Intratrain Communication Requirements for ECP Cable-Based Passenger Train Control Systems

Abstract: This standard sets forth the requirements for an intratrain communication system. It outlines the basic communications hardware, system protocol, and message and performance requirements for the train-line communication network.

Keywords: brake, ECP, emulation, rail car, train

Summary: This standard was prepared by the American Public Transportation Association in cooperation with its member railroads and the supply industry. This standard defines the requirements for an intratrain communications system for passenger equipment in revenue interchange service. It is intended to facilitate interoperability between passenger coaches and locomotives without limiting the proprietary design approaches used by individual suppliers. The intended use of the intratrain communications system is control of electronically controlled pneumatic (ECP) brakes, and the continuous monitoring and safety reporting of various components on passenger coaches and locomotives.

Scope and purpose: This standard designates off-the-shelf communications technology for the purpose of reducing both the cost and time required to bring the benefits of electrically controlled brakes, distributed motive power, and safety/health monitoring to the railroad industry. The inherent principle behind this standard is to define only those necessary interfaces between vehicles within the train, in order to maintain system-wide interchange of coaches and wire distributed power-equipped locomotives, while defining performance levels for subsystem components. The performance requirements are intended to encourage high performance, low cost and maintenance, and high reliability equipment designs.

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Introduction

This introduction is not part of standard requirements for APTA PR-M-S-024-19, "Intratrain Communication Requirements for ECP Cable-Based Passenger Train Control Systems."

This standard applies to all:

1. Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. Tourist, scenic, historic, or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Intratrain Communication Requirements for Cable-Based Passenger Train Control Systems

1. System requirements

1.1 General

The heart of the ECP braking is the network bus. It is used to convey power and to command and control the various devices in the network. This bus has been chosen to be compliant with the ANSI/EIA 709.2 standard, which describes a power line transmission media. All devices, CCDs, HEUs, PSCs, EOT, LCMs, etc., are connected to this bus. The topology is that of a bus whereby a pair of wires runs the length of the train and all devices tee into the bus.

1.1.1 Protocol

To promote the highest reasonable level of interoperability, all nodes using the electric trainline communication media must fully implement the ANSI/EIA 709.1 protocol in the manner prescribed in this document.

1.1.2 Transceiver compatibility

1.1.2.1 In order to control conducted noise on the electric trainline communication media, all transceivers accessing this media must be compliant with ANSI/EIA 709.2. The transceiver shall use a single carrier frequency (SCF) at 132 kHz center frequency. The transceiver coupling circuit shall provide transformer isolation from the trainline communication media and be optimized to a 50Ω transmission line. The communication signal voltage shall be nominally 14 Vpp, measured at the trainline communication media side of the coupling circuit.

1.1.2.2 Three priority slots shall be defined. The first priority slot shall be allocated to the Lead HEU, the second priority slot shall be allocated to the EOT, and the third priority slot shall be allocated to the Lead LCM. A single device performing multiple trainline functions (e.g., HEU as LCM) may use a single priority slot.

1.1.2.3 The network protocol and transceiver performance specifications are contained in the following ANSI/EIA documents:

- **ANSI/EIA-709.1-A, dated April 1999:** "Control Network Protocol Specification"
- **ANSI/EIA-709.2-A, dated December 1999:** "Control Network Power Line Channel Specification"

1.1.3 Allowed device types

In order to effectively manage the message bandwidth and to protect the signal integrity of the trainline communication network, only devices described within this document are allowed access to transmit messages on the trainline communication network while the train is in operation. Furthermore, these devices must fully comply with the guidelines governing message frequency and use.

The device types shown in **Table 1** are allowed:

TABLE 1
Device Types Allowed to Transmit Messages
While Train Is in Operation

Value	Device Type
1	CCD
2	LCM
3	EOT
4	HEU
5	PSC
6	Event Recorder[1]

1. The event recorder is a passive device (receive only)

1.1.4 Device documentation

1.1.4.1 Program identification

This ID is used to identify the type of device. It is an 8-byte value. **Table 2** defines this ID:

TABLE 2
Program Identification

Field Name	Size	Value/Range (Resolution)	Default	Notes
FORMAT	1	128 only (0x80)	128	
MANUFACTURER ID	1	Binary 0 to 255		A
DEVICE TYPE	1	0 to 255		B
MODEL NUMBER (MANUFACTURER SPECIFIC)	1	0 to 255		
MANUFACTURER DEFINED INFORMATION	4	Manufacturer-specific format		

Notes:

A. Manufacturer ID (8 bits). Additional Manufacturer ID numbers will be assigned as required. The following are the current Manufacturer ID numbers:

Value	Manufacturer
1	NYAB
2	EMD
3	Wabtec
4	Zeftron
5	GETS-GS

B. The device type is defined in paragraph 1.1.3.

1.1.5 Version control

A version control mechanism shall be used to promote both forward and backward compatibility of the devices. Adding new features, correcting system deficiencies, coordinating fielded unit upgrades, etc., are reasons for having version control.

Version control is accomplished through the use of four techniques:

1. Variable-length messages
2. Message version
3. Specification version compatibility identification
4. Device compatibility

1.1.5.1 Variable-length messages

The ANSI/EIA 709.1 explicit messaging construct provides a mechanism for the use of variable-length messages. If additional data fields are needed, the message can be expanded at that time. These additional fields should be added to the end of the existing message to maintain backward compatibility. Devices receiving messages with additional data fields at the end of the message that they do not support shall still process the message. It should be noted that this method will force a mandatory APTA PR-M-S-024-19 "Intratrain Communication Requirements for ECP Cable-Based Passenger Train Control Systems" compatibility change if a message must be shortened.

1.1.5.2 Message version

1.1.5.2.1 Message version is a mechanism of attaching a version field to each message to identify its format. This provides receiving devices a means to determine how to process the message. This allows devices with a mix of versions to operate in a train during the transition period after a change has been made when all fielded units have not yet been upgraded. It also allows one device type to correctly process a revised message when its format has been changed to support another device type (e.g., an HEU beacon revision for PSC control-only might not affect CCDs receiving the HEU beacon, and there would be no reason to revise the CCDs in this case).

1.1.5.2.2 The message version is used to promote both forward and backward compatibility. It is used to denote a change in format that does not invalidate the processing of the message by fielded units. This might include defining an undefined field or adding a field at the end of a message. A device receiving a message with a message version that it does not support shall process the message using the nearest lower message version that the device does support until compatibility has been determined. (Note that this requires careful design of message revisions and device software to ensure that default values of data are properly set in the event that the messages available do not support all data used by a device.)

1.1.5.3 ECP specification revision compatibility identification

1.1.5.3.1 Specification revision compatibility identification is used by the Lead HEU to determine the specification compatibility version(s) supported by all of the devices in the train. During train initialization, this information is sent to the Lead HEU as part of the device information messages. This information is also sent to the Lead HEU via an exception message when a device detects a mismatch between the version(s) it supports and the version indicated for its device type in the train dynamic configuration message. Based on revision configuration information stored in the HEU, it may cut out a device that reports a compatibility mismatch.

1.1.5.3.2 Specification revision compatibility identification is used by the devices in the train to determine which level of specification compatibility to operate at. If a device detects a mismatch between the version(s) it supports and the version indicated for its device type in the train dynamic configuration message, it shall send an exception message to the Lead HEU. This exception message shall not be suppressed by the existence of other active, equal or higher priority exceptions in the device.

1.1.5.4 ECP device compatibility

1.1.5.4.1 All trainline devices, at a minimum, shall support the appropriate mandatory specification compatibility version as identified in M-024 Appendix B and in Appendix D of this specification.

1.1.5.4.2 The current compatibility version may be different for different device types. This is accommodated in the Train Dynamic Configuration message (see paragraph 2.3.1), which has separate levels of compatibility for each device type. The mandatory version may be changed by an approved revision to this document. Additional version levels may need to be supported to support mandatory changes while at the same time providing the ability to interoperate with older equipment.

1.1.5.5 Lead HEU version control management

The Lead HEU provides version control management for the train. The HEU uses data provided as part of any M-024 and/or APTA PR-M-S-024-19 revision to determine the specification compatibility version to operate the train at, to determine if any devices must be cut out and upgraded before operating in the train, and to identify devices that require upgrade to become fully specification compliant.

1.2 General messaging requirements

1.2.1 Message types

All network devices shall support explicit messages. All APTA-defined explicit messages shall use a message code of 0x00 through 0x03 (0–3) and shall contain a 1-byte data field representing the message ID number. This allows for up to 1024 unique messages to be supported. The message ID number shall be the first byte in the data field of the message. Other message codes are reserved for manufacturer-specific messages (see paragraph 1.2.8).

1.2.2 Message addressing

1.2.2.1 All messages defined in this document shall be transmitted in the zero-length domain. This domain will be referred to as domain 0 in this document.

1.2.2.2 Manufacturer-specific messages may use other domains.

1.2.3 Message size

Messages defined in this document shall have a maximum message size of 40 bytes. Note that the message ID byte defined in paragraph 1.2.1 is included within the 40-byte limit.

1.2.4 Data field size

In the message definition sections, all values for data field size are given in bytes. The data size includes the message ID byte defined in paragraph 1.2.1.

1.2.5 Byte/bit ordering

All multiple-byte numeric data fields shall be transmitted MSB, LSB. For bit field definitions, bit 0 shall be the least significant bit.

1.2.6 Unknown/undefined data fields

A value of 255 (0xFF) shall indicate an unknown or undefined value for all single-byte numeric data fields. A value of 65,535 (0xFFFF) shall indicate an unknown or undefined value for all 2-byte numeric data fields. In addition, all unused bit fields shall be set to 0. For fields defined as ASCII text, all unused characters shall be set to an ASCII space (0x20).

1.2.7 Message retries

For all messages defined as ACKD or repeated, the retry count shall be set to 3. The transmit timer value for ACKD messages shall be set to 512 ms. For any message defined as repeated, the repeat timer value shall be set to 96 ms.

1.2.8 Manufacturer-specific messages

1.2.8.1 The use of manufacturer-specific messages must not affect system performance. The use of manufacturer-specific messages shall not increase the average network traffic by more than one message per second.

1.2.8.2 All manufacturer-specific messages shall be controlled by the Lead HEU or Lead LCM. That is, no manufacturer-specific messages shall be sent from trailing devices unless enabled to do so by the Lead HEU or Lead LCM. Any manufacturer-specific messages shall automatically cease to be transmitted when commanded by the Lead HEU or the Lead LCM, or when the HEU beacon messages have not been received by the trailing device for 3 s.

1.2.8.3 In addition, manufacturer-specific messages must not conflict with each other. Allowable message codes for manufacturer-defined messages are 0x04 through 0x3E. All manufacturer-specific explicit messages shall contain the manufacturer ID as the first byte in the data field of the message. Manufacturer-specific data shall not be added to other messages defined in this document.

1.3 Network management

Network management requirements include address assignment, message binding and device configuration. These functions are provided through a combination of device self-installation and runtime configuration. The Lead HEU has the responsibility of locating all ECP trainline devices and assigning unique network addresses during the train initialization process. The Lead LCM may use the same process and messages to find and configure all LCMs on the trainline.

1.3.1 Address assignment

1.3.1.1 To ensure interoperability between trainline devices, a minimum level of standardization of network addressing is required. This includes assignment of domain ID, subnet number and node identifier. All trainline devices shall establish a default network address when manufactured. This is accomplished by loading a default domain table entry. This domain table entry shall not be changed when the device resets. The default entry for domain table index 0 shall define the zero-length domain. The allowable device address assignments are defined in **Table 3**.

TABLE 3
Allowable Address Assignments

Device	Allowed Subnet(s)	Allowed Node Assignments
HEU (lead) or combination of HEU (lead) and LCM (lead)	1	2 only
	6–9	1–127
HEU (trail) or combination of HEU (trail) and LCM (trail) or locomotive acting as an EOT	1	3–125
EOT	2	1 only
PSC	2	2–127
CCD or car acting as an EOT	3–5	1–127
LCM (lead)	6–9 10	1–127 1 only
LCM (trail)	10	2–125 only

1.3.1.2 Runtime reassignment of network addresses should be performed only when necessary to resolve network address conflicts. The Lead HEU or Lead LCM shall assign new addresses to devices only if the address of that device conflicts with an address already in the train. Devices should not reassign their own network addresses except for the Lead HEU or Lead LCM. When an HEU or LCM is in trail, it must change its node identifier if necessary so that it will not conflict with an HEU or LCM in lead and so that it will be able to receive messages from the Lead HEU or Lead LCM. Likewise, when an HEU or LCM is in lead, it shall reassign its subnet/node address to identify it as a lead unit as defined by **Table 3**. Default subnet/node addresses of 1/2 (Lead HEU) and 10/1 (Lead LCM) shall be used only to maintain backward compatibility with trailing devices that are not fully compliant to the latest M-024 performance specification.

