SECTION 19100

VOICE RADIO COMMUNICATION SYSTEMS

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes design and installation requirements for extension, upgrade, or retrofit of the existing VHF Voice Radio System.

1.02 REFERENCE STANDARDS

A. Design and installation shall be in accordance with the applicable codes and regulations, including the following:

1. National Electrical Code (NEC)

2. AREMA C&S Manual

3. CAL/OSHA standards

4. California Public Utilities Commission (CPUC) Regulations

5. State of California Electrical Safety Orders, Title 8

6. Federal Communications Commission (FCC) rules and regulations

7. Motorola R56 Grounding Standard

1.03 EXISTING SYSTEM DESCRIPTION - ABOVE-GRADE SUB-SYSTEM

A. Caltrain railroad consists of approximately 78 miles of railroad tracks serving freight and passenger operations between San Francisco and Gilroy. The railroad dispatch, operations and maintenance is served by a VHF Voice radio system which is configured as follows:

1. The VHF Voice Radio system consists of three distinct radio channels: a Road channel used to support train movement; a Maintenance of Way (MOW) channel used to support Operations and the Mechanical department; a Yard channel (aka Blue Flag). The Road channel is an analog, FM, narrowband (12.5 KHz) simplex channel operating on a frequency of 160.8150 MHz. The MOW channel is an analog, FM, narrowband (12.5 KHz) full duplex channel operating on the frequency pair: 161.5050 MHz for Base Station transmit and 160.5750 MHz for Base Station receive. The Yard channel is an analog, FM, narrowband (12.5 KHz) simplex channel, configured for independent local operation at the San Jose CEMOF and San Francisco 4th Street train yards.

2 A total of two independent dispatch work stations are located at the CEMOF, San Jose Centralized Control Facility (CCF). One of the two dispatch stations is responsible for supporting the "Northern" portion of the railroad, between MP (mile post) 0.0 and 44.0, and the second station supports the "Southern" portion of the railroad between MP 44.0 and 55.0

on the Road channel. Between MP 55.0 and the southern end of the railroad, train movement is controlled by the Union Pacific Railroad (UPRR). Although each dispatch station is "stand-alone" or independent of the other, they are also fully redundant to each other, since they are individually capable of supporting rail vehicle movements for both the northern and southern territory of the railroad. The operation of the MOW channel at CEMOF is system wide for both consoles and is therefore not restricted to these North and South limits. The Road and MOW channels are both managed and controlled from the Voice Radio dispatch consoles located at the CEMOF control center. The Yard channel is monitored, but equipment movement is not controlled by the dispatchers.

3. A total of four "above-grade" Road Channel radio Base Station sites, which are located along the Right-of-Way (ROW), are each configured for carrier-squelch, simplex operation on the road channel frequency of 160.8150 MHz. A second carrier-squelch, simplex channel, operating on a frequency of 161.0700 MHz is used to support maintenance and "yard" operation but is repeated only in the vicinity of the San Francisco and San Jose yards using the 4th street and the San Jose Base Station towers respectively. Of the 4 Base Station sites, three are controlled by the "Northern Territory" dispatch, and one by the "Southern Territory" dispatch. Refer to Caltrain Standard Drawings SD-6000 series for further details. The MOW channel uses two "above-grade" Base Station sites located at the Monument Peak and San Bruno mountain top sites. Both Road and MOW channels also utilize four (4) "at-grade" tunnel Base Station sites, described in subpart 1.04 below.

4. The "Northern" Road Channel dispatch Base Station sites are listed in Table 1.1 below, along with their GPS coordinates.

Table 1.1 Northern Dispatch Base Station sites

SITE NAME	GPS COORDINATES	SITE ELEVATION	ANTENNA AZIMUTH
Fourth Street Tower	N 37º 46' 28.8" W 122º 23' 50.2"	65 feet (55+10)	OMNIDIRECTIONAL Gain 0 dBi
Sign Hill	N 37º 39' 53.8" W 122º 25' 14.1"	576 feet (561+15)	156º Gain 8 dBi
San Carlos	N37º 30' 23.4" W122º 15' 43.1"	106 feet (99+7)	140º Gain 8 dBi

5. The lone "Southern" Road Channel dispatch Base Station site is listed in Table 1.2 below, along with its GPS coordinates.

Table 1.2 Southern Dispatch Base Station site

SITE NAME	GPS COORDINATES	SITE ELEVATION	ANTENNA AZIMUTH
CEMOF, San Jose	N 37º 20' 20.28" W 121º 54' 29.22"	138 feet (78+60)	314º /134º Dual Yagi. Gain 10 dBi

B. In addition to the four Base Station sites described above, there are three Dragging Equipment Detectors (DED) located along the ROW at MP 11.3 (between

Millbrae and San Bruno), MP 28.2 (between Menlo Park and Atherton) and MP 42.0 (between Santa Clara and Lawrence). Each of these DED sites is equipped with a VHF voice radio, configured to report wayside status to the train Engineer and the control center by transmitting this data on the same frequency as the road channel: 160.8150 MHz. More location details of the 3 DEDs are shown in table 1.3 below.

Table 1.3 Dragging Equipment Detector sites

DED NAME	GPS COORDINATES	SITE ELEVATION	ANTENNA AZIMUTH
11.3/10.8*	N 37º 37′ 42.2″ W 122º 24′ 37.0″	15 feet	Rail Tx. OMNI Gain 0 dBi
28.2	N 37º 27′ 36.4″ W 122º 11′ 25.9″	36 feet	Rail Tx. OMNI Gain 0 dBi
42.2	N37º 22′ 11.5″ W121º 58′ 27.6″	44 feet	Rail Tx. OMNI Gain 0 dBi

* This DED relocated to 10.8 in 2011

1. The DEDs are transmit-only devices, located along the ROW. They utilize a Harmon Electronics (West Coast Operations) WCO-46 "talker-system" which contains a discrete Motorola HT-440 VHF voice radio connected to a small roof mounted omni-directional antenna. Currently the DEDs transmit each time a train passed by, however this is being changed to an exceptions based configuration, in which DEDs will transmit only upon detection of a problem.

1.04 EXISTING SYSTEM DESCRIPTION - TUNNEL SUB-SYSTEM

A. The terrain between the Fourth Street and the Sign Hill Base Station sites is fairly rugged, with several small, but steep hills in the path of the railroad. In 4 such locations, the railroad tracks are built through tunnels inside these hills. Each tunnel is between 1000 and 3800 feet in length and is equipped with a small, stand-alone radio Base Station located at the south entrance to the respective tunnel. Each of the four tunnel Road-channel radio Base Stations is identical to the 4 above-grade Road-channel radio base stations except that each tunnel radio Base Station is connected to a distributed antenna system, which is installed inside each tunnel to support radio communications inside the confines of the respective tunnel. Each tunnel base station is also connected to a low profile external antenna to provide coverage to the approach/exit of the southern end of the respective tunnel. Additionally, each of the four tunnels is equipped with a MOW base station radio. The Road and MOW channels are transmitter combined and receiver multi-coupled to/from the same antenna system. Refer to the drawings for details. The recovered audio signal from each of the four tunnel Road-channel radio receivers is sent to San Jose via separate leased-lines into a voting comparator to select the best audio signal to present to the dispatcher. The recovered audio signal from each of the four tunnel MOW radio receivers along with the two above-grade base station receivers is voted (compared using a comparator assembly, and from which the signal with the best RSSI is selected) in the same manner in order to select the best audio signal to present to the above-grade, wide area transmitter.

1.05 EXISTING SYSTEM DESCRIPTION - MOBILE USERS

A. Each locomotive and cab car operating between San Francisco and Gilroy is equipped with a VHF-voice mobile radio. Refer the technical specification details of the mobile radio equipment specified in Part 2 of this Section. Each mobile radio is programmed and configured to operate in carrier-squelch simplex mode on the "road" and the "yard" (aka "blue flag") channels, and carrier-squelch full duplex mode on the MOW channel. Likewise all mobile and portable radios used by Caltrain operations and maintenance personnel are programmed to operate on each of the three carrier-squelch channels.

B. During the peak commute hour, there may be as many as seventy (70) locomotive/cab car radios and two hundred (200) mobile and portable radios in use on the VHF voice radio system. They contend, along with the three DEDs for road-channel "air-time" to access the four (4) above-grade Base Station sites in order to communicate with the dispatcher. In addition, these users contend with each other and with the 3 DEDs in order to communicate with each other (only when in close proximity) using the simplex radio-to-radio mode. Similar user contention for access to the four (4) Tunnel Radio Base Stations occurs, except due to logistical reasons, no more than about six (6) locomotives and a slightly greater number of mobiles and portables radios will be within range of these four tunnel Base Station sites. The same holds true for the MOW channel, except that the number of users vying for control/use of the channel is significantly less because it is not used for dispatch.

