

SECTION 27 30 01

TELEPHONE SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Telephone system

1.02 MEASUREMENT AND PAYMENT

- A. Measurement: Telephone systems will be measured for payment as a lump-sum unit acceptably installed and tested for compliance.
- B. Payment: Telephone systems, will be paid for at the Contract lump-sum price for telephone systems, or as part of the lump-sum price for Communications Work, as determined by the lump sum measurement specified above, as indicated in the Bid Schedule of the Bid Form.

1.03 DESCRIPTION

- A. Telephone Systems shall include the following:
 - 1. IP Telephony System
 - 2. Emergency Telephone System
 - 3. Fire Telephone System
 - 4. Emergency Call Box System

1.04 SUBMITTALS

- A. General: Refer to Section 01 33 00 - Submittal Procedures, and Section 01 33 23 - Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.
- B. Functional description of each telephone system and purpose of all proposed test and diagnostic equipment.
- C. Top-down documentation for all IP Telephony System software and firmware. The documentation shall include structured formats or top-level flow charts, functional descriptions, program listings, detailed design descriptions of all algorithms, flowcharts, program design languages or pseudocode, operating instructions, data base descriptions, program logic and data interface diagrams and descriptions, and hardware interfaces. The submittal shall include the following:
 - 1. A functional description and overview of the software
 - 2. An inventory of all software programs and modules, cross-indexed and characterized as standard, modified standard, or custom.

3. A standard that software documentation released by the Contractor conforms to.
4. Documentation on standard software.
5. Documentation on modified standard programs.
6. Functional requirements document, design and specifications document, and program source code for custom-designed software.
7. Complete listing of the database documentation.
8. Complete description of all display formats.
9. Memory map charts of application programs.

PART 2 - PRODUCTS

2.01 IP TELEPHONY SYSTEM

- A. IP Telephony System will be a network based Voice over Internet Protocol (VoIP) Cisco Unified Communications Manager v6.1 or higher. Call control and messaging server clusters to be designed to fail over to geographically diverse servers.
1. IP network to be configured for Quality of Service to give voice and video traffic priority.
 2. IP phones shall be configured to encrypt voice traffic.
 3. Adequate IP network security shall be provided.
 - a. Servers must run Cisco Security Agent.
 - b. Appropriate firewalls in place to prevent unauthorized access.
 - c. Features shall include:
 - 1) Join Across Lines.
 - 2) Mobile Connect = Single Number Reach with single Voice Mail box.
 - 3) Mobility, transparent movement during ongoing calls.
 - 4) Unity Messaging.
 - 5) Presence.
 - 6) Emergency Responder.

- 7) Unified Video Advantage.
- 8) Operations Management Software including:
 - a) Cisco Provisioning Manager.
 - b) Cisco Operations Manager.
 - c) Cisco Service Monitor.
 - d) Cisco Service Statistics Manager.
- 9) Gateways, Cisco 3845 Integrated Service Routers geographically diverse for redundancy.

B. IP Telephony System Design:

1. The IP Telephony system shall be designed for console-less operation, with dial-up service from IP Telephony sets, manual ringdown service from White Courtesy Telephone sets, direct trunk line 911 connection from Emergency Call Box (ECB) locations, and public address access from selected IP Telephony sets. System shall provide wireless network access points for Cisco Unified Wireless IP phones.
2. The equipment shall be of digital solid-state, modular design, utilizing the same Unified Communications Manager with the latest hardware and software technologies available at the time of bid.

Existing Communication Servers are to be used if already in place in BART's network. BART's intent is to build a single Communications Manager cluster to provide call control and messaging for the entire system. Incremental growth may require placement of phones only, phones and gateways and additional server capacity. This will be determined by BART Communication Engineer based on specific circumstances.

3. The hardware and software design shall be such that incremental increases in station lines and trunks, and modifications of user data (adds, moves, or changes) may be easily accomplished without affecting service to any existing lines and trunks.
4. Dial-up Service: The system shall provide station to station direct dialing, capable of processing calls to/from any point in the District's telephone system. IP Telephony users shall be able to go off-hook and dial any network number, regardless of location or serving IP Telephony System, and the system shall automatically complete the call to a system telephone set or route it over network lines for switching by the existing main PABX at LMA, whichever is applicable.
5. Courtesy Telephones: Courtesy telephones shall provide communications between patrons and the Station Agent's booth.

- a. The telephone switch shall provide courtesy telephone service. These phones shall be installed to provide easy access to elderly and handicapped patrons in accordance with ADA requirements.
 - b. Calls made from courtesy telephones shall be directed to the IP Telephony in the Station Agent's booth(s). If the Station Agent does not respond after 15 seconds or the line is busy, a 2-chime code call shall be broadcast over the Station Public Address System. The code call shall be repeated every 15-seconds until the call is answered by the WiFi handset.
 - c. Telephones in the elevators shall initiate the PA-code call without time delay. These calls shall be redirected to Central Control via the Emergency Telephone System if the Station Agent does not respond to the call within 90 seconds.
 - d. Courtesy telephones shall be designed for hands-free speaker phone operation. A permanently affixed sign shall be provided at each telephone location indicating public phones to be used in case of emergencies if the Station Agent does not respond to courtesy telephone call.
6. Emergency Call Box Telephones: The IP Telephony System shall be designed to provide the functions for emergency call box telephones as follows:
- a. The telephone circuits shall be supervised through the IP Telephony System equipment.
 - b. Lifting the handset in the Emergency Call Boxes shall initiate the IP Telephony System to direct the call to BART Police emergency 911 operations.
7. Power to all components in the system needs to be protected to ensure operation in power outage. This includes network components such as ethernet switches, gateways and servers as well as the telephone instruments. IP telephones can be powered by: .
- a. Power over Ethernet.
 - b. Power injectors in the wiring closet.
 - c. Power cubes for each telephone at the desktop.
 - d. PoE ports and IP phones must support Cisco Discovery Protocol.
 - e. Analog phones receive power from VG gateway.

