PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Existing system description.
B. Radiating coaxial cable.
C. System requirements.
D. Installation, optimization, and field testing.
E. Maintenance, manuals, training, and support.

1.02 RELATED SECTIONS:

A. 01 33 00, Submittal Procedures
B. 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures
C. 33 83 01, Radio Network/Trunked Radio System
D. 33 83 05, Radio Network/Regional High-Level Radio System
E. 33 83 06, Radio Network/Bi-Directional Radio Amplifier System
F. 33 83 07, Radio Network/Mutual Aid Radio System

1.03 MEASUREMENT AND PAYMENT

All work required under this Section will be measured separately and will be paid for as part of the Contract lump-sum price, as part of the related item of work, as indicated on the Bid Schedule of the Bid Form.

1.04 REFERENCES

A. Association of Public Safety Communications Officials International (APCO):
   1. APCO Project 25 Standards for Digital Trunk Radio Communications
B. Federal Communications Commission (FCC):
   1. FCC Rules and Regulations Title 47 CFR, Telecommunications
C. National Electrical Manufacturers Association (NEMA)
D. National Public Safety Planning Administration Committee (NPSPAC):
   1. NPSPAC Northern California Region 6 Plan

E. United States Department of Homeland Security (DHS):
   1. DHS Project 25 Compliance Assessment Program (P25 CAP)

1.05 SUBMITTALS

A. Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. The Contractor shall submit the design, validation, and test planning report for the following:
   1. System Design
   2. Downlink and uplink power block design drawings
   3. Test planning submittals
   4. Factory Acceptance Testing (FAT)
   5. Equipment installation
   6. Turn-on
   7. Configuration
   8. Testing and commissioning
   9. Workmanship for RF transmission components and systems
   10. RF systems sweep tests
   11. RF PIM tests
   12. Optical Fiber DAS systems, OTDR test in both directions
   13. RF signal strength coverage mapping
   14. Detailed system configuration and tuning of downlink and uplink
   15. Radio testing, voice quality
   16. Bit Error Rate (BER) testing for all radio types (digital/analogue)
   17. Multiple unit testing, including diverse geographic locations
C. Design validation, workmanship validation of components and systems, completion of test plans, coverage validation, core and application functionality, and quality of radio service in all locations shall be completed before system is certified operational and turned-on.

D. Shop Drawings showing the layout of the system identifying the location of equipment and accessories.

E. Manufacturers’ product data for all manufactured items of materials, equipment, and accessories shown on the Shop Drawings.

F. Submit calibration certificates with greater than three months prior to expiration date, for test measurement equipment used by Contractor.

G. Test reports of tests conducted by the Contractor.

H. Certificates certifying that the equipment tested is ready for use.

1.06 DESCRIPTION

The District owns and operates an 800 MHz radio network. Modifications, coverage expansion, and upgrades or replacement to new radio products or technologies of the radio network are anticipated over time due to expansion and higher utilization of the BART system. The Fiber Distributed Antenna Systems (Fiber DAS) are one element of the BART radio network. Radio signals generated by other elements of the BART Radio Network are connected to and then distributed by the Fiber DAS into the underground trackway, trenches, stations, and facilities. BART currently uses the Harris EDACS and P25 Radio Systems and all the channels broadcast from these are repeated underground.

The existing BART Operational above ground trunked radio system is a 10 channel Enhanced Digital Access Communications System (EDACS™) simulcast system, as manufactured by MACOM/Ericsson/Harris. Later this will be refreshed to current Radio Systems product offering, likely P25 phase 2 when NPSPAC 6.25 KHz channels will be used.