1.06 FUNCTIONAL REQUIREMENTS

A. Footprint and Reliability: The following table defines the footprint and reliability of the cumulative VHF voice radio coverage that shall be provided by the 4 above-grade Base Stations and independently by the 4 tunnel radio Base Station sites. The radio coverage required from the dragging detectors shall be of the same quality, but limited to +/- 3 miles along the ROW.

B. Although Signal to Noise-and-Distortion (SINAD) is the only objective measure of the quality of the radio coverage, the Contractor will be permitted to test the quality of radio coverage using more expeditious measures such as Circuit Merit (CM), Delivered Audio Quality (DAQ) or Signal Strength, provided the Contractor first establishes the correlation between the measure used in the testing and the 20 dB SINAD criterion. Refer to Part 3, 3.02 "Testing" for details of the testing required.

C. All Voice Radio channels are configured for Narrowband operation. Narrowband is currently defined by the FCC (circa 2011) as occupying a channel bandwidth of 12.5 KHz with a transmitter deviation not to exceed ±2.5 Khz. This definition will eventually change to a bandwidth, or bandwidth equivalency of 6.25 KHz by about the year 2018.

D. Frequency And Configuration: One simplex radio channel (the Road Channel) is utilized to coordinate all dispatch operations. It is broadcast along the entire ROW. A second simplex channel, the Yard (aka Blue Flag) channel is used to support maintenance and yard related activities and is only broadcast within the confines of the two "yard" locations along the ROW. The third channel, (called the MOW channel) is configured as full duplex, and, repeated along the entire ROW, as well as on most of the Peninsula and surrounding areas to serve the requirements of operations and maintenance.

Table 1.4 Radio Coverage Footprint and Reliability

LOCATION	PERCENT GEOGRAPHIC COVERAGE	MINIMUM EIA SINAD/CM/DAQ LEVEL	PERCENT OF TIME RX / TX. LEVELS ≥ MIN. LEVELS	COMMENT
Along the ROW	99	20/4/3,4	95/95	To Trains &Trackside
Within 500 feet of Trackside	95	20/4/3,4	95/95	To Portable & Mobile Radios
Inside the tunnels	99	20/4/3,4	95/95	To Trains & Trackside
Around DEDs	99 centered +/- 3 miles along ROW	20/4/3,4	95/95	Plus or minus 3 Miles along ROW

E. Dragging Equipment Detector

1. Each DED shall report wayside status immediately after the passage of a train. This report must be made on the road channel, so that it can be heard by the train Engineer, in the event that there is a problem, in which case the train can be brought to a stop immediately.

2. The report from each DED shall also be recorded, either at the CEMOF, or in equipment mounted along the ROW. The decision regarding where the DED recordings are made, shall be made on a case by case basis, with all DEDs whose RF transmissions cannot establish a viable communication link with one base station site, when the output power is reduced in order to limit the range to +/- 3 miles along the ROW, being recorded along the ROW. This requirement means that each DED, which is not recorded along the ROW, shall have a reliable communication link to at least, but no more than one Base Station site located in the Northern or Southern territory, corresponding to the location of the DED.

3. Supply Motorola HT-750 or Engineer approved equal for use as the radio interface to the dragging equipment detector.

F. Voice Recording:

1. All voice radio communications that require the use of a Base Station site must be recorded at the control center, per FRA regulations, however, because all voice radio communication (even those localized communications utilizing the radio-to-radio mode) will be recovered by at least one Base Station site, then, in effect, all Voice Radio Communications will be recorded at the CCF.

2. The voice logging recorder shall record to a hard-disk or silicon storage drive with an analog interface to the Caltrain voice radio and telephone services. The Voice Recorder shall be capable of supporting a minimum of thirty six (36) channels. The voice recorder shall support a network storage interface, with a minimum of 5 TB of storage and a compression

ratio of 6:1 or higher. Supply a NiceLog NCF3B-24 or Engineer approved equal.

G. Tunnel Base Station Sites

1. The receive audio from the four tunnel Base Station sites shall be voted and only the best quality signal from the four tunnel sites shall be presented to the Dispatch Console. The voters, which are manufactured by JLP/Raytheon, shall be compatible with the EIA (Motorola) signaling tones required to control the GE Mastr III Base Stations.

2. The tunnel radio Base Station sites shall be equipped with an external antenna system extension. This external antenna extension shall be utilized on the south end of each tunnel, with the region outside the north end of each tunnel supported by the antenna extension of the next tunnel to its north. A high gain directional antenna shall be used external to each tunnel in order to extend the radio coverage around the hilly regions adjacent to these tunnels.

H. Dragging Equipment Detectors: The transmit power of each DED shall be reduced to provide an ERP, (dependent on the terrain in the immediate vicinity of the DED) that will restrict radio coverage to provide a receive intensity of ≥ -109 dBm (≥3 watts) within a ± 3 mile region of track. The transmit ERP required to achieve this shall be determined by the Contractor based on the use of radio coverage simulations and field tests.

I. Communications Back-haul

The Communications back-haul serves to connect the CCF (located at the CEMOF in San Jose) with the various Voice Radio Base Station sites through which the dispatchers at the CCF communicate with trains and with field personnel.

The existing voice radio communication backhaul uses leased 4-Wire Point-to-Point (4W PTP) circuits from AT&T between the CCF and the following Voice Radio Base Station sites: 4th Street, Sign Hill, San Carlos and Tunnels 1 to 4.

The MOW voice radio communication backhaul uses an Agency-owned Microwave Radio network between the CCF and the following MOW Radio Base Station sites: Monument Peak and San Bruno Mountain.

The voice radio communication backhaul between the voice radio Base Station co-located at the CEMOF facility is provisioned via a twisted-pair 4-Wire circuit, less than 100 feet in length.

Refer to Caltrain Design Criteria, Chapter 6, Train Control Communication for further details of the existing voice radio communications back-haul.

J. Narrow-banding

1 History

In 1995, the FCC issued a mandate, with rules to address more efficient use of the increasingly crowded frequency spectrum. All licenses below 512 MHz were required to migrate from the default 25 KHz bandwidth to

a 12.5 KHz bandwidth, within 10 years and eventually to a 6.25 KHz bandwidth within 18 years.

This timetable proved too difficult to meet, and after several stays, the FCC issued the *"Third Memorandum Opinion and Order (3rd MO&O)"* in December 2004 that set January 1, 2013 as the deadline by which all licenses operating below 512 MHz must be converted to the 12.5 Khz FCC emission designation and operation. Currently, equipment designed solely for 25 KHz bandwidth operation is no longer available, and is rapidly being replaced by equipment designed to operate on either 25 KHz or 12.5 KHz (user configurable by a minor software/code-plug change)

Notes:

i. In anticipation of this mandate, all voice radio equipment purchased/specified by Caltrain in the last 8 years is 25 KHz/12.5KHz capable.

ii. In spite of the 1/1/2013 deadline, the FCC will still accept new applications for 25KHz operation up until 12/31/2010, however after 1/1/2011, the FCC will force equipment manufacturers to be capable of operating on 6.25 KHz bandwidth.

iii. In an ideal world, Caltrain should be migrating from 25 KHz bandwidth directly to 6.25 KHz bandwidth, to avoid having to perform a second narrow-banding effort later, but there are technical constraints, not anticipated by the FCC that will prevent this. See below for details.

All Caltrain FCC transmitters licensed below 512 MHz will be significantly impacted by this task order. Specifically, all VHF Voice Radio frequencies shall be converted to narrow-band emissions.

In order to reaffirm this "Third Memorandum Opinion and Order", the FCC will occasionally generate press releases, such as the one below, released in March 2007.

Note also that the FCC will ultimately mandate the conversion from 12.5 KHz narrow-band operation to 6.25 KHz narrow-band operation. This was originally a part of the Third Memorandum Opinion, set to occur in 2018; however, the FCC has backed away from that date until it can better understand the technologies required to efficiently support this migration. The problem is, whereas a single analog FM radio can support both 25 KHz and 12.5 KHz operations, (user configurable by a minor software/code-plug change), the same is not the case for operation on 12.5KHz and 6.25 KHz. This is because operation at 6.25 KHz requires digital audio compression and expansion techniques that are incompatible with analog FM audio.

