CHAPTER 6

TRAIN CONTROL COMMUNICATION

A. GENERAL

The Design Criteria presented in this Chapter for mission or operations critical Train Control Communication defines the technical requirements used for the development of specifications and the design of the Advanced Train Control System (ATCS) Data Radio communication system, the various telephone interfaces and the Very High Frequency (VHF) Voice Radio Communication system.

The ATCS Data Radio and the VHF Voice Radio are both independent stand-alone communication systems which are each supported by a Caltrain-owned microwave radio network and by various leased telephone subsystems, including T1, 4-Wire (Analog), 4-Wire E&M (Analog), 4-Wire (Digital), 2-Wire (Analog), Frame Relay and DSL for back-haul. The Design Criteria defines the requirements for these communication systems and sub-systems to safely and efficiently fully support the Caltrain operations, as well as the requirements to expand these systems in order to support future Caltrain communication needs. The ATCS data radio network shall interface to, and the Voice Radio system shall support, the following future system safety and passenger enhancements: Positive Train Control (PTC) and California High Speed Rail (CHSR).

In addition to these three (3) communications systems/sub-systems, there are several other communications sub-systems that are utilized by Caltrain as follows:

a. Public Address System (PAS)

b. Closed Circuit Television (CCTV)

c. Visual Message Sign (VMS)

d. Fare Collection System (Ticket Vending Machine or TVM and fastrak payment system or the “Clipper” card)

The Design Criteria for these sub-systems are addressed separately in **CHAPTER 4 STATION COMMUNICATIONS.**

The designer(s) of the train control system shall be qualified Radio Communications Engineer(s), licensed in the State of California as professional Electrical Engineer(s). They shall have designed and integrated at least two similar projects in the last five years.

B. ATCS DATA RADIO SYSTEM

All train movements on Caltrain tracks are managed and controlled by a Non-Vital Supervisory Control System. This supervisory control system is implemented via a data radio network, which connects the train signaling Control Points (CPs) to the computer workstations, servers and packet switches located at the Central Control Facility (CCF). The CCF is located at the Caltrain CEMOF (Centralized Equipment, Maintenance, and Operations Facility) at 585 Lenzen Avenue, in San Jose. A detailed description of each component of the data radio network and the CCF head-end interface is provided below. The data radio network is implemented via the use of ATCS channels 2 and 5. Each ATCS channel consists of a pair of Multiple-Addressing-Scheme frequencies in the 900MHz band (set aside by the Federal Communications Commission, or FCC for this application) which implements the Advanced Train Control System (ATCS) Protocol.

The ATCS protocol is central to the 900MHz band RF (Radio Frequency) communication links between the network of Control Points and Base Stations, as well as to the base-band (DS0) data links between these Base Stations and the Packet Switches located at the CCF.

1.0 CODE SERVER

At the CCF, the train 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 deciding which Base Station site will be the most-likely-server for the Control Point being commanded (router function).

Until late 2011, Caltrain used a Code Server developed by Digital Concepts, Incorporated (DigiCon). The DigiCon's Code Server does not implement the ATCS protocol. Instead, a variety of other protocols are supported and the following protocols are implemented in the Caltrain system:

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

b. The Genisys Protocol, developed by Union Switch and Signal (now part of Ansaldo). This protocol is used only for the direct telephone 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 Fourth Street site will be replaced with ATCS. The Genisys application 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's Code Server shall be investigated. The DigiCon's Code Server is a rack-mounted computer, using a proprietary operating system developed by DigiCon has the capability to support interfaces to multiple dispatch stations.

c. The DigiCon Console and code servers are currently being replaced with a new IP based dispatch console/head-end provided by AIRINC, called the AIM dispatch head-end console. This new dispatch system which replaces the existing Digicon Console and servers begins service towards the end of 2011.

2.0 PACKET SWITCHES

The CCF Packet Switches currently 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.

The packet switches are capable of performing a dual role, where required. They can perform protocol conversions, as needed as well as RSSI (Received Signal Strength Indicator) selection. Since the AIRINC's AIM /FEP utilize an ATCS over IP protocol, this protocol conversion feature of the packet switch is not required for the interface to the AIM/FEP. However the Packet switches shall be set up to operate in dual mode. SCS-128 serial shall be connected to the DigiCon Code Servers. Additionally, ATCS over IP shall be the configuration used by the AIM system currently being implemented. Currently, the DigiCon system operates as primary with the AIM system under test. After the successful implementation of the full AIM configuration, AIM shall become primary with DigiCon remaining as backup.

The CCF Packet switches shall monitor the inbound signal quality RSSI from each of the three Base Station sites, corresponding to every transmission from a Control Point, 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 Switches 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, this RSSI result is not saved for general future routing of messages to Base Station sites, but shall only be used, in real time, for routing only the *next* message to the most-likely-server Base Station site.

3.0 NETWORK

The third major component of the Non-Vital Supervisory Control System is the network of ATCS Data Radio Base Stations and Control Points. The Caltrain railroad consists of approximately 78 miles of railroad tracks serving freight and passenger operations between San Francisco and Gilroy. Currently, 31 Control Points are in operation, between CP Fourth Street in the north and CP Michael in the south, of which 27 are on the ATCS data radio network.

A total of three (3) Base Station sites are used to support all message transmissions between the CCF and these Control Points. The three Base Station sites used are located at San Bruno Mountain (SB) in Daly City, Monument Peak (MP) in Milpitas, and at the CEMOF in San Jose.

