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SECTION 7 COMMUNICATIONS AND CENTRAL CONTROL

7.1 GENERAL

The Communications and Central Control System (CCS) includes communications equipment, the remote I/O equipment, and the human interface equipment to help allow Controllers to monitor and control the wayside systems and facilities. Additionally, controllers shall supervise mainline rail operation as well as interface with regional Class 1 Railroads. The scope includes:

- A new Commuter Rail CCS with supervisory control to allow commuter rail operations personnel to remotely monitor and control the signal system, traction electrification system (TES), Ticket Vending Machines (TVM), and station and wayside facilities, issue route requests to the signal system and issue commands to open breakers to the TES.
- Remote I/O equipment interconnecting Commuter Rail (CR) Operations Control Center (OCC) with signal cases and houses, communications equipment houses and cabinets, and traction power substations (TPSS).
- Radio control equipment to be used at the control room.
- Telephone PBXs and telephones for voice communication from the control room to other RTD personnel and to outside personnel.
- Emergency telephones installed in elevators, CR tunnels, on platforms and other passenger waiting areas.
- A closed circuit television (CCTV) system to allow personnel at the control room and in the CR Security Command Center (SCC) to monitor activity at parking facilities, elevators and station platforms.
- A public address/variable message sign system (PA/VMS) and interface equipment, accessible from the control room to enable audible and visual text display of passenger information.
- An IP based network to facilitate a communications backbone system to carry voice, data, and video communication information.
- Communication houses, cabinets, batteries, chargers, raceway, etc. to enable reliable operation of wayside communications equipment.

7.2 STANDARDS AND CODES

The communications and central control system shall be designed and implemented to the latest revision, at the time of award of contract, of the applicable codes and standards of the following organizations:

- American National Standards Institute (ANSI)
- Electronic Industries Association (EIA)

- Federal Communication Commission (FCC)
- Institute of Electrical and Electronics Engineers (IEEE)
- International Organization for Standardization (ISO)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Building Industry Consulting Standards Institute (BICSI)
- Internet Engineering Task Force (IETF)

7.3 OPERATIONS CONTROL CENTER

The CR OCC and SCC shall be designed to be a comfortable, quiet, and uncluttered working area, and shall meet the requirements of the Americans with Disabilities Act of 1990, including Appendix A to Part 37 of U.S. Department of Transportation, Final Rule - Transportation for Individuals with Disabilities.

7.3.1 Control Room Layout

The layout of the control room shall be such that the control room staff can work and interact with each other effectively and efficiently. To be most effective, the staff positions within the control room shall be within line-of-sight of one another to allow the use of visual signals to supplement their voices.

Access to the control room shall be located to minimize the disturbance to staff communications or their view of the overview display.

7.3.2 Consoles

Control room staff shall utilize consoles to supervise system activities. Each console within the control room shall contain the communications, reporting, controls, and monitoring equipment necessary to carry out the assigned functions by the Controllers. All Controller consoles shall be identical.

All consoles shall have the following design requirements:

- a) Like equipment and procedures shall be used for like functions and like functions shall be in the same general physical location in each console.
- b) Frequently used equipment shall be located most conveniently. Most-frequently used procedures shall require the fewest, least-extended motions possible.
- c) The amount of equipment and variety of procedures at a console shall be minimized, consistent with requirements for modular and expandable design.

- d) Voice communication interfaces shall be integrated such that CR OCC and SCC staff need not switch between more than two devices to interact with the several parties with whom they may need to maintain contact. Audio outputs shall have volume and tone controls.
- e) Console physical dimensions shall be consistent with ergonomic limits. Consoles shall be designed to accommodate the reach of a 5th percentile female and the size of a 95th percentile male.
- f) Console components shall be modular to allow replacement of a failed unit within 30 minutes, and replacement shall not require shutdown of the functioning portion of the console.
- g) Writing and documentation storage space shall be provided. The Controller consoles shall have the following design requirements:
 - 1) A keyboard and point-and-click device shall be able to be used for display item selection and function initiation. Single purpose function buttons and switches may be used for, but limited to, functions which are frequently used or require rapid activation.
 - 2) Console display monitors shall be high resolution with a minimum of 1280 x 1024 pixels, with a maximum 8ms response time. Contrast ratio shall be not less than 800:1. Color capabilities shall be 24-bit or true color which is comprised of three colors each with 8-bits of color. Brightness shall be a minimum of 300 cd/m². Viewing angles shall be a minimum of 178° for both vertical and horizontal. Console monitors shall be selected and placed to minimize emission exposure. Monitors shall have easily accessible intensity and color controls.
 - 3) Console furniture and chairs shall be consistent with ANSI/HFS 100, "American National Standard for Human Factors Engineering of Visual Display Terminal Workstations".
- h) Controller consoles shall be assignable to a geographic portion of the CR system.

