters, machine screws and all other accessories as required for a functional installation.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Examination.

1. Verify installation conditions as satisfactory to receive work of this Section. Do not install until unsatisfactory conditions are corrected. Beginning work constitutes acceptance of conditions as satisfactory.

2. Verify locations and conduit routing prior to rough-in.

B. General Installation Requirements.

1. Contractor shall develop all installation procedures in accordance with the standards defined in these Specifications.

2. Contractor shall inspect all foundations and report any deficiencies.

3. Contractor shall prepare each foundation base by installing seismic zone 4-rated anchor bolts to a depth of at least four inches.

4. Contractor shall install all additional equipment required by these Specifications. This includes all grounding equipment, power supplies and power cables.

5. Contractor shall inspect each installed cabinet for level, plumb and ground.

6. Install wall mounted cabinets at elevations to accommodate mounting heights.

7. Adjust communication cabinets and distribution cabinet locations prior to rough-in to accommodate intended purpose.

C. Cleaning.

1. Clean interior of boxes to remove dust, debris, and other material.

2. Clean exposed surfaces and restore finish.

D. General.

1. All materials and installation shall comply with requirements specified in the National Electrical Code and all applicable codes and regulations.

2. Install equipment and accessories in accordance with manufacturer’s instructions.

3. All Work described in this Specification shall be installed under the supervision of competent engineers, electricians and mechanics regularly employed in the installation of communication systems. The system installer shall perform engineering, programming, calibration, check out, and testing.

4. All equipment to be installed per approved shop drawings and equipment manufacturer’s written instructions.
5. The cabinets must be securely attached to the building structure (column, permanent wall), superstructure (anchored to the floor, mounted on cable rack, etc.) maintaining service access where appropriate.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17610
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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. The Operation Control Center (OCC) provides the critical human interface with the Communications and Control System that allows the centralized operation of Link and serves as the central supervisory station to meet the intent of NFPA 72. Additionally, the personnel that operate and maintain the ST Communications System will operate and maintain the ST equipment in the OCC. Contractor shall provide facilities (consoles, overview displays, and other equipment necessary) in these rooms to support the full operation of the ST Communications System and the training of OCC staff.

B. This Section includes all preparation Work required at the OCC to make this area operational ready for the installation of communications equipment.

C. The OCC is located on the fourth floor of the Operations and Maintenance Facility installed under Contract C810. The OCC consists of two rooms: the Central Control Room and the Central Control Expansion Room. The construction of these two rooms with walls, HVAC, lighting, fire protection, normal ac power and raised floor will be done by others.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 16610 – Static Uninterruptible Power Supply.

C. Section 17070 – Human Factors Engineering and Ergonomics.

D. Section 17120 – Interior Communication Pathways.

E. Section 17150 – Facility Cabling Requirements.

F. Section 17832 – Access Control System.

1.03 REFERENCE STANDARDS

A. BICSI TDMM

B. NFPA 70

C. J-STD-607

D. NFPA 72

E. MIL-STD-1472F
1.04 SUBMITTALS

A. Prior to the design submittal, Contractor shall perform an ergonomic study based on the operational requirements described in this document. Contractor shall submit this ergonomic study to Engineer for approval prior to designing the facility. Contractor shall demonstrate the results of the ergonomic study in the design of the facility.

B. For the Preliminary Design Review, Contractor shall provide the following:

1. A description of the cable management approach including paths and terminations for power and communications cabling. Power and communications cables shall be specifically noted.

2. A detailed cable diagram showing complete interconnection of equipment.

3. OCC Layout.
   a.) Contractor shall provide OCC equipment layouts. Each layout shall depict the following:

   1.) All OCC equipment, including Control Consoles, Console equipment, Overview Displays, etc.

   2.) Horizontal and vertical viewing angles from each Control Console position to the Overview Display.

   3.) Access to equipment for maintenance.

   4.) Access paths between equipment for operational purposes (e.g., to access printers).

   5.) Carpet layout design and suggested manufacturer of carpet tiles to include material, color, size and sparing.

C. For the Final Design Review, Contractor shall submit updated versions of all previously submitted materials.

PART 2 - PRODUCTS

2.01 OCC REQUIREMENTS

A. Contractor shall design the equipment layout for the initial configuration of the Central Control Room including for Control Consoles, Overview Displays and other furniture. Contractor shall demonstrate the ergonomic study results in the equipment layout and particularly in the layout of the Control Consoles and Overview Displays. Equipment layout shall ensure that Train Controllers viewing the Overview Displays are provided vertical viewing angles within maximum viewing limits, based on eye rotation with head stationary, as defined in MIL-STD-1472F.

B. Contractor shall design the equipment layout for the initial configuration of the Central Control Expansion Room.
C. Based on the approved OCC Layouts, Contractor shall design, furnish, and install the following:

1. UPS power distribution from the ac UPS main panel in the CCER to an electrical sub-panel to be located at the Central Control Room. All Contractor supplied equipment for the OCC (Central Control Room and Central Control Expansion Room) shall be powered from this sub-panel. See Contract Drawings.

2. UPS power distribution in the OCC beneath the finished raised flooring.

3. All cabling for grounding as used for safety and signal grounding.

4. A communications cable distribution system for all communications cabling. This system shall be installed beneath the finished raised floor in the OCC.

5. Sensors and controllers for OCC access control.

D. Contractor shall install carpet in the OCC that meets the following minimum requirements.

1. Carpet shall be anti-static.

2. Carpet shall be neutral in color.

3. Carpet squares shall match in size and shape the floor tiles of the raised floor.

4. Spares carpet squares shall be provided such that after the system is delivered and installed, Contractor shall provide 10 percent spare carpet squares.

2.02 ELECTROMAGNETIC INTERFERENCE (EMI)

The communications system shall be designed to operate reliably with the expected electromagnetic interferences at the Operations and Maintenance Facility. As such Contractor shall design system to maintain lowest EMI levels as reasonably practicable.

PART 3 - EXECUTION

3.01 GENERAL

Records for the execution of the OCC Facility requirements shall be maintained for all installation and test activities, and shall be delivered to Engineer upon request.

3.02 PREPARATION

Contractor shall perform pre-installation inspection of Work by others. Contractor shall prepare a written report of deficiencies and issue this report to Engineer according to the Administrative Requirements described in these Specifications.

3.03 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment.
3.04 INSTALLATION

A. Installation shall be in accordance with approved Installation Plan.

B. Contractor shall install all cabling/wiring.

C. Contractor shall connect to grounding and UPS.

3.05 FIELD TESTING

A. Contractor shall test all cabling and connections to power and grounding.

B. Contractor shall test and certify that the OCC meets the requirements of NFPA 72 Section 8.3.3.

C. Test results shall be recorded and is subject to review by Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17620
SECTION 17625
OPERATIONS CONTROL CENTER FURNITURE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. The personnel that operate and maintain the ST Communications System will operate and maintain the ST equipment in the OCC. Contractor shall provide furniture (operations chairs and other associated furniture) in these rooms to support the full operation and maintenance of the ST Communications System. This furniture shall allow disabled personnel (e.g. wheelchair access) to operate and maintain the ST Communications System in accordance with ADA requirements.

B. This Section includes all furniture required at the Operations Control Center (OCC).

C. All furniture shall be fabricated, finished and arranged to present a uniform and coordinated appearance.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 17070 – Human Factors Engineering and Ergonomics.

C. Section 17120 – Interior Communication Pathways.

D. Section 17150 – Facility Cabling Requirements.

1.03 REFERENCE STANDARDS


1.04 RELIABILITY/FITNESS FOR USE

All furniture and equipment shall be designed, installed and warranted to support 24/7 operation for a period of 5 years.

1.05 SUBMITTALS

A. Prior to the design submittal, Contractor shall perform an ergonomic study based on the operational requirements described in this document. Contractor shall submit this ergonomic study to Engineer for approval prior to designing the facility. Contractor shall demonstrate the results of the ergonomic study in the design of the facility.
B. For the Preliminary Design Review (PDR), Contractor shall provide the following:

1. Consoles.
   a.) Layout and description of the Control Console exterior, including proposed placement of Control Console-based equipment.
   b.) Layout and description of the Control Console interior, including proposed placement of Control Console-based equipment.
   c.) Layout of the room where each Control Console is located including dimensions and description of access to equipment for operational and maintenance purposes.
   d.) Description of features and layout providing compliance with human factors requirements of MIL-STD 1472F for all Control Consoles.
   e.) Cable management including paths and terminations within the Control Console; power and communications cables shall be specifically noted.
   f.) A detailed cable diagram showing complete interconnection of equipment.
   g.) A mockup of the Control Console with the writing surface finished in the proposed color.

2. Communication Maintenance Console.
   a.) Detailed layout and description of the Console, showing interior and exterior and cable access and cable trays.
   b.) Placement of equipment within the Console.
   c.) Cable management including paths and terminations within the Console.
   d.) A detailed cable diagram showing complete interconnection of equipment.


C. For the Final Design Review, Contractor shall submit updated versions of all previously submitted materials.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall provide five Control Consoles at the Central Control Room of the OCC for the following users:
1. Two Train Controllers.

2. CCTV Operator.

3. Train Supervisor.


B. Contractor shall provide two training/simulation Control Consoles at the Central Control Expansion Room of the OCC.

C. Each OCC Control Console shall include the following:

1. CCS Control Console computer.

2. Four CCS color-graphics monitors.

3. Cursor control device.


5. Audible alarm.

6. Integrated communications equipment (see Section 17730, Integrated Communications Controller).

D. Contractor shall provide a workstation, color-graphics monitor, cursor control device, and keyboard for the Sounder CCTV/PA/VMS System. Contractor shall provide the Sounder CCTV position equipment, network connection to Union Station (where the Sounder CCTV/PA/VMS servers reside and space only. Sounder CCTV software and configuration will be provided by others.

2.02 OCC CONTROL CONSOLE FURNITURE

A. Contractor shall demonstrate the use of the Engineer-approved ergonomic study in the design of the Central Console Furniture.

B. Control Console equipment shall be designed and constructed consistent with applicable human engineering standards such as MIL-STD-1472F or an approved equivalent.

C. Each Control Console shall be designed to fit the 95th percentile male and consistent with the reach of the 95th percentile female. Control Console design and equipment layout shall ensure that Train Controllers viewing Control Console displays and the Overview Display are provided vertical viewing angles within maximum viewing limits, based on eye rotation with head stationary, as defined in MIL-STD-1472F.

D. Control Console equipment and layout shall be provided which minimizes equipment noise at the Control Console; super-quiet fans shall be used (e.g. fans shall add no more than 10 dB noise to the ambient noise).

E. Control Console equipment and layout shall minimize user exposure to electro-magnetic radiation.
F. Control Consoles shall be uniform in type of construction and style of appearance.

G. Control Consoles shall be constructed of modular sections and shall allow the following:
   1. Rearranging and expanding Control Console positions.
   2. Adding future Control Console sections, Control Console positions, and Control Console-based terminals and other user interface equipment.

H. Control Console modularity, construction, layout, and features shall be similar to that provided by the Evans Consoles IDENTITY Series, or approved equal.

I. The Control Console structural elements shall be stable and shall fully and securely support the equipment and working environment.

J. Each Control Console shall include a flat writing surface.
   1. Attached to or an extension of the Control Console body in manner to provide a stable and structurally sound Work surface, and shall support a weight of 250 pounds.
   2. Rounded or beveled edges and corners.
   3. Finished in a neutral color, and shall be constructed to resist warping, chipping, and cracking.
   4. At least five square feet of contiguous writing space.

K. At each Control Console, the entire writing surface shall be vertically adjustable.
   1. The surface shall be adjustable preferably to six inches lower than the nominal surface height, and to at least to three and one-half inches lower than the nominal surface height.
   2. The adjustment drive mechanism shall be electro-mechanical and manual, with user access to the control without requiring removal of an external panel.

L. Adequate leg, knee, and toe kick space shall be provided at each Control Console. Leg space shall be a minimum of 26-inches in height and a minimum of 32-inches wide beneath the writing surface to accommodate a wheelchair.

M. Each Control Console position shall provide task lighting, with adjustable lighting level, to provide lighting to the Work surface. Lighting level adjustments shall be able to be accessed by the user without requiring removal of an external panel. There shall be no glare on the terminals from the task lighting.

N. Each Control Console shall include structurally integrated leveling components, providing the ability to vertically adjust each corner for floor height inconsistencies. At least one inch of adjustment shall be provided.

O. Each Control Console position shall have an audible alarm capability of continuous tone or pulse tone operation selectable by the user of the Control Console. The audible alarms shall have individual volume controls.
P. Control Consoles shall provide for air passage into and through the Control Console.

Q. Control Console connections, power, and cabling.
   1. All wiring and cabling connections, power interfaces, and cabling shall be designed, constructed, and located for operating and maintenance safety.
   2. All Control Consoles shall be grounded.
   3. Cabling for external power and data and voice communications shall enter through the base of each Control Console. Cables shall be clearly labeled, and shall utilize internal cable guides to the extent practical.
   4. Cable connections to terminals, CCTV monitors and voice and data input devices shall utilize plug connections and be located to allow for safe and device replacement.
   5. Cables from Control Console-top devices shall be routed through covered “knock-outs” or approved equivalent.
   6. Any other Control Console electronics shall be located within the Control Console and shall be accessible for maintenance.

R. Consoles shall have adequate shelving and drawers to hold operations manuals, pens, pencils and other typical office material.

2.03 CHAIRS

A. One chair shall be provided for each console.

B. An additional chair shall be provided for the System Manager Console.

C. Chairs shall be designed and constructed for, and proven in, an extended use environment. Seating shall comply with ANSI/HSF 100-1988, Chairs, and should be ergonomically designed similar to a Herman Miller Aeron chair and include:
   1. A backrest. The backrest shall be up to shoulder height, shall provide adjustable lumbar support, and shall have an adjustable back angle such that the angle between the backrest.
   2. A padded seat, which shall not compress more than one-inch, with a minimum width of 18-inches and a depth of approximately 18-inches.
   3. Hard rubber wheels on a base mounting with a minimum of five prongs.
   4. Padded arms with adjustable arm rest height.
   5. Pneumatic lift mechanisms, integral to the chair, to provide vertical adjustment of the backrest, seat, and arms together.

D. Chairs shall be covered in a neutral color material. The color and material are subject to approval by Engineer.
2.04 PRINTER TABLES

Contractor shall provide three printer tables in the OCC to support log and alarm printers and fax machines.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall inspect all OCC equipment and furniture described above to ensure they meet these Specifications.

3.02 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment.

3.03 INSTALLATION

A. Installation shall be in accordance with approved Installation Plan.
B. Contractor shall install all equipment and cabling/wiring.
C. Contractor shall connect to power and grounding.
D. Contractor shall secure Control Consoles to the floor.

3.04 FIELD TESTING

A. Contractor shall test all connections to UPS power and grounding.
B. Contractor shall perform end-to-end testing for all communications cabling.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17625
PART 1 - GENERAL

1.01 SECTION INCLUDES

Communications facilities, comprised of the Central Communications Equipment Room (CCER), Communications Maintenance, Communications Rooms (Comm Room), and Telecommunications and Control Rooms (TC/C), form the mission critical facilities that allow the centralized operation of Link and communications amongst and between patrons, staff and emergency personnel. Equipment and maintenance staff dedicated to ensuring the proper operation of these facilities.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.
B. Section 16610 – Static Uninterruptible Power Supply.
C. Section 16615 – Dc Rectifiers and Power Systems.
D. Section 17120 – Interior Communication Pathways.
E. Section 17150 – Facility Cabling Requirements.
F. Section 17832 – Access Control System.

1.03 REFERENCE STANDARDS

C. J-STD-607 Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
1.04  SUBMITTALS

A. For the Preliminary Design Review, Contractor shall provide the following:

1. A description of the cable tray installation and cable management approach including paths and terminations for power, communications, and grounding cables. Each shall be specifically noted.

2. A detailed cable diagram showing complete interconnection of equipment.

3. Room Layouts. Contractor shall provide equipment plan and elevations showing the specific location of all material to be installed into the room. Each layout shall depict the following:

   a.) Layouts for all equipment, including racks, desks, consoles, lockers, cabinets or other equipment and materials that are required or called for in the Contract Drawings.

   b.) Access to equipment for maintenance.

   c.) Access paths between equipment for operational purposes (e.g., to access printers and console equipment).

B. Final Design submittal shall consist of updated drawings of the above after having been adjusted to accommodate any known concerns or questions.

PART 2 - PRODUCTS

2.01  GENERAL

A. Contractor shall supply all the equipment and material necessary to meet the performance criteria and the intent of this Contract, industry accepted practices and manufacturer recommendations. In addition, Contractor shall submit cut sheets for all materials to be used in the buildout of each Communications Facility location. Some general guidelines in choosing equipment are listed below.

1. Commonality of Equipment.

   Contractor shall endeavor to use the same type of equipment for the same general purpose throughout the Work. This shall be for the reduction of spares and efficiencies of scale that are achieved by having common parts.

2. User Ergonomics

   Contractor shall follow MIL-STD-1472F in selection of equipment and layout of design.

3. Durability and Fit for Purpose

   The design life of Link is intended to be 30 years. The Communications Facilities shall be designed to this standard and equipment chosen that is functional and durable. When there is an option of like parts or materials, Contractor shall choose the one with the
longer warranty from the manufacturer, longer MTBF, rated for industrial usage, or other form of tangible durability.

2.02 PLYWOOD BACKBOARDS

A. Plywood backboards used to mount communications equipment in Communications Facilities shall comply with the following:

1. ASTM-E-84.

2. 30 Minute fire rating with a Class 1 flame spread.

3. Installed per Seismic Zone 4 requirements.

2.03 BASEBOARD

A. Contractor shall install baseboard around all floor/wall interfaces. Baseboard shall not block doors, hatches, plugs or other functional element. Baseboard shall be glued to wall such that no part can protrude and cause obstruction or trip hazard.

B. Baseboard material shall have a Class 1 flame spread.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall install materials and equipment per approved drawings. Delivery, installation, and, in general, all other work shall be performed per the provisions in this Document.

3.02 EXISTING INSTALLATIONS

TC/C rooms in the DSTT shall be retrofit to accommodate new design and equipment. Contractor shall prepare Cutover Plan per Section 17020, Cutover of Existing System. Coordination of general items such as flooring and paint shall be on a case by case basis with the Resident Engineer. Contractor shall endeavor to install general items throughout room in as much as feasible.

3.03 NEW INSTALLATIONS

New Communications Rooms, the CCER, and Communications Maintenance shall be delivered to Contractor bare without paint, flooring, or UPS wiring. Only walls, doors, lights, conduits, and electrical service (both standard 120 and a UPS panel) shall be available for the contractor. All other work in these rooms shall be responsibility of Contractor.

3.04 ELECTROMAGNETIC INTERFERENCE (EMI)

The communications system shall be designed to operate reliably with the expected electromagnetic interferences at the Operations and Maintenance Facility. As such Contractor shall design and install a system to maintain lowest EMI levels as reasonably practicable.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17630
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Contractor shall provide furniture in the Communications Facility rooms (CCER, Comm Maintenance, TC/C, and Comm Rooms) to support the full operation and maintenance of the ST Communications System. In some circumstances, furniture must be ADA compliant.

B. This Section includes all furniture required at the Communications Facility rooms (CCER, Comm Maintenance, TC/C, and Comm Rooms).

C. All furniture shall be fabricated, finished and arranged to present a uniform and coordinated appearance.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 17120 – Interior Communication Pathways.

C. Section 17150 – Facility Cabling Requirements.

1.03 REFERENCE STANDARDS


1.04 SUBMITTALS

A. For the Preliminary Design Review (PDR), Contractor shall provide the following:


   a.) Detailed layout and description of the Console, showing interior and exterior and cable access and cable trays.

   b.) Placement of equipment within the Console.

   c.) Description of features and layout providing compliance with human factors requirements of MIL-STD 1472F for all consoles.

   d.) Cable management including paths and terminations within the Console.

   e.) A detailed cable diagram showing complete interconnection of equipment.

3. Specification and cut sheets for workbenches, stools, desks, chairs, lockers, battery racks, bulletin boards, files, and spare maintenance racks.

B. For the Final Design Review, Contractor shall submit updated versions of all previously submitted materials.

PART 2 - PRODUCTS

2.01 GENERAL

Equipment and materials supplied for the Communications Facilities shall be industrial in nature and designed for heavy use and long life. All Products for use in Work shall be approved by Resident Engineer prior to use on jobsite.

2.02 COMMUNICATIONS MAINTENANCE CONSOLE

A. Contractor shall supply a single dual position console (to be considered two consoles) for communications maintenance. Each console shall the following:

1. CCS Control Console computer.

2. Four CCS color-graphics monitors.

3. Cursor control device.


5. Audible alarm.

6. Integrated communications equipment (see Section 17730, Integrated Communications Controller).

B. Contractor shall demonstrate the use of the Resident Engineer-approved ergonomic study in the design of the console furniture.

C. Console equipment shall be designed and constructed consistent with applicable human engineering standards such as MIL-STD-1472F or an approved equivalent.

D. Each Control Console shall be designed to fit the 95th percentile male and consistent with the reach of the 95th percentile female. Console design and equipment layout shall ensure that Maintainers viewing displays are provided vertical viewing angles within maximum viewing limits, based on eye rotation with head stationary, as defined in MIL-STD-1472F.

E. Console equipment and layout shall be provided which minimizes equipment noise at the Control Console; super-quiet fans shall be used (e.g. fans shall add no more than 10 dB noise to the ambient noise).

F. Console equipment and layout shall minimize user exposure to electro-magnetic radiation.

G. Consoles shall be similar in type of construction and style of appearance as OCC consoles.
H. Console shall be constructed of modular sections and shall allow the following:

1. Rearranging and expanding console positions.

2. Adding future sections, positions, and console-based terminals and other user interface equipment.

I. Console modularity, construction, layout, and features shall be similar to that provided by the Evans Consoles IDENTITY Series, or approved equal.

J. Console structural elements shall be stable and shall fully and securely support the equipment and working environment.

K. Each console shall include a flat writing surface.

1. Attached to or an extension of the console body in manner to provide a stable and structurally sound Work surface, and shall support a weight of 250 pounds.

2. Rounded or beveled edges and corners.

3. Finished in a neutral color, and shall be constructed to resist warping, chipping, and cracking.

4. At least five square feet of contiguous writing space.

L. At each console, the entire writing surface shall be vertically adjustable.

1. The surface shall be adjustable preferably to six inches lower than the nominal surface height, and to at least to three and one-half inches lower than the nominal surface height.

2. The adjustment drive mechanism shall be electro-mechanical and manual, with user access to the control without requiring removal of an external panel.

M. Adequate leg, knee, and toe kick space shall be provided at each console. Leg space shall be a minimum of 26-inches in height and a minimum of 32-inches wide beneath the writing surface to accommodate a wheelchair.

N. Console shall provide task lighting, with adjustable lighting level, to provide lighting to the Work surface. Lighting level adjustments shall be able to be accessed by the user without requiring removal of an external panel. There shall be no glare on the terminals from the task lighting.

O. Console shall include structurally integrated leveling components, providing the ability to vertically adjust each corner for floor height inconsistencies. At least one inch of adjustment shall be provided.

P. Console position shall have an audible alarm capability of continuous tone or pulse tone operation selectable by the user of the console. The audible alarms shall have individual volume controls.

Q. Console shall provide for air passage into and through the Control Console.
R. Console connections.

1. Power and cabling:
   
a.) All wiring and cabling connections, power interfaces, and cabling shall be designed, constructed, and located for operating and maintenance safety.
   
b.) Console shall be grounded.
   
c.) Cabling for external power and data and voice communications shall enter through the base of each console. Cables shall be clearly labeled, and shall utilize internal cable guides to the extent practical.
   
d.) Cable connections to terminals, CCTV monitors and voice and data input devices shall utilize plug connections and be located to allow for safe and device replacement.
   
e.) Cables from console-top devices shall be routed through covered “knock-outs” or approved equivalent.
   
f.) Any other console electronics shall be located within the Maintenance Console and shall be accessible for maintenance.

2.03 MAINTENANCE CONSOLE CHAIRS

A. One chair shall be provided for each console.

B. One additional chair shall be provided.

C. Chairs shall be designed and constructed for, and proven in, an extended use environment. Seating shall comply with ANSI/HSF 100-1988. Chairs should be ergonomically design similar to a Herman Miller Aeron chair and include:

1. A backrest. The backrest shall be up to shoulder height, shall provide adjustable lumbar support, and shall have an adjustable back angle such that the angle between the backrest.

2. A padded seat, which shall not compress more than one-inch, with a minimum width of 18-inches and a depth of approximately 18-inches.

3. Hard rubber wheels on a base mounting with a minimum of five prongs.

4. Padded arms with adjustable arm rest height.

5. Pneumatic lift mechanisms, integral to the chair, to provide vertical adjustment of the backrest, seat, and arms together.

D. Chairs shall be covered in a neutral color material. The color and material are subject to approval by Resident Engineer.
2.04 PRINTER TABLE

Contractor shall provide one printer table in Communications Maintenance to support log and alarm printers and fax machines.

2.05 WORKBENCHES

A. Contractor shall supply workbenches in Communications Maintenance as shown on Drawings. Workbenches shall conform to the following:

1. Base portion of workbench.
   a.) .72” wide x 30” deep x 36” high.
   b.) Solid metal construction (non tubular) with 1.5”-2” solid maple table top supporting a weight of 250 lbs. or more.
   c.) 4 integrated lockable drawers with depth of 3” or more.
   d.) Lockable cabinet.
   e.) Integrated 15A power strip.

B. Accessories.

1. Double standard uprights extending 48” above tabletop.
2. 72” suspended light fixture mounted 48” above tabletop.
3. Mounting rail and six plastic bins.
4. 72” shelf mounted 24” above tabletop.
5. 2\textsuperscript{nd} integrated 15A power strip.

2.06 DESKS

A. Contractor shall supply Desks in Communications Maintenance and other Communications Facilities as shown in Contract Drawings. Desks shall conform to the following:

1. 72” wide x 30” deep x 30” high.
2. Solid metal construction (non tubular) with 1.5”-2” solid maple table top supporting a weight of 250 lbs. or more.
3. Four integrated lockable drawers with depth of 3” or more.
2.07 STOOLS

A. Contractor shall supply two ergonomically designed stools for each workbench with the following characteristics:


2. Backrest. The backrest shall be up to shoulder height, shall provide adjustable lumbar support, and shall have an adjustable back angle such that the angle between the backrest.

3. Padded seat, which shall not compress more than one-inch, with a minimum width of 18-inches and a depth of approximately 18-inches.

4. Hard rubber wheels on a base mounting with a minimum of five prongs.

5. Adjustable seat height from 22” – 32”.

6. Integral foot rest.

7. Covered in a neutral color material. The color and material are subject to approval by Resident Engineer.

2.08 CHAIRS

A. Contractor shall supply one chair with each desk. Chairs shall have the following characteristics:


2. Backrest. The backrest shall be up to shoulder height, shall provide adjustable lumbar support, and shall have an adjustable back angle such that the angle between the backrest.

3. Padded seat, which shall not compress more than one-inch, with a minimum width of 18-inches and a depth of approximately 18-inches.

4. Hard rubber wheels on a base mounting with a minimum of five prongs.

5. Adjustable seat height.

6. Covered in a neutral color material. The color and material are subject to approval by Resident Engineer.

2.09 LOCKERS

A. Contractor shall supply Lockers in the Communications Maintenance Room as shown in the Contract Drawings. Lockers shall have the following characteristics:
1. Base Unit Dimensions: 72” height, 24” width and 24” depth.

2. Legs: 4”.

3. Constructed from 16 AWG steel.

4. Open access front.

5. Integral 13” high foot looker with padlock hasp at bottom.

6. Integral 13” high shelf on top.

7. Integral coat rod and two steel coat hangers.

2.10 STORAGE FURNITURE

Contractor shall supply industrial storage cabinets, battery racks, files, bins etc as shown on Drawings.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall inspect all equipment and furniture described above to ensure they meet these Specifications.

3.02 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment.

3.03 INSTALLATION

A. Installation shall be in accordance with approved Installation Plan.

B. Contractor shall install all equipment and cabling/wiring.

C. Contractor shall connect to power and grounding.

D. Contractor shall secure Control Consoles to the floor.

3.04 FIELD TESTING

A. Contractor shall test all connections to UPS or other power and grounding.

B. Contractor shall perform end-to-end testing for all communications cabling.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17635
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes the general requirement for work and designs interfacing with civil, electrical, mechanical, and architectural elements.

1.02 RELATED SECTIONS

Section 17090 – Third Party Interfaces.

1.03 REFERENCE STANDARDS

Not Used.

1.04 NOTED RESTRICTIONS

Not Used.

1.05 QUALITY CONTROL

Contractor shall follow Quality Control standard established in this Agreement.

1.06 SUBMITTALS

Not Used.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

When interfacing with work performed by others in the areas of Civil, Electrical, Mechanical, and Architectural design. Contractor shall make Work match existing or interfacing work. Contractor shall coordinate all such interface work with Resident Engineer.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17640
SECTION 17700
OTHER SYSTEMS OVERVIEW

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall provide Fare Collection Network (FCN), Public Address (PA), Variable Message Sign (VMS), Integrated Communication Controller (ICC), Master Clock, and Closed Circuit Television (CCTV) Systems as part of the Sound Transit Communications System that provide various capabilities to provide a fully integrated transit communications system.

1.02 SECTION INCLUDES

This Section describes the overview and description of the miscellaneous systems for Sound Transit Link Communications.

1.03 RELATED SECTIONS

A. Section 17705 – Fare Collection Network.

B. Section 17710 – Public Address.

C. Section 17720 – Variable Message Signs.

D. Section 17730 – Integrated Communications Controller.

E. Section 17740 – Master Clock System.

F. Section 17750 – Security and Surveillance Overview.

G. Section 17751 – CCTV.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17700
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PART 1 - GENERAL

1.01 OVERVIEW

The Fare Collection Network (FCN) is the set of Ethernet LAN's that extend to all ticket vending machines (TVM's) in the passenger stations. Ticket vending machines will be provided by Sound Transit. The FCN is exclusively for fare vending and shall be isolated from all other networks. At the OCC a network connection shall be provided for the contracted operator of the fare collection system.

1.02 SECTION INCLUDES

A. This Section contains functional and design requirements for:

1. Ethernet Networking at the O&M Facility to the fare collection operator.
2. Ethernet Networking to TVM's in passenger Stations.

1.03 RELATED SECTIONS

A. Section 17040 – Technology Documentation.
B. Section 17170 – Cable Testing, Identification and Administration.
C. Section 17500 – Cable Transmission System/WAN Overview.
D. Section 17800 – Control System Overview.
E. Section 17801 – Control System Network.
F. Section 17910 – Communications Network Management.
G. Section 17930 – Cable Management System.

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section.

1. BICSI Telecommunications Distribution Methods Manual (TDMM).
2. TIA/EIA-455 Fiber Optic Test Standards.
5. TIA/EIA-569-A Commercial Building Standard for Telecommunications Pathways and Spaces.
1.05 SYSTEM DESCRIPTION

A. Functional Requirements.

1. The FCN is the cable, connecting hardware, firmware, software configuration, and active components necessary to provide a unified Ethernet network. The network infrastructure shall be designed to provide fiber optic Ethernet connectivity to all TVM's. See Contract Drawing L00-A100 for a block diagram overview of the FCN.

2. TIA/EIA-568-A provides the standards to be applied when designing and installing the FCN.

a.) O&M Facility FCN Network.

1.) Provide a 10/100 Mbps Ethernet port to be connected to by the Fare Collection operator.

2.) Power FCN equipment within the OCC by the same UPS system supplying other critical OCC systems. Outside of the OCC, FCN equipment shall be powered by the emergency lighting panels.

b.) Station FCN Ethernet Network.

1.) Provide a 10 Mbps Ethernet fiber optic network connection to each installed TVM.

2.) Provision a 10 Mbps Ethernet fiber optic network connection for each future TVM.

B. Design Requirements

FCN shall be designed to meet the needs of the Face Collection System. Contractor shall coordinate design with Engineer to determine the appropriate design parameters.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals are subject to Engineer approval.


a.) Contractor shall submit the following information prior to Conceptual Design Review per the schedule and requirements set in Section 01330, Submittals.
1.) Schematic block diagrams including all active components for all FCN locations. These conceptual drawings shall be used to illustrate the intent of the FCN infrastructure design.

2.) Detailed description of FCN design.

2. Preliminary Design Review.

a.) Contractor shall submit the following information prior to FCN Preliminary Design Review per the schedule and requirements set in Section 01330, Submittals.

   1.) Updated schematic block diagrams.
   
   2.) Installation drawings showing the actual installer how the network is to be installed. Installation drawings shall, at a minimum, show pathway locations and routing, configuration of telecommunications spaces including backboard and equipment rack configurations, and wiring details including identifier assignments.
   
   3.) Detailed list and description of all equipment intended for use.
   
   4.) Updated detailed description of FCN design.
   
   5.) Deviations and exceptions from these Specifications.

3. Final Design Review.

a.) Contractor shall submit the following information prior to FCN Final Design Review, per the schedule and requirements set in Section 01330, Submittals.

   1.) Final Schematic Block Diagrams.
   
   2.) Final Installation Drawings.
   
   3.) Final list and description of all equipment and components.
   
   4.) Field installation details for all types of components.
   
   5.) Rack elevation drawings.
   
   6.) Sample test procedures for all equipment and cable testing.


a.) Prior to Final Acceptance Testing, according to the project schedule, Contractor shall submit final versions of the following:

   1.) User Manuals.
2.) Maintenance Manuals.

3.) Completed test results for all equipment and cable testing.

4.) Training Plan.

5.) Training Manuals.

5. Training.

Training for the FCN shall be included with the training provided for the CSN as described in Section 17801, Control System Network.


Prior to the Final Acceptance Test, according to the project schedule, Contractor shall submit the final test procedure for all testing.

7. Test Results.

Prior to acceptance of the System, all test results shall be submitted. Test results are subject to inspection by Engineer.

8. As-Builts.

Prior to acceptance of the Fare Collection Network, Contractor shall submit all as-builts. As-builts are subject to inspection by Engineer. As-built drawings shall graphically document the installed network infrastructure through floor plan, elevation, and detail drawings. The identifiers for major infrastructure components shall be recorded. The pathways, spaces, and wiring portions of the infrastructure each may have separate drawings if warranted by the complexity of the installation, or the scale of the drawings. Drawings shall be in the latest AutoCAD format on a CD and in printed form.

PART 2 - PRODUCTS

2.01 ETHERNET SWITCHES

A. Ethernet switches shall be provided for fare collection network requirements within the OCC and at all passenger stations.

1. Sized for designed FCN requirements plus 25 percent spare at each location.

2. Compliant with all referenced standards including IEEE 802.3.

3. Ports shall be configurable for 10 / 100 Ethernet auto sensing and auto negotiating.


5. Password protected administration interface.

7. Remote out-of-band management through SNMP or Telnet client.

8. Onboard hardware diagnostics and LED's indicating successful completion or failure of power-up diagnostics; link good LED's for each Ethernet port.

B. Except for the Ethernet Switches, the FCN shall use the same power, equipment racks, grounding and bonding, and network infrastructure in place for the CSN. Refer to Section 17801, Control System Network, for all CSN network design requirements.

PART 3 - EXECUTION

3.01 OVERVIEW

A. The FCN network infrastructure shall be designed and installed in accordance with applicable codes and industry standards. The various components of the structured cabling system shall be installed strictly in accordance with the manufacturer’s instructions and procedures.

B. All design and installation requirements specified in Section 17801 for the CSN shall apply identically to the FCN.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17705
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SECTION 17710
PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.01 OVERVIEW

A. Contractor shall model, design, furnish, install and test an integrated Public Address (PA) and Variable Message Sign (VMS) System to allow transit information to be communicated with patrons and employees. The integrated PA and VMS System shall be used to provide operational information and emergency messages to passengers, employees, and emergency response personnel in public areas.

B. PA messaging shall be directed from OCC and Station EMPs to stations, groups of stations, and the O&M Facility (from OCC only). Each station shall also have the capability for locally generated communications. This Section describes the modeling and initial design requirements of the Public Address component of the integrated PA/VMS System.

1.02 SECTION INCLUDES

This Section include the requirements relating to the modeling, design, furnish and installation of the Public Address System.

1.03 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 16120 – Electrical Wires and Cables.

C. Section 17030 – Reliability Management Program.

D. Section 17040 – Technology Documentation.

E. Section 17050 – Configuration Management.

F. Section 17060 – Special Tools and Spare Parts.

G. Section 17070 – Human Factors Engineering and Ergonomics.

H. Section 17080 – System Support.

I. Section 17140 – Backbone Cabling Requirements.

J. Section 17150 – Facility Cabling Requirements.

K. Section 17310 – PABX.

L. Section 17320 – Telephone Sets.

M. Section 17510 – Communication System Backbone Equipment.
N. Section 17720 – Variable Message Signs.

O. Section 17730 – Integrated Communications Controller.

P. Section 17800 – Control System Overview.

Q. Section 17802 – Field Control System.


S. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:


7. NEMA Enclosures for Electrical Equipment up to 1000 Volts.

8. UL 50 Standards for Safety for Enclosures of Electrical Equipment.

9. IEEE 802 Local and Metropolitan Area Networks.


11. ADA Americans with Disabilities Act.


1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements, of these Specifications. Equipment and equipment installation shall conform to all applicable National Electrical Code regulations and all local regulations. Contractor shall provide UL listed equipment where that meets the performance requirements stated in this Section. At a minimum, Contractor shall meet the intent of NFPA 72 for evacuation notification devices.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals are subject to Engineer approval.

   a.) Contractor shall submit the following information prior to PA Conceptual Design Review per the schedule and requirements set in Section 01330, Submittals:
   1.) Description of PA functions.
   2.) Display layouts showing the selection, queuing, and transmission of PA messages.
   3.) Display layouts showing the creation of PA messages.
   4.) Estimated coverage of individual speakers and coverage zones.

2. Preliminary Design Review.
   a.) Contractor shall submit the following information prior to PA Preliminary Design Review per the schedule and requirements set in Section 01330, Submittals:
   1.) Initial acoustic model with speakers.
   2.) Ambient noise measurements from similar stations.
   3.) Functional Diagram of the station PA System.
   4.) Design method to prevent feedback for local station announcements.
   5.) Description including catalog cuts of the equipment to be installed.
   6.) Demonstration of acoustic model with and without ambient noise.

3. Final Design Review.
   a.) Contractor shall submit the following information prior to PA Final Design Review, per the schedule and requirements set in Section 01330, Submittals:
1.) Optimized 3-D acoustic model with final speaker layouts.

2.) Demonstration of optimized model under all planned conditions and mechanical
interface design of station speakers including speaker housings/backboxes.

3.) Final design drawings for the PA System.

4.) Final list of stored PA messages.


   a.) Contractor shall submit Factory Test Procedures according to schedule.

5. Installation Drawings

   a.) Contractor shall submit Installation Drawings according to schedule described in
   Section 01330, Submittals, of these Specifications.

6. Test Procedures.

   Contractor shall submit Test Procedures according to schedule guidelines described in
   Section 01330, Submittals, of these Specifications.

7. Final User Documents.

   a.) Prior to Final Acceptance Testing, Contractor shall submit final versions of the
   following:

       1.) User Manuals.

       2.) Maintenance Manuals.

       3.) Training Plan.

       4.) Training Manuals.

8. Final Acceptance (Site) Test Procedure.

   Prior to the Final Acceptance Test, Contractor shall submit the final test procedure for the
   test.

9. Test Results.

   Prior to acceptance of the PA System, all test results must be submitted. Results are
   subject to inspection. Contractor shall submit Test Results per the schedule indicated in
   Appendix G, Contract Data Requirements List, of these Specifications.
10. As-Builts.

Prior to acceptance of the System, all as-builts must be submitted. As-builts are subject to inspection. Contractor shall submit as-builts per the schedule indicated in Section 01780, Project Record Documents, of these Specifications.

1.07 TESTING, IDENTIFICATION, AND ADMINISTRATION

A. Testing.

1. Contractor shall test the Public Address System as described below and per the Test Plan.

2. Contractor shall submit factory and field test plans and procedures and shall demonstrate the successful operation and functioning of the Public Address System, according to these Specifications.

B. Identification and Administration.

1. Contractor shall permanently and uniquely label all equipment delivered as part of the Public Address System.

2. Contractor shall provide an identification scheme and list of equipment with Identification Name to Engineer for approval. Contractor shall include in the Identification an indication of the type of equipment and the location.

3. Identification scheme for the PA System shall be uniform with all other Sound Transit Communications equipment labeling.

4. Contractor shall administer the design, development, test and installation of the Public Address System in accordance with these Specifications.

1.08 TRAINING, MANUALS, SPECIAL TOOLS, AND SPARE PARTS

A. Training.

1. After Factory Test and before Final Acceptance Testing, Contractor shall train up to 40 persons on the use of the PA System per the approved Training Plan and Manual.

2. Contractor shall train five (5) persons on the installation and maintenance of the PA System.

3. Contractor shall provide all training materials to include projectors, laptops, whiteboards, videocassette or DVD players, and handouts.

4. Contractor shall provide Engineer with five (5) copies of all training materials to include Videos, DVDs, slides, trainer notes, manuals, and handouts for both users and maintenance personnel.

5. Contractor shall give a test or exercise to the training participants to demonstrate that they have learned the material and are prepared to use or install and maintain the PA System.
B. Manuals.

1. Contractor shall provide manuals for installing, maintaining and operating the PA System, according to the requirements described above in the Submittals Section.

2. The Manuals and Training provided shall be complete such that maintenance personnel that have been trained will be able to use the manual to install, maintain and troubleshoot basic problems associated with the PA System without assistance. Likewise a PA System operator that has been trained will be able to use the PA System without assistance.

C. Special Tools.

Contractor shall provide a list of all special tools used to test, install and maintain the PA System for engineer approval. Contractor shall provide all Engineer-Approved special tools with the PA System.

D. Spare Parts.

1. Contractor shall provide Spare Parts to enable the continuous operation of the PA System, and to minimize the downtime in the case of a PA failure. Contractor shall provide a list of recommended spare parts and their quantity to Engineer for approval. Contractor shall provide the larger of ten (10) percent sparing, or one (1) part, unless otherwise directed by Engineer.

2. Spare parts shall be of the same make and model as the parts they are spares for. Contractor shall test all spares along with the operational parts. Contractor shall replace any faulty spare parts at no cost to Sound Transit during the Contract period and the support period. Additionally, any spare part used to replace a faulty operational part shall be replaced at no additional cost to Sound Transit.

1.09 SUPPORT AND WARRANTY

A. Contractor shall provide support and shall warranty all equipment and hardware delivered for a period of one year after final system acceptance. Should any PA System hardware need upgrading during the support period, Contractor shall replace that hardware or equipment (including spares) at no additional cost to Sound Transit.

B. Contractor shall provide Engineer with all vendor warranty, support and maintenance agreements to include contact information and any relevant information for the timely support of the PA equipment.

1.10 DELIVERABLES

Contractor shall deliver a fully tested, fully functioning, fully documented and approved Public Address System as described in these specifications.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall design and model the PA speaker configuration using Bose Auditioner software, or approved equal. These requirements shall be augmented and updated based on
the results of that design and model. All design and modeling results shall be submitted to Engineer for approval. Any deviations from these Specifications shall be presented to Engineer for approval before proceeding with the design.

1. The Bose Auditioner study shall include a 3-D acoustic model as a design deliverable.

2. Model shall specify speaker locations and final performance characteristics that will provide a Speech Transmission Index (STI) of 0.55 or better in all public areas of the stations within a PA zone. Speaker locations shall be coordinated with Engineer during model development.

3. Contractor shall guarantee that the sound quality of the overall product meets the Bose Model's performance.

B. PA messages to a station, groups of stations, or the O&M Facility shall originate from an Integrated Communications Controller or originate locally via a prerecorded message. EMP shall function as an ICC workstation for the purposes of PA messaging.

C. Contractor shall also provide the capability of generating PA messages from the PABX System.

D. OCC PA Functional Requirements.

The functional requirements for the operation of Public Address from the Control Center are specified in Section 17730, Integrated Communications Controller, and Section 17841, CCS Software and Equipment.

E. PA Coverage.

1. The PA System shall provide intelligible output coverage over a dynamic range of 75 dB to 120 dB, set 15 dB above anticipated normal train, equipment, and public noise levels between three (3) and seven (7 feet) above floor level for nominal train conditions. Contractor shall provide the capability for a ST Controller to change the Nominal Sound Pressure Level per PA/VMS zone or to simply all the system to automatically adjust for changes in ambient noise.

2. For the O&M Facility, Contractor shall provide the PA Speakers at a Nominal Sound Pressure Level of 85 dB for the shop areas, and 65 dB for the office areas, with the capability for an ICC Controller to modify these levels as necessary.

3. Coverage Location. Public Address shall be provided in all public areas of all stations, and on each floor (office area) of the Operations and Maintenance Facility.


   a.) Public Address in stations shall be divided into zones in all reasonably separable areas, such as fare vending, elevators, elevator lobbies, concourses, mezzanines and platforms in stations. A maximum of eight (8) zones shall be used at each station. PA shall be divided to allow for at least one zone per floor as required to support operations in the Operations and Maintenance Facility.
b.) At the O&M Facility, Contractor shall divide the facility such that each floor is a zone, and each shop area is a zone. O&M Facility zones shall also have the following capabilities.

1.) The PA System volume shall be able to turned down in conference rooms and training rooms by anyone using the rooms. (This shall be achieved using a simple resistor, not by creating a new zone.)

2.) ICC Controllers shall be able to access each zone or group of zones from a PABX phone, with an access code for security access purposes.

F. Local PA messages.

1. Local ad-hoc PA messages shall be generated from the Emergency Management Panel and other locations designated in stations or facilities with EMPs at each station that has an EMP, via microphone. Access to local PA shall be restricted to Sound Transit and emergency personnel.

2. At each at-grade station the PA System shall be capable of generating ad-hoc messages for only that station from a local microphone, located with the Emergency Telephones (ETELs) at the north end of the station platforms. The local microphone shall be housed in a separate waterproof box accessible only using an operations or fireman’s key.

3. At each aerial station, Contractor shall provide the capability at the Fire Command Center for a System Operator or fireman to select canned PA/VMS messages and broadcast them to that station. Contractor shall provide access to this PA/VMS device from the ETELs and from the PABX.

G. PA Message Priority. The System shall allow up to 8 priority levels. The priority of PA messages at stations is as follows:

1. Ad-Hoc (Emergency) PA messages from a local station.

2. Ad-Hoc (Emergency) PA messages from OCC.

3. Pre-Recorded (Non-Emergency) PA messages from a local station EMP.

4. Pre-Recorded (Non-Emergency) PA messages from OCC.

H. The PA System shall signal CCS when a local message is being generated.

I. PA Equipment Faults.

1. The PA System shall detect failure of preamplifiers and amplifiers and shall signal the Central Control System (CCS) via the Field Control System (FCS). The PA System shall provide dry contacts (normally closed - open upon fault) to be interfaced to the FCS discrete input module. Signal shall be sent by the FCS to the CCS to be presented as an alarm.

2. The PA System shall detect failure of speakers and shall signal the Central Control System (CCS) via the Field Control System (FCS). The PA System shall include a 25 Hz oscillator and detector. The detector shall provide dry contacts that interface with the
FCS discrete input module. Signal shall be sent by the FCS to the CCS to be presented as an alarm.

J. PA Acoustic Feedback & Noise.

Contractor design shall prevent acoustic feedback from local PA announcements. Contractor shall design, install and test the System such that the signal-to-noise ratio is at least 60 dB for locally generated messages and 90dB for pre-recorded messages.

K. PA Power Amplifier Redundancy.

1. The failure of any one PA power amplifier shall not result in the loss of PA coverage in any zone of any station.

2. Each zone shall be designated to support operating and emergency evacuation plans and procedures. As such, each PA zone shall be equipped with a redundant amplifier to meet NFPA 72 and NFPA 130 intent.

L. PA Speaker Orientation.

The orientation of PA speakers shall be determined from the Bose Auditioner study.

M. PA Chime.

1. The PA shall provide a PA Chime.

2. The PA chimes to alert patrons of a message broadcast.

N. Contractor shall use a Bose Auditioner, or Engineer-approved equal to design and optimize the speaker layout to achieve an STI of 0.55 or better.

2.02 PUBLIC ADDRESS EQUIPMENT

A. Contractor shall provide any and all equipment required to achieve a properly functioning PA System as approved by Engineer. Installation materials required to meet the environmental, structural and architectural demands of each facility shall be considered included.

B. Unless superseded by specific equipment requirements below, the PA electronic equipment shall have the following general specifications. Contractor shall provide additional equipment specifications to Engineer as a result of the Bose Auditioner study mentioned previously.

1. Solid state design.

2. Latest manufacturer’s model.


5. Frequency response: 20 to 20 kHz +/- 1 dB.

6. THD: Less than 1 percent over the frequency range.
7. Hum and Noise: Minimum of 80 dB below full rated output power.

8. TCP/IP or RS-232 output port enabling remote diagnostic and configuration capability.

C. Audio Pre-Amplifiers.

1. Audio pre-amplifiers shall conform to the following:
   a.) Analog inputs and outputs with at least 24 bit A/D & D/A converters @ 48KHz sampling.
   b.) Three I/O configurations: 12x4, 4x12, or 8x8.
   c.) Screen display of the total audio design Control via:
       1) PC/laptop.
       2) Remote control panels.
       3) Third-party control via RS-232.
   d.) Built-in diagnostic tools Remote function control via Ethernet Multi-level security coding
   e.) Ability to select, view, and calibrate:
       1) Mixers: Standard, automatic, matrix, combiners.
       2) Equalizers: Graphic, parametric.
       3) Filters: HPF, LPF, high shelf, low shelf, all-pass.
       4) Crossovers: two (2) Way, three (3) Way and four (4) way.
       5) Dynamics: Leveler, comp/limiter, ducker, ANC.
       6) Routers: 2x4 ~ 40x40.
       7) Delays: 0 ~ 2000mS.
       8) Remote controls.
       9) Meters: Signal present, peak, RMS.
       10) Generators: Tone, pink-noise, white-noise.
       11) Diagnostics: Transfer function.
D. Audio Power Amplifiers.

1. Power amplifiers shall be 100 percent solid state. Power amplifiers shall conform to the following:

   a.) Frequency response: 20 Hz to 20 kHz flat +/- 0.1 dB.

   b.) Noise (20 Hz to 20 kHz) < -106 dB.

   c.) Distortion (SMPTE-IM) < 0.02 percent.

   d.) Distortion (Typical - 20 Hz to 20 kHz) < 0.01 percent.

   e.) Distortion (1KHz @ full power) < 0.01 percent.

   f.) Input Sensitivity @ 8 Ohms < 1.26 Vrms.

   g.) Output: Constant 70.7 volts nominal, AB+B or 2-step-H circuitry.

   h.) Amplifier protection: Full short circuit, open circuit, thermal, ultrasonic, and RF.

   i.) Stable into reactive or mismatched loads.

   j.) Rated power output shall be sufficient to drive all speakers to maximum output (determined by Bose Auditioner design) for extended period without fail.

   k.) Variable Speed Fans.

   l.) Automatic Gain Control (AGC).

m.) Front Panel Controls.

   1.) ON/OFF Switch.

   2.) Volume control.

   3.) Fuse or circuit breaker (maintainable from front of unit).

n.) Front Panel Indications.

   1.) LED ON/OFF.

   2.) Indicator lamp.

   3.) LED Alarm Indicator lamp.
o.) Supervised in accordance with NFPA 72.

E. Priority Audio-Select and Storage.

1. Priority Audio-Select and Storage shall conform to the following:

a.) Priority selection and signaling of audio sources.

b.) Impedance matching of line and microphone to amplifiers.

c.) Frequency compensation.

d.) Signal compression to match multiple sources.

e.) Local feedback prevention.

f.) PA equipment fault supervision

g.) Storage of Local PA messages and VMS messages in digital format or supervisory activation and playback.

F. Amplifier Monitoring Module.

The Public Address System shall include a module to insure continuous amplifier and speaker operation. This module shall include an oscillator, a detector, and any other ancillary equipment required. The module shall be as shown in the Contract Drawings. The module shall detect the presence of a preselected tone continuously generated by the oscillator at the output of each amplifier. Any fault or interruption in the tone shall trigger an alarm which shall be fed to the FCS System.

G. Speakers.

Speakers shall be provided that meet the design requirements generated from the Bose Auditioner study mentioned previously in this Section. Contractor shall provide specific speaker requirements to Engineer prior to final design. Speakers shall have a frequency range of at least 30-18,000 Hz.

H. Speaker Backboxes, Baffles, Enclosures.

1. Speaker Backboxes shall conform to the following:

a.) Corrosion resistant and lined with backing.

b.) Designed to suppress resonances in the audio band of 20 Hz to 20 kHz.

c.) Water resistant and fire resistant.
d.) Contractor shall provide conduit and backboxes at the O&M Facility that conform to the O&M Facility speaker requirements described above, and that are approved by the C810 finish Contractor.

2. Speaker baffles and enclosures shall be vandal proof, weather proof, and corrosion and fire resistant.

I. PA Cables.

PA cables shall conform to the requirements of Section 17150, Facility Cabling Requirements, NFPA 130 and NFPA 72.

J. PA Chime.

1. The PA Chime shall conform to the following:
   a.) Nominal Sound Pressure Level of 95 dBA (at five (5) feet above platform level), adjustable +/- 12dB.
   
   b.) Tones: Multi-Frequency in 500 Hz to 4 kHz band.
   
   c.) Tone shall be constant for adjustable period between two (2) to five (5) seconds.

K. Miscellaneous Equipment.

Contractor shall furnish and install miscellaneous equipment to complete the PA System. This shall include surface conduit between station junction boxes and PA devices, and miscellaneous mounting hardware for PA devices.

PART 3 - EXECUTION

3.01 PREPARATION

Engineer will schedule design reviews with Contractor. The design reviews shall encompass Contractor submittals for the Conceptual, Preliminary, and Final Design. This Section augments the design reviews described in Section 01650, Product Delivery Requirements.

3.02 FACTORY TESTING

A. PA System.

1. Contractor shall perform the following tests:
   a.) Message priority selection.
   
   b.) PA equipment failure supervision.
   
   c.) Frequency response test from audio processor to speaker output at nominal Sound Pressure Levels from all planned inputs.
d.) Redundant power amplifier operation.
e.) Demonstrate functionality of text-to-voice messaging.

B. PA/VMS Integrated System.

1. Contractor shall perform the following tests:
   
   Simulate simultaneous PA and VMS messages.

2. Validate integrated system meets NFPA 72 and ADA.

3.03 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for all delivery, storage, and handling of equipment.

3.04 INSTALLATION

A. Contractor shall submit installation drawings according to the schedule detailed in Section 01330, Submittals, of these Specifications. Contractor shall proceed with the installation only after the approval of installation drawings by Engineer.

B. Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

C. Contractor shall coordinate placement of speakers with the Engineer. Contractor shall take into consideration station finishes and aesthetics into design equipment locations and installation details. Design shall be approved by Engineer prior to installation.

3.05 FIELD TESTING

A. For each installation Contractor shall perform field tests.

1. PA System.

   a.) Functional tests of equipment for all planned inputs at nominal Sound Pressure Level. Line inputs to be generated from OCC and EMP.

   b.) Functional test of PA supervision with the Central Control software.

   c.) Measurement of sound dead spots.

   d.) Functional test of priority select.

   e.) Functional test of local feedback.

   f.) Sound quality tests, test plan approved by Engineer.

   g.) Correct phasing of all speakers.
h.) Functional and sound level test of the chime.

i.) Audio coverage test: every ten (10) feet along each platform edge (every five (5) feet under a canopy) at three (3) feet, five (5) feet, and seven (7) feet above the platform level; test frequencies at 250 Hz, 3 kHz, 8 kHz; Sound Pressure Level, dBA scale.

j.) Demonstrate functionality of text-to-voice messaging.

k.) Demonstrate the sound quality of the delivered PA System meets the Bose model's performance.

l.) Demonstrate that PA meets the intent of NFPA 72 as an evacuation notification device.

2. PA/VMS Integrated System.

a.) Contractor shall perform the following tests:

1.) Simultaneous PA/VMS messages from OCC meeting ADA.

2.) Local test from EMP for PA/VMS messages.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17710
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SECTION 17720
VARIABLE MESSAGE SIGNS

PART 1 - GENERAL

1.01 OVERVIEW

A. Contractor shall model, design, furnish, install and test an integrated Public Address (PA) and Variable Message Sign (VMS) System to allow communications with patrons and employees. The integrated PA and VMS System shall be used to provide operational information and emergency messages to passengers, employees, and emergency response personnel. Communications shall be from OCC to stations or groups of stations. Each station shall also have the capability for locally generated communications. This Section describes the VMS component of the integrated PA/VMS System.

B. This Section includes the requirements for designing, furnishing and installing the VMS System.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 16120 – Electrical Wires and Cables.