The three Base Station sites are configured as redundant pairs on separate radio frequencies 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 northern Control Points along the Caltrain Corridor. The CEMOF and Monument Peak sites provide full radio coverage and/or coverage redundancy for the southern control points, with CP Michael at its south limit to CP Mary as its north limit.

Note, in order for a Control Point to be added to the ATCS Data Radio network, the design criteria 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 along the railroad is not "controlled" by Caltrain (it is 'controlled' by UP), but simply "monitored", hence this coverage criterion does not apply to it.

The ATCS network was designed to grow organically, however in order to preserve system throughput and efficiency, the following parameters must be analyzed prior to adding new Control Points or Base Stations:

a. The maximum number of Control Points that can be safely served by one Base Station, given the required speeds and head-ways required for the efficient operation of the Caltrain. For current Caltrain maximum authorized speeds (MAS) of 79 mph and minimum head-ways of five (5) minutes, empirical data suggests that no more than about 15 Control Points shall be supported by a single Base Station. In order to increase maximum speeds or reduce head-ways further, it will be necessary to obtain additional efficiency improvements by reducing the coding or protocol conversion overhead, or increasing the data rate of the base-band (DS0) channel between the Base Station sites and the Packet Switches. A thorough review of these parameters is required prior to the addition of additional Control Points on the ATCS data network.

b. Where one or more Base Station sites have the geographical advantage, due to the terrain layout of being capable of supporting much more than the maximum number of Control Points, for the designed speeds and head-way, the usage of a second FCC licensed Multiple-Addressing-Scheme frequency pair shall be investigated.

c. The ATCS Data Radio Channel 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 2-Wire POTS (Plain Old Telephone Service) telephone circuits or via the use of Microwave Radio links (with a reliability of 99.999% or better). From the Base Station sites, the messages shall be transmitted to the Control Points along the Corridor via a pair of Multiple-Addressing-Scheme frequencies licensed from the FCC, with a communications reliability of 99.0% or better, sufficient to assure communications at 10 *E-7 BER (Bit Error Rate)* without FEC (Forward Error Correction) coding. A fade margin of 17dB shall be factored into the design to account for Rayleigh fading that will affect radio paths.

   The CCF shall receive from 100% of the Control Points likewise with 99.0% or better, communication reliability, providing 10 *E-7* BER without FEC

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

d. The ATCS communications between the CCF (Code Server) and the Base Station sites is 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.

The ATCS communication between the Base Station sites and the Control Points shall be based on a contention scheme. Two pairs of 900 MHz band ATCS frequencies configured for a Multiple-Address-Scheme are used to implement the network. The following frequencies are currently used:

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

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 must be kept to a minimum in order to preserve the designed maximum speeds and minimum head-ways.

e. Data Radio Base Station repeaters shall employ GMSK (Gaussian Minimum Shift Keying) direct Frequency Modulation (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 however be omni-directional, which allows for efficient expansion of the ATCS network. In special cases, a high-gain directional antenna may be required for certain Control Points where the communication links will not meet the required reliability using the lower gain omni-directional antennas.

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 will be. Additionally the reliability of the RF links is another factor that aggravates data throughput. As communication reliability falls below 99.0%, the number of communication re-tries increased, resulting in a longer time being required to send or receive a message.

The third factor affecting data throughput is the protocol conversion overhead. This is required in the case of the Digicon code server, but not in the case of the AIRINC's AIM/FEP. 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.

f. All control points shall be connected to the leased 4-W telephone circuit that is present at each CP site. Except for CP Sierra and the two CPs at Terminal, this connection acts as a secondary, “cold-standby” backup to the data radio network, such that, in the event of a major radio outage, the control points can be reconfigured to be controlled via the 4-W telephone connections. This reconfiguration requires a maintainer to visit the affected site, and load a new “code plug” that will support an ATCS over telephone interface.

C. VOICE RADIO

A VHF Voice radio system consisting of three distinct channels are currently used to support all operations along the Caltrain ROW. The three channels are: a Road channel used for train dispatch, a Maintenance of Way (MOW) channel used to support Operations and the Mechanical department, and a Yard (aka Blue Flag) channel.

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 yards on a frequency of 161.0700 Mhz. The Road, MOW and Blue Flag channels are all managed and controlled from the Voice Radio dispatch consoles located at the CEMOF control center. This dispatch console is a Safetran Digital Touch Exchange (DTX). The road channel is provisioned along the entire ROW, via the use of above-ground as well as tunnel radio base stations. The yard channel is provisioned only within the confines of the two railroad yards located at Fourth Street near downtown San Francisco and CEMOF in San Jose. The MOW channel is provisioned along the entire ROW, via the use of above-ground as well as tunnel radio base stations in addition to which it is provisioned alongside streets and highways on most of the peninsula and the East Bay. The head-end for railroad

dispatch, operations and maintenance is served by a radio dispatch system which is configured as follows:

A total of two (2) independent dispatch stations are located at the CEMOF. One of the two dispatch stations is responsible for supporting the "Northern" portion of the railroad, between approximate MP 0.0 and 44.0, and the second station supports the "Southern" portion of the railroad between approximate MP 44.0 and 55.0 on the Road dispatch channel.

Between MP 55.0 and the southern end of the railroad, the dispatch is performed by the Union Pacific Railroad. Although Caltrain is capable of monitoring train movements on the UP tracks, Caltrain cannot perform any train dispatch on the UP tracks. Although each dispatch station is "stand-alone" 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 regions 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.

1.0 BASE STATION SITES

A total of eight (8) VHF voice radio base station sites currently exist to support the road channel. Of these, four (4) are "above-grade" radio base station sites, which are located along the ROW, and are each configured for carrier-squelch, simplex operation on the road channel frequency of 160.8150 MHz. The remaining four base station sites are located inside four (4) railroad tunnels located along the ROW. 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 Fourth Street and the San Jose Base Station towers, respectively.