7.3.3 Environmental Considerations

The following site requirements shall apply at the CR OCC and SCC:

- a) The CR OCC and SCC shall meet all applicable fire safety requirements, including NFPA 130. A fire alarm and suppression system shall be provided for the control room and equipment room.
- b) Raised flooring with removable tiles may be provided for the control room and equipment room. These tiles shall be covered with same sized removable carpet. The metallic floor framing shall be grounded.
- c) Wide door access shall be provided at the control room and equipment room to accommodate the movement and placement of equipment.

- d) The control room and equipment room shall each be fully enclosed to create a secure environment and to minimize noise. The Equipment Room shall also be a secure area.
- e) The lighting within the control room shall be generally uniform, and at a level of at least 50 foot-candles. Consoles shall have additional, locally controlled, adjustable spot lighting to 100 foot-candles.
- f) Reflected glare on display screens, overview display, and console work surfaces should be minimized.
- g) Noise within the control room should be minimized. There shall be acoustic treatment of the control room, including floors and walls, to absorb noise. Background noise, including background noise from Communications System equipment, shall not exceed 55 db.
- h) The control room and equipment room shall be provided with air conditioning. There shall be independent temperature controls for the control room and equipment room. The temperature in each area shall be adjustable to be within the comfort zone for humans for interior spaces. The air distribution shall minimize temperature gradient and drafts. The temperature shall be maintained in the range of 64° F-75° F with a humidity range of 30%-55% (non-condensing).
- i) Approximately two air exchanges per hour shall be provided for. The air distribution shall minimize temperature gradient and drafts.
- j) Electrostatic control shall be provided for in the control room and equipment room. Flooring and carpeting shall not allow static build up.

7.4 SCADA

7.4.1 Safety Constraints on SCADA

The relationship between the Communications System and the Signal System shall be such that no action or failure of the CCS/SCADA (nor any other Communications System element) can cause or allow an unsafe train operating condition. Should the CCS/SCADA become completely inoperative, for any reason, the CR system shall be able to continue to operate safely.

7.4.2 System Operation

CCS/SCADA shall normally function without operator intervention except for routine service.

CCS/SCADA shall have the capability for performing orderly system start-up and shut-down as commanded by a system operator.

Remote CCS/SCADA equipment shall operate in an unattended mode. The central CCS/SCADA equipment shall continue operation in the event of a failure of remote SCADA equipment, and upon return to service of failed equipment, automatically resume normal monitoring and management of that equipment.

7.4.3 System Requirements

7.4.3.1 Response Times

- a) The elapsed time from the first possible detection by remote I/O equipment of an alarm or device change of state until display at the control room shall not exceed 2.5 seconds.
- b) When a user enters a command for any individual device control, the remote I/O equipment shall generate the associated output signal, in the field, in no more than 2.5 seconds.
- c) When a user requests a display, the completed display shall appear on the screen in not more than two (2) seconds.

7.4.3.2 Accuracy of Information

Display of train position shall be accurate to within a track circuit for signaled territory.

7.4.3.3 Availability

CCS/SCADA is intended to operate 24 hours a day, seven days a week. The CCS/SCADA central system availability shall be at least 99.8% for all operating functions.

Any console shall be capable of fully backing-up a failed console of the same type. Back-up shall take the form of assuming the full geographic and functional responsibilities of the failed console.

The CCS/SCADA shall be constructed such that it can be put in place and continue to operate while:

- a) Already-operating lines are retrofitted for the new Communications System.
- b) New lines are equipped, tested and brought into service.