C. Section 17030 – Reliability Management Program.

D. Section 17040 – Technology Documentation.

E. Section 17050 – Configuration Management.

F. Section 17060 – Special Tools and Spare Parts.

G. Section 17070 – Human Factors Engineering and Ergonomics.

H. Section 17080 – System Support.

I. Section 17140 – Backbone Cabling Requirements.

J. Section 17150 – Facility Cabling Requirements.

K. Section 17510 – Communication System Backbone Equipment.

L. Section 17710 – Public Address System.

M. Section 17730 – Integrated Communications Controller.

N. Section 17740 – Master Clock System.

O. Section 17800 – Control System Overview.

P. Section 17802 – Field Control System.

R. Section 17910 – Communications Network Management.

1.03 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:

7. NEMA Enclosures for Electrical Equipment up to 1000 Volts.
8. UL 50 Standards for Safety for Enclosures of Electrical Equipment.
9. IEEE 802 Local and Metropolitan Area Networks.
11. ADA Americans with Disabilities Act.

1.04 QUALITY CONTROL

Contractor shall adhere to Quality Control guidelines specified in Section 01450, Systems Quality Requirements, of this document. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations.
1.05 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals
are subject to Engineer approval.


   a.) Contractor shall submit the following information prior to VMS Conceptual Design
       Review per the schedule and requirements set in Section 01330, Submittals:

       1.) Description of VMS functions.

       2.) Display layouts showing the selection, queuing, and transmission of VMS
           messages.

       3.) Display layouts showing the creation of VMS messages.

       4.) VMS displays conforming to ADA requirements.

2. Preliminary Design Review.

   a.) Contractor shall submit the following information prior to VMS Conceptual Design
       Review per the schedule and requirements set in Section 01330, Submittals:

       1.) Station VMS System.

       2.) Proposed configuration of test VMS.

       3.) Description including catalog cuts of the equipment to be installed.

       4.) Electrical interface design of VMS.

       5.) Physical interface design of VMS.

3. Final Design Review.

   a.) Contractor shall submit the following information prior to VMS Conceptual Design
       Review per the schedule and requirements set in Section 01330, Submittals.

   b.) Mechanical interface design of VMS.

   c.) Final design drawings for the VMS System.

   d.) Final list of stored VMS messages.

Contractor shall submit Factory Test Procedures.

5. Installation Drawings and Test Procedures.

Contractor shall submit Installation Drawings and Test Procedures as indicated in these Specifications.


   a.) Prior to Final Acceptance Testing, according to the project schedule guidelines set in Section 01330, Submittals, Contractor shall submit final versions of the following:

      1.) User Manuals.

      2.) Maintenance Manuals.

      3.) Training Plan.

      4.) Training Manuals.

7. Final Acceptance Test Procedure.

Prior to the Final Acceptance Test, according to the project schedule, Contractor shall submit the final test procedure for the test.

8. Test Results and As-Builts.

Prior to acceptance of the VMS System, all test results shall be submitted.

9. As-Builts.

Prior to acceptance of the System, as-built documentation shall be submitted. As-built documentation is subject to inspection.

1.06 TESTING, IDENTIFICATION, AND ADMINISTRATION

A. Testing.

1. Contractor shall test the VMS System as described below in the Execution Section and as described in Section 17030, Reliability Management Program.

2. Contractor shall submit factory and field test plans and procedures and shall demonstrate the successful operation and functioning of the VMS System, according to these specifications.
B. Identification and Administration.

1. Contractor shall permanently and uniquely label all equipment delivered as part of the VMS System.

2. Contractor shall provide an identification scheme and list of equipment with Identification Name to Engineer for approval. Contractor shall include in the Identification Name an indication of the type of equipment and the location.

3. Identification scheme for the VMS System shall be uniform with all other Sound Transit Communications equipment labeling.

4. Contractor shall administer the design, development, test and installation of the VMS System in accordance with these specifications.

1.07 TRAINING, MANUALS, SPECIAL TOOLS, AND SPARE PARTS

A. Training.

1. After Factory Test and before Final Acceptance Testing, Contractor shall train up to 40 persons on the use of the VMS System per the approved Training Plan and Manual.

2. Contractor shall train five (5) persons on the installation and maintenance of the VMS System.

3. Contractor shall provide all training materials to include projectors, laptops, whiteboards, videocassette or DVD players, and handouts.

4. Contractor shall provide Engineer with five copies of all training materials to include Videos, DVDs, slides, trainer notes, manuals, and handouts for both users and maintenance personnel.

5. Contractor shall give a test or exercise to the training participants to demonstrate that they have learned the material and are prepared to use or install and maintain the VMS System.

B. Manuals.

1. Contractor shall provide manuals for installing, maintaining and operating the VMS System, according to the requirements described above in the Submittals Section.

2. The Manuals and Training provided shall be complete such that maintenance personnel that have been trained will be able to use the manual to install, maintain and troubleshoot basic problems associated with the VMS System without assistance. Likewise a VMS System operator that has been trained will be able to use the VMS System without assistance.

C. Special Tools.

Contractor shall provide a list of all special tools used to test, install and maintain the VMS System for engineer approval. Contractor shall provide all engineer-approved special tools with the VMS System.
D. Spare Parts.

1. Contractor shall provide Spare Parts to enable the continuous operation of the VMS System, and to minimize the downtime in the case of a VMS failure. Contractor shall provide a list of recommended spare parts and their quantity to Engineer for approval. Contractor shall provide the larger of ten (10) percent sparing or one (1) part, unless otherwise directed by Engineer.

2. Spare parts shall be of the same make and model as the parts of installed equipment. Contractor shall test all spares along with the operational parts. Contractor shall replace any faulty spare parts at no cost to Sound Transit during the Contract period and the support period. Additionally, any spare part used to replace a faulty operational part shall be replaced at no additional cost to Sound Transit.

1.08 SUPPORT AND WARRANTY

A. Contractor shall provide support and shall warranty all equipment and hardware delivered for a period of one year after final system acceptance. Should any VMS System hardware need upgrading during the support period, Contractor shall replace that hardware or equipment (including spares) at no additional cost to Sound Transit.

B. Contractor shall provide Engineer with all vendor warranty, support and maintenance agreements to include contact information and any relevant information for the timely support of the VMS equipment.

1.09 DELIVERABLES

Contractor shall deliver a fully tested, fully functioning, and fully documented VMS System as described in these Specifications.

PART 2 - PRODUCTS

2.01 GENERAL

A. VMS messages to a station or groups of stations shall originate from OCC and from Station EMPs. In addition, at each EMP station and at-grade station, the VMS System shall be capable of generating local messages.

1. OCC VMS Operational Requirements.

The functional requirements for the operation of Visual Messaging from the OCC are specified in Section 17730, Integrated Communications Controller, and Section 17841, CCS Software and Equipment.

2. VMS Requirements.

a.) The VMS shall provide for visual messages at stations. Visual messages shall be provided from OCC and from station EMPs.

1.) Local Variable Messages.

- EMPs shall be capable of sending messages to the VMS.
- At each aerial station, Contractor shall provide the capability at the Fire Command Center for a System Operator or fireman to select canned PA/VMS messages and broadcast them to that station. Contractor shall provide access to this PA/VMS device from the ETELs and from the PABX.

2.) VMS Message Priority. The priority of VMS messages at stations shall be in the following order:

- Ad-Hoc (Emergency) VMS messages from a local station.

- Ad-Hoc (Emergency) VMS messages from OCC.

- Saved (Non-Emergency) VMS messages from a local station EMP.

- Saved (Non-Emergency) VMS messages from OCC.

3.) Location. Contractor shall provide VMSs at all Sound Transit stations at locations and in quantities shown on Contract Drawings. Contractor shall submit final VMS location design for engineer approval after Public Address speaker model and design has been completed as described in Section 17710, Public Address System, as VMS locations should correspond to PA speaker locations.

4.) VMS Display. The VMS shall be capable of displaying two lines of 24 characters of text with a minimum height of 4.5 inches during normal operations and a single 16-character line of nine (9) inch text during emergencies. The display shall have the following characteristics.

- Black or dark colored face with amber LEDs for maximum contrast.

- Variable character height from two inches to nine inches.

- Automatic intensity control adjusting for ambient light.

- Minimum of 30-degree viewing angle.

- Multiple fonts.

- Multiple languages as specified in Section 17710, Public Address System.

- Multiple display effects; flash, scroll, roll, graphics.

- One to multi-line text.

- MTBF > or = 100,000 hours

5.) VMS Messages.

Contractor shall provide the capability for any operator to select and display saved messages such as Next Train Arrival Time, Current Time, and Destination Station. See Section 17730, Integrated Communications Controller, for further description of this capability.
6.) VMS Addressing.

Each VMS shall be individually addressable from a Control Center or EMP for sending information, configuring memory, and for investigating the contents of memory. VMSs shall also be addressable as groups, such as station, extension, or platform.

7.) VMS Readability.

The VMSs shall be readable under standard station lighting and bright sunlight.

8.) VMS Strobe.

- Each VMS shall include a strobe light to signal deaf patrons when an emergency message is being broadcast.
- Strobe frequency shall not promote epileptic seizures or any other malady.
- Strobe lights shall be controlled by VMS control software.

9.) VMS Sunshade.

VMSs shall be provisioned to reduce glare and minimize direct sunlight on face.

2.02 VARIABLE MESSAGE SIGN EQUIPMENT

General configuration of VMS equipment is shown in Contract Drawings. Information provided below is to augment and more clearly define the design goals of the VMS equipment.

A. VMS equipment shall include the following:

1. LED Matrix Display with vandal resistant cover and antiglare hardware.
2. Integrated VMS strobe.
3. VMS input device including all hardware and software required to control the device.
4. VMS cables.
5. Miscellaneous equipment as needed to add CCTV or PA speakers to the sign assemblies.

B. Select Variable Message Signs on station platforms shall have CCTV cameras and/or PA speakers, as shown on Drawings. Signs shall be made in such a way as not to interfere with the intended operation of cameras or speakers or degrade their performance. Sign housings shall be designed in such a way as to protect the CCTV and PA equipment from weather or damage similar to the LED display.
C. LED Matrix Displays.

1. Contractor shall supply LED Matrix Displays from Daktronics or Telecite or approved equal. The LED Matrix Display shall conform to the following:

a.) Display Characteristics.

b.) LED brightness.

One (1) candela, automatic adjustment to light conditions.

c.) Effects.

Flash, scroll, roll, graphics.

d.) Character height; variable.

e.) Messages.

Multi and single line, minimum requirements of two (2)-lines of test, each line a minimum of 4.5" high.

f.) Viewing angle.

15 degrees to either side of normal.

g.) Double-sided or as noted on drawings.

2. VMS Physical Characteristics.

a.) Enclosure.

NEMA 4.

b.) Enclosure length shall be as shown on drawings.

c.) Display window.

Shatter-proof, vandal resistant, ultra-violet resistant, condensation prevention.

d.) Metal components.

Corrosion resistant or treated for outdoor use.

e.) Maintenance access.

Access doors on each side of sign or at sign ends.
D. VMS Strobe.

1. The VMS Strobe shall conform to the following:
   a.) Mounted on LED Matrix Display.
   b.) Strobe rate: Set as appropriate for the application. Contractor shall ensure strobe rate is not set to rate known to cause epileptic seizures.
   c.) Vandal and weather resistant.

E. VMS Input Device.

1. The VMS Input Device located at Integrated Communications Console, at EMPs and Control Centers shall conform to the following:
   a.) Keyboard to input text strings or commands.
   b.) Display to edit text or commands.

F. VMS Cables.

VMS cables shall conform to the requirements of Section 17150, Facility Cabling Requirements.

G. Test VMS and Associated Equipment.

1. The Test VMS and associated equipment shall conform to the following:
   a.) Test VMS identical to field VMS.
   b.) Permanent mounting dolly for VMS.
   c.) PC based hardware and software for development of VMS messages.
   d.) Moveable 19-inch rack for PC based hardware.
   e.) Data interface to Communications Controller to transfer VMS messages.
   f.) All ancillary equipment and material to make a completely functional Test VMS including any power supplies, power cords, and protection against power overloads.

H. Miscellaneous Equipment.

Contractor shall furnish and install miscellaneous equipment to complete the VMS System. This shall include surface conduit between station junction boxes and VMS devices, and miscellaneous mounting hardware for VMS devices.
I. VMS System Management/Monitoring.

Variable Message Signs shall be provided with a single dry contact as part of the FCS System to provide summary alarms.

PART 3 - EXECUTION

3.01 PREPARATION

Engineer will schedule designs reviews with Contractor. The design reviews shall encompass Contractor submittals for the Conceptual, Preliminary, and Final Design. This Section augments the design reviews described elsewhere in these Specifications.

3.02 FACTORY TESTING

A. VMS System.

1. Contractor shall perform the following tests:

   a.) Message display times.

   b.) Message features: scroll, flash, roll, variable height.

   c.) ADA compliance.

   d.) Maximum viewing angle.

   e.) Brightness and/or contrast.

   f.) Demonstration of local VMS input device.

   g.) Total number of messages.

B. PA/VMS Integrated System.

1. Contractor shall perform the following tests:

   Simulate simultaneous PA and VMS messages.

C. Test VMS.

1. Contractor shall perform the following tests:

   a.) Demonstration of test software and generation and display of visual messages.

   b.) Portability of Test VMS System with operational VMS System.
3.03 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for all delivery, storage, and handling of equipment.

3.04 INSTALLATION

Contractor shall submit installation drawings a minimum of 30 days prior to installation of the VMS System at any station. Contractor shall proceed with the installation only after the approval of installation drawings.

3.05 FIELD TESTING

A. For each installation Contractor shall perform field tests:

1. VMS System.
   a.) Contractor shall perform the following tests:
      1.) ADA compliance.
      2.) Functional test of message features.
      3.) Strobe feature.
      4.) Equipment failure supervision interface with Field Control System.
      5.) Display of locally generated and OCC messages.
      6.) Chime audio level and correct tone.

B. PA/VMS Integrated System.

1. Contractor shall perform the following tests:
   a.) Simultaneous PA/VMS messages from OCC.
   b.) Local test from EMP for PA/VMS messages.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.
SECTION 17730
INTEGRATED COMMUNICATIONS CONTROLLER

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall design, furnish, install and test an Integrated PA/VMS/Radio/PABX (including PET and ETEL phones) Controller. The Integrated Communication Controller shall perform all data routing, audio switching, level control and signaling to consolidate control at the Operations Control Center, the stations, and the O&M Facility for the Sound Transit PA/VMS System. System can be any combination of hardware and software.

1.02 SECTION INCLUDES

This Section describes the Work necessary to design, furnish, and install the Integrated Communication Controller at the CCER, at stations, and at the OCC Consoles.

1.03 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.
B. Section 16120 – Electrical Wires and Cables.
C. Section 17030 – Reliability Management Program.
D. Section 17040 – Technology Documentation.
E. Section 17050 – Configuration Management.
F. Section 17060 – Special Tools and Spare Parts.
G. Section 17070 – Human Factors Engineering & Ergonomics.
H. Section 17080 – System Support.
I. Section 17150 – Facility Cabling Requirements.
J. Section 17310 – PABX.
K. Section 17320 – Telephone Sets.
L. Section 17330 – Voice Mail System.
M. Section 17360 – Emergency Phone System.
N. Section 17365 – Passenger Emergency Telephones.
O. Section 17710 – Public Address System.
P. Section 17720 – Variable Message Signs.
Q. Section 17740 – Master Clock System.

R. Section 17800 – Control System Overview.

S. Section 17802 – Field Control System.

T. Section 17840 – Central Control System.


V. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section.


7. NEMA Enclosures for Electrical Equipment up to 1000 Volts.

8. UL 50 Standards for Safety for Enclosures of Electrical Equipment.

9. IEEE 802 Local and Metropolitan Area Networks.


11. ADA Americans with Disabilities Act.

12. UL 50 Standards for Safety for Enclosures of Electrical Equipment.


1.05 QUALITY CONTROL

A. Quality Control is as specified in Section 01450, Systems Quality Requirements, of this document. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations. All equipment shall be UL listed.
B. All Communications Controller and Console Software shall be developed in accordance with Section 01450, Systems Quality Requirements.

1.06 SUBMITTALS

Contractor shall provide the following submittals for review by Engineer. These submittals are subject to Engineer approval.

A. Preliminary Design Review.

1. Contractor shall submit the following information prior to Preliminary Design Review per the schedule.

   a.) Contractor shall submit descriptions of all equipment required for the Integrated Communication Controller to include the following at a minimum:

       1.) Switch or network controller.

       2.) Console information.

       3.) Line interface.

       4.) Console equipment.

           - Processor with data storage devices to include storage for prerecorded audio and visual messages.

           - Computer console audio boards.

           - Audio digitizer board.

           - Audio jack boards.

           - Monitors.

           - Input devices.

           - Recorder connections.

       5.) Station Audio Controller.

   b.) Contractor shall submit a description of the controller software functionality and design to include screen captures or GUI mockups for the user interface.

   c.) Contractor shall submit a complete set of Use Cases that involve the Integrated Communication Controller.
B. Final Design Review.

1. Contractor shall submit the following information prior to Final Design Review, per the schedule.
   
   a.) Final detailed list and specifications of all equipment required for the Integrated Communication Controller at OCC, CCER and at the stations.
   
   b.) Final drawings of all Integrated Communication Controller equipment and interfaces.
   
   c.) Final list of all stored PA and VMS messages at the stations and at the OCC.

C. Factory Test Procedures.

Contractor shall submit Factory Test Procedures.

D. Installation Drawings and Test Procedures.

Contractor shall submit Installation Drawings and Test Procedures as indicated in this specification.

E. Final User Documents.

1. Prior to Final Acceptance Testing, according guidelines set in Section 17030, Reliability Management Program, Contractor shall submit final versions of the following.
   
   a.) User Manuals.
   
   b.) Maintenance Manuals.
   
   c.) Training Plan.
   
   d.) Training Manuals.

2. After Factory Test and before Final Acceptance Testing, Contractor shall train up to 40 persons on the Integrated Communication Controller per the approved Plan and Manual.

F. Final Acceptance Test Procedure.

Prior to the Final Acceptance Test, according to the project scheduling, Contractor shall submit the final test procedure for the test.

G. Test Results.

Prior to acceptance of the System, all test results shall be submitted. Results and as-builts are subject to inspection.
H. As-Builts.

Prior to acceptance of the System, all as-built documentation and configuration files shall be submitted. As-builts are subject to inspection.

1.07 TESTING, IDENTIFICATION AND ADMINISTRATION

A. Testing.

1. Contractor shall test the ICC as described below in the Execution Section and as described in Section 17030, Reliability Management Program.

2. The ICC integrates with several systems. Contractor shall test the functionality of the ICC with each system it integrates with including the PA, VMS, Radio and PABX Systems. After Contractor has verified each interface is working properly, Contractor shall test the overall integration of the ICC with all systems together to verify complete functionality in an operational environment.

3. Contractor shall submit factory and field test plans and procedures and shall demonstrate the successful operation and functioning of ICC, according to these Specifications.

B. Identification and Administration.

1. Contractor shall permanently and uniquely label all equipment delivered as part of the ICC.

2. Contractor shall provide an identification scheme and list of equipment with Identification Name to Engineer for approval. Contractor shall include in the Identification Name an indication of the type of equipment and the location.

3. Identification scheme for the ICC shall be uniform with all other Sound Transit Communications equipment labeling.

4. Contractor shall administer the design, development, test and installation of the ICC in accordance with these specifications.

1.08 TRAINING, MANUALS, SPECIAL TOOLS AND SPARE PARTS

A. Training.

1. After Factory Test and before Final Acceptance Testing, Contractor shall train up to 40 persons on the use of the ICC per the approved Training Plan and Manual. This training shall be combined with the PA and VMS training and shall include any additional user training that is not already included in the PA and VMS training.

2. Contractor shall train five (5) persons on the installation and maintenance of the ICC.

3. Contractor shall provide all training materials to include projectors, laptops, whiteboards, videocassette or DVD players, and handouts.
4. Contractor shall provide Engineer with five copies of all training materials to include Videos, DVDs, slides, trainer notes, manuals, and handouts for both users and maintenance personnel.

5. Contractor shall give a test or exercise to the training participants to demonstrate that they have learned the material and are prepared to use or install and maintain the ICC.

B. Manuals.

1. Contractor shall provide manuals for installing, maintaining and operating the ICC, according to the requirements described above in the Submittals Section.

2. The Manuals and Training provided shall be complete such that maintenance personnel that have been trained will be able to use the manual to install, maintain and troubleshoot basic problems associated with the ICC without assistance. Likewise a PA, VMS, Radio and/or PABX operator that has been trained will be able to use the integrated system without assistance.

1.09 DELIVERABLES

Contractor shall deliver a fully functioning Integrated Communication Controller System as part of the overall Sound Transit Communications System.

PART 2 - PRODUCTS

2.01 GENERAL

A. PA/VMS Functions.

1. The Integrated Communication Controller switch shall provide the following PA/VMS functions.

a.) Text-to-Voice.

1.) All messages, including ad-hoc messages, shall be created using a keyboard and text-to-voice technology. Keyboards shall be located at the Operations Control Center ICC Consoles.

- Note: For at-grade stations and EMPs, microphones shall be provided for ad-hoc local messages.

2.) Text-to-Voice capability shall meet the following requirements.

- Messages shall be able to be saved as either text or voice or both.

- Typed messages shall be viewed on a display screen before being annunciated and shall be able to be corrected.

- Messages shall have local playback and review capability.

- Text-to-voice shall have spell-checking capability.
- Annunciated messages shall be able to be paused, stopped, skipped, and rewound to be replayed. Paused or stopped messages shall be able to be corrected and replayed.

- Contractor shall supply the voices used in Text-to-Voice recordings in both male and female options each of which shall be approved by Engineer prior to implementation. Speech output from Text-to-Voice processor (over the PA System) shall be high quality, indistinguishable from a live person and fully intelligible by 9 out of 10 listeners as approved by Engineer.

3.) Text-to-voice shall have a minimum of 6 language options to include:

- English.
- Spanish.
- Russian.
- Korean.
- Japanese.
- Mandarin Chinese.

b.) For each message transmitted:

1.) The PAVMS controller shall activate PA messages and VMS messages to the appropriate zones and groups of zones as directed by the OCC operator.

2.) The PAVMS controller shall support multiple VMS zones per station and per the O&M Facility, and single PA zones at the stations or the O&M Facility, and shall be able to transmit to any of those zones individually and in combination.

3.) The PAVMS controller shall support multiple combined PA and VMS zones at each station, with one zone consisting of the station PA zone and one or more VMS zones.

4.) The OCC operator shall be able to select the following, from a single display and shall implement the actions with a single operation.

   - PA/VMS zones for any single station or for the O&M Facility.
   - No less than 100 user definable groups of zones.
   - Any combination of stations simultaneously.
   - All zones.

5.) The OCC Console shall provide a display that allows the operator to determine the messages being displayed at each VMS zone and the messages being broadcast at each PA zone.

6.) The PAVMS System shall support ad hoc and pre-recorded PA transmissions to individual zones and groups of zones from the Control Consoles at the OCC. For
pre-recorded audio messages, the PA/VMS Controller shall direct an audio output path from the digitally stored audio messages at the Control Consoles to the PA equipment in the zone or zones selected by any Console.

7.) The PA/VMS System shall support ad hoc and predefined VMS transmissions to individual zones and groups of zones from the Control Consoles at the OCC. For predefined VMS messages, the Consoles shall be able to do the following:

- Retrieve the specified messages from local digital storage at the Consoles and transmit the message with its predefined message attributes to the VMS equipment in the zone or zones selected by any Control Consoles.

- Automatically repeat transmission of the message up to the value of the repeat count limit.

- Automatically repeat transmission of a message at a specified time interval.

- Continually repeat the message until canceled by an OCC operator or until a higher priority message contends for VMS equipment used by that message. The low priority message shall automatically resume repeat operations when the contention is over.

8.) The PA/VMS controller shall automatically implement simultaneous transmission of PA messages and companion VMS messages to combined PA and VMS zones and groups of combined zones. Upon a Controller command to transmit a pre-recorded PA audio message which is defined to have a companion pre-defined VMS message:

- The audio message shall not be audible at the PA speaker more than one second before the VMS message is viewable on a VMS.

- The VMS message shall not be viewable at a VMS more than one second before the audio message is audible at the PA speaker.

- The time between a command entered at a Control Console to initiate a visual public address text message until the first character of the message is displayed on all applicable VMSs shall be no more than five seconds.

- The time between a command entered at a Control Console to initiate a stored public address audio message until the message is first heard on all applicable PA speakers shall be no more than four seconds.

9.) The PA/VMS Controller shall support simultaneous transmissions from the PA/VMS Consoles of multiple (e.g., one per Control Console) PA messages and VMS messages to each VMS zone. Time related messages shall display actual time if they are delayed in transmission. The Control Console that originated the message shall be able to cancel any message in progress.

10.) Each public address audio message sent over the speakers shall include a passenger alert tone preamble that shall be adjustable in duration from two to five seconds and is separated from the audio message body by approximately one second.
11.) All PA pre-recorded and ad-hoc audio messages sent from the OCC shall be recorded on existing digital recording equipment.

12.) O&M Facility.

- Contractor shall divide the O&M Facility such that each floor and the shop area shall be a separate PA zone.

- Contractor shall provide access to each zone or group of zones in the O&M Facility from the PABX phone system, using a password or access code to restrict access.

c.) Automatic Messages.

The Integrated Communication Controller shall have an interface with the Central Control System in order to automatically display the arrival time and destination of the next train as well as service messages such as “Next Train Out of Service” on the station VMS signs. This message shall be of the lowest priority. It shall be continually updated and displayed as long as there is no other message directed to the VMS.

B. PA/VMS Message Control.

1. The PA/VMS Controller and Console shall provide for definition, storage, and cataloging of PA and VMS messages, and for selection and transmission of PA messages and VMS messages to selected PA and VMS zones. At least 250 pre-recorded PA with corresponding VMS messages shall be supported. At least 250 predefined VMS messages, without corresponding pre-recorded PA shall be supported. Each predefined VMS message may be up to 500 characters. Each pre-recorded PA message may be up to 60 seconds. At least 250 minutes of total PA storage capability shall be provided. PA and VMS messages may be stored at the stations locally and remotely activated.

2. Message control capabilities shall include the following:

a.) Defining zones, based on the actual PA and VMS equipment zones to allow for selection of destination for each message.

b.) Defining pre-recorded/predefined PA and VMS messages, the definition of each to include the following:

1.) The title/identification code and storage location.

2.) Any additional information required by the PA/VMS Controller to access the pre-recorded/predefined PA or VMS message upon Console operator selection.

3.) The priority of the message.

4.) The title/identification code of a corresponding predefined message from the opposite medium (PA/VMS).
c.) Adding, deleting, or modifying pre-recorded PA messages. Modifying PA messages shall be through control of the stored audio messages.

d.) Adding, deleting, or modifying VMS messages. Editing of VMS messages shall be through a text editor with standard editing features. For each message, the following shall be able to be specified:

e.) Display attributes (such as flashing, scrolling) of each message, consistent with the characteristics and capabilities provided by the VMS equipment.

f.) Format attributes (such as character font and size, single line, two lines, graphics) of each message, consistent with the characteristics and capabilities provided by the VMS equipment.

g.) Viewing and printing a list of all pre-recorded/predefined messages. The list for each message shall indicate the following:

1.) Title/identification code.

2.) Location or storage access information.

3.) Priority.

4.) Corresponding PA/VMS message (if any).

3. Any Console shall be able to view the stored message text for any message by selecting the corresponding title/identification code.

C. Message transmission shall satisfy the following requirements:

1. Ad hoc PA and VMS messages destined for multiple stations shall be transmitted simultaneously to each of those zones.

2. A pre-recorded PA message with its corresponding VMS message destined for multiple stations shall be transmitted simultaneously to each of those zones.

3. High priority (emergency) messages shall be transmitted immediately and shall be preceded by an audible alert tone transmitted to the corresponding PA Zones and a strobe initiating signal sent to corresponding VMS Zones.

4. If a contention occurs for multiple message transmission, then the resolution shall be by the specified priority of the message. If a message cannot be transmitted because a zone selected for the message is busy with a higher priority message, the message shall be able to be canceled. However, it shall override any lower priority message in progress.

5. The PA/VMS Controller and Console shall detect completion of transmission of each message. The time between completion of transmission of a message to a zone and start of transmission of the next queued message to that same zone shall not exceed three seconds nor be less than one second.
D. Recording of Audio.

All microphone, select and unselect audio including pre-recorded messages from each active existing and furnished Console shall be output to the recorder at all times. One channel shall be used for unselect audio and one channel for microphone and select audio.

E. Channel Status Cells.

1. One channel status cell shall be displayed for each channel at each Console. Multiple pages of cells shall be utilized.

2. The cell for each channel shall display the following information:

   a.) Channel or line name.

   b.) The current status of the channel.

      1.) Busy.

      2.) Conference.

      3.) Alarm.

F. Alarms.

Alarms from the Integrated Communication Controller equipment shall be displayed at the OCC Console as part of the CCS Software. Handling alarms from the Communication Controller is covered in Section 17841, CCS Software and Equipment.

2.02 INTEGRATED COMMUNICATION CONTROLLER EQUIPMENT

A. The ICC shall be based on the Penta Corporation model PCx Control System non-blocking audio switch, or approved equivalent. Equivalency shall be based upon functionality so as to allow more advanced equipment to be used than was available at time of bid.

B. Processors.

Processors shall be redundant Pentium-based Management Terminal Unit processors that are compatible with the Penta PCx Control System or approved equal. MTU processors shall be subject to Engineer's approval.

C. Audio Switching Matrix.

Contractor shall provide a switch matrix configuration of 256-line configuration. Contractor shall provide Switch Matrix Cards, Switch Card Baskets/Motherboards and interconnecting wire and cable as necessary to support all required lines. Contractor shall perform all configuration and programming necessary.
D. Line Interfaces.

Contractor shall provide Line Interface Cards, Line Card Baskets, and interconnecting wire and cable as necessary to support all required lines. Contractor shall perform all configuration and programming necessary to integrate the line interface hardware enhancements into the Penta PCx Control System or approved equal.

E. ICC Interfaces.

1. The ICC shall interface to several pieces of ST Communications systems, as described here and as shown in the Contract Drawings. Specifically the ICC shall interface with the Radio System, the Central PA network, the Emergency Telephone Controller, and the PABX, as described below.

2. Contractor shall provide DID Lines on the analog switch component of the Integrated Communications Controller in order to provide additional interfaces with external organizations, particularly for emergency phones.

3. Contractor shall provide a one-way interface to the ST Communications System PABX such that data flow is from the ICC to the PABX. The one-way flow of data is for security purposes; the ICC is considered secure within the ST Communications firewall, and the PABX is considered non-secure.

F. Maintenance Interface.

Contractor shall provide Console Interface Cards, Console Interface Card Baskets, and interconnecting wire and cable as necessary for the number of Console positions specified in this document. Contractor shall perform all configuration and programming necessary.

G. Power Supply.

1. Power Supply requirements shall adhere to Section 16610, Static Uninterruptible Power Supply, and/or Section 16615, Dc Rectifiers and Power Systems, of this specification with the following additional requirements.

2. The Integrated Communication Controller's internal power supply shall be in a redundant configuration with load sharing. The internal power supply shall derive all required voltage and signal levels from the 110 V (ac) input. The power supply shall be electrically compatible with the attached PA/VMS Controller electronic equipment.

3. The total attached Integrated Communication Controller electrical load to a single power supply shall not exceed 75 percent of its rated capacity at any of the supplied voltages.

H. Equipment Mounting.

All PCx Control System electronics shall mount on EIA standard 480 mm (19 in.) rails in furnished equipment cabinets.

I. End-to-End Specifications.

1. All enhancements or changes to the Integrated Communication Controller shall not result in a degradation of the current audio performance specifications for transmit and receive
channels, from microphone input to line card output and from line card input to Console speaker output. These performance specifications include, but are not limited to:

a.) Frequency Response: +1 dB to -3dB, 300 Hz to 3.2 kHz.

b.) Distortion: ≤2.0 percent.

c.) Hum, and Noise: >50 dB below audio.

d.) Crosstalk: >60 dB below audio.

e.) PTT Response Time: <1 second.

f.) Switching Setup Time: <1 second from selection to execution.

g.) Integrated Communication Controller Management/Monitoring.

h.) Integrated Communication Controller shall be monitored and managed using the Communications Network Management System per Section 17910, Communications Network Management.

2.03 CONSOLE EQUIPMENT

A. General.

The Console Integrated Communication Controller equipment shall be identical for all Consoles.

B. Processor.

1. The Console interface to the central electronics console line card shall be the latest Penta PCx Control System compatible model, or approved equal.

2. Speed and memory of the workstation equipment at each Console shall allow for performance of all the PA/VMS functions without delays longer than 250 ms in response to operator commands.

C. Workstation Audio Jack Board.

One workstation audio jack board shall be furnished for each furnished Console. The Workstation Audio Jack Board shall be the latest Penta compatible unit, or approved equal. The Audio Jack Board shall connect to the Computer Workstation Audio Board and provide connections for local Console Headset/Handset Microphones, Dynamic Microphone, Push-to-Talk Footswitch, Operate Speaker, and Monitor Speaker.

D. Each Console audio interface shall include audio driver equipment (amplifiers), operate and monitor speakers, two headset/handset microphone jacks, and push-to-talk control equipment.
E. Operate and Monitor speakers shall be mounted within separate panel mounted enclosures. All other audio interface equipment shall be mounted within the Console furniture.

F. Operate and Monitor audio speakers shall be flush mounted within enclosures and covered with a protective grate.

G. Operate and Monitor audio speakers shall have individual volume controls located on the console panel. Mute capability shall be provided for the Monitor audio speaker. The Operate speaker volume control shall have a minimum volume stop such that it cannot be adjusted to an inaudible level.

H. Each Operate and Monitor audio speaker shall be a 5 W, 8-ohm speaker. Each speaker driver and transformer shall be mounted to the rear of the panel.

I. Audio jack receptacles for monitoring Operate or Monitor speakers with headsets shall be located beneath the Console desktop. When a headset is plugged in, the audio path to the Operate speaker shall be disconnected.

J. Ac power shall be supplied to the Console audio interface equipment. Any power supply required shall be internal to the driver equipment.

K. Each Console audio interface shall have a spare audio output port for Monitor audio, with switch selection to direct audio to the port, for use with an external 8 ohm, 5 W remote speaker, provided by others. When audio is directed to this port, it shall not disconnect audio from the Console speaker or affect the audio volume level.

L. Additional Console Equipment.

1. Two Plantronics headsets, or approved equal, shall be furnished with each Console.
   a.) Headset shall be a wireless design.
   b.) The headset shall operate from distances up to 30 m (100 ft.) to the base transceiver.
   c.) The base transceiver shall communicate to the remote headset using a frequency that doesn’t interfere with existing wireless traffic.
   d.) The base transceiver's receive output shall present a source impedance of 25 ohm and the transmit input shall present a source impedance of 300 ohm.
   e.) Earset shall have cushioned earpieces.
   f.) Microphone and earset shall be attached to a padded, adjustable leather headband.
   g.) The base transceiver's audio coil cord's plug shall match the audio jack receptacle type.
   h.) The headset shall use push-to-talk keying.
2. Two headset interface jacks shall be furnished for each Console.
   a.) Each headset interface jack at each Console shall have a plug-in headset outlet.
   b.) The jacks shall include a volume control adjustment with minimum volume stop and shall include a pre-amplifier for the headset microphone.
   c.) When a headset is plugged in, the select audio at the audio panel shall be routed to the headset.

3. Foot Switch.
   a.) A Push-To-Talk (PTT) foot switch shall be furnished and installed beneath the Consoles.
   b.) Foot switch shall be of rugged construction with non-skid feet. Foot switch shall be connected with a heavy-duty insulated card.

4. Desk Top Microphone.
   a.) Contractor shall provide a desktop microphone that shall be Omni-Directional dynamic desk type with coiled cord.
   b.) The microphone shall be low impedance, push-to-talk, with normally shorted microphone element and normally open dc control contacts.
   c.) The microphone shall have a frequency response, which extends beyond the channel bandwidth of 300 Hz to 3.3 kHz at the low and high ends.

2.04 STATION PA/VMS CONTROLLER

A. Station PA/VMS Controller Functionality.

1. Station PA/VMS equipment including public address audio line selection/preamplification, video message signs, and local video message sign input device, shall interface to an Audio Station Controller in each Communications Cabinet or Bungalow. The Station PA/VMS Controller shall perform the following functions:
   a.) Differentiate and route the incoming PA audio signal to its Amplifier Line Out connection serving the attached public address equipment.
   b.) Accept E lead signaling for the purposes of keying attached public address equipment.
   c.) Differentiate and demodulate the incoming VMS modulated and encoded data sent from the OCC and translate the incoming message stream to a format required by the attached visual message signs.
d.) Accept DTMF tones from two locally attached four wire telephones and translate
tones into prerecorded message requests to the OCC.

e.) Accept a data stream from an attached Local VMS input device and translate the
incoming message stream to a format required by the attached video message signs.
Notify the OCC of local generation of VMS messages.

B. Station PA/VMS Controller Equipment.

1. The local Station PA/VMS Controller shall be Penta PAx Zoned Audio and Priority
Controller, or approved equal. The Station PA/VMS Controller shall have the capability to
control up to eight zones with PA and VMS for each station. The Station PA/VMS
Controller shall be equipped with the following modules at a minimum:

a.) One Data Plus Voice Modem Module.

b.) Two each Kiosk 4-Wire Phone Modules.

2. For Aerial stations, Contractor shall provide the capability and equipment required to
send canned PA and VMS messages, and ad hoc PA messages from the Fire Command
Center. This equipment shall be integrated with the PABX and ETEL Systems.

C. Station PA/VMS Controller shall include an option for a local VMS Input Device Wireless
Interface.

D. Station PA/VMS Controller shall have the capability of interfacing with Digital IP Telephones.

2.05 MESSAGE RECORDER

A. Connections from the Integrated Communication Controller to the MDF shall be established
to record all monitored audio output from each console interface using MP3 digital audio
format, or approved equal.

B. Sufficient storage shall be furnished at the Archive Server in the Central Communications
System (see Section 17800, Control System Overview) for at least 90 days of audio
recording from all possible sources plus 50 percent additional growth space.

PART 3 - EXECUTION

3.01 PREPARATION

Engineer will schedule design reviews with Contractor. The design reviews shall encompass
Contractor submittals for the Preliminary and Final Design. This Section augments the design
reviews described in Section 01650, Product Delivery Requirements.

3.02 FACTORY TESTING

A. Functional tests of the Integrated Communication Controller shall be performed after all
wiring has been completed.
B. Contractor shall temporarily connect the manager terminal and at least one Console to the common electronic equipment for factory testing.

C. Contractor shall verify the following:
   1. Audio continuity from each furnished and existing line card to the Console.
   2. PA and VMS Zone selection and connection procedures are functioning.
   3. Signaling to and from furnished and existing line cards is operational.

D. Contractor shall pre-set line levels for all line cards, as follows:
   1. Utilize a Transmission Impairment Measurement Set (TIMS).
   2. Set input and output levels to nominal Transmission Level Point (TLP).
   3. Record gain settings of line cards.
   4. Verify that the end-to-end SNR, Crosstalk, THD, and Frequency Response from controller input to Console output and Console input to controller output are in accordance with the requirements of this Specification.

3.03 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment.

3.04 INSTALLATION

A. Contractor shall submit installation drawings prior to installation of the PA System at any station and the O&M Facility. Contractor shall proceed with the installation only after the approval of installation drawings.

B. Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

C. Contractor shall position equipment according to the approved drawings.

D. Contractor shall route power and audio cables subject to approval by Engineer, and the requirements of NFPA 70 Article 800.

E. Contractor shall terminate all cables and make all connections necessary to activate all channels and all Consoles.

F. Contractor shall test all multi-pair connectors made in the field for crosses, shorts, opens, and color code violations.

3.05 FIELD TESTING

A. Field tests shall be performed after all installation has been completed.
B. A complete functional test shall be performed for each furnished and existing Console.

C. Contractor shall verify operation of each communications source for the following:
   1. Line Selection.
   2. Transmit keying.
   3. Loop closure.
   4. PTT Control.

D. Contractor shall verify Alarm Operations for the following:
   1. Line card failure.
   2. Loss of line continuity to repeaters.

E. Contractor shall verify line assignment files.

F. Contractor shall verify all manager terminal functions including report generation.

G. Contractor shall verify proper audio recording playback and transport switching functions.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17730
PART 1 - GENERAL

1.01 OVERVIEW

A. Sound Transit Communication System shall incorporate timing and synchronization at various levels of the network for synchronous communications, system time, and correlation of events. Contractor design shall accommodate the delivery of Stratum Level 1 synchronization to all communications systems directly connected, and Stratum 2 synchronization to devices connected to the Master Clock System over the communications backbone. The goal of the Master Clock System is to enable the correlation of events across the Link System to the nearest 0.1 second.

B. This Section specifies furnishing, installing, and testing a complete Master Clock System.

1.02 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding Requirements.
B. Section 16120 – Electrical Wires and Cables.
C. Section 17030 – Reliability Management Program.
D. Section 17040 – Technology Documentation.
E. Section 17050 – Configuration Management.
F. Section 17060 – Special Tools and Spare Parts.
G. Section 17070 – Human Factors Engineering and Ergonomics.
H. Section 17150 – Facility Cabling Requirements.
I. Section 17510 – Communication System Backbone Equipment.
J. Section 17550 – Leased Lines.
K. Section 17800 – Control System Overview.
L. Section 17801 – Control System Network.
M. Section 17910 – Communications Network Management.

1.03 REFERENCE STANDARDS

A. ANSI T1.101 Synchronization Interface Standards for Digital Networks.
B. ANSI T1.105 Telecommunications-Synchronous Optical Network (SONET)-Basic Description including Multiplex Structure, Rates, and Formats.
1.04 CITED STANDARDS

A. ANSI T1.101 Synchronization Interface Standards for Digital Networks.

B. ANSI T1.105 Telecommunications-Synchronous Optical Network (SONET)-Basic Description including Multiplex Structure, Rates, and Formats.

1.05 QUALITY CONTROL

Quality Control is as specified in this document. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations. In addition, all equipment shall be UL listed.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals are subject to Engineer approval.

1. Preliminary Design Review.

   a.) Contractor shall submit as part of Contract drawings the layout of the Master Clock System equipment at the equipment room and at each station that has timing equipment. Additionally Contractor shall identify Stratum Level 1 Server, Level 2 Servers and Devices, and Level 3 Computers and Devices.

   b.) Contractor shall submit a detailed list and description of all equipment intended for use in the Master Clock System including manufacturer’s cut sheets.

   c.) Contractor shall submit a draft description of the Master Clock System design to include system operations and maintenance.

2. Final Design Review.

   a.) Contractor shall submit the final location of all Master Clock System equipment at the equipment room and at each station as part of Contract drawings.

   b.) Contractor shall submit a final detailed list and description of all equipment intended for use in the Master Clock System.

   c.) Contractor shall submit a final description of the Master Clock System design to include system operations and maintenance.
3. Factory Test Procedures.

Contractor shall submit Factory Test Procedures prior to Factory Testing in accordance with the administrative requirements detailed in Section 01330, Submittals.

4. Installation Drawings.

Contractor shall submit Installation Drawings as indicated in this specification prior to Installation in accordance with the Administrative requirements detailed in Section 01330, Submittals.

5. Final User Documents.

Prior to Final Acceptance Testing, Contractor shall submit final versions of the following. Contractor shall submit all manufacturer’s standard manuals in addition to the Contractor documents.

a.) User Manuals.

b.) Maintenance Manuals.

c.) Training Plan.

d.) Training Manuals.

6. Training.

After Factory Test and before Final Acceptance Testing, Contractor shall train up to 40 persons on the use of the Master Clock System per the approved Plan and Manual.

7. Final Acceptance Test Procedure.

Prior to the Final Acceptance Test, Contractor shall submit the final Test Plan and Procedures.

8. Test Results.

Prior to acceptance of the Master Clock System, all test results must be submitted. Test results are subject to Engineer inspection.

9. As-Builts.

Prior to acceptance of the Master Clock System, all as-built documentation must be submitted. As-builts are subject to Engineer inspection.

1.07 DELIVERABLES

In addition to the Submittals described above, Contractor shall deliver a fully functioning Master Clock System in accordance with these specifications, as well as user and maintenance documentation supporting the delivered Master Clock System.
PART 2 - PRODUCTS

2.01 GENERAL

A. All SONET network elements shall be integrated into the synchronization hierarchy as described and specified in ANSI T1.101.

B. Contractor shall provide and install all equipment to obtain and distribute date and time of day from the Stratum 1 Clock Oscillator.

2.02 EQUIPMENT RELIABILITY

Contractor shall provide a Master Clock System that maximizes reliability. This Master Clock System shall provide all network and FCS devices with a traceable clock via redundant timing sources.

2.03 STRATUM 1 CLOCK OSCILLATOR

A. Contractor shall meet the North American Stratum 1 clock stability requirements by providing a Stratum 1 Clock Oscillator at the OCC. This shall be utilized to provide an external timing/loop timing configuration for proper SONET network synchronization. The following North American Stratum 1 Clock Oscillator requirements shall be met:

1. Minimum accuracy: 1 x 10⁻¹¹ seconds.


3. Minimum pull-in range: Capable of synchronizing to clock with accuracy of 1 x 10⁻¹¹ seconds.

4. Clock Oscillator shall have the following visual indicators: Power, Tracking GPS, Oscillator Locked, Battery Ready, Battery Charging, Battery Fault, Minor Alarm, and Major Alarm.

5. All SONET ADMs shall be loop timed off the Stratum 1 Clock Oscillator at the OCC.

6. Stratum 1 Clock Oscillator shall be capable of accepting two Clock Sources (primary GPS and a backup timing source) and shall be capable of switching to the backup source should connection to the primary source fail.

7. Interfaces.

a.) The Stratum 1 Clock Oscillator shall provide the following minimum interfaces:

1.) One interface to GPS Antenna: L1, C/A Code transmitted at 1575.42 MHz ("N" Type Female).

2.) One interface to Secondary clock source (Loran-C, GOES Antenna, or NIST).

3.) The Stratum 1 Clock Oscillator shall have two Data Communications interface ports for specialized maintenance and administrative activities. A front access
port shall be configured as a data circuit-terminating equipment (DCE) for direct
terminal access. A rear access port shall be configured as a data terminal
equipment (DTE) to allow a permanent modem connection without requiring a
null modem.

4.) One interface to System Time Server.

5.) Timing Outputs: 1544 kHz and 2048 kHz @ RS-485 levels (RJ-11).

6.) Data Clock Outputs: 9.6 kHz, 18 kHz, and disciplined 1 PPS at RS-485 levels
(DB 9 Female).

7.) Data Sync Outputs: 64 kHz, 18 kHz, 17-2/3 Hz, 33-1/3 Hz at RS-485 levels (DB
15 Female).

8.) Alarm Outputs: Relay contacts SPDT, 2A @ 30 VDC (terminal strip).

9.) Power: 115/230 VAC ±15 percent, 50/60 Hz.

8. The date and time of day shall be distributed to and used by the Communications System
Backbone equipment. The time of day present in the Communications System Backbone
equipment shall be accurate to +/- 0.01 second.

2.04 GPS ANTENNA CLOCK SOURCE

A. Contractor shall provide an active GPS Antenna tuned to receive the 1575.42 MHz L1 band
satellite transmissions.

B. The active antenna circuitry shall provide 30dB of gain and shall require +5 VDC at 27
milliamps. Each antenna shall be terminated with a type "N" female connector.

C. The GPS Antenna shall be of weatherproof compact design.

D. Antenna Location.

The GPS antenna shall be installed outdoors where an unobstructed view of the sky exists.
Contractor shall mount the antenna on a rooftop where possible, with clear views to the
horizon, allowing the antenna to see and track the maximum number of satellites throughout
the day.

E. Antenna Cable.

Contractor shall connect GPS Antenna via a RG-213 coaxial cable. Antenna shall be a
maximum of 200 feet from the Oscillator, if possible. Contractor shall not allow the cable to
be placed in a location where standing water could accumulate, as water may permeate
through the coax jacket over time. On flat roof installations, the coax shall be suspended by
cable hangers or placed in sealed PVC conduit. Contractor shall apply a weatherproofing
sealant or tape over all outdoor connections.
2.05 SECONDARY CLOCK SOURCE

A. A Loran-C, GOES or other Engineer-approved Antenna Clock Source shall be provided as a secondary redundant clock source to the GPS Antenna described above. The Secondary Clock Antenna shall have the following characteristics.

1. The Loran-C (or GOES) Antenna shall be of weatherproof compact design.

2. The active antenna circuitry shall provide 30dB of gain and shall require +5 VDC at 27 milliamps. Each antenna shall be terminated with a type "N" female connector.

3. Antenna Location.

The Loran-C (or GOES) antenna shall be installed outdoors where an unobstructed view of the sky exists. Contractor shall mount the antenna on a rooftop where possible, with clear views to the horizon.

4. Antenna Cable.

Contractor shall connect Loran-C Antenna via a RG-213 coaxial cable. Antenna shall be a maximum of 200 feet from the Receiver, if possible. Contractor shall not allow the cable to be placed in a location where standing water could accumulate, as water may permeate through the coax jacket over time. On flat roof installations, the coax shall be suspended by cable hangers or placed in sealed PVC conduit. Contractor shall apply a weatherproofing sealant or tape over all outdoor connections.

2.06 SYSTEM TIME SERVER

A. The System Time Server shall provide date and time within +/- 0.001 second (Stratum 1) over Ethernet from the Stratum 1 Clock Oscillator to all substation equipment to include at a minimum:

1. Central Control System.

2. Firewall and OS Network.

3. PA/VMS/Radio Server and subsystems.

4. PABX Subsystem.

5. Operations Control Center LAN.


2.07 STATION TIME

Station applications such as FCS, CCTV, and PA/VMS shall acquire timing and synchronization information from the Central application servers and network devices.
PART 3 - EXECUTION

3.01 GENERAL

This Section describes the preparation, testing, installation and acceptance of the Master Clock System.

3.02 PREPARATION

Engineer will schedule design reviews with Contractor. The design reviews shall encompass Contractor submittals for the Preliminary and Final Design.

3.03 FACTORY TESTING

A. Contractor shall assemble all equipment and materials to form a complete functioning system and perform factory tests on each complete system prior to shipment.

B. Factory Testing shall be conducted to ensure functionality of the Master Clock System per the specifications in this Section. Factory testing shall also be conducted to verify that an accurate date and time be communicated to the System Time Server and transmitted over Ethernet to various subsystems, as described above.

C. Factory Testing shall be conducted to ensure accurate date and time is transferred over the Communications System Backbone through the Station Add Drop Multiplexer (ADM) to the Station Time Server, and from there over Ethernet to the Field Control System.

D. Factory Testing shall be conducted to ensure automatic fail over such that if the GPS Antenna fails, accurate time is still transferred to all connected equipment from the secondary antenna source.

3.04 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment.

3.05 INSTALLATION

A. Contractor shall submit installation drawings prior to installation of the Master Clock System at the CCER and at every station. Contractor shall proceed with the installation only after the approval of installation drawings.

B. Contractor shall follow manufacturer's recommended installation practices, Contract Specifications, and Contract Drawings during construction.

3.06 FIELD TESTING

A. Field Tests shall be conducted in compliance with Engineer-approved plans and procedures.

1. Field acceptance tests shall consist of exercising each system function through its required operations, under simulated conditions, to prove that the installation complies with specified requirements.
2. Contractor shall:
   a.) Furnish certified test reports for field acceptance tests.
   b.) Provide equipment and apparatus required for the tests.

B. Contractor shall verify in the field the functionality of each piece of equipment, as well as the accuracy of the Master Clock System at each SONET node, over the operational fiber backbone.

C. Contractor shall verify the secondary clock capability such that if the primary clock source equipment fails the system shall swap to a backup source and all equipment shall continue to accurately synchronize and display time per these specifications.

D. Contractor shall conduct end-to-end field testing of the Master Clock System.

E. Contractor shall verify accurate date, time and synchronization is provided to the Communications and Field Control System via the timing antennas, oscillator and System Time Server.

F. Contractor shall verify accurate date, time and synchronization information is passed through the SONET Communications System Backbone to each Station Time Server, and that accurate time information is communicated to the Field Control System.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17740
SECTION 17750
SECURITY AND SURVEILLANCE SYSTEMS OVERVIEW

PART 1 - GENERAL

1.01 SECTION INCLUDES

This section includes the overview of Security and Surveillance Systems required for the Sound Transit Communications System. The primary Security and Surveillance System specified in this section is the Closed-Circuit Television (CCTV) System, specified in Section 17751. Bar Codes and other FCS-related security is addressed elsewhere in these Specifications.

1.02 RELATED SECTIONS

Section 17751 – CCTV.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 SUMMARY

Separate measurement or payment will not be made for Work required under this section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17750
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PART 1 - GENERAL

1.01 OVERVIEW

A. Contractor shall design, furnish, install and test a Closed Circuit Television (CCTV) System that will record, transmit and store video images for Sound Transit Operations, emergency services and Sound Transit security. The CCTV system includes cameras, monitors, switches, and associated equipment and cables at passenger stations, tail tracks, storage tracks, DSTT, Park & Ride lots and Beacon Hill tunnel entrances and at OCC and Yard.

B. The CCTV system shall be designed to continuously record from every camera at every station 24 hours a day, seven days a week. The system shall store 72 hours of full frame (e.g. 30 frames per second) data at each station, and shall store 30 days of highly compressed video data at the central Storage Area Network. In addition, the CCTV System shall enable Sound Transit operators to select and view live feed of up to 32 cameras at the Operations Control Center (OCC).

C. The intent of the CCTV System is to passively monitor Link from the OCC and facilitate the Operator’s access by linking particular cameras to selected alarms and allowing Operators a “quick view” feature. The digital system shall allow authorized users to search indexed video storage for event analysis as well as view live feed video from any camera at any console or EMP in the system over the WAN. Future capabilities may include remote users accessing video via the internet but only the capability should exist today.

1.02 SECTION INCLUDES

This Section includes the requirements required to design, furnish and install the CCTV System.

1.03 RELATED SECTIONS

A. Section 16060 – Electrical Grounding and Bonding.

B. Section 16120 – Electrical Wires and Cables.

C. Section 17030 – Reliability Management Program.

D. Section 17040 – Technology Documentation.

E. Section 17050 – Configuration Management.

F. Section 17060 – Special Tools and Spare Parts.

G. Section 17070 – Human Factors Engineering and Ergonomics.

H. Section 17080 – System Support.

I. Section 17140 – Backbone Cabling Requirements.

J. Section 17150 – Facility Cabling Requirements.
K. Section 17310 – PABX.

L. Section 17360 – Emergency Phone System.

M. Section 17365 – Passenger Emergency Telephones.

N. Section 17510 – Communication System Backbone Equipment.

O. Section 17530 – Video Circuits.

P. Section 17730 – Integrated Communications Controller.

Q. Section 17740 – Master Clock System.

R. Section 17800 – Control System Overview.

S. Section 17801 – Control System Network.

T. Section 17910 – Communications Network Management.

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section.


7. NEMA Enclosures for Electrical Equipment up to 1000 Volts.

8. UL 50 Standards for Safety for Enclosures of Electrical Equipment.

9. IEEE 802 Local and Metropolitan Area Networks.


11. ADA Americans with Disabilities Act.
B. The standards applicable to CCTV Systems.


6. EIA-310-C Racks, Panel Boards, and Associated Equipment.

1.05 QUALITY CONTROL

Quality control is as specified in this document. Equipment and equipment installation shall conform to all applicable National Electrical Code, and local regulations.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals are subject to Engineer approval.


   a.) Contractor shall submit the following information prior to CCTV Conceptual Design Review per the schedule and requirements set in Section 01330, Submittals.

      1.) Description of CCTV functions.

      2.) Display layouts showing the location and type of CCTV cameras.

      3.) Display layouts showing the Station Control and OCC equipment.

      4.) Preliminary list of equipment.

      5.) Deviations and exceptions from Design Requirements.

2. Preliminary Design Review.

   a.) Contractor shall submit the following information prior to CCTV Preliminary Design Review per the schedule and requirements set in Section 01330, Submittals.
b.) Layout of CCTV cameras and associated CCTV equipment at each station, control center, and equipment room.

c.) Detailed list and description of all equipment intended for use.

d.) Draft Use Cases for CCTV system.

e.) Draft description of CCTV system design, operations and maintenance.

f.) Calculations of storage capacity and link loss.

3. Final Design Review.

a.) Contractor shall submit the following information prior to CCTV Final Design Review, per the schedule and requirements set in Section 01330, Submittals.

1.) Detailed description of CCTV system design, operations and maintenance to include the following:

(a.) System design for a typical station.

(b.) Loss calculations for coaxial cabling from cameras to receiver equipment at a typical station. Contractor shall determine requirements for equalizers.