BART has only deployed Andrews Fiber DAS and BDA fully redundant system throughout its tunnels, which are approximately 30 percent of its rail network. Each cell segment of underground coverage is approximately 2000 feet long, and has redundant radio feeds, UPS, and BDA at either ends. The Andrews Integrated Management Operating System (AIMOS) has its own full coverage Network Management System (NMS) reporting all functionality and graded alarms. This system has its own eight-hour minimum 48 VDC UPS System at each nodes. BART’s Operational EDACS channels are shown in Table 1.
Table 1: BART’s Operational EDACS Channels

<table>
<thead>
<tr>
<th>EDACS</th>
<th>BART MHz</th>
<th>BART Rx MHz</th>
<th>Trunked NPSPAC Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>Tx</td>
<td>Rx</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>851.0375</td>
<td>806.0375</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>851.3125</td>
<td>806.3125</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>851.5625</td>
<td>806.5625</td>
<td>42</td>
</tr>
<tr>
<td>4</td>
<td>851.8875</td>
<td>806.8875</td>
<td>68</td>
</tr>
<tr>
<td>5</td>
<td>852.0375</td>
<td>807.0375</td>
<td>78</td>
</tr>
<tr>
<td>6</td>
<td>852.2375</td>
<td>807.2375</td>
<td>94</td>
</tr>
<tr>
<td>7</td>
<td>852.5625</td>
<td>807.5625</td>
<td>118</td>
</tr>
<tr>
<td>8</td>
<td>852.8125</td>
<td>807.8125</td>
<td>138</td>
</tr>
<tr>
<td>9</td>
<td>853.0375</td>
<td>808.0375</td>
<td>154</td>
</tr>
<tr>
<td>10</td>
<td>853.3625</td>
<td>808.3625</td>
<td>180</td>
</tr>
</tbody>
</table>

Additionally, there is a Harris Corp P25 Core and 6 channel Trunked Radio System for underground only use. Currently this is only used for inter-agency support, and integration of consoles above the capacity of the EDACS system. BART’s current simulcast underground only channels are shown in Table 2.

Table 2: BART’s Current Simulcast P25 Underground only Channels

<table>
<thead>
<tr>
<th>P25</th>
<th>BART MHz</th>
<th>Trunked MHz</th>
<th>NPSPAC Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>Tx</td>
<td>Rx</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>851.6375</td>
<td>806.6375</td>
<td>48</td>
</tr>
<tr>
<td>2</td>
<td>852.1625</td>
<td>807.1625</td>
<td>88</td>
</tr>
<tr>
<td>3</td>
<td>852.3375</td>
<td>807.3375</td>
<td>102</td>
</tr>
<tr>
<td>4</td>
<td>852.6500</td>
<td>807.6500</td>
<td>125</td>
</tr>
<tr>
<td>5</td>
<td>853.6750</td>
<td>808.6750</td>
<td>205</td>
</tr>
<tr>
<td>6</td>
<td>853.8625</td>
<td>808.8625</td>
<td>220</td>
</tr>
</tbody>
</table>

Other conventional channels that are in-use is shown in Table 3.

Table 3: Current BART Conventional High Site and Underground Channels

<table>
<thead>
<tr>
<th>BART Conventional</th>
<th>Duplex Systems</th>
<th>12.5 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>Used By</td>
<td>Base Tx MHz</td>
</tr>
<tr>
<td></td>
<td>BART PD</td>
<td>851.1000</td>
</tr>
<tr>
<td>BART HL 2</td>
<td>Mut Aid</td>
<td>853.9875</td>
</tr>
<tr>
<td>CA HL FIRE 1</td>
<td>Mut Aid</td>
<td>851.2000</td>
</tr>
<tr>
<td>CA LL LAW 9</td>
<td>Mut Aid</td>
<td>853.5375</td>
</tr>
</tbody>
</table>
The existing BART U/G segments and head-end radios locations are:

- **Underground (U/G) Fiber DAS (Bi Directional Amplifiers) – ALL ANDREWs**
- **Channels – 10 Trunk EDACS, 6 Trunk P25, 2 High, 2 St Fire**
  - Millbrae /Colma Tunnel | HE1 W40 Millbrae | HE2 W10 Colma(1)
  - Balboa /SF to Civic Tunnel | HE1 W10 Colma(2) | HE2 LMA(1)
  - Civic to TTB Tunnel | HE1 W10 Colma(3) | HE2 LMA(2)
  - WYE Tunnel | HE1 LMA(3) | HE2 R50 EL C Del N(1)
  - Berkeley Tunnel | HE1 LMA(4) | HE2 R50 EL C Del N(2)
  - Chabot /Berkeley Hills Tunnel | HE1 LMA(5) | HE2 C30 WC West(1)
  - MacArthur Tunnel | HE1 LMA(6)
  - Hwy 238/580 Tunnel |HE1 LMA(7)
  - Walnut Creek Tunnel | HE1 WC West(2)