C. IP Telephony Servers and Gateways Requirements:

1. Rack mountable inside a communication equipment cabinet. Alternative mounting arrangements are acceptable subject to District approval. Physical dimensions, construction, mounting data (wall and/or floor), and enclosure locking mechanism shall be submitted.

2. Employ a four or five-digit dial plan compatible with BART standards. The software shall have an automatic routine that performs number analysis to the third digit. The software must determine if the number dialed is within the BART's IP network or off net. No access level (e.g. "9") shall be required to dial any network number.
3. Interfaces to the Public Switched Telephone Network (PSTN) will be through Cisco 3845 Integrated Service Routers.
4. Cisco VG family analog phone gateways will terminate all analog telephony devices. These gateways convert analog traffic to IP and are under the control of the communications Manager. They are to be placed at the nearest, practical wiring closet to the analog devices.

D. Telephone Sets.

1. Telephone types shall be as specified herein. Wall jacks shall be standard type RJ 45. Plugs shall be RJ-type. Locations of telephones along with the type of telephone and wall jacks to be installed in each location are as shown in the Drawings.

Telephone sets installed at interlocking locations shall be housed in a stainless steel NEMA 4X enclosure.

2. Analog Telephone Sets:

- a. General Requirements:

- 1) One-piece G6 type handset with hearing-aid compatible receiver and noise-canceling transmitter;
- 2) Non-modular, 3 feet length, vandal-resistant, low-risk exposure handset cords;
- 3) Dual-gong, electromechanical ringer; and
- 4) Audio gain control, with a range of +8 to +12dBA, via a handset-mounted thumbwheel.

- b. IP Telephone Sets shall be:

- 1) Cisco Unified Phone 7965G where indicated.
- 2) Cisco Unified Phone 7945G where indicated.
- 3) Cisco Unified Wireless IP Phone 7921G where indicated.
- 4) Cisco Unified IP Phone Expansion Module 7914 where indicated.

- c. Courtesy Telephone Sets:

- 1) Color: White, Elevator: Stainless Steel

- 2) Model: Gai-Tronics Model No. 297, ADA Compliant.
 - 3) Elevator Cab telephone model: Gai-Tronics Model GTA 06024
- E. The Contractor shall develop and implement a Network dial plan that shall update the IP Telephony Systems currently in service and incorporate those which are being supplied as part of this Contract. This plan shall also integrate the new equipment with the current Direct Inward Dialing (DID) and BART Telephone Network Dial Plan. The proposed Plan shall be approved by the District prior to implementation.
- F. Systems conforming to the above requirements shall be compatible with Cisco Unified Communications Manager v6.1 or higher release.
- G. BART shall be placed on the PABX supplier's mailing list to receive announcements of the discovery, documentation, and solution to software problems, new software releases, and other improvements that could be made to the software furnished with the IP Telephony systems. This information shall be made available for 15 years after final acceptance.
- H. Network Requirement:
- As the network becomes more and more congested. Special requirements are need on all switches and routers.
1. High Availability with Dual Switches and Routers on Campus Distribution and Core Layers
 2. Quality of Service (QOS) within all VOIP areas
 3. Resource Reservation Protocol (RSVP) within WAN areas for heterogeneous networks

2.02 EMERGENCY TELEPHONE (ET) SYSTEM

- A. Existing System Description:
1. The ET system consists of telephone sets installed in stations; wayside facilities including train control houses, ventilation structures, and traction power facilities; along the trackway in Emergency Trip Stations. Emergency telephone sets in the Station shall be installed in or near the Platform Trip Stations, and in the Emergency Management Panel Room.
 2. Lifting the handset at any emergency telephone location places the caller on an immediate connection with the LMA operator at Central Control and in the Station Agent's booth of the covering passenger station. Location of the calling party is displayed on the visual display at Central Control, and magnetic tape recordings are automatically made of the entire conversation.
 3. Lifting the handset initiates one-way inbound signaling to Central Control. The calling party receives a "ringback" tone to indicate that the call to Central Control is ringing. The Central Control operator answers the call by depressing the flashing console selector

button after lifting the red emergency telephone (ET) handset from its console hook. The ringback tone is removed when Central Control answers.

4. The Station Agent can also initiate a call to Central Control over the emergency telephone system.

2.03 FIRE TELEPHONE (FT) SYSTEM

A. Existing System Description:

1. The FT system consists of telephone sets installed in 14 below grade Passenger Stations, at the middle of each platform, at mezzanine near the fire alarm panel, at emergency exits, and at street level Command Post. Jackboxes are installed at a Fire Radio Call Box, at cross passages in below grade wayside tunnels (Berkeley Hills Tunnel and Transbay Tube), and at fire hose or standpipe locations.
2. The FT system provides audio communication and visual signaling between handsets located at street level and on each side of platform level below ground and on each jackbox location. The system is a dedicated closed loop design where all handset and jackbox locations on the "party line" can communicate with each other up to six (6) handsets simultaneously.
3. Lifting a handset from the hookswitch or plugging into a jackbox location turns on a normally off strobe light located above the telephone set, this in turn would begin to strobe at all locations on the system. The light continues to strobe until all parties hang-up and remove handset from jackbox.
4. The handsets and strobe lamps are connected by a single communication cable providing conductors for both audio and signaling.
5. The fire telephone system and strobe lamps are battery powered under constant charge. In the event of loss of AC power, the batteries will have enough capacity to operate the system for 200 hours. The batteries and chargers are located in the Train Control Room.