Nonetheless, at some point, Caltrain will be required to operate at 6.25 KHz bandwidth, probably after the year 2020. Unfortunately, operation at 6.25 KHz, either via a second narrowband conversion, or via the use of modulation/access efficient schemes such as FDMA and TDMA, will

require a "forklift" replacement of all Voice radio infrastructure (Base Stations) and subscriber (portable and mobile radio) equipment.

The following is the most recent FCC press release regarding narrow-banding:

The FCC released a Third Report & Order on March 26, 2007 affirming narrowband deadlines affecting Part 90 frequencies allocated between 150 – 174 & 421 - 512 MHz and further encourages more efficient use of this spectrum. The action taken by the Commission was included in WT Docket Number 99-87. Key decisions are as follows:

The FCC declined to establish a fixed date for users to transition to 6.25 kHz technology.

§ The Commission indicated they would later adopt a date when users must migrate to 6.25 kHz technology. On January 1, 2011 applications for equipment certification will be granted only if the equipment either (1) is capable of operating on 6.25 kHz channels, or (2) meets a narrowband efficiency standard of 4800 bits per second per 6.25 kHz of channel bandwidth.

§ Licensees are urged to consider the feasibility of migrating directly from 25 kHz to 6.25 kHz prior to January 1, 2013, as this may prove more cost efficient than going to 12.5 kHz technology by 2013 then further migrating to 6.25 kHz technology again later.

§ The purpose of this interim deadline is to encourage licensees to begin planning and implementing migration to narrowband technology well before January 1, 2013.

For the complete order see:

http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-39A1.pdf

2 Technical Specifications

All Caltrain Voice Radio frequencies operating below 512 MHz and above 80 MHz shall be reconfigured to operate on a bandwidth of 12.5 KHz. To the extent that this configuration reduces the radio coverage footprint, the design of the radio system shall be adjusted to mitigate this. This configuration, and the resulting coverage shall be completed, tested and cut-over to service prior to January 1, 2013.

Caltrain shall, in coordination with tenant railroads and with the AAR explore options of converting to a narrow-band system capable of meeting a narrowband efficiency *standard of 4800 bits per second per 6.25 kHz of channel bandwidth* in order to avoid having to perform a second narrow-banding upgrade by or before the year 2020.

1.07 DESIGN REQUIREMENTS

A. Design extension, upgrade or retrofit of the VHF Voice Radio System, as applicable. Design shall be in accordance with applicable FCC rules and regulations.

B. Design Prerequisites: Execute and submit design of the Radio System in four iterative parts: the 30 percent, 65 percent, 100 percent, and Issued for Bid/Construction (IFB/C).

C. SCADA Interfaces: Equip Radio Base Station sites with Alarm monitoring and remote control/command interfaces that shall permit the Dispatcher at the CCF to monitor Alarm conditions at each site, as well as remotely reboot any component of the Base Station that is micro-processor based. The Base Station shall be interfaced to a SCADA system provided by others. The SCADA system shall be capable of reporting to the existing Train Control server.

1. As a minimum, the following alarms shall be provisioned:

   a. Low/ Loss of RF Power

   b. High VSWR

   c. Loss of AC Power

   d. Loss of DC Power

   e. Rectifier failure

   f. High Temperature

   g. Door Open

2. Each alarm shall be activated via a dry contact relay pair, which shall be normally open.

D. Radio Coverage Simulations:

1. Utilize computer simulations to predict the VHF voice radio coverage and traffic for all new Base Stations or DEDs added. These computer simulations shall utilize terrain data with a resolution no worse than 30 meters. Use the NAD 83 (2007) or later geodetic datum. Utilize a color gradient to display both the uplink and downlink coverage predictions, with each color representing no greater than a 10 dB gradient. Perform simulations for each of train and portable radio user types located within 500 feet on either side of the ROW.

2. In order to predict the quality of radio coverage inside tunnels, construct a Radio Frequency Power Budget, using Microsoft Excel or a similar spreadsheet program. Construct one power budget for each frequency band / user and for each direction (uplink / downlink).

3. To assure a communications reliability of 99 or 95 percent where specified, factor a fade margin of 17 dB or 10 dB respectively into all radio coverage simulations and all power budget analysis.

E. Intermodulation Studies: For all new installations with three or more transmit frequencies, or those with less than three transmit frequencies but more than two external adjacent frequencies (of power, measured internal to the new system, within 10 dB of the power of the transmit frequencies) that cannot be removed with notch filters, construct and execute an intermodulation study. This study

shall examine all receiver intermodulation products created from the mixing of these transmit frequencies. For installations inside tunnels which use Bi Directional Amplifiers (BDA) in addition to the study defined above, perform a second intermodulation study which examines the mixing of multiple receive frequencies and separately multiple transmit frequencies inside an amplifier.

F. Structural Design: Provide structural design for new lattice, monopole or tilt-down towers, tower foundations, and civil structures associated with new installations required for the work of this Section. Design shall take into account specific soil types at each site. Drawings and calculations shall be signed and sealed by a Civil/Structural professional engineer licensed in the State of California. Designs shall be based on the use of a geotechnical report prepared for the respective site(s) and shall include all calculations using maximum weights and wind loads supported by the towers.

1.08 SUBMITTALS

A. Design Submittals: Submit design documents in four phases in accordance with approved submittal schedule. Obtain the Engineer's approval of each part before proceeding to more advanced parts.

1. 30 percent design document

2. 65 percent design document

3. 100 percent design document

4. Final design document

5. Issued for Bid/Construction and As-Built drawings

The 65 percent, 100 percent, IFB/C and As-Built drawings shall, at a minimum, include the following documents:

a. Radio Coverage Simulations

b. Intermodulation Studies

c. Grounding and Lightning Protection. In accordance with requirements indicated on the Contract Drawings, submit detailed drawings depicting the grounding configuration proposed for each radio site

d. Structural Design Calculations and Drawings

e Radio "code plugs"

f Configuration management documents

B. Obtain Engineer's approval of any deviations from the specified design requirements. Submit request explaining the reasons for deviations and a description of the deviation itself for approval.

C. Product Data and Shop Drawings: Submit product data and manufacturer shop drawings at least 60 days prior to start of any installation.

1. Submit product data for approval for Base Station Radio, Locomotive/Cab Car Radio, Vehicular Mobile Radio, Portable Radio, and DED radio proposed by or before the 65 percent design submittal

2. Submit for approval catalog cut- sheets and other manufacturer literature and manufacturer shop drawings describing all products proposed

D. Installation Drawings: At least 60 days prior to the start of the installation of any item, submit a set of installation drawings for approval.

E. Test Plan And Procedures: At least 90 days, prior to the start of testing, the Contractor shall submit a test plan and test procedures to the Engineer for approval. The testing shall thereafter proceed only after written approval of the plan and procedures by the Engineer

F. Quality Assurance: Submit the resume of the Radio Communication Engineer for approval.

G. Operation and Maintenance Manuals, Training, And Spare Parts: Submit Operations and Maintenance (O&M) Manuals, a training plan, and a list of recommended Spare parts.

1. Submit O&M Manuals for all systems and devices provided under this Section. O&M Manual for the Radio System shall include electrical and mechanical specifications of all the components and sub-assemblies used to construct the system.

2. Training Plan: At least 60 days prior to training, submit Training Plan including Operation and Maintenance Manuals and a training outline for the approval. Submit resumes of the instructors.

3. Spare Parts List: Submit a list of recommended spare parts for Engineer approval at least 60 days prior to the start of training. Include manufacturers' prices.

H. Test Equipment and Special Tools: Submit list at least 30 days prior to start of training. Submit list of test equipment and special tools required for the optimal maintenance of the radio system provided. List shall be complete with cost quotations.

I. Cut-Over Plans: Submit cut-over plans for approval.

J. As Built drawings shall be submitted no later than 30 days after system acceptance. To ensure accuracy of the "As-Builts", a set of "red-line" as-constructed drawings shall be maintained at each site for which construction and installation work are in progress.

1.09 QUALITY ASSURANCE

A. Qualifications: Only qualified Radio Communication Engineer(s) shall be allowed for the performance of this work. Radio Communication Engineer shall be a professional Electrical Engineer licensed in the State of California, and shall have designed or integrated at least two similar projects in the last five years.

B. The Contractor shall include a Software Configuration Management document with all design documents to ensure that Caltrain maintains an accurate and documented record of all versions of "code plugs" and software deployed to support the ATCS network.