BART has deployed District Designated Product, Fiber DAS manufactured by Commscope (formerly Andrews) with fully redundant head-end and Commscope fully redundant remote end fiber optical based DAS systems, providing RF signal to each different end of Passive RF Leaky Coax (Radiax) System Segments (generally 2000 feet in length). All BART Commscope Systems have a Commscope, Andrew Integrated Management Operation System (AIMOS) Control and Monitoring System, using fixed software release level. All new units shall be fully compatible with BART’s existing Commscope System and Commscope AIMOS Control /Monitoring System.

BART has only deployed District Designated Product Commscope in-Building BDA Systems. Prior models are Andrews (acquired by Commscope) Node A 4, with LMR module AF 8037.

The radio system is designed to provide clear, intelligible communication from portable radios within the tunnel and building area coverage reliability of 95 percent or better. In some locations, radio signal penetration into tunnel and wayside facilities are insufficient to provide this level of communication performance. The provision of a Fiber DAS system or Bi-directional Radio Amplifier (BDA) system, supported with a local 48 VDC UPS power and battery system, providing eight hours of use on mains power failure, within such a facility corrects for this condition.

**PART 2 – PRODUCTS**

**2.01 DESIGN**

**A.** The Fiber DAS system is a District Designated Matching Product (DMP) and shall be composed of electronic equipment that accepts, combines, splits, processes, and amplifies radio signals, and a passive RF cabling system for distribution of those signals into the BART underground.
1. Below ground radio coverage shall be provided in all subway stations and tunnel areas. Radio coverage shall be made available along the BART operating alignment and wayside facilities. This includes the trackway, both public and secured areas of passenger station concourses and platforms. Highly sensitive sites such as fire command posts; and areas near electrical alarm panels. BART facilities shall be provided with coverage as indicated.

2. The DAS system shall be designed to interface with other elements of the BART radio network in a manner similar to that used by the existing in-service equipment. This generally consists of a transmit and a receive RF signal interface from the trunked radio system, the mutual aid system, and the regional high level system. Each RF input is separately derived and applied to the DAS system.

3. The Fiber DAS system shall consist of necessary equipment for processing, amplification, channelizing, and distribution of selected radio channels. It shall have capacity for operating with BART-use radio channels. It shall also have four channels for future inter-agency operations including fire, police, and other emergency agency personnel. Other channels shall be rejected.

4. The Fiber DAS system shall be constructed in a redundant manner. Radio feeds into the tunnel sections shall be fed from a “north” radio site, and from a “south” radio site. At each bidirectional amplifier node, two separate bidirectional amplifiers shall be provided: one connected to the north feed source, one from the south feed source. The two amplifiers shall be coordinated so that only one is in service at a time but will automatically connect to the other in case of an amplifier failure, feed source failure, or when manually commanded by the AIMOS.

5. Interconnection between the DAS tunnel portal radio feeds and the DAS radio network signal interface, co-located with specific trunked radio sites, shall be by single mode fiber optic cable.

6. DAS Radio System design and equipment shall adhere to applicable codes and regulations, including Federal Communications Commission (FCC) rules, and National Public Safety Planning Administration Committee (NPSPAC) Region 6 (Northern California) planning regulations for 800 MHz public safety agencies. Transmitting equipment shall be FCC type certified.

7. Equipment deployed outside of an environmentally controlled facility shall be housed in a NEMA 4 box, and suitable for operation at temperatures of 40 degrees Celsius.

8. Equipment installed in an environmentally controlled facility shall be mounted in a cabinet in compliance to California Building code.

9. The Fiber DAS shall provide radio coverage with radio signal strength between -90 dBm and -65 dBm, for over 95 percent of the coverage area of BART trackway, public areas of BART Passenger facilities, and other maintenance or operational facilities. Coverage area shall include the inside of BART revenue vehicles, while moving at speeds of up to 80 mph. The Bit Error
Rate (BER) of digital signals shall be greater than 1 in 1000. Performance shall be based upon use of handheld radios.