7.4.4 Displays

Displays at the control room shall be graphic and text displays. Graphic displays shall be provided at both the overview display and at the console displays. The overview display and console graphics displays shall provide a semi-geographic representation of the CR system and its major subsystems. Information displayed shall be kept up-to-date.

At the control room, user interface equipment characteristics, equipment location, and

display contents shall be consistent with MIL-STD-1472 "Human Engineering Design Criteria for Military Systems, Equipment, and Facilities" or an approved equivalent human factors standard or guide such as the FAA's Human Factors Design Guide.

For all graphic displays, the following guidelines shall be followed:

- a) Distinct colors and display attributes (e.g., flashing) shall be used to draw attention to alarm or abnormal conditions.
- b) There shall be consistent use of colors, geographic orientation, labels, display attributes, and object symbols.
- c) Label and message contents shall be in language consistent with RTD train operations terminology.

7.4.5 Software

Software design and implementation of CCS shall:

- a) Follow guidelines for software design and documentation as defined in IEEE Std. 729
- b) Conduct a software quality assurance program for software development consistent with practices as defined in IEEE Std. 730

The CR software system shall be easily definable and modifiable so that: 1) the overview display and console display contents can change as track, stations, and devices are added; and 2) console display devices can be changed.

Application software shall be written in an industry-standard high level language. It shall be built on an approved commercially prevalent or industry-standard operating system and be portable to higher capacity computer system configurations running that standard operating system. All new software shall be compatible with existing CCS network software and network architecture. Networking system software shall satisfy the Open System Interconnect (OSI) requirements and/or utilize approved industry-standard physical level and link level communication protocols.

All CCS software shall be completely tested before it is used for train operations.

7.4.6 Central Equipment

The CCS central equipment shall:

- a) Utilize commercially available computer equipment and peripheral devices. Custom equipment shall be limited to special functions and interfaces.
- b) Normally operate unattended.

- c) Have sufficient redundant equipment to permit automatic switch-over so that no single failure shall interrupt operation for more than 30 seconds.
- d) Automatically detect equipment failures and provide corresponding failure indications.
- e) Where feasible, provide for on-line replacement of failed components, console devices, computers, peripheral devices, and data communications interface equipment while it continues to operate.
- f) Be sized to handle the defined CR system size under peak-period operating conditions and have provisions for future expansion.
- g) Be physically located and configured in such a way so as to provide for easy maintenance access.
- h) Be provided with an uninterruptible power supply (UPS), with a minimum capacity of 4 hours, and a redundant source of AC power.

7.4.7 Remote I/O Equipment

The Remote I/O Equipment (e.g. PLC's), which is the field portion of SCADA, shall:

- a) Be solid-state, microprocessor based with logic elements and auxiliary components configured on easily replaceable plug-in modules.
- b) Be of common design for all remote sites to provide interchangeability of modules.
- c) Be capable of continued operations with the loss of communication to the CR OCC as a result of either communication equipment failures or central equipment failures.
- d) Operate normally unattended. Remote I/O equipment logic and configuration data shall reside in non-volatile memory.
- e) Perform self-tests upon power up and on command from local test equipment and from CR OCC. Self-tests shall also be performed by input/output subsystems and input/output cards.
- f) Provide for maintenance of input/output circuits (including disabling power to output circuits) and safe replacement of input/output cards without the removal of any wiring.
- g) Be capable of continued operation between 32°F and 122°F with 95% humidity (non-condensing).
- h) Operate within a power supply range of 90 to 125 volts ac and a frequency between 57 to 63 Hz.

- i) Be capable of continued operation in the electromagnetic environment where the remote I/O equipment will be located, such as TES sub-stations, signal cases, and communications houses.
- j) Support local initialization and troubleshooting with either a local control panel or portable test equipment. Also support remote initialization and troubleshooting via the data communications network.
- k) Be modular in design to provide expansion of performance and capacity by adding subsystem modules. This shall include the ability to add a minimum of 20% more input/output subsystem modules.
- l) Be supplied with hardware and software tools and documentation for reconfiguration and expansion.