1.10 MAINTENANCE MATERIALS

A. Spare Parts: Furnish spare parts for Caltrain's use in the following quantities. For the total quantity of each powered (active) device provided, furnish 20 percent (rounded to the next highest number) as spares. For the total quantity of each passive (un-powered) device provided, furnish 15 percent (rounded to the next highest number) as spares. These spare parts shall not be used by the Contractor in correction of defective work under the Guaranty of Work.

PART 2 – PRODUCTS

2.01 PRODUCTS

A. At a minimum, the selected radios and antennas shall meet the technical specifications listed in the following tables. Additionally Base Station, CP and DED sites shall be equipped with backup power as specified below:

Table 2.1 Base Station Radio Technical Specifications

SPECIFICATION	DESCRIPTION	COMMENT
Model	MASTR III VHF, Analog, Conventional Base Station or Engineer approved equal	
Operation	Simplex/Duplex	
Squelch Gate	Carrier Only	
Power	10-110 Watts, Adjustable	
Channel Spacing	25/30 KHz and 12.5 Khz	Refer to Contract Documents
Sensitivity (EIA 12dB SINAD)	-116 dBm	
Selectivity (EIA 2-signal)	90 dB	
# of Channels	1 TX, 1 RX	

Table 2.2 Locomotive/Cab Car Radio Technical Specifications

SPECIFICATION	DESCRIPTION	COMMENT
Model	VHF, Analog, Conventional Mobile Radio	
Operation	Simplex/Duplex	
Squelch Gate	Carrier Only	
Power	45 Watts, Adjustable	
Channel Spacing	25/30 KHz, and 12.5 Khz	Refer to Contract Documents
Sensitivity (EIA 12 dB SINAD)	-116 dBm	
Selectivity (EIA 2-signal)	90 dB	
Amount of Channels	>90	

Table 2.3 Mobile Radio Technical Specifications

SPECIFICATION	DESCRIPTION	COMMENT
Model	VHF, Analog, Conventional Mobile Radio	
Operation	Simplex/Duplex	
Squelch Gate	Carrier Only	
Power	45 Watts, Adjustable	
Channel Spacing	25/30 KHz, and 12.5 Khz	Refer to Contract Documents
Sensitivity (EIA 12 dB SINAD)	-116 dBm	
Selectivity (EIA 2-signal)	90 dB	
Amount of Channels	>90	

Table 2.4 Portable Radio Technical Specifications

SPECIFICATION	DESCRIPTION	COMMENT
Model	VHF, Analog, Conventional Portable Radio	
Operation	Simplex/Duplex	
Squelch Gate	Carrier Only	
Power	5 Watts	
Channel Spacing	25/30 KHz, and 12.5 Khz	Refer to Contract Documents
Sensitivity (EIA 12 dB SINAD)	-116 dBm	
Selectivity (EIA 2-signal)	90 dB	
Amount of Channels	>4	

Table 2.5 Dragging Equipment Detector Radio Technical Specifications

SPECIFICATION	DESCRIPTION	COMMENT
Model	Motorola VHF HT-750, Analog, Conventional Transmitter or Engineer approved equal	
Operation	Transmit Only	
Power	10 Watts, Adjustable	

Table 2.6 Antenna and Antenna Array Technical Specifications

SPECIFICATION	DESCRIPTION	COMMENT
Pointing Azimuth	Directional, as required	BASE STATIONS AND DED
Frequency	159-162 MHz	ALL SITES
Gain	As needed	ALL SITES
Impedance	50 ohms	ALL SITES
Lightning Protection	DC Ground through support mast	
Beam-Tilt	As Needed	ALL SITES
Beam-width	As needed	ALL SITES

Table 2.7 Backup Power

SPECIFICATION	DESCRIPTION	COMMENT
Backup Power	48 hours	BASE STATIONS SITES
Backup Power	8 hours	CONTROL POINTS
Backup Power	8 hours	DED

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install system in accordance with the approved shop and construction drawings and manufacturers written procedures.

B. Installers shall provide environmental protection of all outdoor installations: connectors shall have protective sleeves for weatherproofing, cabling and equipment shall be secured against strong winds, and electronics shall be mounted in NEMA 4 enclosures. Where antennas or other equipment is mounted on towers or poles, installations designs shall be stamped by a registered Civil/Structural Engineer, licensed in the State of California to ensure equipment does not exceed the maximum load of the tower or pole.

3.02 TESTING

A. Thoroughly test all installations and thoroughly document tests. Test radio system to ensure that the minimum RF coverage requirements specified herein are met.

B. Test Plan:

1. Prepare plan which shall, at a minimum, define the types of tests to be performed, the sequence of these tests, as well as any conditions that would require any changes to the amount, type or sequence of said tests. In addition, identify the personnel and protocol responsible for the execution, witnessing, and acceptance of these tests.

2. At a minimum, include in the test plan and develop detail test procedures for the following categories of tests:

   a. Factory Acceptance Tests (FAT)

   b. Miscellaneous Field Tests

   c. Radio Coverage Tests

   d. System-wide Field Acceptance Tests (SWFAT)

C. Perform all required Factory Acceptance Tests (FAT), Field Tests, (which may include ground resistance tests, battery capacity tests and site alarm tests), Radio Coverage tests and System-wide Field Acceptance Tests (SWFAT), in accordance with the approved Test Plan. All test plans and procedures involving the railroad

ROW, or affecting an active signal or communication system shall follow the Site Specific Work Plan (SSWP) process.

D. Perform Factory Acceptance Tests for all components, subsystems or subassemblies that are manufactured independent of other subsystems or subassemblies. Notify the Engineer when Factory Acceptance Tests are performed sufficiently in advance of tests to give the Engineer the opportunity to witness tests. The Engineer may, at his sole discretion, elect to waive some of these FATs.

E. Perform miscellaneous field tests on any component, subsystem or subassembly that is required to be put into service prior to the completion of the SWFAT. These may include ground resistance tests, battery capacity tests and site alarm tests.

F. Perform Radio Coverage testing for all portions of the ROW. Test coverage to/from trains moving along the ROW on the downlink paths, using a computer-controlled measurement and recording device that continuously monitors and records the RF signal levels that would be measured by a train radio as it travels the length of the ROW. Since the reverse process of measuring the uplink signal strength is considerably more difficult, the Contractor may utilize a combination of sample uplink signal strength measurements, along with a correlation, which shall be computed by the Contractor, between the measured downlink signal strength and the expected uplink signal strength from the same location pair.

Additionally, in order for measured signal strength to be used as the predictor of signal quality, the Contractor shall derive a correlation between the measured signal strength to be used as the pass/fail criterion and 20 dB SINAD. This derived mathematical relation shall also be supported by sample measurements of 20 dB SINAD and signal strength in 5% of the test locations to confirm the correlation. The Contractor shall prepare and submit the derived uplink/downlink correlation, as well as the derived 20 dB SINAD/signal strength correlation to the Engineer for approval at the same time that the test procedures are submitted for approval. The sample measurements shall be taken at the start of testing, and if necessary, the models tuned until the correct correlations are confirmed. Correlations between 20 dB SINAD and DAQ 3.4 or CM 4 will also be considered in lieu of signal strength. If the Contractor proposes to use such correlation analysis, submit it to the Engineer for review and approval.

G. Conduct System-wide Field Acceptance Testing (SWFAT) in all areas where the radio coverage or radio equipment interfaces to users or other subsystems. Conduct these tests only after the radio system is placed in its final configuration and interfaced to all other systems with which it is expected to interact during normal operations. The tests shall fully demonstrate the operation of all the radio sites, Base Stations, and equipment as a single system, capable of meeting all of the coverage, reliability and other specification parameters defined herein.

3.03 CUT-OVER

A. Prepare cut-over plans, where applicable. Prepare a cut-over plan for all installation work along the ROW as well as at remote Radio Base Station sites, irrespective of whether or not this work is scheduled for revenue or non-revenue hours. Plans shall clearly and thoroughly define the required sequence of activities, including staging, installation and testing of all materials and

subsystems, in such a way as to minimize interruption to the Owner's revenue system and other railroad operations.

B. Execute approved cut-over plan.

3.04 TRAINING

A. Provide a training program for Caltrain and their Operating Railroad of Record personnel at least 4 , but no earlier than 13 weeks, prior to the completion of the final acceptance testing. Training shall be tailored for Maintenance and Operations personnel, and training material specific to these two groups shall be designed and provided. Duration of training as well as the class size shall be as specified in the Contract Documents.