B. FT System Requirements:

1. The fire telephone system shall be designed in accordance with the technical and operational requirements of the existing FT as described above.
2. Fire Telephone handsets shall be provided in underground stations as indicated. Jackboxes shall be provided in subways and tunnels as indicated.
3. Major components and devices for the FT system shall include the following;
 - a. Telephone handsets with hookswitch and portable handsets shall be of rugged and durable construction and intended for emergency applications. Handsets installed in station premises shall be either pole or wall mounted units. Portable handsets shall have a shoulder strap carrying case. The handsets shall be a push-to-talk amplified unit with an armored cord.

- b. Jackboxes shall be yellow in color and shall contain one standard telephone jack (tip, ring and ground sleeve). The box shall be weather resistant with a spring loaded or gravity-drop door. The jacks shall have corrosion resistant contacts (gold plated) and wired to a four position terminal strip in the box.
 - c. The batteries shall be sealed lead-calcium type designed with a life expectancy of twenty years. The battery charger shall be current limited with short circuit protection for 120 VAC input and filtered DC output. The battery shall be sized to provide full operation at room temperature for ninety minutes after loss of normal power.
 - d. Telephone enclosures shall be weatherproof and constructed of die-cast aluminum. The enclosure shall be lockable with yellow color and mark with "TELEPHONE" on the door. All hardware, including straps for pole mounting shall be stainless steel.
 - e. The strobe lamps with a yellow colored dome shall be designed for surface or pole mounting. The housing shall be aluminum die-cast or stainless steel with stainless steel hardware. The flash rate of the lamp shall be 80 flashes per minute rated at 1,000 effective candlepower with a peak candlepower of 75,000.
 - f. Other miscellaneous materials including cables, conduit and fittings, pull boxes and termination blocks shall be as specified in Section 20 70 26 - Common Materials and Methods for Electrical Systems, and Section 20 50 13 - Raceways for Facility Services
4. A connection shall be provided at each passenger station such that monitoring (recording) shall be possible at the LMA Central Control.

2.04 INTERCOM SYSTEM.

- A. An intercom system shall be provided at end-of-line Stations.
- B. The intercom system shall provide communications between the Supervisor's Booth and the Employee Lounge/Break Room.
- C. Communications between room locations shall be hands-free after initially pushing a call button.
- D. The intercom unit in the Supervisor's Booth shall be provided with volume control adjustment.
- E. The intercom unit in the Supervisor's Booth shall be a Desk-type, and in the Employee Lounge/Break Room shall be a wall-mounted unit.

2.05 EMERGENCY CALL BOX.

- A. Emergency Call Boxes (ECB) shall be located, as shown on site plans, for parking lots and parking structures to provide a direct line to BART Police Dispatch via the 911 emergency assistance feature of the Telephone switch.
- B. Communications shall be hands-free after initially pushing a call button.

- C. A blue light with emergency strobe will be provided at each ECB location.
- D. ECB telephone, strobe light and housing will be weatherproof.
- E. ECB housing will be provided with appropriate ADA approved signage.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Station wiring for all telephone systems shall be four-pair telephone CAT 5E cables. Station and feeder cables shall not be spliced together.
- B. The power source for all telephone systems (except for the fire telephone system) shall be fed from the DC distribution power panel.
- C. Quantity and approximate locations of telephone system equipment are shown on the Contract Drawings.

3.02 TESTING

- A. Testing shall be performed in accordance with the requirements specified in Contract Specifications Section 01 45 24 - Testing Program Requirements. The following tests shall be performed on each telephone system to demonstrate the above named features as applicable:
 - 1. Station to station calling.
 - 2. Station to trunk calling.
 - 3. Trunk to station calls.
 - 4. Initiate traffic to/from the system that shall activate the various progress and signaling signals/tones generated by the respective system:
 - a. Dial tone.
 - b. Station busy tone.
 - c. All trunks busy (congestion) tone.
 - d. Ringback tone.
 - e. Station ringing.
 - f. Distinctive ringing.
 - g. Delayed ringing at LMA Central (90 seconds for Elevator intercom to ET system).

TELEPHONE SYSTEMS

- h. Maintenance and Administration data is received, accepted, and transmitted in accordance with District and manufacturer's specifications.
- i. Transmission and signal levels across all interfaces with other systems and subsystems.

END OF SECTION 27 30 01

COMMUNICATION CABLES AND RELATED EQUIPMENT

1. Unshielded cables shall only be utilized in non-wayside facilities such as the Lake Merritt, maintenance facilities, administrative offices, etc. Unshielded cables shall be plenum rated with four balanced, unshielded twisted pairs (UTP). Conductors shall be #24 AWG solid copper. Cable insulation jackets shall be color coded for the service type: blue for data, white for voice, and green for video applications.
2. Shielded cables shall be used in all wayside facilities. Shielded cables shall be plenum rated with an overall foil tape shield and four balanced, unshielded twisted pairs (F/UTP). Conductors shall be #24 AWG solid copper. The shield shall be an aluminum foil tape enclosing a 24 AWG tinned copper drain wire. Cable insulation jackets shall be color coded for the service type: blue for data, white for voice, and green for video applications.
3. Cable jackets shall be legibly marked with the following information:
 - a. Manufacturer's Name
 - b. Copper conductor gauge
 - c. Pair count
 - d. UL or CSA listing
 - e. Manufacturer's Trademark
 - f. Category rating, including UTP, F/UTP or ScTP (screened twisted pair)
 - g. Sequential foot markings, in one or two foot increments
4. Unshielded Category 6 patch cables shall be rated for 250 MHz or better and shall be composed of four, 24 AWG stranded copper conductors with 50-micron, gold plated RJ-45 male to male connectors and a plenum jacket.
5. Shielded Category 6 patch cables shall be rated for 250 MHz or better and shall be composed of four, 24 AWG stranded copper conductors with shielded 50-micron, gold plated RJ-45 male to male connectors, an overall shield with aluminum foil tape enclosing a 24 AWG tinned copper drain wire, and a plenum jacket.