10. The system shall be provided with an AIMOS compatible System that permits remote interrogation and control of the equipment for the purposes of adjustment, diagnostics, and alarms.

11. Fiber Distributed Antenna Systems (Fiber DAS) or Bi-directional amplifiers (BDA) shall support the simultaneous flow of radio energy in uplink and downlink directions as follows:
   a. 806 to 809 MHz for uplink direction (handheld to base).
   b. 851 to 854 MHz for downlink direction (base to handheld).

12. The Radiating cable antenna system shall provide and support distribution of radio signals at levels sufficient to provide the radio performance described herein. Furnish RF budget calculations showing signal distribution and predicted performance throughout the facilities with stated coverage parameters. Splices and connectors shall be minimized. The fixings and supports touching the Radiax and within a 6-inch (150 mm) diameter from the center of the cable shall be non-metallic, low smoke zero halogen polymer, plastic or similar material. DC blocks shall be used to isolate between each BDA approximately 2000 feet Radiax sections.

13. Deployment of Radiating Cable
   a. In Tunnels:
      1) Two radiating cables, on the same side and 24 inches apart, shall be deployed along the length of each track, from tunnel portal to tunnel portal. The top cable shall be used for radio transmission (downlink), and the bottom cable for reception (uplink).
         a) The placement of the radiating cable shall be along each track and on the opposite side wall from the tunnel walkway, at a height 8 to 11 feet above the top of rail, but no lower than the top corner of the BART revenue vehicle. Six-inch edge to edge clearance will be provided around the radiating cable to other obstructions or infrastructure.
         b) The placement of the non-metallic, cable hanging, and hanger assemblies shall be in a straight line, consistently at the same tunnel position throughout the track environment. Alternative placement shall be permitted within the BART passenger station environment, such that the cable shall not be able to be touched by patrons.
         c) The cable system shall not encroach within the train car dynamic safety envelope.
         d) The cable shall not be placed in a manner that prevents its maintenance, or maintenance of adjacent equipment, or within 12 inches of tunnel lighting.
         e) It shall be up to the Designer to ascertain the proper radiating cable placement using these parameters.
2) Each track shall be provisioned with its own radiating cable. In underground areas that have more than two tracks and a common opening between tracks, two radiating cables, one cable on each outside side wall shall be deemed sufficient if radio calculations show adequate radio signal margin will be provided by this arrangement for all tracks.

3) Underground RF cable segments that interconnect adjacent amplifier equipment locations which are spaced more than 100 feet apart shall be provided with DC isolation.

4) The cable size shall be as large as required to minimize the attenuation loss in the cable for the spans as designed. The cable shall be optimized for radio signals from 400 MHz to 6000 MHz.

5) The cable jacket and hanging assemblies shall be of a low smoke, non-halogen design.

6) Connectors shall have weatherproof boots or wrappings, suitable for the installation environment, applied to them prior to placing the radiating cable system into service operation.

b. In Stations:

1) Radiating cable system deployed for the stations must provide coverage for the public including normal and emergency egress and secured areas of the station. They shall be located in areas where they cannot be touched or damaged by the public.

2) Free space antennas may be used if their coverage will provide equivalent coverage as the radiating cable.

B. Design Modifications and Additions Requirements:

Modifications or additions to the DAS Radio System shall satisfy the following general design principles:

1. It shall be designed and deployed in a manner so that no single point failure will render the radio coverage to the underground BART trackway environment inoperable. If a failure occurs, the redundant path equipment shall take over operation of the system and provide annunciation of the failure into the AIMOS.

2. Fully compatible with and become an integral part of the existing radio network.

3. Provide redundancy of system by separate RF sources, FIBER DAS equipment, and UPS batteries.

4. Unless otherwise specified, DAS shall be configured to operate up to 25 duplex 800 MHz NPSPAC radio channels simultaneously and in composite, without performance degradation below requirements.

5. DAS system additions shall be compatible with and provide the same functions and operability as the existing Fiber DAS (Commscope/Andrews) system. This includes the redundancy, remote network management (Commscope/Andrews AIMOS System) capability, and interface ports available to other BART radio systems. If upgrades to the existing BART DAS system equipment are required
to establish compatibility to the new equipment, then those upgrades shall become part of the Work.