7.4.8 Simulator

The design shall include a CR CCS simulator for training of CCS users.

The simulator shall model the physical plant so as to present accurate representations of train movement, interlocking response, and traction power system response for the above purposes. The simulator shall model all discrete state indications, which are normally presented to the CCS. The simulator shall be deterministic. The simulator shall be capable of simulating normal and abnormal equipment operation. The simulator shall also provide the capability to playback (e.g. re-display) real wayside events as originally depicted on the Controllers' displays and the overview display.

The simulator shall provide both an Instructor user interface and a trainee user interface. The Instructor shall be able to alter the simulated behavior of trains as well as all wayside devices. The trainee's user interface to the simulator shall be the same displays as those used in normal operations at the Controller consoles. The simulator shall use the standard commands and displays, which normally support active operations, supplemented by simulator-specific commands.

The simulator shall model the entire physical plant including the traction power system. The simulator shall be capable of modeling train control and traction power simultaneously together. The simulator shall be capable of being upgraded to represent the latest physical plant layout.

7.5 COMMUNICATIONS

7.5.1 Radio System

Modifications to RTD's radio system shall be made to enable communication between:

- a) CR trains and Controllers.
- b) CR trains and Rail Supervisors.

- c) CR Rail Supervisors and Controllers.
- d) CR non-revenue vehicles and Controllers.
- e) CR MOW personnel and Controllers.
- f) CR trains and maintenance personnel.
- g) CR Controllers and other CRT personnel along the ROW.

All commuter rail trains and Maintenance (MOW) non-revenue vehicles shall be equipped with mobile radio transceivers, with a minimum of 25 watts of radio frequency output power. A sufficient number of hand-held portable radios shall be furnished to allow CR train operators and maintainers along the CR right of way to carry a portable transceiver.

Radio coverage along the CR alignment including tunnel sections and within the rolling stock shall enable a two-watt portable radio to be heard with 20-dB quieting at the CR OCC along 98% of the alignment, 99% of the time. No "dead sections," with less than 20-dB quieting, longer than 50 feet shall be allowed.

7.5.2 PBX/Telephone System

Each CR maintenance and operations facility shall be equipped with its own Private Automatic Branch Exchange (PBX). PBX, telephones, and interface equipment shall provide communications between Operations personnel and CR personnel and personnel outside of CR property.

The emergency telephone system shall be designed to permit passengers at stations, in elevators, walkway tunnels and at other passenger waiting areas to communicate with the SCC and the control room for emergency purposes. The phones shall be activated by push button and contain Braille lettering for ADA compliance.

The SCC personnel shall receive emergency phone calls from the passenger areas. Tunnel 'bluelight' phones shall be received by Controllers.

All phone conversations received/initiated by the Controllers shall be recorded.

7.5.3 CCTV System

Refer to Section 14, System Safety and System Security for camera details.

7.5.4 PA/VMS System

Station platforms and public areas will be equipped with PA/VMS equipment. PA/VMS equipment shall consist of amplifier-driven loudspeakers and variable message signs installed and operated in compliance with ADA requirements. Local input to both audible and visual portions of the PA/VMS system shall be provided at designated stations.

Text message entry shall be by way of easily and understandable graphical user interface with Windows-type entry screens and prompts. Audible and text messages shall be coordinated so that playback to the public occurs at the same time. It shall also be possible to transmit audio and text messages independent of each other.

Controllers at the control room shall be provided with the ability to distribute both pre-recorded and ad-hoc messages to passenger stations. This ability shall include provisions to send messages to an individual station, a group of stations, or all stations.

7.5.5 Communication Transmission System

A fiber-optic IP-based high speed network communications transmission system (CTS) shall be installed along the CR right of way to inter-connect the various field SCADA, CCTV, data and voice signals to/from the field and from/to the CR OCC. The CTS includes a fiber-optic cable plant, optical and electronic transmission equipment, and other equipment necessary to provide communications between sites. The backbone, IP network system shall be configured to continue to operate normally on loss of a single fiber or any single equipment module. One high speed IP network shall be provided for all data, voice and CCTV.

There shall be a minimum of six single mode fibers pulled between Communication houses and Signal houses. There shall be a minimum of twelve single mode fibers pulled between Communication houses and TPSS.