(c.) Loss calculations for fiber-optic cables from stations to interface stations for all stations. Contractor shall include losses due to splices and connectors.

(d.) Description and purpose of proposed test and diagnostic equipment.

(e.) List of proposed lenses for all camera installations. Contractor shall provide calculations of coverage for all camera installations.

(f.) Control scheme for preset position(s) and recording for PTZ cameras.

2.) Final design schematics for the CCTV system.

3.) Contractor shall provide a technology review as part of the Final Design Package.

(a.) The technology review shall identify products that perform the following tasks.

(1.) Identify conditions such as hazards (smoke/poison gas, left baggage, or potential terrorists).

(2.) Alarm the conditions listed above to the OCC CCTV Operator.
(3.) Track selected individuals through the stations.

(4.) Provide greater resolution for identification purposes.

(b.) Contractor shall identify how Sound Transit could incorporate these technologies to achieve the functions listed above. At a minimum, Contractor shall produce evidence that the technology provided in this contract has a viable migration path to achieve the desired functions noted above.

4.) Final list and description of all equipment used for CCTV system.

5.) Installation manual and field installation details as required.

6.) User and Maintenance manuals.

7.) Test Plans, including Factory and Field tests.


Contractor shall submit Factory Test Procedures as described in Part 3 of this Specification Section.

5. Installation Drawings and Test Procedures.

Contractor shall submit Installation Drawings and Test Procedures as described in Part 3 of this Section.


a.) Prior to Final Acceptance Testing Contractor shall submit final versions of the following:

1.) User Manuals.

2.) Maintenance Manuals.

3.) Training Plan.

4.) Training Manuals.

7. Final Acceptance Test Procedure.

Prior to the Final Acceptance Test, Contractor shall submit the final test procedure for all testing.
8. Test Results.

Prior to acceptance of the System, all test results must be submitted. Test results are subject to approval by Engineer.

9. As-Builts.

Prior to acceptance of the System, Contractor shall submit all as-builts. As-builts are subject to inspection by Engineer.

1.07 TESTING, IDENTIFICATION, AND ADMINISTRATION

A. Testing.

1. Contractor shall test the CCTV System as described below in the Execution Section and as described in Section 17030, Reliability Management Program.

2. Contractor shall submit factory and field test plans and procedures and shall demonstrate the successful operation and functioning of the CCTV System, according to these Specifications.

B. Identification and Administration.

1. Contractor shall permanently and uniquely label all equipment delivered as part of the CCTV system.

2. Contractor shall provide an identification scheme and list of equipment with Identification Name to Engineer for approval. Contractor shall include in the Identification an indication of the type of equipment and the location. Contractor shall distinguish between PTZ and fixed cameras in the camera ID name.

3. Identification scheme for the CCTV System shall be uniform with all other Sound Transit Communications equipment labeling.

4. Contractor shall administer the design, development, test and installation of the CCTV System in accordance with these Specifications.

1.08 TRAINING, MANUALS, SPECIAL TOOLS, AND SPARE PARTS

A. Training.

1. After Factory Test and before Final Acceptance Testing, Contractor shall train up to 40 persons on the use of the CCTV System per the approved Training Plan and Manual.

2. Contractor shall train five (5) persons on the installation and maintenance of the CCTV System.

3. Contractor shall provide all training materials to include projectors, laptops, whiteboards, videocassette or DVD players, and handouts.
4. Contractor shall provide Engineer with five (5) copies of all training materials to include Videos, DVDs, slides, trainer notes, manuals, and handouts for both users and maintenance personnel.

5. Contractor shall give a test or exercise to the training participants to demonstrate that they have learned the material and are prepared to use or install and maintain the CCTV system.

B. Manuals.

1. Contractor shall provide manuals for installing, maintaining and operating the CCTV System, according to the requirements described above in the Submittals Section.

2. The Manuals and Training provided shall be complete such that maintenance personnel that have been trained will be able to use the manual to install, maintain and troubleshoot basic problems associated with the CCTV System without assistance. Likewise a CCTV System operator that has been trained will be able to use the CCTV System without assistance.

1.09 SUPPORT AND WARRANTY

A. Contractor shall provide support and shall warranty all equipment and hardware delivered for a period of one year after final system acceptance. Should any CCTV System hardware need upgrading (due to component failure or not meeting performance requirements) during the support period, Contractor shall replace that hardware or equipment (including spares) at no additional cost to Sound Transit.

B. Contractor shall provide Engineer with all vendor warranty, support and maintenance agreements to include contact information and any relevant information for the timely support of the CCTV equipment.

1.10 DELIVERABLES

Contractor shall deliver a fully tested, fully functioning, fully documented and Engineer approved CCTV System as described in these Specifications.

PART 2 - PRODUCTS

2.01 GENERAL

Contractor shall provide a CCTV system at the Sound Transit stations, tail and storage tracks and DSTT and Beacon Hill tunnel entrances indicated on the Contract Drawings. This system shall include cameras, housings, mountings, monitors, video switchers, video transmission and control equipment, and video recording equipment.

2.02 CCTV

A. OCC CCTV Functional Requirements.

1. The functional requirements for the operation of CCTV from the OCC augment those specified in Section 17841, CCS Software and Equipment.
a.) Standard Operations.

1.) OCC.

- Designated personnel (to include operators, train controllers and designated security fire/police or operational personnel) at OCC shall have the capability of selecting and viewing a video feed from any camera at any station from the CCTV Console.

- Operators shall be able to view video feed on their consoles and/or on the OCC overview display screen.

- Select Sound Transit and non-Sound Transit (e.g. emergency) personnel shall have the capability of accessing the CCTV control software remotely. This remote access shall allow for full capability of viewing and controlling the CCTV system, e.g., the remote user shall have the same capability remotely that he or she has on an OCC console. The remote access shall not require special software to be installed on the remote PC or laptop other than a standard web browser.

- Operators shall be able to record via DVD select events at their console in real-time. Recorded selected video events shall be watermarked and authenticated as specified elsewhere in this Section.

- Up to 16 simultaneous video streams shall be able to be viewed.

- The operator shall be able to select video feeds when there are multiple windows displayed, and shall be able to modify the size of the video view window on the screen.

- An operator shall have the capability of retrieving and viewing video feed from any camera for up to 72 hours of full frame (e.g. 30 frames per second).

- An operator shall have the capability of retrieving and viewing video from any camera for up to 30 days of compressed video (e.g. minimum of one frame per second.)

- OCC shall have priority for PTZ control over all other users except the EMP.

b.) Emergency Management Panel

Authorized personnel at the Station EMP shall have the capability of selecting and viewing a video feed from any camera at that station. EMP shall have the highest level of priority control for local PTZ cameras.

c.) Emergency Phone Off-hook.

1.) Passenger Emergency Telephone (PET) off-hook conditions shall cause an alarm in the CCS System. The alarm, when the field designating automatic
2.) Wherever possible, the image shall appear on the screen of the operator who is taking the call, especially in the case of multiple PET calls.

3.) The PET CCTV image shall be 200 percent of the nominal default CCTV window.

4.) The operator shall have the capability of closing the video window and of selecting another video feed.

B. CCTV Design.

1. The equipment under this Contract shall provide for surveillance of passenger station areas, end-of-line tail tracks, storage tracks, DSTT and Beacon Hill tunnel entrances, and Automatic Fare Collection equipment.

a.) Passenger Stations.

1.) All CCTV video shall be in color. The following areas shall have CCTV coverage. Specific locations of CCTV cameras are indicated on the Contract Drawings.

- Elevator Cabs (except for DSTT Elevator Cabs).
- Elevator lobbies.
- Escalators and public stairwells.
- Platforms.
- Platform edges.
- Station entrances and exits.
- O&M facility vehicle entrances, vehicle exits, public entrances, public exits and staff parking lots.
- Yard tracks, leads, and vehicles.
- Ticket Vending Machines (TVMs).
- Passenger Emergency Telephones (PETs).
- Tunnel Entrances for Intrusion.
b.) PTZ and Fixed Camera Locations.

1.) Fixed lens cameras shall be used at all above noted locations focusing on events at platforms and in fare vending areas. PTZ cameras shall be provided as needed. Cameras focused on elevator entrances are for assisting patrons using elevators. Cameras on the platform are for viewing the platform edges for the length of the platform.

2.) The operator at OCC shall have control over video sequencing and any camera selection. In addition an operator or approved personnel at the station may control the video feed and camera selection locally at the EMP.

c.) Passenger station equipment.

PTZ and Fixed Lens Surveillance cameras completely equipped with environmental housings. Cameras that are Pan Tilt Zoom (PTZ) shall have a default position set such that when not controlled they shall be set to focus on a default area, settable by the operator.

d.) The Station equipment room equipment.

1.) CCTV patch panel.

2.) CCTV transmission equipment for transmission to OCC.

3.) Video monitor.

4.) Camera control panel.

5.) Digital Video Recorders capable of minimum of 72 hours of full frame video.

e.) Tail and Storage Tracks.

1.) Contractor shall provide CCTV equipment for viewing tail tracks and mainline storage tracks. The designated operator shall have the capability of switching his/her view to any camera and controlling any camera position. Distances between cameras and monitors shall require fiber-optic video links. This equipment includes the following:

- Surveillance cameras, each complete with PTZ control (where applicable), environmental housing and mountings.

f.) DSTT Tunnel Entrances.

1.) Contractor shall provide the CCTV equipment for viewing DSTT and Beacon Hill tunnel entrances. The designated operator shall have the capability of switching his/her view to any camera and controlling any camera position. Distances between cameras and monitors shall require fiber-optic video links. This equipment includes the following:
- Surveillance cameras, each complete with PTZ control (where applicable), environmental housing and mountings.

- Night or day/night vision cameras should be used if needed to view 30 feet or less into any tunnel

g.) Automatic Fare Collection Equipment.

1.) Contractor shall provide color CCTV equipment for monitoring Automatic Fare Collection equipment at stations. Intrusion alarms at fare vending machines shall cause an alarm at the CCS that causes cameras to move to a position to monitor the alarmed machine when selected by Operator. Operators may then select the alarmed camera to view the machine in alarm. Machines in alarm shall be monitored in order of alarms. When the system is unalarmed the camera shall return to a pre-assigned position. The equipment shall include the following:

- PTZ cameras or fixed cameras with detachable mounting and preset control.

- Camera security enclosure.

- Video monitor.

- Camera control panel.

h.) OCC.

1.) Contractor shall provide termination equipment at the OCC to terminate video signals from Sound Transit stations, tail and storage track, and DSTT and Beacon Hill tunnel entrances. Equipment to monitor the CCTV system shall be provided at the station. The CCTV equipment shall include:

- Video monitors.

- CCTV Controller, server and controlling software.

- CCTV Storage (see Section 17510, Communication System Backbone Equipment, for CCTV Storage requirements).

i.) CCTV System at OCC shall monitor the video network. CCTV System shall be capable of detecting a video drop and alarming the operator. CCTV System shall be capable, wherever possible, of rerouting video if a remote connection fails.

2. CCTV Interfaces.

a.) Design, integration and testing interfaces between the CCTV subsystem and other subsystems and Work are as follows:
1.) The CCS shall monitor intrusion alarms for fare vending machines, and shall monitor Passenger Emergency Telephones for off-hook conditions for the purpose of selective positioning of associated cameras.

2.) Systemwide Cable Network.

    Modulator/demodulator interconnect for video back to OCC shall be implemented.

3.) Station Contract.

    Conduit for all cables between cameras, controls and monitors and local power for cameras at selected stations shall be implemented as indicated in the Contract Drawings and in Section 17150, Facility Cabling Requirements.

b.) User Interface.

1.) A single graphical user interface shall be provided to seamlessly control all camera switching, PTZ, storage, recording, viewing, playback, diagnostic and management functions.

2.) Features of the User Interface shall be made available to users by authorization

3.) User Interface shall be available to all users on the secure WAN including EMP’s. However, initially only Beacon Hill EMP need be fitted with monitors for CCTV viewing.

3. Equipment.

a.) Cameras.

1.) Cameras shall be color, vandal resistant, weather resistant, and auto-focus. Cameras will be a combination of fixed and PTZ, as indicated in the Contract Drawings.

2.) Cameras shall be recording continuously and recorded video shall be indexed by time. Recordings shall be stored digitally for a period of 72 hours at 30 frames per second. Video recordings shall also be compressed at a minimum of one frame per second and sent to central storage, where they will be archived for a period of 30 days. Digital video shall be in MPEG 4 format or Engineer approved equal.

3.) The compressed video stream shall be sent via the communications backbone network to the OCC to be archived for 30 days.

4.) The video recording method shall be an industry standard, non-proprietary format that includes the ability to digitally authenticate recording by an acceptable method to validate recording for use in a court of law. Digital authentication
method may be proprietary. Contractor shall identify the method of authentication in the design documentation.

5.) Basic Color Camera characteristics shall be as follows:

- **Input Voltage:** The camera shall operate meeting all specifications over a voltage range of 104 to 125 volts AC at 60 Hz, or 24 volts AC + 10 percent at 60 Hz. 120VAC shall be available at all camera sites.

- **Internal Synchronization:** In the absence of an external composite synchronization signal the camera shall provide the option of reverting to a synchronization signal that shall revert to crystal-controlled oscillator. The synchronization at the video output shall conform to the timing specified by EIA RS-170A. Contractor shall ensure that all cameras being monitored as part of a station system shall be powered off of the same power phase.

- **Video Format/Line Rate:** Video Format/Line Rate shall be determined by the synchronization source and shall be 2:1 interlaced at 480 lines 60 fields (or 30 frames).

- **Vertical Rate:** Vertical Rate shall be 59.95 Hz as determined by the synchronization source.

- **Horizontal Rate:** The Horizontal Rate shall be 15.750 Khz as determined by the RS-170A synchronization source.

- **Camera Image Sensor:** The Camera Image Sensor shall be a 1/3-inch, 2/3-inch, or 1/2-inch format Charge Coupled Device. All image sensors supplied shall be of a single type and size.

- **Signal to Noise Ratio (SNR):** The SNR shall be no less than 48 dB (unweighted).

- **Resolution Stability:** Resolution shall be maintained over the specified input voltage and frequency range and shall not vary.

- **Automatic Light Range:** The composite video output level shall be automatically maintained to within +/- 0.2 volts over scene changes of 1.1 footcandles to 10,000 footcandles with lenses of f/1.4 to f/360.

- **Video Output:** The video output shall be 1.0 volt peak to peak (0.7V video, 0.3V sync.) unbalanced composite signal, polarity black negative across a load impedance of 75 Ohms or other suitable format.

- **Impedance:** The camera output impedance shall be 75 Ohms +/-5 percent over the video frequency range, shall be source terminated, and shall be in compliance with EIA RS-170A.
- Lens Mounting: All Camera lens mounting shall be a standard C or CS mount, 1.0 inch in diameter with 32 threads per inch. Contractor shall standardize on a single type of mount.

- Camera grounding.

- Contractor shall provide power and signal grounding for the CCTV system according to the following guidelines, or Contractor may provide an approved equivalent camera grounding design.

- A camera mounted on a building should be grounded to the building's structural steel as near the camera as possible. (Contractor shall use 1-1/2 inch copper strap for grounding.) If the camera is mounted on a metal pole, it should be grounded to the pole and a proper ground system installed at the base. When mounted on a wood or other insulating support, the camera should be grounded to a 3-inch copper strap running from the camera mount to a proper ground system installed at the base. An additional 3-inch copper strap would run from a lightning rod or diverter to the ground system at the base. Separate the two straps on opposite sides of the pole and connect together only below grade. Side mounting the camera or providing a diverter above the camera provides some additional protection from a direct strike.

b.) Lenses.

1.) The iris lens installed on each camera shall be 1/3-inch format unless otherwise noted or required to meet performance requirements.

- All auto-iris lenses shall be directly interchangeable without electrical or mechanical modifications or adaptations. Each lens shall have a neutral density spot filter. Fixed focal length lenses shall be capable of mounting in a sealed environmental housing.

- Zoom lenses shall be equipped with a magnification of 6X. The lenses shall have a motorized zoom, iris and focus functions. Zoom and focus shall be remotely controlled; iris shall be automatically controlled at the camera. Each lens shall have a neutral density spot filter. Zoom lenses shall be capable of mounting in a sealed environmental housing.

c.) Environmental Housing.

1.) The environmental housing shall have the following characteristics:

(a.) Construction.

The housing shall be constructed of 6061T6 aluminum material and finished with a white, weatherproof, heat-reflecting paint in accordance with Manufacturing Method (MM) MM-33A. The primer shall be applied in accordance with MM-42. Dome type housing shall have mirror glass or plastic.
(b.) Performance.

The environmental enclosure shall prevent moisture or water from entering the camera. The enclosure shall protect the camera from water sources such as rain and fog. The enclosure shall be tamper-proof, with tamper-proof designs subject to approval of the Engineer.

(c.) Connector.

The camera connector/s for the environmental housing shall mount on the rear plate and be watertight.

(d.) Sun Shields.

Camera enclosures exposed to direct sunlight, at any time of the day, shall be equipped with a sun shield. Sun shield coatings shall blend into the coloration of the environmental enclosure.

d.) Video Displays.

1.) Video feed shall be displayed on the consoles as part of the Control Center display screens, as well as on the video wall at the OCC, and shall be displayed at the EMP console at the stations that have EMPs.

- Video Characteristics.

  Video Signal Format: The monitor shall meet the requirements of EIA Standard RS-170.

  Input Signal Level: Manually adjustable to accommodate composite NTSC signals from .50 volt to 2.0 volts peak to peak.

  Input Connection: Type BNC connector. High-impedance loop-through to Type BNC output connector, or switched internal 75-ohm termination.

  Horizontal Resolution: 480 TV lines minimum center of the video screen on color camera.

  Geometric Distortion: < 2% of EIA BALL Chart, maximum.

- Display Wall.

  The video display wall shall composed of the same type and style of displays as for the OCC Overview Display except LED technology shall only be acceptable if sufficient resolution is provided from the viewing console. A minimum of two screens shall be supplied, allowing sufficient screen area for the display of at least 32 windows of approximately ten (10) inch diagonal measurement containing CCTV images. All windows shall be movable and resizable up to the limits of the screen, preserving the aspect ratio of the image.
It shall be possible to define a default arrangement of CCTV images and the camera assignments thereto which will appear upon system startup.

e.) Camera Control Panel.

1.) The Camera Control Panel shall be a software driven control program. Specific hardware for heavy CCTV users shall be integrated into part of the ST OCC CCTV Console. The Camera Control Panel ensemble shall provide the operator with the ability to control the pan, tilt, zoom and focus of any camera; select any camera for control; and select any camera or cameras for viewing.

2.) Via the camera control panel, the user may select any camera for display in any existing window of the Display Wall or in a new window.

3.) The Camera Control Panel ensemble shall have the following additional capabilities:

- The Camera Control Panel ensemble shall have the capability of communicating with the camera and pan/tilt/zoom control receivers.

- The Camera Control Panel ensemble shall have the capability of communicating with peripheral devices such as video switches, digital video recorders, and video storage devices.

- The Camera Control Panel ensemble shall have the capability of the following operator control features:

  Display.

  Keypad.

  Zoom and Focus Control.

  Pan/Tilt Joystick Control (at OCC only, keypad control for EMPs and control outside of the OCC).

  Switcher Control.

- The Camera Control Panel ensemble features shall have the following functions:

  Display - shall be able to display the indicator for the current camera(s) selected for viewing.

  Keypad - shall be used to program the Control Panel for the following functions:

  Camera Selection.
Monitor Selection.

Sequence Programming.

Function Selection for selected cameras.

- The Camera Control Panel Video Switcher Interface. The keyboard shall be used to program these additional functions:
  
  Sequence/Hold Control.
  
  Sequence Order.
  
- The Zoom Lens control shall activate the selected lens to zoom in and out and to focus. The speed, fast or normal, at which the lens operates, shall be selectable.
  
- The joystick shall be utilized to adjust the addressed camera pan/tilt location to required ranges. Contractor shall provide joystick at fixed Camera Control Panels, and keypad equivalents for camera control from outside of the OCC, such as from the Station EMP.

4.) Preset Position Driver.

The preset position panel shall be capable of positioning a PTZ camera to up to 16 preselected positions. This shall include positioning of pan, tilt, and zoom and focus of the individual cameras. Contact closures from the Field Control System shall signal an intrusion to vending or add fare machine. An off-hook condition for an Emergency Phone (PET) shall also trigger an alarm via FCS to CCS. The individual camera assigned to an emergency phone or a set of vending machines shall point and focus to the front of the alarmed phone or machine. Pan and tilt accuracy shall be within 1.0 degree. Zoom and focus accuracy shall be within 0.5% of one lens rotation.

5.) Video Loss Detector and Alarm Panel.

- Video Loss Detector: The video loss detector shall provide alarm closure and visual alarm indications when the video signal exceeds or falls below preset levels or upon loss of sync. The video loss detector shall meet the following specifications:

  Input level: 2V p-p maximum.

  Input impedance: 10k looping.

  Output impedance: passive loop from input.

  Level adjustment: (high) 100mV to 1V p-p; (low) 100 mV to 700 mV p-p.
• Alarm Panel: The alarm panel shall provide a visual indication of video loss status for each installed camera. The alarm panel shall meet the following specifications:

  LED lamps with lamp test pushbutton.

  Display status and alarm states.

  Alarm state flashes upon initiation and holds steady upon operator initiation.

  Alarm state resets on removal of alarm condition.

  Connectorized cabling.

  Display expansion by 50 percent above base camera count.

  Power supply and other equipment to make panel fully functional.

f.) Camera Mounting.

Camera mounting shall be provided as follows:

1.) Wall or Ceiling Mount: The camera mount unit shall be designed to support loads of up to 75 lbs. at an attitude of 90 degrees perpendicular to a wall surface. Each mount assembly shall be equipped with an adjustable head adapter which shall allow 360 degree horizontal and + 90 degree vertical plane adjustment. All parts shall be protected from corrosion.

• Pan/Tilt Unit: The Pan/Tilt unit shall be designed to meet the following specifications:

  Pan: 0-355 degrees in horizontal plane.

  Tilt: + 90 degrees in vertical plane.

  Pan Speed: nine (9) degrees per second.

  Tilt Speed: three (3) degrees per second.

  Construction: metal, corrosion protected, painted white.

• Drivers for Pan/Tilt units shall be mounted near the Pan/Tilt units within tamper-proof and weatherproof enclosures. Tamper-proof designs shall be subject to approval of the Engineer.

2.) Pole Mount: Adapters shall be provided for placing standard wall or ceiling mount units on camera equipped poles. All parts shall be protected from corrosion.
g.) Camera Security Enclosure.

Camera security enclosures shall be suitable for outdoor service. The housings exterior surface shall be tinted or mirrored to conceal the interior camera from view. The view from the housing shall encompass a 360-degree horizontal view and 45 degree vertical view. The vertical view shall extend from 5 (five) degrees above the horizontal to 40 degrees below the horizontal. Security enclosures shall be tamper-proof to prevent the general public from accessing the interior of the enclosure. Tamper-proof designs shall be subject to the approval of the Engineer. The camera security enclosure shall also act as an environmental enclosure.

h.) Source Identifier.

1.) A source identifier generator shall be provided for positive identification of the source of the video signal displayed on the monitor screen and saved in the stored video. The alphanumeric characters superimposed on the video display shall contain a minimum of 16 characters. Input and output signal levels shall be a nominal 1.0 volts p-p. Input and output impedance levels shall be 75 ohms.

2.) Source Identifier shall include Camera ID of minimum of eight characters. Camera ID character settings shall be adjustable per camera. The placement of the Camera ID on the monitor shall be adjustable. Source Identifier shall also include time and date of recording.

i.) Digital Video Recorders.

1.) Contractor shall furnish Digital Video Recorders (DVRs) at each station capable of simultaneously recording, digitizing, compressing, and storing 72 hours of video at MPEG 4 standard compression. Note, Contractor shall also provide CCTV storage devices for central storage for storing video from all cameras for 30 days, as specified in this Section.

2.) Digital Video Recorders shall be NiceVision Pro or approved equal and meet the following minimum requirements.

- DVRs shall be capable of JPG, MPG, and H.263 video compression technologies.

- DVRs shall be capable of exporting video images of pixel size 640 x 480.

- DVRs shall be capable of recovering from a power loss within 15 seconds.

3.) DVRs shall meet the CCTV functional and storage requirements described elsewhere in this Section.

4.) DVRs shall detect loss of signal and report back to the FCS and/or NMS systems.
j.) Network Storage Devices.

1.) Contractor shall provide a Storage Device as shown in the Contract drawings that will accommodate the following storage requirements.

- Storage Devices at the Central Communications Equipment Room shall be appropriately sized to store and retrieve the following data:

2.) CCTV Video Data.

- The Central Storage devices shall continuously store 30 days of CCTV video data from all station cameras. This data will have been digitized, compressed in MPEG 4 format or approved equal and sampled at a minimum of 1 frame per second at each station, and sent over the backbone for storage at Central.

- This archived data shall be able to be queried, retrieved and viewed by an Operator in the Operations Control Center.

3.) Contractor shall provide a removable media storage device as shown in the Contract drawings, in order to store video incidents.

4.) Network Storage Devices shall be manageable by the Network Management System as specified in Section 17910, Communications Network Management.

5.) The Network Storage Devices shall be connected to the Network Backbone via the CCER/OCC OC-12 ADM, described above.

k.) Other Equipment.

Contractor shall provide all equipment and do all Work to make the CCTV system fully functional per these specifications.

PART 3 - EXECUTION

3.01 PREPARATION

Engineer will schedule design reviews with Contractor. The design reviews shall encompass Contractor submittals for the Conceptual, Preliminary, and Final Design.

3.02 FACTORY TESTING

A. Closed Circuit Television (CCTV) System.

1. Contractor shall include the tests and certifications listed below, as a minimum, in factory testing schedule for CCTV systems.

   a.) Resolution of video display.
b.) Video Transmission Links.

c.) Signal levels.

d.) Insertion gain.

e.) Frequency response (multi-burst).

f.) Differential phase and differential gain.

g.) Signal-to-noise ratio.

h.) Periodic noise or hum.

2. Input and output signal levels at all systems interfaces.

3. CCTV handling of PET off-hook conditions and vending machine intrusion conditions.

3.03 TRAINING, MANUALS, SPECIAL TOOLS, AND SPARE PARTS

A. Training.

1. Contractor shall provide training for up to 40 users of the CCTV System, and 40 maintainers of the CCTV system. All training shall follow the guidelines set in Section 01820, Training Program. Multiple training classes shall be scheduled at different times of the day to accommodate different shifts of workers, and shall be scheduled such that an entire shift of operators can be split into separate classes so as not to interrupt daily operations. Contractor shall provide separate training classes for users and for maintainers of the CCTV System.

a.) Users of the CCTV system shall be able perform the following minimum functions at the end of Contractor training.

1.) Execute the CCTV application software from the CCTV Console.

2.) Select cameras for viewing on Operator’s console.

3.) Select cameras for viewing on CCTV Overview Display.

4.) Deselect cameras for viewing on console and overview display.

5.) Pan, Tilt and Zoom selected PTZ cameras.

6.) Retrieve video from the archives and view on operator console.

7.) View, resize and close PET CCTV video window when it is opened due to a PET off-hook alarm indication.
b.) Maintainers of the CCTV system shall be able to perform the following minimum functions at the end of Contractor training.

1.) Load and configure CCTV software at the CCER and OCC servers and workstations.

2.) Set up overview CCTV display and configure.

3.) Troubleshoot basic CCTV software configuration issues.

4.) Replace fixed and PTZ cameras at all locations.

5.) Replace lenses and any other replaceable components of fixed and PTZ cameras.

6.) Connect and configure CCTV Controller at the Central Communications Equipment Room and at Station Communication Rooms and Cabinets.

7.) Perform all software and hardware manufacturer maintenance functions.

B. Manuals.

Contractor shall provide CCTV Maintenance and User Manuals as described above and in Section 01785, Operations and Maintenance Manuals. Contractor shall provide all manufacturer Maintenance and User Manuals for all CCTV products delivered.

3.04 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for all delivery, storage, and handling of equipment.

3.05 INSTALLATION

A. Contractor shall submit installation drawings. Contractor shall proceed with the installation only after the approval of installation drawings by Engineer.

B. Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

3.06 FIELD TESTING

A. Closed Circuit Television (CCTV) System.

1. Contractor shall include the tests and certifications listed below, as a minimum, in field-testing schedule for CCTV systems.

   a.) Horizontal resolution and video sensitivity of each camera.

   b.) Resolution of video display.
c.) Video Transmission Links.

d.) Signal levels.

e.) Insertion gain.

f.) Frequency response (multi-burst).

g.) Differential phase and differential gain.

h.) Signal-to-noise ratio.

i.) Periodic noise or hum.

j.) Input and output signal levels at all systems interfaces.

k.) CCTV handling of PET off-hook conditions and fare collection machine intrusion conditions.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17751
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PART 1 - GENERAL

1.01 OVERVIEW

A. The Control System (CS) monitors and controls Link systems in the passenger stations, along the right of way, and at the Operation & Maintenance (O&M) Facility. Operators can monitor and control these Link systems through graphical interfaces located in the Operations Control Center (OCC) or from Emergency Management Panels in the tunnel passenger stations.

B. The overall structure, system interfacing, and functional intent of the CS are described in this Section.

1.02 RELATED SECTIONS

A. Section 17801 – Control System Network.

B. Section 17802 – Field Control System.

C. Section 17840 – Central Control System.

D. Section 17842 – Emergency Management Panel.

1.03 SYSTEM INTERFACES

A. The CS provides remote monitoring and control capability for the operation and maintenance of equipment and systems within Link. These monitored and controlled systems are located in the O&M Facility, within passenger stations, and along the right of way.

B. Most of the systems interfaced to the CS are provided to Sound Transit by other Contracts or are existing. Some of the systems interfaced to the CS are provided by this Contract including the CCTV, PA / VMS, and telephone systems.

1. O&M Facility.

2. Access Control System.

3. CCTV Cameras.

4. Communications and Network Equipment.


7. Intrusion Detection.

8. PA/VMS Equipment.
10. Telephone Equipment.
11. Traction Electrification System.

C. Passenger Stations.
2. CCTV Cameras.
3. Communications and Network Equipment.
4. Electrical Distribution Equipment.
5. Elevators and Escalators.
8. Fare Collection Equipment.
10. HVAC Systems.
11. Intrusion Detection.
12. Station Lighting.

D. Right of Way and Tunnels.
1. Radio Systems.
2. Traction Electrification System.
3. City Traffic Signals.
4. Train Signaling Systems.
5. Train to Wayside Communication.
1.04 STRUCTURAL DESCRIPTION

A. The CS is organized into the following subsystems.

1. Control System Network (CSN).

   a.) The Control System Network (CSN) is the set of Ethernet networks in each station and the Operations Control Center (OCC). The CSN is the communication framework for the CS. Each Ethernet local area networks is linked through the SONET backbone with drops at the O&M Facility and at passenger stations. At each SONET drop a redundant Ethernet switch manages the communication for all nodes within that location.

   b.) Other communications subsystems use the CSN, but are not defined as part of the CS. These systems include the CCTV and PA/VMS systems.

   c.) There are other, special purpose Ethernet networks connected through the SONET backbone in place at the O&M Facility and passenger stations that are not part of the CS. The Fare Vending, Emergency Phone, and Office Services Network (OSN) are separate and distinct from the CSN. A firewall connection between the CSN and OSN permits the exchange of operational data.

2. Central Control System (CCS).

   The Central Control System (CCS) is a collection of computers and software located in the OCC and CCER. The CCS interfaces to the FCS through the CSN in order to provide an operator interface and upper level monitoring/control functions. The CCS also interfaces to other communications subsystems including the CCTV, PA/VMS, and telephones for monitoring and control.

3. Field Control System (FCS).

   a.) The FCS is a distributed network of monitoring and control devices that is interfaced to other equipment and systems throughout Link. A wide range of equipment is interfaced to the CS. Most of this equipment is supplied to the Sound Transit by other contracts. The FCS includes the following main categories of components:

      1.) LonWorks Network.

         - LonWorks is used throughout Link for monitoring and control interfacing. In general, all facilities have one or more LonWorks networks including the O&M Facility, passenger stations, traction power substations and TWC cases. These LonWorks networks communicate over a systemwide LonWorks fiber ring that operates independently of the SONET backbone or the CSN. At each station, the LonWorks network is connected through LonWorks/IP routers to the CSN.
2.) Modbus Network.

- Programmable logic controllers (PLC's) are used for interfacing to existing I/O in the Downtown Seattle Transit Tunnel (DSTT) stations. Existing I/O wiring in the DSTT shall be moved from the existing Remote Telemetry Units (RTUs) to the new PLCs. The primary communication interface for the PLCs is Modbus/TCP via the CSN. Each PLC can also send and receive data on the LonWorks network.

- Other devices will also use Modbus protocol including the bus detection processors in the DSTT, train signaling processors, and traction electrification system power meters.

4. Instrumentation.

Instruments provide voltage, current, RF output, temperature and vibration measurements to the LonWorks or PLC analog input devices. In general, instruments are to be provided by the other Contracts. This Contract provides instruments for monitoring the tunnel radio bidirectional amplifiers and for the Track Isolation Monitoring system.

B. Emergency Services Interface (ESI).

The ESI is computers and software located in the Emergency Management Panels (EMP). The ESI communicates with the FCS through LonWorks and Ethernet to provide a graphical interface of Link systems similar to the CCS. (Other Communications Systems are also present in the EMP including CCTV, PA/VMS, and Emergency Phones.)

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.
PART 1 - GENERAL

1.01 OVERVIEW

A. The Control System Network (CSN) is the set of Ethernet LANs in the Operations Control Center (OCC), Central Communications Equipment Room (CCER) and at each station. Each LAN in the CSN is connected through the systemwide SONET backbone. In the OCC the architecture of the CSN LAN is dual 100 Base T to each node. For the station LANs, a single 10BaseT network is extended to each node.

B. As the communication framework for the Control System, the CSN provides Ethernet to all communications equipment except for those nodes defined as part of the Fare Vending Network or Office Services Network. The primary function for the CSN is to support the monitoring and control functions of the Central Control System (CCS) and the Field Control System (FCS). The CSN also supports the PA/VMS, emergency phones, and CCTV systems.

1.02 SECTION INCLUDES

A. This Section contains functional and design requirements for the following:

1. Ethernet networking within the OCC and CCER.
2. Ethernet Terminal Servers within the OCC, CCER and Stations.
3. Network Printers in the OCC and CCER.
4. Firewalls from the CSN to other networks.
5. Ethernet networking in passenger stations.
6. Ethernet networking in signal houses.

1.03 RELATED SECTIONS

A. Section 17040 – Technology Documentation.
B. Section 17200 – Office Services Network.
C. Section 17500 – Cable Transmission System/WAN Overview.
D. Section 17570 – WAN System Testing, Identification and Administration.
E. Section 17800 – Control System Overview.
F. Section 17802 – Field Control System.
G. Section 17840 – Central Control System.

I. Section 17843 – Backup Control.

J. Section 17910 – Communications Network Management.

K. Section 17930 – Cable Management System.

1.04 REFERENCE STANDARDS

A. BICSI

Telecommunications Distribution Methods Manual (TDMM).

B. TIA/EIA

1. TIA/EIA-455: Fiber Optic Test Standards.


6. TIA/EIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.

7. TIA/EIA-758: Customer Owned Outside Plant.


1.05 SYSTEM DESCRIPTION

A. Functional Requirements.

1. CCS Ethernet Networking.

   a.) Provide dual 100 Mbps Ethernet connections from the Central Communications Switch to all CCS nodes in the OCC/CCER. See Section 17510, Communication System Backbone Equipment, for switch requirements. Nodes in the OCC include the following:

   1.) System Time Server provided for the SONET ring.

   2.) PA/VMS/Radio Server.
3.) LonWorks/IP routers provided for the FCS within the O&M Facility.

4.) CCTV Servers provided for the CCTV System within the O&M Facility.

2. CCN / OSN Firewall.

Provide a Stateful multilayer inspection firewall in the CSN for the secure exchange of operational data between the CSN and the Office Services Network (OSN). Provide a dual 100 Mbps Ethernet connection from the main network router/switches to this firewall.


a.) Provide a 10 Mbps Ethernet connection from the Station Network Switch to all nodes in each station. See Section 17510, Communication System Backbone Equipment, for Station Network Switch requirements. Nodes in the stations include the following:


2.) LonWorks/IP routers provided for the FCS.

3.) Programmable Logic Controllers (PLCs) provided for the FCS.

4.) Bus Detection Processors in DSTT stations provided by Sound Transit.

5.) CCTV Servers provided for the CCTV System.

6.) PA/VMS Controllers (PVC) provided for the PA / VMS System.

7.) Emergency Telephone Hub/Controllers provided for the emergency phone system.
4. Ethernet Terminal Servers.

   Provide Ethernet Terminal Servers for serial port configuration of communications
equipment in the OCC and in the Stations. Terminal servers shall convert all available
serial “craft” ports to 10 Mbps Ethernet connections for configuration from the
Communications Maintenance Console.


   a.) Provide a 10 Mbps Ethernet connection to the Signal Processor provided by Sound
   Transit. If the Signal Processor does not include an Ethernet port, provide a Terminal
   Server to convert the Modbus serial communication port to Modbus/TCP via
   Ethernet.

   b.) Provide a 10 Mbps Ethernet connection for one PABX phone on the Communications
   Terminal Board in the Signal House.

   c.) Provide a 10 Mbps Ethernet connection for one network maintenance port on the
   Communications Terminal Board in the Signal House.


   a.) Provide a 10 Mbps Ethernet connection to each switchgear power meter provided by
   Sound Transit.

   b.) Provide a 10 Mbps Ethernet connection to each Access Control System control panel
   on the Communications Mounting Board.

   c.) Provide a 10 Mbps Ethernet connection for one PABX phone on the Communications
   Terminal Board in the Signal House.

   d.) Provide a 10 Mbps Ethernet connection for one network maintenance port on the
   Communications Terminal Board in the Signal House.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals are
subject to Engineer approval.


   a.) Contractor shall submit the following information prior to CSN Conceptual Design
   Review per the schedule and requirements set in Section 01330, Submittals:

       1.) Schematic block diagrams including all of active components for all CSN
       locations.

       2.) Draft description of CSN design.
2. Preliminary Design Review.

   a.) Contractor shall submit the following information prior to CSN Preliminary Design Review per the schedule and requirements set in Section 01330, Submittals:

      1.) Schematic block diagrams showing all of the active components and connections for all CSN locations.

      2.) Detailed list and description of all equipment intended for use.

      3.) Description of CSN design.

      4.) Room layouts and elevations of CSN equipment.

      5.) Deviations and exceptions from Design Requirements.

3. Final Design Review.

   a.) Contractor shall submit the following information prior to CSN Final Design Review, per the schedule and requirements set in Section 01330, Submittals:

      1.) Final schematic block diagrams for the CSN.

      2.) Final list and description of all CSN equipment.

      3.) Field installation details for all types of components.

      4.) Rack elevation drawings.

      5.) Detailed test procedures for all equipment and cable testing.


   a.) Prior to Final Acceptance Testing, according to the project schedule guidelines set in Section 01330, Submittals, Contractor shall submit final versions of the following:

      1.) User Manuals.

      2.) Maintenance Manuals.

      3.) Training Plan.

      4.) Training Manuals.
5. Training.

Contractor shall train up to 20 persons on the configuration and maintenance of the CSN per the approved Training Plan and Manuals.


Prior to the Final Acceptance Test, according to the project schedule guidelines set in Section 01330, Submittals, Contractor shall submit the final test procedure for all testing.

7. Test Results.

Prior to acceptance of the CSN, all test results must be submitted. Test results are subject to inspection by Engineer.

8. As-Builts.

Prior to acceptance of the CSN, Contractor shall submit all as-builts. As-builts are subject to inspection by Engineer.

### 1.07 QUALITY ASSURANCE

A. Qualifications.

1. Contractor and/or installation subcontractor must be engaged in the normal business of installing telecommunications cabling systems, and licensed to operate in the State of Washington. All installation technicians must be familiar with the codes, standards, and procedures required by these Specifications. All installation technicians must explicitly follow the manufacturer’s installation procedures for the products being installed.

a.) Certifications

Contractor shall employ a Registered Communications Distribution Designer (RCDD) for the detailed design and development of the CSN. The RCDD shall review and approve all drawings and detailed technical specifications for the CSN. The RCDD shall certify that the detailed network design complies with all applicable codes and standards. The signature and RCDD logo stamp with registration number and expiration date shall be applied to all design drawings for the CSN network.

### PART 2 - PRODUCTS

2.01 COMPONENTS

A. Ethernet Switches.

1. Management features of all switches shall include SNMP, Telnet, and OpenView.

2. As required in each location, switches shall support mixed media and port types including 10 Mb or 100 Mb RJ-45 and single or multimode fiber ports. Switches shall be a base unit with plug-in modules for different port combinations and configurations.
3. Each RJ-45 and fiber port shall include LED’s to indicate link status and activity.

4. Mechanical enclosure shall be rugged high strength sheet metal and shall be DIN rail or rack mountable.

5. Power supply options shall include 120VAC, 24 VDC, 48 VDC, or 125 VDC and shall be chosen appropriately for the type of power available at each location.

6. Switches shall configurable in a ring topology between stations. If a switch or a link fails between two stations, the switches shall determine the new route around the failure in less than 5 seconds.

B. Terminal servers.

1. Terminal servers shall provide the normal COM port connectivity to a serial port device from a remote computer on the CSN.

2. Convert the RS-232, RS-422 or RS-485 ports to Ethernet 10/100 Base-T.

3. Include support for TCP/IP and UDP/IP sockets and tunneling protocols.

4. Supply single or multiport units as appropriate for the number of serial devices at a location.

C. Firewalls.

1. The Firewall shall be a dedicated security appliance to provide perimeter security to prevent unauthorized network access using stateful packet inspection. Network packets can get through the firewall based on the protocol, port, and source and destination addresses. For every request that is allowed, a limited time window shall allow response packets, but only from the same host. By maintaining information about previous packets, the Firewall shall verify that packets meet the criteria for authorized traffic.

2. Tools for configuring the Firewall shall include policy wizards, policy import capabilities and a network topology map. Remote configuration, monitoring and troubleshooting shall be supported through Telnet and Web-based access.

3. Firewall shall include remote monitoring and logging capabilities through SNMP and Syslog support.

4. Overall data throughput capability shall be sized to meet the specified requirements for passing data from the CSN to external networks, but shall not be less than 100 Mbps.

D. Equipment Room Racks and Cabinets.

1. All CSN racks shall be a general purpose open frame 19-inch wide EIA standard equipment rack. The rack may be either floor standing, from five (5) feet to seven (7) feet tall, or may be a wall mounted rack with a swing-out front Section to provide access to the rear of the equipment. Floor standing equipment racks must always be securely bolted to the floor. Use cable ladders to interconnect multiple equipment racks, to brace equipment racks to the wall, and as a means of routing cables to and from the rack.
2. If required by the type of equipment, rack shall include both front and rear mounting rails. Provide 36” clear work space front, rear, and at one end of each equipment rack / cabinet line up for floor mounted racks / cabinets leaving sufficient front and rear rack / cabinet footprints for any equipment planned for installation. All cabinets must have a minimum of 20” from the front rail to the wall. All racks must have a minimum of 20” from the front rail to the rear isle workspace. All racks must be equipped with an appropriate number and type or horizontal and vertical wire management modules, both front and rear, with strain relief brackets to insure proper bend radius and strain relief is maintained for all data and power cables.

E. Communication Distribution Cabinet Racks.

1. In certain locations the Communication Distribution Cabinets shall be 19” racks that include CSN equipment. The cabinet and shall be sized to allow room for 25 percent future growth, and shall allow room for computer network equipment such as hubs or routers. Rack mounted Communication Distribution Cabinets must provide:

2. Physical security to protect the contents and prevent unauthorized access. The cabinets shall be constructed of heavy gauge steel and shall be lockable. Any removable panels must have tamper proof screws. The construction and locking characteristics of the cabinet must be appropriate for the security of the area in which installed.

3. All power and telecommunications cables for equipment housed within the cabinet are to be contained within the cabinet. No exposed cables are allowed.

4. All power and telecommunications cables routed to or from the cabinet must be contained in conduit, surface mounted raceway, or routed within the adjacent wall.

5. The cabinet must contain a plywood backboard for mounting telecommunications hardware.

6. The cabinet must provide a means of mounting electronics equipment including a LAN switch and UPS. Acceptable means are rails for rack mounting or adequate space on the plywood backboard for electronics equipment wall mounting brackets.

7. The cabinet must have a minimum of one 20-amp 120 VAC quad (4-plex) electrical outlet installed inside the cabinet, on a dedicated circuit breaker from the electrical panel. The outlets shall be colored orange, and labeled as electronic power only.

8. Cooling fans shall be installed in the cabinet.

9. The cabinet shall include a telecommunications grounding busbar.

10. Floor standing cabinets shall be securely bolted to the floor.

F. Communications Termination Backboards.

Backboards shall be three-quarter (¾)-inch A-C grade fire retardant plywood, painted with two coats of light colored, non-conductive fire retardant paint. The plywood shall extend from the floor to eight (8) feet above the finished floor and shall be mounted with the “A” side exposed. Cutouts shall be provided around existing power and telecommunications outlets. Power and network maintenance ports shall be surface mounted on the plywood backboard.
PART 3 - EXECUTION

3.01 OVERVIEW

The network infrastructure shall be designed and installed in accordance with applicable codes and industry standards.

3.02 SYSTEMS PLANNING, LAYOUT, AND SIZING

A. The CSN shall be planned in coordination with all other communications equipment to be installed in each location. Contractor shall identify the quantity, size and variety of systems to be installed in the area, and the space required for each of the systems.

B. CSN equipment shall be laid out in a functionally efficient arrangement. Equipment requiring more regular access for servicing shall be located where it is more easily accessible.

C. The design layout for all equipment and racks is subject to approval by Engineer.

D. When laying out the arrangement in a communications equipment room, Signal House or other CSN location the following requirements and issues shall be addressed:

1. Groups of like equipment types shall be located together.

2. Separate wall and equipment rack space is designated for the termination and cross connection of distribution cables, both copper and fiber optic. These areas shall be located adjacent to the equipment providing the services, such as hubs, routers, and switches.

3. Careful design planning must be performed to ensure that all telecommunications cabling, including the entrance facility cable, has the minimum setback distanced from all potential sources of electromagnetic interference (EMI) or radio frequency interference (RFI), such as electric motors or power transformers.

4. Equipment racks and rack mounted equipment shall have a minimum of three (3) feet of unrestricted clearance in front and back for technician access. In smaller installations, wall mounted swing-out equipment racks can be used to save space, but must have three (3)-feet clearance to the front of the rack.

5. Each equipment rack, and all major freestanding equipment shall be provided with two dedicated 20-amp 110VAC electrical circuits from the emergency power panel, each terminated in a quad (4-plex) outlet. Technical power shall be identified with orange colored electrical outlets. These outlets shall be labeled for electronics equipment use only.

6. Some equipment such as large LAN switches and routers are ordered with dual power supplies. The placement of equipment with dual power supplies shall be identified and the appropriate racks must have three, separate, dedicated 20-amp 110VAC electrical circuits from the emergency power panel, each terminated in separate quad (4-plex) outlets, and be appropriately marked to identify the separate circuit breakers.

7. Contractor shall locate network equipment no closer than 20 feet to power panels or equipment that may cause electrical interference from RFI or EMI.
3.03 NETWORK CABLING REQUIREMENTS

A. Network cabling shall have its own independent support structure consisting of conduit, cable tray, or other cable support devices such as bridle rings or J-hooks.

B. Telecommunications cable may not be attached directly to electrical conduit, T-bar ceiling support wires, or any non-communications cabling.

C. Supporting structures shall be spaced no greater than five (5) feet apart.

D. The cable pathway shall be sized to support the initial installation of cable, plus 25 percent growth.

E. Network cabling shall be installed in a home-run fashion with individual cables running from the work area all the way to the telecommunications closet. Splices in horizontal distribution cable are not allowed.

F. In new construction, all wall outlets shall have a minimum three-quarter (¾)-inch conduit routing through the wall to an accessible cable pulling location. Increase the conduit size as necessary for the quantity of cables to be installed.

G. In new construction, all wall outlets shall be mounted in a minimum four (4)-inch by four (4)-inch by two and one-half (2 ½)-inch deep double gang outlet box with a single gang mud ring.

H. Network outlets shall be located within three feet of an electrical outlet.

3.04 INSIDE PLANT CONDUIT REQUIREMENTS

A. The maximum length of copper horizontal distribution cable is 90 meters (295 ft) from the network outlet to the patch panel. Where this length would be exceeded Contractor shall notify the Engineer.

B. Factory-manufactured sweeps which meet ANSI/TIA/EIA569-A bend radius requirements shall be used for all telecommunications conduit. The bend radius of the sweeps must be a minimum of 10-times the internal conduit diameter. Bending conduit in the field using manual or mechanical methods is not acceptable. Standard electrical elbows shall not be used. The use of 90°condulets, also known as an "LB", is prohibited.

C. All horizontal conduit will be tested by the conduit installation Contractor with a mandrel to prove compliance with the sweep radius requirements throughout the conduit run.

D. Each telecommunications outlet box shall have an individual conduit routing to the telecommunications closet, or to the pullbox or pulling point, connecting to a major cable pathway routing to the telecommunications closet. Looping, or “daisy-chaining,” of conduits between outlet boxes is not allowed.

E. All conduit ends shall have plastic bushings installed before the cable is pulled into the conduit.

F. Conduits will not be run next to hot water lines, steam pipes, or other utilities that may present a safety hazard or cause a degradation of system performance.
G. Conduits entering the Communications Closet should be designed and located allowing for the most flexibility in the routing and racking of cables.

H. Conduits or conduit sleeves entering through the floor of the Communications Closet shall terminate four (4) inches above the finished floor.

I. All metallic telecommunications conduits entering the Communications Closet, Equipment Room, or Entrance Facility shall be bonded together, and bonded to the Telecommunications Main Grounding Busbar with a #6 AWG ground cable.

J. All in-use and spare conduits entering the Communications Closet, Equipment Room, or Entrance Facility shall be sealed.

K. All conduits and cables that penetrate fire rated walls or floors must be firestopped.

3.05 FIELD QUALITY CONTROL

A. Inspections.

Contractor shall perform field inspections at all CSN installation locations. All CSN installations must be inspected and approved by an RCDD. The RCDD must apply an RCDD logo stamp and signature to the as-built drawings and provide a written inspection report with the RCDD’s signature, to the Engineer.

B. Testing.

Field testing shall include all appropriate industry standard tests for the cable and components installed within the TIA/EIA standards and IEEE 802.3 Ethernet standards identified in article 1.03 above. In addition, the cable installation must pass all installation and performance tests both recommended and mandated by the cable manufacturer. 100 percent of the cables installed shall be tested and certified at the designed and intended performance level.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17801
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PART 1 - GENERAL

1.01 OVERVIEW

A. The Field Control System (FCS) is the collection of monitoring and control devices interfaced to equipment and systems throughout Link. The FCS provides the means for persons using the Central Control System (CCS) or Emergency Management Panel to monitor and control Link. Data communication between the FCS, CCS and EMP is through the Control System Network (CSN). The fundamental components of the FCS are LonWorks devices, Communication Gateways, and Programmable Logic Controllers (PLC’s).

B. This Section contains general functional and design requirements for the FCS. Particular requirements for specific control technologies are found in Section 17811, LonWorks Network and Devices, and Section 17812, Modbus/TCP Network and Devices.

1.02 PRODUCTS INTERFACED BUT NOT SUPPLIED

A. Certain FCS components are supplied by the Sound Transit through other Link contracts. Coordinate with supplying Contractor to integrate, configure and/or program these components to function on the FCS. These components include the following:

1. Signal Processors provided by Contract C802.

2. Bus Detection Processors provided by Contract C802.


4. Lighting Controllers provided by the electrical portion of the station construction contracts.

5. Fire Alarm Control Panels by the mechanical or electrical portions of the station construction contracts.

6. HVAC Control Panels provided by the mechanical portion of Contract C710 for the Beacon Hill tunnel.

1.03 RELATED SECTIONS

A. Section 17040 – Technology Documentation.

B. Section 17500 – Cable Transmission System/ WAN Overview.

C. Section 17800 – Control System Overview.

D. Section 17801 – Control System Network.

E. Section 17802 – Field Control System.

F. Section 17811 – LonWorks Network and Devices.
G. Section 17812 – Modbus/TCP Network and Devices.

H. Section 17840 – Central Control System.


J. Section 17930 – Cable Management System.

K. Appendix B – Communications Equipment List.

L. Appendix C – Monitored Equipment List.

M. Appendix E – C802/C803 Data Interface.

N. Appendix F – Control System Functions (Use Cases).

1.04 REFERENCE STANDARDS


1.05 SYSTEM DESCRIPTION

A. The FCS uses both Modbus/TCP and LonWorks because of their advantages for different interfacing situations. LonWorks is used where I/O density is low and where its strong networking capabilities are efficient. Modbus/TCP is used where high I/O density is required or if LonWorks is not available for a certain subsystem interface provided by others.

B. LonWorks networking extends throughout Link for monitoring and control interfacing. In general, LonWorks twisted pair, FT-10 networks shall be designed and installed in the O&M Facility, passenger stations, traction power substations and TWC cases. These local FT-10 networks shall be combined over a system wide LonWorks fiber ring that is independent of the SONET ring or the CSN. In addition LonWorks to IP Ethernet routers shall connect all FT-10 networks to the CSN.

C. Modbus/TCP via Ethernet shall be used for monitoring and control interfacing to certain subsystems and to the PLC’s. PLC’s shall be used for interfacing in the Downtown Seattle Transit Tunnel (DSTT) stations. Existing I/O wiring in the DSTT shall be moved from the existing Remote Telemetry Units (RTU’s) to the new PLC’s. The primary communication interface for the PLC’s is Modbus/TCP via Ethernet. Each PLC shall also be capable of communicating on the LonWorks network.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals are subject to Engineer approval.

   a.) Contractor shall submit the following information prior to Conceptual Design Review per the schedule and requirements set in Section 01330, Submittals.

      1.) FCS Overall Block Diagram shall show the overall network architecture of the FCS.

2. Preliminary Design Review.

   a.) Contractor shall submit the following information prior to Preliminary Design Review per the schedule and requirements set in Section 01330, Submittals.

      1.) Network Block Diagrams shall show the detailed network architecture of the FCS. Blocks shall represent routers and panel assemblies. The intent of these diagrams is to clearly show system wide FCS communication and where the FCS interfaces with the Control System Network (CSN).

      2.) Schematic Block Diagrams of each typical FCS installation and/or subsystem interface. Blocks shall represent active components such as routers, controllers, and I/O modules. The intent of these diagrams is to show the interfacing to the monitored or controlled subsystems.

      3.) Itemized Functional Descriptions of FCS monitoring and control software functions for each Schematic Block Diagram.

3. Intermediate Design Review.

   a.) Contractor shall submit the following information prior to FCS Intermediate Design Review per the schedule and requirements set in Section 01330, Submittals.

      1.) Updated Network Block Diagrams, Schematic Block Diagrams, and Itemized Functional Descriptions.

      2.) FCS Equipment List (per Appendix B, Communications Equipment List) of all interfaces assemblies and panels for the entire FCS. An item shall be included on this list if it is delivered as a unit that actively communicates using Modbus/TCP or LonWorks. Associate each item on this list with the appropriate typical Assembly Fabrication Drawing.

      3.) Assembly Fabrication Drawings typical for each kind of FCS panel assembly including all panels, enclosures, LonWorks Interface Assemblies, and PLC control panel retrofits. Fabrication drawings shall include elevations, power wiring schematics, I/O wiring schematics, and installation details.

      4.) Monitored Equipment List based (per Appendix C, Monitored Equipment List) shall be expanded and corrected for all equipment that is monitored and/or controlled.
5.) Custom Software Typicals for each Itemized Functional Description item. Provide actual documented code samples for each item in the programming language used by the actual controller.

4. Final Design Review.
   a.) Contractor shall submit the following information prior to FCS Final Design Review, per the schedule and requirements set in Section 01330, Submittals.
      1.) Final Network Block Diagrams.
      2.) Final Schematic Block Diagrams for each individual FCS installation and subsystem interface.
      3.) Final Itemized Functional Descriptions.
      4.) Final FCS Equipment List.
      5.) Final Monitored Equipment List.
      6.) Assembly Fabrication Drawings for all FCS panels.
      7.) FCS Custom Software for all individual programs in the entire FCS.
      8.) FCS I/O List itemization of all discrete and analog I/O points in the FCS.
      9.) Sample Test Procedures for each type of FCS installation.

5. Final User Documents.
   a.) Prior to Final Acceptance Testing, according to the project schedule guidelines set in Section 01330, Submittals, Contractor shall submit final versions of the following:
      1.) User Manuals.
      2.) Maintenance Manuals.
      3.) Completed test results for all equipment and cable testing.
      4.) Training Plan.
      5.) Training Manuals.