A total of six (6) VHF voice radio base station sites currently exist to support the MOW channel. Of these, four (4) are co-located with the road channel at the four tunnel sites, and two are co-located at the mountain top sites with the ATCS radio base stations. This channel is configured for carrier-squelch, full duplex operation on the frequency pair: 161.5050 MHz for Base Station transmit and 160.5750 MHz for Base Station receive.

1.1 The Above-Ground Base Station Sites

Of the four (4) above-ground road base station sites, three are controlled by the "Northern territory" dispatch, and one by the "Southern territory" dispatch. Future Voice Radio base station sites, operating on the road and yard channels shall be designed using the same configuration. For the road channel, they shall use multiple low-level sites each capable of providing radio coverage within a radius of 10 to15 miles, so as to manage radio traffic congestion amongst the users in the field. For the yard channel, the coverage shall be similar, except localized to the vicinity of the respective railroad yards.

The two above-ground MOW base station sites are located at San Bruno Mountain and Monument Peak, and each is capable of providing radio coverage along the

entire ROW and to most of the peninsula and surrounding areas. This is used to ensure that a train engineer and signal maintainer can communicate with anyone else along the ROW, without the assistance of a third party, such as the dispatcher.

To support this configuration, the Maintenance Base Stations shall be configured as full duplex, carrier-squelch repeaters, with the receive audio from each site routed to the CCF for voting and steering of the transmit audio. The dispatcher shall have access to this channel via the use of a Push-to-Talk (PTT) foot pedal, and shall therefore have the highest priority for use of the channel. The Maintenance channel shall be capable of use as an emergency backup for the road channel.

The existing "Northern" dispatch Base Station sites are listed in **TABLE 6-1** below, along with their GPS (Global Positioning System) coordinates.

TABLE 6-1 NORTHERN DISPATCH BASE STATION SITES

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

The "Southern" dispatch Base Station site is listed in **TABLE 6-2** below, along with its GPS coordinates.

TABLE 6-2 SOUTHERN DISPATCH BASE STATION SITES

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

1.2 The Tunnel Radio Base Station Sites

Located between the Fourth Street tower and Sign Hill Base Station sites are four (4) railroad tunnels. Each tunnel is between 1000 and 3800 feet in length and is equipped with a small, stand-alone VHF radio base station configured for simplex, carrier squelch operations located at the south entrance to the respective tunnel. Each of the four (4) tunnel radio Base Stations is identical to the four (4) above-grade 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.

The recovered audio signal from each of the four road channel tunnel radio sub-systems is passed via 4-wire leased lines to San Jose where a voting comparator selects the best audio signal to present to the dispatcher. The voters, which are manufactured by JLP/Raytheon, shall be compatible with the EIA (Electronic Industry Alliance) signaling tones required to control the GE Mastr III Base Stations.

The tunnel-repeater systems are located in very hilly regions, the quality of radio coverage provided by the "above-grade" Base Stations are marginal in some spots near the tunnels, and further, the level of RF signals to/from the tunnels' distribution antenna system is insufficient to supplement any marginal coverage from the "above-grade" Base Station" sites in these regions. As a result, the tunnel radio Base Station sites are equipped with an external antenna system extension. This external antenna extension is utilized on only one side of each tunnel (the south end), 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 is used external to each tunnel in order to extend the radio coverage into the hilly regions adjacent to these tunnels.

The four MOW tunnel radio channels are voted and steered with the two MOW above-ground channels as a single system through a Motorola voter and TSAM (Transmitter Steering Audio Matrix) device.

As Caltrain expands, it will become necessary to either build new railroad tunnels or to add new radio channels to the existing railroad tunnels. The following railroad tunnel radio criteria shall apply:

a. In order to provision radio coverage inside tunnels, trenches and other subterranean areas, the designer shall use a distributed antenna system comprising of radiating cable and low profile antennas. Radiating cable shall be used to support radio coverage for all subterranean areas except the large open areas where antennas can be used. The design of the Base Station, the donor antenna interface and the distribution antenna shall be provided by Caltrain.

b. The designer shall prepare a RF power budget which shall depict the worst-case scenarios for the transmission and coupling of the RF signals along and from the radiating cables installed along the tunnels and trenches. The power budgets shall be prepared using a spreadsheet program such as Microsoft Excel, and shall prove the viability of the communication links.

c. The designer shall perform an Intermodulation study in order to determine what combination of frequencies are likely to create harmful Intermodulation products inside the Base Station equipment. The designer shall use the results of the Intermodulation study to fine-tune the design and installation in order to mitigate the creation of these harmful IM products.

d. The design shall guarantee radio coverage of 99% of the subterranean areas, with a reliability of 99% based on a signal quality of 20 dB SINAD (Signal In Noise and Distortion). The designer shall be allowed to test the system based on the use of a CM (Circuit Merit), DAQ (Delivered Audio Quality) or

signal level test, providing the designer is able to first establish a correlation between a measured signal quality of 20 dB SINAD and the proposed CM, DAQ or signal level tests.

1.3 Dragging Equipment Detector (DED)

In addition to the four (4) "above-ground" Base Station sites, there are three (3) Dragging Equipment Detectors (DEDs) located along the ROW at MP 10.8 (between Millbrae and San Bruno; location being moved from MP 11.3 to MP 10.8), MP 28.2 (between Menlo Park and Atherton) and MP 42.0 (between Santa Clara and Lawrence). Each of these DED sites shall be equipped with a VHF Voice Radio, configured to report wayside status to the train engineer and the dispatch control center at CCF by transmitting this data on the same frequency as the road channel: 160.8150 MHz. More location details of the three (3) DEDs are shown in **TABLE 6-3** below.