2.07 VIDEO COAXIAL CABLE

- A. Provide coaxial cables for analog video signal transmission:
 1. 75 Ω characteristic impedance.
 2. Double braided copper shield.
 3. AWG No. 20 solid copper center conductor.

COMMUNICATION CABLES AND RELATED EQUIPMENT

2.08 RADIO COAXIAL CABLE

- A. Provide coaxial cables for radio signal transmission. Coaxial cables shall be size ¼" minimum, jacketed, corrugated, low density foam-filled for trunked radio applications. The minimum design requirements and general characteristics are as follows:
1. 50 Ω characteristic impedance.
 2. VSWR shall be 1.2: maximum at center frequency.
 3. Minimum bending radius shall be 10 inches.
 4. Attenuation shall not exceed 1.8dB, referenced to MHz.
 5. Outer conductor shall be solid copper.
 6. Inner conductor shall be copper.
 7. The cable shall be permanently identified.
 8. Connectors shall be EIA type N jack (female) on both ends.
 9. Grounding kits shall be provided to ground all coaxial cables to the tower top, tower bottom, and at the building entrance.
 10. Snap-in hanger kits shall be provided to mount coax cable directly into holes in the tower support members.

2.09 SLOTTED RADIO COAXIAL CABLE

- A. The minimal design requirements and general characteristics of the slotted coaxial cables are as follows:
1. The slotted coaxial cables shall pass the UL 854 and 1581 flame tests (similar to IEEE 383, NES 711/713, and IEC 332-3), UL listed under Article 820 of the National Electrical Code, and all code requirements must be approved by the fire inspector.
 2. The slotted coaxial cables shall be jacketed, corrugated foam-filled cables suitable for mounting to a metallic (galvanized steel) messenger wire or hangers.
 3. Cable jacket shall offer fire-retardant, hydro-carbon protection, halogen-free performance, low-level smoke and toxic fume emissions. The jacket shall be vertical tested and approved by Underwriters Laboratories.
 4. Coupling loss measured at 20 feet shall not exceed the following:
 - a. Coupling Loss (dB) @ Frequency Band (MHz).
 - i. 82 @ 800
 - ii. 82 @ 900

COMMUNICATION CABLES AND RELATED EQUIPMENT

- iii. 73 @ 1800
 - iv. 72 @ 1900
 - v. 71 @ 2200
5. Characteristics impedance shall be 50 ohms.
 6. Typical VSWR shall be less than 1.3:1, referenced to 30, 150, 450 and 900MHz.
 7. Minimum bending radius shall be 10 x diameter.
 8. Attenuation measured at free space shall be less than 1.0 dB per 100 feet, referenced to 900 MHz.
 9. Inner and outer conductors shall be copper
 10. The cable shall be permanently identified.
 11. Slotted coaxial cables shall be factory assembled, tested and furnished in continuous reel lengths of 2300 feet maximum with factory installed EIA type N female connectors on both ends.
 12. The outer conductor shall be two layers of mica insulated barrier tape wrapped around the conductor to prevent dielectric material from leaking through the slots under fire conditions.
 13. The cable shall have a flooding compound between the jacket and outer conductor barrier tape to prevent entry of water.

2.10 OPTICAL CONNECTORS

- A. Patch Panel Connectors: LC ultra physical contact (UPC) connector with 126um (single mode) or aqua 127um (multimode) ceramic zirconia alignment ferrules shall be used for fiber patch panels. Connector insertion loss shall be nominally 0.3 db and less than 0.5 db. LC connectors shall be field installable. Dust caps shall be provided for all sleeves.
- B. Equipment Connectors
 1. Fiber optic connectors shall match and be compatible with equipment terminations. Connector insertion loss shall be nominally 0.3 db and less than 0.5 db. Connectors shall be field installable. Dust caps shall be provided for all sleeves.
 - a. Equipment connector preference order:
 - i. LC (Lucent Connector) UPC
 - ii. SC (Subscriber Connector)
 - iii. BART-approved

COMMUNICATION CABLES AND RELATED EQUIPMENT

2. Multimode connectors shall be an aqua multimode LC connector pair with a duplex clip, a 127 um ceramic zirconia ferrule, supplied with a white 900 um for buffered fiber and a 1.6 mm boot with white and yellow shrink sleeves for patch cables.
3. Singlemode connectors shall be a single mode LC connector pair with a duplex clip, a 126 um ceramic zirconia ferrule, supplied with a white 900 um for buffered fiber and a 1.6 mm boot with white and yellow shrink sleeves for patch cables.

2.11 FIBER PATCH PANELS

- A. Fiber patch panels shall be a complete system of components furnished by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Fiber patch panels shall be ADC TFP series with specified accessories or approved equal. Patch panels shall employ wall-mountable connector housings equipped as follows:
 1. Sized to accommodate 48 fibers.
 2. Three multi-mode connector panels accommodating 12 fibers with LC connectors.
 3. One single-mode connector panel accommodating six fibers with LC connectors.
 4. Four splice trays with splice protectors.
 5. One splice tray holder.

2.12 CATEGORY 6 PATCH PANELS

- A. Category 6 Patch Panel Design Requirements
 1. Unshielded category 6 patch panels shall employ a modular design that utilizes jacks installed into each panel position.
 2. Unshielded category 6 jacks supplied with the panel shall meet the TIA/EIA-568-C.2: "Balanced Twisted – Pair Telecommunications Cabling and Component Standard". Unshielded category 6 jacks shall also be available separately with detailed installation instructions.
 3. Panel ports shall have a rectangular, industry standard keystone opening (.760" x .580") with a permanent port identifier number under each opening.
 4. Panels shall have integral cable management features in front for patch cords and features in the rear for horizontal cable management.
 5. Panels with installed jacks shall be backward compatible with existing category 3, 5, 5E, and category 6 cabling systems for fit, form, and function.
 6. Shielded patch panels shall have provisions for connection of grounding jumpers from each installed shielded jack.