1.3.1.3 A device performing multiple trainline functions (e.g., Trail HEU as EOT, or Lead HEU as Lead LCM, or Trail HEU as Remote LCM) may have a single network address.

1.3.1.4 If a device is found and assigned a subnet/node address as a Trail HEU or CCD, it shall not be reassigned a different subnet/node address if it is also found as a Trail LCM or EOT. A Trail or Remote LCM shall determine the subnet/node address of a Lead LCM device from the originating subnet/node address of the WDP beacon.

1.3.2 Message binding

Message binding is predefined and is handled through self-installation of each device. No message binding is performed at runtime.

1.3.3 Device configuration

Device configuration is accomplished during installation and at runtime using the messages defined in this specification or manufacturer-specific messages for installation only.

1.3.4 Train ID

The Train ID is a unique 3-byte identifier whose value is determined by the Lead HEU and that is included in certain safety- or performance-critical messages to prevent ECP and WDP devices from processing messages incorrectly received from other trains.

1.3.4.1 Lead HEU determination

The Lead HEU shall set its Train ID value based on the following:

1.3.4.1.1 The Most Significant 7 bits shall be set to the most significant 7 bits of the simple checksum of the Lead HEU's 6-byte Neuron ID.

1.3.4.1.2 The Least Significant 17 bits shall be set to the numeric value of the rightmost 5 digits of the Lead HEU's Locomotive Reporting Mark.

1.3.4.2 Trail ECP device determination

1.3.4.2.1 If the trailing devices are connected to a Lead HEU with a Train ID, then their Train ID shall be the Train ID of the Lead HEU.

1.3.4.2.2 If the trailing devices are connected to a Lead HEU without a Train ID, then their Train ID shall be Unknown, represented as hexadecimal 0xFFFFFF.

1.3.4.2.3 If the trailing devices are not connected to a Lead HEU, then their Train ID shall be NONE, represented as hexadecimal 0x000000 (applies only to EOT).

1.3.4.3 Lead LCM determination

The Lead LCM shall set its Train ID to the Train ID of the Lead HEU on the same locomotive prior to operating as a Lead LCM.

1.3.4.4 Trail LCM device determination

Each Trail LCM shall set its Train ID to the Train ID of the Trail HEU on the same locomotive.

2. ECP brake and WDP system messages

2.1 Device installation messages

When ECP equipment is installed on a vehicle, certain information must be loaded into the car or locomotive ID device as defined by M-024. This may be accomplished through a network or installation tool. The messages defined in this section are for support of downloading this information via the communications trainline.

> **NOTE:** The numbers in parentheses denote the message code, followed by the message ID number.

2.1.1 Car Static Info (0,0)

Source:	CCD	**Message Rate:**	On
Dest:	Requesting Device	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	34 bytes
Priority:	No		

Description: This message is used to transmit Car ID configuration information in response to a Query Vehicle Static Info message.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	0 only		0	
MSG VERSION	1	0 to 255		1	
CAR ID MODULE'S MANUFACTURER	1	0 to 250 (as defined in paragraph 1.1.4.1)			
REPORTING MARK	11	ASCII text		CAR********	A, B
CAR TYPE	4	ASCII text (UMLER CODE)		****	A
CAR LENGTH	2	0 to 6550.0 ft	(LSB = 0.1 ft)	60.0	
BRAKES CONTROLLED	1	0 to 25.0 brakes	(LSB = 0.1 brakes)	1.0	
NUM AXLES	1	0 to 250		4	
EMPTY WEIGHT	2	0 to 6,550,000 lb	(LSB = 100 lb)	50,000	
LOADED WEIGHT	2	0 to 6,550,000 lb	(LSB = 100 lb)	286,000	
BRAKE CONSTANT	2	0 to 65,550 sq. in.	(LSB = 1 sq. in.)	572	
RESERVOIR CONSTANT	2	0 to 1.000	(LSB = 0.001)	0.711	
NET BRAKING RATIO DEFAULT	1	12.8 only	(LSB = 0.2%)	12.8	
MIN SERVICE PRESSURE	1	0 to 250 psi	(LSB = 1 psi)	7	
EMPTY/LOAD DEVICE TYPE	1	Bits 0–1: 0 = None Installed 1 = Mechanical Device 2 = Electronic Device		0	
		Bit 2 0 = Single CCD 1 = Multiple CCDs		0	C
		Bits 3–7: Manufacturer-Specific Field		0	
Sequencing Orientation	1	0 = Load at B-End 1 = Load at A-End 2–255 = Not used		0	

Notes:
A. * is an ASCII asterisk (0x2A)
B. The last character of the reporting mark is reserved for identifying a CCD when multiple CCDs are installed on a car (e.g., multiplatform passenger cars). This may be a letter (e.g., A, B, C, D, E) or a number (1–9). If only a single CCD is installed, then the full 11 characters may be used.
C. This bit shall be set to 0 when only one CCD is installed on a car; otherwise this bit shall be set to 1 to indicate that more than one CCD is installed (i.e., multiplatform passenger cars).

2.1.2 Locomotive Static Info (0,1)

Source:	HEU, PSC	**Message Rate:**	As needed
Dest:	PSC, Installation Tool	**Service Type:**	ACKD or UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	30 bytes
Priority:	No		

Description: This message is used to transmit locomotive ID configuration information. This message may be used during installation to configure the PSC with required vehicle information and operating parameters. It also may be transmitted to a device installation tool upon request.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	1 only	1	
MSG VERSION	1	0 to 255	0	
LOCOMOTIVE ID MODULE'S MANUFACTURER	1	0 to 250 (as defined in paragraph 1.1.4.1)		
VEHICLE REPORTING MARK	11	ASCII text	LOCO*******	A, B, C
LOCOMOTIVE TYPE	4	ASCII text (Catalog Type)	****	A
LOCOMOTIVE LENGTH	2	0 to 6550.0 ft (LSB = 0.1 ft)	80.2	
NOMINAL WEIGHT	2	0 to 6,550,000 lb (LSB = 100 lb)	420,000	
NUM AXLES	1	0 to 250	6	
NOMINAL WHEEL DIAMETER	1	0 to 127.0 in. (LSB = 0.5 in.)	45.0	
NET BRAKING RATIO DEFAULT	1	0 to 50.0% (LSB = 0.2%)	12.8	
BP PRESSURE SETPOINT DEFAULT	1	0 to 250 psi (LSB = 1 psi)	90	
SUPPRESSION APPLICATION	1	0 to 120% (LSB = 1%)	100%	
LOW BATTERY FAULT THRESHOLD	1	0 to 250 VDC (LSB = 1 VDC)	50	
LOW BATTERY FAULT CLEAR THRESHOLD	1	0 to 250 VDC (LSB = 1 VDC)	60	
SEQUENCING ORIENTATION	1	0 = Load at Long Hood End 1 = Load at Short Hood End 2–255 = Not used	0	

Notes:
A. * is an ASCII asterisk (0x2A)
B. The presence of one or more alpha characters shall represent the Railroad Identifier (e.g., AMTK, UP, BNSF). The presence of one or more numeric characters shall represent the locomotive road number (e.g., 013, 2557).
C. The last character of the reporting mark is reserved for identifying a PSC if multiple PSCs are installed on a locomotive. This may be a letter (e.g., A, B, C, D, E) or a number (1–9).

2.1.3 Query Vehicle Static Info (0,2)

Source:	Installation Tool	**Message Rate:**	As needed
Dest:	HEU, CCD, PSC	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	2 bytes
Priority:	No		

Description: This message is used to request locomotive or car ID configuration information. The receiving device responds with a Static Info message (car or locomotive).

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	2 only	2	
MSG VERSION	1	0 to 255	0	

2.2 Train initialization messages

Train initialization involves establishing or confirming the identity and position of all ECP and DP devices on the trainline communications network. It also involves establishing unique network addresses for all devices,

collecting device information and downloading configuration information. The Lead HEU controls the initialization process by first identifying and configuring at least one PSC so that trainline power can be activated. After trainline power is activated, the remaining trainline ECP devices can be identified and configured. This process shall be performed using the application level messages defined in this section. The Lead LCM identifies and configures other LCMs in the train. This process shall be performed using the application level messages defined in this section. The specific sequence for identifying network devices is left up to the manufacturer of the HEU and LCM. The recommended sequence is to first identify and configure all HEUs, then find and configure all PSCs, and then locate and configure all remaining ECP and LCM devices. Collection of device information shall be performed using the Device Info Control/Query message defined in this section. Downloading of device configuration information shall be accomplished using the Dynamic Configuration messages defined in paragraph 2.3 of this specification. Examples of possible train makeup messaging sequences are given in Appendix B.

2.2.1 Device Info Control/Query (0,3)

Source:	HEU Lead, LCM Lead	**Message Rate:**	As needed
Dest:	HEU Trail, CCD, PSC, EOT, LCM	**Service Type:**	UNACKD or ACKD
Msg Type:	Explicit	**Addressing:**	BCAST or UNICAST
Msg Code:	0x00	**Data Size:**	4 bytes
Priority:	No		

Description: This message is used for controlling and requesting transmission of device info during train makeup.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	3 only		3	
MSG VERSION	1	0 to 255		1	
COMMAND	1	Bits 0–1:	0 = UNLOCK 1 = LOCK 2 = SEND Device Info 3 = Not used		A
		Bits 2–4:	Device Type		B
		Bits 5–7:	Not used (set to 0)		
RANDOMIZING INTERVAL	1	0 to 254 s	(LSB = 1 s)	0	C

Notes:
A. After a LOCK is received, the device will no longer respond to SEND Device Info Queries until an UNLOCK command is received or the device resets. Devices shall default to UNLOCKED at power-up or after a reset. If a single node (with one APTA address) acting as two AAR devices is locked via a Device Info/Control Query message for one device type, it shall remain unlocked as the other device type.
B. Device type is as defined in paragraph 1.1.3. A device type of 0 indicates all devices. A single node (with one APTA address) acting as two AAR devices shall respond to received Device Info/Control Queries containing a device type of 0-All Devices with a separate response for each device type that it supports.
C. This field indicates the time period over which responding network devices are to randomize their responses to this message when broadcast addressing is used. The responding network devices shall randomize their responses in increments of 50 ms over the specified randomizing interval. For unicast messages, this field shall be set to 0. For unicast messages, the destination address for this message shall be a Unique ID, except when the device type is an EOT. If a device receives this message while waiting to respond to a prior message, then it shall respond only to the latest message.

2.2.2 Assign Node ID (0,4)

Source: Lead HEU, Lead LCM **Message Rate:** When requested
Dest: CCD, EOT, PSC, HEU Trail, LCM Trail **Service Type:** ACKD
Msg Type: Explicit **Addressing:** UNICAST
Msg Code: 0x00 **Data Size:** 4 bytes
Priority: No

Description: This message is sent from a Lead HEU or Lead LCM to assign a unique subnet and node ID to a device. This message locks the device to prevent it from responding to further device info queries until it is unlocked (see Note B). Except when the device is an EOT, the destination address for this message shall be a Unique ID.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	4 only	4	
MSG VERSION	1	0 to 255	0	
SUBNET	1	1 to 10		A
NODE ID	1	1 to 127		A

Notes:
A. These fields must include the subnet and Node ID used for the device even if no change is being made in the address for the device.
B. A single node (with one APTA address) acting as two APTA devices shall lock only as an HEU device on receipt of an Assign Node ID message. (Paragraph 1.2.1 of this document precludes the assignment of any address other than a Trail HEU address for nodes of this type.)

2.2.3 Device Info (EOT) (0,5)

Source:	EOT	**Message Rate:**	When requested
Dest:	Requesting Node	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	24 bytes
Priority:	No		

Description: This message is sent from an EOT device in response to a Device Info Request message.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	5 only	5	
MSG VERSION	1	0 to 255	2	
MANUFACTURER ID	1	0 to 250 (as defined in paragraph 1.1.4.1)		
EOT IDENTIFICATION NUMBER	11	ASCII text	EOT********	A, B
UNIQUE ID	6	00 00 00 00 00 01 only (01 is LSB)		C
MANUFACTURER REVISION LEVEL	1	0 to 255		
M-021COMPATIBILITY VERSION	1	0 to 255	2	
M-024 COMPATIBILITY VERSION	1	0 to 255	2	
DEVICE CHARACTERISTICS	1	Bit 0: 1 = Marker Light Available Bit 1: 1 = Motion Sensor Available Bits 2–3: 0 = Standalone EOT 1 = Last vehicle (Locomotive/car) Functioning as EOT 2 = Trainline Termination Plug 3 = Undefined Bits 4–6: Not used (set to 0) Bit 7: 1 = Crosstalk Protection Capable		

Notes:
A. * is an ASCII asterisk (0x2A)
B. If the EOT function is being performed by the last vehicle (locomotive/car) in the train as defined in M-024, latest version, then this field shall be the reporting mark of the locomotive/car.
C. The EOT function uses a fixed Unique ID.