TABLE 6-3 DRAGGING EQUIPMENT DETECTION SITES

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

The DEDs are transmit-only devices, located along the ROW. They utilize a GE/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 Sinclair 'low-profile', omni-directional "railroad" antenna. The Motorola HT-440 has been discontinued by the Manufacturer and replaced with the HT-750 model.

The transmit power of each DED shall be reduced to provide an ERP (Effective Radiated Power, dependent on the terrain in the immediate vicinity of the DED) that will restrict radio coverage to provide a receive intensity of ≥ -109 dBm within a ± 3 mile region of track. The transmit ERP required to achieve this shall be determined by the designer based on the use of radio coverage simulations and field tests. If by limiting the DED radio coverage to +/- 3 miles, results in a loss of a reliable link to at least one radio base station site, the DED messages shall be recorded locally, otherwise all DED messages shall be recorded at the CCF.

1.4 Voice Radio Field Equipment

Each locomotive and cab car operating within the ROW (Right-of-way) northbound through Gilroy will be equipped with a VHF-voice mobile radio. Each radio is programmable to all AAR frequencies allowing it to be interoperably used on any railroad. Each mobile radio is programmed and configured to operate in carrier-squelch simplex mode on both the "Road" and the "Yard" (aka "Blue Flag") channels.

Likewise all mobile and portable radios used by Caltrain operations and maintenance personnel are programmed to operate on each of the two carrier-squelch simplex channels. Each radio is also programmed and configured to operate in carrier-squelched, half-duplex mode on the MOW channel.

The road channel is heavily used, particularly during the morning and evening rush hours. In addition to the locomotive, vehicle mobile and portable radio users, the three DED's add to radio traffic by broadcasting from the respective DED each time a train passes. They contend, with the other users 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 three 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 (4) tunnel Base Station sites.

2.0 VOICE RADIO OPERATIONAL REQUIREMENTS

The following are non-negotiable operational requirements of the Voice Radio road channel. Any expansion of the Voice Radio system must also simultaneously preserve the following operational specifications:

a. One simplex radio channel (the Road Channel) is utilized to coordinate all train movement. It is therefore repeated along the entire ROW. A second simplex channel, the Yard channel is used to support maintenance and yard related activities and is only broadcast within the confines of the two specific "yard" locations.

b. Each DED must 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. This configuration is currently being changed to an exceptions-based reporting configuration. DEDs configured in this way will report only when it detects a problem, but must continually report its health status to the CCF.

c. The report from each DED must be recorded, either at the CCF or locally at the site.

d. All Voice Radio communications that require the use of a Base Station site must be recorded at the CCF, per FRA (Federal Railroad Administration) 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 communication will be recorded at the CCF.

e. All Caltrain groups that must have a reliable and guaranteed communication link to other Caltrain groups, as defined by **TABLE 6-4 WHO NEEDS TO HEAR FROM WHOM** matrix must also be preserved with the retrofits.

All voice radio communication along the ROW takes one of the following three (3) modes: a) Point-to-Point Global, b) Point-to-Point Local and c) Point-to-Space Global. Every user on the road channel, intending to speak to the dispatcher utilizes mode 'a'. When the dispatcher responds, mode 'c' is used to repeat his/her instruction to the "space" surrounding one or more Base Station sites. Finally for localized communications, such as between a locomotive and an EIC (Employee in Charge), mode 'b' is utilized.

f. **TABLE 6-4** presents a matrix showing all ten (10) users groups currently using the VHF Voice radio system. The Matrix defines which groups need to hear which other groups, and which communication links are guaranteed, system global and system localized.

TABLE 6-4 WHO NEEDS TO HEAR FROM WHOM

Receive / Transmit	Control Center Recording Equipment	Dispatcher	Train Engr	Train Cndr	EIC	Maintainer (Mobiles)	Maintainer (Portables)	Yard	Terminal Manager	CEMOF
Dispatcher	√ G	N/A	√ L	√ L	√ L	√ L	√ L	√ L	√ L	√ L
Train Engineer	√ G	√ G	N/A	√ L	√ L	√ L	√ L	√ L	√ L	√ L
Train Conductor	√ G	√ G	√ L	N/A	√ L	√ L	√ L	√ L	√ L	√ L
EIC	√ G	√ G	√ L	√ L	N/A	√ L	√ L	√ L	√ L	√ L
Maintainer (Mobiles)	√ G	√ G	√ L	√ L	√ L	N/A	√ L	√ L	√ L	√ L
Maintainer (Portables)	√ G	√ G	√ L	√ L	√ L	√ L	N/A	√ L	√ L	√ L
Yard	√ G	√ G	√ L	√ L	√ L	√ L	√ L	N/A	√PL	N/A
Terminal Manager	√ G	√ G	√ L	√ L	√ L	√ L	√ L	√PL	N/A	N/A
CEMOF	√ G	√ G	√ L	√ L	√ L	√ L	√ L	N/A	N/A	N/A
DED	√ G	No	√PL	No	No	No	No	No	No	No

Notes:

G = GLOBAL COMMUNICATION REQUIRED. This means that the identified radios must be capable of direct communications with each other IRRESPECTIVE of their relative position along the ROW. For example, each radio communication message from the Train Engineer must be heard by the dispatcher and the CCF recording equipment irrespective of where the train (Train Engineer's radio) is along the ROW.