COMMUNICATION CABLES AND RELATED EQUIPMENT

B. Category 6 Patch Panel Performance Requirements

1. All transmission parameters shall be verified by a UL or ETL testing organization. Transmission testing shall be to 250 MHz.
2. Unshielded category 6 panels with unshielded jacks installed shall exceed transmission requirements specified in ANSI/TIA/EIA-568-C (specification limit is 250 MHz).
3. The Manufacturer shall provide compliance certificates from a third party testing organization upon request.
4. Panels shall be UL listed 1863 and CSA certified.
5. Panels shall exceed IEEE 802.3 DTE power specification to four times the rated current limits with no degradation of performance or materials.
6. Panels shall be third party verified to Gigabit Ethernet performance according to IEEE 802.3Z (current draft).
7. Panels shall meet or exceed the four-connector channel performance requirements of ANSI/TIA/EIA-568-C.2 standard.
8. Unshielded Patch Panels: The four-connector channel test configuration shall utilize unshielded Category 6 jacks, patch panels and patch cords, from the same manufacturer, with qualified unshielded twisted pair (UTP) Category 6 cable.
9. Shielded Patch Panels: The four-connector channel test configuration shall utilize shielded Category 6 jacks, patch panels and patch cords, from the same manufacturer, with qualified screened (ScTP OR F/UTP), or shielded (STP) Category 6 cable.

2.13 OUTLETS, HARDWARE, AND CONNECTIONS

- A. Work Area Outlets (WAOs): WAOs shall be Category 6 keystone jacks with universal wiring (TIA568A/B) mounted in single or dual port faceplates as required when within TIA568C.1 length specifications. Category 6 WAOs exceeding TIA568C.1 length specifications can use fiber cable terminated to District approved flush-mounted wall boxes or fiber style keystone jacks with 2 or 3 duplex port face plates as required.
- B. Category 6 Keystone Jack color:
 1. Wayside Facilities
 - a. Red - Analog Telephone
 - b. Yellow - Digital Telephone
 - c. Purple - IP Telephone (voice only)
 - d. Green - Async, T1 Connection
 - e. White - Administrative network
 - f. Orange - Network Management Systems (NMS) network
 - g. Black - Security network
 - h. Blue - BARTnet network
 - i. Grey - Unassigned
 - j. Beige - Unassigned

COMMUNICATION CABLES AND RELATED EQUIPMENT

2. Central Facilities
 - a. Shall be coordinated with the District.
- C. Fiber Keystone Jack Color:
 1. Shall be coordinated with the District.
- D. Destination Sign Units (DSUs): Connector modules for DSU outlets shall be Designated Matching Product, Seimon SMC-SA-02-C. Sign hangers shall be constructed of ASTM A500 Grade B structural steel tubing.
- E. Automatic Fare Collection (AFC) Equipment: Telecommunication outlets for AFC equipment fiber cable connection shall be Designated Matching Product Seimon Model SM6-BL-02. Three dual ST to ST connector sleeve insert modules, Designated Matching Products, Seimon Part No. SMC-SA-02-C, shall be furnished for each AFC equipment outlet.

2.14 FIBER OPTIC PATCH CORDS

- A. Patch cords shall be cable assemblies consisting of flexible optical fiber cable equipped with compatible connectors. Patch cords shall be complete assemblies from manufacturer's standard product lines. Length shall be as required. Patch cords shall meet the following requirements:
 1. Fiber optic patch cords shall be two-fiber zip cord type with a 1.6 mm OD or approved equal.
 2. 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. The cable jacket color shall be orange. The fiber core size shall be identified on the outer jacket
 3. Fibers shall be terminated at each end with connectors as specified herein.

2.15 RADIO COAXIAL PATCH CORDS

- A. Jumper Cables shall be size ¼" minimum, jacketed, corrugated, super flexible foam-filled for patch applications. The cables shall be suitable for connecting coaxial foam cable to antenna and trunk radio combiners and/or multicouplers. The minimum design requirements and general characteristics are as follows:
 1. VSWR shall be less than 1.2:1.
 2. Connectors shall be type N plug (male) on both ends.
 3. Attenuation measured at 100 feet shall not exceed 5 dB referenced to 1800 MHz.
 4. Characteristics impedance shall be 50 ohms.
 5. Length shall be approximately 6 feet.

COMMUNICATION CABLES AND RELATED EQUIPMENT

6. Cables shall be factory assembled and tested.

2.16 SLOTTED RADIO COAXIAL PATCH CORDS

- A. Patch Cables shall be size ¼" minimum, jacketed, corrugated, super flexible foam-filled for patch applications. The cables shall be suitable for connecting coaxial foam cable to antennas and bidirectional heterodyne repeater amplifiers. The minimum design requirements and general characteristics are as follows:
 1. VSWR shall be less than 1.5:1.
 2. Connectors shall be type N plug (male) on both ends.
 3. Characteristics impedance shall be 50 ohms.
 4. Length shall be approximately 6 feet.
 5. Cables shall be factory assembled and tested.
 6. Patch cables shall be designed to meet the minimum requirement of 2.11.A, 1 and 2,

2.17 PIGTAIL CABLES

- A. Cables used for connections to equipment shall be flexible fiber pigtail cables having the same physical and operational characteristics as the parent cable. The cable jacket shall be flame retardant PVC or FCP, which complies with NFPA 70 for OFNP applications. Maximum db loss for pigtail cables shall be 3.5 db/km at 850 nm, and 1.0 db/km at 1300 nm.