2.2.4 Device Info (HEU) (0,6)

Source:	HEU Trail	**Message Rate:**	When requested
Dest:	Requesting Node	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	33 bytes
Priority:	No		

Description: This message is sent from a Trail HEU in response to a Device Info Request message.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	6 only	6	
MSG VERSION	1	0 to 255	1	
MANUFACTURER ID	1	0 to 250 (as defined in paragraph 1.1.4.1)		
REPORTING MARK	11	ASCII text	LOCO*******	A, C
UNIQUE ID	6	0 to 0xFFFFFFFFFFFF	N/A	

Field Name	Size	Value/Range (Resolution)		Default	Notes
MANUFACTURER REVISION LEVEL	1	0 to 255			
M-021 COMPATIBILITY VERSION	1	0 to 255		2	
M-024 COMPATIBILITY VERSION	1	0 to 255		2	
DEVICE CHARACTERISTICS	1	Bit 0: 1 = Termination Sensed 0 = Termination Not Sensed Bit 1: 1 = Train Sequencing Capable 0 = Not Train Sequencing Capable Bits 2–6: Not used (set to 0) Bit 7: Crosstalk Protection Capable			B
VEHICLE TYPE	4	ASCII text		****	A
VEHICLE LENGTH	2	0 to 6550.0 ft	(LSB = 0.1 ft)		
VEHICLE WEIGHT	2	0 to 6,550,000 lb	(LSB = 100 lb)		
NUM AXLES	1	0 to 250			

Notes:
A. * is an ASCII asterisk (0x2A)
B. Bit 1 is used to support the transition to a fully specification-compliant locomotive system. This bit also is used to identify the ECP network device (HEU or PSC) on a locomotive that is capable of performing the sequencing function. Systems that are specification compliant will always have this bit set on either the HEU or the PSC or both.
C. The locomotive reporting mark shall be as defined in the Locomotive Static Info (0,1) message.

2.2.5 Device Info (CCD) (0,7)

Source: CCD   **Message Rate:** When requested
Dest: Requesting Node   **Service Type:** UNACKD
Msg Type: Explicit   **Addressing:** UNICAST
Msg Code: 0x00   **Data Size:** 38 bytes
Priority: No

Description: This message is sent from a car control device in response to a Device Info Request message.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	7 only	7	
MSG VERSION	1	0 to 255	2	
MANUFACTURER ID	1	0 to 250 (as defined in paragraph 1.1.4.1)		
REPORTING MARK	11	ASCII text	CAR**** ****	A, C
UNIQUE ID	6	0 to 0xFFFFFFFFFFFF	N/A	
MANUFACTURER REVISION LEVEL	1	0 to 255		
M-021COMPATIBILITY VERSION	1	0 to 255	2	
M-024 COMPATIBILITY VERSION	1	0 to 255	2	

Field Name	Size	Value/Range (Resolution)		Default	Notes
DEVICE CHARACTERISTICS	1	Bits 0–1:	0 = Overlay CCD 1 = Standalone CCD 2 = Emulator CCD 3 = Not used		
		Bit 2:	1 = Train Sequencing Capable 0 = Not Train Sequencing Capable		B
		Bit 3:	1 = Stuck Brake Protection		D
		Bit 4:	1 = Handbrake Sense Capable		
		Bit 5:	1 = Handbrake Release Capable		
		Bit 6:	1 = Handbrake Apply Capable		
		Bits 7:	1 = Crosstalk Protection Capable		
VEHICLE TYPE	4	ASCII text		****	A
VEHICLE LENGTH	2	0 to 6,550.0 ft	(LSB = 0.1 ft)		
EMPTY WEIGHT	2	0 to 6,550,000 lb	(LSB = 100 lb)		
LOADED WEIGHT	2	0 to 6,550,000 lb	(LSB = 100 lb)		
NUM AXLES	1	0 to 250			
OPERABLE BRAKES CONTROLLED	1	0 to 25.0 brakes	(LSB = 0.1 brakes)		
EMPTY/LOAD DEVICE TYPE	1	Bits 0–1:	0 = None Installed 1 = Mechanical Device 2 = Electronic Device 3 = Not used	0	
		Bit 2:	0 = Single CCD 1 = Multiple CCDs		E
		Bits 3–7:	Not used (set to 0)		
STATUS INFO	1	Bits 0-1:	0 = Handbrake Status Unknown 1 = Handbrake Released 2 = Handbrake Applied 3= Not used (invalid)	0	F
		Bit 2:	1 = Low BP Pressure		F
		Bit 3:	1 = Low RES Pressure		F
		Bit 4:	1 = Low Battery		F
		Bits 5–6:	0 = Trainline Power Status Unknown 1 = Trainline Power Not Detected 2 = Trainline Power Detected 3 = Not used (invalid)		F
		Bit 7:	1 = CCD Inoperative		F

Notes:
A. * is an ASCII asterisk (0x2A)
B. Bit 2 is used to support the transition to a fully specification-compliant CCD. Systems that are specification compliant will always have this bit set.
C. The last character of the reporting mark is reserved for identifying a CCD when multiple CCDs are installed on a car (e.g., multiplatform passenger cars). This may be a letter (e.g., A, B, C, D, E) or a number (1–9). If only a single CCD is installed, then the full 11 characters may be used.
D. This bit applies only if bits 0–1 indicate an Overlay CCD.
E. This bit shall be set to 0 when only one CCD is installed on a car; otherwise this bit shall be set to 1 to indicate that more than one CCD is installed (i.e., multiplatform passenger cars).
F. The Status Info represents the most current known state of data that may dynamically change.

2.2.6 Device Info (PSC) (0,8)

Source:	PSC	**Message Rate:**	When requested
Dest:	Requesting Node	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	33 bytes
Priority:	No		

Description: This message is sent from a power supply controller in response to a Device Info Request message.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	8 only	8	
MSG VERSION	1	0 to 255	1	
MANUFACTURER ID	1	0 to 250 (as defined in paragraph 1.1.4.1)		
REPORTING MARK	11	ASCII text	LOCO*******	A, C
UNIQUE ID	6	0 to 0xFFFFFFFFFFFF	N/A	
MANUFACTURER REVISION LEVEL	1	0 to 255		
M-021 COMPATIBILITY VERSION	1	0 to 255	2	
M-024 COMPATIBILITY VERSION	1	0 to 255	2	
DEVICE CHARACTERISTICS	1	Bit 0: 1 = Train Sequencing Capable 0 = Not Train Sequencing Capable Bits 1–6: Not used (set to 0) Bit 7: 1 = Crosstalk Protection Capable		B
VEHICLE TYPE	4	ASCII text	****	A
VEHICLE LENGTH	2	0 to 6,550.0 ft (LSB = 0.1 ft)		
VEHICLE WEIGHT	2	0 to 6,550,000 lb (LSB = 100 lb)		
NUM AXLES	1	0 to 250		

Notes:
A. * is an ASCII asterisk (0x2A)
B. Bit 0 is used to support the transition to a fully specification-compliant locomotive system. This bit is also used to identify the ECP network device (PSC or HEU) on a locomotive that is capable of performing the sequencing function. Systems that are specification compliant will always have this bit set on either the PSC or the HEU or both.
C. The locomotive reporting mark shall be as defined in the Locomotive Static Info (0,1) message.

2.3 ECP brake run-time configuration messages

2.3.1 Train Dynamic Configuration (0,9)

Source:	HEU Lead	**Message Rate:**	On change and every 120 s
Dest:	All Devices	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	BCAST
Msg Code:	0x00	**Data Size:**	16 bytes
Priority:	No		

Description: This message is used to update configuration information to the entire train during train initialization and normal operation. This message also contains version control information for determining

specification compatibility between the Lead HEU and each network device type. After a reset or loss of HEU beacon, a device shall not respond to any trainline messages with a message version it does not support until this message is received and compatibility is determined. This message shall be sent 8 to 10 s after trainline power has been activated and at other times as necessary.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	9 only	9	
MSG VERSION	1	0 to 255	2	
M-021 REV COMPATIBILITY	4	Byte 1 = HEU Compatibility Rev Level Byte 2 = CCD Compatibility Rev Level Byte 3 = PSC Compatibility Rev Level Byte 4 = EOT Compatibility Rev Level		A
M-024 REV COMPATIBILITY	4	Byte 1 = HEU Compatibility Rev Level Byte 2 = CCD Compatibility Rev Level Byte 3 = PSC Compatibility Rev Level Byte 4 = EOT Compatibility Rev Level		A
BP PRESSURE SETPOINT	1	0 to 250 psi (LSB = 1 psi)	90	
NET BRAKING RATIO	1	0 to 50.0% (LSB = 0.2%)	12.8	
SPARE	1	Not used	0	
TRAIN POWER MODE	1	Bit 0: 0 = Normal Power Mode 1 = Low Power Mode (5-Watt/CCD) Bits 1–7: Not used (set to 0)	0	
FAULT LOGIC CONTROL	1	Bit 0: 1 = Reset Critical Faults Bit 1: 1 = Reset CRC Error Count Bit 2: 1 = Reset Compatibility State Bits 3–7: Not used (set to 0)		B C
CRC ERROR THRESHOLD	1	0 to 255 Errors		

Notes:
A. This field identifies the compatibility version level between the Lead HEU and each device type.
B. This bit field is used to command devices to reset their fault logic after a critical loss emergency condition is cleared by the HEU. Devices should reset their fault logic when this bit changes from 0 to 1.
C. This bit is used to command all trainline devices to reset their compatibility state to unknown. A device that was commanded to cut out due to incompatibility would reset and cut in if no other cut-out conditions exist.

2.3.2 CCD Dynamic Configuration (0,10)

Source: HEU Lead   **Message Rate:** On change
Dest: CCD   **Service Type:** ACKD (see Note B)
Msg Type: Explicit   **Addressing:** UNICAST (see Note B)
Msg Code: 0x00   **Data Size:** 4 bytes
Priority: No

Description: This message is used to change the configuration of a single CCD during train initialization and normal operations. A command to cut in a CCD should not be sent during CUTOUT mode. Anytime duplicate subnet/node addresses could exist in the train, this message shall be sent using a Unique ID as the destination address.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	10 only		10	
MSG VERSION	1	0 to 255		1	
CCD STATUS	1	Bit 0:	0 = Cut-in 1 = Cutout	0	
		Bit 1:	0 = Normal ECP Mode 1 = BP Emulation Mode	0	B
		Bits 2–7:	Not used (set to 0)		
EMPTY/LOAD STATUS	1	0 to 100% (LSB = 1%)		255	A

Notes:
A. If this field is set to 255, then the CCD maintains its current empty/load status.
B. This bit may be used to command the CCD to enter BP Emulation Mode. During normal ECP operation, this field shall be set to Normal ECP Mode (0). If this bit is set to 1, then this message may be sent as BCAST and UNACKD.

2.3.3 PSC Dynamic Configuration (0,11)

Source:	HEU Lead	**Message Rate:**	On change
Dest:	PSC	**Service Type:**	ACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	3 bytes
Priority:	No		

Description: This message is used to change the configuration of a power supply during train initialization and normal operation. This message shall always be sent using a Unique ID as the destination address.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	11 only		11	
MSG VERSION	1	0 to 255		1	
POWER SUPPLY COMMAND	1	Bits 0–1:	0 = DISABLE Output 1 = ENABLE Output as Primary 2 = ENABLE Output as Secondary 3 = ENABLE Low Voltage Output	0	A
		Bit 2:	1 = Reset PSC Exceptions		
		Bits 3–7:	Not used (set to 0)		

Note:
A. This field is used to control the state of the specified trainline power supply based on the HEU beacon power control flag. A PSC may be enabled as primary or secondary only when the HEU beacon indicates that trainline power is ON. A PSC may enable its low-voltage output only when the HEU beacon indicates that trainline power is OFF. A PSC shall default to the disabled state after power-up/reset and when the HEU beacon power control flag changes state.