L = LOCAL COMMUNICATION REQUIRED. This means that the identified radios shall expect to have reliable radio communication only when they are in the local vicinity of each other. The exact range of this local communication is a function of the terrain, the HAAT of the two transmitters and the respective transmit powers. This communication is neither protected nor guaranteed, but occurs by the radio-to-radio mechanism with no assistance or intervention from the Radio System (The Base Stations and CCF)

PL = PROTECTED LOCAL COMMUNICATION REQUIRED. This means that although the identified radios shall only be able to communicate via the radio-to-radio mechanism when they are in the local vicinity of

each other, this Local Communication capability is protected and guaranteed by the Radio System design. In the case of the DED, this Local Communication capability is guaranteed for a distance of +/- 3 miles with respect to the DED along the track. In the case of the Yard and Terminal Manager, this Local Communication capability is guaranteed within a circle of radius about 5 miles centered about the Fourth Street tower and about the CCF.

No = NO COMMUNICATION REQUIRED
N/A = NOT APPLICABLE

g. The following **TABLE 6-5** defines the extent and quality of the cumulative VHF voice radio coverage that shall be provided by the four (4) above-ground and four (4) tunnel radio Base Station sites. The radio coverage required from the dragging equipment detectors shall be of the same quality, but limited to +/- 3 miles along ROW.

TABLE 6-5 RADIO COVERAGE FOOTPRINT AND QUALITY

LOCATION	GEOGRAPHIC COVERAGE (%)	MINIMUM EIA SINAD/CM /DAQ LEVEL	% OF TIME Rx / Tx LEVELS ≥ MINIMUM 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	+/- 3 Miles along ROW

D COMMUNICATIONS BACK-HAUL

A mixture of Caltrain-owned microwave radio and POTS 2-wire telephone circuits are currently used to support all communications back-haul for the train control communication systems. Future safety and passenger enhancements such as Positive Train Control (PTC) and California High Speed Rail (CHSR) will require significant expansions of the Caltrain-owned microwave radio network and /or the deployment of new Fiber Optic based networks along the railroad ROW. Limited use of Multi Protocol Label Switching, another leased service, but significantly more costly, shall be considered where it provides the greatest cost/benefit.

At this time, the predominant back-haul resource used for the communication systems/networks is the leased 4-wire telephone service. The following **TABLE 6-6 COMMUNICATION SYSTEMS AND LEASED TELEPHONE INFRASTRUCTURE**, presents a summary of all leased telephone services currently in use on the railroad.

TABLE 6-6 lists the current leased telephone infrastructure used by Caltrain to support the ATCS Data Radio and the VHF Voice Radio systems.

TABLE 6-6 COMMUNICATION SYSTEMS AND LEASED TELEPHONE INFRASTRUCTURE

CRITICAL SYSTEMS	CIRCUITS	TYPES	OFFICE PAIRS	FIELD PAIRS
VISUAL MESSAGING SYSTEM LINES				
	1	T1 FRAME RELAY	1	
	1	4W ADM 8LEGS	2	
DIGISIGN LINE				
	1	DSL	1	
PUBLIC ADDRESS LINES				
	1	T1 MP IN THE CO	1	
	1	T1 MP IN THE CO	1	
ATCS BASE STATIONS LINES				
	1	4W PTP	2	2
	1	2W AUDIO	1	1
	1	4W PTP	2	2
	1	2W AUDIO	1	1
	1	4W PTP	2	2
	1	2W AUDIO	1	1
DIGICON NET-ROUTER				
	2	DSL	2	2
CONTROL POINTS				
	1	4W 5LEGS	2	
	NEW	4W		2
	NEW	4W		2
	NEW	4W		2
	NEW	4W		2
	1	4W DIGITAL	2	2
	1	4W 4LEGS	2	
		4W		2
		4W		2
		4W		2
	1	4W 6LEGS	2	
		4W		2
		4W		2
		4W		2
		4W		2
		4W		2
TUNNEL RADIO				
	1	4W PTP	2	2
	1	4W PTP	2	2
	1	4W PTP	2	2
	1	4W PTP	2	2
ROAD RADIO				
	1	4W PTP	2	2
	1	4W PTP	2	2
	1	4W PTP	2	2
	1	4W Twisted Pair	2	N/A
UPRR RADIO				
	1	4W Twisted Pair	2	N/A
TOTALS CIRCUITS	**26**		**43**	**51**

The following four (4) circuit types are used:

a. 4-WIRE POINT to POINT (PTP)

A 4-Wire PTP line is a leased 9600 bps baud rate telephone circuit that is provisioned between two fixed locations. It provides a single telephone circuit with 4 wires, which enable it to support full-duplex telephone communication. This type of leased circuit was required between each of the 27 ATCS Control Point sites, the two mountain top sites and the CCF.

b. 4-WIRE DIGITAL

A 4-Wire digital line is a leased telephone circuit that is provisioned between two fixed locations. It provides a faster (56K) single telephone circuit with 4 wires, which enables it to support full-duplex data communication. The quality of the line is enhanced in order to support the more demanding channel requirements for digital communications. This type of leased circuit was used between CP Army and the CCF to support data messages between the two sites.

c. 4-WIRE E&M

A 4-Wire E & M line is a 9600 bps baud rate leased telephone circuit that is provisioned between two fixed locations. It provides a single telephone circuit with 4 wires, which enable it to support full-duplex voice or telephone communication. In addition to the four analog audio lines, additional telephone lines (typically between 4 and 8) are provisioned to support 'E' and 'M' signaling between the two sites. This type of leased circuit is required between each station stop public address (PA) system head-end and the CCF. For 'E' and 'M' signaling, the 'E' lead is used to ground a DC battery voltage from the telephone company to energize a relay at the PA system head end at each station. The 'M' lead opens the voice input path into the PA mixer.