B. The following are the minimum required items in the course outline:

1. Prerequisite Mathematics
2. Prerequisite Background/Introductory material
3. Detailed System Description
4. System Tolerances
5. System Troubleshooting
6. As-Built Drawings of Radio System
7. Configuration Management plan

END OF SECTION

SECTION 19200

ATCS DATA RADIO NETWORK

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for extension, upgrade, or retrofit of the existing ATCS Data Radio Network design and installation.

1.02 REFERENCE STANDARDS

A. Design and installation shall be in accordance with the applicable codes and regulations, including the following:

1. National Electrical Code (NEC)

2. AREMA C&S Manual

3. CAL/OSHA standards

4. California Public Utilities Commission (CPUC) Regulations

5. State of California Electrical Safety Orders, Title 8, CAC

6. Applicable Federal Communications Commission (FCC) regulations

7. Motorolla R56 Grounding Standard

1.03 EXISTING SYSTEM DESCRIPTION - GENERAL

A. The Advanced Train Control System (ATCS) is a radio communication network, including a network protocol that is used in support of the Centralized Traffic Control (CTC) system.

B The ATCS is a network of Base Station radio and Control Point radio sites implementing a Non-Vital Supervisory Control System in support of all train movement along the Peninsula Corridor. This supervisory control system is implemented via a data radio network, which connects the Control Points to the computer workstations, servers and packet switches located within the Centralized Equipment Maintenance and Operations Facility (CEMOF).

C. The three major parts of the ATCS Data Radio System are the Base Station radio sites, the Control Point radio sites and the CCF (Central Control Facility) Head-end interface. The ATCS protocol is utilized for the data radio communication links between the Base Station sites and the network of Control Point radio sites, as well on the DS0 communication links between the Base Station sites and the CCF.

D. Two (2) ATCS frequency pairs are utilized to implement the network paths and network redundancy. The two frequency pairs are: ATCS channel 2, which is used at the Monument Peak and San Bruno Mountain Base Station sites, with full coverage overlap and redundancy for Control Points from CP Mayfield as the south limit to CP 4th street as the north limit. ATCS channel 5, which is used at

the Monument Peak and CEMOF Base Station sites, with full coverage overlap and redundancy for Control Points from CP Michael as the south limit and CP Mary as the north limit. CP Lick, receives coverage support only from the Monument Peak site, yet is a part of the ATCS network, because it is monitored, not controlled, by Caltrain.

E. ATCS communication Backhaul between base station sites and the "Office" is provisioned via a Caltrain-owned microwave radio network, with nodes at the Monument Peak ATCS base station site, San Bruno ATCS base station site, San Carlos Headquarters and CEMOF.

1.04 EXISTING SYSTEM DESCRIPTION - BASE STATION SITES

A. Caltrain railroad consists of approximately 78 miles of railroad tracks serving freight and passenger operations between San Francisco and Gilroy. A total of three Base Station sites are used to support all message transmissions between the CCF and these Control Points (CP). The three Base Station sites used are located at Monument Peak in Milpitas, San Bruno Mountain in Daly City and at the CEMOF in San Jose (all in California).

B. The three Base Stations (two on mountain tops and the single base station at CEMOF) are configured in pairs as redundant to each other, to the extent of their respective radio coverage footprints. The Monument Peak and San Bruno Mountain sites are each capable of providing ATCS data radio support to all of the North Dispatch Control Points along the Peninsula Corridor. Pairing the CEMOF site with the Monument Peak site provides full radio coverage and/or coverage redundancy for the South Dispatch Control Points from CP Michael at its south limit to CP Mayfield as its north limit.

Note, the design criteria for the addition of a Control Point to the ATCS Data Radio network is that it must receive full radio coverage, with an availability of at least 99 percent, from a minimum of two Base Station sites, otherwise it shall be supported using leased telephone circuits. CP Lick, which is the southernmost CP, is not "controlled" by Caltrain, but simply "monitored", hence this coverage criterion does not apply to it.

1.05 EXISTING SYSTEM DESCRIPTION - CONTROL POINTS

A. Currently approximately 31 Control Points (circa 2011) are in operation, between CP Fourth Street to the north and CP Lick to the south, of which 27 are on the ATCS data radio network.

B. For ease of maintenance, the antenna towers used at each Control Point are a tilt down design capable of safely lowering the antenna and cable without damage.

1.06 EXISTING SYSTEM DESCRIPTION - CCF HEAD-END

A. The management of the ATCS network is performed at the CCF Head-end. A Dispatch Console, a Code Server and a Packet Switch are configured to manage the network. At the CCF, the dispatcher implements a route request by first inputting a control command into the Code Server. The Code Server decodes the command and passes another encoded message to the Packet Switches, which have the dual function of ensuring that the output protocol to the Base Station network is implementing the ATCS protocol (gateway function) as well as decide which Base Station site will be the most-likely-server for the Control Point being

commanded (router function). Caltrain uses a Code Server manufactured by DigiCon Incorporated. The DigiCon Code Server does not implement the ATCS protocol. Instead, a variety of other protocols are supported and implemented in the Caltrain system. This Digicon system, replaced beginning 2012, by a new IP based dispatch console head-end provided by AIRINC, called AIM dispatch head-end console.

B. The Supervisory Control Systems (SCS)-128 protocol, developed by Safetran Systems (Invensys), is used for all direct, leased telephone line links between Control Points and the CCF, as well as for the links between the Base Station sites and the CCF.

C. The Genisys Protocol is also utilized. This protocol is used only for the direct, leased telephone line link between the major Control Point at Fourth Street and the CCF, and the leased line to CP Army. As Caltrain expands its data radio network, the use of the Genisys protocol, for the 4th Street site will be replaced with SCS-128. The Genisys at CP Army will be converted to ATCS. Further, in order to improve data radio throughput, the use of an ATCS protocol directly on the Digicon Code Server or AIRINC Front End Processor (FEP) shall be investigated. The Digicon Code Server is a rack-mounted computer, using a proprietary operating system developed by Digital Concepts Incorporated. It has the capability to support interfaces to several dispatch stations.

D. The CCF Packet Switches used in support of the ATCS data radio network are manufactured by Safetran Systems. They incorporate built-in hardware redundancy via the use of a dual packet-switch design in one box, one of which is redundant, and connected to the code server/FEP.

E. The Packet Switches shall convert all messages from the code server in SCS-128 protocol to the ATCS protocol. Likewise DS0 messages from the field Base Station sites, which are encoded with the ATCS protocol, shall be converted to SCS- 128 before being routed to the Code Server.

F. The CCF Packet switches shall also monitor the inbound signal quality (RSSI) from each of the 28 Control Points to their respective Base Station sites, in order to determine which Base Station site received the strongest signal from the Control Point. This RSSI information shall be used by the Packet Switch(es) to determine, in real time, which Base Station site will be the most-likely server, and shall route the next message from the Code Server to this Base Station site. Note: the current RSSI result is not saved for general future routing of messages to Base Station sites, but is used in real time for routing only the next outbound message to the most-likely-server Base Station site.

1.07 FUNCTIONAL REQUIREMENTS - COMMUNICATION LINKS

A. Caltrain owns and operates licenses for two ATCS channels. The two ATCS Data Radio Channels shall be configured to provide full duplex Data Radio Operation between the CCF and all Control Points along the Corridor. From the CCF, the Data Radio messages shall be transmitted to each of the Base Station sites via the use of Microwave Radio links (with a reliability of 99.999 percent or better) or direct 4-wire 600 ohm cable (in the case of the CEMOF base station) or the use of carrier-leased 4-Wire telephone circuits as a backup.

B. The Data Radios shall utilize the specification compliant ATCS communication protocol for communication between the Control Points and the Base Station

Sites. The network can support the following interface options: HDLC LAPD, HDLC LAPB and/or TCP/IP. From the Base Station sites, the messages shall be transmitted to the Control Points along the Corridor via a pair of Multiple Addressing Scheme (MAS) ATCS frequencies licensed from the FCC, with a communications reliability of 99.0 percent or better, sufficient to ensure communications at 10 E-7 BER without FEC coding. A fade margin of 17dB shall be factored into the design to account for Rayleigh fading that will affect radio paths. The Base Station sites shall receive from 100 percent of the Control Points, likewise, with 99.0 percent communication reliability, providing 10 E-7 BER without FEC Coding.

C. The Communications back-haul serves to connect the CTC network and code servers, located at the CCF in the CEMOF in San Jose with the two mountain top ATCS Radio Base Station sites. Control requests and Signal indications are communicated between the CCF and the ATCS Radio Base Stations using this communications back-haul.