6. Training.
   Contractor shall train up to 20 persons on the configuration and maintenance of the FCS per the approved Training Plan and Manuals.
7. Final Acceptance Test Procedure.

Prior to the Final Acceptance Test, according to the project schedule guidelines set in Section 01330, Submittals, Contractor shall submit the final test procedures for all FCS testing.

8. Test Results.

Prior to acceptance of the System, all test results shall be submitted. Test results are subject to inspection by Engineer.

9. As-Builts.

Prior to acceptance of the System, Contractor shall submit all as-builts. As-builts are subject to inspection by Engineer. As-builts shall include all items listed for the Final Design Review, updated and corrected to match the actual installed conditions. Drawings shall be in the latest AutoCAD format on a CD and in printed form.

1.07 WARRANTY

A. The FCS shall be free from defects in workmanship and material and shall be guaranteed to operate as required to maintain specified conditions and functions. The Contractor without charge shall make any repairs, adjustments or replacements made necessary by such defects during the first full year from the time of acceptance of the project by the Owner.

B. The Contractor's authorized and qualified service technician shall respond to the Owner's call for service within 2 hours for malfunctions that have a critical impact on effectively operating the FCS. The response time for non-critical service calls shall not exceed 24 hours unless otherwise waived by the Sound Transit.

PART 2 - PRODUCTS

2.01 ASSEMBLY AND COMPONENT LIST

A. The following is a list of each type of assembly or unit that shall be supplied for all FCS monitoring and control. For requirements specific to LonWorks, see Section 17811, LonWorks Network and Devices. For requirements specific to Modbus/TCP, see Section 17812, Modbus/TCP Network and Devices.

1. LonWorks Interface Assemblies (LIA).

a.) LIA's shall include one or more interfaces to the following systems:

1.) Train to Wayside Communication (TWC) Interrogators. See Contract Drawings L00-D301 and L00-D302.

- TWC’s are provided by Contract C802. The TWC interrogators receive train identification and data as the train passes over inductive loops embedded in the track. The LIA shall include custom gateways that convert the proprietary serial communication from each interrogator to LonWorks messages and transmit the train data to the CCS. Interrogators also exchange signals through dry contact interfacing with the LIA. The discrete signals are passed
by C802 to City of Seattle traffic signal cabinets near the TWC case for control of signal lights. Appendix E, C802/C803 Data Interface, includes a comprehensive description of all TWC and LonWorks interfacing.

- Contractor shall coordinate with Contract C802 to integrate the LIA into the TWC cases to for all power, panel sizing and installation, serial protocol, and discrete signal interfacing requirements.


- Signal Houses are provided by Contract C802. These buildings are monitored for fire and security through discrete dry contact interfacing with the LIA. See Appendix E, C802/803 Data Interface, for a comprehensive list of discrete interfaces.

- Contractor shall coordinate with Contract C802 to integrate the LIA into the equipment rack (provided by C802) for all power, panel sizing and installation, and discrete signal interfacing requirements.

3.) Traction Power Station Alarm Panels – See Contract Drawings L00-D303 and L00-D304.

- Station Alarm Panels are provided by Contract C807. An alarm annunciator unit by C807 provides local alarming within the traction power substation at these panels. The FCS monitors and/or controls all traction power substation equipment through the LIA in the Station Alarm Panel. Appendix C, Monitored Equipment List, itemizes all traction power equipment monitored by the LIA.

- Contractor shall coordinate with Contract C807 to integrate the LIA into the station alarm panel for all power, panel sizing and installation, and discrete or analog signal interfacing requirements. The LIA shall be built by Contractor and delivered to the C807 panel fabricator for factory installation and integration by the C807 Contractor. Contractor shall support the C807 contractor for all testing and integration.

4.) Bi-directional Amplifiers (BDA) – See Contract Drawing L00-D304.

- Contractor shall provide BDA’s for transmitting radio in the DSTT and Beacon Hill tunnels. In the Beacon Hill tunnel the BDA’s are monitored through LIA’s. The FCS shall monitor the analog signals from instrumentation in the BDA. These analog inputs shall not be transmitted to the CCS. FCS logic shall compare the analog inputs to threshold values (defined by the BDA manufacturer). If the analog is outside of the threshold, FCS shall generate and send an alarm to the CCS. Appendix C, Monitored Equipment List, itemizes all BDA’s monitored by the FCS.

- Contractor shall provide for all analog inputs and thresholds from the BDA to the LIA.
5.) Ticket Vending Machines (TVM) – See Contract Drawing L00-D306.

TVM’s are provided by Sound Transit in each passenger station. The FCS monitors discrete status from each TVM through the LIA in Communication Distribution Cabinets near the TVM. Appendix C, Monitored Equipment List, itemizes all TVM’s monitored by the FCS.

6.) Fire Alarm Control Panels (FACP) – See Contract Drawing L00-D308.

- FACP’s are provided under several different Contracts in various locations including the O&M Facility, passenger stations, and signal houses. Depending on the type and size of the FACP provided, the FCS shall employ different interfacing methods. Small FACP shall provide dry contact interfacing to the LIA to monitor the alarms. FCS shall send the alarms to the CCS and to the EMP (if the EMP monitors the location). Appendix C, Monitored Equipment List, itemizes the FACP’s monitored by the FCS.

- Contractor shall coordinate with the contractor supplying the FACP to identify the discrete signal interface to the LIA.


- Emergency fan dampers are provided for the Beacon Hill tunnel by Contract 710. The FCS monitors and controls the dampers through dry contact interfacing from the LIA to the hardwired control circuits provided by the C710 electrical contractor. Appendix C, Monitored Equipment List, itemizes all dampers monitored and/or controlled through the LIA’s.

- Contractor shall coordinate with the C710 electrical contract to identify the hardwired control logic and discrete signal interface to the LIA.


- Sump and sewage ejector pumps are provided for the Beacon Hill tunnel by Contract 710. The FCS monitors the pumps through dry contact interfacing from the LIA to the packaged control system provided by the C710 mechanical contractor. Appendix C, Monitored Equipment List, itemizes all pumps monitored through the LIA’s.

- Contractor shall coordinate with the C710 mechanical Contract to identify the discrete signal interface to the LIA.


- Emergency fans are provided for the Beacon Hill tunnel by Contract 710. The FCS monitors and controls the fans through dry contact interfacing from the LIA to the hardwired control circuits provided by the C710 electrical contractor. Appendix C, Monitored Equipment List, itemizes all fans monitored and/or controlled through the LIA’s.

- Contractor shall coordinate with the C710 electrical Contract to identify the hardwired control logic and discrete signal interface to the LIA.
10.) Reversible Emergency Fans and Jet Fans – See Contract Drawing L00-D314

- Reversible emergency fans and jet fans are monitored and controlled in a similar fashion to the non-reversible fans (described above). These fans also include instrumentation provided by contract C710. FCS shall monitor the analog signals from the fan instrumentation. These analog inputs shall not be transmitted to the CCS. FCS logic shall compare the analog inputs to threshold values (defined by the fan Contractor). If the analog is outside of the threshold, FCS shall generate and send an alarm to the CCS. Appendix C, Monitored Equipment List, itemizes all reversible fans and jet fans monitored by the FCS.

- Contractor shall coordinate with contract C710 to identify the hardwired control logic and discrete signal interface to the LIA. Contractor shall coordinate with contract C710 for analog signal monitoring and alarming.


- Supply fans are provided for the Beacon Hill tunnel by Contract 710. The FCS monitors and controls the fans through dry contact interfacing from the LIA to the hardwired control circuits provided by the C710 electrical Contractor. Appendix C, Monitored Equipment List, itemizes all supply fans monitored and/or controlled through the LIAs.

- Contractor shall coordinate with contract C710 to identify the hardwired control logic and discrete signal interface to the LIA.

12.) Service Switchboards – See Contract Drawing L00-D316.

- Service switchboards are provided for the Beacon Hill tunnel by Contract 710. The FCS monitors the breakers through dry contact interfacing from the switchboard to the LIA. Contract Drawing L00-D316 itemizes all points monitored for both switchboards by the LIA.

- Contractor shall coordinate with contract C710 to identify the discrete signal interface to the LIA.


- Dry standpipes for the Beacon Hill tunnels bores are charged with water when the motorized valves are opened. These valves are provided for the Beacon Hill tunnel by Contract 710. The CCS shall monitor and control these valves through the FCS. Appendix C, Monitored Equipment List, itemizes the valves that are monitored and controlled through the LIA’s.

- Contractor shall coordinate with the C710 fire, mechanical or electrical Contract to identify the discrete signal interface to the LIA.


PA amplifiers and VMS controllers are provided by this C803 Contract in all passenger stations. The FCS shall monitor the health status of this equipment.
through the LIA and send alarms to the CCS. Appendix C, Monitored Equipment List, estimates the number of VMS controllers monitored by the FCS. The number of PA amplifiers is subject to C803 PA design and is not estimated.


Radio fiber switches and transceivers are provided by this Contract as part of the radio system design. The FCS shall monitor the health status of this equipment through the LIA and send alarms to the CCS. Appendix C, Monitored Equipment List, estimates the number of these devices to be monitored by the LIA.


- UPSs are provided by various electrical Contracts and this Contract. Depending on the type of UPS provided, the FCS shall employ different interfacing methods. Some UPSs shall provide dry contact interfacing to the LIA to monitor the alarms. FCS shall send the alarms to the CCS. Appendix C, Monitored Equipment List, itemizes the UPSs monitored by the FCS.
- Contractor shall coordinate with the contractor supplying the UPS to identify the discrete signal interface to the LIA.

17.) Elevators – See Contract Drawing L00-D323.

- Elevators in the Beacon Hill Station are provided by contract C710. The FCS shall monitor and control all elevators through LIA dry contact interfacing. Appendix C, Monitored Equipment List, itemizes all elevators monitored by the LIA.
- Contractor shall coordinate with contract C710 elevator to identify the discrete signal interface to the LIA.

18.) Escalators – See Contract Drawing L00-D324.

- Escalators in new aerial station are provided by various Contracts. The FCS shall monitor all escalators through LIA dry contact interfacing. Appendix C, Monitored Equipment List, itemizes all escalators monitored by the LIA.
- Contractor shall coordinate with the appropriate elevator Contractor to identify the discrete signal interface to the LIA.

19.) Door Intrusion Detectors – See Contract Drawing L00-D327.

Doors in Beacon Hill Station and McClellan Station are provided with magnetic contact switches. The FCS shall monitor the status of the contact closures using supervised loops that can detect if the circuit has been tampered with. The LIA shall monitor the status of these doors and report an intrusion alarm to the CCS if the door is opened. Appendix C, Monitored Equipment List, itemizes all doors monitored by the FCS.
20.) Room Intrusion Detectors – See Contract Drawing L00-D327.

Certain rooms in Beacon Hill Station shall be provided with occupancy sensors. The LIA shall monitor the status of the sensor contact closures, and report an intrusion alarm to the CCS when the room is occupied. Appendix C, Monitored Equipment List, itemizes all rooms monitored by the FCS.

21.) Motor Operated Disconnects (MOD) – See Contract Drawing L00-D328.

- MODs are provided by Contract C807. Most of these MODs are at the traction power substations and are accounted for in the Station Alarm Panel interface above. A number of MODs are located on the trackway and shall be monitored and controlled by the FCS. Appendix C, Monitored Equipment List, itemizes all MODs monitored by the LIA.

- Contractor shall coordinate with Contract C807 to integrate the LIA into the field control panel provided by C807 for all power, panel sizing and installation, and discrete / analog signal interfacing requirements. The LIA shall be built by Contractor and delivered to the C807 panel fabricator for factory installation and integration by the C807 contractor. Contractor shall support the C807 contractor for all testing and integration.

22.) Trackway Intrusion Detectors (TID) – See Contract Drawing L00-D329.

TIDs are provided by this Contract to detect any person or vehicle (except trains or buses) entering a tunnel or aerial section. The TID shall provide dry contact signals to the LIA. Depending on the location, the LIA may be in a separate cabinet or integrated into the TID cabinet. The FCS shall monitor the discrete inputs through the LIA and send alarms to the CCS. Appendix C, Monitored Equipment List, itemizes all TIDs monitored by the LIA.


Dc power systems are provided by this Contract as part of the communications design. The FCS shall monitor the health status of this equipment through the LIA and send alarms to the CCS. Appendix C, Monitored Equipment List, estimates the number of these devices to be monitored by the LIA. Contractor shall provide monitoring for all dc power systems that are provided.

24.) Track Isolation Monitoring (TIO) – See Contract Drawing L00-D331.

In this Contract, the TIO is a pilot version of a complete system. The TIO shall be added at three locations to LIA’s that are otherwise required. LonWorks Application Generic Controllers (AGC’s), analog input modules and data logging modules shall be designed to support the TIO automated testing functions. See Section 17831, Track Isolation Monitoring, for details.
2. LonWorks Application Specific Controllers (ASC).

   a.) ASCs provide monitoring and control for following systems:


          In the Beacon Hill Tunnel lighting controllers are provided the electrical portion of contract C710. Contractor shall coordinate with the electrical Contractor to configure and integrate the Lighting Controller into the FCS.

3. LonWorks HVAC Local Control Panels (LCP).

   a.) In the Beacon Hill Tunnel certain HVAC system controls are designed and installed under the mechanical portion of contract C710. The following equipment shall be controlled by an FCS LonWorks interface to these HVAC LCPs. See Contract Drawing L00-D309.

      1.) Air Handling Unit.
      2.) Exhaust Fan.
      3.) Air Cooled Condenser.
      4.) Air Conditioning Unit.
      5.) Filter Fan.
      6.) Supply Fan.

   b.) Contractor shall support the C710 HVAC Contractor for all testing and integration.


   a.) Modbus/TCP devices are FCS nodes that communicate on the CSN to the CCS. These nodes are provided by Contractor and other contracts.

      1.) Train Signal System Processor – See Contract Drawing L00-D302.

          - Signal Processors are provided by Contract C802. The FCS monitors and controls the signaling system through this interface. It is not known whether the Signal Processor will be provided with an on-board Ethernet port with Modbus/TCP protocol. If the Signal Processor provides an RS-232 Modbus serial interface, Contractor shall provide a Terminal Server to convert to Modbus/TCP. Appendix C, Monitored Equipment List, itemizes all Signal Processors.

          - Appendix E, C802/C803 Data Interface is a document shared by both Contracts to facilitate the requirements for this interface. Contractor shall coordinate with Contract C802 to identify the discrete and analog data
signals to support all functional requirements. Contractor shall support the C802 contractor for all testing and integration.

2.) Ac Power Meters – See Contract Drawing L00-D303.

- Power Meters are provided by contract C807. The FCS monitors power consumption at traction power substation switchgear equipment through the Power Meter. Appendix C, Monitored Equipment List, itemizes all Power Meters.

- Contractor shall coordinate with contract C807 to integrate the Power Meter into the FCS. Contractor shall support the C807 contractor for all testing and integration.

3.) DSTT PLC System.

In the existing DSTT stations Contractor shall replace the existing Remote Telemetry Units with Modbus PLC’s. See Section 17812, Modbus/TCP Network and Devices, for PLC requirements. All existing DSTT equipment shall be monitored and controlled as itemized in Appendix D, DSTT I/O List. The following new equipment shall also be interfaced through these PLC’s. See descriptions for these items under LonWorks Interface Assemblies for interfacing requirements:

- Bi-directional Amplifiers – See Contract Drawing L00-D305.

- Ticket Vending Machines – See Contract Drawing L00-D306.


5. Communication Gateways – LonWorks or Modbus/TCP.

a.) Communication gateways shall be used only for the interfaces identified below and where defined by Appendix C, Monitored Equipment List. Gateways may convert the interfacing to LonWorks, Modbus/TCP or both as appropriate to the communication requirements.

1.) Fire Alarm Control Panel Gateways – See Contract Drawing L00-D308.

FACPs in the O&M Facility, Beacon Hill and DSTT stations are provided with proprietary serial interfaces. Contractor shall supply a Gateway to the FACP compatible with the FACP protocol. Contractor shall coordinate with the fire
system Contractor to obtain all specific data points to be obtained through the interface.


Certain large UPS's are provided with proprietary serial interfaces. Contractor shall supply a Gateway to the UPS compatible with the UPS protocol. Contractor shall coordinate with the UPS vendor to obtain all specific data points to be obtained through the interface.

2.02 PANEL / ASSEMBLY COMPONENTS.

A. Enclosures.

1. Wherever an enclosure is supplied for an FCS installation it shall be NEMA rated for the environment. If enclosure is exposed to outdoor weather or within three feet of water or steam lines shall have a NEMA 3R designation All other enclosures shall have a NEMA 1 designation.

2. Enclosures shall be sized for ample space of all components with room for 25 percent expansion of the I/O.

3. Mounting panel shall be painted enamel, 16 gauge stainless steel.

4. Panels shall have hinged doors and keyed lock.

B. Control Relays.

1. UL listed.

2. Enclosed in a dust proof enclosure.

3. Four-pole minimum, eight-pole installed maximum, unless noted or indicated otherwise on the Contract Drawings. Relays shall have a complete set of contacts (e.g., a four-pole block shall have all contacts furnished).

4. Provided with track mounted socket and mounting tracks.

5. Rated for the intended purpose.

6. Provided with non-incandescent, mechanical, neon or LED indicators that illuminate or change position to indicate that the coil is energized.

7. Mechanical Life: 30,000,000 operations.

C. Circuit Breakers.

1. DIN rail mounted.

2. Continuous duty ampacity appropriately rated and indicated on the drawings.
3. Breakers shall have a maximum interrupting capacity of 200 Amps but not exceeding 100 times rated current.

4. Operating life shall be a minimum 6,000 cycles at rated current and 4,000 cycles at 200 percent rated current and minimum dielectric strength of 1,500 Volts ac, mounting track must be provided.

D. Dc Power Supplies.

1. DIN rail mounted.

2. UL 508 Listing.

3. Fusing on both the primary and secondary.

4. Provide disconnecting means for servicing and replacement.

5. Output voltage adjustable plus or minus 10 percent.

6. Input Voltage single voltage 2 wire, 100 to 240 Vac.

7. Operating Temperature 14 – 140 degrees Fahrenheit.

8. Rated for actual loads plus 50 percent.

E. Control Power Transformers.

1. Provide factory-assembled, general-purpose, ventilated, dry-type distribution transformers of rated kVA capacities required.

2. Rated for continuous operation, at rated kVA, without exceeding a total winding temperature, as indicated below.

3. Insulation System Classification.

4. Electrically grounded to enclosure by means of a flexible metal grounding strap.

5. An electrostatic shield shall be placed between the primary and secondary windings.

6. Include fusing on both the primary and secondary.

7. Provide disconnecting means for servicing and replacement.

F. Terminal Blocks.

1. All incoming and outgoing wiring to the panel shall be landed on DIN rail mounted, finger safe terminal blocks.

2. Discrete I/O wiring terminal blocks shall accept between #28 to #12 AWG wire. Select different colors to distinguish inputs and outputs.
3. Analog inputs circuits shall be landed on fused terminal blocks with indicating lamp for blown fuse. Include appropriate fuses rated to protect PLC inputs.

4. All terminal blocks shall accept the wires using a spring clamping mechanism. Screw-type terminal blocks shall not be accepted.

G. Wire and Cable.

1. Power and 120 Vac control wiring shall be single conductor, stranded (all sizes), soft annealed copper conductors with 600 volt insulation type THHN/THWN. Wire smaller than No. 14 gauge shall not be used unless specifically called for on drawings.

2. 24V wiring shall be shielded twisted pair, 600V, 90° C.

3. Conductors-18 AWG, stranded copper rated for 300 Vac service.

4. Conductor insulation of 15 mils PVC and 5 mils nylon.

5. Foil shield with tinned copper drain wire.

6. Jacket of 50 mil Black PVC.

7. Signal wiring for analog inputs shall be 18 AWG single or multiple twisted pair and have 18 AWG drain wire. Insulation shall be rated for 300 Vac.

8. Discrete alarm wiring shall be either two-wire normally closed or three-wire normally open circuitry.

H. Panel Holes.

1. All panel holes shall be drilled and tapped for long-term flexibility and ease of equipment replacement and/or upgrade.

2. Each hole and/or penetration point shall be touched-up with proper sealant to minimize corrosion prior to mounting components.

I. Labels and Nameplates.

1. All nameplates shall be both glued and screwed in place for longevity.

2. All wires shall be identified at both ends with permanent labels.

J. Wiring.

1. Wiring duct shall be used to enclose panel wiring as required to provide the appearance of good workmanship. The wire duct color shall be the same throughout the panel. The duct shall be securely fastened to the panel with screws and washers or rivets. Ducts shall be a maximum of 75 percent full.

2. Wiring within digital and ancillary control panels shall be routed by duct wherever possible. Wire shall be neatly and symmetrically arranged within the control cabinet.
3. Wiring ducts shall be provided from the entry point of external cable to the termination point of the cables. The ac and dc wiring leading from the devices and terminal blocks to the field shall be formed to exit separately in dedicated areas on the top and/or bottom of the panel.

4. All studs for supporting cable bundles at key stress points shall be welded without the use of adhesive style mounting devices.

5. All wires shall be combed and neatly aligned preventing unnecessary stress in the wire bundle.

6. When terminating twisted shielded cables, the PVC shall be insulated with heat shrink and the ground conductor sleeved for safety.

K. Terminal Block Wiring.

1. All wiring entering and leaving control panels shall be terminated on a numbered terminal strip.

2. Arrange for vertical conduit entry. Terminal blocks shall have no more than two wires connected per termination point. Factory jumpers may be used where required.

3. All terminals shall be numbered with a permanent, nonconductive strip on each block according to the detailed wiring drawings. Provide mounting track to anchor terminal blocks to control panel.

4. Terminal strip colors indicated below shall be used for all terminal strips (not wire colors):

   a.) Digital input points: Beige.
   b.) Digital output points: Brown.
   c.) Analog input points: Purple.
   d.) Analog output points: Yellow.
   f.) Power supply (48 Vdc Blue plant): Blue (hot) Gray (return).
   g.) Power supply (internal 24 Vac or Vdc): Blue Hot Gray (neutral).
   h.) Power supply (external 24 Vac or Vdc): White (hot) Gray (neutral).
   i.) Power supply (120 Vac or less): Black (hot) Gray (neutral).
   j.) Any voltage greater than 120 Vac: Orange (hot) Gray (neutral).
   k.) Network: Red/Orange.
l.) Grounds: Green.

m.) All other terminal connections: Beige.

L. Grounding.

All FCS installations shall be properly grounded. The ground wire terminal of each device shall be connected to the grounding conductor. Material and installation shall comply with National Electrical Contractors Association's "Standard of Installation" pertaining to the installation, grounding and bonding of circuits and equipment.

PART 3 - EXECUTION

3.01 PREPARATION

A. Contractor shall obtain installation drawings and details from the appropriate Contract for all systems monitored or controlled by the FCS. Appendix C, Monitored Equipment List, of these Specifications shall be considered a preliminary list that identifies approximately 90 percent of the equipment interfaced to the FCS.

B. For each piece of equipment monitored/controlled by the FCS, Contractor shall verify with the Contractor supplying and/or installing the equipment, the interface details shown on the FCS Interface Diagrams.

C. Many FCS assemblies are to be mounted within enclosures that are existing or supplied by others. Contractor shall positively determine all necessary installation requirements including available size, power, terminal strip interface details, and conduit availability.

D. Contractor shall carefully review all relevant Control System Functions to verify that all necessary I/O has been provided to implement the required functions.

3.02 INSTALLATION

A. General.

1. All materials and installation shall comply with requirements specified in the National Electrical Code and all applicable codes and regulations.

2. Install equipment and accessories in accordance with manufacturer’s instructions.

3. Coordinate all facility modifications prior to developing detailed submittal drawings as specified above.

4. All Work described in this Specification shall be installed under the supervision of competent engineers, electricians and mechanics regularly employed in the installation of control systems. The system installer shall perform engineering, programming, calibration, check out, and testing.

5. All equipment to be installed per approved shop drawings and equipment manufacturer’s written instructions.
6. The FCS equipment and components must be securely attached to the building structure (column, permanent wall), superstructure (anchored to the floor, mounted on cable rack, etc.) maintaining service access where appropriate.

B. Control Wire and Cable.

1. Coordinate cable installation with other Work, equipment suppliers, system manufacturers.

2. Pull conductors simultaneously where more than one is being installed in same conduit. Use UL listed pulling compound, dry talc or lubricant, where necessary, unless indicated otherwise in this specification or on drawings.

3. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

4. Conceal all cable in conduit.

5. Install cable in conduits parallel and perpendicular to surfaces or exposed structural members, and follow surface contours.

6. Keep conductor splices to minimum and provide not less than 8" slack conductors at outlet and junction boxes for splices.

7. Pull conductors simultaneously where more than one is being installed on the same cable rack.

8. Provide adequate length of conductors within electrical enclosures and neatly train the conductors to terminal points with adequate excess. Bundle multiple conductors, cables and conductors larger than 10 AWG cabled in individual circuits. Make terminations with no bare conductor showing at the terminal.

C. Programming.

1. The Contractor shall provide all application software and development including writing, loading and debugging.

2. Install software in controllers. Implement all program features to meet specified requirements and appropriate to sequence of operation. Connect and configure equipment and software to achieve the sequence of operation specified.

3.03 INTERFACE WITH OTHER WORK.

A. Examine and compare the FCS Specifications and Contract Drawings with the actual installations by other Contractors. Report any discrepancies between them to the Engineer. Install and coordinate the FCS Work in cooperation with the other Contractors installing interrelated Work. Before installation, take proper provisions to avoid interference in a manner approved by the Engineer. Specific Interface requirements are determined after control Contractor is selected.

B. Other contracts will provide certain products and systems that shall be directly interfaced with the FCS. Examine the specifications and drawings to ascertain these requirements.
C. Carefully check space requirements to insure that all material can be installed in the allotted spaces, especially in cabinets and enclosures provided by others. Adjust locations of panels, equipment, devices, and the like, to accommodate Work and prevent interference. Where specific details and dimensions are not shown on the Contract Drawings, the Contractor shall take measurements and make layouts as required for the proper installation of the Work and coordination with all other Work on the project.

D. Coordinate with other Contracts for information required for installation. Wherever Work interconnects with Work of other trades, coordinate with other trades to insure that all trades have the information necessary so that they may properly install all the necessary connections and equipment.

E. Coordinate, protect and schedule Work with other trades in accordance with the construction sequence.

F. Install the FCS to permit replacement of parts without damage to other parts.

G. Make certain that all materials selected directly or selected by suppliers conform to the requirements of the Specifications. Transmittal of such Specification information to persons manufacturing and supplying materials to the project, and rigid adherence is the Contractor’s responsibility. Acceptance of a manufacturer’s name by the Engineer does not release the Contractor of the responsibility for providing materials that comply with the requirements in the Contract Documents.

3.04 DEMONSTRATION

Upon the successful completion of all FCS Startup Tests in the Link system, the FCS shall be considered acceptable to the Sound Transit. At this time, the Contractor shall issue a letter to the Engineer signifying Sound Transit acceptance of the FCS, and that the FCS is substantially complete. The date of the letter will signify the start of the system warranty period.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17802
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SECTION 17811
LONWORKS NETWORK AND DEVICES

PART 1 - GENERAL

1.01 OVERVIEW

LonWorks shall be used throughout Link for monitoring and control interfacing. In general, all facilities have one or more local LonWorks twisted pair, FT-10 networks including the O&M Facility, passenger stations, traction power substations and TWC cases. These local FT-10 networks are connected over a system wide LonWorks fiber ring that is independent of the SONET ring or any Ethernet network. There are also LonWorks to IP Ethernet routers that connect all FT-10 networks to the CSN.

1.02 SECTION INCLUDES

A. This Section contains functional and design requirements for:
   1. LonWorks Interface Assemblies.
   2. LonWorks Gateways.
   3. LonWorks TP/FT-10 networks.
   5. LonWorks / IP routers.

1.03 PRODUCTS CONFIGURED BUT NOT SUPPLIED

A. Certain LonWorks devices are supplied by the Sound Transit through other Link contracts. Integrate, configure and/or program these devices to function on the LonWorks network. These components include the following:
   1. HVAC Control Panels.
   2. Lighting Controllers.

1.04 RELATED SECTIONS

A. Section 17040 – Technology Documentation.

B. Section 17500 – Cable Transmission System/ WAN Overview.

C. Section 17800 – Control System Overview.

D. Section 17801 – Control System Network.

E. Section 17802 – Field Control System.
F. Section 17840 – Central Control System.
G. Section 17842 – Emergency Management Panel.
H. Section 17910 – Communications Network Management.
I. Section 17930 – Cable Management System.
J. Appendix B – Communications Equipment List.
K. Appendix C – Monitored Equipment List.
L. Appendix E – C802/C803 Data Interface.
M. Appendix F – Control System Function (Use Cases).

1.05 REFERENCE STANDARDS

C. EIA-709.3 Free-Topology Twisted-Pair Channel Specification.

1.06 DEFINITIONS

A. General.

Analog: A continuously varying signal value (temperature, current, voltage, etc.).

B. LonWorks.

1. Application Generic Controller (AGC).

A networked device or node that contains a complete, configurable application that is generic in nature and suited for various control tasks. The device manufacturer produces this application. The manufacturer exposes a high number of network variables and configuration properties on the device to allow the specific use of the device to be configured with network tools.

2. Application Specific Controller (ASC)

A networked device or node that contains a complete, configurable application that is specific to a particular task. This application is normally produced by the device manufacturer and contains a number of configuration parameters that may be adjusted by network tools.

3. Bridge.

A device that routes messages or isolates message traffic to a particular segment, subnet or domain of the same physical communication media.
4. Channel.

A physical media serving a number of nodes. All nodes on any given channel hear messages produced by other nodes on the channel. The network configuration and node application program determines whether or not a device responds to the messages.

5. Control Unit (CU).

Control product that incorporates solid state components to perform multiple control loops or functions.

6. Custom Application Controller (CAC).

Programmable control product that incorporates solid state components based upon the Neuron ® chip to perform control loops or functions. The application in the controller is custom software produced by the integrator specifically for the project. These applications shall conform to the LONMARK ® functional profiles and interoperability standards. Complete documentation including object diagrams and external interface files must be submitted to owner when such devices are used.

7. Diagnostic Program.

Machine-executable instructions used to detect and isolate system and component malfunctions.

8. Domain.

A domain is logical collection of nodes on one or more channels. Communications can only take place among nodes configured in a common domain; therefore, a domain forms a virtual network. Multiple domains can occupy the same channels, so domains may be used.


A device that contains an I/O software driver to translate data from a particular format to that conforming to another format. All LCGs will translate from other formats to the LonTalk® protocol.

10. Intelligent Devices (ID’s).

Control products that incorporate solid state components based around the Neuron chip to perform a dedicated functions (ex: actuators, sensors, switches). Each such device should be submitted with functional profiles based on LONMARK Interoperability Association Standards.

11. LONWORKS Technology.

The generic technology that supports products that communicate using LonTalk Communication protocol. The technology employs routers, gateways, bridges and multimedia transceivers permitting topology and media independent control solutions.

A device (PC, laptop or dumb display terminal) which incorporates the LonWorks Network Services Interface (NSI), Application Program Interface (API) for remote network client services. The operator interface workstation may connect either to a LonTalk or IP network. A GUI is a graphical subset of Operator interfaces.

13. Router.

A device that routes or forwards messages destined for a node on another subnet or domain of the control network. The device controls message traffic based on node address and priority.


A set of channels connected by bridges or repeaters. A node sees every packet from every other node on its segment.

1.07 ABBREVIATIONS

A. AGC  Application Generic Controller.
B. ASC  Application Specific Controller.
C. CAC  Custom Application Controller.
D. COS  Change of State.
E. CPU  Central Processing Unit.
F. DDC  Direct Digital Controller.
G. DRF  Device Resource File.
H. FACP  Fire Alarm Control Panel.
I. GUI  Graphical User Interface.
J. I/O  Input/Output.
K. IP  Internet Protocol.
L. LNS  LonWorks Network Services.
M. NSS  Network Services Server.
N. NSI  Network Services Interface.
O. XIF  External Interface File.
1.08 SYSTEM DESCRIPTION

A. Design Requirements.

1. Contractor shall provide all Work described in this Specification which consists of all labor, materials, equipment wiring, hardware, software and services necessary to design, install and make operational a fully functional and integrated system.

a.) LonWorks Network.

1.) In each station or facility the LonWorks portion of the FCS will consist of a flat, open network architecture that uses LonTalk (EIA 709.1) as the common communication protocol between all controlled and controlling devices.

2.) The system design shall provide self-checking features and be such that there shall be no single point of failure. The failure of any component shall impact only the functions associated with that component.

3.) Where necessary and at every SONET drop, LonTalk packets shall be encapsulated into IP packets for communication with the CCS using LonWorks / IP routers. Encapsulation of the LonTalk protocol into IP packets shall conform to LonMark Interoperability Association guidelines.

4.) Gateways shall be used only where the Contract documents specifically require it.

5.) Network services for the FCS shall be provided by LonWorks Network Services (LNS). Configuration tools, and operator interfaces in the CCS or ESI shall be supported by the LNS database in a client-server fashion.

6.) Proposed alternatives to LNS must demonstrate industry standardization by documenting an ability to support tools, applications, and products manufactured by no fewer than ten (10) distinct companies in the control industry. Proposed alternatives will then be field-tested with network management tools from at least five (5) distinct manufacturers.

B. Performance Requirements.

1. The LonWorks portion of the FCS shall reliably and efficiently provide the field monitoring and control functions required for the Control System.

a.) Communication performance shall be measured from any analog or discrete input module to the I/O server at the OCC. The time measured from when the input changes until the change is registered at the OCC shall be a maximum of 2 seconds.

b.) Monitoring and control performance is specific for the requirements of the Link system being interfaced to.
1.09 SUBMITTALS

See Section 17802, Field Control System, for all submittal requirements.

1.10 QUALITY ASSURANCE

A. LonWorks Qualifications.

1. Contractor shall have an office that is staffed with engineers trained in designing LonWorks networks and programming and fully capable of providing LonWorks instruction.

2. Contractor shall use LonWorks Network Management Application Programs that have been developed by LonWorks product developers who have been trained in the use of LNS. Qualified firms shall be engaged in development of LonWorks Network Management Tools and have products that have been in satisfactory use in similar service for not less than one (1) year.

3. Contractor shall be willing and able to supply products from a variety of manufacturers.

4. Contractor shall be competent in the use of a LonManager® Protocol Analyzer or equivalent.

1.11 WARRANTY

A. The FCS shall be free from defects in workmanship and material and shall be guaranteed to operate as required to maintain specified conditions and functions. The Contractor without charge shall make any repairs, adjustments or replacements made necessary by such defects during the first full year from the time of acceptance of the project by the Owner.

B. The Contractor’s authorized and qualified service technician shall respond to the Owner’s call for service within 2 hours for malfunctions that have a critical impact on effectively operating the FCS. The response time for non-critical service calls shall not exceed 24 hours unless otherwise waived by the Owner.

PART 2 - PRODUCTS

2.01 OVERVIEW

The FCS design indicates the minimum requirements. Where additional wiring and controls devices are necessary to meet the intent of the control requirements defined in Appendix F, Control System Functions (Use Cases), these devices shall be provided regardless if shown on drawings.

2.02 COMPONENTS

A. LonWorks Network Devices.

1. General.

a.) The products used shall be LonMark compliant. Individual products shall conform whenever possible to the LonMark Interoperability Standards. If products are not
certified by the LonMark organization, product submittals must include the application source code, external interface file, resource files and complete documentation regarding all network variables and configuration properties supported by the device.

b.) Control devices connected to the LonWorks control network should be readily replaceable with devices from multiple manufacturers.

c.) Materials and equipment shall be catalogued products and shall be manufacturer’s latest standard design that complies with the specification requirements.

d.) All microprocessor based controllers shall include a Neuron chip or other processor with complete implementation of the LonTalk protocol stack.

e.) Use published functional profiles for all product network message and configuration parameters. Where published profiles do not exist, use draft profile standards or submit a proposed draft as part of the submittals.

f.) Use Standard Configuration Parameter Types (SCPT’s) for all product configuration parameters. Do not use network variables for this purpose. If User Defined Configuration Parameters (UCPT’s) are used, provide resource files to allow installation of device by third party tools.

g.) All products shall use an Echelon 3120 or 3150 Neuron chip as a general purpose microcontroller with built-in communications.

h.) Each controller shall use an Echelon, FTT-10a transceiver for all communication transmissions. It shall comply with FCC and VDE requirements, and be a UL recognized component. The physical network shall use polarity insensitive twisted pair wiring in a loop configuration.

2. Routers.

a.) Provide routers, bridges and repeaters to combine different communication channels onto a common field bus backbone, to isolate segment communication traffic, allow network baud rate changes, and extend Network segment distances. Use LONTalk™ protocol transport to transparently route messages bound for a node address in another sub-net or domain.

b.) Routers, bridges and repeaters shall be fully programmable and permit a systems integrator to define message traffic, destination, and other network management functions using LonWorks®, NetMaker and Net Profiler installation tools through the LONManager Software package or similar API based network management tool.

c.) Routers, bridges, and repeaters shall be capable of DIN rail or panel mounting and be equipped with status LED lights for Network traffic and power.

d.) Provide a minimum of (2) Neuron 3150 processors for use as the network router communication controller.
e.) Routers shall be designed to route messages from a segment, subnet, or domain in full duplex communication mode.

f.) LonWorks fiber ring routers shall support bi-directional communication on single fiber, up to 750 nodes per ring, and up to 30 km single links without repeaters.

3. Controllers.

Provide controllers with all necessary programming capability to meet the specific requirements of the interface. All physical wiring connections shall be made on removable screw down connections for quick disconnect and serviceability of the controller. Controllers shall be self sufficient units that include an internal clock, operating system, communication timing, and interrupt controls. Network communications will conform to LONWorks® standards.

4. I/O Modules.

a.) As a rule, all discrete interfacing is through dry contacts. Discrete outputs modules shall be form C dry contacts rated for the voltage and current of the particular interface. Discrete input modules shall be suitable for 24VAC / VDC wetting voltage.

b.) As a rule, all analog signals will be 4-20 mA. Analog inputs modules will have 12 bit accuracy with no more than + 1 percent of error.

B. Wire and Cable.

1. Power and 120VAC control wiring shall be single conductor, stranded (all sizes), soft annealed copper conductors with 600 volt insulation type THHN/THWN. Wire smaller than No. 14 gauge shall not be used unless specifically called for on drawings.

2. 24V wiring shall be shielded twisted pair, 600V, 90° C.

3. Conductors-18 AWG, stranded copper rated for 300 VAC service.

4. Conductor insulation of 15 mils PVC and 5 mils nylon.

5. Foil shield with tinned copper drain wire.

6. Jacket of 50 mil Black PVC.

7. Wire insulation color coded black and white.

8. Signal wiring for analog inputs shall be 18 AWG single or multiple twisted pair and have 18 AWG drain wire. Insulation shall be rated for 300 VAC.

9. Discrete alarm wiring shall be either two-wire normally closed or three-wire normally open circuitry.

C. Off-the-Shelf Software.

1. LonWorks Programming Software.
a.) Furnish and install programming software with the following capabilities: device
installation, device configuration, device diagnostics, field programming, device
maintenance, network variable binding, channel traffic analysis, message routing and
repeating and protocol conversion.

b.) The software shall be based on a graphical object-oriented software system that
provides an intuitive interface for network design and installation. This software must
allow for creation of multiple logical subsystems within the overall control strategy.
The software shall include all modules necessary to provide complete network
management, installation and maintenance.

c.) Network Management Tools and software applications shall support multiple service
tools in a client/server network fashion. Application Programs shall be based on the
LonWorks Network Services (LNS) Operating System.

d.) Network Management software shall support ‘plug-in’ applets. That is, the network
management application should act as a ‘director’ program that provides a published
interface, which allows other manufacturers to construct plug-in applets to run within
the director application.

2. LonWorks Network Services (LNS).

a.) Furnish and install a 32 bit, object oriented multiple client server based Network
Management application program(s) using the latest LonWorks Network Services
(LNS) API.

b.) Network Management clients shall be capable of performing the following network
services by accessing the appropriate network node databases from the Network
Services Server:

1.) Device / node installation.

2.) Device / node configuration.

3.) Device / node diagnostics.

4.) Device / node maintenance.

5.) Field programming.

6.) Network variable binding.

7.) Network variable browsing.

8.) Graphical user interface.

9.) System diagnostics.
c.) The Network Management Network Services Server Application (NSS) shall reside on the FCS Local Area Network servers in the OCC. This application shall support multiple clients on the Local Area Network anywhere on the FCS control network.


a.) The software shall include a protocol analyzer package with the following three tools for network analysis and monitoring:

1.) Protocol Analyzer Tool.

   - Packet Display Contents: Packet number, packet size, time stamp, packet attributes, service type, transaction number, source address, destination address, network variable, message class and message code.

   - Packet Display Attributes: Priority, alternate path, authentication and idempotent response.

   - Configurable Display Attributes: Visible packet fields, font name and size and column widths.

   - Packet Log Options: Log size and fixed size or circular log.

   - Packet Match Options: Node name, network variable name, message code and transactions.

   - Packet Type Receive Filter Options: Ack, acked, acked/reminder, challenge, reply, request, request/reminder, response, unacked, unacked repeat and unknown.

   - Packet Source Node Receive Filter Options: Node name, neuron ID and subnet/node ID.

   - Packet Destination Node Receive Filter Options: Node name, neuron ID subnet/node ID, group ID and broadcast address.

   - Packet Source or Destination Receive Filter Options: Network variable name and message code name.

   - Detected Error Conditions: CRC error, time-out error, packet too short, packet too long, preamble too short and preamble too long.

2.) Traffic Analysis Tool.

   - Collective Options: Cumulative or snapshot.

   - Summary Data: Start time, update time, elapsed time, total packets received, average packet size, average packets per second, maximum packets per second, bandwidth utilization, packet counts, network error counts, total errors and error rate.
- Packet Count Categories: Ack, acked, acked/reminder, challenge, reply, request, request/reminder, response, unacked, unacked repeat and unknown.

- Network Error Count Categories: CRC errors, time-out error, packet too long, preamble too short, preamble too long and packets lost.

- Data Available via DDE: All summary data.

3.) Network Diagnostics Tool

- Commands: Ping, proxy ping, status (test), proxy status, reset, off-line, on-line, wink and clear error log, reset cause and statistics.

- Test Data: Software version, most recent error, most recent reset cause and node statistics.

- Command Options: Interval or number of operations.

- Node Statistics: Transaction errors, transaction time-outs, receive transactions full, lost messages, missed messages, number of packets transmitted at layer 3, number of packets received at layer 3, number of packets received at layer 4, retries, backlog overflow, late acknowledgments and collisions.

D. Database and File Servers.

Provide four dedicated servers to support the LonWorks® Network Services Server (NSS) database, CCS interface database. Install and configure two servers to act as a primary and back-up server at the OCC. The back-up servers shall be active in a stand-by operating mode. In the case of failure of the primary servers, the back-up servers shall automatically pick-up network operations; the primary servers shall be disabled and taken off-line for diagnostic testing and repair. All data base(s), application programs and other common software platforms shall be duplicated on the back-up servers.

PART 3 - EXECUTION

3.01 OVERVIEW

Complete the installation of the FCS in a facility or station, install system software, debug and commission the system and then notify the Engineer that the FCS is ready for initial startup testing. Submit to the Engineer the Startup Test Plan, in writing, sixty (60) days prior to the period of the testing. During this time frame the Engineer will prepare a detailed punch list of the FCS installation.

3.02 INSTALLERS

All Work shall be performed by trained technicians of the particular specialty involved, and shall be done in a neat and workmanlike manner as approved by the Engineer.
3.03 INSTALLATION

A. General.

1. All materials and installation shall comply with requirements specified in the National Electrical Code and all applicable codes and regulations.

2. Install equipment and accessories in accordance with manufacturer’s instructions.

3. Coordinate all facility modifications prior to developing detailed submittal drawings as specified above.

4. All work described in this specification shall be installed under the supervision of competent engineers, electricians and mechanics regularly employed in the installation of control systems. The system installer shall perform engineering, programming, calibration, check out, and testing.

5. All equipment to be installed per approved shop drawings and equipment manufacturer’s written instructions.

6. The FCS equipment and components must be securely attached to the building structure (column, permanent wall), superstructure (anchored to the floor, mounted on cable rack, etc.) maintaining service access where appropriate.

B. Control Wire and Cable.

1. Coordinate cable installation with other work, equipment suppliers, system manufacturers.

2. Pull conductors simultaneously where more than one is being installed in same conduit. Use UL listed pulling compound, dry talc or lubricant, where necessary, unless indicated otherwise in this specification or on drawings.

3. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

4. Conceal all cable in conduit.

5. Install cable in conduits parallel and perpendicular to surfaces or exposed structural members, and follow surface contours.

6. Keep conductor splices to minimum and provide not less than 8” slack conductors at outlet and junction boxes for splices.

7. Pull conductors simultaneously where more than one is being installed on the same cable rack.

8. Provide adequate length of conductors within electrical enclosures and neatly train the conductors to terminal points with adequate excess. Bundle multiple conductors, cables and conductors larger than 10 AWG cabled in individual circuits. Make terminations with no bare conductor showing at the terminal.
C. Network Cable.

Copper network cabling shall not be located within ten feet of equipment which uses AC power at 440 volts and above. The cabling shall be installed in protective grounded conduit if this requirement can not be met.

D. Power.

As a rule, 120 VAC power will be available in proximity to FCS locations. Provision FCS equipment and assemblies to receive 120 VAC power with terminals, grounding lugs, and circuit breakers as necessary. Install and extend conduit from junction boxes or power panels to the cabinet, enclosure or rack containing FCS equipment.

E. Application Software.

1. The Contractor shall provide all application software and development including writing, loading and debugging.

2. Install software in controllers and operator workstation. Implement all program features to meet specified requirements and appropriate to sequence of operation. Connect and configure equipment and software to achieve the sequence of operation specified.

3. After network devices or nodes and wiring have been physically installed provide all necessary device installation, device configuration, device diagnostics, network variable binding and systems diagnostics.

4. Use a protocol analyzer tool to monitor network traffic on all installed control channels for a minimum of 24 hours per channel. Compare actual traffic data versus predicted channel traffic. Reconfigure nodes or add repeaters and/or routers as necessary to maintain traffic to at most 50 percent of channel bandwidth capacity.

3.04 INTERFACE WITH OTHER WORK

A. Examine and compare the FCS Specifications and Drawings with the actual installations by other contractors. Report any discrepancies between them to the Engineer. Install and coordinate the FCS work in cooperation with the other contractors installing interrelated work. Before installation, take proper provisions to avoid interference in a manner approved by the Engineer. Specific Interface requirements are determined after control contractor is selected.

B. Other contracts will provide certain products and systems that shall be directly interfaced with the FCS. Examine the Specifications and Drawings to ascertain these requirements.

C. Carefully check space requirements to insure that all material can be installed in the allotted spaces, especially in cabinets and enclosures provided by others. Adjust locations of panels, equipment, devices, and the like, to accommodate work and prevent interference. Where specific details and dimensions are not shown on the drawings, the Contractor shall take measurements and make layouts as required for the proper installation of the Work and coordination with all other Work on the project.

D. Coordinate with other contracts for information required for installation. Wherever Work interconnects with Work of other trades, coordinate with other trades to insure that all trades have the information necessary so that they may properly install all the necessary connections and equipment.
E. Coordinate, protect and schedule Work with other trades in accordance with the construction sequence.

F. Install the FCS to permit replacement of parts without damage to other parts.

G. Make certain that all materials selected directly or selected by suppliers conform to the requirements of the Specifications. Transmittal of such Specification information to persons manufacturing and supplying materials to the project, and rigid adherence is the Contractor’s responsibility. Acceptance of a manufacturer’s name by the Engineer does not release the Contractor of the responsibility for providing materials that comply with the requirements in the Contract Documents and Specifications.

3.05 DEMONSTRATION

Upon the successful completion of all FCS Startup Tests in the Link system, the FCS shall be considered acceptable to the Sound Transit. At this time, the Contractor shall issue a letter to the Engineer signifying Sound Transit acceptance of the FCS, and that the FCS is substantially complete. The date of the letter will signify the start of the system warranty period.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17811
PART 1 - GENERAL

1.01 OVERVIEW

Modbus/TCP shall be used throughout Link for monitoring and control interfacing. In general, all Modbus/TCP devices shall communicate via Ethernet on the CSN. If there are devices with serial Modbus only, the communication shall be converted to Modbus/TCP.

1.02 SECTION INCLUDES

A. This Section contains functional and design requirements for:

1. PLC Retrofit of DSTT Stations.
4. Ac Power Meter Communication.
5. Fire Alarm Control Panel (FACP) Gateways.
7. I/O Server Software.

B. Products Configured But Not Supplied.

1. Certain Modbus/TCP devices are supplied by Sound Transit through other Link contracts. Integrate, configure and/or program these devices to function with the FCS on the CSN. These components include the following:

a.) Signal Processors - Provided by Contract C802.
b.) Bus Detection Processors – Provided by Contract C802.
c.) Fire Alarm Control Panels – Provided by Contract C500.
d.) Ac Power Meters – Provided by Contract C807.
e.) Fire Alarm Control Panels – Provided by Contract C500.
f.) Uninterruptible Power Supplies – Provided by Contract C710.
1.03 RELATED SECTIONS

A. Section 17500 – Cable Transmission System/WAN Overview.

B. Section 17800 – Control System Overview.

C. Section 17801 – Control System Network.

D. Section 17802 – Field Control System.

E. Section 17811 – LonWorks Network and Devices.

F. Section 17840 – Central Control System.

G. Section 17842 – Emergency Management Panel.

H. Section 17910 – Communications Network Management.

I. Section 17930 – Cable Management System.

J. Appendix B – Communications Equipment List.

K. Appendix C – Monitored Equipment List.

L. Appendix D – DSTT I/O List.

M. Appendix E – C802 / C803 Data Interface.

N. Appendix F – Control System Functions (Use Cases).

O. Appendix H – DSTT Cable List.

P. Appendix I – DSTT Emergency Ventilation Scenarios.

1.04 REFERENCE STANDARDS


B. The Modbus Organization.


1.05 SYSTEM DESCRIPTION

A. Design Requirements.

1. Contractor shall provide all Work described in these Specifications which consists of all labor, materials, equipment wiring, hardware, software and services necessary to design, install and make operational a fully functional and integrated system.
2. IP addresses shall be assigned and coordinated with the design of the CSN. Modbus station addressing shall be used only as necessary. Contractor may use TCP or UDP protocol as appropriate to satisfy performance requirements.

3. Appendix C, Monitored Equipment List, itemizes the end equipment that is monitored or controlled. This list also includes the devices supplied by other contracts that shall be Modbus/TCP nodes on the CSN.

B. PLC Retrofit of DSTT Stations.

1. A new PLC system shall replace all of the existing Remote Terminal Units (RTU’s) in the DSTT tunnel stations - Westlake, University Street, Pioneer Square, and International District. All PLC system hardware replacing the RTU’s shall be designed to fit within the existing S&C cabinets in the TC/C rooms. Additional remote racks shall be located in the tunnel cross passage to monitor the radio system Bi-directional amplifiers. All PLC’s are listed in Appendix B, Communications Equipment List.

2. All RTU’s are located in the S&C cabinets in the tunnel station TC/C rooms. All Field I/O wiring originates from the existing Interface Terminal Cabinets (ITC’s) throughout the station to the S&C cabinets. The field I/O wiring shall be retained and retrofitted to the PLC system I/O. Appendix D, DSTT I/O List, itemizes all of the RTU I/O. Appendix H, DSTT Cable List, itemizes all DSTT cabling from the ITC’s.

3. The existing RTU’s are "dumb" with no control logic. The RTU’s simply transmit the I/O status to King County Metro’s Vax tunnel computer where all logic is executed. The new Control System will eliminate the Vax tunnel computer. The CCS shall provide supervisory level control. All other logic shall be implemented in the PLC’s. Source code for the Vax tunnel computer will be made available for Contractor's reference.

4. Each RTU communicates only with the tunnel computer, not with other RTU’s. PLC’s shall communicate directly with other PLC’s on the CSN using Modbus/TCP. Also, the PLC’s shall be included on the LonWorks network to permit communication with any LonWorks device. The end result shall be that the tunnel PLC system shall not depend on the CCS for any communication functions.

C. Signal Processor Communication.

1. Signal Processors (provided by Contract C802) are supplied with serial (EIA-232) Modbus ports. For all Signal Processors, Contractor shall convert the serial Modbus to Modbus/TCP to support all data communication requirements with the CCS. Appendix C, Monitored Equipment List, includes all Signal Processors.

2. Details of the interface and data that shall be exchanged with CCS are described in Appendix E, C803 / C802 Signal Processor Interface. Contractor shall coordinate with the C802 contractor to identify the specific data points to be exchanged and to integrate the Signal Processors on the CSN and FCS.

D. Bus Detection Processor Communication.

1. Bus Detection Processors (provided by Contract C802) include an integral AUI port for connection to an Ethernet network. Contractor shall provide an appropriate transceiver for this AUI port and shall integrate the Bus Detection Processors on the CSN. Contractor shall include all Bus Detection Processors on the CSN to provide communication between processors and with the CCS. Appendix C, Monitored Equipment List, includes all Bus Detection Processors.
2. Communications between the Bus Detection Processors and to the FCS/CCS will be through Modbus/TCP. Details of the interface and data that shall be exchanged with the CCS are to be defined in the detailed design of the Bus Detection System by C802. The C802 contractor will furnish Contractor with an interface software document which will explain the functions of registers, commands and other functions needed to perform CCS functions for the combined bus and train signal system.

3. In addition to the interface document, the C802 contractor will furnish Contractor with a prototype software package that will emulate the CCS and demonstrate these functions with the Bus Detection Processor. Prototype software will be written in an object oriented language such as C++ and will include source code documentation.

E. Ac Power Meter Communication.

1. Ac power meters (provided by Contract C807) are supplied with Ethernet Modbus/TCP ports. Contractor shall include all ac power meters on the CSN to provide Modbus/TCP communication with the CCS. Appendix C, Monitored Equipment List, includes all ac power meters.

2. Data points that shall be exchanged with the ac power meters by the CCS are shown on the Traction Power Interface Diagram, drawing L00-D304.

F. Fire Alarm Control Panel (FACP) Gateways.

1. FACP’s communicate using a proprietary protocol through a serial port. Contractor shall provide redundant Gateways configured in a hot standby mode to convert the FACP serial protocol to Modbus/TCP. The Gateway shall be a node on the CSN. Appendix C, Monitored Equipment List, lists all FACP’s requiring a Gateway.

2. The Gateway shall automatically collect all status and alarm data from the FACP and serve this data to the PLC’s, CCS and EMP via Modbus/TCP. Contractor shall coordinate with the fire system contractor to obtain all alarm and status data available from each FACP.

G. Uninterruptible Power Supply (UPS) Gateways.

1. Certain UPS’s communicate using a proprietary protocol through a serial port. Contractor shall provide a Gateway device to convert the UPS serial protocol to Modbus/TCP. The Gateway shall be a node on the CSN. Appendix C, Monitored Equipment List, lists all UPS’s requiring a Gateway.

2. The Gateway shall automatically collect all status and alarm data from the UPS and serve this data to the CCS via Modbus/TCP. Contractor shall coordinate with the UPS vendor to obtain all alarm and status data available from the UPS.

H. I/O Server Software.

I/O Servers shall be provided to read and write to all of the Modbus/TCP devices to support the data communication requirements with the CCS and all EMP’s in the DSTT. The computer hardware on which the I/O Servers run is subject to the design of the CCS (Section 17841, CCS Software and Equipment) and EMP’s (Section 17842, Emergency Management Panel). I/O Servers in the EMP’s and CCS shall be separate and shall function compatibly and shall independently collect all data from the Modbus/TCP devices.
I. Performance Requirements.

1. The Modbus/TCP portion of the FCS shall reliably and efficiently provide the field monitoring and control functions required for the Control System.

2. Communication performance shall be measured from any analog or discrete input module to the I/O server at the OCC. The time measured from when the input changes until the change is registered at the OCC shall be a maximum of 2 seconds.

3. Monitoring and control performance is specific to the requirements of the Link system being interfaced.

1.06 SUBMITTALS

See Section 17802, Field Control System, for all FCS submittal requirements.

1.07 QUALITY ASSURANCE

A. Qualifications.

1. Contractor shall have an office that is staffed with engineers trained in designing industrial Ethernet networks and PLC programming and fully capable of providing instruction.

2. Contractor shall submit resumes with the bid proposal. Include summary of relevant and similar system integration and/or PLC retrofit projects. Include all relevant training and certifications.

3. Contractor shall submit an organizational diagram indicating the key technical staff proposed for this portion of the project.