2.18 INNERDUCTS

- A. Innerducts shall be corrugated semi-ridged construction, LSZT material, and shall have an inner diameter of no less than 1.25 inches and no more than 2.0 inches. Couplers, if used, shall not reduce the inside diameter of the innerduct.

2.19 COPPER CABLE SPLICE CASES

- A. Cases for splicing copper cables shall be of the type capable of being re-opened without disturbing splices, and of being reclosed. Cases shall have devices for centering cable so as to allow filling compound to cover conductors. Hardware shall be of stainless steel. Cases shall be braced to prevent cracking.
 1. Filling Compound: Compound for filling splice cases shall be a polyurethane telephone material that is transparent after curing. The compound shall adhere to conductors and splices, but shall be capable of being easily pulled away in a mass from conductors and splices. Compound shall be non-corrosive to conductors and splicing devices and shall not be toxic.
 2. Splice Connectors: Connectors shall be sized for the specific conductors to be spliced or tapped. The connector material shall be compatible with the conductor. The tools used for application shall have a positive action that will prevent over- or under-crimping.

COMMUNICATION CABLES AND RELATED EQUIPMENT

2.20 TERMINAL BLOCKS

- A. Terminal blocks shall be DIN-rail mounted, single or two level as required by the application, and meet the following requirements:
 - 1. Wire gauge range: 28 – 12 AWG.
 - 2. Current rating: 25 amps.
 - 3. Voltage rating: 600 V
 - 4. Terminal width: 5 or 6 mm.
 - 5. DIN rail: 35 mm.
- B. Terminal blocks shall be as manufactured by ASI. Inc., series ASI1492 or equal.

2.21 TEST EQUIPMENT

- A. A test report including data sheets shall be generated by tester and submitted to the District for approval.
- B. Multifunction loss testers shall perform the following instrument functions:
 - 1. Loss meter.
 - 2. Power meter.
 - 3. Optical return loss (ORL) meter.
 - 4. Visual fault locator.
 - 5. Multimode and single mode light sources.
 - 6. Digital talk set.
 - 7. Fiber length tester.
 - 8. Video fiber inspection probe.
- C. The multifunction loss tester shall be an EXFO FOT-930 MaxTester or equal. The Contractor may use the testers for ORL and optical power loss testing.
- D. The optical spectrum analyzer (OSA) shall be optimized for 100 GHz spacing and DWDM network testing. The OSA shall be EXFO model FTB-5230 or equal.
- E. The copper and fiber cable analyzer shall provide certification testing meeting EIA/TIA standards. The Cable Analyzer (copper and fiber) shall be model FLUKE DTX-1800-MSO or equal.
- F. Surface Inspection interferometer testing for field fiber connector termination. The surface

COMMUNICATION CABLES AND RELATED EQUIPMENT

Inspection interferometer shall be model DAISI Digital Automated Interferometer or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Coordinate installation of wires and cables with the requirements of Section 20 70 26 - Common Materials and Methods for Electrical Systems, and Section 20 50 13 - Raceways for Facility Services.
- 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 California Electrical Code and NEMA WC70, Appendix N.
- D. Bundle cable and conductors neatly and securely with nylon straps located in branch circuit panel boards, equipment cabinets and control panels. Use nylon bundling straps; bundle power cables separately from control cables.
- E. For wire pulling, comply with the following requirements:
 - 1. Do not pull wires into conduit until conduits and outlets have been thoroughly cleaned and swabbed. Do not use a block and tackle or other mechanical means for pulling conductors smaller than 2 AWG in raceways.
 - 2. 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, provide the Engineer with cable pulling calculations prior to making the pull.
 - 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.
- F. Power and Control Cable Installation in Manholes and Pull boxes: Route cables along the manhole or handhole walls providing the longest possible slack. Form cables closely parallel to the walls so that they do not interfere with duct entrances, supported on brackets and cable insulators spaced at a maximum of four feet. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, modify the existing locations of cables, cable supports, and grounding as required providing a properly arranged and supported installation.
- G. Wayside Copper Cable: Wayside copper cable shall be homerun from the device such as the telephone in a BLS to the protector blocks in the associated wayside facility. Wayside copper cable splicing is not allowed.

COMMUNICATION CABLES AND RELATED EQUIPMENT

- H. Install fiber optic cables as follows:
1. Install all horizontal and interfacility fiber optic cables in innerducts. Provide all unused innerducts with lubricated pull tape or line.
 2. Install each communication cable, including traction power cables, between wayside facilities in an innerduct in the communications section of the system-wide raceway.
 3. Install each train control cable between TCRs or TCHs in an innerduct in the train control section of the system-wide raceway.
 4. Install all lateral cables between the system-wide raceway and wayside facilities in separate innerducts.
 5. Spare fibers shall be secured and supported neatly with Velcro.
 6. Terminate all backbone and horizontal fiber optic cable to maintain manufacturer-recommended bending radii, pulling tension, and cable support requirements. All cables and equipment shall be securely and neatly installed. Inside routing shall be installed parallel and perpendicular to existing structural lines and members. Plastic or metal cable ties shall not be used; only Velcro or Millipede ties are permitted.
- I. Fiber optic cable pulling shall comply with the following:
1. Pull on the cable strength members only. Do not pull on the jacket unless it is specifically approved by the cable manufacturer and an approved cable grip is used.
 2. Do not exceed the maximum pulling load rating. On long runs, use proper lubricants and make sure they are compatible with the cable jacket. If possible, use an automated puller with tension control or at least a breakaway pulling eye.
 3. Do not exceed the cable bend radius.
 4. Do not twist the cable. Roll the cable off the spool instead of spinning it off the spool end. When laying cable out for a long pull, use a "Figure 8" on the ground or use a swivel pulling eye to prevent twisting forces on the cable.
 5. Verify that the cable is long enough for the run.

