

SECTION 15 SERIAL TRAINLINE AND DATA COMMUNICATIONS

15.01 GENERAL

A. Overview

1. This Section describes the requirements for E1 serial trainlines, redundant serial trainline multiplexers, unit (married pair) networks, touch screens, trainlined digitized audio, Smart Card Readers, Data Radios and related systems
2. The Control and Monitoring Network (CMN) and the Propulsion Control Network (PCN) shall be based upon IEEE Std. 1473-L service proven designs using readily available commercial off-the-shelf hardware and software.
3. Application specific software and custom designs developed for CTA shall be considered "Work for Hire" and become the property of CTA. All application specific software and designs shall be provided to CTA in computer-readable format on standard optical media. The Contractor shall provide to CTA a perpetual license, as required, for all other non-application specific software and custom designs. See also Section 9.15.D.
4. Proposers shall submit system block diagrams with the proposal.
5. The redundant E1 Serial Trainline and Data Communications System design shall be reviewed by the Engineer.
6. The Serial Trainline and Data Communications equipment shall be powered from the car's Low Voltage System through appropriate circuit breakers and reviewed by the Engineer.

B. Open Interface Design Requirements

1. All device interfaces shall be fully open and fully exposed so as to permit network modifications and enhancements by CTA or other CTA-designated third parties without the need for additional or proprietary information.
2. The Contractor shall submit complete, comprehensive and detailed Compatibility and Interoperability Documentation for each network. At a minimum such network documentation reports shall include a glossary of terms, references, system description, system operation, system architecture, node object descriptions, and node installation.
3. All necessary application and network specific source code, hardware, and development system hardware and development system software shall be provided to CTA, as required, to enable CTA to make future system modifications without reliance on additional hardware, software or other information. Two (2) complete network development system workstations shall be provided to the Authority to permit future modifications and changes by Authority engineering staff. The development system hardware and software shall be reviewed by the Engineer.

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15.01 GENERAL (Continued)

B. Open Interface Design Requirements (Continued)

4. The Contractor shall provide all hardware, software and documentation concurrent with the delivery of the first production cars. Any applicable software and/or hardware upgrades through the warranty period shall be provided by the Contractor at no additional cost to CTA.

C. Automatic Train Sequencing

1. A means shall be provided to automatically determine the sequence of units (married pairs) in a train.
2. The means to automatically determine unit sequencing shall be considered an open interface that is fully and completely described as required per Section 15.01.B

D. Network Training Courses

1. The Contractor shall provide two (2) comprehensive “hands-on” network training classes to CTA Engineering staff. Classes shall consist of not less than 80 total classroom hours of technical network training. Classes shall be conducted following the delivery of the first production cars.
2. The first training class shall consist of not less than 40 classroom hours for up to 20 students. This class shall describe standard networking techniques for creating and modifying IEEE Std.1473-L networks. It shall be equal to and as comprehensive as that provided by Echelon Corporation and provided at a mutually agreeable time and location. If training courses are available on video media, they shall be provided.
3. The second training class shall consist of not less than 40 classroom hours for up to 20 students. This class shall be a custom class developed by the Contractor specifically to train CTA Engineering staff on how to modify and add new network devices to CTA train and unit networks. This training class shall be held at a mutually agreeable time at a CTA-designated facility.
4. Following the completion of the training, the Contractor shall provide copies of all print and electronic media used in these classes.

SECTION 15 SERIAL TRAINLINE AND DATA COMMUNICATIONS (Continued)

15.02 UNIT NETWORK REQUIREMENTS

A. General

1. All trainlined serial communications shall be configured to ensure high system availability.
2. Hot standby with automatic transfer shall be provided in the Trainline Multiplexers (TLM) for IEEE-1473-L networks and digitized audio channels such that the failure of the primary system shall result in immediate transfer to the backup system. An indicator in each unit shall report whether the train is operating on the primary or backup system. A means shall be provided to permit manual selection of the primary or backup system.
3. Two separate IEEE-1473-L networks shall be provided within each unit.
 - a. The Propulsion Control Network (PCN) shall be used exclusively for tractive effort interface and direction control of the Propulsion System.
 - b. The Control and Monitoring Network (CMN) shall be used for all other networked systems.