Communication Houses and Enclosures

Field communications equipment shall be located in dedicated communications equipment houses or cabinets. Communication houses shall be a minimum size of 10x10 feet. All houses and cabinets shall be equipped with appropriately sized air-conditioning and heating equipment to maintain temperatures within the operating range of all equipment.

Outdoor security lighting shall be provided on and/or above communications houses. The security lighting shall be controlled by a photo-electric cell and shall not overflow into surrounding residential communities.

Communication house and cabinet foundations shall be designed to withstand all live and dead loads of the house and cabinet and equipment. Foundations shall be designed in accordance with all applicable standards as well as local Building Codes. An appropriate factor of safety according to the standards shall be applied at each site. Each foundation slab shall be provided with openings to connect the equipment to the local power supply system and to outside circuits.

Communication houses shall be of double roof and wall construction to accommodate insulation material to reduce heat transfer.

7.5.6 Communication Power System

CTS, remote I/O equipment, network equipment, CCTV equipment, and radio equipment shall all be powered from an Uninterruptible Power System (UPS). The UPS shall be sized to carry the full load of the above equipment at a communication house for at least 4 hours. The charger shall be sized to carry the same load while recharging a completely discharged battery set. The charger shall be able to recharge the batteries under these conditions in less than 12 hours. The batteries shall be of maintenance free design and shall be sealed, non-spillable technology.

7.5.7 Location of Communication Enclosures and Equipment

All communication devices, including platform mounted equipment, houses, cabinets, antennas and raceway shall be not less than 8' 6" from track centerline. This requirement includes clearance for enclosure doors in any open, intermediate, or closed position. Communication houses and cabinets shall be located so as not to obstruct the train operators', motorists' or pedestrians' view of trains.

7.6 INTERFACE REQUIREMENTS

7.6.1 Central Control Facility

The communications system and human interface equipment within the CR OCC, including consoles, radios, telephones and computers, shall be connected to essential power. Other equipment to be connected to essential power includes all CR OCC emergency systems and at least 40 percent of CR OCC and equipment room lighting.

The CR OCC system equipment shall utilize two independent grounding systems; one grounding system shall be for equipment grounding and the other for electronic signal grounding. The grounding systems shall interface to connection points in the equipment room and the CR OCC.

7.6.2 SCADA Remote I/O Equipment

Remote I/O equipment shall support digital inputs and outputs via relay contact closures (or optically isolated solid state equivalents such as a silicon controlled rectifiers). All digital inputs to SCADA shall be of the same type. All digital outputs by SCADA shall be of the same type. The following SCADA input and output requirements shall be met:

- a) Digital inputs to SCADA shall be from normally open and normally-closed contacts. The operating voltage DC power supply shall nominally be in the SCADA domain. Contact ratings shall be as required for the circuit.
- b) Input and output signals shall be electrically isolated from SCADA equipment.

- c) SCADA shall generate outputs via relays. Transient suppression circuits shall be provided by the SCADA contractor. Contact ratings shall be as required for the circuit. SCADA interface relays and relay contacts shall have an MTBF, at rated loads, of 5,000,000 cycles or more.
- d) SCADA outputs shall be momentary contact closures with a time duration that is stable and adjustable.
- e) The remote SCADA equipment shall prevent unintended action such as energizing output circuits upon power-up and power-restore.

SCADA shall be designed and implemented so that wiring and cabling between remote I/O equipment and field devices are uniform in type, routing, and connection locations. The following interface requirements shall be met:

- a) I/O signals to/from SCADA at each signal facility shall terminate at one centralized location.
- b) I/O signals to/from SCADA at each TPSS site shall terminate at one centralized location.
- c) SCADA terminations shall include test points and rapid disconnect.
- d) All wires and cable shall be labeled using a logically consistent labeling convention.

Remote I/O equipment shall be equipped for protection from electromagnetic interference levels consistent with their locations. Bus bars shall be provided for grounding in all input/output termination cabinets.

Data communications between SCADA remote I/O equipment and the CR OCC shall utilize approved industry standard protocols, which support error detection and message retransmission.

END OF SECTION