Note that the 2-Wire audio circuits are dial backup circuits provisioned by the service provider to act as backup communication lines between the two mountain top Base Station sites and the CCF. These are not leased circuits, and are used only in the event of a failure of the (primary) back haul or leased circuits.

E. REFERENCE STANDARDS

The installation of both Data Radio and Voice Radio communication systems shall only be performed by qualified Radio Communications Technician(s). Each of the Radio Technicians shall be proposed to the Engineer for approval. Technicians shall have an FCC license and a minimum of 5 years of recent experience performing similar work.

1.0 ATCS DATA RADIO

All designs shall be in accordance with FCC rules and regulations and shall be coordinated via the AAR (Automatic Alternate Routing). All installations shall be in accordance with the following codes:

a. National Electrical Code (NEC)

b. AREMA C & S Manual

c. CAL/OSHA standards

d. CPUC Regulations

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

f. FCC rules and regulations

g. The Motorola R56 grounding standard

2.0 TELCO INTERFACES

The telephone company shall perform all electrical work up to the MPOE (Main Point of Entry). It shall be the responsibility of the Installer to connect from the MPOE to the various equipment assemblies used by the Caltrain communication systems.

All Installations shall be in accordance with the following codes:

a. National Electrical Code (NEC)

b. AREMA C & S Manual

c. CAL/OSHA standards

d. CPUC Regulations

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

f. Applicable TIA/EIA references

3.0 VOICE RADIO

All designs shall be in accordance with FCC rules and shall be coordinated via the AAR. All Installations shall be in accordance with the following codes:

a. National Electrical Code (NEC)

b. CAL/OSHA standards

c. CPUC Regulations

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

e FCC rules and regulations

f. The Motorola R56 grounding standard

F. DESIGN REQUIREMENTS

The designer shall be responsible to produce the Design Documents in phases, which shall be submitted in phases for ATCS and Voice Radio. The 65% and 100% design shall, at a minimum, include the following documents:

a. Radio coverage/link simulations

b. Intermodulation studies

c. Grounding and Lightning protection

d. Tower structural calculations for operation and licensing

During installation, the following documentations shall be provided as needed:

a. All deviations from the installation requirements specified in the Contract Documents shall first have the approval of the Engineer. The Installer shall submit an RFI (Request for Information), explaining the reason(s) for any deviations and a description of the deviation itself to the Engineer for approval.

b. Prior to the start of any installation, the Installer shall submit catalog cut-sheets and other manufacturer literature describing the product being considered for installation to the Engineer for approval.

c. At least thirty (30) days prior to the start of the installation of any item, the Installer shall submit a set of installation drawings, “code plugs” and software configuration management to the Engineer for approval. The Installation shall thereafter proceed only after written approval of the drawings by the Engineer.

d. Test Plans and procedures shall be provided at least 90 days prior to the start of testing, Training and O&M manuals shall likewise be submitted at least 60 days prior to maintenance training and a list of recommended spare parts, test equipment and special tools, at least 60 days prior to the start of training.

G. PRODUCTS

1.0 ATCS DATA RADIO COMMUNICATION

The antenna tower shall be either eighty (80), sixty (60) or forty (40) foot, Tilt-Down Towers from Western Towers or Engineer Caltrain approved equal. The designer shall determine quantity and height of the tower. The Installer shall coordinate with Caltrain to verify the exact location for the installation of each tower. The Mobile Communications Package (MCP) Radios shall be from Safetran Systems (Invensys), or from Harmon Industries (GE Transportation Systems).

The coaxial cable, CP Antennas, Ethernet Spread Spectrum radios, the 12Vdc batteries and chargers and other Data Radio products, where required, shall be procured from the sources listed in **TABLE 6-7** below.

TABLE 6-7 DATA RADIO SYSTEM PRODUCTS AND EQUIPMENT LIST

ITEM NO	EQUIPMENT DESCRIPTION	EQUIPMENT PART NO.	MANUFACTURER OR VENDOR
1	Spread Spectrum (Ethernet) radio	A53325	Safetran (Invensys)
2	WCP ATCS Radio MCP II	9011-53411-0205	Safetran or equal
3	Router	2811	Cisco Systems or equal
4	Ethernet Switch	Part of #3	Cisco Systems or equal
5	WAG	A53457	Safetran
6	UPS	APC	SUA1500RM2U or equal
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 or equal
10	2.4 GHz Lightning Arrestor	IS-MT50LN-MA	Polyphaser/ Tessco
11	900MHz Lightning Arrestor	DSXL-D-ME	Polyphaser/ Tessco
12	Alarm Relays/Sensors	N/A	N/A
13	Spread Spectrum 2.4 GHz Antenna	As required	Maxrad/Tessco
14	ATCS 900MHz Antenna	As required	Maxrad/ Tessco
15	Coaxial Cables	LCFS114-50A or equal	Cellwave/ Andrew
16	Coaxial Cables	LCF78-50A LCF12-50A or equal	Cellwave/ Andrew Cellwave/ Andrew
17	Tilt-down Antenna Mast & Installation accessories	N/A	Various
18	Miscellaneous Accessories	N/A	Various

These following tables, **TABLE 6-8** through **TABLE 6-10** list specifications for the ATCS Data Radio equipment, which are based on the Safetran BCP and GE/Harmon MCP ATCS data radio transceivers.