2.3.4 Device Compatibility Command (0,12)

Source:	HEU Lead	**Message Rate:**	As needed
Dest:	CCD, EOT, PSC, HEU Trail	**Service Type:**	ACKD or UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST or BROADCAST
Msg Code:	0x00	**Data Size:**	4 bytes
Priority:	No		

Description: This message is used to respond to device compatibility exceptions. This message commands the device to either cut out or disregard the compatibility mismatch. Receipt of this message by a device

clears the compatibility exception. This message shall be unacknowledged if it is broadcast. When unicast, this message shall be sent using a Unique ID as the destination address.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	12 only		12	
MSG VERSION	1	0 to 255		1	
DEVICE COMPATIBILITY COMMAND	1	Bit 0:	0 = Clear exception and run 1 = Cut out		A
		Bits 1–7:	Not used (set to 0)		
DEVICE TYPE	1	0 to 5		0	B

Notes:
A. Bit 0 may be set to 1 (cutout) only in a unicast message.
B. Device type is as defined in paragraph 1.1.3. A device type of 0 indicates all devices. A single node (with one APTA address) acting as two APTA devices shall respond to received Device Compatibility Commands containing a device type of 0-All Devices with the same response for each device type that it supports. Otherwise, it shall respond only as the device type indicated.

2.4 Normal operational messages

2.4.1 HEU Beacon (0,13)

Source: HEU Lead   **Message Rate:** 1/s
Dest: HEU Trail, CCD, PSC, EOT, LCM   **Service Type:** UNACKD
Msg Type: Explicit   **Addressing:** BCAST
Msg Code: 0x00   **Data Size:** 11 bytes
Priority: Yes (first priority slot)

Description: This is the primary ECP train brake control message. Its main purpose is for commanding the level of braking desired for the train.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	13 only		13	
MSG VERSION	1	0 to 255		2	
OPERATING MODE	1	Bits 0–2:	0 = RUN 1 = INITIALIZATION 2 = SWITCH 3 = CUTOUT 4–7 = Not used	0	
		Bit 3:	1 = T/L Power ON 0 = OFF		
		Bit 4:	1 = Quiet Trainline Commanded		B
		Bit 5:	Empty/Load Command 1 0 = EMPTY 1 = LOADED		
		Bit 6:	Empty/Load Command 2 0 = EMPTY 1 = LOADED		
		Bit 7:	0=Freight 1=Passenger		
TRAIN BRAKE COMMAND	1	0 to 120%	(LSB = 1%)		
SUBNET	1	0 to 9			A

Field Name	Size	Value/Range (Resolution)	Default	Notes
NODE	1	0 to 127		A
TRAIN SPEED	1	0 to 250 mph (LSB = 1 mph) 251 = moving ≤ 20 mph 252 = moving > 20 mph		
AUX COMMAND	1	Bit 0: 1 = Connect to Lead Flag Bit 1: 1=Snow Brake Commanded Bits 2–7: Not used (set to 0)		C
TRAIN ID	3	Per paragraph 1.3.4 of this standard		

Notes:
A. This is the address of the device being polled. A subnet/node address of 0/0 indicates that no trainline devices are being polled.
B. The trainline quiet command shall be used only while Initialization mode is selected. This command shall cause the EOT to stop transmitting beacons. This command also shall cause LCM messages to stop.
C. The Connect to Lead flag shall be set by the Lead HEU when in the process of activating trainline power and shall be used by the receiving devices to determine the appropriate HEU to connect to.

2.4.2 Device Status Query (0,14)

Source:	HEU Lead	**Message Rate:**	As needed
Dest:	HEU Trail, CCD, PSC	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST or BROADCAST
Msg Code:	0x00	**Data Size:**	4 bytes
Priority:	No		

Description: This message is used as a secondary means of querying status information from a network device. The addressed device responds with the Status Response message that is normally transmitted in response to the HEU beacon poll. This message is normally sent as a unicast message and shall only be sent as a broadcast message to determine if all devices in the train have been upgraded with crosstalk mitigation functionality (see Note B).

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	14 only		14	
MSG VERSION	1	0 to 255		2	
DEVICE TYPE	1	0 to 5		0	A
RESPONSE CONTROL	1	Bit 0:	1 = Do Not Respond if Crosstalk Protection Capable	0	B
		Bits 1–7:	Not used (set to 0)		

Notes:
A. Device type is as defined in paragraph 1.1.3. A device type of 0 indicates all devices. A single node (with one APTA address) acting as two APTA devices shall respond to received Device Status Queries containing a device type of 0-All Devices with a response for each device type that it supports. Otherwise, it shall respond only as the device type indicated.
B. This field shall be set to 1 to determine if there are any devices that do not support crosstalk protection. If a device receiving this message supports crosstalk protection, then it shall not respond to the query when this field is set to 1.

2.4.3 CCD Status Response (0,15)

Source:	CCD	**Message Rate:** On request (1 Hz effective)	
Dest:	HEU Lead/Requesting Node	**Service Type:** UNACKD	
Msg Type:	Explicit	**Addressing:** UNICAST	
Msg Code:	0x00	**Data Size:** 15 bytes	
Priority:	No		

Description: This message is sent from a CCD in response to the HEU beacon when its subnet/node address matches. It also is sent in response to a Device Status Query.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	15 only	15	
MSG VERSION	1	0 to 255	3	
STATUS	1	Bit 0: 0 = CUT-IN 1 = CUTOUT	0	A
		Bit 1: 1 = HEU Cutout commanded		A
		Bit 2: 1 = Isolated Critical Loss		A
		Bit 3: 1 = CCD Fault Detected		A
		Bit 4: 1 = CCD Inoperative		B
		Bit 5: 1 = CRC Error Count Threshold		
		Bit 6: 1 = Low Reservoir		
		Bit 7: 1 = Low Battery		
BRAKE PIPE PRESSURE	1	0 to 250 psi (LSB = 1 psi)		
RESERVOIR PRESSURE	1	0 to 250 psi (LSB = 1 psi)		
BRAKE CYLINDER PRESSURE	1	0 to 250 psi (LSB = 1 psi)		
PERCENT BRAKE APPLIED	1	0 to 250% (LSB = 1%)		
CAR LOAD	1	Bits 0–6: 0 to 100% (LSB = 1%)		
		Bit 7: 0 = HEU E/L command valid 1 = HEU E/L command mismatch		C
HIGHEST PRIORITY ACTIVE EXCEPTION	2	0 to 65534		D
POWER STATUS	1	Bits 0–3: Battery Charge (LSB = 10%)		E
		Bits 4–6: Not used (set to 0)		
		Bit 7: 1 = Trainline Power Detected		

Field Name	Size	Value/Range (Resolution)	Default	Notes
AUX STATUS	1	Bits 0–1: 0 = Handbrake Status Unknown 1 = Handbrake Released 2 = Handbrake Applied 3 = Not used (invalid) Bit 2:　　1 = Crosstalk Detected Bits 3–5: Percentage Enabled Brake Sets 0 = 100% 1 = 75% 2 = 50% 3 = 25% 4 = 0% 5 = 0% 6 = 0% 7 = 0% Bits 6–7: Not used (set to 0)		F
TRAIN ID	3	Per paragraph 1.3.4 of this standard		G

Notes:
A. When Bit 0 is set to cutout status, Bits 1–3 indicate the reason for it being cut out.
B. Bit 4 is set to 1 when a CCD is cut out, has a low battery charge or has a low reservoir charge.
C. Bit 7 is set to 1 when the CCD detects that the E/L commands in the HEU beacon do not match.
D. This field shall reflect the exception code of the highest priority active exception. Otherwise, this field shall be set to 65535.
E. Battery Charge shall be sent as a value in the range of 0 to 10 where 1=10%, 2=20%, 3=30%, etc. A value of 15 (all bits set to 1) for bits 0–3 shall indicate an unknown battery charge value.
F. Bit 2 shall be set to 1 if crosstalk was detected during the previous poll cycle.
G. If the Crosstalk Detected bit (see Note F) is set to 0, then this field shall be set to the Train ID of the Lead HEU to which the CCD is connected. If the Crosstalk Detected bit is set to 1, then this field shall be set to the Train ID from the detected crosstalk message if one is present. Otherwise, this field shall be set to UNKNOWN (0xFFFFFF).

2.4.4 PSC Status Response (0,16)

Source:　　PSC　　　　　　　　　　　　**Message Rate:**　On request
Dest:　　　HEU Lead/Requesting Node　　**Service Type:**　UNACKD
Msg Type:　Explicit　　　　　　　　　　**Addressing:**　　UNICAST
Msg Code:　0x00　　　　　　　　　　　**Data Size:**　　11 bytes
Priority:　No

Description: This message is sent from a PSC in response to the HEU beacon when its subnet/node address matches. It also is sent in response to a Device Status Query.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	16 only	16	
MSG VERSION	1	0 to 255	3	

Field Name	Size	Value/Range (Resolution)	Default	Notes

STATUS	1	Bits 0–1: Power control status:
		    0 = OFF
		    1 = ON as Primary
		    2 = ON as Secondary
		    3 = Low Voltage Output ON
		
		Bit 2: 1 = Low input voltage
		
		Bits 3–4: Power supply availability:
		    0 = Not available
		    1 = Available as Primary
		    2 = Available as Secondary
		    3 = Not used
		
		Bit 5: 1 = CRC Error Count > Threshold
		
		Bit 6: 1 = Crosstalk Detected
		
		Bit 7: 1 = Temporary Connection
					B
					
					D

TRAINLINE VOLTAGE	1	0 to 250 VDC (LSB = 1 VDC)		
OUTPUT CURRENT	1	0 to 25.0 A (LSB = 0.1 A)		
INPUT VOLTAGE	1	0 to 250 VDC (LSB = 1 VDC)		
HIGHEST PRIORITY ACTIVE EXCEPTION	2	0 to 65534		A
TRAIN ID	3	Per paragraph 1.3.4 of this standard		C

Notes:
A. This field shall reflect the exception code of the highest priority active exception. Otherwise, this field shall be set to 65535.
B. This bit shall be set to 1 if crosstalk was detected during the previous poll cycle.
C. If the Crosstalk Detected bit (see Note B) is set to 0, then this field shall be set to the Train ID of the Lead HEU to which the PSC is connected. If the Crosstalk Detected bit is set to 1, then this field shall be set to the Train ID from the detected crosstalk message if one is present. Otherwise, this field shall be set to UNKNOWN (0xFFFFFF).
D. This bit shall be set to 1 if the PSC is in the "Connected—Temporary Connection to Lead HEU" crosstalk protection state.

2.4.5 HEU Trail Status Response (0,17)

Source: HEU Trail   **Message Rate:**   On request
Dest: HEU Lead/Requesting Node   **Service Type:**   UNACKD
Msg Type: Explicit   **Addressing:**   UNICAST
Msg Code: 0x00   **Data Size:**   8 bytes
Priority: No

Description: This message is sent from a Trail HEU in response to the HEU beacon when its subnet/node address matches. It also is sent in response to a Device Status Query.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	17 only	17	
MSG VERSION	1	0 to 255	3	

Field Name	Size	Value/Range (Resolution)		Default	Notes
STATUS	1	Bit 0:	1 = Head End Termination Sensed		
		Bits 1–3:	Percentage Enabled Brake Sets 0 = 100% 1 = 75% 2 = 50% 3 = 25% 4 = 0% 5 = 0% 6 = 0% 7 = 0%		
		Bit 4:	1 = HEU Not Operable		
		Bit 5:	1 = Crosstalk Detected		B
		Bit 6:	Not used (set to 0)		
		Bit 7:	Not used (set to 0)		
HIGHEST PRIORITY ACTIVE EXCEPTION	2	0 to 65534			A
TRAIN ID	3	Per paragraph 1.3.4 of this standard			C

Notes:
A. This field shall reflect the exception code of the highest priority active exception. Otherwise, this field shall be set to 65535.
B. Bit 5 shall be set to 1 if crosstalk was detected during the previous poll cycle.
C. If the Crosstalk Detected bit (see Note B) is set to 0, then this field shall be set to the Train ID of the Lead HEU to which the Trail HEU is connected. If the Crosstalk Detected bit is set to 1, then this field shall be set to the Train ID from the detected crosstalk message if one is present. Otherwise, this field shall be set to UNKNOWN (0xFFFFFF).