B. Network Architecture Design Requirements

1. To optimize train network bandwidth, each unit (married-pair) shall be its own logical network separated via IEEE Std.1473-L based routers.
2. To facilitate network device commissioning, diagnostics, and maintenance, each unit shall have its own dedicated Unit Network Manager (UNM).
3. Physical network interconnections within each unit shall be via direct copper connection and connectors, as specified in Section 9.02, J.
4. Trains comprised of multiple units shall communicate train networked data to adjacent unit networks via routers. Routers shall facilitate and simplify trainline communications and minimize network traffic.
5. The use of gateways is expressly prohibited.
6. Vehicle and train network designs shall be inherently flexible and “network flat” so as to permit any existing networked device (or any future networked device) to communicate to any other device via a fully routable network architecture compliant with IEEE Std. 1473-L.

SECTION 15 SERIAL TRAINLINE AND DATA COMMUNICATIONS (Continued)

15.02 UNIT NETWORK REQUIREMENTS (Continued)

C. Open Network Interface Requirements

In addition to the requirements above to ensure interoperability with existing and future network interfaces, the following requirements shall be satisfied:

1. All networked devices shall communicate using Standard Network Variable Types (SNVT) as defined by LonMark International.
2. Should a network variable be required that is not in the LonMark SNVT Master List said network variable shall be provided in a resource file.
3. Use of explicit messages is prohibited, including secondary interfaces.
4. Application software in networked devices shall comply with open interoperable LonMark Guidelines.
5. Unless otherwise agreed to by the Engineer, all networked devices on IEEE 1473-L networks shall be LonMark Certified. All networked nodes shall conform to the LonMark Interoperability Standards Version 3.3 or higher.
6. The Contractor shall provide a complete list and comprehensive description of all network interconnections, including all application software, databases, and/or configuration files as necessary to reproduce the network connections.
7. All network designs shall be based upon readily available commercial off-the-shelf hardware and software tools.
8. All networks shall continually detect added or removed networked devices and automatically and dynamically reconfigure the network.
9. The network management scheme shall permit easy system upgrades without the need to alter hard-coded addresses.
10. A node's application software shall not update its own network address, domain table, network variable table or address table entries.
11. It shall be possible to install any future networked device given only the standard IEEE Std.1473-L based XIF file. The XIF file is a text file containing a description of a device's network features, program ID, and program version.

SECTION 15 SERIAL TRAINLINE AND DATA COMMUNICATIONS (Continued)

15.03 REDUNDANT TRAINLINE MULTIPLEXERS

A. General

1. Redundant Trainline Multiplexers (TLM) shall be provided in each unit (married pair) to interface all serial, network, and other signals to redundant serial trainlines as shown in CTA Drawing SKE 050304, Page DR-11.
2. Serial trainlines shall conform to industry standard E1 Pulse Code Modulation. To ensure maximum E1 performance and minimal propagation delay, the redundant TLM design shall be based upon "Add/Drop" architecture as shown in CTA Drawing SKE-050304A, Page DR-11A.
3. Discrete trainline functions shall not go through the TLM.

B. Nonproprietary Interface Requirements

1. TLMs shall be based upon readily available commercial of-the-shelf components and products.
2. The use of proprietary interfaces is prohibited. The Contractor shall deliver to CTA concurrent with the first prototype cars all the interface definitions and functional requirements including but not limited to:
 - a. All network data conversion, protocols, methods, schemes and techniques.
 - b. Monitoring and diagnostic information.
 - c. E1 Channel assignments.
 - d. Redundancy and bypass management.
 - e. Train wide clock synchronization.
 - f. Communication network control protocol.
 - g. Degraded mode management.

C. Translation of Train Networks

1. TLMs shall efficiently and effectively translate all serial, network and other signals onto E1 channels using "Add/Drop" architecture.
2. The method for translation shall be fully described and provided to CTA concurrent with the delivery of the first prototype cars.

SECTION 15 SERIAL TRAINLINE AND DATA COMMUNICATIONS (Continued)

15.04 NETWORK MANAGERS

A. Overview

1. Each unit (married pair) shall have a dedicated Unit Network Manager (UNM) to manage all networked devices within the unit.
2. In a multi unit train, the UNM associated with the unit in control shall take on the additional function of a Train Network Manager (TNM).
3. See also Section 10.08, A, 2, regarding train operation from any cab in ATC bypass mode.