3.02 CABLE IDENTIFICATION

- A. 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.
- B. 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.
- C. If suspended type identification tags are provided, attach the tags to slip-free plastic cable lacing units or to nylon bundling straps.

COMMUNICATION CABLES AND RELATED EQUIPMENT

3.03 CABLE LABELING

- A. Provide identification tags or labels for each cable. Markers, tags and labels shall use indelible ink or etching which will not fade in sunlight or in duct applications. Markers, tags, and labels shall not become brittle or deteriorate for 30 years. Label all termination panels with cable number or pair identifier for cables in accordance with EIA TIA-606 and as specified. Identify the labeling format and provide a complete record to the District with the final documentation. Identify each cable with type of signal being carried and termination points.
- B. Affix identification and warning signs and tags to fiber distribution panels, terminal equipment, patch cords and fiber optic cables.
- C. Provide weatherproof warning tags to flag the presence of optical cables. Install such tags on or near optical cables, using distinctive tags to identify the cables, in the following locations:
 - 1. Every 100 feet in underground track ways.
 - 2. Every 10 feet in communications equipment areas.
 - 3. At each location where optical cables enter or exit raceways of any sort.
 - 4. On exposed conduit runs under station platforms or in plenums, at intervals of 50 feet.
 - 5. At each manhole location along the communications wayside conduit bank runs.

3.04 SPLICING AND TERMINATION OF FIBER OPTIC CABLES

- A. Make splices in fiber optic cable fibers only inside TCRs and TCHs, protected equipment rooms, or in accessible wayside splice enclosures. Submit a description of each type and location of splice that will be used, naming the materials, devices, tools, instruments, and other details.
 - 1. All splices, including splices of pigtails to incoming fibers, shall be the fusion type. Apply protective covering and coating, made of compatible material, to all completed and tested splices.
 - 2. Contain splices within re-enterable splice modules that are designed specifically to accommodate fiber splices and the prescribed extra lengths of fiber.
 - 3. If splices are not made immediately after cable installation, seal the free ends of such cables as recommended by the manufacturer to prevent entrance of moisture and contaminants.
 - 4. Do not splice optical cables along the wayside unless all other options have been explored and found to be technically impractical. Splices along the wayside shall be subject to the approval of the District Representative. Where allowed, make splices in outdoor weatherproof splice enclosures, complete with entry raceways, foundations, mounting hardware, secured access door, and exterior fittings.
 - 5. Equip the interior of wayside splice enclosures with modules and fittings designed to organize the cables, splices, and prescribed extra length of fibers. Make provisions to add a renewable desiccant compound to protect against condensation or migration of water.

COMMUNICATION CABLES AND RELATED EQUIPMENT

6. Optical Cable Terminations at TCRs/TCHs, Vent Structures and Portal Communication Cases (PCCs): Terminate all fibers at the fiber distribution panel within each TCR/TCH, vent structure and PCC as follows:
 - a. Terminate incoming optical fibers using matching single-mode optical fiber pigtail assemblies. Splice such optical fibers to the pigtail assemblies within a splice tray or trays.
 - b. Assign and terminate incoming and outgoing optical fibers; spares that are designed to pass through the local site shall be spliced together within a splice tray or trays where designated splices are configured.
 - c. Configure terminations so as to use the least number of splices feasible.

3.05 CATEGORY 6 CABLE AND PATCH CORD INSTALLATION

- A. All backbone and horizontal Category 6 cable shall be terminated to Keystone style jacks. Maintain Manufacturer- recommended bending radius, pulling tension, and cable support requirements. All cables, wires, and equipment shall be securely and neatly installed. Inside routing shall be installed parallel and perpendicular to existing structural lines and members. Plastic or metal cable ties may not be used; only Velcro or Millipede ties may be used.
- B. Category 6 data cabling shall be terminated in accordance with the TIA/EIA 568B sequence specification.
- C. Category 6 patch cords shall be terminated in accordance with the TIA/EIA 568A or TIA/EIA 568B sequence specification.

3.06 CATEGORY 6 PATCH PANEL INSTALLATION

- A. Mount patch panels into the designated rack, cabinet, or bracket locations. Surface mount or DIN rail patch panels may be used when the use of rack mount patch panels is not feasible.
- B. Keystone jacks are required for Category 6 cable termination. Terminate the shielded or unshielded jacks as applicable and install into the patch panel according to manufacturer's instructions.
- C. Cable terminations shall have no tensile or bending strain on the installed shielded jacks.
- D. Consolidation point equipment, where applicable, shall be fully installed and terminated prior to testing.
- E. Panels shall be labeled on front and back with the cable number and port connections for each port.
- F. Shielded Patch Panels: The panel grounding strap shall be installed to connect the cable shield and drain wire to the building signal ground in accordance with ANSI-J-STD-607-A.

3.07 FACTORY TESTS

- A. Refer to Contract Specifications Section 20 72 25 - Factory and Field Testing.

COMMUNICATION CABLES AND RELATED EQUIPMENT

- B. Cable Tests: Test single mode and multimode fiber optic cables in accordance with EIA RS-455.

3.08 FIELD TESTS

- A. The requirements for test planning, scheduling, performance, recording of data, and reporting of test results shall be as specified in Contract Specifications Section 20 72 25 - Factory and Field Testing.

- B. Fiber Optic Cable Reel Tests.

1. Fiber Optic Reel tests: Perform the following tests on fiber optic cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the media. Perform optical time domain reflectometer (OTDR) tests with media on the reels and compare factory and field test data.
2. Reel Test Results: Provide results of reel tests to the District at least 10 working days before installation is to commence. Results shall indicate reel number of the media, manufacturer, type and number of fiber tested, and recorded readings. When reel tests indicate that the media does not comply with factory reel test results, remove the media from the job site and replace with compliant media.