1.08 WARRANTY

A. The FCS shall be free from defects in workmanship and material and shall be guaranteed to operate as required to maintain specified conditions and functions. The Contractor without charge shall make any repairs, adjustments or replacements made necessary by such defects during the first full year from the time of acceptance of the project by the Sound Transit.

B. The Contractor's authorized and qualified service technician shall respond to the Sound Transit's call for service within 2 hours for malfunctions that have a critical impact on effectively operating the FCS. The response time for non-critical service calls shall not exceed 24 hours unless otherwise waived by the Sound Transit.

1.09 PRODUCTS

1.10 OVERVIEW

The FCS design indicates the minimum requirements. Where additional wiring and controls devices are necessary to meet the intent of the control requirements defined in Appendix F, Control System Functions (Use Cases), these devices shall be provided regardless if shown on drawings.
1.11 COMPONENTS

A. DSTT PLC System.

1. General.

   a.) Provide racks with PLC processors, redundant power supplies, hot standby capability, Ethernet and LonWorks Communication capability.

   b.) Provide independent communication channels from both PLC processors to all I/O racks.

   c.) Provide discrete input modules, discrete output modules and analog input modules for all I/O listed in Appendix D, DSTT I/O List, plus 10 percent spare.

   d.) Provide discrete input modules, discrete output modules and analog input modules for I/O for all new equipment listed in Appendix C, Monitored Equipment List.

   e.) All processors, power supplies, communication modules, and I/O modules shall be replaceable while the PLC system is powered up and running.

2. Rack.

   All processors, power supplies, communication modules, and I/O modules shall be mounted in a rack or backplane. Contractor shall size the rack or backplane to allow the maximum number slots possible within the width of the available cabinet. Provide slots for all required modules plus 25 percent spare slots.

3. CPU Processor.

   a.) Provide identical and redundant CPU processors in a hot standby configuration:

      1.) Application software memory in battery backed RAM sufficient for all control requirements plus 25 percent spare.

      2.) CPU executive firmware in nonvolatile memory shall support upgrade downloads by the end user.

      3.) Support all standard ladder logic functions. User may create custom function blocks.

      4.) Two Configurable Modbus serial programming ports.


   a.) Provide redundant power supplies in each rack or backplane:

      1.) Adequately sized for the modules in the rack.

      2.) Each power supply shall be individually capable of powering the entire rack.
3.) Over-current and over-voltage protection.

b.) Facilitates orderly shutdown of PLC rack modules if input power is lost.


Remote I/O Modules shall provide remote I/O rack located away from the TC/C room in the tunnel cross passages for monitoring the Bi-directional amplifiers. Contractor shall provide and install cabling from the TC/C room to the cross passage appropriate for the remote I/O modules.


Provide module for LonWorks communication to the local FT-10 channel. Any available network variable in the entire LonWorks system may be read or written by the PLC through this channel. Communication between PLC's shall be supported through this channel.

7. Ethernet Communication Module.

a.) Provide modules to place both PLC's as nodes on the CSN to support all Modbus/TCP communication requirements.

b.) Assignable IP address and subnet mask.

c.) PLC shall be completely programmable remotely through TCP/IP.

d.) Peer to peer communication between PLC's through this channel.


a.) Provide high density discrete input modules appropriate for the existing and new inputs with 10 percent spare.

b.) Input addresses assignable in software independent of slot position.

c.) Configurable failure modes for each individual input: Off, On, Hold Last value.

d.) Module may be removed and replaced without powering down the rack.

1.) LED indication of on/off state of each input.

2.) LED indication of health status of module.

e.) Provide prewired terminal block assemblies for all inputs. Assembly shall include cable and connector matched to input module terminals. Each input shall include fusing and blown fuse indication.

a.) Provide high density discrete output modules appropriate for the existing and new outputs with 10 percent spare:

1.) Output addresses assignable in software independent of slot position.

2.) Configurable failure modes for each individual input: Off, On, Hold Last value.

3.) Module may be removed and replaced without powering down the rack.
   - LED indication of on/off state of each output.
   - LED indication of health status of module.
   - Provide prewired terminal block assemblies for all outputs. Assembly shall include cable and connector matched to input module terminals. Each output shall include fusing and blown fuse indication.

10. Analog Input Module.

a.) Provide analog input modules appropriate for the existing and new inputs with 10 percent spare:

1.) Input addresses assignable in software independent of slot position.

2.) Configurable for 4-20 mA or 1-5 Volt inputs with internal precision resistor.

3.) No separate power supply required - operable from backplane DC power.

4.) Module may be removed and replaced without powering down the rack.
   - LED indication of valid state of each input
   - LED indication of health status of module

11. FACP / UPS Gateways.

a.) Gateway shall convert and buffer communication with the serial device such that the I/O Server or any other Modbus/TCP client can read all available data points.

1.) Two configurable EIA-232 serial ports.

2.) Two 10BaseT RJ45 Ethernet ports.

3.) Assignable IP address and subnet mask.

b.) All Gateways shall be identical hardware. Customized drivers, downloadable by the user shall adapt the Gateway for the particular serial device to be interfaced.
1. Configurable to read specific data from the serial device and load into Modbus registers. Custom configuration downloadable with included utility program through Ethernet or serial port.

2. LED indications for power, error status, port connection, or port activity.

3. Redundant gateways capable of hot standby configuration.


a.) Device shall convert serial Modbus RTU or Modbus ASCII protocol to Modbus/TCP:

1.) Configurable EIA-232 or EIA-485 serial ports.

2.) 10BaseT RJ45 Ethernet ports.

3.) Assignable IP address and subnet mask.

4.) Compatible drivers for host computer for operating system platform at the CCS and on EMP.

13. I/O Server Software.

a.) Software shall be a standard off-the-shelf and supported product:

1.) Report data quality problems, if a node does not respond or if a requested data item is not read or written.

2.) Capable of running as a standard executable or as a background service.

3.) Optimized to minimize the number of transactions for reading or writing non-contiguous data areas.

4.) Include built-in monitor mode to allow reading and writing data points from within server window without a client application.

5.) Configuration of data points through batch export and import utility.

PART 2 - EXECUTION

2.01 PREPARATION

A. Transmit submittals and deliverables required by Section 17802, Field Control System.

B. Furnish products as indicated.
2.02 EXAMINATION

A. Contractor shall evaluate existing RTU installations in all DSTT locations to determine availability of space and power requirements for PLC. Evaluate means to move existing field I/O wiring to PLC I/O modules. Field verify Appendix D, DSTT I/O, and Appendix H, DSTT Cable List, for accuracy and completeness.

B. Contractor shall perform a detailed review of the tunnel computer Vax interface software operated by King County Metro to determine all current control functions. Create written descriptions of all automated controls to be implemented in PLC software. Control functions shall be updated as necessary for modifications being made to the ventilation system and other systems.

2.03 INSTALLATION

A. Contractor shall install all equipment as per approved installation drawings.

B. The DSTT will be closed during the retrofit. Therefore, it will be possible to remove the RTU’s at a station and decommission the existing system first.

C. Contractor shall completely retrofit a single DSTT station before commencing any decommissioning of any other station. Knowledge and experience gained from the first completed station will then be applied to the subsequent stations.

D. Field Testing.

1. Contractor shall perform on-site testing which shall include the following:

   a.) All PLC configuration and diagnostic functions shall be exercised and demonstrated as operational. Diagnostic hardware testing shall be performed for all equipment upon installation.

   b.) Communications to all LonWorks and Modbus/TCP devices in the station shall be verified.

   c.) Comprehensive interface testing shall be performed for all inputs and outputs to field equipment.

   d.) All PLC software control functions shall be tested and demonstrated.

2.04 SIGNAL PROCESSOR / BUS DETECTION PROCESSOR

A. Installation.

1. Contractor shall obtain detailed design data from the C802 contractor to verify locations of processors, and communication port details.

2. Contractor shall provide IP address information to C802 contractor.

3. Contractor shall provide Ethernet connection to processor.
4. Contractor shall verify Modbus/TCP communication with processor using I/O Server on field test computer.

2.05 FACP GATEWAY

A. Installation.

1. Contractor shall obtain detailed design data from the contractor or vendor of interfaced equipment to obtain serial port protocol and addresses of alarm and status data points.

2. Contractor shall configure and install Gateway, and place Gateway on CSN.

3. Contractor shall verify communication with Gateway and reception of valid data using I/O Server on field test computer.

2.06 AC POWER METER

A. Installation.

1. Contractor shall obtain detailed design data from the C807 contractor to verify locations of meters and communication port details.

2. Contractor shall provide IP address information to C807 contractor.

3. Contractor shall provide Ethernet connection to processor.

4. Contractor shall verify Modbus/TCP communication with ac power meter using I/O Server on field test computer.

PART 3 - MEASUREMENT AND PAYMENT

3.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17812
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section describes the functional requirements for the Track Isolation Monitoring (TIO). The TIO shall provide for the measurement of track-to-earth isolation by controlling and measuring the voltages across spans of rails, the rail-to-earth voltages, and the dc current source output. The TIO shall include menu driven software operated from the OCC for the initiation and completion of measurements. The TIO shall be designed to accommodate the initial Link implementation and to accommodate future line extensions.

1.02 RELATED SECTIONS

A. Section 17800 – Control System Overview.
B. Section 17802 – Field Control System.
C. Appendix B – Communications Equipment List.
D. Appendix C – Monitored Equipment List.
E. Appendix F – Control System Functions (Use Cases).

1.03 SUBMITTALS

A. CDR.

1. Contractor shall submit the following information 21 days prior to CDR:
   a.) System block diagram of the CCER Hardware.
   b.) Preliminary Hardware and Software Requirement Document (PSRS).

B. PDR.

1. The Contractor shall submit the following minimum information 21 days prior to Hardware PDR:
   Preliminary Hardware and Software Detailed Design Document (PSDD).

C. FDR.

1. The Contractor shall submit the following minimum information 21 days prior to software FDR:
   Final Hardware and Software Design Document (SDD).
D. Factory (FAT) Test Procedures.
   1. 60 days prior to the conduct of Factory Acceptance Tests, Contractor shall supply a FAT Test Plan.
   2. 30 Days prior to the conduct of Factory Acceptance Tests, Contractor shall supply Test Procedures.

E. Final User Documents.
   1. 30 days prior to Final Acceptance Testing, Contractor shall submit final versions of the following:
      a.) User Manuals.
      b.) Maintenance Manuals.
      c.) Training Plan.
      d.) Training Manuals.

F. Training.
   After Factory Test and before Final Acceptance Testing, Contractor shall train up to 5 persons on the use of the TIO System per the approved Plan and Manual.

G. Final Acceptance (Site) Test Procedure.
   30 days prior to the Final Acceptance Test, Contractor shall submit the final test procedure for the test.

H. Test Results and As-Built Documentation.
   Within 14 days of the successful conclusion of the Final Acceptance Tests, the Contractor shall supply versions of all documentation which has been updated to reflect any changes that may have been made in the course of testing or since the last version of each document was issued.

I. Deliverables.
   Contractor shall provide a functioning system to monitor the track-to-earth resistance values for segments of the trackwork designated on the Contract Drawings. Included are the hardware and software required to verify operation of measurement devices and current sources, initiate measurement sequences, collect and store data, and transfer data to a central database defined by Sound Transit.
PART 2 - PRODUCTS

2.01 GENERAL

A. Monitoring.

1. The TIO shall provide for monitoring and control of remote system devices from the OCC. TIO measurement locations shall be as indicated in the Contract Drawings. Devices shall be compatible with the LonWorks system used for the Central Control System (CCS). Analog transducer devices shall have minimum input impedances sufficient to prevent inaccuracies due to measurement circuit resistance. The TIO shall monitor the following:

a.) Dc voltage drops across spans of rail in the range of plus and minus 10 millivolts with a resolution of one microvolt.

b.) Dc rail-to-earth voltages in the range of 0 to 100 volts with resolution within 10 millivolts.

c.) Dc Current Source shunt voltage drops in the range of 0 to 50 millivolts with a resolution of one microvolt.

d.) Dc Current Source voltage in the range of 0 to 100 volts with a resolution within 10 microvolt.

2.02 DC POWER SOURCE

A. Provide factory pre-assembled dc power source consisting of transformer, rectifier, automatic control circuits, cabinet, convenience outlet, measurement shunt, protection devices, and ac power input.

1. Cabinet.

a.) Provide NEMA 4X epoxy painted steel enclosure. Enclosure shall have hinged door and locking hasp. Cabinet shall be designed for floor mounting.

b.) Cabinet shall contain separate slide out panels for step down transformer, rectifier, automatic control circuitry, remote monitoring instrumentation, external connections, and ancillary equipment.

c.) Cabinet shall have a pull out shelf suitable to hold a lap top computer at an appropriate height.

d.) Cabinet shall be equipped with a thermostatically controlled fan.

e.) Cabinet shall have removable side panels or shall have doors to permit access to the power source components placed behind the panels.
2. Ac Power.
   a.) Dc power source shall be designed for 230 Vac/1-phase/60 Hertz input.
   b.) Ac input shall have double pole fully magnetic circuit breakers rated for the appropriate load in the:
      1.) Main input.
      2.) Feed to the transformer.
      3.) Feed to the automatic controller.
      4.) Feed to the 120 Vac convenience outlet.
      5.) Feed to the cooling fan.
   c.) Provide grounding provisions in conformance with NFPA 70 and UL 467.

   a.) Provide an isolation transformer with fine and coarse secondary taps of not less than 25 equal steps from 5 percent of rated voltage to 100 percent of rated voltage.
   b.) Provide secondary taps with a protective Lexan panel sufficient to prevent accidental contact with the taps. Provide wing nuts for removal of protective panel for manual adjustment of the transformer secondary voltage.
   c.) Transformer shall be oven dried Class II varnish impregnated. Transformer core iron shall be NEMA grade M19. Magnetic core losses shall not exceed 1 watt per pound at 60 HZ when tested in accordance with ASTM A34.
   d.) Transformer insulation shall be rated for a 130° C with a dielectric strength of a minimum 2,000 volts RMS applied for one minute between transformer winding and core.
   e.) Transformer efficiency shall be a minimum 95 percent.

4. Rectifier Stacks.
   a.) Provide silicon diode rectifying stacks, full wave, bridge connected rated at a minimum 800 PIV capable of providing a minimum of 80 Vdc and 50 Adc.
   b.) Provide diodes and SCR devises for electronic adjustment of the rectifier dc output.
   c.) Provide rectifier with over voltage surge protection for both the ac input and dc output. Voltage surge protection must conduct to ground before voltage surge reaches the PIV rating of the silicon diodes.
d.) Provide the rectifier with current limiting devices protect for over current surges.

e.) Provide high speed fuses in one leg of the ac secondary to the rectifier stacks and in the dc negative from the rectifier stack.

f.) Provide heat sinks sized to maintain diode junction temperatures below those temperatures recommended by the diode manufacturer for $45^\circ$ C ambient operation.

g.) Provide a terminal for the dc positive and the dc negative on the Panel.

5. Automatic Controller.

a.) Provide automatic control modes for constant current and constant voltage operation of the rectifier as selected from a remote location and at the dc Power Source panel.

b.) Constant current control and constant voltage control shall be provided for the dc output of the rectifier with current output level adjustment selected from a remote location and at the dc Power Source panel.

c.) Provide automatic control of the dc output within plus or minus 5 percent of the selected output provided that the selected output is within the rated capacity of the dc Power Source.

d.) Provide automatic safety shutdown in the event a control circuit failure.

e.) Provide dc current limiting device to prevent rectifier dc current from exceeding the rated current of the unit.

f.) Provide an integral selector switch to permit operation in either the manual voltage control mode or in automatic control mode.

g.) Automatic controller shall have a visual display of the mode of control, time, date, rectifier dc Volts, and dc Amps.

h.) Automatic controller shall be adjustable either from the remote location or from on board controls directly connected to the automatic controller. Communications software for the remote adjustment shall be provided with the automatic controller.

i.) Automatic controller shall be mounted on the Panel in an accessible location.

j.) Provide a relay interrupting device that permits switching the power to the rectifier stacks off and on within 50 milliseconds of commands sent to the automatic controller from the remote location.

6. Provide a minimum 15 ac ampere convenience outlet on the panel face and in an accessible location.
7. Provide 50 millivolts rated current measuring shunt in the dc output portion of the rectifier circuit. Shunt DCA shall be rated as required by the DCA rated output of the rectifier stacks.

8. Panel.
   a.) Panel shall be a minimum 3/16" thick black phenolic.
   b.) All external wiring shall be terminated on the panel.
   c.) All terminals shall be accessible from the front of the panel.
   d.) Terminals shall be identified by fully engraving of the panel.
   e.) Panel shall be securely mounted to the cabinet in a manner that permits removal of the panel for maintenance or repair of the components.

B. Supplier

Dc Power Source Automatic Controller and associated appurtenances shall be provided a single source such as Integrated Rectifier Technologies LTD, Edmonton, Alberta, Canada, or Universal Rectifiers Inc., Houston, Texas, or approved equal.

2.03 CONTROL

A. The TIO shall implement device controls based on user commands (entered through appropriate control console actions and software directed) for the following field equipment:
   1. LonWorks Analog I/O module plus and minus 10 millivolts analog input.
   2. LonWorks Analog I/O module 0 to 100 volts analog input.
   3. LonWorks Analog I/O module 0 to 50 millivolts analog input.
   4. Dc Current Source shunt voltage drops in the range of 0 to 50 millivolts with a resolution of 1 microvolt.
   5. Dc Current Source voltage in the range of 0 to 100 volts with a resolution of 10 microvolt.
   6. Dc Current Source control module and interrupting relay device.
   7. TIO data logger.

2.04 USER INTERFACE

A. The TIO shall present up-to-date device status, alarms, and logically derived information on a computer interface with custom graphical displays. The following displays shall be included as a minimum.
1. The Main Overview display shall depict the entire TIO installation in a schematic form with the resultant calculated resistance values for each segment of track. Each calculated value shall be clickable to open a pop-up display showing the internal calculation with the actual analog voltage measurements in the form of an arithmetical equation.

2. Test Configuration display(s) shall provide the user with the means to configure the scheduling of tests and to adjust all necessary parameters for fully automated and unattended testing.

3. Calculation Configuration displays shall provide the user with the means to adjust the all internal calculation constants and parameters that convert the raw measurements to results.

4. Tabular Data displays shall present all recent and archived test data in a spreadsheet format with all field collected data with timestamps, constants, and calculated results. These displays shall include a function to export all current or archived tabular data for any time period to a comma separated variable (CSV) file.

5. Alarm displays shall show status and alarm messages for all TIO system equipment including current sources, voltage transmitters, and LonWorks field devices and network. Include the means to show current status and alarms and a chronological history of all previous status and alarms.

2.05 EQUIPMENT RELIABILITY

A. Operations of the OCC will be 24 hours a day, seven days a week. The TIO shall be available 99.98 percent of the time.

B. The system shall be deemed available as long as:

1. All dc Current sources are available and functional.

2. All LonWorks transducers are available and functional.

3. At least one operating console is available and fully functional.

4. At least one printer is available and fully functional.

5. There is no failure of storage devices such that any historical information will be lost.

6. All user functions are available.

2.06 INTEGRITY OF OPERATION

A. Failure Mode.

1. There shall be no failure mode of the system which would allow a false command to be sent to a field device.

2. No single failure shall make the system unavailable to the users.
2.07 MONITORING AND CONTROL

A. The following functions are required. Contractor shall provide a system that supports the implementation of these following functions without restriction to geographic locations.

1. Sources of Data.

Data shall be acquired from the existing and new field devices located at monitoring locations indicated on the Contract Drawings.

2. Origin of Commands.

Commands shall be sent to all accessible devices from user input or automatic algorithms.

3. Filtering of Commands.

Except for exceptions cited in these Specifications, no command shall be sent to a device when TIO has knowledge that the command will not be performed.


Data to be acquired and commands to be issued are listed in the Contract Drawings. Prior to implementation, Contractor shall obtain from Link the actual lists for entry into the TIO database. Software shall provide for a minimum of 250 data points.

5. Sound Transit IS Network.

The TIO shall interface to the data link with the Sound Transit Office Services Network (OSN). The protocol and data format shall be developed jointly by Contractor and Sound Transit.


Data shall be acquired using message exchange sequences that shall be initiated by field equipment or TIO. The message exchange sequence shall generate the necessary commands to retrieve data, perform all required error checking to ensure the validity of the received data, and provide for recovery from errors to complete the message exchange. All data acquisition malfunctions shall be recorded and reported.

7. Data Acquisition Features.

a.) Allow a field device to be temporarily placed in a continuous scan mode.

b.) Allow a field device to be placed off-scan.

c.) Allow a periodic diagnostic check of all communication equipment to ensure the proper operation of these devices.

d.) Allow users to remove a point from alarm processing or calculation.
e.) Allow manual entry of device value when a device is off-scan.

f.) Data acquisition shall compare the state of a device with its commanded state and shall issue an uncommanded change of state alarm when they disagree.

8. Data Acquisition.

Measurements shall be taken at a time when the mainline tracks are clear of trains or work activity. The TIO shall be designed to perform one complete data acquisition cycle in two minutes or less.

2.08 MONITORING OF COMMANDED DEVICES

After the issuance of a command, the state of the device will be monitored for a time period particular to the device type. If the device has not assumed the commanded position within that time, a failure to operate alarm shall be issued.

2.09 SOFTWARE

A. Contractor shall provide menu driven software to perform the remote monitoring data acquisition, system integrity testing, current control, and transfer of data to a designated network directory in a format compatible for input into an Excel™ spreadsheet.

B. The software shall include provisions for the establishment and control of a minimum of 250 acquisition devices and 10 dc current sources.

C. The software shall permit modifications and changes of parameters by Sound Transit personnel with a valid password.

D. The software shall provide for the automatic acquisition of data and shall include the following items:

1. Poll all LonWorks field devices units for function and reset times.

2. At each LonWorks field devices, measure millivolt drops and time stamp data for each rail to establish no load base line.

3. At each LonWorks field device, measure track-to-earth voltage and time stamp data to establish no load base line.

4. Measure no load dc amperes and volts and time stamp data at the power sources.

5. Repeat Steps (a) through (d) to obtain a series of 10 data sets with the power shut down.

6. Energize the dc power sources.

7. Measure dc amperes and volts at the power sources and time stamp data.

8. At each data RMU, measure millivolt drops and time stamp data for each rail.

9. At each data RMU, measure track-to-earth voltage and time stamp data.
10. Shut down the dc power sources and time stamp data.

11. Repeat Steps (g) through (i) with the dc power source shut down.

12. Repeat Steps (f) through (k) to obtain a series of 10 data sets with the power units energized and with the dc power supply shut down.

13. Poll all LonWorks data loggers for results and transfer files to a dedicated track isolation monitoring computer.

2.10 TIO USERS

A. List of Users.

1. System Manager.
2. Trainer.
3. Trainee.
4. Maintenance Staff.
5. Engineering Staff.

B. TIO/User Interface.

The TIO interface to its users includes all visual, audio, and tactile functions including display screens, printed outputs, audible alarms, keyboard, and trackball/mouse.

C. Logon.

Users of the TIO shall be required to conduct a logon process. Each user shall be required to enter a valid identification and password, either by keyboard or by keycard, to logon at the track isolation monitoring computer. Each user shall be assigned a level of authority, which will provide limitations on the access to the TIO.

D. Logoff.

1. A logged-on user may logoff.
2. Another user logging on to a console with an already logged-on TIO user will not automatically logoff the first user.

2.11 SYSTEM MANAGER

The System Manager is a user of the TIO. The System Manager shall be provided with equipment to perform all the TIO functions provided to other users and the functions specified below in “System Management” and “On-line Diagnostics and Maintenance”.

PART 3 - EXECUTION

3.01 GENERAL

A. Install Track Isolation Monitoring at the locations indicated on the Contract Drawings.

B. Install dc Current Power Sources at the Traction Power Substations indicated on the Contract Drawings.

C. Provide interconnection wiring in conformance with these Specifications and Contract Drawings sufficient to operate all TIO equipment.

D. Provide ac power as required in conformance with these Specifications and Contract Drawings sufficient to operate all TIO equipment.

E. Provide Final Acceptance Testing of all components and related software.

1. As a minimum, Final Acceptance testing shall consist of a minimum of 30 days of remote track isolation monitoring with a minimum of one testing cycle per day. Contractor shall schedule testing to avoid conflicts with activities of other contractors.

2. Contractor shall obtain the services of a Link approved testing agency with a minimum of 10 years experience in track isolation testing to perform a manual survey of the track isolation using identical measurement sequences as in the TIO software. Contractor shall schedule testing to avoid conflicts with activities of other contractors. The testing agency shall provide a report that includes:
   a.) All test data.
   b.) Detailed step by step sample calculations of track isolation resistance.
   c.) A summary of all track segment resistance to earth values.
   d.) A written certification that the procedures used were identical to the measurement sequences directed by the TIO software

3. Contractor shall provide a report that includes the results of the 30 days of remote track isolation testing and the results of the testing agency’s manual survey.

4. Final Acceptance shall be contingent of the ability of the remote TIO to provide consistent and accurate results to the satisfaction of Link.

F. Provide training of Link designated personnel in the set up and operation of the TIO hardware and related software.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17831
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Contractor shall design, furnish, install and test a card key based Access Control System (ACS) for facility security within Link. Secure areas are found in the O&M Facility and Traction Power Substations. ACS configuration shall be centrally managed through software and databases at the Operations Control Center.

B. This Section includes the requirements for designing, furnishing, installing and testing the FCS elements of the ACS.

1.02 RELATED SECTIONS

A. Section 17050 – Configuration Management.

B. Section 17170 – Cable Testing, Identification and Administration.

C. Section 17751 – CCTV.

D. Section 17800 – Control System Overview.

E. Section 17802 – Field Control System.

F. Section 17833 – Intrusion Detection.

G. Section 17840 – Central Control System.


I. Section 17880 – FCS and CSN Training, Manuals, Special Tools and Spare Parts.

J. Appendix B – Communications Equipment List.

K. Appendix C – Monitored Equipment List.

L. Appendix F – Control System Functions (Use Cases).

1.03 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:


2. NEMA Enclosures for Electrical Equipment up to 50 Volts.

3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.

4. ADA Americans with Disabilities Act.
1.04 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations. ACS equipment shall be UL listed.

1.05 SUBMITTALS

A. Contractor shall provide the following submittals for review by Engineer. These submittals are subject to Engineer approval. See Section 01330, Submittals.


a.) The approved Conceptual Design Review submittal shall be the basis for all installation, programming, and configuration of the ACS.

b.) Provide a Deployment Diagram that includes all computers, off-the-shelf software applications, custom software and databases for the ACS.

c.) Provide Use Cases that expand upon and develop in detail the Use Cases for intrusion detection in Appendix F, Control System Functions (Use Cases), of these Specifications.

2. Preliminary Design Review.

a.) Provide Network schematics showing all ACS devices that communicate on the local network in each facility. Include schematics for the O&M Facility and each traction power substation.

   1.) Identify all relevant network devices including routers, repeaters, access card readers, and door controllers.

   2.) Show equipment locations and network cable routing and wiring in conduits, raceways and cable trays.

   3.) Indicate cable types and sizes.

3. Final Design Review.

a.) The approved Detailed Design shall be used for the actual system installation.

   1.) Provide architecturally scaled floor plan drawings of the O&M facility. Provide plan drawings for each Traction Power Substation.

      - Show equipment locations, cable routing and wiring.

      - Identify all card key access controlled doors.

      - Show equipment locations and network cable routing and wiring in conduits, raceways and cable trays.
- Indicate cable types and sizes, routing, splice and connection points, equipment locations, and equipment ID names.

- For all identification of equipment on drawings, use the standard convention in general use for all communications equipment. See Section 17170, Cable Testing, Identification and Administration.

2.) Provide installation detail drawings showing the physical and electrical installation of all access control components.

- Provide details for each different type of installation including single doors, double doors, elevators, vehicle gates, and pedestrian entrance gates.

- Provide electrical schematics and point-to-point wiring diagrams indicating terminal-to-terminal connections between system components.

- Provide details for the physical mounting and installing of all components including control panels, door controllers, card readers, contact switches, and request to exit detectors.

3.) Provide product data sheets for all products proposed for use under this Section.


a.) Prior to Final Acceptance Testing, according to the project schedule guidelines set in Section 01320, Construction Contract Schedules, Contractor shall submit final versions of the following:

1.) User Manuals.

2.) Maintenance Manuals.

3.) Training Plan.

4.) Training Manuals.

5. Training.

Before Final Acceptance Testing, Contractor shall train up to 20 persons on the use of the ACS per the approved Training Plan and Manual.


Prior to the Final Acceptance Test, according to the project schedule guidelines set in Section 01320, Construction Contract Schedules, Contractor shall submit the Final Acceptance Test procedure.

7. Test Results.

Prior to acceptance of the System, all test results must be submitted. Test results are subject to inspection by Engineer.
8. As-Builts.

a.) Prior to acceptance of the System, Contractor shall submit all as-builts. As-builts are subject to inspection by Engineer.

b.) Contractor shall update the Communications Equipment List, Appendix B, Communications Equipment List, to include the following kinds of components:

1.) All ACS devices that communicate on the Control System network.

2.) All ACS computers and network components.

3.) All ACS enclosures.

1.06 DELIVERABLES

Contractor shall deliver a fully tested, fully functioning, and fully documented ACS as described in these Specifications.

PART 2 - PRODUCTS

2.01 GENERAL

A. Configuration and operation of the ACS shall be centrally managed. Access Control software available from the OCC shall provide a user interface to manage a central ACS database. This database shall be configurable to define all aspects of the ACS.

B. The ACS shall be capable of functioning normally when the central ACS database is not available. The central database shall be automatically distributed and retained by the field database servers.

C. Coverage of the ACS shall include facilities throughout Link. All ACS devices shall communicate through the CSN to the central ACS database.

D. ACS shall generate an intrusion alarm for any access-controlled door or gate whenever a door is held open or opened without a card key. The time that a door may be held open without triggering an alarm shall be an adjustable parameter. Intrusion alarms shall be reported to the CCS by the ACS. See Section 17833, Intrusion Detection.

E. The Monitored Equipment List, Appendix C, Monitored Equipment List, itemizes all areas requiring card key access. Contractor shall provide card key access for all items in Appendix C, Monitored Equipment List, including the following:

1. All entrance doors to traction power substations and tie stations.

2. Exterior and interior doors in the Operation & Maintenance Building as itemized in Appendix C, Monitored Equipment List.

3. All elevators in the Operation & Maintenance Building as itemized in Appendix C, Monitored Equipment List.

4. All vehicle and pedestrian entrance gates into the Operation & Maintenance Facility.
F. Computer security for operator consoles within the Operations Control Center shall include card keys for user log on. Operators shall use the same card key used to enter the building for logging on at the console.

G. The Communications Equipment List, Appendix B, Communications Equipment List, itemizes all components used to build the Communications System. Contractor shall update this list to include the following ACS components:

1. All ACS devices that communicate on the Control System network.
2. Enclosures containing ACS components.
3. Off-the-shelf ACS application software.
4. Computers used for ACS software and database functions.

2.02 EQUIPMENT

A. Gate Controllers.

1. Gate controllers shall control the electrical inputs and outputs for a door, gate or elevator. The gate controller shall include:
   a.) Two digital inputs for door status for magnetic contact switches.
   b.) Two relay outputs to drive electronic door locks.
   c.) Two dedicated outputs for driving LEDs on the card readers to signify granted/denied access.

B. Field Database Servers.

Field Database Servers shall process all access control requests in an area. The server shall communicate with the card readers and gate controllers to grant or deny access through a door. The Field Database Server shall be updated from the ACS central database, but shall be able to continue normal operations while the central database is unavailable.

C. Card Readers.

1. Card readers shall be proximity type capable of reading the same cards currently used by Sound Transit at the Union Station facility. Card readers shall include:
   a.) Capability to receive input from compatible magnetic or proximity card readers.
   b.) 12 Vdc or 5 Vdc power input.
   c.) All necessary accessories, including mounting brackets, mounting kits, connectors, cables, installation tools, and other such components necessary for a complete installation.
d.) Trim plates, adapters, or back boxes for card readers as needed to mount to electrical back boxes provided by others.

e.) Color and finish of all trim plates, adapters or back boxes used shall closely match that of card reader. Submit color samples for approval to the Engineer.

D. Card Keys.

Engineer will supply sample cards currently used by Sound Transit at the Contractor’s request. Contractor shall match the new card keys to the existing cards keys including bit format and facility code. Cards shall be capable of printing Sound Transit logo and photograph of the card holder.

E. Enclosures.

All control equipment, relays, modules, circuit boards and other such devices shall be contained within enclosures of all-metal construction. All enclosures shall be closed with tamper resistant screws. Contractor shall provide NEMA enclosures for all equipment that is not provided by the manufacturer in a suitable enclosure. NEMA rating shall be appropriate to the area of installation.

F. Power Supplies & Batteries.

1. Contractor shall provide two 24 Vdc power supplies for each intelligent controller, each rated for 150 percent of the normal load.

2. Power supplies shall not be used to power electric lock hardware.

3. Contractor shall provide each 24 Vdc power supply with two 12 Vdc gelled electrolyte sealed lead acid batteries. Batteries shall be sized for 90 minute life under normal load.

4. Contractor shall provide battery wiring harness as needed to properly connect batteries to power supply.

5. Contractor shall provide power supplies with dry contact relay that opens upon power fault. Power supply power fault shall be managed as an alarm by the CCS.

G. Magnetic Contact Switch.

Contractor shall provide magnetic contact switches to detect door or gate open conditions. Contractor shall determine the materials and methods for each door for an inconspicuous installation.

H. Request to Exit Detectors (REX).

1. Contractor shall provide passive infrared detectors with normally open contact output and integral walk-test indicator.

2. Detector shall be specifically designed for use as REX detector.

3. REX detector coverage pattern shall provide positive REX detection of person at exit side of door, but shall be adjustable to avoid unwanted detection in other areas.
4. Contractor shall select color that complements wall and doorframe on which REX detector is being installed. Submit color samples for approval to the Engineer.

5. Contractor shall provide trim plate to enable mounting of REX detector to single-gang electrical box mounted horizontally.

I. Wire and Cable.

1. Contractor shall provide cabling between all ACS equipment in accordance with manufacturer’s requirements. All cabling shall be shielded unless otherwise specified by manufacturer.

2. No conductor shall be smaller than #22 AWG gauge.

3. Wire to electric lock hardware and transformers shall be no smaller than #16 AWG gauge unless otherwise noted.

4. All wire and cable installed in cable trays shall be specifically UL listed for such use.

5. Contractor shall comply with equipment manufacturer’s recommendations for wire and cable.

J. Off-the-Shelf Software.

1. Contractor shall provide Commercial Off-The-Shelf (COTS) software to easily configure and manage the ACS. Software shall allow the ACS system administrator to configure the following:

   a.) Access card holder names and card number.

   b.) Up to 256 access groups shall be defined and each individual card holder shall be assigned to a single access group. Each access group shall be defined as a matrix of all access controlled doors and the hours of day that access shall be granted for the individuals in the access group. Engineer will provide an initial list of all users and their access needs.

   c.) Days of the week and times of day when access is permitted to any particular area for a particular group.

   d.) Days of the week and times of day when intrusion alarms are active.

K. Miscellaneous Equipment.

Contractor shall furnish and install miscellaneous equipment to complete the ACS. This shall include surface conduit between electrical junction boxes and ACS devices, and miscellaneous mounting hardware.
PART 3 - EXECUTION

3.01 GENERAL

Contractor shall provide all labor, tools, supplies, materials and equipment required for the design, installation, configuration, programming, and testing of a complete and operational access control system. Contractor shall install all equipment in accordance with manufacturer’s instructions and approved shop drawings.

3.02 PREPARATION

Engineer will schedule design reviews with Contractor. The design reviews shall encompass all design submittals.

3.03 NAMING

Contractor shall assign unique identification names to the major components and equipment used to build the ACS. These identification names shall be used on submittal drawings. Appendix B, Communications Equipment list, shall include all named items. See Section 17170, Cable Testing, Identification and Administration, for detailed requirements for naming.

3.04 FACTORY TESTING

Contractor shall include ACS components for simulating access control and intrusion detection of a single door as part of the general Control System factory simulation demonstration.

3.05 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment.

3.06 INSTALLATION

A. Contractor shall submit installation drawings prior to installation of the ACS in any facility. Contractor shall proceed with the installation only after the approval of installation drawings.

B. Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

C. Contractor shall provide initial programming and configuration of the ACS. Programming shall include defining doors, access levels, and users. Contractor shall consult with Engineer for initial lists of users and access levels.

3.07 OPERATOR TRAINING

A. Contractor shall provide complete operator training on the ACS. Two types of operator training shall be provided:

1. System Administrator Training.

   One week comprehensive training course for system managers and maintenance personnel. Provide two separate on-site training sessions. Training sessions shall be three days in length.
2. Manager Training.

   One day session on basic operation. A minimum of five separate on-site training
   sessions shall be conducted. Training sessions will be held approximately three weeks
   apart. Training sessions shall be two days in length.

B. Training sessions shall include the opportunity for each person to operate the system and to
   practice each operation that an operator would be expected to perform.

C. Contractor shall provide written training materials for each of ten people at each training
   session.

D. Training sessions are to be held at Sound Transit's facility, and are to be scheduled at the
   convenience of Sound Transit. Some training sessions may be required to be held during
   evening hours and on weekends to accommodate users whose schedule does not permit
   attendance during regular hours.

E. Contractor shall provide written training outline and agenda for each training sessions prior to
   scheduling.

F. Training shall cover all operating features of the system, including the following:
   1. System set-up and card holder database configuration.
   2. Access control features.
   3. Alarm monitoring features.
   5. Card management.
   6. Disk backup procedures.
   7. Routine maintenance and adjustment procedures.

3.08 TECHNICIAN TRAINING

A. Contractor shall provide complete technician training on the ACS. Technician training shall
   enable Sound Transit's maintenance provider to make basic repairs, additions, and
   modifications to the system.

B. A minimum of two separate technician training sessions shall be conducted. The exact
   schedule of training sessions shall be determined by Sound Transit.

C. Each technician training session shall consist of three consecutive days of classroom
   instruction for ten people selected by Sound Transit.

D. Contractor shall provide a fully operational mock-up for use during training sessions. Mock-
   up shall include all devices necessary to fully demonstrate system operation and repair. All
   mock-up equipment shall be provided by Contractor and left at Sound Transit's facility for the
   duration of the training period. Sound Transit owned equipment shall not be used in the
   mock-up.
E. Contractor shall provide written training materials for each of ten people at each technician training session.

F. Technician training shall cover the installation, configuration, and repair of the security management system. Topics to be covered shall include, but shall not be limited to, the following:

1. Overview of security management system hardware and software.
2. Intelligent Controller installation and repair.
4. Installation and repair of detection devices: contact switches, REX detectors, motion detectors, and other such devices.
5. Isolating hardware/software problems.
6. Diagnosis of communications and related problems.
7. Routine maintenance and repair.

G. Technician training sessions are to be held at Sound Transit’s facility, and are to be scheduled at the convenience of Sound Transit.

H. Contractor shall provide written training outline and agenda for each technician training session prior to scheduling.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17832
PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall design, furnish, install and test intrusion detection functions as part of the FCS and CCS. Intrusion shall be detected for ACS controlled doors, and other doors in the passenger stations. Custom intrusion detection systems shall detect persons or vehicles entering tunnels or aerial structure on the right-of-way. Intrusion detection equipment shall be included within all Communication Cabinets and Communication Distribution Cabinets.

1.02 SECTION INCLUDES

This Section includes the requirements for designing, furnishing, installing and testing the intrusion detection functions in the FCS and CCS.

1.03 RELATED SECTIONS

A. Section 17050 – Configuration Management.
B. Section 17170 – Cable Testing, Identification and Administration.
C. Section 17800 – Control System Overview.
D. Section 17802 – Field Control System.
E. Section 17832 – Access Control System.
F. Section 17840 – Central Control System.
H. Section 17880 – FCS and CSN Training, Manuals, Special Tools and Spare Parts.
I. Appendix B – Communications Equipment List.
J. Appendix C – Monitored Equipment List.
K. Appendix D – DSTT I/O List.
L. Appendix F – Control System Functions (Use Cases).

1.04 REFERENCE STANDARDS

A. The following references shall be adhered to in the performance of this Section:

2. NEMA Enclosures for Electrical Equipment up to 50 Volts.
3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.
4. ADA Americans with Disabilities Act.

1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Codes and local regulations.

1.06 SUBMITTALS

A. Contractor shall provide the following submittals for review by Resident Engineer. These submittals are subject to Resident Engineer approval. See Appendix G, Contract Data Requirements List, for submittal dates and requirements.


a.) The approved Conceptual Design Review shall be the basis for all installation, programming, and configuration of intrusion detection functions.

1.) Provide a Deployment Diagram that includes all types of logical devices and software used to detect and report intrusion alarms. Include PLCs, LonWorks processors, computers, software, and databases.

2.) Provide Use Cases that expand upon and develop in detail the Use Cases for intrusion detection in Appendix F, Control System Functions (Use Cases), of these Specifications.

2. Preliminary Design Review.

a.) The approved Installation Design submittal shall be used for the physical installation of components necessary for intrusion detection functions in the FCS.

1.) Contractor shall provide architecturally scaled floor plan drawings showing the location of all rooms, cabinets, or areas that are monitored for intrusion detection. Drawings used for the ACS design submittal, Section 17832, Access Control System shall be reused for ACS controlled doors.

- Show equipment locations, cable routing and wiring.

- Identify all doors that are monitored for intrusion on the same intrusion circuit.

- Identify the location of all communication distribution cabinets for trackway intrusion detection for tunnel and aerial structures.

- Show equipment locations and LonWorks network cable routing and wiring in conduits, raceways, and cable trays.

- Indicate cable types and sizes, routing, splice, and connection points, equipment locations, and equipment ID names.
For all identification of equipment on drawings, Contractor shall use the standard convention in general use for all communications equipment.

3. Final Design Review.

   a.) Contractor shall provide detailed design drawings for photoelectric and passive infrared detectors at tunnel entry and aerial structure entry points. Include panel elevations, electrical schematics, and mounting details for the enclosures and detectors.

   b.) Contractor shall provide product data sheets for all products proposed for use under this Section.


   a.) Prior to Final Acceptance Testing, Contractor shall submit final versions of the following:

      1.) User Manuals.

      2.) Maintenance Manuals.

      3.) Training Plan.

      4.) Training Manuals.

5. Final Acceptance Test Procedure.

   Prior to the Final Acceptance Test, Contractor shall submit the Final Acceptance Test procedure.

6. Test Results.

   Prior to acceptance of the intrusion detection system, all test results must be submitted. Test results are subject to inspection by Resident Engineer.

7. As-Builts.

   a.) Prior to acceptance of the intrusion detection system, Contractor shall submit all as-builts. As-builts are subject to inspection by Resident Engineer.

   b.) Contractor shall update Appendix B, Communications Equipment List, to include the following kinds of components:

      1.) All intrusion detection devices that communicate on the LonWorks network.

      2.) Trackway Intrusion Detection control cabinets and detectors.
1.07 DELIVERABLES

Contractor shall deliver fully tested, fully functioning, and fully documented intrusion detection functions as described in these Specifications.

PART 2 - PRODUCTS

2.01 GENERAL

A. Various types of intrusion detectors shall be installed to detect unauthorized access into a monitored area. The FCS shall detect unauthorized intrusions that shall be reported and alarmed by the CCS.

1. ACS Controlled Doors.

All doors controlled by ACS card keys shall report intrusion alarms as detected by the ACS gate controllers. See Section 17832, Access Control System.

2. DSTT Station Intrusion Loops.

Stations in the DSTT have existing intrusion detection loop inputs. See Appendix D, DSTT I/O List. Contractor shall include these intrusion loop inputs in the retrofit of the DSTT. Logic shall be included in the PLCs to monitor these intrusion inputs and to generate an alarm when appropriate. Inputs associated with public areas of the station shall generate alarms only when the station is closed. Inputs associated with nonpublic areas of the station shall generate an alarm whenever a door on the loop is opened.

3. Cabinet Intrusion Detection.

A circuit that detects when the cabinet door is open shall be installed to protect all Communications Cabinets containing SONET or Ethernet network communications. Whenever the cabinet door is opened, an alarm shall be generated.

4. Trackway Intrusion Detectors.

a.) Passive infrared motion detectors and photoelectric sensors shall be installed to detect persons or vehicles entering a tunnel or aerial structure section of the right-of-way. The detectors shall positively identify trains so that false alarms are not triggered.

b.) Detection logic shall be managed by LonWorks devices located in nearby control cabinets. Photoelectric sensor inputs shall be used to distinguish trains from persons by the height at which the sensors are mounted. The length of time that the photoelectric beam is broken shall be used to distinguish a train from a tall vehicle. If the passive infrared detectors detect any movement into the restricted area and a train has not been detected by the photoelectric sensor, then an alarm shall be triggered and sent to the CCS.
2.02 EQUIPMENT

A. Gate Controllers.

Gate controllers are specified in Section 17832, Access Control System, as part of the Access Control System. The gate controller shall generate intrusion alarms from the magnetic contact switch inputs on the door or gate.

B. Magnetic Contact Switches.

1. Magnetic contact switches are specified in Section 17832, Access Control System, as part of the Access Control System. Additional magnetic contact switches shall be installed on doors that are not ACS controlled. Contractor shall determine the materials and methods for each door for an inconspicuous installation. Contact closures shall be wired singly or to a nearby Gate Controller, LonWorks discrete input, or PLC discrete input.

2. All intrusion contacts shall be monitored by using a supervised loop that uses an end of line resistor at the contact to detect a change in impedance when the door opens. Resistor shall be selected to match the supervised loop input device in the LonWorks or PLC.

C. Tamper Switches.

Tamper switches shall cause activation of alarms whenever the door of an enclosure is opened. Tamper switches shall be recessed plunger switches with closed-loop contacts. Contractor shall provide with mounting brackets and other miscellaneous hardware to mount to panels and within enclosures. Tamper switch shall be selected as required to suit conditions.

D. Photoelectric Sensors.

Photoelectric sensors shall include transmitter and receiver elements mounted at an eight foot height to detect trains but not persons. Sensors shall be rated for outdoor installation. Sensors shall include dry contact outputs for interfacing with LonWorks discrete input modules in the control cabinet.

E. Passive Infrared Detectors.

Passive infrared detectors shall be installed to detect any motion along the tracks into the tunnel or onto an aerial structure. The coverage pattern of the passive infrared detectors shall be in the plane across the tracks below the beams of the photoelectric sensors. The detectors shall be rated for outdoor installation. Detectors shall include dry contact outputs for interfacing with LonWorks discrete input modules in the control cabinet.

F. Enclosures.

All control equipment, relays, modules, circuit boards and other such devices shall be contained within enclosures of all-metal construction. All enclosures shall be closed with tamper resistant screws. Contractor shall provide NEMA enclosures for all equipment that is not provided by the manufacturer in a suitable enclosure. NEMA rating shall be appropriate to the area of installation.
G. Power Supplies & Batteries.

1. Provide two 24 Vdc power supplies for devices in each trackway intrusion cabinet. Each shall be rated for 150 percent of the load of the estimated load.

2. Provide each 24 Vdc power supply with two 12 Vdc gelled electrolyte sealed lead acid batteries. Batteries shall be sized for 90 minute life under normal load.

3. Provide battery wiring harness as needed to properly connect batteries to power supply.

4. Provide power supplies with dry contact relay that opens upon power fault. Power supply power fault shall be managed as an alarm by the CCS.

H. Wire and Cable.

1. Provide cabling between all intrusion detection components in accordance with manufacturer’s requirements. All cabling shall be shielded unless otherwise specified by manufacturer.

2. Comply with equipment manufacturer’s recommendations for wire and cable.

I. Miscellaneous Equipment.

Contractor shall furnish and install miscellaneous equipment to complete the ACS. This shall include surface conduit between electrical junction boxes and ACS devices, and miscellaneous mounting hardware.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall provide all labor, tools, supplies, materials and equipment required for the design, installation, configuration, programming, and testing of the intrusion detection functions of the FCS. Install all equipment in accordance with manufacturer’s instructions and approved shop drawings.

3.02 PREPARATION

Resident Engineer will schedule design reviews with Contractor. The design reviews shall encompass all design submittals.

3.03 NAMING

Contractor shall assign unique identification names to the major components and equipment used for intrusion detection. These identification names shall be used on submittal drawings. Appendix B, Communications Equipment list, shall include all named items. See Section 17170, Cable Testing, Identification and Administration. for detailed requirements for naming.
3.04 FACTORY TESTING

Contractor shall provide a complete trackway intrusion detection system for one location for generating intrusion alarms as part of the general Control System factory simulation demonstration.

3.05 DELIVERY, STORAGE AND HANDLING

Contractor is responsible for all delivery, storage and handling of equipment.

3.06 INSTALLATION

A. Contractor shall submit installation drawings prior to installation of intrusion detection components. Contractor shall proceed with the installation only after the approval of installation drawings. See Section 01330, Submittals.

B. Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17833
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PART 1 - GENERAL

1.01 OVERVIEW

The Central Control System (CCS) provides the interface to allow users and/or automatic processes to supervise and control Link systems and devices.

1.02 SECTION INCLUDES

This Section describes the functional requirements for the Central Control System (CCS). CCS will be used for supervision of LRT operation from the OCC. CCS shall be designed to accommodate the initial Link implementation and to accommodate future line extensions.

1.03 RELATED SECTIONS

A. Section 17420 – Tunnel Radio System.
B. Section 17620 – OCC Facility Requirements.
C. Section 17625 – OCC Furniture.
D. Section 17800 – Control System Overview.
E. Section 17802 – Field Control System.
F. Section 17833 – Intrusion Detection.
H. Section 17843 – Backup Control.
I. Section 17844 – Training Simulator.
J. Section 17860 – Software Engineering Requirements.
K. Appendix A – Glossary.
L. Appendix B – Communications Equipment List.
M. Appendix C – Monitored Equipment List.
N. Appendix D – DSTT I/O List.
O. Appendix F – Control System Functions (Use Cases).
P. Appendix I – DSTT Emergency Ventilation Scenarios.
Q. Appendix J – Beacon Hill Emergency Ventilation Scenarios.

1.04 CITED STANDARDS

A. Mil-Std 1472 Human Engineering.
F. IEEE 1008-2002 Software Unit Testing.
G. IEEE 1012-1998 Software Verification and Validation.

1.05 REFERENCES

A. Communications and Central Control System Block Diagram L00-Z100.
B. Control System Dataflow Diagram L00-Q100X.

1.06 QUALITY CONTROL

A. In addition to the QC requirements stated elsewhere in these Specifications, Contractor shall submit a plan and utilize a comprehensive software engineering system that shall include support for the following:

1. Requirements Generation.
2. Requirements Tracking.
4. Software Modeling.
5. Software Implementation.

7. Software Configuration and Change Management.

8. Software Deployment.


10. Software Documentation.

1.07 SUBMITTALS

A. Conceptual Design Review (CDR) (NTP + 30 days).

1. Contractor shall submit the following information for software CDR:

a.) System block diagram of the Operations Control Center hardware and software.

b.) Preliminary Software Requirement Specification (PSRS).

B. Preliminary Design Review (PDR) (NTP + 90 days).

1. Contractor shall submit the following minimum information prior to software PDR:

a.) Final Software Requirement Specification (SRS) for the CCS.

b.) Software Engineering Plan.

C. Intermediate Design Review (IDR) (NTP + 180 days).


The SDD shall be consistent with IEEE STD 1016. The software architecture shall be described from multiple views, including the logical (or functional) view, the process view (e.g., synchronization, contention for resources, flow of control, inter-process communications, etc.), the structural view (e.g., identification of subsystems and modules, description of the structure of each subsystem), and the physical view (e.g., allocation of processes to hardware, interface between processes and system software).

2. Performance analysis of CCS. The response time for FCS equipment provided under this Contract shall also be provided. The performance analysis shall include the following:

a.) A performance model which identifies, for typical functional scenarios, all processes and physical resources (e.g., LAN, database disc array) which participate in the function.

b.) For each of those processes and physical resources, the expected service time and wait time (with corresponding underlying assumptions about atomic service times and
service request quantities) for each of those functions when the system is operating at a sustained peak second workload.

c.) The expected utilization of underlying physical resources (e.g. each processor) which participate in the servicing of each function when the system is operating at a sustained peak second workload.

3. Documentation of the protocol(s) and message formats between CCS and the FCS equipment.

4. Documentation of the protocol(s) and message formats between CCS and the systems/equipment which are connected to CCS.

5. Prototype Graphics including each display, navigation to other displays, and the operator interactions necessary to perform each function.


D. Final Design Review (FDR) (NTP + 270 days).

1. Contractor shall submit the following minimum information prior to software FDR.
   a.) Final Software Design Document (SDD).
   b.) Requirements Tracability Matrix.
   c.) Software Engineering Status and Reports.

E. Factory Acceptance Test (FAT) Procedures.

1. Contractor shall supply a FAT Test Plan 90 days prior to the start of Factory Acceptance Tests.

2. Contractor shall supply preliminary Test Procedures 60 days prior to the start of Factory Acceptance Tests.

3. Contractor shall supply final Test Procedures 30 days prior to the start of Factory Acceptance Tests.

F. System Acceptance Test (SAT) Procedures.

1. Contractor shall supply a SAT Test Plan 90 days prior to the start of System Acceptance Tests.

2. Contractor shall supply Test Procedures 60 days prior to the start of System Acceptance Tests.

G. Final User Documents.

1. Contractor shall submit final versions of the following 60 days prior to Final Acceptance Testing:
a.) User Manuals.

1.) User’s Manual for Controllers and other users.

2.) System Manager User’s Manual.

b.) Maintenance Manuals.

c.) Training Plan.

d.) Training Manuals.

H. Training.

After Factory Test and before Final Acceptance Testing, Contractor shall provide training on the use of the system per the approved plans and manuals.

I. Test Results and As-Built Documentation.

Subsequent to the successful conclusion of the Final Acceptance Tests, the Contractor shall supply versions of all system documentation which has been updated to reflect any changes that may have been made in the course of testing or since the last version of each document was issued.

1.08 DELIVERABLES

A. Users Manuals.

B. Installation Manuals.

C. Hardware Maintenance Manuals.

D. Software Maintenance Manuals.

E. Training Manuals.

F. Complete UML compliant software documentation set including updated and current Use Cases, requirements, models, change management, and testing.

G. Software source code in hardcopy and machine readable format.

H. Software Binaries in loadable format.

I. Recommended Spare Parts List.
PART 2 - PRODUCTS

2.01 GENERAL

A. Alarms.

1. Alarm attributes shall be individually configurable. The following attributes shall be assigned to each alarm in coordination with the Engineer and the operating agency.

   a.) Color (Alarm Priority).

   b.) Audible alarm (Yes/No).

   c.) Audible alarm type.

   d.) Acknowledgement required.

   e.) Link to CCTV image covering the device in alarm.

   f.) Link to graphic containing the alarm point.

   g.) Geographic partition.

   h.) Functional partition.

B. Monitoring.

See Use Case Q-37-00.

1. CCS shall provide for monitoring and control of remote system devices from the control center(s). CCS shall monitor the following:

   a.) Signal system devices.

   b.) Train-to-Wayside (TWC) Communications.

   c.) Traction electrification system devices.

   d.) Tunnel ventilation equipment.

   e.) Station ventilation equipment.

   f.) Intrusion detectors.

   g.) Fire alarms.

   h.) Emergency Management Panels (EMPs).
i.) Elevators and escalators.

j.) Station electrical equipment (See Use Case E-01-00).

k.) Fare collection equipment.

l.) Flood detectors and pumps.

m.) Communications equipment.

n.) OCC and Equipment Room support facilities.

o.) Passenger and Emergency Telephone System.

p.) PA and VMS Devices.

q.) Radio Bi-directional amplifiers.

r.) Access control.

s.) Station Lighting.

t.) Fire Suppression system equipment.

u.) CCTV Cameras.

2. Status Display.

a.) See Use Case Q-35-00.

b.) CCS shall update the database with all status inputs upon receipt.

c.) CCS shall update the status of all displayed points within 0.5 seconds of database update.

C. Control.

1. CCS shall implement device controls based on user commands (entered through appropriate control console actions utilizing a point and click method) for the following field equipment:

a.) Signal system devices.

b.) Traction electrification devices.

c.) Ventilation control devices.
d.) Elevators at Beacon Hill Station.

e.) Station lighting (See Use Cases E-02-00 and E-03-00).

f.) Fire Suppression equipment (See Use Case F-02-00).

g.) PA and VMS devices.

h.) CCTV cameras (See Use Cases V-01-00 and V-02-00).

D. User Interface.

1. CCS shall present up-to-date device status, alarms, and logically derived information to the users at the OCC via:

a.) Console displays.

b.) Overview displays and.

c.) Hard copy outputs.

E. Train tracking.

CCS System shall track the location of trains throughout the system, including the yard to the limit of signalization, tracking the location of trains through all normal conditions and all single failures of signal equipment.