2.4.6 EOT Beacon (0,18)

Source: EOT **Message Rate:** 1/s
Dest: HEU **Service Type:** UNACKD
Msg Type: Explicit **Addressing:** BCAST
Msg Code: 0x00 **Data Size:** 10 bytes
Priority: Yes

Description: This message is broadcast by the EOT or a device on the last vehicle functioning as an EOT to indicate its presence on the trainline for determining trainline continuity. It also transmits end-of-train system parameters and conditions to the Lead HEU.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	18 only		18	
MSG VERSION	1	0 to 255		3	
STATUS	1	Bits 0–1:	0 = Unknown 1 = Marker Light On 2 = Marker Light Off 3 = Marker Light Fail		G
		Bit 2–3:	0 = Unknown 1 = Motion Detected 2 = Motion Not Detected 3 = Unused		
		Bit 4:	1 = Last Vehicle Sending EOT Beacons		A
		Bit 5:	1 = CRC Error Count > Threshold		
		Bit 6:	1 = Exception Active		
		Bit 7:	1 = Battery Charged		C

Field Name	Size	Value/Range (Resolution)		Default	Notes
BRAKE PIPE PRESSURE	1	0 to 254 psi	(LSB = 1 psi)		
BATTERY CHARGE	1	0 to 100%	(LSB = 1%)		B
TRAINLINE VOLTAGE	1	0 to 250 VDC	(LSB = 1 VDC)		
AUX STATUS	1	Bit 0:	1 = Loss of HEU Critical Loss Exception Active		
		Bit 1:	1 = Trainline Termination Plug		D
		Bit 2:	1 = Crosstalk Detected		E
		Bits 3–7:	Not used (set to 0)		
TRAIN ID	3	Per paragraph 1.3.4 of this standard			F

Notes:
A. If a last vehicle is performing the EOT function, then Bit 4 shall be set to 1 (see Note D).
B. If a last vehicle is performing the EOT function, then this field is set to 100%. If the device performing the EOT function is a Trainline Termination Plug, then this field shall be set to 0%.
C. This bit shall be set to 1 when the EOT low battery exception is clear. If the device performing the EOT function is a Trainline Termination Plug, then this bit shall be set to 0.
D. This bit shall be set to 1 when the device performing the EOT function is a Trainline Termination Plug. If this bit is set to 1, then Brake Pipe Pressure shall be set to 254 and STATUS bit 4 shall be set to 0.
E. This bit shall be set to 1 if crosstalk was detected prior to sending the message and shall be cleared after sending the message.
F. This field shall be set to the Train ID of the Lead HEU to which the EOT is connected. If the EOT is connected to a Lead HEU without a Train ID, this field shall be set to UNKNOWN (0xFFFFFF). If the EOT is not yet connected to a Lead HEU, this field shall be set to NONE (0x000000).
G. This field shall be set when the EOT has determined that the warning light did not turn on after dusk.

2.4.7 Car Auxiliary Command (0,43)

Source:	HEU Lead	**Message Rate:**	As needed
Dest:	CCD	**Service Type:**	ACKD or UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST or BCAST
Msg Code:	0x00	**Data Size:**	3 bytes
Priority:	No		

Description: This message is used to command auxiliary CCD functions. When sent to a single CCD, this message shall be sent using a Unique ID as the destination address and ACKD. When commanded to all CCDs, this message shall be sent as UNACKD.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	43 only		43	
MSG VERSION	1	0 to 255		0	
HANDBRAKE CONTROL	1	Bits 0–1:	0 = No Handbrake Command 1 = Release Handbrake 2 = Apply Handbrake 3 = Not used (invalid)	0	
		Bits 2–7:	Not used (set to 0)		

2.5 Train sequencing messages

The messages defined in this section are used only for train sequencing. See Appendix C for an example of message transfer for sequencing.

2.5.1 Train Sequencing Command (0,19)

Source:	HEU Lead	**Message Rate:**	As needed
Dest:	All Devices	**Service Type:**	UNACKD_RPT
Msg Type:	Explicit	**Addressing:**	BCAST
Msg Code:	0x00	**Data Size:**	4 bytes
Priority:	No		

Description: This message is used to command all vehicles to a given sequencing state. Its purpose is to control the train sequencing process at a train level. The Lead HEU shall wait a minimum of 5 s after sending this message before sending other vehicle sequencing commands or queries to allow all repeats of this broadcast to complete and to allow time for trailing devices to prepare for sequencing.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	19 only	19	
MSG VERSION	1	0 to 255	0	
SEQUENCING COMMAND	1	0 = Prepare for Sequencing 1 = Enable Lead Sense 2 = Reset/Start Pulse Count 3 = Hold/Stop Pulse Count 4 = End Sequencing 5–255 = Not used		A B C D E
SEQUENCING STATUS	1	0 = Sequencing in Progress 1 = Sequencing Successful 2 = Sequencing Failed 3–255 = Not used	0	F

Notes:
A. The sequencing command is set to 0 prior to shutting down normal trainline power and activating the 24 VDC trainline voltage for sequencing. When the command is set to 0, the CCDs and EOT disable their low-battery shutdown feature, and all participating trainline devices reset their position count and orientation status to unknown.
B. When the sequencing command is set to 1, all participating devices shall monitor trainline current and set their locomotive lead sense status accordingly.
C. When the sequencing command is set to 2, all participating devices will reset their current pulse count to 0.
D. When the sequencing command is set to 3, all participating devices will stop counting current pulses and retain their current pulse count.
E. When the sequencing command is set to 4, the sequencing process is complete and the CCDs and EOT can re-enable their low-battery shutdown feature.
F. This field is used to inform all vehicles of the status of sequencing. This field should be set to 0 whenever the sequencing command is 0, 1, 2 or 3. When the sequencing command is set to 4, this field indicates whether sequencing was successful or not. If this field is set to 2, then the vehicles should set their position count and orientation status to unknown.

2.5.2 Vehicle Sequence Command (0,20)

Source:	HEU Lead	**Message Rate:**	As needed
Dest:	HEU Trail, CCD, PSC	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	5 bytes
Priority:	No		

Description: This message is used to control the sequencing process at a vehicle level.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	20 only	20	
MSG VERSION	1	0 to 255	0	
SEQUENCE COMMAND	1	0 = Connect Load 1 = Assign Vehicle Position 2–254 = Not used	0	B C
VEHICLE POSITION	2	0–65,500	0	A

Notes:
A. This field is used only when the Sequence Command field is set to 1.
B. If the sequence command is 0, then the receiving device shall respond with a Vehicle Sequence Status message (paragraph 2.5.3) when its load is connected and again when its load is removed.
C. If the sequence command is 1, then the receiving device shall respond with a single Vehicle Sequence Status message (paragraph 2.5.3).

2.5.3 Vehicle Sequence Status (0,21)

Source: CCD, HEU Trail, PSC **Message Rate:** On occurrence
Dest: Requesting Node **Service Type:** UNACKD
Msg Type: Explicit **Addressing:** UNICAST
Msg Code: 0x00 **Data Size:** 3 bytes
Priority: No

Description: This message is sent in response to the Vehicle Sequence Command message and when a device removes its sequencing load as a result of a timeout.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	21 only	21	
MSG VERSION	1	0 to 255	1	
SEQUENCE STATUS	1	Bits 0–2: 0 = Load Not Applied 1 = Load Applied 2 = Load Removed 3 = Load Not Removed 4 = Assign Vehicle Position Command Response 5–7 = Not used Bits 3–7: Not used		A

Note:
A. A value of 0 indicates that the load was not applied when commanded due to either a sensed load failure or for other reasons such as load too hot or high trainline voltage present.

2.5.4 Vehicle Sequence Info Query (0,22)

Source: HEU Lead **Message Rate:** As needed
Dest: CCD, HEU Trail, PSC **Service Type:** UNACKD
Msg Type: Explicit **Addressing:** UNICAST
Msg Code: 0x00 **Data Size:** 5 bytes
Priority: No

Description: This message is used to collect sequencing results.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	22 only	22	
MSG VERSION	1	0 to 255	0	
QUERY COMMAND	1	Bit 0: 0 = Do Not Update Vehicle Position 1 = Update Vehicle Position Bits 1–7: Not used		A
NUMBER OF VEHICLES	2	0 to 65,500		B

Notes:
A. A value of 0 indicates that the vehicle position should not be updated. This is used for recovering from sequencing errors. When this value is set to 1, the device uses the Number of Vehicles field to calculate actual train position.
B. This field indicates the total number of vehicles in the train.

2.5.5 Vehicle Sequence Info (0,23)

Source: CCD, HEU Trail, PSC   **Message Rate:** When requested
Dest: Requesting Node   **Service Type:** UNACKD
Msg Type: Explicit   **Addressing:** UNICAST
Msg Code: 0x00   **Data Size:** 9 bytes
Priority: No

Description: This message is sent in response to the Vehicle Sequence Info Query message to report sequencing results.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	23 only	23	
MSG VERSION	1	0 to 255	0	
VEHICLE SEQUENCE STATE	1	0 = Prepared 1 = Lead Sense 2 = Counting 3 = Holding 4 = Done 5–254 = Not used	255	
SEQUENCING FLAGS	1	Bit 0: 1 = Lead Locomotive Sensed Bit 1: 1 = Stuck Load Detected Bits 2–7: Not used		
VEHICLE ORIENTATION	1	0 = A End/Short Hood Forward 1 = B End/Long Hood Forward 2–254 = Not used	255	
PULSE COUNT	2	0 to 65,500	0	
VEHICLE POSITION	2	0 to 65,500	0	

2.6 Train Status Data (0,24)

Source: HEU Lead   **Message Rate:** On change and every 120 s, but no more often than every 10 s
Dest: Event Recorder   **Service Type:** UNACKD
Msg Type: Explicit   **Addressing:** BCAST
Msg Code: 0x00   **Data Size:** 7 bytes
Priority: No

Description: This message is used to provide train status information to the event recorder that is not available from the other messages on the trainline.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	24 only	24	
MSG VERSION	1	0 to 255	1	
TRAIN BRAKE COMMAND SOURCE	1	Bits 0–4: 0 = Normal ECP Brake Control 1 = ECP Critical Loss Penalty 2 = No EOT Beacon Penalty 3 = Operable Brakes < 85% Penalty 4 = Op Brk < 90% & Lo V Penalty 5 = Low EOT Battery Penalty 6 = Pneumatic Brk in ECP & Moving 7 = Switch Mode & >20 MPH 8 = Train Move In Setup Penalty 9 = Alerter Penalty 10 = Cab Signal/Overspeed Penalty 11 = Suppression Application 12 = EOT Critical Loss Penalty 13 = WDP Related Source 14 = Equipment Failure 15 = Other 16–31 = Not used Bit 5: 1 = Interlock Active Bits 6–7: Not used		A
HEU OPERATIONAL STATE	1	Bit 0: 1 = Sequencing In Process Bit 1: 1 = Setup In Process Bit 2: 1 = Diagnostic Test In Process Bits 3–7: Not used		B
PERCENT OF OPERABLE BRAKES	1	0 to 100% (LSB = 1%)		
TOTAL POTENTIALLY OPERATIVE BRAKES	2	0 to 65,534		

Notes:
A. This field indicates the source for the current train brake command.
B. This field indicates the current operating state of the Lead HEU.

2.7 Exception messages

2.7.1 Critical Exception (0,25)

Source: CCD, EOT, Trail HEU, PSC   **Message Rate:** On occurrence
Dest: All Devices   **Service Type:** UNACKD
Msg Type: Explicit   **Addressing:** BCAST
Msg Code: 0x00   **Data Size:** Variable (10 to 19 bytes)
Priority: No

Description: This message is used to report critical faults that could affect the safety of the train.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	25 only	25	
MSG VERSION	1	0 to 255	2	
EXCEPTION CODE	2	10,000 to 10,009		
UNIQUE ID	6	0 to 0xFFFFFFFFFFFF		A

TRAIN ID	3	Per paragraph 1.3.4 of this standard		B
SUPPORTING DATA	0–12	See Appendix A, Section 2		

Notes:
A. The EOT function uses a fixed Unique ID (see paragraph 2.2.3).
B. This field shall be set to the Train ID of the Lead HEU to which the device is connected.

2.7.2 Normal Exception (0,26)

Source: Any Device   **Message Rate:** On occurrence
Dest: HEU Lead, LCM Lead or Requesting Node   **Service Type:** ACKD or UNACKD (see Note C)
Msg Type: Explicit   **Addressing:** UNICAST
Msg Code: 0x00   **Data Size:** Variable (23 to 29 bytes)
Priority: No

Description: This message is used to report noncritical exceptions to the Lead HEU or LCM. It also is sent to the requesting node in response to an Exception Query.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	26 only	26	
MSG VERSION	1	0 to 255	2	
EXCEPTION CODE	2	0 to 65534		
UNIQUE ID	6	0 to 0xFFFFFFFFFFFF		B
VEHICLE REPORTING MARK	11	ASCII text		A
EXCEPTION STATUS	1	Bit 0: 0 = Normal Report 1 = Response to Query Bits 1–7: Not used		
SUPPORTING DATA VERSION	1	0 to 255		
SUPPORTING DATA	0–6	See Appendix A, Section 2		

Notes:
A. For an EOT this field shall be set to the EOT identification number as defined in paragraph 2.2.3.
B. The EOT function uses a fixed Unique ID (see paragraph 2.2.3)
C. For exception codes that require display to the operator as defined in **Table 4** of Appendix A, this message shall be sent as an ACKD message. Otherwise, it shall be sent as UNACKD. When sent in response to an Exception Query, this message shall always be sent as UNACKD.