The existing voice radio communication backhaul uses a Caltrain-owned Microwave Radio network between the CCF and the following two ATCS Radio Base Station sites: Monument Peak and San Bruno Mountain. The communication backhaul between the ATCS Radio Base Station site co-located at the CEMOF facility is provisioned via a twisted-pair 4-wire circuit, less than 100 feet in length.

At the Monument Peak and San Bruno Mountain sites, the Caltrain has provisioned the infrastructure to support a two-wire data line backup, which is currently configured for cold-stand-by operation. Refer to Caltrain Design Criteria, Chapter 6, Train Control Communication for further details of the existing ATCS Radio communications back-haul.

1.08 FUNCTIONAL REQUIREMENTS - COMMUNICATION PROTOCOLS

A. The ATCS communications between the CCF (Code Server) and the Base Station sites shall be based on a polling scheme. Each Base Station site shall be assigned to a unique "code-line" on the Code Server, which shall poll each Base Station site in turn, in order to retrieve messages sent from the various Control Points.

B. The ATCS communication between the Base Station sites and the Control Points shall be based on a contention scheme. A pair of 900 MHz band ATCS frequencies configured for a Multiple-Address-Scheme is used to implement the channel.

1.09 FUNCTIONAL REQUIREMENTS - FREQUENCIES AND LICENSING

A. The following ATCS channels and frequencies are used currently, and additional ATCS pairs shall be licensed as required:

ATCS CHANNEL	FREQUENCY	DESCRIPTION
2	935.9375 MHz	Base Station Tx. Frequency
2	896.9375 MHz	Base Station Rx. Frequency

ATCS CHANNEL	FREQUENCY	DESCRIPTION
5	936.9375 MHz	Base Station Tx. Frequency
5	897.9375 MHz	Base Station Rx. Frequency

B. Under this scheme, each Control Point, which has a message to send to the CCF, will "contend" for the radio channel with all other Control Points. This will result in some RF-Network collisions, the amount of which shall be kept to a minimum in order to preserve the designed maximum speeds and minimum head-ways.

C. Data Radio Base Station repeaters shall employ GMSK direct FM configured for 12.5 KHz channel spacing. Base Station antennas shall be directional, high gain yagi antennas with the horizontal and vertical beam widths and orientation that would allow them to establish point to point radio links with each of the Control Points with the required communication reliability and signal quality. The Antennas used at Control Points shall be omni-directional, which allows for efficient expansion of the ATCS network. In special cases, a high-gain directional antenna may be required to maintain system design specifications at certain Control Point location(s).

D. The quantity of collisions is a direct function of the ratio of Control Points to Base Stations: the higher this ratio, the greater the number of collisions; the larger the number of collisions, the lower the data throughput of the ATCS network. Additionally the reliability of the RF links is another factor that aggravates data throughput. As communication reliability falls below 99 percent, the number of communication re-tries increases, resulting in a longer time required to send or receive a message.

E. The third factor affecting data throughput is the protocol conversion overhead. Currently there are four (4) protocol conversions required per message round-trip (two per direction).

F. The maximum railroad speeds and the minimum railroad head-ways are dependent on these design parameters. As the system expands, a thorough analysis of these parameters will be necessary to ensure reliable and efficient operations.

1.10 DESIGN REQUIREMENTS

A. Design extension, upgrade or retrofit of the ATCS Data Radio Network, as applicable. Design shall be in accordance with applicable FCC rules and regulations.

B. Design Prerequisites: Execute and submit design of the Radio System in four iterative parts: the 30 percent, 65 percent, 100 percent, and IFB/IFC.

C. SCADA Interfaces: Equip mountain top Base Station Radio sites with Alarm monitoring and remote control/command interfaces that shall permit the Dispatcher at the CCF to monitor Alarm conditions at each site, as well as remotely reboot any component of the Base Station that is micro-processor

based. The Base Station shall be interfaced to a SCADA system provided by others. The SCADA system shall be capable of reporting to the existing Train Control server.

1. As a minimum, the following alarms shall be provisioned:

   a. Low/ Loss of RF Power

   b. High VSWR

   c. Loss of AC Power

   d. Loss of DC Power

   e. Rectifier failure

   f. High Temperature

   g. Door Open

2. Each alarm shall be activated via a dry contact relay pair, which shall be normally open.

D. Radio Coverage Simulations: Utilize computer simulations to predict the reliability of the various ATCS UHF radio links between the Base Station sites and Control Points. These computer simulations shall utilize terrain data with a resolution no worse than 30 meters. Use the NAD 83 or later geodetic datum. The radio communication links between all Base Stations and Control Points shall have a reliability of 99.0 percent or greater.

E. Intermodulation Studies: For all new installations with three or more transmit frequencies, or those with less than three transmit frequencies but more than two external adjacent frequencies (of power, measured internal to the new system, within 10 dB of the power of the transmit frequencies) that cannot be removed with notch filters, construct and execute an intermodulation study. This study shall examine all receiver intermodulation products created from the mixing of these transmit frequencies.

F. Structural Design: Provide structural design for new lattice, monopole or tilt-down towers, tower foundations, and civil structures associated with new installations required for the work of this Section. Design shall take into account specific soil types at each site. Drawings and calculations shall be signed and sealed by a professional engineer licensed in the State of California. Designs shall be based on the use of a geotechnical report prepared for the respective site(s) and shall include all calculations using maximum weights and wind loads supported by the towers.

1.11 SYSTEM AND EQUIPMENT UPGRADES

A. Caltrain is currently evaluating the following ATCS system and equipment upgrades:

1. ATCS to IP for all messages to/from Control Points resulting in an ATCS over IP message architecture.

2. A new IP based dispatch console/head-end to replace the obsolete Digicon Console and code servers. The AIRINC AIM dispatch head-end console and code servers will replace the existing Digicon Console and code servers in beginning 2012.

1.12 FUTURE SYSTEM ENHANCEMENTS

The following future railroad safety and passenger enhancements are currently planned. The existing CTC system shall be loosely interfaced to these systems and may share some site infrastructure/resources, such as Base Station sites.

A Positive Train Control (PTC)

PTC is a safety enhancement mandated by the Federal Government and is required to be operable for the Caltrain by 12/31/2015. The PTC safety enhancement shall be an overlay on top of the existing CTC system, which is currently implemented using the ATCS network. The following subsystems are required for PTC:

1. A digital Radio Communication network operating in the 217- 222 MHz PTC band.

2. One 802.11x WLAN (where x = selected standard such as b, a, g, ne or e) and/or commercial cellular mode subsystems that shall be deployed to support PTC data uploads inside each of the designated Caltrain yards, terminals and lay-over sites.

3. Right-of-Way survey of existing GPS coverage that shall be used for navigational and TDMA timing purposes.

4. A bi-directional amplifier and combiner/multi-coupler interface to repeat the PTC 220 MHz radio communications traffic, to/from inside and TDMA timing information to the four (4) tunnels using the existing distribution antenna systems (radiating cable) already installed inside each tunnel.

B California High Speed Rail (CHSR)

CHSR is a Federal and State sponsored initiative that will interface to the Caltrain railroad, and as a result will interface to the existing CTC/ATCS system/network.

1.13 SUBMITTALS

A. Design Submittals: Submit design documents in four phases in accordance with an approved submittal schedule. Obtain the Engineer's approval of each part before proceeding to more advanced parts.

1. 30 percent design document

2. 65 percent design document

3. 100 percent design document

4. Issued for Construction document

5. As Constructed (As-Built) document

The 65%, 100% IFB/IFC and As-Built design documents shall, at a minimum, include the following documents:

a. Radio Coverage Simulations

b. Intermodulation Studies

c. Grounding and Lightning Protection: In accordance with requirements indicated on the Contract Drawings, submit detailed drawings depicting the grounding configuration proposed for each radio site

d. Structural Design Calculations and Drawings

e. Radio "code plugs"

f Configuration management documents

B. Obtain Engineer's approval of any deviations from the specified design requirements. Submit request explaining the reasons for deviations and a description of the deviation itself for approval.

C. Product Data and Shop Drawings: Submit product data and manufacturer shop drawings at least 60 days prior to start of any installation.

1. Submit for approval catalog cut-sheets and other manufacturer literature and manufacturer shop drawings describing products proposed.

D. Installation Drawings: At least 60 days prior to the start of the installation of any item, submit a set of installation drawings for approval.