F. CCTV.

CCS shall provide for viewing of system wide CCTV images from the OCC.

2.02 EQUIPMENT RELIABILITY.

A. Operations of the OCC will be 24 hours a day, seven days a week. This specifically means that OCC functionality shall be available, both hardware and software. Redundant, load sharing, or back-up components are permissible so long as the availability objective is met without exception.

B. All functions in the OCC shall be at least 99.996 percent available. The availability estimate of the OCC shall be included in the Quantified Risk Assessment (QRA) defined in section 17030, Reliability Management Program.

C. The CCS shall be deemed available as long as:

1. At least one operating console is available and fully functional.

2. There is no failure of storage devices such that any current or historical information will be lost.

3. All user functions are available.
2.03 INTEGRITY OF OPERATION

A. Failure Mode.
   1. There shall be no failure mode of the system that would allow a false command to be sent to a field device.
   2. No single failure shall make the system unavailable to the OCC Users.

B. Peak Load Conditions.
   CCS will function without degradation under the specified Peak Load Conditions.

2.04 MONITORING AND CONTROL

A. The following functions are required. Contractor shall provide a system that supports the implementation of these following functions without restriction to geographic locations.
   1. Sources of Data.
      a.) Locations.
         1.) Data shall be acquired from the existing and new field devices located at the following locations:
            - Passenger stations.
            - Elevators.
            - Escalators.
            - Sump pumps.
            - Ticket Vending Machines.
            - PA System.
            - VMS System.
            - CCTV System.
            - Intrusion Detection.
            - Fire alarms.
         2.) Signal Rooms and Houses.
            - Track circuits.
            - Signals.
- Routes.
- Switches.
- Train-to-wayside communications.
- Fire alarms.

3.) TPSS.
- ac main breakers.
- Dc Main breakers.
- Dc feeder breakers.
- Sectionalizing switches.
- Rectifier health.
- Track electrification status.
- Fire Alarms.
- Miscellaneous alarms.

b.) Acquisition Devices.

1.) Data shall be acquired via the following devices:
- LonWorks I/O.
- PLCs I/O.
- Signal Processor I/O
- Bus Processor I/O.
- Train to Wayside Communication.
- LonWorks Devices.

2. CCS shall have the capability of generating data points by the logical and/or arithmetic combination of any other data points.

3. Control of Data Acquisition.

   a.) Data shall be acquired from FCS either automatically on an exception basis or polled by CCS.
b.) CCS shall have the capability of requesting all data from all FCS for startup or whenever re-initialization of the database is required.

4. Device commands.

CCS shall enable all commands appropriate to the device to be initiated and transmitted.

5. Control Inhibit.

Controller shall be capable of inhibiting all controls to any device (red-tagging).


Commands shall be sent to all accessible devices from user input or automatic algorithms.

7. Data Quantities.

Data to be acquired and commands to be issued are listed in Appendix A, Glossary. Prior to implementation, Contractor shall coordinate with Link the actual lists for entry into CCS database.

8. Sound Transit IS Network.

CCS shall accommodate the data link to the Sound Transit IS Network. The protocol and data format shall be developed jointly by Contractor and Sound Transit.


Data shall be acquired using message exchange sequences that shall be initiated by FCS or CCS. The message exchange sequence shall generate the necessary commands to retrieve data, perform all required error checking to ensure the validity of the received data, and provide for recovery from errors to complete the message exchange. All data acquisition malfunctions shall be recorded and reported.

10. Data Acquisition Features.

a.) Allow a field device to be placed off-scan (See Use Case Q-17-00).

b.) Allow a periodic diagnostic check of all communication equipment to ensure the proper operation of these devices.

c.) Allow users to remove a point from alarm processing or calculation.

d.) Allow manual entry of device value when a device is off-scan.

e.) Data acquisition shall compare the state of a device with its commanded state and shall issue an uncommanded change of state alarm when they disagree. (See Use Case Q-025-00).

After the issuance of a command, the state of the device will be monitored for a time period particular to the device type. If the device has not assumed the commanded position within that time, a failure to operate alarm shall be issued.

2.05 CCS USERS

A. List of Users.

1. Train Controller.
2. DSTT Controller.
3. Control Supervisor.
4. System Manager.
5. Trainee.
6. Replay User.
7. Train Operators.
8. Maintenance staff.
9. Remote Users including emergency service personnel.

B. Geographic Partitioning.

1. Each point in CCS database shall be assigned to a geographic partition. A total of sixteen partitions shall be available. With the exception of points in the DSTT, points may reside in multiple geographic partitions. Points in the DSTT may reside in one and only one geographic partition.
2. All CCS users shall have in their profile the geographic partition to which they are assigned.
3. Users assigned to a geographic partition shall be able to control only those devices that are in the user's geographic partition.
4. Only those alarms associated with the user's geographic partition shall be displayed on his console.
5. The user shall be allowed access to all displays without constraint.

C. Functional Partitioning.

1. Each point in CCS database shall be assigned to a functional partition. A total of sixteen partitions shall be available. With the exception of points in the DSTT, points may reside in multiple functional partitions. Points in the DSTT may reside in one and only one functional partition.
2. All CCS users shall have in their profile the functional partition to which they are assigned.

3. Users assigned to a functional partition shall be able to control only those devices that are in the user's functional partition.

4. Only those alarms associated with the user's functional partition shall be displayed on his console.

5. The user shall be allowed access to all displays without constraint.

D. CCS/User Interface.

CCS interface to its users includes all visual, audio, and tactile functions including voice communications equipment, display screens, printed outputs, audible alarms, keyboard, and trackball/mouse.

E. Logon.

1. Logon is the process whereby a User identifies himself to the CCS and gains access to the system according to the privileges assigned to him by the System Manager.

2. Users of CCS shall be required to conduct a logon process. Each user shall be required to enter a valid identification by means of a keycard and a password to logon at a Control Console, the System Manager Console, or any authorized remote terminal. Each user shall be assigned a level of authority, which will provide limitations on the access to CCS.

3. The keycard reader will physically capture the keycard during the time that a User is logged onto the system.

4. Logon shall be possible at any location served by the operating network. In the absence of failure, the functions available at a remote location will be identical to those available at the central facility.

F. Logoff.

1. Logoff is the process whereby a user relinquishes his access to the system.

   a.) Logoff is accomplished by removing the keycard from the keycard reader.

   b.) Upon user logoff, any unallocated geographic territories or functional privileges shall be alarmed after an interval sufficient to allow another User to logon or those unallocated items assigned to be another logged-on console.

G. Control Console Properties.

1. The primary users of CCS are the Train Controllers, Control Supervisor, and CCTV Operators. They shall be provided with the capability to perform monitoring and control functions via the Control Consoles.
a.) Each Control Console shall include the following:

Integrated Communications Controller Interface, allowing control and monitoring of voice equipment for radio, phone, PA, and VMS as per Specification Section 17730.

2. Each Control Console shall be assignable to a pre-defined user profile based on logon. The user profile defines user functions and geographic territory.

a.) The user profile may be all of, or a subset of, the LRT System.

b.) The user profiles assigned to Control Consoles may overlap one another.

c.) Device status indications for field devices within the domain of a user profile and those requiring acknowledgment from that user profile shall be presented at the associated Control Console.

d.) Device controls for field devices within the domain of a user profile shall be able to be initiated at the associated Control Console.

3. Each Control Console shall have individual control points assigned to it such that when a user logs on, control points associated with that user profile shall be assigned to the logged-on Control Console.

4. If a Control Console fails, an alarm shall be annunciated if there are points and/or territory that are not assigned to any console. If the unassigned partitions are not manually reassigned to a surviving console within a configurable time period, these partitions shall be automatically assigned to a surviving console with appropriate notice to the user at the reassigned console. Automatic re-assignment of the partitions assigned to the DSTT Control Console shall be prohibited.

5. The Control Consoles shall be identical. Each shall be capable of assuming the assignments of and performing the functions of the other Control Consoles quickly and conveniently without requiring CCS to be shutdown or restarted. It shall be possible to perform reassignment and/or reallocation of assignments to a Control Console in the event of the failure of another Control Console.

6. All displays shall be available at all Control Consoles.

7. CCS shall support a simulator mode for user training at any of the Control Consoles. In this mode, users shall be able to perform all monitoring and support functions related to LRT operations with realistic feedback but without any remote device control capabilities. All simulated screens shall be clearly identified as such.

8. CCS shall support a replay mode for users at any of the Control Consoles. In this mode, users shall be able to replay previously recorded log data for analysis.

H. System Manager.

The System Manager is a user of CCS. The System Manager shall be provided with equipment to perform all CCS functions provided to other users and the functions specified below in "System Management" and "On-line Diagnostics and Maintenance".
I. Maintenance Staff.

Maintenance staff personnel may logon to the system either on OCC, DSTT consoles, or laptop computers in station communication cabinets. The functions allowed to these users will be determined by their individual privileges as managed in the CCS.

J. Remote Users.

Remote users, including Emergency Services Personnel, may monitor and control subsets of the system at Emergency Management Panels located at underground stations. Operation of the Emergency Management Panel shall be signalized to CCS.

2.06 TRAIN SUPERVISION

A. Train Tracking (See Use Cases G-22-00 through G-22-13).

1. CCS shall determine train positions in real-time for all trains operating on the LRT System. Train positions for each train shall be maintained from two perspectives: tracked train position; and projected train position. The projected train location shall be used for monitoring the arrival of trains at time points and shall not be displayed except in unsignalled territory (See Use Case G-32-00). Train location shall be determined accurately through any single failure of signalized equipment.

a.) Tracked Train Positions.

1.) CCS shall monitor train movements to determine the Tracked Train Position. System wide train tracking shall be limited to vehicles equipped with TWC equipment. Mainline tracking shall also include any shunting vehicle. The position of non-shunting vehicles may be entered manually.

2.) CCS shall use TWC data, track occupancy, switch position, and signal indications to track trains entering the mainline, while on the mainline, and exiting the mainline. CCS shall monitor wayside TWC equipment to confirm the identity and the destination of each train. The destination information transmitted by the trains is set by Train Operators on board each train. The information from a train may change during a trip.

3.) Shunting vehicles without TWC capabilities and identified manually by a Train Controller shall be tracked. In unsignalled territory, the location of these vehicles shall be displayed in the sequence of vehicles in which they entered the Section.

4.) Train tracking shall support the following track configurations:

- Track segments with and without indicating track circuits.
- Interlockings.
- Mid-line pockets.
- End-of-line turnbacks.
- In signaled territories, CCS shall determine the Tracked Train Position of each train within each track circuit.

5.) In unsignaled territories, CCS shall determine the Tracked Train Position of each train to each section of non-indicating track bounded by the following:

- Two TWCs.
- A track circuit and a TWC.

6.) CCS shall acquire and utilize data from TWCs at mainline entrances and exits and along the mainline to:

- Determine the identity of trains.
- Determine the destination of trains.
- Establish the location of identified trains.
- Identify and maintain records of the cars and their sequence within each train.

7.) CCS shall track each train based on (in descending order of precedence):

- Train Controller inputs.
- Progressive and contiguous train movement, corresponding to track circuit occupancy indications, through continuous track from its last encountered TWC. Continuous track shall be based on:
  - Connectivity of track in the dynamic track configuration plan.
  - Time dependent switch and crossover alignments forming continuous track during the determined train approach to, and entry into, the switch and/or crossover track.
- Data from TWCs.
- Conservation of each train, independent of its identity, unless it is added to another train.
- Continued same direction of travel for each train, and first-in-first-out train movement through each track circuit and through each non-indicating section of track.

8.) For signaled territories, CCS shall assign a train identification to each track circuit occupancy, if:

- The train identification was obtained from a TWC at that track circuit.
- A train had been determined to be in an adjacent track circuit or an adjacent non-indicating section of track.

9.) For unsignalled territories, CCS shall:

- Assign a train identification to the specific TWC location upon detection.

- Assign a train identification to each section of non-indicating track bounded by track circuits and TWCs if a train is determined to have traveled into this track section.

- Maintain the list of trains within each section of non-indicating track in the order in which they entered.

10.) CCS shall provide the Train Controllers the capabilities to assign a train identification number to an unidentified train or to correct a train identification number (See Use Case G-11-00). The manually entered train identification number shall be associated with that train until a confirmation is made via a valid message received from a TWC.

11.) Train tracking shall be designed and implemented to continue to allow accurate tracking in the event of changes in track configuration with only database changes.

b.) Multiple trains in the same track circuit or block shall be indicated on all displays. A tabular list of all trains in the subject area shall be available. (See Use Case G-07-00).

c.) CCS shall predict the arrival time of all trains at their next station. (See Use Case G-02-00).

d.) Projected Train Position:

1.) For unsignaled territories, CCS shall maintain Projected Train Positions based on most recent Tracked Train Position, train destination, and predefined run times. The Projected Train Position shall be from:

- Signal territory boundary to first TWC in the unsignalled territory.

- Last encountered TWC to the next TWC in unsignalled territory.

- TWC in unsignalled territory to signaled territory boundary.

2.) Projected Train Positions shall generally be limited to the next expected Tracked Train Position.

3.) In determination of Projected Train Positions, the signalled direction of travel shall be assumed.
4.) CCS shall provide the Train Controllers the capabilities to turn off/on the determination of Projected Train Positions in a section of track.

5.) In signalled territories, CCS shall display the Tracked Train. In unsignalled territories, CCS shall display the Projected Train Positions.

6.) CCS shall use the tracked and projected train positions to display the next train arrival time, destination, and other service related information such as out-of-service messages on variable message signs (VMS) at passenger station.

B. Monitoring Performance (See Use Case G-12-00).

1. If a train is tracked to be in an out-of-service track segment, an alarm shall be generated.

2. CCS shall issue alarms for lateness above a user-adjustable system-wide threshold between the Tracked Train Positions and scheduled time points. For example, if a train is more than some epsilon (user adjustable) late to a scheduled time point, a late train alarm shall be generated. CCS shall provide the Train Controller the capability to turn on/off lateness determination and to set the lateness threshold.

3. If the train’s lateness changes by some additional time, gamma, the alarm will be re-annunciated.

4. Failure to arrive at a station at the predicted time shall cause the predicted time to be incremented by the run time from the train’s current position to the station.

5. Based on the train tracking, CCS shall:

   Record the time of yard entry and exit of a train to and from mainline and the train’s consist.

C. Train Locating

A user with appropriate privileges shall be able to interrogate the system to find out the current location of a train or LRV.

2.07 TRAIN OPERATIONS SUPPORT FUNCTIONS

A. Local Control.

When an interlocking is in local control, no commands from CCS shall be possible.

B. Yard Departure.

When a train is ready to depart from the yard to mainline CCS shall accept commands from the Train Controllers to request a route onto mainline tracks. CCS shall confirm the train ID and consist based on the operating schedule and manually entered data, including the operator ID (See Use Case G-09-00) with the information received from the associated TWC. CCS shall report if there is a discrepancy. As the train leaves the yard, CCS shall then track the movement of this train until the train returns to the yard.
C. Terminal Zone Dispatch (See Use Case G-06-00).

1. If the next scheduled train is occupying a terminal point (i.e. 154th, Pine street tail track, or Henderson pocket going north.)
   a.) 10 seconds prior to the scheduled departure, CCS will send the dispatch signal to that terminal zone signal (example: at 154th IBL 2N or IBL 4N).
   b.) 10 seconds after sending the dispatch signal, CCS will clear the route. If the route should not be available such that no correct exit available indication returns from the field logic, then OCC shall continue to attempt clearing the route on 5 second intervals for 1 minute before quitting.

2. If the dispatch is given, the route is cleared and the train does not leave on time, CCS will continue to dispatch subsequent trains as per the schedule or as soon as possible after the delayed train has cleared the route, whichever comes last.

3. If the next scheduled train is not at the terminal zone 10 seconds prior to the scheduled dispatch time.
   a.) CCS will provide an alarm “dispatch train missing” and then do nothing until the next scheduled train dispatch time arrives.
   b.) Upon arrival of a late train, it will be the responsibility of the OCC operator and the train driver to determine time and aligning of route.
   c.) At the time of the next scheduled train, CCS will send the dispatch signal, assuming one is there and the signal was not put into manual.

4. Procedure at Pine Street.
   a.) At 20 seconds prior to dispatch time OCC shall send the dispatch signal to Pine Street for the signal to be dispatching (i.e. PIN 2S or PIN 4S).
   b.) The field logic will automatically inhibit any automatic bus routes at CPS bus signals 1, 2, or 3.
   c.) If no bus signals are already clear and no buses are in detection zones CPS 1, 2, or 3, then the field logic will also put bus signal WLS B4 to stop to hold northbound buses.
   d.) When buses have vacated zone CPS4, the field logic will put bus signal PIN B1 to stop. When buses have vacated zone WLS4, the field logic will put bus signal PIN B2 to stop.
   e.) 10 seconds after PINB1 and PINB2 are put to stop, and the dispatch signal is present, the grade crossing flashers will begin to operate. The amber bar on the interlocking signal shall also start to flash warning the driver to prepare to depart.
f.) After the grade crossing flashers have operated for 10 seconds, the interlocking signal PIN2N will become a valid exit for southbound dispatch moves.

g.) OCC will attempt to send a route request at the dispatch time. If the exit does not display as available, then the Control System should make recurring attempts to clear the route every 5 seconds for 1 minute. Note from the times above, that if no buses need to clear from the route inhibiting zones, then the LRV route clear will be on schedule. However, if buses are present, then the dispatch will be delayed by the clearance time.

D. Interlocking Mode Selection (See Use Case G-14-00).

CCS shall monitor the mode of each interlocking and shall display their current mode. For each interlocking, CCS shall accept commands from the Train Controllers to select either the Central Control or Field Automatic modes.

E. Signal Mode Selection (See Use Case G-34-00).

CCS shall accept commands from the Train Controllers to place a signal into either automatic or manual mode.

F. Route Selection (See Use Case G-15-00 and G-24-00).

For interlocking placed in the Central Control mode, CCS shall accept commands from the Train Controller or automatic routines to issue and cancel route requests if no conflicting route is in effect and shall monitor the indication of the requested route. CCS shall monitor switch positions and signal status to determine the routing in effect. The displays shall show the route requested and routes established.

G. Direct Switch Control (See Use Case G-03-00 and G-13-00).

1. For interlocking placed in the Central Control mode, CCS shall accept commands from the Train Controller to set a switch (or crossover switch pair controlled as a single switch) in normal or reverse positions.

2. It shall be possible to request a switch position irrespective of its indicated position.

H. Terminal Mode Selection.

1. For each end-of-line interlocking, CCS shall accept commands from the Train Controllers to select any of the following terminal operating modes:

   a.) Mode 1: automatic route selection to either track for incoming trains, diverging route being the preferred route.

   b.) Mode 2: automatic route selection of diverging track into terminal station.

   c.) Mode 3: automatic route selection to normal track into terminal station.

I. Fleeting (See Use Case G-10-00).

CCS shall accept commands from the Train Controllers to request fleeting for a signal or a group of signals. Fleeting is a feature of the signal system permitting automatic re-initiation the same route for a signal as soon as the field conditions permit.

J. Crossing Gates (See Use Case G-18-00).

CCS shall determine whenever a crossing gate is in the down position beyond a Supervisor-definable threshold time period. CCS shall generate an alarm for such occurrences.

K. Swap Schedule (See Use Case G-20-00).

1. CCS shall provide a function to allow the Train Controller to swap the schedules between two trains. All data will be swapped except for accumulated mileage, operator ID and consist.

2. This function will generally be used to change the order of trains leaving the yard or a terminal zone.

L. Prohibit Move into Unpowered Section (See Use Case G-25-00).

CCS shall cancel the route when detecting a train approaching a signal that would lead into an unpowered track section.

M. Locate Train (See Use Case G-30-00).

CCS shall provide a function whereby the Train Controller may request the Location of a train by its ID. Upon such a request, CCS brings up a window showing the track zone in which the train is located and flashes the train's symbol.

2.08 DSTT CONTROL (SEE USE CASE J-01-00)

A. CCS shall provide monitoring and control for the DSTT. All existing monitoring and control shall be reproduced.

1. Train Tracking shall be implemented in the DSTT as at all other locations.

2. Bus tracking shall be implemented in the tunnel utilizing data from the signaling system as received from bus transponders.

3. CCS shall have the ability to assign an ID to a bus in the case of failure of its transponder.

4. CCS shall have the ability to adjust the position of busses to account for buses passing in the station areas.

5. Monitored and/or controlled devices are specified in Appendix C, Monitored Equipment List.
2.09 SUPERVISION OF TRACTION ELECTRIFICATION SYSTEM

A. Monitor and Alarm TPSS (See Use Case T-04-00).
   1. CCS shall monitor the status of traction power devices at each TPSS, and shall issue
      alarms for the following:
      a.) Uncommanded change of state of devices which can be controlled by CCS.
      b.) Equipment failures, abnormal conditions, and substation fire and intrusion.

B. Monitor and Display.

CCS shall monitor and display the TES equipment and facility statuses.

C. Control of Electrification Devices (See Use Case T-05-00 and T-06-00)
   1. CCS shall, unless the traction power station is in local control, upon User command or by
      automatic means, command traction power breakers/switches to open and close.
   2. CCS will not issue a command to a device which would be prohibited from executing the
      command, such as commanding a breaker to open which cannot open under load.
      Instead, CCS will annunciate the problem to the User.

D. Determination of Powered Status (See Use Case T-01-00).

CCS shall determine the powered/unpowered status of all devices and conductors in the
Traction Power System by knowledge of the traction power system topology and the status of
all devices therein, either as input from the field or manually entered.

E. Removal of Power.

CCS shall provide for removing power from a catenary section by a single user command.
Upon initiation of this command by a user, CCS shall calculate the TES devices affected by
the command and highlight them. The user shall then have the option of executing or
canceling the command.

F. Power Metering.
   1. CCS shall monitor and log the power consumption of each traction power substation.
   2. Calculation of power will be performed at the substations. The accuracy of such
      monitoring shall be sufficient to verify utility billing under a peak demand contract.
   3. Contractor shall coordinate with the electric utility as to the specific requirements of a
      peak demand contract.
2.10 TUNNEL EMERGENCY VENTILATION MONITORING AND CONTROL

A. (See Use Case W-03-00).

B. Emergency Ventilation System Objectives.

1. The DSTT and the Beacon Hill Tunnel contain a ventilation system used for both emergency ventilation and normal operation. The objective of emergency ventilation system operation is to:

   a.) Supply fresh air into the face of passenger evacuation path.

   b.) Exhaust dirty and/or hot air away from and behind evacuating passengers.

   c.) Control those ancillary devices that permit and/or assist in the management of a tunnel emergency such as escalators, remote controlled doors, variable message signs, and public address.

C. Ventilation Modes.

There are predefined tunnel ventilation system modes. (See Appendixes I, DSTT Emergency Ventilation Scenarios and J, Beacon Hill Tunnel Emergency Scenarios) Contractor shall coordinate with the tunnel contractor and/or the operating agency in determining the operating requirements of each mode.

D. Mode Control.

1. A control to implement each of the modes is available to CCS. CCS shall provide for user selection of any of the modes, and shall issue the mode designation to local equipment.

   a.) Upon user command, CCS shall solicit and aid the user in defining the following ventilation mode components:

      1.) The ventilation zone, or precise location, of the fire.

      2.) The direction of passenger evacuation within the selected zone.

   b.) CCS shall present to the Controller a preview of the air flow that would be produced by the scenario appropriate to the data entered.

      The user shall be prompted to have CCS initiate the ventilation mode.

E. Coordination with Emergency Management Panel.

1. Ventilation local equipment control panels will exist at each of the fan control rooms at the underground stations. When any is active, CCS shall indicate the specific panel active to OCC users and shall prevent users from issuing commands to control ventilation system equipment for that site. All devices controlled by the local panel shall be indicated as in Local control on all graphics containing them.
2. An EMP exists at each underground station. When this panel is in control mode, CCS shall indicate such to the users, and shall prevent users from issuing commands to control ventilation system equipment. All devices controlled by the EMP shall be indicated as in EMP control on all graphics containing them.

3. In order to take control, the personnel at the EMP requests control from OCC by turning a key switch. This alerts CCS and the Controller who then allows the control or denies it. If the Controller does not respond within 30 seconds, control is automatically granted.

4. While CCS is able to supervise the tunnel emergency ventilation system, CCS and FCS equipment shall maintain a control signal that provides indication to the EMPs of CCS/FCS Alive. Upon any CCS failure, communications path failure, or FCS failure which prevents CCS from being able to supervise the tunnel emergency ventilation system, CCS/FCS Alive signal shall no longer be provided to the EMPs.

F. Supervision of Ventilation Equipment

1. CCS shall provide displays for users to command ventilation system equipment into the defined modes.

2. CCS shall provide for user commands to control individual fans and dampers.

3. CCS shall report an alarm condition if the tunnel ventilation system is not in the mode commanded within a prescribed time limit.

G. Coordination of Other Systems

It shall be necessary to coordinate the response of other systems to a tunnel emergency. This may include the signal system, escalators and elevators, and PA and VMS. Specific scenarios for all systems will be supplied by the Engineer.

2.11 MONITORING OF INTRUSION (SEE USE CASE L-02-00)

A. CCS shall monitor and display intrusion conditions at rooms and cabinets equipped with detection devices including tunnel portals.

B. CCS shall support Intrusion Supervision as required by Section 17833.

2.12 MONITORING OF FIRE ALARMS

CCS shall monitor and display fire alarms conditions, consistent with NFPA-072, as available from each FACP and other locations.

2.13 SUPERVISION OF FIRE SUPPRESSION EQUIPMENT

CCS shall supervise Fire Suppression Equipment at all facilities where provided. CCS shall control the valves of the fire suppression system.
2.14 MONITORING OF PASSENGER EMERGENCY TELEPHONES (PET) AND EMERGENCY TELEPHONES (ETEL)

A. (See USE Case B-01-00 and B-02-00).

B. Off Hook Conditions.

CCS shall monitor and display emergency telephone off-hook conditions for PET and ETEL phones. This condition shall generate an alarm at the OCC.

C. Control of Associated CCTV Cameras.

For PET locations viewable with CCTV cameras, CCS, upon detection of off-hook conditions shall issue an alarm. Selection of the alarm by the Controller shall automatically select the appropriate CCTV cameras for viewing at the OCC and bring up a display of that camera on the assigned console.

2.15 SUPERVISION OF ELEVATORS AND ESCALATORS

A. (See Use Cases O-01-00 and O-02-00).

B. CCS shall monitor the status of elevators and escalators at required stations.

1. Alarms.
   a.) Uncommanded change of state of elevators and escalators that can be controlled by CCS.
   b.) Equipment failures and abnormal conditions.
   c.) Local controls in effect.
   d.) Alarm conditions originating in the local equipment

2. Control.

CCS shall provide for required control capabilities for elevators.

2.16 MONITORING OF STATION ELECTRICAL EQUIPMENT

A. CCS shall monitor and display the status of station electrical equipment at each station.

1. Alarms.

2. CCS shall monitor and display power consumption from local utility, usage by each TPSS and usage by station.

3. Control of Station Lighting (See Use Case E-02-00 and E-03-00).
a.) Lighting in the public areas of each station shall be turned on a pre-defined time before the arrival of the first train and turned off a pre-defined time after the last train has departed the station.

b.) In addition, more detailed lighting scenarios potentially involving all station lights will be defined by Engineer for automatic implementation by CCS.

c.) The User may adjust the timers for turn-off and turn-on of public area lighting.

d.) A User may control the lighting at a station.

2.17 MONITORING OF FARE VENDING EQUIPMENT

CCS shall monitor and display the fare vending equipment malfunction status and intrusion.

2.18 MONITORING OF FLOOD DETECTORS AND PUMPS

CCS shall monitor and display the statuses of flood detectors and sump pumps.

2.19 MONITORING OF ADDITIONAL COMMUNICATIONS EQUIPMENT

A. Tunnel Radio Amplifiers.

B. PA amplifiers.

C. VMS.

D. FCS Equipment.

E. RF Fiber Optic Link Equipment.

2.20 ACCESS CONTROL

A. (See Use Case L-01-00).

B. CCS shall support Access Control as required by Section 17832.

2.21 INTRUSION SUPERVISION

2.22 HUMAN MACHINE INTERFACE GENERAL REQUIREMENTS

A. Design Standards.

Displays and display characteristics, such as layout and spatial relationships, colors, symbols and symbol size, text fonts and text size, symbol and text display attributes, and command and navigation functions shall be designed according to commonly accepted standards and norms for human factors engineering, such as those in Mil-Std 1472 or equivalent.
B. Design Consistency.

For all graphic-oriented displays, there shall be consistent use of colors, labels, display attributes, object symbols, and to the extent practical (or unless defined otherwise in these specifications) geographic orientation and track alignment. Symbols depicting field devices shall, to the extent possible, depict the physical attributes of the device. Device symbols shall show the device in all of its states including local control, inhibited, tagged, failed, in alarm and, in the case of multi-bit inputs, transition and invalid states.

C. Identification of Real-time, Play-back or Simulator Mode

All screens shall clearly identify whether they are presenting real-time, play-back, or simulated data.

D. Prototyping.

1. Contractor shall, as part of the PDR, provide a prototype of all displays to be delivered for review and approval. Displays shall be delivered in color hard copy and electronic form.

2. Concurrent with the supply of prototype graphics, Contractor shall supply a prototype workstation with hardware and software necessary to view the prototype graphics. This workstation shall be similar if not identical to the workstation to ultimately be supplied.

3. Prototype graphics shall demonstrate the proposed navigation methods and links.

4. Prototype Displays shall depict all possible states of active graphic symbols.

E. Types of Displays.

1. Graphic Displays.

The ability to create, modify and display graphical representations of the systems shall be provided. The graphics editor supplied to perform this function shall itself be graphical, allowing symbols to be created, located, connected, and linked to the database by use of the mouse without the necessity to enter text commands.

2. Tabular Displays.

The ability to create, modify and display tabular (text) displays of the systems shall be provided.

F. Alert Features.

1. Displays shall draw attention to the exception conditions by use of distinct color, symbol, and/or flashing of the affected device representation. For all items flashing on a console display monitor, all items shall flash at the same time and at the same rate.

2. Attention shall be brought to alarms by the use of color, flashing and audible alerts.
G. Alarm Summaries.

Alarm summary indicators shall flash until all alarm conditions associated with the summary indicator are acknowledged; alarm summary indicators shall be shown in the color of the highest priority active alarm condition associated with the summary indicator.

H. Navigation.

1. All displays shall contain navigation aids that, with a single selection, will allow the User to select displays of adjacent areas or more detailed displays of the selected item.

2. There shall be a Main Menu which will allow navigation to any display.

I. Help.

Each screen shall include a HELP button which, when selected, will open a window displaying a static text Help screen describing the function and operation of the subject screen.

2.23 OVERVIEW DISPLAY

A. The Overview Display shall provide an easily comprehended summary of LRT system operations showing important alarm and exception conditions and the location of trains in signaled and unsignalled territories. The Overview Display shall provide information and status in the context of both geographic and functional relationships (i.e. across multiple functional subsystems such as signals, tunnel emergency ventilation and traction electrification).

1. Display Orientation.

The Overview Display shall represent the LRT system in a semi-geographic orientation. Geographic directions shall be represented where possible, consistent with actual compass directions.

2. Exception Conditions.

a.) Exception conditions shall be brought to the attention of the Train Controllers by the use of distinct color or flashing display attribute. These conditions shall include the following:

1.) Alarms.

2.) Off-normal device statuses including: circuit breaker open; switch aligned in reverse position; and OCS section unpowered.

3.) Interlocking in local mode.

4.) TPSS in local control.

5.) EMP in control.
6.) Special device states such as: Out-of-Service, Control Inhibited.


   a.) The sensed alarm conditions to be displayed include the following:

   1.) Fire alarms.

   2.) TPSS equipment alarms.

   3.) Station Electrical alarms.

   4.) UPS equipment alarms.

   5.) Elevator/escalator alarms.

   6.) PET and ETEL alarms.

   7.) PA and VMS alarms.

   8.) TVM alarms (See Use Case A-01-00).

   9.) Train signal alarms.

       - Ac and dc power failures.

       - Gate crossing alarm.

       - Microprocessor failure alarm.

       - Blown fuse.

   10.) High water in depressed areas.

   11.) Alarm conditions associated with station platform or signal room power.

   12.) Intrusion alarms.

4. Derived Alarms

   a.) The derived alarm conditions to be displayed include the following:

   1.) Late train.

   2.) Excessive time for gate crossing in the down position.
3.) Device failure to operate within a time period appropriate to the device.

4.) Uncommanded change of state.

5.) Multiple trains occupying a single track circuit unless a call-on was in effect upon the entry of the second train.

6.) Displayed Objects.

5. Displayed objects, represented by symbol and/or name, shall include:

a.) Each passenger station.

b.) Each TPSS.

c.) Each section of track, including crossovers and yard lead.

d.) Major reference points, including the following:

   1.) Maintenance Facility.

   2.) Maintenance access points.

   3.) Milepost locations.

   4.) Boundaries for signaled and unsignaled territories.

   5.) Jurisdictional limits.

6. Dynamic Information.

a.) Dynamic information displayed shall include:

   1.) Train identifications at last tracked train position.

   2.) Train status (in service or not-in-service).

   3.) Number of cars stored in a section of track.

   4.) Date and time.

   5.) Geographic territory not assigned to a logged-on user.
7. Flashing.

For items flashing on the Overview Display, all items shall flash at the same time and at the same rate.

8. CCTV on Overview Display.

The Overview Display subsystem shall allow a user to select one or more CCTV images to be directed to the Overview Display. The user shall be able to assign the CCTV images individually to any area of the Overview Display and to resize the CCTV image as necessary. Up to 8 images shall be able to be selected by the Train Users and directed to the Overview Display.

2.24 SPECIFIC CONSOLE DISPLAYS

A. Contractor shall provide at least the following CCS displays:

1. Logon/Logoff Display.
   a.) The Logon/Logoff Display will be used to gain and relinquish access to CCS. Logon shall require identification of user and be protected with passwords and by keycard.
   b.) Upon user logon, the following information shall be displayed:
      1.) User profile assigned to the logged on individual console.
      2.) Logical track states.
      3.) Suppressed alarms.
      4.) Track blocks.
      5.) Signal blocks.
      6.) Special device states.
   c.) Upon a user initiation of logoff at a console not caused by the log-on of another user with the same privileges, all unacknowledged alarms (if any) shall be displayed to the user.
   d.) In the event that the newly logged-on User does not have the same privileges as the previous User, all unacknowledged alarm which are not within the purview of the new user shall be displayed.
   e.) CCS shall advise the user that logoff cannot be completed until all outstanding unacknowledged alarms are acknowledged.
2. Main Menu Display.

The Main Menu Display or equivalent navigation facilities shall provide for fast selection of any CCS display.

3. Track Zone display.

a.) The Track Zone Display shall provide an easily comprehended summary of system operations using the same format as the Overview Display.

b.) The Track Zone Display shall show the same information as the Overview Display with the following additions:

1.) Signal numbers and status.

2.) Track circuit occupancies.

3.) Switch positions.

4.) Switch numbers.

5.) Route status.

6.) Interlocking names and mode.

7.) Crossing Gate Status.

8.) Track segment identifier.

9.) Reference points.

10.) Cross street.

11.) TPSS names.

12.) OCS powered/unpowered status (corresponding to track segments).

13.) Upon an alarm event in a signal equipment bungalow/room or communications equipment room/cabinet, a corresponding symbol correctly located.

c.) The Train Controller shall be able to use the Track Zone Display to:

1.) Request a change in interlocking mode (request/release of central mode).

2.) When in the central mode, issue and cancel route requests by selecting the signals for the requested route.
3.) Declare track block (See Use Case G-05-00) and remove block (See Use Case G-33-00).

4.) Declare signal block (See Use Case G-04-00) and remove signal block (See Use Case G-26-00).

5.) Declare out-of-service track.

6.) Upon command to take track out-of-service, define the track through selection of two exit track circuits at any crossovers shown.

7.) Declare track back in-service.

8.) Assign a train identification number to an unidentified train in signaled territory.

9.) Modify a train identification number.

10.) Turn on/off lateness and out-of-sequence determination.

4. Overview Display.

A display shall be provided for the overview display units to be mounted at the front of the control room. This display shall be configured specifically for the overview display units and shall contain all the information required on the Track Zone Display with the exception of track circuit identifiers.

5. Alarm Summary Display.

a.) The Alarm Summary Display shall always be in view on each user's desktop. It shall provide the means to view and acknowledge alarms. The Alarm Summary Display shall support all current alarms. The Alarm Summary Display shall show:

1.) A list of current alarms in order by priority and descending chronological order.

2.) The time and the acknowledged/unacknowledged status of each alarm.

6. Historical Alarm Display.

The Historical Alarm Display shall show all alarms within the last 30 days sortable by LRT subsystem (e.g., TES, Signals, Communication) and location (e.g., TPSS number xx).

7. Off-Normal Display.

a.) The Off-Normal Summary Display shall list all points that are not in a predefined normal state. Each entry shall identify the point by name and the associated FCS equipment and shall also specify the nature of the off-normal condition. The Off-Normal Summary Display shall support all current off-normal activities. Communications and CCS points/alarms shall also be shown. Future unimplemented
or spare points shall not appear on this display. The display shall include the following types of points:

1.) Manual - points which currently have manually entered values.

2.) Inhibited - points which have their alarm processing inhibited.

3.) Deactivated - points which have been removed from the scanning sequence.

4.) Control Inhibited (Tagged) - points which have all control actions inhibited.


The Event Summary Display shall list the most current user initiated events. Event entries shall identify the action taken, the old state, the new state, the time of action, and the user performing the action. Event entries shall be listed either in chronological or reverse chronological order.

9. OCS Zone Display.

a.) The OCS Zone Display is divided into segments, separated by insulators or section breaks. Each segment is called an OCS zone. The OCS Zone Display shall show where the power is distributed along the LRT system. The OCS Zone Display shall:

1.) Show:
   - Three TPSS on each display with all breakers, switches, and associated OCS sections; each display shall show the bounding TPSS of the adjacent display as the center TPSS.
   - Summarized alarms for each TPSS within zone.
   - OCS powered and unpowered status.

2.) Contain navigation features which will allow adjacent traction power territory to be displayed.

3.) Provide commands to open and close ac and dc breakers.

4.) Support commands to remove or restore power to a catenary section (See Use Case T-02-00 and T-03-00).

5.) Support commands to remove power from any selected region composed of one or many catenary sections.

6.) Provide for one command navigation to.
8. Communications Systems Central Control System Sample IFB No. RTA/LR 101-03
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- Checklist for Removal of Power.
- Checklist for Restoration of Power.

10. TPSS Detailed Display.

a.) Each TPSS shall be depicted on a TPSS Detailed Display. CCS shall provide a tabular display for each traction power substation. The tabular display shall:

1.) Show:
- Identification of all ac and dc breakers.
- Status for all electrification devices.
- All alarms associated with the TPSS including fire, intrusion, loss of utility power, and loss of control voltage.
- Automatic transfer switchover.

2.) Provide for one-touch navigation to:
- OCS Zone Display.
- Checklist for Removal of Power.
- Checklist for Restoration of Power.
- Track Zone Display.


a.) Tabular displays shall be provided for each signal system location showing all inputs including TWC information.

b.) Tabular displays shall be provided for each bus processor showing all inputs.


a.) This display encompasses the territory between the tunnel portals. CCS shall display information known to CCS including:

1.) Shows the same information as the overview display for that territory, with the following additions:
- Ventilation Zones.
- Status of the fire protection equipment.
- Status of tunnel facility equipment.
- Electrical devices.
- UPS.
- Sump Pumps.
- Elevators.
- Escalators.
- Location of trains.
- Location of cross-passages.
- Location of PET and ETEL telephones and their status.
- Location of tunnel portals.
- Status of OCS energization.
- The air flow in each section corresponding to the current ventilation mode in effect.
- Which entity (CCS, the EMP, or a specific ventilation equipment local control panel) is in control of the tunnel emergency ventilation system. (Unless the EMP or a local control panel is active, CCS shall be in control whenever it can supervise ventilation equipment.)

2.) Provides the Train Controller the means to:

- Declare a fire, and input the fire location. Fire location shall, at Train Controller option, be entered as a ventilation zone, or as a specific location through selection of a location corresponding to CCS-displayed milepost.

- Input the desired direction of evacuation in order to assist passenger evacuation within the zone.

- Confirm the corresponding ventilation mode and the resulting air flow as shown on the graphic.

- Initiate the CCS control of the corresponding field devices appropriate to the selected ventilation mode.

- Stop the tunnel emergency ventilation.
3.) Has a pop-up sub-display which can be accessed with one-touch to the tunnel fire emergency checklist.

4.) Has a pop-up sub-display that provides means for the Train Controller to command CCS to initiate device controls to place the tunnel emergency ventilation system into any one of the predefined modes.


a.) The tunnel fire protection system display shall:

1.) Provide a top level schematic presentation of the fire protection system.

2.) Provide the Train Controller a command to start/stop fire suppression equipment.

3.) Depict the status of all monitored devices.

4.) Show the time commanded actions were taken.

5.) Indicate alarm conditions.


a.) The tunnel ventilation equipment utility display uses approximately the same graphic representation of the tunnel as the tunnel emergency ventilation display. It:

1.) Displays the active status of the ventilation equipment local control panels and the EMPs.

2.) Displays the current ventilation mode being executed.

3.) Displays the status of each fan and damper, and provides the Train Controller the means to command CCS to initiate a selected device control for each individual fan and damper.

15. Tunnel Facilities Display

1.) Shows the status of the underground station and tunnel equipment and subsystems and any alarms for sump pumps, the tunnel radio system and other communications subsystems.

2.) Provides means for the Train Controller to initiate control actions to:

   - Operate tunnel facility devices.

   - Operate the tunnel fire protection system.
3.) Has a pop-up sub-display that provides means for the user to view a tunnel emergency checklist.


The Yard Display is a graphical representation of the yard track and facilities, including maintenance areas. The display shall allow the Train Controller to record and view the status and location of each LRV within the yard. The Train Controller shall be able to assign each LRV to a train, and define and view its position in the train; each LRV shall be capable of being shown as part of a train. For each LRV, the symbol or object shall be clearly identified by the LRV number and status. The Train Controller shall be able to view the set of LRVs which have entered the yard and which have not been assigned a yard track location and which have not subsequently left the yard.

17. Train Consist Display.

The Train Consist Display is a list of the trains that are currently operating or scheduled to be operating during the day. It includes train number, the identification numbers for cars, and the four-character operator ID number and the name of the train operator. The Train Consist Display shall be automatically updated from train tracking information. The display shall provide a scrollable list of at least 100 trains, in order by train number.

18. Operating Schedule Display (See Use Cases G-16-00 and G-17-00).

a.) CCS shall enable Train Controllers to:

1.) Select a schedule from a library of schedules.

2.) View and edit operating schedules.

19. Facility Display.

a.) CCS shall provide a station display for each station and other major facility including the O&M base. This display shall, in a spatially correct manner, show the status of the following:

1.) Escalators.

2.) Elevators.

3.) CCTV Cameras.

4.) TVMs.

5.) Passenger Emergency Telephones.

6.) PA amplifiers.

7.) Variable Message Signs.
8.) Station Control Panel.

9.) Station and adjacent track occupancy.

10.) Catenary.

20. CCS Equipment Display.

CCS/FCS Equipment Display is a display for general-purpose management of all CCS/FCS device indication and control signals. The display shall provide the present status of all indications and active commanded action.


a.) This display shall:

1.) Provide summary status (for fare collection, intrusion, emergency phones, elevator and escalator subsystems) of all stations, and summary status (for intrusion) for all tunnel building facilities, and locations such as the tunnel portals, with intrusion alarms monitored by CCS.

2.) Allow selection of a station or building facility, and allow viewing of all indications and alarms for the fare collection, intrusion, and elevator subsystems, and acknowledging of the alarm indications.

3.) Provide display of the enabled/disabled reporting status of fare collection equipment at each station, and allow the CCTV Operator to temporarily disable (and re-enable) reporting of fare collection alarms for each station.

4.) Provide display of the enabled/disabled reporting status of intrusion alarms at selected locations in the tunnel.

5.) Provide display of status, and allow for control, for elevators/escalators at stations where controls are enabled.

6.) Provide display of CCTV camera equipment on/off status, and allow for control of the on/off status for all supervised CCTV camera equipment locations.

7.) Provide display of platform emergency phone “activated” and “answered” conditions at all stations and other emergency phone locations.

8.) Display and provide for acknowledgment of assigned alarms.

2.25 ALARMS

A. Alarm Types.

1. CCS shall support both sensed and derived alarms. Alarms may be:
a.) Abnormal states or conditions for field devices. These abnormal states shall be able to be predefined.

b.) Alarm sensor indications.

c.) Fault or failure conditions in Communications System equipment or software.

d.) Logically inconsistent field conditions.

e.) CCS-derived conditions such as:

1.) No indication of device status corresponding to previous control action.

2.) Selected controllable devices (e.g., breaker) that changed state without a CCS-initiated control action.

f.) Loss of communication with field devices and other systems including:

1.) FCS devices.

2.) Signal processors.

3.) TWCs.

B. Logical Operations (See Use Case Q-03-00).

1. CCS shall provide facilities to define logical criteria to be used by CCS in alarm determination, and CCS shall use those criteria.

a.) Logical operations shall include, at a minimum: OR, XOR, AND, NOT.

b.) For example, a user shall be able to define criteria such that the presence of two distinct indications being TRUE shall result in an alarm condition (while individually the two indications are not alarm conditions).

C. Alarm Characteristics (See Use Case Q-01-00 and Q-02-00).

1. Alarm conditions shall be represented by any combination of the following characteristics. The set of characteristics for each alarm condition shall be configurable.

a.) Graphics device status symbol, which displays the current status on console displays:

1.) In the color defined for the alarm priority corresponding to that specific alarm condition.

2.) With flashing attribute, if a text alarm message is also defined to be generated for the alarm condition and the text alarm message has not yet been acknowledged.
b.) Summary graphics symbol, which displays the current status on the Overview Display and on console displays by:

1.) In the color defined for the alarm priority corresponding to the highest priority current alarm condition associated with that summary symbol.

2.) With flashing attribute, while any text message corresponding to a current alarm condition associated with that summary symbol has not yet been acknowledged.

c.) Text message, which shall:

1.) Be displayed in the color associated with the priority of the alarm condition.

2.) Be accompanied by a flashing icon until acknowledged.

3.) Based on priority, be accompanied by an audible alarm until acknowledged.

4.) Be logged in CCS log.

D. Alarm Distribution.

The User Types (e.g., Control Supervisor) to whom the alarm is to be distributed shall be definable for each type of alarm.

E. Alarm Priorities.

1. A minimum of five alarm priorities shall be provided. A priority shall be able to be defined for each alarm type. Each priority shall be able to be defined with any of the following characteristics:

a.) Whether an audible alarm is to sound (until the alarm is acknowledged) upon the alarm condition, and if so which type of audible alarm.

b.) Color and flashing of the text message and symbol.

c.) Acknowledgement required.

F. Alarm Disable (See Use Case Q-11-00).

The Train Controller shall be able to disable the audible alarm for the Control Console he/she is logged-on.

G. Order of Alarms.

Where alarm text messages are displayed in a list, and unless otherwise defined, the alarms shall be reported based on the alarm priority with higher priority alarms displayed first, and within priority by reverse chronological order (i.e., most recent first).
H. Alarm Persistence.

1. CCS shall detect when an alarm condition no longer exists (e.g., as a result of a device alarm state going from true to false).

   a.) The displayed alarm-condition symbol (with its alarm-related display attributes) shall persist only until the alarm condition no longer exists.

   b.) The alarm text message (e.g., in the Alarm Summary) shall persist until both, the alarm condition no longer exists and the alarm (text message) has been acknowledged.

I. Alarm Expiration Indication.

1. Upon expiration of the alarm condition CCS shall generate a new alarm condition, requiring acknowledgement, indicating that the previous alarm condition is no longer in existence.

   a.) The new alarm condition shall be of the same priority as the original alarm condition.

   b.) If a text alarm message was generated for the original alarm condition, a text alarm message shall be generated for the new alarm condition; if a display symbol flashed for the original alarm condition, that display symbol shall flash for the new alarm condition until the new alarm is acknowledged.

   c.) The new alarm condition shall persist until the text alarm message is acknowledged.

J. Alarm Acknowledgment (See Use Case Q-01-00).

1. Alarms shall be able to be acknowledged by CCS users using console interface equipment.

2. Acknowledgement may be accomplished by selection any instantiation of the object device.

3. A function shall be provided to acknowledge all alarms. This function shall be available only to designated personnel, typically the Supervisor.

4. For alarms that require acknowledgement, the device symbol, summary indicator and text message shall flash on applicable displays at consoles where the logged-on user is responsible for acknowledging the alarm. Upon acknowledgement by any responsible logged-on user, the flashing shall stop.

K. Alarm Actions.

Alarm messages shall contain selectable fields to instigate other actions such as the display of an associated CCTV image or the display of the graphic which contains the point in alarm.

L. Text Message Properties.

Alarm text message contents shall be modifiable, and shall include date and timestamp.
2.26 TIME

A. (See Use Case Y-01-00).

B. Source.

CCS shall acquire time from the supplied time source (Section 17740, Master Clock System).

C. Automatic Features.

CCS shall support automatic changeover to/from Day Light Savings and to leap year.

2.27 CCS DATA LOG

A. Log and Event Logs.

1. CCS shall maintain a log of CCS events and alarms in CCS database. Items to be logged include:

   a.) All device change of states (e.g. track circuit occupancy changes, signal aspect changes, etc.).

   b.) All derived change of states (e.g. train late, all train movements).

   c.) All alarms.

   d.) All Train Controller commands, except display navigation, and including:

      1.) Log-on, log-off, and territory assignment changes.

      2.) Alarm acknowledgements.

      3.) Device control actions (both for individual devices, and higher-level commands).

      4.) Placing devices in, and returning devices from, special device states.

   e.) Loss of data communications with PLCs and other devices and systems (e.g. Signal System processors).

   f.) Resumption of data communications with PLCs and other devices and systems (e.g. Signal System processors).

   g.) CCS component or process failures and/or removal from service; CCS component or process restoration to service.
B. Logged Alarm Content.

Items logged shall include a date & time stamp, representing, at the latest, the time the item is logged (and at the earliest, the time the event is first detected by CCS). The time stamp shall be accurate to within ±0.1 second of the time derived from CCS time source.

C. Log Storage.

Log entries shall be stored on disk in CCS database in a form available for ad hoc queries and reports using the query and report packages provided as part of CCS.

D. Length of Storage.

Sufficient storage space shall be provided in CCS database to hold at least 60 days of log entries on line. Data shall be rolled off to DVD recordings for permanent storage.

2.28 PRINTING REQUIREMENTS

A. CCS shall print the following at user request:

1. PrintScreen output.

2. Alarms for a requested period sortable by time, criticality, system, and/or location.

3. Historical reports of inputs and/or outputs sortable by time, system and/or location.

2.29 CCS DATABASE

A. Database Contents.

CCS database shall contain: LRT configuration data, CCS configuration data, CCS operating configuration data, operating schedules, and the log of all actions and events.

B. Database content examples.

1. Device and Point definitions, including:

   a.) Device name and device points.

   b.) Device type control timeout value.

   c.) Point "True" state value (0/1).

2. Summary display point definitions, including the set of individual points making up the summary point.

3. Alarm definitions, including: priority, distribution.

4. LRT System Configuration data, including:
a.) Normal dwell times at each station.

b.) Normal and maximum run times for each section of track.

5. CCS operating configuration data, including:

a.) Territory definitions.

b.) User profiles.

c.) User IDs and Passwords.

d.) Train Order and Special Instruction information.

e.) Configurable parameters and values.

6. Data from forms-based display data (e.g. Train Orders, Special Instructions).

C. Replicate Database.

1. A replicate database, separate from CCS database, shall also be provided.

a.) The replicate database shall use the same database management system product as CCS database.

b.) The replicate database shall contain the same information as CCS database, with the exception that it shall have the capability to store at least two years worth of on-line log.

c.) Entries shall be logged to the on-line log in the replicate database within three seconds after that same information is logged into CCS database.

d.) No single point of failure shall cause the replicate database to lose data or to become inaccessible.

D. Database Tools.

1. Tools shall be provided to backup and restore CCS database and the replicate database.

2. Tools shall be provided to roll off old log data from CCS database. These tools shall be initiated automatically at a pre-defined interval (e.g. at the end of each transit day) and shall function automatically without human intervention.

3. Tools shall be provided to roll off old on-line log data from the replicate database.
E. Trending and Analysis.

1. CCS shall provide a function to graphically trend any variable or set of up to three variables against time utilizing user defined scaling.

2. CCS shall provide a function to plot a variable or a set of up to three variables against any other variable.

2.30 MANAGEMENT OF CCTV

A. CCTV Operator Capabilities.

1. Pan Tilt Zoom.

2. (See Use Case V-01-00).

B. Overview Display Capabilities.

1. (See Use Case V-02-00).

2. It shall be possible from any Control Console in the OCC to select up to 8 CCTV images for display on the Overview Display.

3. The display of CCTV images on the Overview Display shall not degrade its normal operating characteristics.

2.31 INTERFACE TO OTHER SYSTEMS

A. Office Services Network (via security Firewall).

B. FCS.

C. CCTV.

D. Radio.

E. PA/VMS.

F. Telephone.

2.32 SYSTEM MANAGEMENT

A. System Manager Functions.

1. Update LRT system configuration definitions in CCS database.

2. Load, edit operations related data such as schedules and run times.

3. Edit console assignment definitions and logon identification codes in CCS database.

4. Create, delete, and edit system user profiles.
5. Perform alarm definition including:
   a.) Indications or conditions constituting an alarm condition.
   b.) Priority for alarms.
   c.) Routing of alarms to users.

6. Utilize SQL tools to compose and initiate reports and queries against CCS database, the disk-based log, and re-loaded log data.

7. Off-load and re-load log data.

8. Perform orderly system startup and shutdown.

9. Logically remove failed FCS equipment and (re)introduce replacement equipment.

10. Introduce new FCS equipment, data communications interface equipment, and Console equipment into CCS.

11. Delete FCS equipment, data communications interface equipment, and Console equipment from CCS.

12. Perform configuration definition of CCS computer equipment, LAN equipment, data communications equipment and operating system software.

13. Perform CCS equipment management, including:
   a.) Monitor performance and utilization of LAN equipment.
   b.) Defining, maintaining, and monitoring status of, and administering the LAN configuration.
   c.) Viewing equipment and software error message.
   d.) Troubleshooting and testing the LAN, Consoles, and servers.
   e.) Initiating, and reporting results of diagnostics.

14. Create, edit, delete and view visual messages.

15. Record, edit, delete and playback audio recordings.

16. Perform software maintenance and modification. Maintain and augment the application software including display editing and generation.

17. Perform all functions provided to Train Controllers.
B. Software Management Tools.

CCS shall include comprehensive software maintenance tools, including editing, compiling, linking, debugging, and testing tools and manuals shall be provided to allow the System Manager to maintain, modify, and test the application software. (See section 17860, Software Engineering Requirements).

2.33 ON-LINE DIAGNOSTICS AND MAINTENANCE

A. OCC Failure Detection and Correction.

1. CCS shall detect equipment and software failures and provide corresponding failure indications to active consoles. CCS shall provide for replacement and subsequent resumption of operation, while CCS continues to operate, of the following:

   a.) Console devices.
   
   b.) Printers.
   
   c.) Database server.
   
   d.) Communications server or network switch.
   
   e.) Serial data link.
   
   f.) LAN Hubs.
   
   g.) LAN Bridges.
   
   h.) IS Firewall/Router.

B. Remote Failure Detection and Correction.

   CCS shall, upon detection of a FCS fault, report the fault to active Control Consoles. CCS shall also provide capability for initiating remote FCS equipment self-tests and/or diagnostics, both during normal operation, and during resumption of operation.

C. Failure Reporting.

   CCS shall, upon detection of failures of devices (connected with data links), report the failure to active consoles. CCS shall report when the device is back to service.

PART 3 - EXECUTION

3.01 GENERAL

   Contractor shall nominate a software engineering manager who shall have responsibility for the production of the system's software. The software engineering manager shall be Engineer's point of contact for all software related items.
3.02 PREPARATION

Contractor shall produce the software of the system with the aid of software engineering tools which are described in Section 17860, Software Engineering Requirements.

3.03 FACTORY TESTING

A factory test shall be conducted which shall demonstrate the functioning of the complete system of hardware and software. All components of the system shall be integrated on the factory floor. Where multiple instances of a system component exist, a sufficient number of that item shall be integrated and tested in order to comprehensively demonstrate the functioning of the system and the interaction between like components.

3.04 DELIVERY, STORAGE AND HANDLING

A. All components of the system shall be delivered to the Sound Transit Link Operations and Maintenance Facility.

B. Both source and executable software shall be delivered on CD ROM as well as a complete loadable software build.

C. Complete listings of all software shall be provided.

D. Licenses for all third party software shall be provided.

3.05 INSTALLATION

Contractor shall install all equipment according to Contractor supplied installation drawings.