2.7.3 Exception Clear (0,27)

Source: Any Device   **Message Rate:** On occurrence
Dest: HEU Lead, LCM Lead or Requesting Node   **Service Type:** UNACKD
Msg Type: Explicit   **Addressing:** UNICAST
Msg Code: 0x00   **Data Size:** 22 bytes
Priority: No

Description: This message is used to report an exception cleared to the Lead HEU or LCM. It also is sent to the requesting node in response to an Exception Query.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	27 only		27	
MSG VERSION	1	0 to 255		0	
EXCEPTION CODE	2	0 to 65535			
UNIQUE ID	6	0 to 0xFFFFFFFFFFFF			A
VEHICLE REPORTING MARK	11	ASCII text			
EXCEPTION STATUS	1	Bit 0: 0 = Normal Report 1 = Response to Query Bits 1–7: Not used			

Note:
A.   The EOT function uses a fixed Unique ID (see paragraph 2.2.3)

2.7.4 Exception Update Request (0,28)

Source: HEU Lead, LCM Lead   **Message Rate:**   As needed
Dest: Any device   **Service Type:**   UNACKD
Msg Type: Explicit   **Addressing:**   UNICAST
Msg Code: 0x00   **Data Size:**   4 bytes
Priority: No

Description: This message is used to request the exception description from a device. This allows interpretation of manufacturer-specific exception codes, as well as any new exception codes that may be implemented in the future.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	28 only		28	
MSG VERSION	1	0 to 255		0	
EXCEPTION CODE	2	0 to 65534			A

Note:
A.   Descriptions for exception codes defined in Appendix A of the mandatory M-024 compatibility version as defined in Appendix D do not need to be supported. No response is required for these exceptions.

2.7.5 Exception Update (0,29)

Source: Any device   **Message Rate:**   When requested
Dest: Requesting Node   **Service Type:**   UNACKD
Msg Type: Explicit   **Addressing:**   UNICAST
Msg Code: 0x00   **Data Size:**   10–33 bytes
Priority: No

Description: This message is sent in response to an Exception Update Request message. A device shall generate this message within 3 s after receiving an Exception Update Request.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	29 only		29	
MSG VERSION	1	0 to 255		0	
EXCEPTION CODE	2	0 to 65534			
DISPLAY/PRIORITY	1	Bits 0–2:	Priority (1–5)	0	A, D
		Bit 3:	1 = Display		
		Bit 4:	1 = Engineer ACK Required		C
		Bits 5–6:	0 = No Automatic Application 1 = Full Service Application 2 = Emergency Brake Application 3 = Not used		C
		Bit 7:	Spare		
EXCEPTION DESCRIPTION	5 to 28	ASCII text			B

Notes:
A. This field defines the priority of the exception for display to the train operator. A value of 1 indicates the highest priority for display to the operator. The priority values are shown in the exception table (see Appendix A).
B. This field is defined to be the Exception Description as shown in the exception table (see Appendix A). If the device does not recognize the Exception Code requested, then this field should contain "UNDEFINED CODE."
C. Manufacturer exception messages setting bits 4 through 6 require AAR approval.
D. A value of 0 to the entire byte represents an invalid exception code.

2.7.6 Exception Query (0,30)

Source:	HEU Lead, LCM Lead	**Message Rate:**	As needed
Dest:	Any device	**Service Type:**	ACKD or UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST or BCAST
Msg Code:	0x00	**Data Size:**	6 bytes
Priority:	No		

Description: This message is used to request an exception report. If this message is sent UNICAST, then it shall use a service type of ACKD; otherwise the UNACKD service type shall be used.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	30 only	30	
MSG VERSION	1	0 to 255	2	
EXCEPTION REQUEST TYPE	1	0 = Send Active Exceptions Only		B, C, D, E, F
		1 = Send Active/Clear		
		2 = Send Highest Priority Exception/Clear		
		3 = Send Highest Priority Exception		
		4–255 = Not used		
EXCEPTION CODE	2	0–65535		A, C, D
DEVICE TYPE	1	0 to 5	0	G

Notes:
A. This field is used to specify the Exception Code being requested for exception types 0 and 1. A value of 65535 indicates all or any exceptions. A value of 65535 will always be set for exception types 2 and 3.
B. The exception query shall not be broadcast if the Exception Request Type field is set to "Send Active/Clear" (1) or "Send Highest Priority Exception/Clear" (2).
C. Devices receiving this query shall generate and send their first response to this message within 1 s.
D. Devices shall not respond to this query if they do not have exceptions meeting the specified exception code for Exception Request Types 0 or 3.
E. Devices shall respond with a single Exception Clear message (paragraph 2.7.3) with the Exception Code field set to 65535 if they do not have exceptions meeting the specified Exception Code for Exception Request Types 1 or 2.
F. LCM devices are required to support only Exception Request Types 0 and 3.
G. Device Type is as defined in paragraph 1.1.3. A Device Type of 0 indicates all devices. A single node (with one APTA address) acting as two AAR devices shall respond to received exception queries containing a Device Type of 0-All Devices with a response for each Device Type that it supports. Otherwise, it shall respond only as the Device Type indicated.

2.8 Diagnostic test messages

2.8.1 Device Echo Query (0,39)

Source:	HEU Lead	**Message Rate:**	As needed
Dest:	Any device	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	Variable 2 to 37 bytes
Priority:	No		

Description: This message is sent from the Lead HEU to a trailing device to support testing of the trainline communications. The receiving device responds with a Device Echo Reply (0,40) message.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	39 only	39	
MSG VERSION	1	0 to 255	0	
DATA TO ECHO	0–35	Defined per message		

2.8.2 Device Echo Reply (0,40)

Source:	Any device	**Message Rate:**	As needed
Dest:	Requesting node	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	Variable 2 to 37 bytes
Priority:	No		

Description: This message is sent in response to a Device Echo Query (0,39) and contains identical data in the Data to Echo field.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	40 only	40	
MSG VERSION	1	0 to 255	0	
DATA TO ECHO	0–35	Same as in Device Echo Query		

2.8.3 Device Communications Diagnostic Query (0,44)

Source: HEU Lead   **Message Rate:** As needed
Dest: Any device   **Service Type:** UNACKD
Msg Type: Explicit   **Addressing:** UNICAST or BCAST (see Note A)
Msg Code: 0x00   **Data Size:** 3 bytes
Priority: No

Description: This message is sent from the Lead HEU to a trailing device to request the device's communications status information. The receiving device responds with a Device Communications Diagnostic Response (0,45) message.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	44 only		44	
MSG VERSION	1	0 to 255		0	
COMMAND	1	Bit 0:	0 = Respond to query 1 = Reset Stored Info	0	A
		Bits 1–7:	Not used (set to 0)		

Note:
A. This field is used to command the device to either respond to the query with a Device Communications Diagnostic Response message or reset its stored diagnostic data back to the default values. When this bit is set to 1, this message may be sent as BCAST. Otherwise, it shall be sent as UNICAST.

2.8.4 Device Communications Diagnostic Response (0,45)

Source: Any device   **Message Rate:** As needed
Dest: Requesting node   **Service Type:** UNACKD
Msg Type: Explicit   **Addressing:** UNICAST
Msg Code: 0x00   **Data Size:** 9 bytes
Priority: No

Description: This message is sent in response to a Device Communications Diagnostic Query (0,44) and contains the device's communication diagnostic information.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	45 only	45	
MSG VERSION	1	0 to 255	0	
LAST DETECTED CROSSTALK TRAIN ID	3		0	A
TOTAL DETECTED CROSSTALK MESSAGES	2	0-65535	0	B
TOTAL CRC ERRORS	2	0-65535	0	C

Notes:
A. This field is used to identify the Train ID of the crosstalk message the device last detected. It shall be set to Unknown (0xFFFFFF) if the device detected crosstalk but the last detected crosstalk message did not contain a Train ID, or shall be set to None (0x000000) if crosstalk was not detected.
B. This field is used to identify the total number of crosstalk messages detected by the device.
C. This field is used to identify the total number of CRC errors detected by the device.

3. WDP system messages

The messages in this section are not currently used by APTA ECP systems and are provided as a reference to reserve message allocations used by AAR Wire DP systems.

3.1 Train initialization messages

3.1.1 Device Info (LCM) (0,31)

Source:	LCM Remote	**Message Rate:**	When Requested
Dest:	Requesting Node	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	26 bytes
Priority:	No		

Description: This message is sent from a Remote LCM in response to a Device Info Control/Query message. Only units equipped for WDP service shall respond with this message.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	31 only		31	
MSG VERSION	1	0 to 255		0	
MANUFACTURER ID	1	0 to 255			
REPORTING MARK	11	ASCII text		LOCO*******	
UNIQUE ID	6	0 to 0xFFFFFFFFFFFF		N/A	
MANUFACTURER REVISION LEVEL	1	0 to 255			
LCM COMPATIBILITY VERSION	1	0 to 255		4	A
FEATURE AVAILABILITY—MONITORED UNIT	1	Bit 0:	1 = Available as a Monitored Unit	0	D
		Bit 1:	1 = Engine Stop Override Available		
		Bit 2:	1 = Idle Override Available		
		Bit 3:	1 = Fuel Savings Override Available		
		Bits 4–7:	Not used		
FEATURE AVAILABILITY—CONTROLLED UNIT	1	Bit 0:	1 = Available as a Controlled Unit	0	D
		Bit 1:	1 = Traction Speed Control Available		
		Bit 2:	1 = Plugging Speed Control Available		
		Bit 3:	1 = Dynamic Brake Available		
		Bit 4:	1 = CTE Mode Available		
		Bits 5–7:	Not used		

Field Name	Size	Value/Range (Resolution)	Default	Notes
ORIENTATION	1	Bits 0–1: Remote Orientation 0 = Same as Lead 1 = Opposite from Lead 2–3 = Direction Unknown Bits 2–7: Not used		B
RAILROAD-SPECIFIC DATA	1	Defined as necessary	0	C

Notes:
A. Maximum compatibility level to which the remote is capable of receiving and sending messages. Refer to Appendix D of this specification for a version reference table.
B. The Remote Orientation field reflects either the orientation that was last manually entered on the remote unit or the last lead-commanded orientation received from any lead, whichever is the most recent.
C. This field is reserved for definition by each specific railroad customer. It is intended to support the potential need for railroads that do not normally interchange equipment to assign bits in the LCM Device Info message that reflect capabilities that are specific to their operation (pantograph, dump-door control, etc.).
D. The features within the Controlled and Monitored Unit Availability fields shall be set to available to identify when the locomotive is so equipped.