- C. Fiber Optic Cable Installation Tests:

1. Test all single mode and multimode fiber strands end-to-end for bi-directional attenuation, 850 nm/1300 nm for multimode and 1310 nm/1550 nm for single mode fibers. Conduct tests in compliance with EIA/TIA-526-14 or OFSTP 14, Method B, according to the manufacturer's instructions for the test set being utilized.
2. Tests must ensure that the measured link loss for each strand does not exceed the "worst case" allowable loss defined as the sum of the connector loss (based on the number of mated connector pairs at the EIA/TIA-568 B maximum allowable loss of 0.75 dB per mated pair) and the optical loss (based on the previously-specified performance standards).
3. After the cable is terminated, perform the following tests:
 - a. After termination, test each fiber with an OTDR for length, transmission anomalies, and end-to-end attenuation. Perform the test in accordance with ANSI/TIA/EIA-455-8-2000, Measurement of Splice or Connector Loss and Reflectance Using an OTDR.
 - b. Insertion Loss: An OTDR shall be used to measure splice losses and identify events such as bad or dirty connectors, fiber bends, bad splices, and mismatched core sizes. Conduct the test in accordance with ANSI/TIA/EIA-455-34-A-2002, Interconnection Device Insertion Loss Test. Detected problems on a given link shall be corrected and then retested before proceeding with subsequent tests.
 - c. Optical Power Loss (OPL) and Optical Return Loss (ORL): The specified multifunction loss tester shall be used to measure OPL and ORL on each link. The ORL shall be 20 dB minimum for multimode fiber and 26 dB minimum for single mode fiber.

COMMUNICATION CABLES AND RELATED EQUIPMENT

- d. The maximum allowable attenuation for any splice or termination is 0.3 dB.
 4. Review all end faces of field terminated connectors with a fiber inspection scope following the final polish. Connector end faces with hackles, scratches, cracks, chips, or surface pitting shall be rejected and repolished or replaced if repolishing will not remove the end face surface defects. The recommended minimum viewing magnifications for connector ends are 100X for multimode fiber and 200X for single mode fiber.
 5. Conduct surface inspection testing of each fiber connector using the DAISI interferometer. The return loss performance of UPC fiber optic connectors shall be 50 dB or higher. Surface inspection testing for manufactured connector pigtails provided with factory certification documentation is not required.
- D. Fiber Optic Network End-to-End Testing.
1. General: End-to-end testing shall be performed for all links that comprise two or more link segments that are connected via splices or patch cords. In each of the following tests, inspect and clean the fiber connectors before hooking them up to the test equipment. Test patchcords and patch panels shall also be cleaned. All tests shall be performed in both directions for each end-to-end fiber link.
 2. Repeat the OTDR, OPL and ORL tests specified in Section 3.08C.
 3. Spectral Domain Measurements for UON cables: Use the specified optical spectrum analyzer to measure the following parameters in an end-to-end test of all 24 WSX UON fibers from S20 to cabinet 204 located in the computer room at LMA designated for DWDM. This test shall be coordinated with and supervised by BART.
 - a. Chromatic dispersion (CD)
 - b. Polarization mode dispersion (PMD)
 - c. Spectral attenuation (multi-lambda)
- E. Shielded Category 6 Patch Panel Testing
1. Shielded category 6 patch panels shall be tested as part of the installed horizontal or backbone cabling system. Jacks and faceplates shall be assembled complete and properly mounted. Panels shall be terminated and fully dressed with proper cable management.
 2. Each link or channel in the cabling system shall be identified and tested individually, using at minimum an industry standard level IIIIE tester, capable of testing to TIA/EIA-568-C.2 field test requirements.
 3. Each panel port in the cable channel or link shall be tested for the shielded category 6 parameters listed below.

COMMUNICATION CABLES AND RELATED EQUIPMENT

WIRE MAP / CONTINUITY	LENGTH	INSERTION LOSS
NEXT	PSNEXT	ELFEXT
PSELFEXT	Delay and delay skew	Return loss

LEGEND:

ELFEXT - Equal Level Far-End Crosstalk

NEXT - Near End Cross Talk

PSELFEXT – Power Sum Equal Level Far-End Crosstalk

PSNEXT - Power Sum Near End Cross Talk

4. In addition to the above test parameters, the continuity of the cable shield and drain wire shall also be verified.
5. A “pass” indication shall be obtained for each channel or link, using at minimum a level IIIE tester that complies with TIA/EIA-568-C.2 field testing requirements.

F. Category 6 Cable Testing.

1. **General:** Test pairs of all installed F/UTP wiring for full compliance with Category 6 specifications regardless of intended use. Provide documentation of test results for all conductor pairs of each cable. Perform testing using the specified Category 6 cable tester. Test results shall be approved by the District prior to cable activation for voice, video, or data applications.
2. **Testing Parameters:** All four pairs shall meet or exceed the following measured specifications. Inspect any cable not meeting or exceeding the following for anomalies, and re-terminate or replace if necessary to ensure compliance.
 - a. Line map cables to verify pin-to-pin continuity, lack of opens, shorts, and/or polarity reversals.
 - b. The characteristic cable impedance shall be 100 ohms plus or minus 15 percent at 1 MHz to 100 MHz.
 - c. Mutual capacitance of any pair at 1 kHz shall not exceed 17 nF per 1000 feet.
 - d. Ambient noise shall be less than or equal to 40 dB.
 - e. Signal to noise ratio shall be greater than or equal to 7 dB.
 - f. Cable length shall be less than or equal to 90 meters.

END OF SECTION 27 13 01