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