3.2 Run-time configuration messages

3.2.1 WDP Link Command (0,32)

Source:	LCM Lead	**Message Rate:**	As Needed
Dest:	LCM Remote	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	23 bytes
Priority:	No		

Description: This message is sent from the Lead LCM to configure and link to a Trail or Remote WDP unit. A Trail or Remote WDP unit shall be capable of receiving and responding to a new link command regardless of its current link state.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	32 only	32	
MSG VERSION	1	0 to 255	1	
LEAD LCM REPORTING MARK	11	ASCII text	LOCO*******	
UNIT ASSIGNMENT/FUNCTION	1	Bits 0–2: Consist Designator 0 = Consist A 1 = Consist B 2 = Consist C 3 = Consist D 4 = Consist E 5–7 = Not used Bit 3: Unit Assignment 0 = ITC-Monitored Unit 1 = ITC-Controlled Unit Bit 4: Unit Orientation 0 = Same as Lead 1 = Opposite from Lead Bits 5–7: Not used		
TIME/DATE SYNCH SECONDS	1	Seconds (0–59)		
TIME/DATE SYNCH MINUTES	1	Minutes (0–59)		
TIME/DATE SYNCH HOURS	1	Hours (0–23)		

Field Name	Size	Value/Range (Resolution)	Default	Notes
TIME/DATE SYNCH DAY	1	Day (1–31)		
TIME/DATE SYNCH MONTH	1	Month (1–12)		
TIME/DATE SYNCH YEAR	1	Year (0–99)		
TRAIN ID	3	Per paragraph 1.3.4 of this standard		

3.2.2 WDP Unlink Command (0,33)

Source:	LCM Lead	**Message Rate:**	As Needed
Dest:	LCM Remote	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST or BCAST
Msg Code:	0x00	**Data Size:**	5 bytes
Priority:	No		

Description: This message is sent from the Lead LCM to unlink a Trail or Remote WDP unit. This message may be sent to individual LCMs or broadcast to unlink all units.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	33 only	33	
MSG VERSION	1	0 to 255	1	
TRAIN ID	3	Per paragraph 1.3.4 of this standard		

3.2.3 WDP Link Response (0,34)

Source:	LCM Remote	**Message Rate:**	Response to WDP Link Command
Dest:	Requesting Node	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	6 bytes
Priority:	No		

Description: This message is sent from the Trail or Remote LCM to acknowledge that the WDP Link Command from the Lead LCM has taken effect. This message is not just an echo of the Link Command. It contains the status of the Trail or Remote LCM as a result of receiving and responding to the Link command. If a unit receives a WDP Link Command but is unable to link for any reason, it will not send a WDP Link Response. The Lead LCM shall use the link response message to verify that the assignments of the last link command have been met.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MSG ID NUMBER	1	34 only		34	
MSG VERSION	1	0 to 255		1	
UNIT ASSIGNMENT/FUNCTION ACKNOWLEDGE	1	Bits 0–2:	Consist Designator 0 = Consist A 1 = Consist B 2 = Consist C 3 = Consist D 4 = Consist E 5–7 = Not used		
		Bit 3:	Unit Assignment 0 = Linked as ITC-Monitored Unit 1 = Linked as ITC-Controlled Unit		
		Bit 4:	Unit Orientation 0 = Same as Lead 1 = Opposite from Lead		
		Bits 5–7:	Not used		
TRAIN ID	3	Per paragraph 1.3.4 of this standard			

3.3 Normal operational messages

3.3.1 WDP Beacon (0,35)

Source: LCM Lead   **Message Rate:**   1 Hz
Dest: LCM Remote   **Service Type:**   UNACKD
Msg Type: Explicit   **Addressing:**   BCAST
Msg Code: 0x00   **Data Size:**   19, 24, 29, 34, or 39 bytes
Priority: Yes

Description: This message is broadcast from the Lead LCM to the Trail and Remote LCMs to command the Remote WDP equipment and provide a poll for remote locomotive status information.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	35 only	35	
MSG VERSION	1	0 to 255	3	0: orig. 2: S-4230 v. 4
LCM COMPATIBILITY VERSION	1	0 to 255	4	A

Field Name	Size	Value/Range (Resolution)		Default	Notes
PROPULSION COMMAND	1	Bits 0–1:	System Mode 0 = INIT 1 = IDLE 2 = RUN 3 = Not used		
		Bits 2–3:	Direction of Lead's Reverser Setting 0 = Neutral (Centered) 1 = Forward 2 = Reverse 3 = Invalid		
		Bit 4:	1 = Lead Engine Run		
		Bit 5:	1 = Power Knockdown		
		Bit 6:	1 = Manual Sand		
		Bit 7:	Not used		
AIR BRAKE COMMAND	1	Bit 0:	1 = ECP Enforcement (Penalty or EM)		B
		Bit 1:	1 = Pneumatic Emergency Enforcement		
		Bit 2:	1 = Bail Off		
		Bits 3–7:	Not used		
INDEPENDENT BRAKE COMMAND	1	0–100% (1% resolution)			
LEAD SPEED CONTROL EXCITATION	1	0–100% Effort (LSB = 0.5%)		0	G
SPARE FIELD 2	1	Reserved for Future Feature Development		0	
POLL SUBNET ADDRESS	1				C
POLL NODE ADDRESS	1				C
NUMBER OF CONSISTS	1	Valid Range: 1–5			D
End of Common Command Block					
Beginning of Individual Consist Command Block(s) The data defined below shall always be present for Consist A and may be followed by data for consists B, C, D, and E.					
GENERAL COMMANDS	1	Bits 0–2:	Mode Command 0 = Throttle Mode 1 = Dynamic Brake Mode 2 = Engine Stop 3 = Unit Idle Mode 4 = Slow Speed Traction Control 5 = Slow Speed Plugging Control 6 = Set-out Mode 7 = Invalid Mode		
		Bit 3:	1 = BV Out		
		Bit 4:	1 = Group Transition Active		
		Bit 5:	1 = Fuel Savings Mode		
		Bit 6:	1 = CTE Mode		
		Bit 7:	Not used		
THROTTLE/DYNAMIC BRAKE EFFORT/SET SPEED TARGET	1	0–100% (LSB = 0.5%) or 0–12.70 mph (LSB = 0.05 mph)			E

Field Name	Size	Value/Range (Resolution)	Default	Notes
RAILROAD-SPECIFIC DATA FIELD 1	1	Defined as Necessary	0	F
RAILROAD-SPECIFIC DATA FIELD 2	1	Defined as Necessary	0	F
RAILROAD-SPECIFIC DATA FIELD 3	1	Defined as Necessary	0	F
End of Individual Consist Command Block(s)				
TRAIN ID	3	Per paragraph 1.3.4 of this standard		

Notes:
A. Compatibility level to which the lead is sending messages. Refer to Appendix D of this standard for a version reference table.
B. ECP Enforcement is an indication to the WDP system that a penalty/emergency brake application is in effect. The remote locomotive uses this bit as an indication to open PCS, adjust brake cylinder pressure, etc., during a penalty/emergency.
C. This is the address of the device being polled. A subnet/node address of 0/0 indicates that no trainline devices are being polled.
D. This field is used to establish how many consists are being commanded by the beacon message.
E. When in Throttle Mode or Dynamic Brake Mode, this field shall contain a value of 0–100%, representing the magnitude of the Throttle or Dynamic Brake command. Upon receipt of this message field, the ITC-controlled unit shall select the nearest distinct notched command. Locomotives with eight discrete throttle notches shall use the following table to convert notch settings to percentage:

Throttle Notch	Percentage		Throttle Notch	Percentage
Idle	0		5	62.5
1	12.5		6	75
2	25		7	87.5
3	37.5		8	100
4	50			

When in Unit Idle Mode, this field shall contain a value of 0%.

When in Slow Speed Traction Control or Slow Speed Plugging Control, this field shall contain a value of 0–12.70 mph, representing the absolute Set Speed Target.

When in Engine Stop Mode, this field shall contain a value of Invalid.

F. These fields are reserved for definition by each specific railroad customer. They are intended to support the potential need for railroads that do not normally interchange equipment to assign bits in the WDP beacon message that are specific to their operation (pantograph, dump-door control, etc.).
G. This field is a common command that applies to all ITC-controlled units. This data represents the lead's reported excitation for speed control balancing operation.

3.3.2 WDP Remote Status (0,36)

Source: LCM Remote **Message Rate:** When Requested
Dest: Requesting Node **Service Type:** UNACKD
Msg Type: Explicit **Addressing:** UNICAST
Msg Code: 0x00 **Data Size:** 26 bytes
Priority: No

Description: This message is sent from a Trail or Remote LCM to the Lead LCM to provide Remote status. This message is sent in response to the WDP Beacon or WDP Remote Status Query.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MSG ID NUMBER	1	36 only	36	
MSG VERSION	1	0 to 255	3	0: orig. 2: S-4230 v. 4
UNIT STATUS FIELD 1	1	Bit 0: 1 = Distributed Power Subsystem Data Invalid (tied to exception 20001)		A

Field Name	Size	Value/Range (Resolution)		Default	Notes
		Bit 1:	Unit State 0 = Monitored 1 = Controlled		A2
		Bits 2–4:	Mode Command 0 = Throttle Mode 1 = Dynamic Brake Mode 2 = Engine Stop 3 = Unit Idle Mode 4 = Slow Speed Traction Control 5 = Slow Speed Plugging Control 6 = Set-out Mode 7 = Invalid Mode		A2
		Bit 5:	1 = Manual Sand Active		A2
		Bit 6:	1 = Fuel Saver Mode Active		A2
		Bit 7:	1 = CTE Mode Active		A2
UNIT STATUS FIELD 2	1	Bit 0:	1 = Wheel Slip Active (tied to exception 20013)		A2
		Bit 1:	1 = Ground Fault Relay Active (tied to exception 20015)		A2
		Bit 2:	1 = Unit Alarm Bell Active (tied to exception 20016)		A2
		Bit 3:	1 = Critical DP Fault Active (tied to exception 20010)		A2
		Bit 4:	1 = Locked Axle		A2
		Bit 5:	1 = Engine Shutdown		A2
		Bit 6:	1 = Automated Traction Mode Cut-Out		A2
		Bit 7:	Not used		
THROTTLE AND DYNAMIC BRAKE STATUS FIELD 1	1	Bit 0:	1 = Propulsion Subsystem Data Invalid (tied to exception 20003)		B
		Bit 1:	1 = Power Knockdown Active		B2
		Bits 2–3:	Direction (Local Propulsion Command) 0 = Neutral (Centered) 1 = Forward 2 = Reverse 3 = Invalid		B2, G
		Bits 4–6:	Propulsion Mode Command 0 = Throttle Mode 1 = Dynamic Brake Mode 2 = Engine Stop 3 = Slow Speed 4 –7= Invalid		B2
		Bit 7:	Not used		

Field Name	Size	Value/Range (Resolution)		Default	Notes
THROTTLE AND DYNAMIC BRAKE STATUS FIELD 2	1	Bit 0:	1 = Propulsion Mode Command Miscompare Active (tied to exception 20004)		B2
		Bit 1:	1 = Direction Miscompare Active(tied to exception 20005)		B2
		Bit 2:	1 = Throttle Step Miscompare Active (tied to exception 20006)		B2
		Bit 3:	1 = Dynamic Brake Step Miscompare Active(tied to exception 20007)		B2
		Bit 4:	1 = Critical Propulsion Fault Active (tied to exception 20012)		B2
		Bit 5:	1 = Dynamic Brake Warning Active (tied to exception 20014)		B2
		Bit 6:	1 = Not Responding to CTE		B2
		Bit 7:	1 = Not Responding to FTE		B2
THROTTLE/DYNAMIC BRAKE EFFORT	1	0–100% (LSB = 0.5%)			B2, D
THROTTLE/DYNAMIC BRAKE TRACTIVE EFFORT—ITC CONTROLLED UNIT	1	0 to 254,000 lb (LSB = 1000 lb)			B2, E
THROTTLE/DYNAMIC BRAKE TRACTIVE EFFORT—DBM AGGREGATE	2	YYYYYYYY SXXXXXXX Where: 1 bit = 1 Klb S is sign bit 0 = Positive/Motoring and 1 = Negative/Dynamic Braking			B2, I
DBM REPORTING LOCOMOTIVES	1	Bits 0–2:	0–7 = Number of Locomotives in the Consist Reporting Throttle/Dynamic Brake Tractive Effort Info		B2, F
		Bits 3–5:	0–7 = Number of contributing Locomotives Accumulated in the Throttle/Dynamic Brake Tractive Effort DBM Aggregate Field		B2, F
		Bit 6:	1 = TE/BE Conflict		
		Bit 7:	1 = DBM Data Valid		
AIR BRAKE STATUS FIELD 1	1	Bit 0:	1 = Air Brake Subsystem Data Invalid (tied to exception 20002)		C
		Bit 1:	1 = BV Out		C2
		Bit 2:	1 = Bail Off Active		C2
		Bit 3:	1 = Local Pneumatic Emergency in Effect		C2
		Bits 4–7:	Not used		

Field Name	Size	Value/Range (Resolution)		Default	Notes
AIR BRAKE STATUS FIELD 2	1	Bit 0:	1 = Brake Valve Miscompare Active (tied to exception 20008)		C2
		Bit 1:	1 = High BC Pressure Active (tied to exception 20009)		C2
		Bit 2:	1 = Critical Air Brake Fault Active (tied to exception 20011)		C2
		Bit 3:	1 = Low MR (tied to exception 20017)		C2
		Bits 4–7:	Not used		
BRAKE PIPE PRESSURE	2	0 to 254.0 psi (LSB = 0.1 psi)			C2
EQUALIZING RESERVOIR PRESSURE	1	0 to 254 psi (LSB = 1 psi)			C2
BRAKE CYLINDER PRESSURE	1	0 to 254 psi (LSB = 1 psi)			C2
MAIN RESERVOIR PRESSURE	1	0 to 254 psi (LSB = 1 psi)			C2
CHARGING FLOW RATE	1	0 to 254 scfm (LSB = 1 scfm)			C2
FUEL LEVEL	1	0 to 12,700 gal (LSB = 50 gal)		255	
RAILROAD-SPECIFIC DATA FIELD 1	1	Defined as necessary		0	H
RAILROAD-SPECIFIC DATA FIELD 2	1	Defined as necessary		0	H

Field Name	Size	Value/Range (Resolution)	Default	Notes
RAILROAD-SPECIFIC DATA FIELD 3	1	Defined as necessary	0	H
TRAIN ID	3	Per paragraph 1.3.4 of this standard		

Notes:
A. This bit indicates to the lead when all the provided data relating to the status of the WDP system are either unknown or invalid. The fields that are qualified by this bit are identified with "A2" in the Notes column.
B. This bit indicates to the lead when all the provided data relating to the status of the throttle and dynamic brake system are either unknown or invalid. The fields that are qualified by this bit are identified with "B2" in the Notes column
C. This bit indicates to the lead when all the provided data relating to the status of the air brake system are either unknown or invalid. The fields that are qualified by this bit are identified with "C2" in the Notes column.
D. When in Throttle Mode, Dynamic Brake Mode or Slow Speed Mode, this field shall contain a value of 0–100%, representing the current magnitude of the throttle or dynamic brake setting. Locomotives with eight discrete throttle notches shall use the following table to convert notch settings to percentage:

Throttle Notch	Percentage		Throttle Notch	Percentage
Idle	0		5	62.5
1	12.5		6	75
2	25		7	87.5
3	37.5		8	100
4	50			

When in Engine Stop Mode, this field shall be set to Invalid.