TABLE 6-8 BASE STATION DATA RADIO SPECIFICATIONS

DESCRIPTION	SPECIFICATIONS
General	
FCC Compliance	Parts 15, 90
Transmitter	
RF Power Output	25-75W Adjustable
Duty Cycle	Continuous
Spurious Emissions	-90dBc
Harmonic Emissions	-90dBc
Audio Response	+1/-3 dB per TIA-603
Hum & Noise	-45 dB per TIA-603
Frequency Spread	5 MHz
Frequency Stability	0.1ppm, -30°C to +60°C (-22°F to + 140°F)
RF Data Communication	
Frequency Range	Transmit @ 935-940 MHz, Receive @ 896-901 MHz
Number of Channels	1 (Synthesized, programmable)
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)
Ground Network Port	
Port Type	Sync. / Async., EIA-232 with Configurable port Modem Signaling
Baud Rate	Up to 2.048 Mbit/sec, 9600 bit/sec typical
Data Link Protocol	HDLC Balanced, HDLC Polled
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 & Image Rejection	-90 dB
Audio Squelch Sensitivity	12 dB SINAD

TABLE 6-8 BASE STATION DATA RADIO SPECIFICATIONS (Continue)

DESCRIPTION	SPECIFICATIONS
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 6-9 CONTROL POINT DATA RADIO SPECIFICATIONS

DESCRIPTION	SPECIFICATIONS
General	
Dimensions	5”HX10”WX10”L
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, Transmit @ 896-902 MHz, Normal, Transmit @ 935-941 MHz, T/A Mode
Number of Channels	6 (Synthesized, programmable)
Channel Spacing	12.5 kHz
Channel Resolution	12.5 kHz

TABLE 6-9 CONTROL POINT DATA RADIO SPECIFICATIONS (Continue)

DESCRIPTION	SPECIFICATIONS
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)
RF Channel Access	Data “Busy-Bit” protocol
Maximum Frequency Deviation	Adjust per the Operations Manual
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.), 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)

TABLE 6-10 BASE STATION UHF ANTENNA SPECIFICATIONS

DESCRIPTION	SPECIFICATIONS
Frequency	890-940 Mhz
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

2.0 TELEPHONE INTERFACES

Products should be in accordance with the existing agreements between Caltrain and the service providers.

3.0 VOICE RADIO COMMUNICATIONS

The more significant characteristics of the technical specifications of the radio equipment and sub-systems that shall be used to replace or retrofit the VHF voice radio are presented in the following tables, **TABLE 6-11** through **TABLE 6-15**.

TABLE 6-11 BASE STATION RADIO SPECIFICATIONS

SPECIFICATION	DESCRIPTION	NOTE
Model	MASTR III VHF, Analog, Conventional Base Station.	
Operation	Simplex / Full Duplex	
Squelch Gate	Carrier Only	
Power	10-110 Watts, Adjustable	
Channel Spacing	12.5/25/30 KHz	Capable of 12.5 KHz
Sensitivity (EIA 12dB SINAD)	-116 dBm	
Selectivity	90 dB	
Amount of Channels	1 TX, 1 RX	

TABLE 6-12 LOCOMOTIVE/ CAB CAR SPECIFICATIONS

SPECIFICATION	DESCRIPTION	NOTE
Model	VHF, Analog, Conventional Mobile Radio	
Operation	Simplex / Half Duplex	
Squelch Gate	Carrier Only	
Power	45 Watts, Adjustable	
Channel Spacing	25/30 KHz	Capable of 12.5 KHz
Sensitivity (EIA 12dB SINAD)	-116 dBm	
Selectivity	90 dB	
Amount of Channels	>90	

TABLE 6-13 MOBILE RADIO SPECIFICATIONS

SPECIFICATION	DESCRIPTION	NOTE
Model	VHF, Analog, Conventional Mobile Radio	
Operation	Simplex / Half Duplex	
Squelch Gate	Carrier Only	
Power	45 Watts, Adjustable	
Channel Spacing	12.5/25/30 KHz	Capable of 12.5 KHz
Sensitivity (EIA 12dB SINAD)	-116 dBm	
Selectivity	90 dB	
Amount of Channels	>90	

TABLE 6-14 PORTABLE RADIO SPECIFICATIONS

SPECIFICATION	DESCRIPTION	NOTE
Model	VHF, Analog, Conventional Portable Radio	
Operation	Simplex / Half Duplex	
Squelch Gate	Carrier Only	
Power	5 Watts	
Channel Spacing	12.5/25/30 KHz	Capable of 12.5 KHz
Sensitivity (EIA 12dB SINAD)	-116 dBm	
Selectivity	90 dB	
Amount of Channels	>10	

TABLE 6-15 DRAGGING EQUIPMENT DETECTOR RADIO SPECIFICATIONS

SPECIFICATION	DESCRIPTION	NOTE
Model	Motorola VHF HT-750 , Analog, Conventional Transmitter	Narrow-band capable
Operation	Transmit Only	
Power	5 Watts, Adjustable	

H. INSTALLATION REQUIREMENTS

Special instructions for the installation of portions of the Voice Radio and Data Radio systems are described as follows.

1.0 VHF AND ATCS BASE STATION

Base Station antennas shall meet the technical requirements of **TABLE 6.10 and TABLE 6-11**, in particular the horizontal and vertical beam-width shall be designed to support coverage to the range of control points specified. Gain shall be as required to meet the coverage requirements. Antenna may be custom built if required to provide the necessary gain and beam-width.