B. Unit Network Manager (UNM)

1. The primary function of the UNM is to manage all of the networked nodes in the Control and Monitoring Network (CMN).
2. Each UNM shall maintain a database of all network nodes under its domain.
3. Each UNM shall periodically ping each network node within its unit to verify node health and shall generate an alarm when a failure has been detected.
4. Every UNM shall automatically identify installation of a replacement networked part and automatically bind the new part to the unit network without the need for special tools, PTU, or other equipment.
5. The UNM shall facilitate interfacing with internal diagnostic and monitoring system software and external hardware and software tools and systems.

C. Train Network Manager (TNM)

1. The TNM shall interface with the means for Train Sequencing.
2. Means shall be provided to prevent the operation of the train with more than one (1) active TNM.
3. Based upon the train sequence information and its associated UNM, the TNM, shall ascertain the relative location of every IEEE Std. 1473-L node in a multi-unit train.
4. The node locations shall be used by the train operator and maintenance personnel to rapidly locate vehicle system failures and other problems.

SECTION 15 SERIAL TRAINLINE AND DATA COMMUNICATIONS (Continued)

15.05 GPS RECEIVER

- A. Each unit (married pair) shall include a GPS receiver to provide train position, speed, and a standard train time reference upon receipt of a valid GPS signal. The GPS receiver shall be energized when the Master Controller is turned on.
- B. GPS networked receivers shall be capable of receiving twelve (12) satellites simultaneously and have Wide Area Augmentation System (WAAS) capability.
- C. It shall be possible for any networked device on a train to subscribe to the information broadcast by the active GPS receiver.
- D. Train Position shall be represented as a network variable conforming to LonMark SNVT_earth_position.
- E. Time of Day information shall be represented as a network variable conforming to LonMark SNVT_time_stamp.
- F. Time of Day and Date shall be displayed on the Train Operator's Touch Screen and Passenger Information Signs.
- G. All train networked devices with time of day clocks shall be automatically synchronized to the GPS train time network variable as described in Section 9.15, E, on initial power-up of the train. The ATC clock, as described in Section 13.15, shall also be synchronized with the GPS train time network variable upon each power up of the train.
- H. Train Speed shall be represented as a network variable conforming to LonMark SNVT_speed.
- I. If an approved Profile for a GPS Receiver is published by LonMark International (www.lonmark.org) prior to Notice to Proceed, the LonMark Profile definition shall be used to define the GPS interface to the IEEE Std. 1473-L network.

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15.06 CONTROL AND MONITORING NETWORK CONNECTED DEVICES

1. Doors.
2. Propulsion/Brakes.
3. Active Suspension System (Fail/Operational).
4. Event Recorder (Fail/Operational).
5. Video System (Fail/Operational).
6. Communications System.
7. Auxiliary Power Supply System.
8. ATC/ATO System.
9. GPS.
10. Smart Card Reader (Fail/Operational).

15.07 PROPULSION CONTROL NETWORK (PCN)

- A. Tractive Effort signals shall be based upon IEEE Std. 1473-L.
- B. Tractive Effort signals shall conform to Type III interfaces as defined in IEEE Std. 1475. The PCN shall be configured as a Master/Slave network to ensure fully deterministic behavior.
- C. See Section 10.03, B, for details.

15.08 RF ID (SMART CARD) SYSTEM

- A. Smart Card Reader
 1. The Contractor shall provide in each cab an RF ID Smart Card Reader that shall read and validate industry standard ISO 14443 and ISO 15693 and the Cubic GoCard® platform.
 2. The Smart Car Reader shall be submitted to the Engineer for review.
 3. The mounting location for the Smart Card Reader shall be part of the Cab Mock-Up. See also Section 9.05, C.

SECTION 15 SERIAL TRAINLINE AND DATA COMMUNICATIONS (Continued)

15.08 RF ID (SMART CARD) SYSTEM (Continued)

B. Smart Card Interface

1. The Smart Card Reader shall interface with the IEEE Std. 1473-L Control and Monitoring Network.
2. The Smart Card Reader shall interface with car systems through the CMN.
3. The Smart Card ID serial number read by the Smart Card Reader shall be stored in the Event Recorder. See Section 9.16, B.
4. If an approved LonMark Profile for an ISO compatible Smart Card is published by LonMark International (www.lonmark.org) prior to Notice to Proceed, the LonMark Profile definition shall be used to define the IEEE Std. 1473-L network interface.