E. Test Plan And Procedures: At least ninety (90) days, prior to the start of testing, submit a test plan and test procedures to the Engineer for approval. The testing shall thereafter proceed only after written approval of the plan and procedures by the Engineer. All test plans and procedures involving the railroad ROW, or affecting an active signal or communication system shall follow the Site Specific Work Plan (SSWP) process.

F. Quality Assurance: Submit the resume of the Radio Communication Engineer for approval.

G. Operation and Maintenance Manuals, Training, And Spare Parts: Submit Operations and Maintenance (O&M) Manuals, a training plan, and a list of recommended Spare parts.

1. Submit O&M Manuals for all systems and devices provided under this Section. Operations and Maintenance Manual for the Radio System shall include electrical and mechanical specifications of all the components and sub-assemblies used to construct the system.

2. Training Plan: At least 60 days prior to training, submit Training Plan including Operation and Maintenance Manuals and a training outline for the approval. Submit resumes of the instructors.

3. Spare Parts List: Submit a list of recommended spare parts for approval at least 60 days prior to the start of training. Include manufacturers' prices.

H. Test Equipment and Special Tools: Submit list at least 30 days prior to start of training. Submit list of test equipment and special tools required for the optimal maintenance of the radio system provided. List shall be complete with cost quotations.

I. Cut-Over Plans: Submit cut-over plans for approval.

J. As Built drawings shall be submitted no later than 30 days after system acceptance. To ensure accuracy of the "As-Builts" , a set of "red-line" as-constructed drawings shall be maintained at each site for which construction and installation work are in progress.

1.14 QUALITY ASSURANCE

A. Qualifications: Only qualified Radio Communication Engineer(s) shall be allowed for the performance of this work. Radio Communication Engineer shall be a professional Electrical Engineer licensed in the State of California, and shall have designed or integrated at least two similar projects in the last five years.

B. The Contractor shall include a Software Configuration Management document with all design documents to ensure that Caltrain maintains an accurate and documented record of all versions of "code plugs" and software deployed to support the ATCS network.

1.15 MAINTENANCE MATERIALS

A. Spare Parts: Furnish spare parts for Caltrain's use in the following quantities. For the total quantity of each powered (active) device provided, furnish 20 percent (rounded to the next highest number) as spares. For the total quantity of each passive (un-powered) device provided, furnish 15 percent (rounded to the next highest number) as spares. These spare parts shall not be used by the Contractor in the correction of defective work under the Guaranty of Work.

PART 2 – PRODUCTS

2.01 GENERAL

A. Use the equipment identified herein in the design, extension, upgrade, or retrofit of the ATCS network.

2.02 BASE STATION EQUIPMENT

A. These following specifications for the ATCS Data Radio Base Station equipment are based on the SAFETRAN BCP ATCS data radio transceiver. The Contractor may submit alternate BCP transceivers, manufactured by others, to the Engineer for consideration.

TABLE 2.1 Base Station Data Radio Technical Specifications

GENERAL:	
FCC Compliance	Parts 15, 90
Transmitter	
RF Power Output	25-75W Adjustable
Duty Cycle	Continuous
Spurious Emissions	-90 dBc
Harmonic Emissions	-90 dBc
Audio Response	+1/-3 dB per TIA-603
Hum & Noise	-45 dB per TIA-603
Frequency Spread	5 MHz
Frequency Stability	˜0.1 ppm, -30°C to +60°C
	(-22°F to + 140°F)
RF Data Communication	
Frequency Range	Transmit @ 935-940 MHz
	Receiver @ 896-901 MHz
Number of Channels	1 (Synthesized, programmable) TX, 1 RX
Channel Spacing	12.5 kHz
Channel Resolution	12.5 kHz
Data Modulation	GMSK, Direct FM
RF Bit Rate	4800 bits/sec
Error Correction	Reed-Solomon (16,12) Forward
	Error Correction (FEC) and 16 bit
	Cyclical Redundancy Check (CRC)
	per ATCS Spec. 200 Appendix L
Ground Network Port	
Port Type	Sync. / Async., EIA-232 with Configurable Ports
	Modem Signaling
Baud Rate	Up to 2.048 Mbit/sec 9600 bit/sec typical
Data Link Protocol	HDLC Balanced
	per ATCS Spec. 200, Appendix K;
	HDLC Polled

	per ATCS Spec. 200, Appendix J
Receiver	
Sensitivity 12 dB EIA SINAD	0.35 uV
20 dB Quieting	0.50 uV
Adjacent Channel Rejection	-75 dB
Intermodulation Rejection (EIA SINAD)	-75 dB
Spurious and Image Rejection	-90 dB
Audio Squelch Sensitivity	12 dB SINAD
Audio Response	+1/-3 dB per TIA-603
Hum & Noise Ratio	-45 dB
Frequency Spread	5 MHz
Frequency Stability	+0.1 ppm, -30°C to + 60°C
	(-22°F to + 140°F)
Diagnostic Service Port	
Port Type	Async. EIA-232
Baud Rate	19200 bit/sec typical
Data Link Protocol	ANSI, 8 Data bits
	No Parity, 1 Stop bit
Electrical Requirements	
AC Input Voltage	120-240 VAC @ 50-60 Hz
AC Input Current	0.4A (Standby @ 117VAC)
	1.8A (Tx@ 25W, @ 117VAC)
	3.3A (Tx @ 75W, @ 117VAC)
AC Input Power	47W (Standby)
	211W (Tx@25W)
	390W (Tx@75W)
DC Input Voltage	26.5 VDC
DC Input Current	6A (Tx@25W)
	11A (Tx@75W)

TABLE 2.2 BASE STATION UHF Antenna Specifications

Frequency	890-940 Mhz
Pointing Azimuth	Base Station: Directional Control Points: Omni-directional
Bandwidth for 1.5 to 1 VSWR	50 Mhz

Horizontal Beam width (1/2 power points)	As required
Vertical Beam width (1/2 power points)	As required
Gain	As required
Antenna Impedance	50 ohms
Front to Back Ratio	10 dB
Lightning protection (through support pipe)	DC Ground

2.03 CONTROL POINT EQUIPMENT

A. Furnish either 80, 60 or 40 foot, Tilt-Down Towers, as determined by the design, from Western Towers or approved equal. Height of the tower shall be as indicated in the Contract Documents or as proposed by the Contractor and approved by the Engineer. Foundations for 80 foot towers shall be pre-built by tower manufacturer. Furnish padlock of size and type approved by the Engineer. Padlock shall be four (4) inch or larger padlock as manufactured by Master Lock or equal. Include the following at each tower:

1. Aluminum mast in order to raise the overall height of the Tilt-Down tower plus mast to height indicated in the Contract Documents. (Note, Antenna plus Aluminum mast shall have a combined weight no greater than 20 pounds)

2. A 900 MHz lightning arrestor

B. Furnish the Mobile Communications Package (MCP) Radios from Safetran Systems (Invensys) or from GE/ Harmon or Engineer approved equal.

C. Provide the coaxial cable, CP Antennas, Ethernet Spread Spectrum radios (where required per the design), the 12Vdc batteries and chargers and other Data Radio products procured from the sources listed in Table 2.3 below or from an Engineer approved equal source.

D. Provide 7/8 inch coaxial cable transmission line complete with Type N connectors (Male to mate with N female on antenna and N Female for the other end of the 7/8" coaxial cable transmission line). Furnish a minimum of one spare connector of each type. Provide a minimum of two (2) weatherproofing/heat-shrinking kits.