Transmission line used shall be 50 ohm, flexible coaxial cable, the size of the cable as specified in the Contract Documents. Cable installations on towers shall be supported with hangers and clips as instructed by the manufacturer. The outer shield of the cable shall be grounded to the tower, using grounding kits, at the base of the tower, where the cable turns parallel to the ground.

Design of the installation of all Base Station towers shall be performed by a Civil or Structural Engineer, licensed in the State of California. The Engineer shall certify that the tower foundation, as well as the soil type at the installation site, meets the structural and wind loading requirements.

Base Station radio equipment shall be installed in lockable enclosed cabinets, mounted inside air conditioned rooms or enclosures. Base Station towers, antennas and equipment shall be grounded in accordancew with Caltrain Standard Specifications.

1.1 ATCS Data Radio Control Point

A total of one (1) Tilt-down Antenna Tower, one (1) Omni-directional Antenna, one (1) MCP Radio, associated Batteries, Battery Charger, dc/dc Converter and Lightning Arrestor shall be required per Data Radio CP site. The Installer shall provide the Tilt-down Antenna Tower and installation accessories, the Coaxial Cables, per the Contract Documents, the required multi-strand and ground cables, connectors and installation accessories.

The following equipment and material shall be required at each Data Radio CP site:

a. One (1) MCP Radio configured to communicate with the two (2) Base Station sites. The Radios shall be ATCS MCP data radios manufactured by either Safetran or GE/Harmon. The Safetran unit is preferred due to the remote diagnostic capabilities.

b. One (1) Omni-Directional Antenna. Each Antenna shall be equipped with a Type N Female connector, and shall be mounted to the top of each tilt-down tower using a 10 to 12 foot section of Aluminum pipe, weighing no more than 16 pounds.

c. One (1) 12 Vdc Battery plants, (each plant comprised of ten 1.2Vdc batteries), plus a 12Vdc Battery Charger, a dc/dc Converter and a Lightning Arrestor.

2.0 INSTALLATION INSTRUCTIONS

2.1 ATCS Data Radio Control Point

Installation of the Antennas, Tilt-down Antenna Towers, MCP Radios, Batteries, Battery Chargers, dc/dc Converters and Lightning Arrestors shall be performed in accordance with the Manufacturers written specifications. The Manufacturers written installation instructions shall be provided with the equipment.

3.0 RADIO PROGRAMMING AND CONFIGURATION

3.1 ATCS Data Radio MCP

MCP Radios shall be configured for operation on either of two ATCS Channels based on its area of operation. ATCS Channel number 2 corresponds to an MCP Transmit frequency of 896.9375 MHz and an MCP Receive frequency of 935.9375 MHz. ATCS Channel number 5 corresponds to an MCP Transmit frequency of 897.9375 Mhz and an MCP receive frequency of 936.9375 Mhz. Radios shall provide up to 30 Watts Transmit Power, and shall have a receiver sensitivity of 0.35uV or better for 12 dB SINAD. The transmitter shall be aligned to ensure that it is operating on-frequency, with proper deviation and output power into a 50 ohm load..

Additionally, the transmitter should be aligned to ensure that it produces the maximum frequency deviation allowed per the emission designation. The Installer shall install and connect the MCP Radios provided to the Radio Antenna system and to the dc Power plant as shown on the Contract Documents. The interface cable shall be provided by the Contractor. The connection between the MCP Radio and the VHLC shall be performed by others. The MCP Radios provided shall be manufactured be either GE Harmon or by Safetran Systems. The Installer shall follow the directions provided in of the Grounding requirements provided with the Contract Documents to ensure the proper grounding of the MCP, Antenna, Tilt-down Antenna Tower and other Radio equipment.

4.0 ANTENNA AND ANTENNA MAST

Antennas shall be grounded through their Tilt-down antenna masts. This shall be provisioned by ensuring a reliable electrical connection between each antenna and the supporting tilt-down mast.

5.0 BATTERY PLANT

5.1 ATCS Data Radio

A Battery bank and 12Vdc Battery Charger shall be installed at each Control Point. All Radio Equipment shall be powered directly by the batteries which shall be configured to "Float Charge" so that momentary interruptions of ac power will not interrupt Radio Service. The design of the battery plant, and charger shall be performed by others, to provide a minimum of 24 hours of battery backup at full load.

A dc/dc converter shall also be installed in series with the Charger, as shown in the Contract Documents, to provide additional isolation. The Installer shall install the lightning arrestor directly to the coaxial antenna cable, at the closest convenient location to the point of entry to the CP signal house. A 2/0 ground cable shall be installed between the lightning arrestor and the CP ground plate.

6.0 GROUNDING AND LIGHTNING PROTECTION

Refer to the Caltrain Grounding requirements for details of the requirements applicable to Caltrain Standard Specifications.

7.0 SAFETY

The Installer shall follow the written safety instructions provided by GE/Harmon or Safetran, and Western Towers for the installation of the MCP and the Tilt-down towers respectively, in particular the installation and operation of the towers. All towers shall be installed in such a way that they tilt down PARALLEL to the tracks.

The Installer shall coordinate with Caltrain to determine the minimum distance, on a case by case basis, of the foundation of each tilt-down tower from the center of the track. The Installer shall take note of the locations of all spur tracks or intersecting tracks adjacent to the locations of the tilt-down tower installation to ensure that the minimum safety distances and orientations are maintained.

The Installer shall make special note of the locations of overhead Power and Utility lines to ensure that they are beyond the path of any part of their tower as it tilts up and down.

All work shall be in accordance with the Caltrain Roadway Worker Protection (RWP) training and manual.

END OF CHAPTER