15.09 TRAIN OPERATOR'S TOUCH SCREEN (TOTS)

A. General

1. A Train Operator's Touch Screen (TOTS) shall be located in each cab and used by the Train Operator to operate the pre-recorded announcement system, set and modify destination and run number signs and assist the Train Operator in rapidly determining the status of key train systems and identifying vehicle problems.
2. The Contractor's user interface and display screens shall be similar to those described in NYC Transit's R142 Monitoring and Diagnostics Systems Compatibility Document # 043-BRA-0072.
3. The TOTS shall also be used to assist maintenance crews to identify failures and intermittent problems associated with devices connected to the network.
4. Entry into maintenance mode and access to Maintenance Screens shall require additional security consisting of both the validation of a Smart Card and entry of a valid password.
5. The password shall be selected by the Engineer.

SECTION 15 SERIAL TRAINLINE AND DATA COMMUNICATIONS (Continued)

15.09 TRAIN OPERATOR'S TOUCH SCREEN (TOTS) (Continued)

B. Color Display and Touch Screen

1. The color display and touch screen shall be based upon service proven industry standard solid-state display and touch screen technology. The touch screen interface shall be ergonomic and facilitate easy and rapid entry of all data. Touch Screens shall provide immediate operator feedback upon data entry.
2. Displays shall have a resolution of not less than 800 by 600 or more than 1024 by 768 picture elements and shall support a minimum of 16-bits of color depth.
3. Displays shall be approximately 8" x 10", and its location shall be determined in the cab mock-up.
4. Displayed images shall be easily viewable day and night with automatic intensity adjustment.
5. The Contractor shall take all reasonable measures and use any other appropriate technique(s) to prevent sunlight and glare from reducing the visibility of the screen information.

15.10 DATA RADIO

A. General

1. The Contractor shall provide an IEEE Std. 802.11 (WiFi) compatible Data Radio in each unit (married pair).
2. The radio technology provided at the time of proposal shall be based upon IEEE Std. 802.11g. However, the mechanical, electrical, and network interfaces shall be fully defined, described, and exposed so that future generation IEEE Std. 802.11 radios can be easily upgraded by the Authority without the need for additional proprietary information.
3. If commercial off-the-shelf IEEE Std. 802.11g radios with built in IEEE Std. 802.11i security and authentication capability are available at the time of the Contractor's proposal submittal, such radios shall be provided.
4. Sufficient space shall be provided to permit the future addition of a mobile access router and two (2) additional data radio types such as CDPD, GPRS, CDMA, etc.

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15.10 DATA RADIO (Continued)

B. Data Radio Interfaces

1. The Data Radio antenna(e), cabling, and location shall be reviewed by the Engineer.
2. The Data Radio wired network interface shall be based upon IEEE Std. 802.3 (Ethernet).
3. An IEEE Std. 802.3 router shall interconnect the Data Radio with other vehicle systems as described below:
 - a. The Data Radio shall interface to the IEEE Std. 1473-L Control and Monitoring Network via a commercial off-the-shelf CEA-852 (LonWorks to IP) tunneling router.
 - b. The Data Radio shall interface to the Communications System to facilitate the rapid uploading of new voice announcements to the pre-recorded announcement system. See Section 14.02, I.
 - c. The Data Radio shall interface to the Video System to provide the capability of sending video images to future wayside Data Radios.
 - d. The 802.3 router shall have two (2) additional spare IEEE 802.3 ports to interface to future vehicle systems.

C. Data Radio and Network Security

1. The Contractor shall ensure its Data Radio and network architecture is secure and shall provide all necessary hardware and software firewalls and other secure means to preclude unauthorized access to train and unit networks.
2. The Contractor shall submit to the Engineer for review a detailed description of the hardware and software techniques to ensure that the Wireless Network is inaccessible to all but authorized users.

15.11 TEST EQUIPMENT

The test equipment specified in Section 9.11 shall be supplied for all elements in this Section, unless otherwise agreed to by the Engineer.