3.06 FIELD TESTING

Contractor shall perform a test of the complete system after all installation activities are complete. This test will repeat the Factory Acceptance Test and will also allow Engineer to perform various scripted and ad-hoc tests at his discretion.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17840
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SECTION 17841
CCS SOFTWARE AND EQUIPMENT

PART 1 - GENERAL

1.01 OVERVIEW

This Section defines the CCS software and equipment necessary to support the functional requirements described in Section 17840, Central Control System.

1.02 SECTION INCLUDES

Requirements for the following:

A. CCS software.

B. CCS equipment.

1.03 REFERENCED SECTIONS

A. Section 17420 – Tunnel Radio System.

B. Section 17620 – OCC Facility Requirements.

C. Section 17625 – OCC Furniture.

D. Section 17800 – Control System Overview.

E. Section 17802 – Field Control System.

F. Section 17832 – Access Control System.

G. Section 17833 – Intrusion Detection.

H. Section 17843 – Backup Control.

I. Section 17844 – Training Simulator.

J. Section 17860 – Software Engineering Requirements.

K. Appendix A – Glossary.

L. Appendix B – Communications Equipment List.

M. Appendix C – Monitored Equipment List.

N. Appendix D – DSTT I/O List.

O. Appendix F – Control System Functions (Use Cases).
P. Appendix I – DSTT Emergency Ventilation Scenarios.


1.04 REFERENCE STANDARDS


B. Mil-Std 1472 – Human Engineering.


1.05 QUALITY CONTROL

A. Contractor shall be registered and compliant with ISO 9001 for the entire scope.

B. Contractor shall be verifiably certified, by The Software Engineering Institute or a licensee thereof, to have attained CMM Level 2 certification or higher.

1.06 SUBMITTALS

A. Preliminary Design Review (PDR) (NTP + 30 days).

B. Contractor shall provide the following as part of the PDR (See IEEE STD 830).

1. CCS Equipment Configuration.

2. Description and model numbers, shop drawings, catalog cuts, and technical literature describing all of CCS equipment.

3. Detailed CCS equipment block diagrams with physical interconnections and interfaces.
4. Identification and description of all external interfaces.

5. Description of all facilities and functions provided to implement availability requirements.

6. Name and brief description of all copyrighted commercial off-the-shelf software, including operating system software, data communications software, database software, forms package and report package, database query package, local area network management software, FCS software, and object oriented language compiler and associated software.

C. Final Design Review (FDR)(NTP + 270 days).

1. Contractor shall provide the following as part of the FDR (See IEEE STD 830).
   a.) Updated versions of all previously submitted materials.
   b.) Equipment wiring and cabling diagrams.
   c.) Rack layouts and rack interconnections.
   d.) Equipment and System Software parameter settings.
   e.) Physical Inventory Data.

1.07 DELIVERABLES

A. Contractor shall transmit submittals and deliverables required by Sections 01330, Submittals, and Appendix F, Contract Data Requirements List (CDRL).

B. Contractor shall furnish products as indicated.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall provide CCS Control Console equipment.
   1. Contractor shall provide equipment at each of the Control Consoles.
   2. Software (including all system software and application software) shall be provided.
   3. The CCS database shall be designed, built, and fully functioning according to this Specification.

B. Contractor shall supply dual or clustered computers to act as the servers for the system. These computers shall operate in a load-sharing mode with each computer being loaded to no more than 40 percent of its capacity.

C. The CCS shall be constructed around a redundant local area network (the CCS LAN) connecting CCS workstations, CCS server computers, and database servers.
2.02 CCS CONFIGURATION

A. The CCS hardware shall be configured as a distributed system consisting of the following:

1. Multiple CCS server computers.

2. Computer and peripheral equipment for four Control Consoles.

3. Overview display equipment and controllers.

4. CCS LAN equipment and data communications interfaces.

5. Archival storage system consisting of a controller (Processor) and associated read/writable mass storage devices.

6. Firewall between the CCS system and the Office Services Network.

B. CCS hardware shall be commercially available off-the-shelf equipment.

C. The CCS shall be designed to operate seven days per week, 24 hours per day.

D. The CCS hardware and software, together with the CCS LAN, shall function and be configured in a manner such that the CCS shall continue to be fully available (i.e. all functions, all displays, all database data, and all interfaces to other equipment shall continue to be fully available and operational; all capacity, workload and response time requirements shall continue to be met; all I/O integrity of operation requirements shall continue to be met; all CCS functions, displays, and data are available at all control consoles) in the event of any single point of failure or any combination of events reasonably or as defined in the Reliability Study, Section 17030, Reliability Management Program.

1. The only failures that are allowed to be exceptions to this are the following:

   a.) A failure of console power, CCS console equipment or console software process may cause that console and only that console to become unavailable. In the event of a failure of console power, equipment or software the following:

      1.) No alarms presented at that console shall be lost.

      2.) No alarm acknowledgment performed at that console shall be lost.

      3.) No user-initiated control actions performed at that console, and acknowledged by the CCS, shall be lost.

   b.) A failure of an Overview Display unit may cause that portion of the Overview Display to become unavailable.
E. The CCS hardware and software shall function and be configured in a manner such that while CCS continues to operate and be fully available, CCS shall provide for reconfiguration, replacement, resumption of operation, and automatic re-incorporation into the working CCS configuration of failed components such as the following:

1. Console equipment.
2. Printers.
3. LAN equipment such as hubs.
4. Database server discs, disc controller and power supply.
5. Computer equipment for terminal servers, printer servers or other servers (e.g. database server, communications server, system server) and Overview Display controllers.
6. Application software processes.

F. CCS shall comprehensively detect and report all equipment and software failures and faults.

1. Failures and faults shall include operational conditions such as the following:
   a.) Printer faults such as: paper jam and printer out of paper.
   b.) Database warnings such as database 80 percent full.
   c.) Backup/Restore warnings such as no backup media loaded.

G. Any failed component shall be diagnosed and replaced or repaired within 60 minutes of detection.

H. It shall be possible to add and operate with the following without change to any CCS software source code, and without need for additional CCS hardware.

1. Additional Control Consoles, with full complement of CCS user interface equipment and console equipment.
2. Printers.

I. The CCS hardware configuration shall be able to grow to accommodate future modifications and/or extensions to Link without loss of investment in and without need to replace hardware provided under this Contract. The CCS software shall be able to support and take advantage of that growth.

1. It shall be possible to add and operate with additional track, and interlockings with database changes and only minimal change only to CCS software code which implements train tracking and routing.
2. It shall be possible to add and operate with additional workstations, and with additional users without change to CCS software code.
3. It shall be possible to replace workstation and server computers with more powerful computers from the same manufacturer or of the same type without change to CCS software code.

J. All software shall be constructed with modular device driver interfaces, and shall employ standard I/O system, operating system, file system, and database management system calls to facilitate migration to new versions of system software.

2.03 CCS DATABASE AND DATABASE MANAGEMENT SYSTEM

A. The CCS database shall contain: current device/point status information, immediate past device/point status information; Link configuration data, CCS configuration data, CCS operating configuration data; forms data, and the on-line log.

B. The CCS database shall contain, among other items, the following:

1. The current and immediate past state of all devices and points, including quality code indicators to indicate states.

   a.) The point status reflects a user entered value.
   
   b.) The point status was not provided in the current report from field units.
   
   c.) Special device states.
   
   d.) The point status is as a result of a CCS-initiated device control action.

2. Device and Point definitions.

   a.) Device name and device point tag name (unique to each point).
   
   b.) Point alarm priority.
   
   c.) Point alarm message distribution.
   
   d.) Control point timeout value.
   
   e.) Point "True" state value (0/1).
   
   f.) ID of logical criteria for point alarm processing.
   
   g.) Device subsystem.
   
   h.) Device physical location.

3. Point configuration definitions, including the following:

   PLC memory register address.
4. Summary display point definitions, including the set of individual points making up the summary point.

5. Alarm priority definitions, including the following:
   a.) Color.
   b.) Requiring acknowledgment Y/N.
   c.) Audible alert type.

6. Link system configuration data, including the following:
   a.) Track configuration.
   b.) Signal System configuration.
   c.) Traction Power System configuration.

7. CCS configuration data.

8. CCS operating configuration data, including the following:
   Default and current printer assignments.

9. Data entry data from forms-based displays.

10. All on-line log data.

C. Configurable/definable parameters.

D. Point alarm logical criteria shall be maintained in the CCS database. User-friendly interactive tools shall be provided to define and modify these criteria.

E. The CCS database shall include the most recent 61 days of the on-line log. CCS shall automatically, at the end of each transit day, roll off to archival storage on-line log data not within the last 61 days.

1. The CCS shall have an Archival Database, allowing for storage of and queries and report on archived data.

2. The Archival Database shall contain every on-line log entry, as well as any configuration data and point data in the CCS database needed to be able to produce complete reports and queries from the Archival Database data.

3. The Archival Database shall be separate from the CCS database, and shall be periodically updated to include the latest on-line log data, as well as previously stored data. CCS shall support data archiving and generation of reports and queries against data in the Archival Database during the ongoing operation of the CCS.
4. The definitions of elements (e.g., data elements, tables) in the Archival Database shall be identical to those in the CCS Database.

5. Query and report software, identical to that provided for the CCS database, shall be provided to operate against the Archival Database.

6. Minimum size for the Archival Database storage shall be the larger of:
   a.) 3 terabits
   b.) Large enough to store 10 years of on-line log data.

7. The ability to roll-off archival data to DVD permanent storage.

F. No single point of failure shall cause the CCS database to be unavailable. The database server and database storage configuration shall be multiple (e.g., at least two server computers accessing a RAID (Redundant Array of Independent Discs), Storage Area Network, or approved equivalent.

1. If a RAID is used:
   a.) No failure of a disc, disc controller, power supply, or computer I/O bus interface shall cause the database to become unavailable.
   b.) Discs and power supplies shall be hot swappable.
   c.) Level 1 or Level 5 RAID shall be provided.

2. The Archival Database shall reside on the same storage equipment, e.g., on the RAID, as the CCS Database.

3. The minimum requirements for system data availability shall always be maintained.

G. The database management system shall be Oracle or Engineer approved equivalent.

H. The CCS database data, as well as the Archival database data, shall be accessible during on-line CCS operation, by users at all CCS workstations for forms data entry and retrieval, SQL queries, and reports. The forms, query, and report packages shall be provided and shall be, respectively: Oracle Forms, Oracle Data Query, and Chrystal Reports, or approved equals.

I. Backup and Restore/Recover equipment and software shall be provided for both the CCS database and the Archival database.

1. Contractor shall develop and implement a strategy and schedule for incremental and full backups that conform to system availability requirements as well as procedures for database restore/recovery. All scripts and files needed to perform the backups, as well as restore and recovery, shall be developed and tested.
2. Backup media shall be DVD or CD-ROM. The capacity of the media shall be such that a single media unit can hold a complete backup copy of the Archival database. The data transfer rate of the backup equipment shall be at least 1 megabyte per second.

3. Backup of the CCS database shall be able to be performed while CCS and the CCS database continue to operate.

2.04 CONFIGURING CCS

A. CCS shall be able to be configured through entry of data into the CCS database and graphics display generator.

B. It shall be possible to configure CCS to extend the LRT line by database and graphics changes only without the addition of software code as long as the objects used in the extension are represented in the original system.

C. For data entered manually into the database.

1. Forms-based data entry displays shall be provided to enter and modify configuration data. Entry system shall be graphical windowing based with pull-down menus to minimize user typing.

2. Checks for the following shall be applied.

   a.) Data type checking, including for in-range, and in-enumerated data type list.

   b.) Logical consistency between data entered and data already in the database.

D. A graphical display generator shall be provided to define and update the layout, display attributes, colors, and contents of the Overview Display and the console graphics-based displays.

1. It shall not be necessary to modify CCS software source code to define or modify layout, display attributes, colors or contents of graphics-based displays.

2. Display layout and display symbol/icon selection shall operate by editing a WYSIWYG image of the target display.

3. Display layout images shall be able to be imported for subsequent editing and for further definition using the graphical display generator.

E. Assignment of individual points to each display symbol/icon shall be defined and updated in a manner which integrates graphics-based display definition and point alarm “criteria”.

F. Configuration data shall not be required to be entered in more than one place (i.e., either through a data entry tool used to enter data into the CCS database, or through the graphical display generator); configuration data shall not be required to be entered more than once.
2.05 CCS COMPUTER EQUIPMENT AND PRINTERS

A. CCS computer equipment.

1. All CCS computers (e.g., for workstations, Overview Display controllers, and servers) shall be commercially available from a single manufacturer. Contractor shall standardize upon classes of computers utilized in the CCS.

   a.) Computers.

      1.) The manufacturer shall be one of the top five in domestic sales of computer equipment.

      2.) The processor shall be from the latest line (e.g. Pentium IV or higher) of processors, and its performance shall be in the top fifteen percent of processors in that line.

      3.) Processors should support dual load sharing or cluster configuration.

      4.) Processors shall be hot-swappable.

   b.) Computer equipment for each workstation.

      1.) Shall be equipped to limit the emanated noise from fans to no more than 40 dBA at 900 mm (3 ft.) from the equipment.

      2.) Shall be capable of handling the full workload, and shall be capable of performing all workstation functions.

   c.) Each CCS computer shall have a minimum of 512 MB of main memory. Memory shall be field expandable to an ultimate memory capacity of at least twice that provided initially.

   d.) Each computer shall include a hard drive (with minimum 40 GB capacity) and CD-ROM read/write drive with a minimum of 6x write and 50x read.

   e.) Each console computer shall include four 19" diagonal LCD monitors, a keyboard and a pointing device.

   f.) Overview Display controller computers may use a shared monitor and keyboard that is on-line switchable between computers.

   g.) Server computers shall each have a 19" LCD monitor, a keyboard and a pointing device.

   h.) Overview Display Computer(s) may be configured with a single switchable monitor, keyboard and pointing device. Monitor will be 17" diagonal LCD.
2. Printers.

a.) One desktop laser color printer shall be provided.

1.) The printer shall be the latest product offered by Hewlett Packard, or approved equal, with the following minimum characteristics:

- 47 x 47 dot per mm (1200 x 1200 dot per inch) print quality.
- 17 pages per minute at high quality output.
- 250-page paper tray capacity.
- 32 MB of RAM memory.
- Prints on letter, legal, or tabloid size paper from individual paper trays.
- Paper empty and paper jam detection and reporting.
- SNMP agent compatible with the Network Manager system, which shall include printer MIB in accordance with TETF RFC 1586.

b.) Two desktop laser black and white printers shall be provided.

1.) The printers shall be the latest product offered by Hewlett Packard, or approved equal, with the following minimum characteristics:

- 47 x 47 dot per mm (1200 x 1200 dot per inch) print quality.
- 17 pages per minute at high quality output.
- 250-page paper tray capacity.
- 32 MB of RAM memory.
- Prints on letter, legal, or tabloid size paper from individual paper trays.
- Paper empty and paper jam detection and reporting.
- SNMP agent compatible with the Network Manager system, which shall include printer MIB in accordance with TETF RFC 1586.

2.06 CCS SOFTWARE

A. Contractor shall supply all required software.

B. Software shall be free of defects.
C. All software developed or modified under this Contract shall be written in an object oriented language. The language compiler shall conform to the latest specifications of the American National Standards Institute (ANSI).

D. Interfaces to and between various manufacturer’s software package shall be provided through industry standard APIs.

E. Software licenses shall be provided for all software. The types of licenses provided:

1. Shall allow Sound Transit or its designated operator to operate the CCS.

2. Shall allow Sound Transit and its designated operator, as well as a third party contracted by Sound Transit or its designated operator, to modify, update, and extend the software (except the "System Software").

3. Shall allow Sound Transit or its designated operator to operate with that modified, updated, and/or extended CCS software.

4. Shall allow Sound Transit or its designated operator to add Link elements (such as track and interlockings), to configure CCS to support those additions, and to operate with that newly configured CCS.

F. At a minimum, "System Software" to be provided shall include:

1. Basic System Software.
   a.) Operating system / Network operating system.
   b.) Graphical User Interface.
   c.) LAN Management System.
   d.) Database Management System.
   e.) Forms Package, Report Package, and Query Package.

2. System Software Utilities.
   a.) Software generation tools.
   b.) Software configuration management package.
   c.) Software performance monitoring and reporting tools (that portion not specific to the application).
   d.) Equipment diagnostic software.
G. All "Basic System Software" shall include the following:

1. Be commercially prevalent or open software.

2. Have training available from one or more manufacturer-approved training groups/companies in the Seattle area.

3. Have technical support available for purchase from the software manufacturer and/or distributors.

H. All CCS computers shall use the same operating system. Operating system software shall be Microsoft NT, UNIX, or LINUX or the currently available upgrade of those systems with at least one year of operating experience in similar applications. All system software, application software and middle-ware shall be native to the operating system environment. Emulators, or equivalent software used to provide a software platform for non-native software, shall not be utilized.

I. Software tools shall be provided to edit, debug, generate and reproduce executable code from the source code provided by the Vendor. Examples of such tools to be provided include editors, compilers, linkers, debuggers and object libraries. Batch files shall be included.

J. A comprehensive software development and configuration management package, such as the suite of software produced by The Rational Corporation, shall be provided and configured for the CCS software. (See Section 17860, Software Engineering Requirements).

1. Configuration management package shall include the following:

   a.) Software Version Description Document, software and firmware listings, and software and firmware source code (uncompiled with comments as well as compiled), for applications software and firmware provided under this Contract.

   b.) All "make" or equivalent files for editing, compiling, linking, and installing application software; all files required to define, allocate, and load the CCS database.

   c.) All other files required to maintain and update the CCS software; all other files required to move the CCS software to newer, more powerful, hardware models. Corresponding instructions shall be provided. All software shall be provided on CD-ROM with a minimum of 3 copies.

2. Software Development package shall include tools for the following:

   a.) Requirements definition (Use Cases).

   b.) Requirements Traceability throughout all stages of software generation and test.

   c.) Configuration Management.

   d.) Software Deployment.

   e.) Test Generation.
3. Tools shall be provided to the following:
   a.) Monitor and report utilization of processors, discs, and local area network equipment.
   b.) Monitor and report processor and disc subsystem I/O counts.
   c.) Monitor and report workload of server processes; monitor and report server process request (incoming message) queues.
   d.) Monitor and report the number of indications into the system in a period of time.

K. Diagnostic and/or test programs shall be provided for all CCS equipment.

2.07 TIME OF DAY

A. System time shall be acquired from the Master Clock System, Section 17740, Master Clock System. Time shall be automatically adjusted for Day Light Savings and Leap Year.

B. The system shall distribute time to all connected devices including CCTV, PA, radio, and FCS within an accuracy of 10 msec.

2.08 SYSTEM MANAGEMENT AND MODIFICATION

A. A CCS Maintenance Workstation shall be provided for all system management functions.

B. CCS shall include tools to do the following:
   1. Perform functions normally provided to users.
   2. Update configuration data in the CCS database.
   3. Audit the Configuration.
   4. Query and report on database data.
   5. Utilize the graphical display generator to create/update graphics-based displays.
   6. Off-load and reload archive data.
   7. Perform orderly system startup and shutdown.
   9. Define, maintain, monitor the status of, and administer the LAN configuration.
   10. View equipment and software error messages.
   11. Troubleshoot CCS equipment.
   12. Initiate, and receive reports of, hardware diagnostics.
13. Logically remove failed CCS central equipment and (re)introduce replacement
equipment.

14. Introduce new CCS equipment such as console equipment into CCS.

15. Perform CCS equipment and software process configuration definition, management,
troubleshooting and testing.

16. Perform software maintenance and modification.

2.09 CCS CONTROL CONSOLE EQUIPMENT

A. Each Control Console shall be equipped with the following CCS equipment:

1. CCS console computer.

2. Mouse and or trackball cursor control device.


4. Audible alarm.

5. Alarm printer (shared by all consoles).

6. Four 19” color display LCD flat-panel monitors.

B. Color-graphics monitors.

1. Each monitor/color graphics card combination shall operate at a resolution of 1280 x
1024 minimum. Sampling rate of 13.5 MHz to 140 MHz Hz or higher, 1.08 mm or
smaller dot pitch, and with ability to display at least 64,000 simultaneous colors. Video
controllers to drive the monitors shall support that resolution, refresh rate, and color
range.

2. Each monitor shall have a nominal diagonal viewing size of no less than 19 inches.

3. Monitors shall be designed for 24-hour a day continuous operation.

4. Each monitor shall be mounted on console furniture in a manner consistent with the
console design.

C. Keyboards.

1. Each keyboard shall be a 104-key (minimum) QWERTY low profile unit mounted on the
control console and equipped as a minimum with the following:

a.) Cursor arrow keys (4).

b.) Repeat of write characters and cursor control.

c.) Cursor Tab function.
d.) One-character Backspace-Erase function.

e.) Insert and delete functions.

f.) Standard typewriter alphanumeric and punctuation characters.

g.) 10-key numeric keypad.

h.) 12 function keys.

2. All characters, symbols, and edit and control functions shall be clearly indicated by engraved letters on the associated keycaps.

3. Each keyboard shall be sealed to prevent liquids from damaging keyboard electronics.

D. Audible Alarm.

Each Control Console shall include an audible alarm provided through the use of a 32-bit wavetable sound card and minimum 40 W speakers. The alarm shall have a volume control to allow adjustment to a minimum level of approximately 50 dBA. Changes to alarm level shall only affect the console where the adjustment was made. This alarm shall be capable of two distinctly different tones controlled by software. These tones shall be a timed output and a continuous output. The selection of alarm tone shall be determined by the alarm priority level definition.

E. Mouse and/or Trackball Cursor Control.

1. A single multi-button mouse and/or trackball shall be provided on each console. Device type shall be agreed upon by Engineer. The mouse and/or trackball shall support selections at both of the CCS monitors. The mouse and/or trackball shall be located on the console surface. The top surface of the mouse and/or trackball shall be shaped and positioned to minimize wrist strain. The mouse and/or trackball shall be capable of the following:

   a.) Utilize an optical or opto-mechanical operating mechanism.

   b.) Have a trackball diameter of at least 57 mm (2.25 in.), if trackball is supplied.

   c.) Have a resolution of at least 8 dots per millimeter (200 dots per inch).

   d.) Have dynamic acceleration and user adjustable speed and sensitivity.

2. Mouse and/or trackball devices shall include conveniently placed "select" key to request computer action determined by the cursor position.

3. Each mouse and/or trackball shall be moveable around the console and shall be provided with sufficient cable to allow placement at any convenient position in front of or besides each monitor.
2.10 DATA COMMUNICATIONS

A. CCS shall support the field devices listed in Appendix C, Monitored Equipment List.

B. Data Communications Malfunctions.

1. CCS shall detect the inability to communicate with a field device within 10 seconds of the failure that caused that inability. Upon detection:

   a.) An alarm condition shall exist and shall be reported.

   b.) CCS shall periodically try to reestablish communications with the field device. The interval between tries shall be configurable, and will be between 10 seconds and two minutes.

C. Reestablishing communications.

Upon reestablishing communications with a field device, CCS shall acquire the current status of all devices which report through that equipment.

2.11 OVERVIEW DISPLAY AND CONTROLLERS

A. Information on the Overview Display shall be clearly readable from all consoles positions. Display contents shall be bright, sharp and crisp.

B. The Overview Display shall initially consist of three LCD, DLP, or LED display screens each approximately 60" wide by 45" tall. The initial displays shall be mounted linearly. It shall be possible to expand the display array to 5 x 2.

C. The Overview Display equipment shall provide for ease of operation, maintainability, and low cost of operation. For example:

   1. For more common operations such as display alignments and adjustment (e.g. convergence, color) controls shall be easily accessible and alignment operations are preferred to be automatic.

   2. If required, service access shall be simple from the rear.

   3. Service intervals shall be infrequent compared to that for other types and models of Overview Display equipment.

   4. Service procedures shall be simple, and time to repair shall be short.

D. Multiple display monitors shall be combined to makeup the Overview Display.

   The border (non-displayable area) between the displayable area of two adjacent units shall not exceed 5 mm.

E. Minimum requirements include the following:

   1. Resolution: 1024 x 768.
2. Brightness: 600 lumens.


F. Contractor shall provide Overview Display controller computer equipment. The controller computer equipment:

1. Shall be identical in model number to the computers supplied elsewhere.

2. Shall include the minimum number of computers necessary to drive all monitors of the Overview Display.

3. Shall allow for increases in memory, upgrades to new video controller boards, and expansion in the size of the Overview Display.

4. Shall update the display within 0.1 seconds of the same information displayed on the Operator console displays.

2.12 CCS WORKLOAD AND RESPONSE TIME REQUIREMENTS

A. CCS shall support the following combined workload. For the purposes of performance analyses, Contractor may assume that the probability of the workload will be exceeded is no more than 5 percent.

B. When operating under sustained peak 1-minute workloads (sustained for up to 15 minutes), the following response times shall be met:

1. The display response for newly requested graphic displays at a console shall be no more than 1.5 seconds, including dynamic data, as measured from the time between the user request and the last pixel is written on the display.

2. The CCS shall provide a visual cue acknowledging each request or command at a console within 300 ms of entry of that request or command.

3. The time from a user query entered at a console until the result is displayed on the screen shall not exceed the following:

   a.) 6 seconds for simple queries (e.g., multiple data fields from a single table, using two selection criteria).

   b.) 12 seconds for medium queries (e.g., not more than three database fields from each of two tables, using two selection criteria).

   c.) 20 seconds for complex queries (e.g., more complex than the criteria for medium queries stated above).
C. When operating under sustained peak 1-minute workloads (sustained for up to 15 minutes):
   1. No CCS processor (i.e., database server processor, console processor, terminal server, etc.) shall experience a utilization greater than 60 percent.
   2. Neither the CCS database disc controller nor the CCS database disc array shall experience a utilization greater than 50 percent.

D. In cases where the peak 1-minute workload defined above is exceeded by up to 100 percent:
   1. The CCS shall continue to meet all functional requirements.
   2. Response times may be as much as 200 percent of those stated above.

E. All data storage capacities shall be able to support data quantities based on, as a minimum, the peak 1-minute workload sustained for 24 hours per day.

2.13 I/O INTEGRITY OF OPERATION

A. CCS shall not fail to report and log indications and alarms received from field equipment.

B. CCS shall not fail to issue any device control commanded by the user where receipt from the user of that command has been acknowledged to the user.

C. CCS shall not issue any unintended device control action.

2.14 STARTUP TIMES

A. The time to bring up the system from a cold start until the system is "fully available" (i.e., all functions, all displays, all database data, and all interfaces to FCS and PLC equipment are fully operational and available; all capacity, workload and response time requirements are met; all I/O integrity of operation requirements are met) shall not be more than 5 minutes.

B. The time to bring up any server (hardware and software), control console (hardware and software), or software process shall not take more than 5 minutes.

C. The time for a console to assume the workload of a user at another control console shall not take more than fifteen seconds.

2.15 EQUIPMENT RELIABILITY

A. All hard discs shall have a Mean-Time-Between-Failures (MTBF) of at least 200,000 hours.

B. All console color-graphics monitors shall have an MTBF of at least 20,000 hours.

C. All computer power supplies shall have an MTBF of at least 150,000 hours.

D. All printers shall have an MTBF of at least 10,000 hours.

E. Equipment to backup/restore the CCS database and off-load the disc-based log shall have an MTBF of at least 100,000 hours.
F. The Overview display shall have an MTBF > 50,000 hours.

PART 3 - EXECUTION

3.01 PREPARATION

A. Transmit submittals and deliverables required by this Section.

B. Furnish products as indicated.

3.02 FACTORY TESTING

A. A 72-hour burn-in shall be performed for all equipment.

B. Factory Acceptance Test.

1. The complete CCS system shall be tested at the Contractor's facility. The test configuration shall consist of all consoles, displays, and at least two instances of all devices to which CCS communicates. This includes VMS signs, PA, FCS equipment, EMPs, etc.

   a.) Diagnostic testing, utilizing standard manufacturer supplied tests, shall be performed for all equipment and all communications ports.

   b.) Functional testing shall be performed for all equipment.

   c.) Validation of equipment settings shall be performed for all equipment.

   d.) The equipment shall be connected and function as a system, running CCS software.

C. CCS LAN Equipment Tests.

1. Contractor shall perform all manufacturers recommended equipment and cable testing utilizing test cables fabricated for the tests. All available equipment built-in unit and communications paired tests shall be performed. All equipment configuration, management and diagnostic functions shall be exercised and demonstrated as operational. Diagnostic hardware testing shall be performed for all equipment upon installation.

2. Operating system software and LAN software testing shall be performed for all computer equipment.

3. Configuration settings for all equipment shall be verified after power-on.

3.03 INSTALLATION.

Contractor shall install all CCS equipment as per approved installation drawings.
3.04 CCS EQUIPMENT TESTS.

A. Contractor shall perform on-site testing which shall include the following:

1. All manufacturers recommended equipment and cable tests shall be performed. All available equipment built-in unit and communications paired tests shall be performed. All equipment configuration, management and diagnostic functions shall be exercised and demonstrated as operational. Diagnostic hardware testing shall be performed for all equipment upon installation.

2. Operating system software testing shall be performed for all computer equipment.

3. Configuration settings for all equipment shall be verified after power-on.

4. Comprehensive interface testing shall be performed for all external interfaces to field devices.

5. A sub-set of the Factory Acceptance Test shall be performed to verify that there has been no degradation of operation or function.

6. All software shall be verified to be the latest approved release.

7. The serial numbers on all hardware shall be verified.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17841
SECTION 17842
EMERGENCY MANAGEMENT PANEL

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section describes the features and functions of the Emergency Management Panels (EMP) at all stations.

1.02 RELATED SECTIONS

A. Section 17020 – Cutover of Existing Systems.

B. Section 17360 – Emergency Phone System.

C. Section 17710 – Public Address.

D. Section 17840 – Central Control System.


1.03 REFERENCE STANDARDS

The following standards shall apply:


I. The Contractor's software quality assurance program consistent with the intent and scope defined in ANSI/IEEE Std 730 and ANSI/IEEE Std 1012 respectively, shall apply to all EMP software and firmware developed or modified under this Contract and all EMP software and firmware which is not a copyrighted commercially available off-the-shelf product.

1. The design of the EMP shall meet all requirements of the Communications Design and Fire/Life Safety Criteria.
1.04 QUALITY CONTROL

Contractor shall submit a Quality Control Program.

1.05 SUBMITTALS

A. The Contractor shall submit design information for the EMP reviews.
   1. Preliminary Design Review information shall be provided at NTP + 90.
   2. Final Design Review information shall be provided at NTP + 270.

B. Factory test procedures shall be provided 90 days prior to Final Design Review.

C. Factory test records shall be provided within 30 days after the factory acceptance test.

D. Installation and test procedures shall be submitted for approval 30 days prior to any EMP installation. Installation and test records shall be provided upon request.

E. Full documentation and tools shall be provided to allow SoundTransit technical staff to update, debug, and test EMP software/firmware as needed.

F. A manual for operation and maintenance of the EMP and a manual for operation and maintenance of the EMP shall be provided, each in hardcopy and machine-readable formats.

G. The Contractor shall provide the following:
   1. Quick reference operating sheet, in hardcopy and PC compatible text/graphic formats, able to be printed on no more than two 8½-inch by 11-inch sheets of paper, and making use of graphic presentation to the extent practical.
   2. Troubleshooting instruction sheet, in hardcopy and PC compatible text/graphic formats, able to be printed on no more than two 8½-inch by 11-inch sheets of paper, and making use of graphic presentation such as flow charts to the extent practical.

1.06 DELIVERABLES

Contractor shall deliver a fully functioning EMP for all required locations.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. EMPs will be a complete new design, employing computer technology, replacing the current panels in toto.

B. The primary HMI of the EMP shall be implemented by a screen, keyboard, and trackball.

C. One Emergency Management Panel (EMP) will be installed at each tunnel station.

D. The EMPs for the DSTT will be identical in construction and function.
E. The EMP at Beacon Hill shall have the capability to supervise elevators.

F. The EMP at Beacon Hill shall have the capability to display a CCTV from any camera in the station.

G. The EMPs shall be connected to an un-interruptible power source and shall normally be powered on.

H. The EMP shall be designed such that the following four functional areas operate independently with no common failure modes (excluding power):
   1. ETEL.
   2. PABX phone.
   3. PA/VMS functions.
   4. Monitoring and Control of Emergency Ventilation, the Overhead Catenary System, of elevators and escalators (Beacon Hill Only), Fire Control and Suppression System, and display of CCTV images (Beacon Hill Only).

I. The EMPs shall not perform any unintended device control actions in normal operations, upon power on, or upon loss of power.

J. The EMPs shall perform self-tests, and, if a malfunction is detected, shall indicate so at the EMP and to the CCS. Self-tests shall include memory checks, timer checks, system bus check, and I/O interface checks for interfaces to the panel face and to the I/O signal cable(s).

K. Provision shall be made in the EMP enclosure for a lock box keyed to fire department keys. This box shall be for the storage of all keys necessary to allow emergency access to all areas of the station.

2.02 TUNNEL EMERGENCY VENTILATION

A. Since control of all stations in the DSTT is required for Emergency Ventilation of the DSTT, the first EMP in local mode shall be in control of all stations.

B. Displays for the control of Emergency Ventilation shall be identical to those in CCS.

C. There are predefined tunnel ventilation system modes and emergency ventilation modes. Each emergency ventilation mode corresponds to a fire location, and a direction of passenger evacuation in that zone. The objective of each emergency ventilation mode is to supply fresh air into the face of passenger evacuation path and exhaust dirty and/or hot air away from and behind evacuating passengers. For each mode, a complete set of required settings of ventilation system fan and damper equipment is defined. The EMP shall determine and display the currently executing ventilation mode.

D. All commands issued by the EMP while in control shall be echoed to CCS and logged.

E. Device controls to implement each of the modes shall be made available to the EMP. The EMP shall provide for operator selection of any of the emergency ventilation modes and shall issue the set of device controls defined for that mode.
F. Ventilation equipment local control panels, to monitor and control ventilation equipment, will exist at each of the fan control rooms. Additionally the CCS can, through the FCS equipment, monitor ventilation equipment status and issue controls to that equipment.

1. The ventilation equipment coordinates control actions from the local control panels, the EMP, and CCS as follows:

   a.) When a local control panel is active, the ventilation equipment will not act on any control signal sent by the EMP or the CCS.

   b.) When the EMP is active, the ventilation equipment will not act on any control signal sent by the CCS nor to any other EMP in the DSTT.

2. When any local control panel is active, the EMP shall indicate such to the operator and shall prevent panel operators from issuing commands to control ventilation system equipment.

3. The EMP shall illuminate the "Ventilation Control at the OCC" indicator on the EMP monitor while:

   a.) The EMP is receiving a "CCS Alive and Able to Control Ventilation" indication from CCS.

   b.) No local control panel is active.

   c.) The EMP is not in control mode.

G. The EMP shall support the following modes for emergency ventilation:

1. The Monitor mode is the default mode.

2. The Control mode is entered by operator selection. The EMP shall not enter the Control mode if a malfunction was detected during self-tests, or if a ventilation equipment local control panel is active.

H. When in the Monitor or Control modes, the EMP shall show:

1. Tunnel layout, with ventilation zone boundaries.

2. Track circuit occupancies.

3. Bus locations in the DSTT only.


5. Off, on-supply, or on-exhaust status on each tunnel ventilation fan.

I. Ventilation equipment malfunction status.

J. The EMP shall monitor and display the ventilation equipment indications and alarms.
K. The EMP shall display if a ventilation equipment local control panel is active.

L. Upon entry into the Control mode, the EMP shall indicate on the EMP monitor that it is in control.
   1. Once the emergency ventilation mode request is initiated:
   2. The selected mode shall be displayed.
   3. The EMP shall send the corresponding control signals to the ventilation equipment.
   4. The Stop button, which when depressed shall command the ventilation system to the Off mode, shall be illuminated.

M. A new ventilation mode shall be able to be initiated by the operator only after the Stop button is depressed or after key switch is moved from and then back into the Control position.
   1. In addition to direct malfunction conditions, the EMP shall monitor for and report a malfunction in the following ventilation equipment conditions:
   2. Inconsistent states such as tunnel ventilation fan in exhaust or supply when the corresponding fan damper is closed.

N. The ventilation equipment has not provided an indication corresponding to a device control initiated by the panel.

O. The EMP shall incorporate the necessary logic for determination of current ventilation mode, and determination of malfunctions.

P. When in Control mode, the EMP shall provide an indication to CCS that the EMP is active and provide an indication to each ventilation equipment fan control room that the EMP is active.

2.03 CATENARY MONITORING AND CONTROL

A. The EMP allows the operator to view the state of each Catenary Line Section and the dc circuit breakers within the station area of the tunnel, and to command the Traction Electrification System (TES) to open or close the breakers for those Catenary Line Sections.

B. The EMP shall support the following modes for catenary control:
   1. The Monitor mode is the default mode.
   2. The Control mode is entered by operator selection. The EMP shall not enter the Control mode if a malfunction was detected during self-tests, or if a TES local control panel is active.

C. When in the Monitor and Control modes, the EMP shall show the open/closed state of the DC breakers within the associated are in the tunnel.
D. When in Control mode, the EMP shall provide an indication to CCS that the EMP is active. The EMP shall allow an operator to command the DC breakers for any line section to become opened/closed.

2.04 TELEPHONES

A. Each EMP shall be equipped with one emergency telephone (ETEL) and one PABX phone with dial-up capabilities.

B. The EMP shall be capable of displaying the station area ETEL off-hook conditions.

C. Each EMP shall be capable of connecting the EMP ETEL to the ETELS at the next adjacent station EMPs.

2.05 FIRE DETECTION AND SUPPRESSION

The EMP shall, utilizing identical displays to those provided in CCS, allow the monitoring and control of the fire detection and fire suppression system.

2.06 PA/VMS

A. The EMP shall allow an operator to select up to ten pre-defined PA/VMS messages for transmission to all PA/VMS zones at the associated station.

B. It shall be possible for an operator to make ad hoc PA announcements.

C. When the EMP is active in PA/VMS operations, the PA/VMS operations from OCC shall be disabled.

2.07 TIME

A. The EMP shall automatically obtain the time of day.

B. The time shall be accurate to plus or minus one second compared to National Bureau of Standards time.

2.08 EMP PERFORMANCE REQUIREMENTS

A. The probability of a single failure of the EMP causing the panel active indication to become or remain true shall be less than one in $10^6$.

B. The probability of a single failure of the EMP causing an unintended or otherwise incorrect control signal to be sent to a field device shall be less than one in $10^6$.

C. The time from when the EMP "Monitor" switch/button is set/pushed until all required indications are shown on the panel shall not exceed two seconds.

D. The time from when the EMP key switch is placed in the "Control" position until all required indications are shown on the panel, the corresponding panel "active" indication signal is available, and the panel is ready for the operator to make appropriate selections shall not exceed two seconds.
E. The time from when an EMP switch/button is set/pushed until the corresponding control signals are initiated shall not exceed two seconds.

PART 3 - EXECUTION

3.01 EMP DEVELOPMENT REQUIREMENTS

A. The displays at the EMP shall be identical to the same displays at the OCC.

B. To the greatest extent possible, software identical to that provided for CCS shall be utilized in the EMP.

C. The Contractor shall participate in:
   1. Coordination meetings with the tunnel contractor/designer to help ensure correct design and implementation.
   2. Coordination meetings with the tunnel contractor/designer to help plan and coordinate field testing.
   3. Interactive design reviews for the EMP form, function, usability and maintainability.

D. The Contractor shall conduct a series of design reviews for the EMP. Design review materials shall include:
   1. Detailed functional description with operating procedures.
   2. Display layouts.
   3. Description of the EMP construction.
   4. Panel block diagram and interface definition, defining all external interfaces.
   5. Sample of the panel face materials and other panel elements.
   7. Software verification and validation records - Documented results of the verification and validation activities equivalent to those in Task 301 of MIL-STD-882.
   8. Assembly drawings, installation drawings, and parts list.
   10. Installation and test procedures.

3.02 FACTORY TESTING

Factory testing of the EMP shall be conducted at the same time and in coordination with the Factory Acceptance Test of the CCS.
3.03 INSTALLATION

Contractor shall be responsible for construction of the EMP compatible with the size and location of the current EMP panels in the DSTT and in accordance with drawing L00-F200.

3.04 FIELD TESTING

Field testing of the EMP shall be conducted at the same time and in coordination with Field Testing of the CCS.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17842
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section describes the features, functions and equipment which provide backup control for the Link project.

1.02 RELATED SECTIONS

A. Section 17800 – Control System Overview.
B. Section 17840 – Central Control System.
D. Section 17860 – Software Engineering Requirements.
E. Appendix A – Glossary.
F. Appendix B – Communications Equipment List.
G. Appendix C – Monitored Equipment List.
H. Appendix D – DSTT I/O List.
I. Appendix F – Control System Functions (Use Cases).

1.03 REFERENCE STANDARDS

This software shall abide by all standards cited in the related Section(s).

1.04 QUALITY CONTROL

Quality control for this software shall be identical to that for all other software supplied under this Specification.

1.05 SUBMITTALS

Contractor shall supply all submittals required in the related Sections of these Specifications. The backup software may be included in other submittals or documented separately.

1.06 DELIVERABLES

A. Media.

Contractor shall supply all backup software on machine readable media, preferably CD-ROM.
B. Documentation.

Contractor shall supply a User's Manual; for the backup software.

C. Hardware.

Contractor shall supply two laptop computers with all devices necessary to run the backup software and perform the specified functions.

PART 2 - PRODUCTS

2.01 GENERAL

A. Backup control of the Central Control System shall be possible from any location having a network connection. This includes all stations and control locations such as the control center for the DSTT.

B. Laptop computers shall be provided containing the requisite software to communicate on the network and to provide all functions available to users at the OCC. In the event of failure of the central servers or of the communications link to them, higher level functions will not be available.

1. Levels of Backup Control.

a.) Fully functioning but unmanned OCC.

A user may log on to the CCS at any port on the network and be provided with all the capabilities that the logged-on user would be provided at a Control Console in the central control room including all displays.

2. Non-functioning OCC.

a.) A user may log on to the network at any port on the network. The user will be able to monitor and control all devices which would normally be available for monitor and control from a Control Console in the OCC, viewing the device status on displays identical to those provided at the OCC.

1.) Allowable Unavailable Functions.

- Train Tracking.
- Logs.
- Consist Verification.
- Database Maintenance.
- Manage Controller Profile.
- Uncommanded change of state detection (other than FCS monitored devices).
- Display of CCTV images.
- Functional and Geographic Partitioning.
- Playback of logged data.
- Interface to other computer systems.
- Supervisory Control of radio.
- Any other function requiring a global knowledge of the system or historical database access.

2.02 BACKUP CONTROL SOFTWARE

A. Functioning CCS.

The software running on the Control Consoles shall be provided in a form and format loadable into a laptop computer. The laptop computer shall run the same operating system as the Control Consoles.

B. Non-functioning CCS.

Such additional software as is required shall be provided to allow the laptop computer to request status and issue controls for all devices via the FCS.

C. Security.

Security shall be provided through the normal access control on the areas in which backup control may be established and the logon process.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall specify the parameters of the laptop computer required to support this software.

3.02 PREPARATION

Software shall be designed and developed to the same standards and requirements as all other software supplied under these Specifications.

3.03 FACTORY TESTING

The backup software shall be tested as part of Factory Acceptance Tests.

3.04 DELIVERY, STORAGE AND HANDLING

Software shall be supplied on machine readable media, preferably CD-ROM.
3.05 INSTALLATION

Contractor shall demonstrate, as part of system testing, that the backup software can be loaded and execute on a laptop computer.

3.06 FIELD TESTING

The backup software shall be tested as part of Field Acceptance Tests.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17843
SECTION 17844
TRAINING SIMULATOR

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section includes the requirements and operating interface for the training simulator for CCS.

1.02 RELATED SECTIONS

A. Section 17840 – Central Control System.
B. Section 17841 – CCS Software and Equipment.
C. Section 17860 – Software Engineering Requirements.
D. Appendix F – Control System Functions (Use Cases).

1.03 SUBMITTALS

A. CDR.

1. Contractor shall submit the following information no later than NTP+30 days:
   a.) System block diagram of the Simulator System.

B. PDR.

1. The Contractor shall submit the following minimum information no later than NTP+90 days:
   a.) Final Software Requirement Document for the Simulator System (SRS).

C. FDR.

1. Contractor shall submit the following minimum information no later than NTP+270 days:

   Final Software Design Document (SDD).

D. Factory (FAT) Test Procedures.

1. Sixty days prior to the conduct of Factory Acceptance Tests, the Contractor shall supply a FAT Test Plan.
2. 30 Days prior to the conduct of Factory Acceptance Tests, the Contractor shall supply Test Procedures.

E. Final User Documents.

1. 30 days prior to Final Acceptance Testing, Contractor shall submit final versions of the following:

   a.) User Manuals.

   b.) Maintenance Manuals.

   c.) Training Plan.

   d.) Training Manuals.

F. Training.

After Factory Test and before Final Acceptance Testing, Contractor shall train up to 20 persons on the use of the Simulator System per the approved Plan and Manual.

G. Final Acceptance (Site) Test Procedure.

Thirty (30) days prior to the Final Acceptance Test, Contractor shall submit the final test procedure for the test.

H. Test Results and As-Built Documentation.

Within 30 days of the successful conclusion of the Final Acceptance Tests, the Contractor shall supply versions of all Simulator System documentation which has been updated to reflect any changes that may have been made in the course of testing or since the last version of each document was issued.

1.04 DELIVERABLES

See Submittals.

PART 2 - PRODUCTS

2.01 GENERAL

A. CCS shall include a Simulator to facilitate training of Controllers in the operation of the CCS. The Simulator shall simulate behavior of the LRT System. That simulated behavior shall be consistent with actual operation of wayside system, trains, and operating procedures.

It shall not be necessary to utilize a script file for the simulation of the system; the simulation shall operate autonomically. It shall be capable of utilizing a script file to simulate special conditions. In this case, the script file shall be triggered either by specific events or by time.
B. Minimum Simulator Requirements.

1. Traction Power System.
   a.) Commands sent to a traction power device will automatically result in the device changing state to that commanded.
   b.) Breakers switches opening and closing will result in appropriate changes to the powered/unpowered status of the Overhead Catenary System.

2. Signal System.
   a.) Selection of an entrance will result in the display of available exits; selection of an available exit will result in the route aligning and locking automatically.
   b.) Selection of a cleared signal (not red) will result in the option to cancel the signal; issuance of the command will automatically put the signal to stop.
   c.) Selection of a track switch will result in the option to move the switch; issuance of the command will automatically move the switch to the commanded position.

3. Trains.
   a.) Trains will move in the signalled direction, obeying signals, and moving in approximation of the times and speeds achievable in reality.
   b.) With interlockings in automatic, trains will request routes via TWC; interlockings will automatically align and lock route.
   c.) With interlockings in Central control, train will obey signals and follow routes established.
   d.) Trains will automatically reverse direction at the ends of line.
   e.) Trains in a pocket track will automatically change direction, if required, as a function of signal cleared out of the pocket track.

4. DSTT.
   As a priced option, the coordinated movement of buses and trains in the DSTT shall be simulated.(See Use Case J-01-00)

5. Ventilation.
   Since the simulation of tunnel ventilation scenarios requires the presence of a PLC containing the device states for each scenario, emergency ventilation scenarios will not be simulated.

a.) Simulator operator will be able to inhibit the response of any device to a command.

b.) Simulator operator will be able to change the status of any device or input.

c.) Simulator operator will be able to start a simulation from a pre-set condition either from a script or historical recording.

d.) Commands sent to any controlled device will automatically change the state of that device to the state commanded.

C. Simulated behavior shall also be consistent with Trainer-injected external events and with Trainee device control commands which are issued via CCS operating in a simulation environment.

D. The Simulator shall be able operate concurrently with CCS supervision of on-going LRT operations, and shall have minimum impact on performance of the on-line system. Simulator data, and data associated with Trainer actions and Trainee actions, shall be separate from CCS on-line data and the CCS database, and shall not contaminate or otherwise distort the status of the actual LRT system as perceived by Train Controllers or other on-line users supervising actual on-going operations. The Simulator shall use its own copy of the CCS database, structured and with data element types identical to the CCS database.

E. In general, Simulator monitoring and control, supervision, and display functions and logic applied in the simulator environment shall be identical to CCS when those functions and logic apply in the on-line supervision environment. Displays and display behavior, as seen by the Trainee, shall be identical to displays and display behavior as seen by on-line users except that they shall be clearly identified as simulated. Other CCS on-line functions, such as support for entry of operating data and on-line logging of events, shall be performed in the simulated environment.

F. The Simulator shall not initiate any data communications to external LRT systems or equipment.

G. Each Trainee’s geographic territory and functional scope shall be determined by the user profile corresponding to the log-on ID just as for any on-line user. At the Trainee’s console, displays and commands shall appear the same as for user displays and commands in the on-line supervision environment. All CCS functions/displays shall be available to the Trainee.

H. The Trainer shall be able to:

1. Define a simulated set of starting conditions, including:

   a.) Schedule in effect, run assignments in effect.

   b.) Current date (and day of the week) and time (in the simulated environment).

   c.) Abnormal conditions such as:
1.) Train locations (differing from scheduled).

2.) Track Closed.

3.) Breaker Open.

4.) Alarm conditions.

5.) LRV on storage track.

6.) TWC out of operation.

7.) Non-reporting devices.

8.) Falsely reporting devices.

2. Develop scripts of external events. Events shall be automatically initiated by the simulator at a specific time, and upon occurrence of another simulated event (e.g. when a train arrives in a station). External events shall include abnormal events and alarm conditions such as having a train dwell at a station for an additional "n" seconds, delaying a train from pulling out of the yard, slowing a train down (i.e. causing a train to operate at a fraction of normal speed), causing a train to run a red signal, loss of Signal Power, feeder breaker tripped, causing a field device to fail to respond to a user device control command, etc. The events shall be able to be applied to any LRT system device.

3. Select an initial set of conditions, choosing from either:

   a.) The set of previously saved simulations.

   b.) The set of previously saved initial conditions.

4. Initiate simulated operation of the LRT system, using the initial conditions and scripts specified.

5. Pause and restart the simulator (and thus also simulation time of day).

6. Cause the simulator to operate faster and slower than real time.

I. The Simulator shall simulate LRT System operations and train movement consistent with the following:

   1. The configuration data in the simulator version of the CCS database.

   2. Initial conditions as defined by the Trainer, or as saved from a previous simulation.

   3. Trains progressing on routes according to a selected operating schedule, and to normal run times for each section of track and dwell times defined for each station. For unscheduled trains, the destination shall be as defined by the Trainee.
4. Correct behavior of signal system devices and logic, including signals, switches, interlockings and TWCs, in response to train approach, presence and passage. The signal system logic and timing associated with signal route calls, conflict checking, switch movement and signal clear and stop states shall be implemented by the simulation.

5. Correct train interaction with the signal system: TWC-based signal route calls, waiting at a red signal, proceeding upon a clear signal shall be implemented by the simulator. (Note that trains cannot request routes while an interlocking is in Central Control mode).

6. Correct behavior of the TES system in response to train movement. Correct behavior of trains in response to TES system conditions.

7. Prescribed train separation, consistent with operating procedures, in unsignalled territory.

8. Correct behavior in response to Trainee device controls issued.

J. CCS shall provide for saving, cataloguing and recalling starting conditions, ending conditions (to be subsequently used as starting conditions), and event scripts.

K. Configurable parameters shall be provided and used for all significant decisions and rules relating to train behavior.

L. Event scripting facilities shall provide for efficient creation of scripts and shall utilize existing device names.

2.02 REPLAY

A. CCS shall provide a replay facility which plays back the LRT system on Control Console displays exactly as originally viewable on those displays.

B. Playback information shall include all acquired and derived LRT system information, including all train movement, all alarm conditions, and all responses by the LRT system to user-initiated device controls.

C. Playback shall be for as much as a single day.

D. Playback data shall be saved and catalogued along with the relevant version of software executables and configuration data so that playback data does not become obsolete as the live system is upgraded to newer versions.

E. A convenient mechanism shall be provided to enable/disable recording of playback data.

F. Enables the user to:

1. Recall the recorded data based on date/time.

2. Start, stop, pause the playback.

3. Set the playback speed. Several speeds shall be supported including real time through five times faster than real time.
G. Displays shall be accurate (i.e. identical to the original, with any content changes in the same time ordered sequence as during the original except that they are clearly identified as playback) during the playback. The Playback function shall provide the capability to navigate between the various CCS displays during playback.

2.03 INTEGRITY OF OPERATION

The Simulator System shall not have any interaction with the online system. No failure of the Simulator System shall cause any perturbation of the online system.

PART 3 - EXECUTION

3.01 GENERAL

The Contractor may combine documentation and testing of the Simulator System with similar documentation and testing of the remainder of the Central Control System.

3.02 PREPARATION

Contractor shall employ a software tool such as the Rational Suite of products for the maintenance of requirements, the management of development, the management of changes, and the documentation of the Simulator software.

3.03 FACTORY TESTING

Contractor shall perform a Factory Acceptance Test of the Simulator System demonstrating all requirements including the separation of the Simulator System from online activity of the CCS.

3.04 DELIVERY, STORAGE AND HANDLING

A. All components of the system shall be delivered to the Sound Transit Link Maintenance Facility.

B. Both source and executable software shall be delivered on CD ROM as well as a complete loadable software build.

C. Complete listings of all software shall be provided.

D. Licenses for all third party software shall be provided.

3.05 INSTALLATION

Contractor shall install all equipment according to Contractor supplied installation drawings.

3.06 FIELD TESTING

Contractor shall perform a fully integrated test of the Simulator System in operation concurrently with online operation of the CCS.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17844
PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section describes the interface to CCS administrative and maintenance functions.

1.02 RELATED SECTIONS

A. Section 17200 – Office Services Network.

B. Section 17840 – Central Control System.


D. Section 17910 – Communication Network Management.

1.03 REFERENCE STANDARDS

None.

1.04 CITED STANDARDS

Standards shall be followed as specified in the related Sections.

1.05 NOTED RESTRICTIONS

None.

1.06 QUALITY CONTROL

Contractor shall provide and follow a Quality Control Plan as detailed in the related Sections.

1.07 SUBMITTALS

Contractor shall provide submittals as detailed in the related Sections.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 CCS ADMINISTRATION

A. A Communications Maintenance Console shall be provided. From this console, personnel logged on with the appropriate privileges may perform the following functions:
1. Manage user profiles including passwords and privileges.
2. Perform database schema updates such as adding points and/or calculations.
3. Update graphics, including the generation of new graphics.
4. Perform operating system software updates.
5. Perform application software updates.
6. Run system diagnostics.
7. Re-load the system after catastrophic failure of a server.
8. Restore the database from a backup.
9. Mount and un-mount files for playback of data from archived datasets.
10. Manage the archival of records.
11. Supervise the CCS LAN including automatic periodic configuration audits.
12. Supervise all CCS devices including their removal from service and restoration to service.

3.02 NETWORK MANAGEMENT SYSTEM

As described in related Sections, a management system shall be supplied to manage the entire network including the Communications Backbone.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17845
PART 1 - GENERAL

1.01 OVERVIEW

This Section describes the requirements for data exchange within and external to the Communication System. Refer to drawing L00-Q100, Control System Data Flow Diagram.

1.02 RELATED SECTIONS

A. Section 17040 – Technology Documentation.

B. Section 17200 – Office Services Network.

C. Section 17751 – CCTV.

D. Section 17801 – Control System Network.

E. Section 17802 – Field Control System.

F. Section 17811 – LonWorks Network and Devices.

G. Section 17812 – Modbus/TCP Network and Devices.

H. Section 17831 – Track Isolation Monitoring.

I. Section 17832 – Access Control System.

J. Section 17840 – Central Control System.

1.03 SYSTEM DESCRIPTION

A. The Field Control System (FCS) collects data through LonWorks and Modbus devices. This data is requested and sent to the Central Control System (CCS) and Emergency Management Panels (EMP). There are independent LonWorks I/O Servers and Modbus I/O Servers that manage this exchange of data. Independent instances of these I/O Servers are at the CCS and at each EMP.

B. The Track Isolation Monitoring (TIM) system shall collect data through the I/O Servers, but shall otherwise be completely separate from the CCS. All status and command data exchanged shall pass through a Firewall. TIM data shall be logged to a separate and dedicated historical database.

C. Data is logged by the CCS to an internal CCS historical database. No process external to the Control System Network (CSN) shall have access to this database.

D. The Access Control System (ACS) maintains an access control database for controlling all doors and gates with card readers. Access control panels in the field are updated from this
database. Intrusion alarms detected by the access control panels are sent to the CCS for display and logging to the CCS database.

E. The existing Keri System access control database used at Union Station shall be provided with a conversion utility to export card holder data that can then be imported into the main ACS database.