TABLE 2.3 Data Radio System Product (Equipment List)

Item No.	Equipment Description	Equipment Part No.	Manufacturer/ Vendor
1	Spread Spectrum (Ethernet) radio	A53325	Safetran (Invensys)
2	WCP II ATCS Radio	9011-53411-0205	Safetran (Invensys)
3	Router	2811	Cisco Systems
4	Ethernet Switch	Part of Item No. 3	Cisco Systems
5	WAG	A53457	Safetran (Invensys)

6	UPS	APC	SUA1500RM2U
7	Batteries	SAFT	ED 240
8	Battery Charger	NRS	ERB-C 12/201 C, ERB-C 12/401 C
9	DC/DC Converter	Part of #2	Safetran
10	2.4 GHz Lightning Arrestor	IS-MT50LN-MA	Polyphaser/ Tessco
11	900MHz Lightning Arrestor	DSXL-D-ME	Polyphaser/ Tessco
12	PLC	N/A	Allen/Bradley
13	Spread Spectrum 2.4 GHz Antenna	WISP24009PTNF	Maxrad/Tessco
14	ATCS 900MHz Antenna	DB586-Y	Decibel Products /Tessco
15	Coaxial Cables	LCFS114-50A	Cellwave/Andrew
16	Coaxial Cables	LCF78-50A LCF12-50A	Cellwave/Andrew Cellwave/Andrew
17	Tilt-Down Antenna Mast & Installation accessories	N/A	Various
18	Miscellaneous Accessories	N/A	Various

TABLE 2.4 Control Point Data Radio Technical Specifications

General	
Dimensions	5 inches high by 10 inches wide by 10 inches long
Weight	16 lbs
FCC Compliance	Parts 15, 90
Transmitter	
RF Power Output	30W Normal
Duty Cycle	Per TIA-603
Spurious Emissions	-65 dBc
Harmonic Emissions	-65 dBc
Frequency Stability	1.5 ppm, -30°C to 60°C
	(-22° to + 140°F)
RF Data Communications	
Frequency Range	Receive @ 935-941 MHz
	Transit @ 896-902 MHz, Normal
	Transmit @ 935-941 MHz, T/A Mode
Number of Channels	6 pairs (Synthesized, programmable)
Channel Spacing	12.5 kHz
Channel Resolution	12.5 kHz
Data Modulation	GMSK, Direct FM

RF Bite Rate	4800 bits/sec
Error Correction	Reed-Solomon (16, 12) Forward
	Error Correction (FEC) and 16 bit
	Cyclical Redundancy Check (CRC)
	per ATCS Spec. 200. Appendix L
RF Channel Access	Data "Busy-Bit" protocol
	per ATCS Spec. 200, Appendix I
Client Ports	
Types of Ports	3 software configurable interfaces
	2 Sync. / Async., EIA-422/EIA-232
	1 Sync. / Async., EIA-422
Baud Rate	9600 bit/sec typical
Data Link Protocol	HDLC Balanced
	(Sync. Or PPP Async.)
	Per ATCS Spec. 200, Appendix K
	HDLC Polled (Dial Backup)
	Others Available
Alarm Inputs	7 Total
Receiver	
Sensitivity 12 dB EIA SINAD	0.35 uV
Selectivity	-70 dB
Intermodulation Rejection (EIA SINAD)	-65 dB
Spurious and Image Rejection	-75 dB
Frequency Stability	1.5 ppm, -30° to + 60°C
	(-22°F to + 140°F)
Input Impedance	50 ohms
Diagnostic Service Port	
Port Type	Async. EIA-RS-422
Baud Rate	19200 bit/sec typical
Data Link Protocol	HDLC
Electrical Requirements	
DC Input Voltage	13.6 VDC, Negative Ground
DC Input Current	3A (Rx)
	14A (Tx)

2.04 CCF HEAD-END EQUIPMENT

A. Due to the nature of the CCF Head-end interfaces, Caltrain will not allow equipment substitutions to the major CCF assemblies identified below, unless the Contractor can prove that the substitutions will not compromise the stability and reliability of the system. Generic network equipment such as switches and hubs can be replaced with COTS products.

TABLE 2.5 CCF Head-End Equipment

TABLE 2.5 CCF Head-End Equipment				
Item No.	**Equipment Description**	**Equipment Part No.**	**Manufacturer/ Vendor**	**Substitutions Allowed**
1	Code / FEP Server	Various	AIRINC AIM	Disallowed
2	Packet Switch	Various	Safetran (invensys)	Disallowed
3	Dispatch Workstation	Various	AIRINC AIM	Disallowed

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install system in accordance with the approved shop and construction drawings and manufacturers written procedures.

B. Installers shall provide environmental protection of all outdoor installations: connectors shall have protective sleeves for weatherproofing, cabling and equipment shall be secured against strong winds, and electronics shall be mounted in NEMA 4 enclosures. Where antennas or other equipment is mounted on towers or poles, installations designs shall be stamped by a registered Civil Engineer, licensed in the State of California to ensure equipment does not exceed the maximum load of the tower or pole.

3.02 TILT-DOWN TOWER INSTALLATION

A. Install tilt down towers as the Antenna Tower at each CP in accordance with approved installation drawings, manufacturer's instructions and design submittals. Follow the manufacturer's written safety precautions for the installation and lowering of the tower. In particular, ensure that the path of the rotating tower arm is parallel to the track(s) as it spins about the pivot and is clear of overhead power lines and other obstacles. The Tilt-Down tower shall not be within 10 feet of the nearest rail, or any point above the tracks at any point during its range of motion or while in the full horizontal position.

B. Install foundations for 80 foot Tilt-Down towers per detailed instructions provided by the manufacturer. Install cast-in-place concrete foundations in accordance with approved submittals for 40 and 60 foot towers.

C. Ground the entire Tilt-Down tower and foundation assembly in accordance with the approved submittals.

D. Lock the pivot of the tilt down tower immediately after the erection of the tower with padlock. The Tilt-Down tower shall remain locked, until such time as the Owner takes possession of it and replaces this lock.

E. In the process of installing tower foundation and grounding system, cad-weld the ground wires to the steel foundation.

F. Utilize a trained installation technician to prepare and install coaxial cable transmission line connectors.

G. Ensure there is the correct Data cable to interface the VHLC to the data port of the MCP radio, and also the correct code plug.

3.03 TESTING

A. Thoroughly test all installations and thoroughly document tests. Test radio system to ensure that the minimum RF coverage requirements specified herein are met.

B. Test Plan:

1. Prepare a plan which shall, at a minimum, define the types of test to be performed, the sequence of these tests, as well as any conditions that would require any changes to the amount, type or sequence of said tests. In addition, identify the personnel and protocol responsible for the execution, witnessing, and acceptance of these tests. Include a sample of test data sheets.

2. At a minimum, include in the test plan and develop detail test procedures for the following categories of tests:

    a. Factory Acceptance Tests (FAT)

    b. Miscellaneous Field Tests

    c. Radio Coverage Tests

    d. System-wide Field Acceptance Tests (SWFAT)

C. Perform all required Factory Acceptance Tests (FAT), Field Tests, (which may include ground resistance tests, battery capacity tests and site alarm tests), Radio Coverage tests and System-wide Field Acceptance Tests (SWFAT), in accordance with the approved Test Plan.

D. Perform Factory Acceptance Tests for all components, subsystems or subassemblies that are manufactured independent of other subsystems or subassemblies. Notify the Engineer when Factory Acceptance Tests are performed sufficiently in advance of tests to give the Engineer the opportunity to witness tests. The Engineer may, at his sole discretion, elect to waive some of these FATs.

E. Perform miscellaneous field tests on any component, subsystem or subassembly that is required to be put into service prior to the completion of the SWFAT. These may include ground resistance tests, battery capacity tests and site alarm tests.

1. Prior to cutting the system over, conduct a Voltage Standing Wave Ratio (VSWR) sweep and an impedance test on the end-to-end connection of the three sections of coaxial antenna cable (less the lightning arrester) at new tilt-down tower installations.

F. Perform radio Link testing between all Base Station sites and the Control Points they serve. Individually test all links for the downlink as well as the uplink paths. Attach a computing device, configured to measure BER, at the end of each link under test in order to verify that they meet the minimum data error requirements.

G. Conduct Systemwide Field Acceptance Testing (SWFAT) in all areas where the radio coverage or radio equipment interfaces to users or other subsystems. Conduct these tests only after the radio system is placed in its final configuration and interfaced to all other systems with which it is expected to interact during normal operations. The tests shall fully demonstrate the operation of all the radio sites, Base Stations, and equipment as a single system, capable of meeting all of the coverage, reliability and other specification parameters defined herein.

3.04 CUT-OVER

A. Prepare a cut-over plan, where applicable. Plan shall clearly and thoroughly define the required sequence of activities, including staging, installation and testing of all materials and subsystems, in such a way as to minimize interruption to the Caltrain's revenue system and other railroad operations.

B. Execute approved cut-over plan.

3.05 TRAINING

A. Provide a training program for Caltrain and their Operating Railroad of Record personnel at least four 4 , but no earlier than 13 weeks, prior to the completion of the final acceptance testing. Training shall be tailored for maintenance and Operations personnel, and training material specific to these two groups shall be designed and provided. Duration of training as well as the class size shall be as specified in the Contract Documents.

B. The following are the minimum required items in the course outline:

1. Prerequisite Mathematics

2. Prerequisite Background/Introductory material

3. Detailed System Description

4. System Tolerances

5. System Troubleshooting

6. As-Built Drawings of Radio System

END OF SECTION