2.02 SYSTEM REQUIREMENTS

A. The following are system interface requirements:

1. RF signals from Trunked Radio shall be applied to the DAS equipment by use of RF couplers installed in the transmit and receive coaxial cables to the site above ground antenna system. RF signals from mutual aid radio and the regional high-level radio shall be coupled directly from local base stations, installed in the above ground radio site, into a DAS RF port. RF signal levels shall be coordinated, and specified by the DAS manufacturer.

2. Data, and control signals to and from DAS equipment site shall interface with the existing EDACS and P25 control point radio equipment systems at Lake Merritt and shall also be configured to be compatible with the requirements of the BARTnet.

3. RF Coverage: The Fiber DAS shall provide radio coverage in a manner that provides radio signal strength between -90 dBm and -65 dBm, over 95 percent of the coverage area of BART trackway, public areas of BART passenger facilities, and other maintenance or operational facilities. Coverage area shall include the inside of BART revenue vehicles, while moving at speeds of up to 80 mph. The Bit Error Rate of digital signals shall not be greater than 1 in 1000. Performance shall be based upon use of handheld radios.

4. Redundant fiber optic cables shall be used to transfer the RF signals between tunnel portal section equipment and specific above ground radio site equipment.

5. Power to the amplifier nodes shall be –48 V DC. Unless otherwise noted, the power supply, batteries, charging, and telemetry circuits shall be provided by the DAS manufacturer. The 48 VDC UPS batteries shall be capable of providing normal operation for a period of eight hours after loss of AC power.

6. Newly proposed Fiber DAS radio redundant amplifier sites shall be located to provide at least primary and secondary system radio coverage. New transmit site facilities shall be located away from existing source of signal interference to limit or minimize degradation to the trunk radio system.

7. New site locations shall be placed upon District-owned property or projected-District-owned property along the right-of-way if possible. If the location of District property is not suitable for establishing radio coverage performance, then the designer shall attempt to find space in an existing and developed radio facility. Failing that, other off-site property locations may be proposed and evaluated.
PART 3 – EXECUTION

3.01 INSTALLATION
A. The Radio System elements and backup electric power housing shall be located adjacently.
B. Installation work shall be completed to the site-specific drawings and specifications.

3.02 SYSTEM OPTIMIZATION
A. Each Fiber DAS and RF Passive Distribution System shall be optimized for coverage and performance. Then it shall be integrated into the full BART Radio System, without any deterioration of service throughout any part of BARTs network.

3.03 FIELD TESTING
A. Work shall be performed to complete the testing set out in the test planning submittals, Contract Drawings, and Specifications.
B. Verify that the radio systems equipment has been installed in accordance with the Contract Specifications, Contract Drawings, and the system performance criteria. This shall include inspection, test and measurements of the DC power, ground tests, RF components sweep tests, the coverage maps, system configuration and attenuation settings on updated power block diagram, Radio Voice Quality DAQ, and BER testing. Record all test measurements. Provide diagrams showing equipment placement and routing for antennas, coaxial cables, and AC power to the District’s Representative prior to acceptance testing. Power and network configuration settings shall be supplied with each test report. Submit an RF compliance certificate for each radio system at the conclusion of the acceptance testing.

3.04 TRAINING, MANUALS, SPARES AND SUPPORT
A. Full operating manuals and electronic documents shall be provided at each equipment location. Copies shall be provided to BART Engineering and Maintenance Departments.
B. Training shall be conducted by the original equipment manufacturer (OEM) or OEM partner engineering staff at BART premises for both engineering and maintenance engineers and technicians. Sufficient quantity shall be set up to allow staff from all shifts to complete training in small class sizes.
C. Spares shall be available for the Systems for 15 years from purchase, and if any components become unavailable, then OEM or OEM partners shall redesign replacements at their own cost, to keep equipment fully functional for this life-span.
D. OEM and OEM partners shall provide 24-hour support and support centers with knowledgeable tier 1 through 4 support staff available to support the systems for life of the product.
3.05 PREVENTATIVE MAINTENANCE SCHEDULES

A. OEM or OEM partner shall provide full preventative maintenance procedures and schedules for equipment and systems.

END OF SECTION 33 83 04