F. The Network Management System (NMS) collects data on the operational status of Communication System devices and stores this data to an internal NMS database. All communication equipment failure alarms are sent to the CCS. For all communication equipment that is not monitored by the NMS, the CCS shall send equipment failure alarms to the NMS for display and logging.

G. Data from the CCS and NMS is saved to an external historical database on the Office Services Network (OSN) for access by processes external to the CSN. The Maintenance Management System (MMS) shall access this external CCS/NMS historical database for collecting all necessary operational data.

H. The external CCS/NMS historical database shall include train location data for use by the future Regional ITS Data Warehouse.

I. The digital CCTV system in each station stores the video locally for all cameras in the station. When requested by the EMP or CCS, the CCTV System sends real-time or archived video data. The Central CCTV Control System at the O&M Facility shall collect video from all remote locations and shall compress and store this data in a central video storage archive.

J. External CCTV clients at police or fire departments shall have access to live and archived CCTV data via the Internet or other TCP/IP network.

1.04 SUBMITTALS

A. Contractor shall provide the following for review by Engineer. Include these design documents with and in accordance with the Central Control System design submittals.

1. Final Design Review.

Data Flow Diagrams. Diagrams shall be similar in style and content to Drawing L00-Q100, Control System Data Flow Diagram, but shall accurately define the design in detail.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17850
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SECTION 17850
DATA SHARING AND ORGANIZATIONAL INTERFACES

PART 1 - GENERAL

1.01 OVERVIEW

This Section describes the requirements for data exchange within and external to the Communication System. Refer to drawing L00-Q100, Control System Data Flow Diagram.

1.02 RELATED SECTIONS

A. Section 17040 – Technology Documentation.
B. Section 17200 – Office Services Network.
C. Section 17751 – CCTV.
D. Section 17801 – Control System Network.
E. Section 17802 – Field Control System.
F. Section 17811 – LonWorks Network and Devices.
G. Section 17812 – Modbus/TCP Network and Devices.
H. Section 17831 – Track Isolation Monitoring.
I. Section 17832 – Access Control System.
J. Section 17840 – Central Control System.

1.03 SYSTEM DESCRIPTION

A. The Field Control System (FCS) collects data through LonWorks and Modbus devices. This data is requested and sent to the Central Control System (CCS) and Emergency Management Panels (EMP). There are independent LonWorks I/O Servers and Modbus I/O Servers that manage this exchange of data. Independent instances of these I/O Servers are at the CCS and at each EMP.

B. The Track Isolation Monitoring (TIM) system shall collect data through the I/O Servers, but shall otherwise be completely separate from the CCS. All status and command data exchanged shall pass through a Firewall. TIM data shall be logged to a separate and dedicated historical database.

C. Data is logged by the CCS to an internal CCS historical database. No process external to the Control System Network (CSN) shall have access to this database.

D. The Access Control System (ACS) maintains an access control database for controlling all doors and gates with card readers. Access control panels in the field are updated from this
database. Intrusion alarms detected by the access control panels are sent to the CCS for display and logging to the CCS database.

E. The existing Keri System access control database used at Union Station shall be provided with a conversion utility to export card holder data that can then be imported into the main ACS database.

F. The Network Management System (NMS) collects data on the operational status of Communication System devices and stores this data to an internal NMS database. All communication equipment failure alarms are sent to the CCS. For all communication equipment that is not monitored by the NMS, the CCS shall send equipment failure alarms to the NMS for display and logging.

G. Data from the CCS and NMS is saved to an external historical database on the Office Services Network (OSN) for access by processes external to the CSN. The Maintenance Management System (MMS) shall access this external CCS/NMS historical database for collecting all necessary operational data.

H. The external CCS/NMS historical database shall include train location data for use by the future Regional ITS Data Warehouse.

I. The digital CCTV system in each station stores the video locally for all cameras in the station. When requested by the EMP or CCS, the CCTV System sends real-time or archived video data. The Central CCTV Control System at the O&M Facility shall collect video from all remote locations and shall compress and store this data in a central video storage archive.

J. External CCTV clients at police or fire departments shall have access to live and archived CCTV data via the Internet or other TCP/IP network.

1.04 SUBMITTALS

A. Contractor shall provide the following for review by Engineer. Include these design documents with and in accordance with the Central Control System design submittals.

1. Final Design Review.

Data Flow Diagrams. Diagrams shall be similar in style and content to Drawing L00-Q100, Control System Data Flow Diagram, but shall accurately define the design in detail.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17850
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SECTION 17860
SOFTWARE ENGINEERING REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section describes the software engineering requirements for all software to be delivered under this contract.

1.02 RELATED SECTIONS

A. Section 17050 – Configuration Management.
B. Section 17800 – Control System Overview.
C. Section 17802 – Field Control System.
D. Section 17840 – Central Control System.
F. Section 17842 – Emergency Management Panel.
G. Section 17843 – Backup Control.
H. Section 17844 – Training Simulator.
I. Appendix G – Contract Data Requirements List.

1.03 REFERENCE STANDARDS

A. Writing Effective Use Cases – Alistair Cockburn.

1.04 CITED STANDARDS


1.05 NOTED RESTRICTIONS

None.

1.06 QUALITY CONTROL

Contractor shall have a Software Assurance Quality Plan which is in agreement with the cited standards and Section 01450, Systems Quality Requirements, and shall submit a copy for approval.

1.07 SUBMITTALS

Submittals shall be as specified in this Section, Appendix G, Contract Data Requirements List and Section 01330, Submittals.

A. Software Quality Assurance Plan in accordance with IEEE-730 – 30 days after NTP.

B. Software Configuration Plan in accordance with IEEE-828 – 30 days after NTP.

C. Software Test Documentation – five (5) days after test completion.

D. Software Verification and Validation Results – five (5) days after completion.

E. Software Design Description.

F. Software Project Management Plan in accordance with IEEE-1058 – 30 days after NTP.

1.08 DELIVERABLES

Contractor shall deliver and otherwise make available all reports emanating from the software engineering system.
PART 2 - PRODUCTS

2.01 SOFTWARE ENGINEERING COMPONENTS

A. Overview.

1. In an effort to enforce discipline in the software engineering process, to insure the quality of the software, the documentation, and an easily maintainable system, Contractor shall employ an integrated set of software engineering tools.

a.) Manage and Track Requirements.

Contractor shall use a tool such as Rational RequisitePro or approved equal to manage and track requirements. Contractor shall utilize Use Cases in the collection and documentation of requirements.

b.) Analysis and Design.

Contractor shall use a tool such as Rational Rose or approved equal to design the application utilizing industry standard UML to describe and communicate the design.

c.) Manage Change.

Contractor shall use a tool such as Rational ClearCase or approved equal to manage changes and insure traceability in the system.

d.) Testing.

Contractor shall use a tool such as Rational Suite TestStudio or approved equal to ensure that all aspects of quality including functional, performance and reliability testing are monitored throughout the development lifecycle.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17860
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SECTION 17880
FCS AND CSN TRAINING, MANUALS, SPECIAL TOOLS AND SPARE PARTS

PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall furnish all training, manuals, special tools and spare parts required for the operations and maintenance of the FCS & CSN. The goal of providing training, manuals, documentation, special tools and spare parts is so that at time of System Acceptance, Sound Transit is fully equipped to operate, maintain and resolve all issues associated with the delivered system.

1.02 SECTION INCLUDES

This Section includes the requirements for training, manuals, special tools and spare parts for the FCS & CSN.

1.03 RELATED SECTIONS

A. Section 17060 – Special Tools and Spare Parts.
B. Section 17800 – Control System Overview.
C. Section 17801 – Control System Network.
D. Section 17802 – Field Control System.
E. Section 17811 – LonWorks Network and Devices.
F. Section 17812 – Modbus/TCP Network and Devices.
G. Section 17890 – FCS and CSN Support and Warranty.

1.04 REFERENCES

A. OSHA Occupational Health and Safety Administration.
B. ADA Americans with Disabilities Act.

1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Quality Control. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.
1.06 SUBMITTALS

A. Contractor shall submit the following as part of the FCS & CSN delivery.

1. Training Plan.

   a.) Contractor shall provide a training plan that includes all vendor training required by user and maintenance personnel and a schedule for when that training needs to occur relative to the project delivery schedule.

   b.) Contractor shall list all prerequisite training or knowledge required in order to participate in the FCS & CSN training.

   c.) Contractor shall also provide as part of the Training Plan a description of proficiency assessments for each class to assess how well the users and maintainers mastered the material.

   d.) Contractor shall include a schedule of manufacturer, vendor, and contractor provided training for both users and maintainers of the FCS & CSN. All training shall be scheduled to be completed no more than 30 days prior to system acceptance.

   e.) Contractor shall provide, as part of the training plan, a list of all required and recommended vendor and manufacturer training. Contractor shall also provide a list of all Contractor training that is required. Contractor shall provide with this list a brief description of what material each class is intended to cover, and how long the class lasts.

2. Contractor shall deliver all training materials used to train, to include Presentation Slides, Training Notes, and Handouts, training software, and a video of each training class.

3. Manuals.

   a.) Manufacturer’s Manuals.

       Contractor shall provide all Manufacturer’s User and Maintenance Manuals for every type of equipment in the FCS & CSN. Contractor shall submit any other Manufacturer manuals or documentation that would aid Sound Transit in operating or maintaining the FCS & CSN.

   b.) Contractor’s Manuals.

       Contractor shall submit User and Maintenance Manuals for FCS & CSN equipment and software developed by Contractor to develop the FCS & CSN.
4. Documentation.

a.) Manufacturer's Documentation.

Contractor shall submit all Manufacturer documentation in addition to the user and maintenance manuals described earlier required for installation, operations, maintenance and management of the FCS & CSN.

b.) Contractor's Documentation.

Contractor shall provide all design, test and installation documentation for the FCS & CSN. This includes, but is not limited to, all design documents and drawings, installation documentation and drawings, as-built documents and drawings, test reports, documentation of configuration and software delivered. A list of any open discrepancy reports or issues at each design review, test review and at acceptance shall be submitted as well.

5. List of Special Tools.

Contractor shall submit a list of all special tools required for test, operation, maintenance, or troubleshooting recommended by Contractor and submitted for approval by Resident Engineer.


Contractor shall submit a list of all recommended spare parts and components for the FCS & CSN for Resident Engineer approval. This shall include network troubleshooting, software utilities, all LonWorks modules used, PLC processors and cards, routers, gateways, and panel components. Contractor shall assume in general sparing of 10 percent of number of operational parts, or one part, whichever is greater.

1.07 TRAINING

A. Maintenance Training.

1. Contractor shall provide Manufacturer training classes, or shall schedule ST personnel to attend Manufacturer training on the FCS & CSN. Training shall include instruction on loading, configuring, troubleshooting, and maintaining the FCS & CSN. Specific procedures on troubleshooting common problems and troubleshooting techniques shall be trained.

2. Training shall cover the following areas of FCS & CSN operation, maintenance, and troubleshooting:

a.) Operation and maintenance for each control device and demonstrate calibration technique.

b.) I/O point definition, software strategy and system backup procedures.
c.) Operation of the Host Computer system. Explanation of all software required for system startup, control and operation, system software commands, graphic generation, and all modification techniques.

d.) Operation and function of LON network including routers and repeaters used for communication between control nodes and host computer systems.

e.) Use of portable Operators Interface Device (OID).

f.) Remote systems access procedures.

g.) Troubleshooting of input devices.

h.) Sequence of operation review.

i.) Modifying warning limits, alarm limits and start-stop times.

j.) System initialization.

k.) Download and initialization of remote nodes.

1.08 MANUALS

A. Contractor shall provide the following manuals for using and maintaining the FCS & CSN. Manuals shall be professionally bound.

1. User Manuals.


1.09 SPECIAL TOOLS

A. Contractor shall furnish all special tools required to test, install and troubleshoot the FCS & CSN.

B. Contractor shall provide a list of all special tools required to test, install, and troubleshoot the FCS & CSN to Resident Engineer for approval.

C. Contractor shall furnish all special tools approved by Resident Engineer. Contractor shall ensure all special tools function correctly at the time of contract approval. Should any tool be found to be defective or not properly functioning, Contractor shall replace the tool at no cost to Sound Transit.

1.10 SPARE PARTS

A. Contractor shall provide sufficient FCS & CSN system parts and components to allow replacement of any malfunctioning part to meet MTTR requirements that cannot be met by simple troubleshooting.

B. Contractor shall provide a list of all recommended Spare Parts based on the following.
1. Actual delivered system design.

2. Number devices installed.

3. Relative criticality of component.

4. Manufacturer recommendations.

5. Sound Transit general sparing guidelines described in Section 17060, Special Tools and Spare Parts.

C. Contractor shall submit a draft of this list of Spare Parts for Resident Engineer Approval as part of the Preliminary Design Review, and a final Spares List as part of the Final Design documentation.

D. Contractor shall furnish and configure (where appropriate) all spare parts and components along with furnished operational parts and components.

E. Contractor shall test all spare parts and components along with all system parts and components as part of FCS & CSN Factory Testing.

F. Contractor shall replace any spare parts that fail prior to final system acceptance at no cost to Sound Transit. Should any operational part fail prior to final system acceptance and a spare part used to replace the operational part, the spare part shall be replaced at no additional cost to Sound Transit.

G. All spare parts shall be of identical make, model and version as the operational part that it is a spare for, unless directed otherwise by Resident Engineer.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17880
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PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section provides the requirements for training, manuals, special tools, and spare parts for CCS.

1.02 RELATED SECTIONS

A. Section 17840 – Central Control System.

B. Section 17841 – CCS Software and Equipment.

C. Section 17843 – Backup Control.

1.03 REFERENCE STANDARDS

None.

1.04 NOTED RESTRICTIONS

None.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall supply training, manuals, special tools, spare parts, and consumables as per the following.

1. Training.

Contractor shall provide training which shall, at a minimum, provide the training shown in Table 1.
# TABLE 1
## CCS Training Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Course</th>
<th>Description</th>
<th>Attendees</th>
<th>Number of Attendees per Iteration</th>
<th>Minimum Hours</th>
<th>Iterations</th>
<th>Total Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control Console Operations</td>
<td>This course will instruct personnel in the console Human-Machine Interface including: Display selection, Navigation, Function Keys (Soft and hard), Window resize, placement, etc. Device selection, Device control, Alarm management, Logon/off, Geographic partitioning, Functional partitioning, Tunnel ventilation control, Train supervision, Traction Power Supervision</td>
<td>Operating personnel and supervisors</td>
<td>15</td>
<td>20</td>
<td>2</td>
<td>40</td>
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<tr>
<td>2</td>
<td>CCS Equipment Maintenance</td>
<td>This course will instruct personnel in the maintenance of the CCS hardware</td>
<td>Maintenance Personnel</td>
<td>6</td>
<td>40</td>
<td>2</td>
<td>80</td>
</tr>
<tr>
<td>3</td>
<td>CCS System Administration</td>
<td>This course will instruct personnel in the administration of the system including: Maintenance of passwords and profiles, Backup and restore, Network management</td>
<td>Technical Support Personnel</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>CCS Graphics Generation</td>
<td>This course will instruct personnel in the modification and creation of graphics including the linking of Graphic elements to the database</td>
<td>Technical Support Personnel</td>
<td>4</td>
<td>20</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Item</td>
<td>Course</td>
<td>Description</td>
<td>Attendees</td>
<td>Number of Attendees per Iteration</td>
<td>Minimum Hours</td>
<td>Iterations</td>
<td>Total Hours</td>
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</table>
| 5    | CCS Database Maintenance      | This course will instruct personnel in the maintenance of the application database including:  
Addition of points  
Deletion of points  
Addition of system objects such as stations, track, and interlockings  
Installation of additional system devices  
Installation of new system devices | Technical Support Personnel | 4                | 20                      | 2            | 40          |
| 6    | CCS Application Software      | This course will instruct personnel in the maintenance of application software including:  
Installation of updates  
Installation of new applications | Technical Support Personnel | 4                | 20                      | 2            | 40          |
| 7    | CCS Operating System Software | This course will instruct personnel in the maintenance of the system software | Technical Support Personnel | 4                | 20                      | 2            | 40          |
|      |                               |                                                                             |                  |                                   |               |            | 296         |

Total Hours 296
2.02 MANUALS

A. Contractor shall supply the following manuals.


2.03 SPECIAL TOOLS

Contractor shall supply any special tools required for the maintenance of the system including diagnostic software for all system components.

2.04 SPARE PARTS

A. Contractor shall supply spare parts for all CCS components.

1. Each Lowest Level Replacable Unit (LLRU) part shall be spared at a level of one or 10 percent, which ever is greater.

2. One spare processor shall be provided, in lieu of its constituent LLRUs, for each type of processor in the system.

2.05 CONSUMABLES

A. Contractor shall supply one year’s consumables for the system including lamp bulbs, projector bulbs, printer ribbons and printer toner.

B. No paper for the printers shall be supplied.

PART 3 - EXECUTION

3.01 GENERAL

A. Schedule of Supply.

1. Training.

Training shall be provided on a schedule to be negotiated with Sound Transit.
2. Manuals.
   Manuals shall be supplied 30 days prior to Factory Acceptance Test.

   Special Tools shall be provided upon final acceptance.

4. Spare Parts.
   Spare parts shall be provided upon final acceptance.

5. Consumables.
   Consumables shall be provided upon final acceptance.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17881
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PART 1 - GENERAL

1.01 OVERVIEW

Contractor shall provide support and warranty of the Sound Transit FCS & CSN such that the FCS & CSN will be supported during the time of delivery through a year after the final acceptance of the final phase of the ST Communications System.

1.02 SECTION INCLUDES

This Section includes requirements for the support and warranty of the FCS & CSN.

1.03 RELATED SECTIONS

A. The following Sections are related to Section 17390:

1. Section 17060 – Special Tools and Spare Parts.
2. Section 17800 – Control System Overview.
3. Section 17801 – Control System Network.
4. Section 17802 – Field Control System.
5. Section 17811 – LonWorks Network and Devices.
7. Section 17880 – FCS and CSN Training, Manuals, Special Tools and Spare Parts.

1.04 REFERENCE STANDARDS

A. Contractor shall adhere to the following references:

3. UL 50 Standards for Safety for Enclosures of Electrical Equipment.
4. OSHA Occupational Health and Safety Administration.
5. ADA Americans with Disabilities Act.
1.05 QUALITY CONTROL

Quality Control is as specified in Section 01450, Systems Quality Requirements. Equipment and equipment installation shall conform to all applicable National Electrical Code and local regulations.

1.06 SUBMITTALS

A. Contractor shall submit the following as part of the Support and Warranty delivery of the FCS & CSN. See Section 17080, System Support.

B. Contractor shall submit copies of all Manufacturer support and warranty agreements for all equipment delivered at System Acceptance. Contractor shall provide the contact information for all FCS & CSN Manufacturers, in accordance with delivered support and warranty agreements.

C. Contractor shall deliver the Configuration Management of the system at the time of final delivery, including hardware make and model, version number, software version number, software patch number, etc.

D. Contractor shall submit a complete list of all problems encountered during installation and field testing, when they occurred, and how they were corrected. Contractor shall deliver a complete list of all open problems, bugs, and requirements not met at the time of System Acceptance.

1.07 SUPPORT

A. Contractor shall provide FCS & CSN support for all software and hardware from the beginning of acceptance. Contractor support for FCS & CSN shall be supplemented by manufacturer support.

B. Contractor shall provide a maintenance agreement for a level of support that meets the following requirements.

C. Manufacturer support shall be available 24 hours a day, 7 days a week.

D. Manufacturer Support shall respond to a problem within 4 hours during normal business hours defined here as 9 am to 5 pm Monday through Friday, Pacific time, and shall respond to a problem within 8 hours at all other times.

1.08 WARRANTY

A. Contractor shall provide a warranty for the FCS & CSN that covers the repair or replacement of all equipment and software through a period from factory testing through one year after final acceptance of the FCS & CSN at no additional cost to Sound Transit. Contractor shall ensure that all manufacturer warranties cover support and replacement during this period. Where any Manufacturer warranties cover less than this period or do not cover this period, Contractor shall provide the warranty for this equipment.

B. Any upgrades or fixes to FCS & CSN hardware and software shall be made with Resident Engineer approval, at no additional cost to Sound Transit.
PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17890
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SECTION 17891
CCS SUPPORT AND WARRANTY

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section states the requirements for continued support after acceptance, including warranty, for the Central Control System, including the Simulator.

1.02 RELATED SECTIONS

A. Section 17080 – System Support.
B. Section 17840 – Central Control System.

1.03 QUALITY CONTROL

Not applicable.

1.04 SUBMITTALS

A. At the completion of installation and throughout the warranty period, Contractor shall maintain and submit monthly a log of all service requests, failures, repairs, and replacements.

B. Monthly report shall include accumulated numbers of failures, repairs, and replacements by part.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall provide service prior to acceptance and during the warranty period for all equipment and software provided as part of this contract.

3.02 SERVICE PRIOR TO ACCEPTANCE

Contractor shall maintain an on-site presence until Final Acceptance is accomplished. Personnel shall be available from 8AM to 5PM daily and within four hours outside those hours.

3.03 WARRANTY PERIOD

Warranty shall extend from acceptance of the Phase I scope of supply until one year after the acceptance of the Phase II scope of supply.
3.04 COVERAGE

All items of the scope of supply shall be covered for the full warranty period without regard to manufacturer’s warranties of lesser duration.

3.05 REMOTE DIAGNOSTICS

A. Contractor shall maintain a remote diagnostic capability from his home office. Such capability shall allow Contractor personnel to remotely log-on to the system, perform diagnostics, and install software, database, or graphic updates.

B. Contractor shall supply all hardware necessary to allow remote access to the system either via the Internet or dial-up, as allowed by Sound Transit.

3.06 LEVEL OF SERVICE

A. Contractor Response times to a request for service:

1. Within one hour between the hours of 8AM to 5PM Pacific time, Monday through Friday.

2. Within four hours between the hours of 5PM and 8AM Pacific time, Monday through Friday.

3. Within four hours on weekends and holidays.

3.07 ON-SITE COVERAGE DURING WARRANTY

If on-site service is required during the warranty period, Contractor shall have personnel on-site within 24 hours.

3.08 SPARE PARTS

Contractor will use spare parts in the possession of Sound Transit as required, replacing any withdrawals within seven days.

3.09 UPGRADES AND FIXES

During the warranty period, Contractor shall make all product upgrades and fixes available to Sound Transit at no charge. Owner may elect to install or not install the upgrade with appropriate advice and counsel of Contractor.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17891
SECTION 17900
COMMUNICATIONS MAINTENANCE AND SUPPORT SYSTEM

PART 1 - GENERAL

1.01 OVERVIEW

The Communications Maintenance and Support System provides cable and network monitoring, systems management, and maintenance support for the entire Communications Systems as provided in this Contract.

1.02 SECTION INCLUDES

This Section includes an overview of the requirements included in the 900 series specifications.

1.03 RELATED SECTIONS

A. Section 17910 – Communication Network Management.

B. Section 17930 – Cable Management System.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17900
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SECTION 17891
CCS SUPPORT AND WARRANTY

PART 1 - GENERAL

1.01 SECTION INCLUDES

This Section states the requirements for continued support after acceptance, including warranty, for the Central Control System, including the Simulator.

1.02 RELATED SECTIONS

A. Section 17080 – System Support.

B. Section 17840 – Central Control System.


1.03 QUALITY CONTROL

Not applicable.

1.04 SUBMITTALS

A. At the completion of installation and throughout the warranty period, Contractor shall maintain and submit monthly a log of all service requests, failures, repairs, and replacements.

B. Monthly report shall include accumulated numbers of failures, repairs, and replacements by part.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 GENERAL

Contractor shall provide service prior to acceptance and during the warranty period for all equipment and software provided as part of this contract.

3.02 SERVICE PRIOR TO ACCEPTANCE

Contractor shall maintain an on-site presence until Final Acceptance is accomplished. Personnel shall be available from 8AM to 5PM daily and within four hours outside those hours.

3.03 WARRANTY PERIOD

Warranty shall extend from acceptance of the Phase I scope of supply until one year after the acceptance of the Phase II scope of supply.
3.04 COVERAGE

All items of the scope of supply shall be covered for the full warranty period without regard to
manufacturer’s warranties of lesser duration.

3.05 REMOTE DIAGNOSTICS

A. Contractor shall maintain a remote diagnostic capability from his home office. Such capability
shall allow Contractor personnel to remotely log-on to the system, perform diagnostics, and
install software, database, or graphic updates.

B. Contractor shall supply all hardware necessary to allow remote access to the system either
via the Internet or dial-up, as allowed by Sound Transit.

3.06 LEVEL OF SERVICE

A. Contractor Response times to a request for service:

1. Within one hour between the hours of 8AM to 5PM Pacific time, Monday through Friday.

2. Within four hours between the hours of 5PM and 8AM Pacific time, Monday through Friday.

3. Within four hours on weekends and holidays.

3.07 ON-SITE COVERAGE DURING WARRANTY

If on-site service is required during the warranty period, Contractor shall have personnel on-site
within 24 hours.

3.08 SPARE PARTS

Contractor will use spare parts in the possession of Sound Transit as required, replacing any
withdrawals within seven days.

3.09 UPGRADES AND FIXES

During the warranty period, Contractor shall make all product upgrades and fixes available to
Sound Transit at no charge. Owner may elect to install or not install the upgrade with appropriate
advice and counsel of Contractor.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All
costs in connection with the Work specified herein will be considered to be included with the
related item of Work in the bid schedule, or incidental to the Work.
PART 1 - GENERAL

1.01 OVERVIEW

The Communications Maintenance and Support System provides cable and network monitoring, systems management, and maintenance support for the entire Communications Systems as provided in this Contract.

1.02 SECTION INCLUDES

This Section includes an overview of the requirements included in the 900 series specifications.

1.03 RELATED SECTIONS

A. Section 17910 – Communication Network Management.

B. Section 17930 – Cable Management System.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17900
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SECTION 17910
COMMUNICATIONS NETWORK MANAGEMENT

PART 1 - GENERAL

1.01 OVERVIEW

A. Contractor shall provide a Network Management System (NMS) to monitor, alarm and remotely configure all communications network devices that connect to the Sound Transit Communications Systems.

B. The NMS compliments the Field Control System in that it allows maintenance staff to monitor and manage the network equipment, while the FCS allows ST Staff to monitor and control the FCS equipment.

1.02 SECTION INCLUDES

This Section includes the requirements to design, implement and test the NMS.

1.03 RELATED SECTIONS

A. Section 17080 – System Support.

B. Section 17140 – Backbone Cabling Requirements.

C. Section 17150 – Facility Cabling Requirements.

D. Section 17310 – PABX.

E. Section 17320 – Telephone Sets.

F. Section 17360 – Emergency Phone System.

G. Section 17365 – Passenger Emergency Telephones.

H. Section 17510 – Communication System Backbone Equipment.

I. Section 17530 – Video Circuits.

J. Section 17540 – Data Circuits.

K. Section 17560 – Quality of Service Requirements.

L. Section 17620 – OCC Facility Requirements.

M. Section 17625 – OCC Furniture.

N. Section 17730 – Integrated Communications Controller.

O. Section 17840 – Central Control System.

Q. Section 17930 – Cable Management System.

1.04 REFERENCES


C. IEEE 802.1, Bridging and Management.


1.05 SUBMITTALS

A. Contractor shall submit the following prior to the Preliminary Design Review:

1. Description of the NMS, identifying all equipment that is monitored, managed and controlled, and how it is to be monitored, managed and/or controlled.

2. Description of NMS Auditing functions and how the proposed design will perform those functions.

3. Description of all hardware, software and tools required to implement the Network Management System, as well as a description of how the hardware, software and tools will be configured.

4. Preliminary operating procedures and use cases for the Network Management Center identifying how the NMS is to be used to fulfill the requirements described in this Section.

B. Contractor shall submit the following prior to the Final Design Review:

1. Final detailed NMS Implementation Plan.

2. Final list and specifications of all hardware, software, tools and configurations required to implement the NMS.

3. Final NMS Operations and Maintenance documentation describing how the NMS is to be used and maintained to fulfill the requirements in this Section.

C. Contractor shall submit Factory Test Procedures.

D. Contractor shall submit Installation Drawings and Test Procedures as indicated in this specification.
E. Prior to Final Acceptance Testing, Contractor shall submit final versions of the following:

1. User Manuals.
3. Training Plan.
4. Training Manuals.

F. After Factory Test and before Final Acceptance Testing, Contractor shall train up to 20 persons on the use of the NMS per the approved plan and manual.

G. Prior to the Final Acceptance Test, Contractor shall submit final test procedures.

H. Prior to acceptance of the System, all test results and as-builts shall be submitted. Results and as-builts are subject to inspection.

1.06 DELIVERABLES

In addition to the Submittals above, Contractor shall deliver a functional NMS according to these Specifications.

PART 2 - PRODUCTS

2.01 GENERAL

A. The NMS is the primary means for alarm notification, event notification, remote management and remote configuration for the Communications System.

B. Primary users of the NMS shall be the communications systems maintenance staff.


D. All NMS equipment, software and tools shall be Commercial Off The Shelf (COTS) products, where possible.

E. NMS shall have the following functions at a minimum:

1. Monitor and report change-of-state of all communications equipment, where applicable.
2. Exchange information with the Central Control System in order to display status of devices that are safety-related in the CCS.
3. Remote device login and configuration capability where feasible for all communications equipment owned and maintained by Sound Transit.
4. Graphical HMI for physical and logical system configuration to enhance troubleshooting of the Communications System.
5. Failure and maintenance recording with trend tracking and predictive failure analysis capability.

6. Auditing capability including the following:

   a.) Listing of all specified managed devices with model number, firmware and software loaded on each device with version number and patch number where appropriate.

   b.) Log of all failures associated with a device or incident to include date and time, alarm severity, alarm name, alarm description, and alarm or issue resolution.

7. Quick device and system recovery capability.

8. Fully detailed on-line help feature including detailed procedures for troubleshooting, system recovery, and setting up individual device configurations.

F. Network management and monitoring shall occur in-band wherever possible. Contractor shall identify which equipment will be monitored in-band, out-of-band, and which equipment, if any, cannot be monitored/managed via the network.

2.02 NETWORK MANAGEMENT SYSTEM

A. Contractor shall provide a NMS capability at the Communications Maintenance Room for monitoring the performance of, reconfiguring and controlling equipment to include switches, routers, hubs, FCS devices, storage devices, PA/VMS equipment, Integrated Communications Controller, and other equipment to be determined at the CCER and at the stations. The NMS shall support the standardized single-ended automated operations capabilities provided in the SONET overhead. The OC-12 signal contains the overhead information on SONET framing. The overhead conveys orderwire channels, commands, controls, alarms, and error checking for performance monitoring (PM). The NMS shall be capable of providing a graphical display of the SONET network, and equipment located throughout the network.

B. The NMS shall support the basic management functions:

1. Configuration Management.

   a.) Configuration Management shall include:

      1.) Installation, modification and tracking of network configuration parameters (hardware and software) to enable the continuous operation of services. The NMS shall be able to reconfigure the SONET ADMs electronically and remotely. All interface models, interface ports and system controller options and settings shall be configurable, without using hardware option settings. A replaced module shall have its options automatically downloaded from the database contained in the online memory.

      2.) Contingency reconfiguration. A power failure outside of the SONET ADM equipment causing the ADM to lose service, shall upon power restoral, initiate a restoral to full service without operator intervention. The system shall be fully operational (OS interfaces, alarm resets, PM processing) within 10 minutes of
system restart. The system shall be in service within two (2) minutes of a system restart.

3.) Reporting of change-of-state of all communications equipment, where applicable.

4.) Path management with provisioning, modification and auditing capabilities.

5.) Backbone network topology control.

6.) Remote provisioning of communications equipment, facilities and cross-connects. The following service provisioning functions shall be available from both locally and remotely:
   - Establishment/removal/rearrangement of connection.
   - Placement of equipment into service.
   - Removal of equipment from service.

7.) Software download capability of new generic releases to communications equipment, where applicable.


   a.) Sound Transit’s network must be protected from unauthorized, incorrect or accidental use, modification or disclosure. A system administrator security system shall be available for implementation. Security requirements include the following features:

   1.) Backup and restore features to protect provisioning information in ring networks. This feature shall save a copy of a node’s provision parameters so they can be restored at a later date, if necessary.

   2.) Backup and restore features to protect network switch configurations, network storage device configurations and OCC critical server and workstation configurations. This will save a copy of the equipment or device’s configuration information in order to restore a device later, if necessary, or to load an identical configuration to a new device, if necessary.

   3.) Control of network user access.

   4.) Security violations reporting. Access to the NMS shall be limited accordingly. The system shall be designed to protect the sensitivity, availability, privacy and integrity of the information transported and processed.

   5.) Remote memory backup of the communications equipment configurations for restorative purposes. All memory storage devices used in the SONET system shall be non-volatile. On-line data storage shall be provided to back up processor memory due to power failures or processor memory contamination. This data storage shall be modifiable from the data received over the remote data provisioning/maintenance. The on-line data storage shall contain all data
necessary to restore the SONET system to its current state. Restore of optioning data to a specific module in a SONET ADM shall not be service affecting to the other SONET ADM operations.

3. Account Management.

a.) Account Management shall include the following:

1.) Automatic version recognition of all hardware firmware, and software installed in the system. Each circuit pack (CLEI) code, equipment catalog item (ECI) code, apparatus code and series number shall be stored on the circuit pack and shall be accessible by the system controller.

2.) An inventory function, via a software command, shall be provided. This function shall be available on a system, shelf and plug-in level as an option in the software command.

3.) Logging and storage of all NMS activity for convenient access.

4.) Collection of network traffic statistics.

5.) Administrative support for fault tickets and inventory.

6.) Historical files of alarms, commands messages and operator actions.

7.) Message log retrieval for past events analysis.

4. Fault Management.

a.) Fault Management shall provide the detection, isolation and correction of abnormal network conditions, and include the monitoring of:

1.) Automatic/manual diagnostics: Diagnostics shall be performed on the SONET ADM, Network Switch and other communications equipment, whether in service, redundant or out-of-service. These diagnostics shall be available on a per circuit pack basis. All diagnostics shall be available on demand via a software command.

2.) Testing: Test access functions shall be available, via software command, from the NMS OS interface. The SONET ADM shall provide both a Facility Access Digroup (FAD) and a Test Access Digroup (TAD). The FAD shall be used to test any DS1 signal with asynchronous mapping. The FAD access must include monitor, split and release access functions. The FAD interface requirements shall be in accordance with FR-476, Section 6.3. The TAD will be used to test any DS0 mapped in a byte synchronous VT1.5. The TAD must conform to the requirements in FR-476. The TAD test access unit shall allow the following functions to be performed:
5. Monitoring of circuit.


5. Hardware/software functions.

6. Fault isolation.

7. Status of transmission links.

8. Reporting.

a.) Status and Alarms.

1.) The NMS shall be able to compile status and alarm data from the various registers into a summary report for recall and demand. At a minimum, the NMS shall have the capability to compile this report up to 24 hours in duration.


a.) Performance Management shall include:

1.) Historical data collection of PM data in 15-minute and 24-hour intervals. The PM data shall be displayable as histograms, with all data stored in history records. This report, at a minimum, shall consist of the following parameters, and shall be configurable to display user-selectable time intervals:

- Current 15 minutes.

- Previous 15 minutes.

- Current day.

- Previous day.

- Threshold register for current 15 minutes.

2.) Capability to receive individual or group reports on a scheduled basis over the appropriate OS link. If the OS link is out-of-service at the time of the scheduled delivery of the report, it shall be saved by the SONET ADM and begin compilation of the next report. Following restore of the OS link, a notification shall be delivered, indicating the reports(s) are available for transfer.

3.) Threshold crossing alarms. PM parameters capable of setting to threshold levels to generate alarms when the threshold has been crossed. All threshold crossings shall be stored in a historical database. Thresholds for each performance parameter shall be user selectable via a software command. Threshold crossing shall generate (non-alarm) a notification to the NMS OS and
to the local craft interface and continue counting. Threshold defaults shall be provided per FR-475.

C. NMS Software Requirements.

1. NMS software interface shall include an easy-to-use intuitive graphical user interface displaying a hierarchical view of the network down to the shelf and card level.

D. Craft Interface Terminal (CIT)/Local Craft Access.

1. The SONET ADMs shall be equipped with EIA-232-E ports to be used with a Craft Interface Terminal (CIT) for provisioning and maintaining the SONET ADM. The physical interface to the CIT shall be via a 25 pin subminiature D style EIA-232-E connection. Messages sent to and accepted from the CIT shall be in the TL1 style commands for effective man-machine interaction. The Contractor may choose to provide menuing capability or user friendly interface displays for ease of use, however the default operation for the CIT interface must use TL1 style commands.

2. Contractor shall provide a CIT to support the installation, maintenance and administrative activities. A personal computer (PC) is required for software download.

E. The following commands shall be executable via the CIT:

1. Testing and loopback.
2. Provisioning.
4. Initialization of PM registers.
5. Memory administration.

F. The CIT shall support remote service including the following:

1. Establishment/removal/rearrangement of connection.
2. Placement of equipment into service.
3. Removal of equipment from service.

G. NMS equipment requirements.

1. Contractor shall provide all hardware, software and tools required to equip a Communications Maintenance Center in the CCER in order to fulfill the above requirements. Such equipment shall include at a minimum the following:

   a.) Communications Management Center Local Area Network.
1.) Hub connecting NMS LAN with the Communication System Backbone via the Backbone Ethernet Switches (as described in Section 17510, Communication Backbone Equipment).

2.) NMS Server.

3.) NMS Workstations (to include the CIT workstation described above)

4.) KVM Switch.

5.) NMS Monitors.

6.) Printer.

2.03 OUT-OF-BAND NETWORK MANAGEMENT

A. Terminal Server.

A Terminal Server shall be provided that provides management and maintenance services for station and central devices that must be managed out-of-band (e.g. PA, ILON devices). These devices shall be managed through Craft interfaces.

PART 3 - EXECUTION

3.01 GENERAL

A. Overview.

This Section describes the preparation, testing, installation and acceptance of the NMS.

3.02 PREPARATION

Resident Engineer will schedule design reviews with Contractor. The design reviews shall encompass the Contractor submittals for the Preliminary and Final Design.

3.03 FACTORY TESTING

A. Contractor shall assemble all equipment and materials to form a complete functioning system and perform factory tests on each complete system prior to shipment.

B. Factory Testing shall be conducted to ensure functionality of the NMS per these Specifications in this Section.

3.04 DELIVERY, STORAGE, AND HANDLING

Contractor is responsible for all delivery, storage, and handling of equipment.
3.05  INSTALLATION

Contractor shall follow manufacturer’s recommended installation practices, Contract Specifications and Contract Drawings during construction.

3.06  FIELD TESTING

A. Field Tests shall be conducted in compliance with Resident Engineer-approved plans and procedures.

1. Field acceptance tests shall consist of exercising each NMS system function through its required operations, under simulated conditions, to prove that the installation complies with specified requirements.

2. Contractor shall.

   a.) Furnish certified test reports for field acceptance tests.

   b.) Provide equipment and apparatus required for the tests.

B. Contractor shall verify in the field the functionality of each piece of equipment, as well as the functionality of the NMS over the operational fiber backbone and over the CCER network and each station local network.

PART 4 - MEASUREMENT AND PAYMENT

4.01  GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

END OF SECTION 17910
SECTION 17930
CABLE MANAGEMENT SYSTEM

PART 1 - GENERAL

1.01 OVERVIEW

This Section contains the requirements for a software based cable management documentation system.

1.02 RELATED SECTIONS

A. Section 17105 – Grounding and Bonding of Cables.
B. Section 17120 – Interior Communication Pathways.
C. Section 17130 – Exterior Communication Pathways.
D. Section 17140 – Backbone Cabling Requirements.
E. Section 17150 – Facility Cabling Requirements.
F. Section 17160 – Cabling Requirements.
G. Section 17170 – Cable Testing, Identification and Administration.

1.03 REFERENCE STANDARDS

B. IEEE STD 830, Recommended Practice for Software Requirements Specifications.

1.04 NOTED RESTRICTIONS

No restrictions at this time.

1.05 QUALITY CONTROL

A. Contractor shall be registered and compliant with ISO 9001.
B. Contractor shall be verifiably certified to have attained CMM Level 3 certification.

1.06 SUBMITTALS

A. PDR.

1. Contractor shall provide the following as part of the PDR (See IEEE STD 830):
a.) CMS Equipment and Software Configuration.

b.) Description and model numbers, shop drawings, catalog cuts, and technical literature describing all of CMS equipment, applications, and modules.

c.) Detailed CMS equipment block diagrams with physical interconnections and interfaces.

d.) Identification and description of all external interfaces (i.e. Line Cards, Ports).

e.) Description of all hardware, facilities and functions provided to implement availability requirements.

f.) Name and brief description of all copyrighted commercial off-the-shelf software, including operating system software, data communications software, database software, forms package, report package and additional modules.

B. FDR.

1. Contractor shall provide the following as part of the FDR (See IEEE STD 830):

   a.) Updated versions of all previously submitted materials.

   b.) Equipment wiring and cabling diagrams.

   c.) Rack layouts and rack interconnections.

   d.) Equipment and System Software parameter settings.

   e.) Physical Inventory Data.

1.07 DELIVERABLES

A. Contractor shall transmit submittals and deliverables required by this Section.

B. Contractor shall furnish products as indicated.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall provide CMS Control Console equipment.

   1. Contractor shall provide any needed equipment at each of the Consoles.

   2. Software (including all system software and application software) shall be provided.
3. The CMS database shall be designed and built with Contract specific information populating data fields in approved locations.

B. Contractor shall supply dual or clustered computers to act as the servers for the system.

C. The CMS shall be constructed around a redundant local area network (the CMS LAN) connecting CMS workstations, CMS server computers, and databases.

2.02 EQUIPMENT RELIABILITY

A. All hard discs shall have a Mean-Time-Between-Failures (MTBF) of at least 200,000 hours.

B. All console color-graphics monitors shall have an MTBF of at least 20,000 hours.

C. All computer power supplies shall have an MTBF of at least 150,000 hours.

D. All printers shall have an MTBF of at least 10,000 hours.

E. Equipment to backup/restore the CMS database and off-load the disc-based log shall have an MTBF of at least 35,000 hours.

2.03 CMS SOFTWARE REQUIREMENTS

A. Overview.

1. Sound Transit will to capture and maintain all information with regards to the existing and future cable plant. Using the ANSI/TIA/EIA 606A as a guideline, this installation fall under the requirements for a Class 4 system.

   a.) Class 1 – Premises with a single Telecommunications Room (TR).

   b.) Class 2 – Premises with multiple TRs within a single building.

   c.) Class 3 – Campus with multiple TRs in more than one building.

   d.) Class 4 – Multi-site or Multi-Campus Environment.

2. In accordance with the ANSI/TIA/EIA 606A guidelines for required identifiers and associated records, this will include, but not be limited to:

   a.) Horizontal Cabling (workstation cabling).

   b.) Backbone Cabling.

   c.) Grounding and Bonding.

   d.) Fire-stopping.

   e.) Pathways and Spaces.
f.) Asset Management (connected devices).

g.) Work Order System (Future).

3. Below are detailed descriptions of the above-mentioned items. The descriptions shall be considered the minimum requirements for each category. If upon review, a single solution (product) cannot be found by the vendor to satisfy all criteria, Sound Transit will consider a solution that consists of multiple products that can be or already are integrated as a management solution. In the proposal these products need to be clearly defined and their integration demonstrated upon the request of Sound Transit.

B. CMS software shall be the latest version (at time of submittal) of Textron’s docIT or approved equal.

2.04 HORIZONTAL LINK RECORD

A. All station cabling is installed in accordance with ANSI/TIA/EIA 568A standards. The CMS shall adhere to all guidelines set by ANSI/TIA/EIA 606A standards.

B. The horizontal link record shall contain the following information:

1. Horizontal link identifier: (Primary indexing identifier, e.g.: A47).

2. Cable type: (e.g. 4 pr, UTP, category 6, plenum).

3. Location of telecommunications outlet/connector: (room, office, or grid location).

4. Outlet connector type: (e.g.: 8 position modular, T568A, category 6).

5. Cable length: (e.g.: 51m/154ft).

6. Location of TR and or CP: (class 4).

7. Cross-connect hardware type: (e.g. 48 port modular patch panel, T568A, category 6).

8. Service record of link: (e.g. passed category 6 at installation 1/12/99, re-terminated and re-tested at cross-connect 4/22/99 due to broken wire).

C. Additional items of information desired by Sound Transit may be added at the end of the record, such as:

1. Location of test results.

2. Location of outlet within room or office.

3. Color of the connector or icon on the connector (e.g.: orange icon; or blue jack).

4. Other telecommunications outlet/connectors at same location (generally, the other outlet connectors in the same faceplate, e.g.: A02, A03, A04; or B01, C01, D01).

5. Faceplate configuration (e.g.: single gang, four port, telco ivory).
6. Position of outlet connector on faceplate or multi-user telecommunications outlet assembly (MUTOA) – for example: top left.

7. Pathway to outlet (e.g.: fishable wall or surface raceway).

8. Presence or absence of MUTOA (Is there a MUTOA in this link? Yes or no).

9. Length of work area cord if MUTOA is present.

10. Presence of absence of CP (Is there a CP in this link? Yes or no).

11. Equipment circuit currently using link (e.g.: 100BaseT switch port #16).

12. Current user name (e.g.: Max Headroom), as per logon.

D. CMS shall be capable of documenting multiple media and mixed media horizontal cabling. This shall include copper, fiber optic and coaxial cables.

E. Ability to print station numbers as a list from CMS to a labeler.

2.05 BACKBONE CABLING

A. CMS shall be capable of documenting all building riser cables, horizontal closet to closet cables and building inter-connect cables in accordance with ANSI/TIA/EIA 606A.

B. The Backbone cable records shall contain the following information:

1. Backbone cable identifier (the primary indexing identifier, e.g. 2A/3A1).

2. Type of cable (e.g. 600pr 24ga shielded riser cable).

3. Type of connecting hardware, first TR (e.g. 36 SC duplex coupler panel).

4. Type of connecting hardware, second TR (e.g. 36 SC duplex coupler panel).

5. Table relating each backbone cable pair or strand to other backbone cable pairs or strands or to a horizontal link, to which it is cross-connected.

C. Additional items of information desired by the Sound Transit shall be added to each record.

D. The CMS shall allow Sound Transit to build a connection sequence that from the station cable to backbone cable to backbone device. If several backbone cable segments are needed to reach the required backbone device, the CMS shall only allow those segments, which are valid to be included in the path. No backbone cable shall be available for selection unless it is physically available within the last TR point of connectivity in the circuit.

E. Example: Horizontal link 3A-A22 runs to TR 3A. The only backbone cables I can select from for connectivity are those that in TR 3A.

F. If a pair within that backbone cabling is in use by another connection, then the next person to try and select it must be notified that that particular pair or strand is not available.
2.06 GROUNDING AND BONDING

A. The CMS shall be capable of maintaining all information with regards to the Telecommunication Main Grounding Busbar (TMGB), Telecommunication Grounding Busbar (TGB), and connected Bonding conductors in accordance with ANSI/TIA/EIA 606A.

B. The TMGB record shall contain the following information:

1. Telecommunications main grounding busbar identifier (primary indexing identifier, e.g.: TMGB).

2. Location of the TMGB (TR identifier).

3. Size of the TMGB.

4. Location of attachment of TMGB to electrical system ground or building structural steel.

5. Additional items of information desired by the system owner or operator may be added to each record, such as:
   a.) Conductor ID (connected bonding conductor).
   b.) Conductor Type (gauge, solid/stranded, insulated/bare).
   c.) Conductor Destination (space, device type and ID).

C. The TGB records shall contain the following information:

1. Telecommunications grounding busbar identifier (primary indexing identifier, e.g.: 3A-TGB).

2. Location of TGB (TR identifier).

3. Size of the TGB.

2.07 FIRE-STOPPING

A. All firewall penetrations, floor penetrations and exterior wall penetrations shall require the use of fire-stops. In accordance with ANSI/TIA/EIA 606A the fire-stopping record shall contain the following information:

1. Fire-stopping location identifier (primary indexing identifier, e.g.: 3FSL02(6)).

2. Location of the fire-stopping installation (e.g.: room number and location within room).

3. Type and manufacturer of fire-stopping installed.

4. Date of fire-stopping installation.

5. Name of installer of fire-stopping material.
6. Service record of fire-stopping location (e.g.: 4/22/99 fire-stopping removed and replaced with same type by ABC Cabling to add cabling runs).

B. Additional items of information desired by the Sound Transit or operator may be added to each record.

2.08 PATHWAYS AND SPACES

A. This project shall require the administration of pathways and spaces within the administrative jurisdiction. As changes are made to the pathways or spaces, affected labels, records, reports, and drawings shall be updated.

B. Pathways are conveyances for telecommunications media that link spaces together. Spaces (equipment room, telecommunications closet, work area, entrance facility, manhole, and hand-hole) are areas where telecommunications equipment and cable may be located.

C. The Pathway record shall contain the following information:

1. Pathway identifier (horizontal, inter-building and outside plant pathway, e.g.: CT64).

2. Pathway type (cable tray, conduit, inner-duct).

3. Pathway fill (percent fill capacity).

4. Pathway load (kg/m or lbs/ft).

5. Cable records (C0001, C0002).

6. Space record end 1 (D306).

7. Space record end 2 (3A).

8. Space records (access).

9. Pathway records other (n/a).

10. Grounding record (n/a).

D. Additional items of information desired by the system owner or operator may be added to each record, such as:

1. Pathway length (40 m or 132 ft).

2. Pathway maximum fill (40 percent).

3. Pathway maximum load (kg/m or lbs/ft).

4. Pathway usage (horizontal distribution).

5. Number of bends (2).
6. Fire-stopping (room 3A).
7. Drawing number (C3).

E. The Space record shall contain the following information:
   1. Space identifier (3A).
   2. Space type (TC).
   3. Pathway records (CD34, CT64, SL02-05, CD02).
   4. Attached horizontal links (C0001, C0011, CB02).
   5. Grounding record (TGB35).

2.09 ASSET MANAGEMENT

A. The CMS must have the ability to track all devices connected at the work area, as well as devices in the Telecommunications Room (TR). The following is not a requirement of the ANSI/TIA/EIA 606A, but is required as a part of this Contract.

B. The Asset record shall contain the following information:
   1. Asset identifier (Phone 001).
   2. Asset Name (ETEL Phone).
   3. Asset type (INFO Phone).
   4. Manufacture (Lucent, Nortel).
   5. Received from (Lucent, Nortel).
   6. Attached horizontal links (C0001, C0011, CB02).
   7. Location (building, floor, space).
   8. Receipt Date (01/01/01).
   11. Current value or replacement value (in dollars).
   12. Connected Assets (Modem 001).
2.10 CABLE TEST RESULTS

Sound Transit requires cabling vendors to test all station cables with an approved tester. The CMS must have the ability to store all test results for future reference. Each cable in the CMS shall have the corresponding test result attached to the record within the database to allow easy access to this information in the future.

2.11 WORK ORDER SYSTEM

A. The CMS shall have the ability to incorporate itself into the daily operation of the IT department. It must have an integrated work order system that allows the IT department to identify options and make changes to the cable plant in a proactive manner.

B. This work order utility shall be used to manage all moves, adds and changes to the cable plant as well as the hardware attached. All work orders must have a unique numbering system tied to project numbers, date assigned, service person assigned, due date, description of service to be provided and actual changes or adds defined.

2.12 REPORTS

A. Reports present information selected from the various telecommunications infrastructure records. Reports may be generated from a single set of records or from several sets of interlinked records. It may be desirable that the information from these reports be presented in several different formats.

B. The CMS shall allow Sound Transit to generate custom reports for all items mentioned above. In addition, the reporting system shall allow the user to select and sort information. Browser based report generation is preferred.

2.13 FLOOR PLANS

A. The CMS shall have the ability to generate or import a floor plan to the system. Floor plans shall have the all the station locations, devices and wiring closets clearly identified. Cable pathways and above ceiling obstructions should be documented, but are not a requirement of this proposal.

B. Sound Transit should be capable of selecting what information in the database is attached to the objects on the floor plan. The floor plans shall share a relationship with the database so that any changes are automatically updated. All objects within the drawings shall come from a predetermined library of cabling, network and telecommunications objects within the CMS or drawing solution.

C. CMS shall be able to import and export drawings from all standard drawing applications such as VISIO, Autocad and Microstation. All floor plans shall have a residence within the CMS structure or Hyperlink that allows easy access to multiple drawings. All floor plans shall be to scale with the output options for industry standard printers and plotters.

2.14 CLOSET DIAGRAMS

A. Sound Transit will require the CMS to generate or import closet detail drawings. Each drawing shall be capable of demonstrating both logical and physical rendering of the closet. The logical rendering is a CAD drawing with all cabling, support hardware and active hardware placed in both “rack elevation” and “top-down” views. The CMS shall have an
extensive library of product specific components with the ability to expand that list as needed to include Sound Transits selected and future hardware.

B. The physical rendering shall consist of pictures taken with a digital camera and either placed on the same drawing with the logical or a separate drawing. Pictures shall typically consist of floor conduits, ceiling conduits backboard layouts and rack layout (front and back).

C. All closet drawings shall have a residence within the CMS structure that allows easy access to multiple drawings. All closet drawings shall be to scale with the output options for industry standard printers and plotters.

2.15 INTERCONNECT DIAGRAM

A. The CMS shall be capable of generating or importing drawings that demonstrate closet and building inter-connectivity. Drawings shall demonstrate all buildings, closets, interconnect cables and pathways clearly.

B. For the closet-to-closet drawings all horizontal and vertical connections within a building shall be identified. Cable names, source and destinations, count ranges and cable types shall also be clearly marked on these drawings.

C. For the building inter-connectivity drawing or campus drawing all cables that connect these buildings shall be identified. Cable names, building names, closet names, count ranges; cable types, manholes, hand-holes and utility poles shall also be clearly marked on these drawings.

D. Sound Transit should be capable of selecting what information in the database is attached to the objects on the floor plan. The floor plans shall share a relationship with the database so that any changes are automatically updated. All objects within the drawings shall come from a predetermined library of cabling, network and telecommunications objects within the CMS or drawing solution.

E. All interconnect drawings shall have a residence within the CMS structure that allows easy access to multiple drawings. All drawings shall be to scale with the output options for industry standard printers and plotters.

2.16 MISCELLANEOUS REQUIREMENTS

A. The CMS shall run on a Windows 2000/Unix Based computer as a stand-alone application or Windows NT/2000/Linux platform if networked. In a networked environment the CMS shall be capable of assigning users and passwords with either full editable access or read only access as a minimum.

B. Looking to the future Sound Transit will require the CMS to be fully ODBC-32bit compatible for the possible integration with other IT and telecommunications based management solutions.
PART 3 - EXECUTION

3.01 PREPARATION

A. Transmit submittals and deliverables required by this Section.

B. Furnish products as indicated.

3.02 FACTORY TESTING

A. A 72-hour burn-in shall be performed for all equipment.

B. Subsequent to burn-in:
   1. Diagnostic testing, utilizing standard manufacturer supplied tests, shall be performed for all equipment and all communications ports.
   2. Functional testing shall be performed for all hardware equipment.
   3. Validation of equipment settings shall be performed for all equipment.
   4. The equipment shall be connected and function as a system, running CMS software.

C. CMS LAN Equipment Tests.
   1. Contractor shall perform all manufacturers recommended equipment and cable testing utilizing test cables fabricated for the tests. All available equipment built-in unit and communications paired tests shall be performed. All equipment configuration, management and diagnostic functions shall be exercised and demonstrated as operational. Diagnostic hardware testing shall be performed for all equipment upon installation at Engineer.
   2. Operating system software and LAN software testing shall be performed for all computer equipment.
   3. Configuration settings for all equipment shall be verified after power-on.

3.03 INSTALLATION

Contractor shall install all CMS equipment as per approved installation drawings.

3.04 CMS EQUIPMENT TESTS

A. Contractor shall perform on-site testing which shall include the following:
   1. All manufacturers recommended equipment and cable tests shall be performed. All available equipment built-in unit and communications paired tests shall be performed. All equipment configuration, management and diagnostic functions shall be exercised and demonstrated as operational. Diagnostic hardware testing shall be performed for all equipment upon installation at Engineers discretion.
   2. Operating system software testing shall be performed for all computer equipment.
3. Configuration settings for all equipment shall be verified after power-on.

4. Comprehensive interface testing shall be performed for all external interfaces to field devices.

5. A sub-set of the Factory Acceptance Test shall be performed to verify that there has been no degradation of operation or function.

6. All software shall be verified to be the latest approved release.

7. The serial number on all hardware shall be verified.

**PART 4 - MEASUREMENT AND PAYMENT**

4.01 GENERAL

Separate measurement or payment will not be made for Work required under this Section. All costs in connection with the Work specified herein will be considered to be included with the related item of Work in the bid schedule, or incidental to the Work.

**END OF SECTION 17930**