E. This field represents the ITC-controlled unit's tractive effort or dynamic brake effort, depending on the setting of the mode command in the Propulsion Mode field. Conversion to kilopounds (1 klb = 1000 lb) is performed on the remote locomotive.
F. When implemented on an ITC-controlled locomotive that is capable of receiving the tractive and dynamic effort of other locomotives within the consist (e.g., dynamic brake monitoring), this field shall contain the total number of reporting locomotives, a count of the total number of individual locomotives that are contributing to the aggregate tractive effort, if a throttle/dynamic brake conflict is present within the consist, and the validity of the information as provided by the DBM system (reference Manual of Standards and Recommended Practices, Section M, Standard S-5509).
G. On remote locomotives equipped with a standard AAR 27-pin MU cable, these fields reflect the setting of the 8T and 9T trainlines at the control stand.
H. These fields are reserved for definition by each specific railroad customer. They are intended to support the potential need for railroads that do not normally interchange equipment to assign bits in the WDP Remote Status message that are specific to their operation (pantograph, dump-door control, etc.).
I. When implemented on an ITC-controlled locomotive that is capable of receiving the tractive and dynamic effort of other locomotives within its consist (e.g., dynamic brake monitoring), this field shall contain the aggregate of the tractive/dynamic brake effort of the reporting locomotives within the ITC-controlled unit's remote consist. This field shall provide a Signed Magnitude value (−32767 to +32767) as provided by the DBM system (reference MSRP Standard S-5509). Note: The byte order of the DBM data has been specified as listed in the MSRP Standard S-5509.

3.3.3 WDP Remote Status Query (0,37)

Source:	LCM Lead	**Message Rate:**	As Needed
Dest:	LCM Remote	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	5 bytes
Priority:	No		

Description: This message is used to request a remote to send its status information without sending a WDP beacon message.

Field Name	Size	Value/Range (Resolution)	Default	Notes
MESSAGE ID NUMBER	1	37 only	37	
MSG VERSION	1	0 to 255	1	
TRAIN ID	3	Per paragraph 1.3.4 of this standard		

3.3.4 WDP-Monitored Unit Override Command (0,38)

Source:	LCM Lead	**Message Rate:**	As Needed
Dest:	LCM-Monitored Remote	**Service Type:**	ACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	6 bytes
Priority:	No		

Description: This message is used to command an individual, appropriately equipped, ITC-monitored locomotive. It is intended as a lower-priority method of controlling optional locomotive features.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MESSAGE ID NUMBER	1	38 only		38	
MSG VERSION	1	0 to 255		1	
UNIT OVERRIDE REDUCED MODE COMMAND	1	Bits 0–2:	Unit Override Reduced Mode Command 0 = None 1 = Engine Stop 2 = Idle Mode 3 = Fuel Savings 4–7 = Not used		A
		Bits 3–7:	Not used		
TRAIN ID	3	Per paragraph 1.3.4 of this standard			

Note:
A. This field is used to override the consist command from the MU trainline when the monitored locomotive is equipped with appropriate hardware. The override stays in effect until a subsequent WDP-Monitored Unit Override Command causes a change or until the unit unlinks.

3.3.5 WDP Remote DBM Status Query (0,41)

Source:	LCM Lead	**Message Rate:**	As Needed
Dest:	LCM Remote	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	6 bytes
Priority:	No		

Description: This message is used to request a remote to send the dynamic brake monitoring (DBM) status of an individual locomotive in the remote consist.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MESSAGE ID NUMBER	1	41 only		41	
MSG VERSION	1	0 to 255		1	
REQUEST TYPE	1	Bits 0–2:	Locomotive Index (0–7)		A
		Bits 3–7:	Not used (set to 0)		
TRAIN ID	3	Per paragraph 1.3.4 of this standard			

Note:
A. An index value of 1 will request the DBM status of the WDP remote locomotive itself, while index values of 2–7 will request the status of the other DBM-equipped locomotives that are MU'ed to the WDP remote locomotive. The locomotive index to locomotive road number assignment is basically stable but may change at any time.

3.3.6 WDP DBM Response (0,42)

Source:	LCM Remote	**Message Rate:**	As Needed
Dest:	Requesting Node	**Service Type:**	UNACKD
Msg Type:	Explicit	**Addressing:**	UNICAST
Msg Code:	0x00	**Data Size:**	3–22 bytes
Priority:	No		

Description: This message is used to respond to a WDP Remote DBM Status Query.

Field Name	Size	Value/Range (Resolution)		Default	Notes
MESSAGE ID NUMBER	1	42 only		42	
MSG VERSION	1	0 to 255		0	
STATUS AVAILABILITY	1	Bit 0:	0 = Status Not Available 1 = Status Is Available		A, B
		Bits 1–3:	Locomotive Index (0–7)		
		Bits 4–7:	Not used (set to 0)		
STATUS TEXT	19	ASCII text		spaces	C, D

Notes:
A. This is the locomotive index from the original request.
B. An index value of 1 is for the DBM status of this WDP remote locomotive, while index values of 2–7 will request the status of the other DBM-equipped locomotives that are MU'ed to this locomotive. The locomotive index to locomotive road number assignment is basically stable but may change at any time.
C. Line of text for the target locomotive as received from the "listener port" of the local DBM system equipment. Refer to the AAR Manual of Standards and Recommended Practices, Section L, Standard S-5509, "Locomotive Dynamic Brake Status Reporting," for a breakdown of the various sub-fields that are contained within this text. The WDP system is responsible only for transferring this text to the WDP lead and for providing a display of the text to the crew, and not for parsing the contents of the text. Updates to the sub-field definitions in AAR S-5509 should not require a corresponding update to the WDP system.
D. These bytes shall not be sent when status information from this locomotive index is not available.

Related APTA standards

The following standards are the complete set of Passenger ECP standards:

APTA PR-M-S-020-17, "Passenger Electronic 26C Emulation Braking System—Performance Requirements"
APTA PR-M-S-021-17, "ECP Passenger Cable-Based Braking System—Performance Requirements"
APTA PR-M-S-022-19, "ECP Passenger Cable-Based Brake System Cable, Connectors and Junction Boxes—Performance Requirements"
APTA PR-M-S-023-19, "ECP Passenger Cable-Based Brake DC Power Supply—Performance Requirements"
APTA PR-M-S-024-19, "Intratrain Communication Requirements for ECP Cable-Based Passenger Train Control Systems"
APTA PR-M-S-025-19, "ECP Passenger Cable-Based and Passenger Emulation Braking System—Approval Procedure"
APTA PR-M-S-026-19, "ECP Passenger Cable-Based Braking System—Interoperability Procedure"
APTA PR-M-S-027-19, "ECP Passenger Cable-Based Braking System—Configuration Management"

References

American National Standards Institute standards:
ANSI/EIA-709.1-A, "Control Network Protocol Specification"
ANSI/EIA-709.2-A, "Control Network Power Line Channel Specification"

Association of American Railroads
AAR S-4230, "Intratrain Communication Specification for Cable-Based Freight Train Control Systems"
AAR S-5509, "Locomotive Dynamic Brake Status Reporting"

Abbreviations and acronyms

A	ampere
ACKD	acknowledged
ANSI	American National Standards Institute
BCAST	broadcast
BCP	brake cylinder pressure
BPP	brake pipe pressure
CCD	car control device
CRC	cyclic redundancy check
CTE	controlled tractive effort
DBM	dynamic brake monitoring
E/L	empty/load
ECP	electronically controlled pneumatic
EIA	Electronic Industries Association
EOT	end of train
HEU	head end unit
kHz	kilohertz
klb	kilopounds
LCM	locomotive control module
LSB	least significant bit
ms	milliseconds
MSB	most significant bit
MSRP	Manual of Standards and Recommended Practices
MU	multiple unit
M-024	refers to this standard

NATSA   North American Transportation Services Association
PSC   power supply controller
psi   pounds per square inch
s   seconds
SCF   single carrier frequency
scfm   standard cubic feet per minute
TBC   train brake call
UNACKD   unacknowledged
UNICAST   sending a message to just one device (opposite of broadcast)
VDC   volts direct current
Vpp   voltage peak to peak
WDP   wired distributed power

Summary of document changes

- This is the first publication of this standard.

Document history

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First published	Nov. 30, 2018	March 4, 2019	April 8, 2019	June 17, 2019	August 7, 2019

Appendix A: Exception codes

1. Exception codes

Table 4 provides a list of defined exception codes that are generated by individual devices. Additional information listed in this table for manufacturer-specific exception codes, such as priority, display, acknowledgment requirements and brake application requirements, shall be provided by an individual device to the HEU via the exception update mechanism.

TABLE 4
Exception Codes

Exception Number	Exception Description	Priority	Display	Operator Ack Req'd	Brake App	Msg Type	Msg Ref	Source Device
Manufacturer-Specific Exceptions								
0 to 1023	NYAB Specific							
1024 to 2047	Wabtec Specific							
2048 to 3071	Zeftron Specific							
3072 to 4095	GETS-GS Specific							
4096 to 5119	Not used							
5120 to 6143	EMD Specific							
6144 to 9999	Manufacturer-Specific Spares							
ECP Exceptions								
10000	LOSS OF HEU BEACON	2	No (Note A)	No	None (Note A)	Critical	2.1	CCD, EOT, Trail HEU
10001	LOSS OF BRAKE PIPE PRESSURE	2	No (Note A)	No	None (Note A)	Critical	2.2	CCD, EOT, Trail HEU
10002	CRITICAL LOSS RELAY	2	Yes	No	Yes (Emergency)	Critical	2.16	CCD, Trail HEU
10003 to 10009	Reserved for Future Critical Exceptions							
10010	LOW BRAKE PIPE PRESSURE	4	Yes	Yes	None	Normal	2.3	EOT
10011	LOW RESERVOIR	4	No (Note A)	No	None	Normal	2.4	CCD
10012	LOW TRAINLINE VOLTAGE	4	Yes	Yes	None	Normal	2.5	EOT, PSC
10013	HIGH TRAINLINE VOLTAGE	4	Yes	Yes	None	Normal	2.6	EOT, PSC
10014	TRAINLINE SHORT CIRCUIT	4	Yes	No	None	Normal	2.7	PSC
10015	LOW INPUT VOLTAGE	4	Yes (Note B)	No	None	Normal	2.8	PSC
10016	LOW BATTERY	4(CCD) 3(EOT)	No (CCD) (Note A) Yes (EOT)	No (CCD) No (EOT)	None (CCD) FS (EOT)	Normal	2.9	CCD EOT
10017	INCORRECT BC PRESSURE	5	Yes	Yes	None	Normal	2.10	CCD
10018	CAR ID FAULT	5	No (Note B)	No	None	Normal	2.11	CCD
10019	LOCOMOTIVE ID FAULT	5	No (Note B)	No	None	Normal	2.12	PSC, HEU
10020	CCD CUTOUT	4	No (Note A)	No (Note A)	None	Normal	2.13	CCD
10021	COMPATIBILITY ERROR	5	Yes (Note B)	No	None	Normal	2.14	ALL
10022	MULTIPLE LEAD HEUs	2	Yes	No	FS	Normal	2.15	PSC

TABLE 4
Exception Codes

Exception Number	Exception Description	Priority	Display	Operator Ack Req'd	Brake App	Msg Type	Msg Ref	Source Device
10023	PSC ENABLE FAULT	4	Yes (Note B)	No	None	Normal	2.17	PSC
10024	HANDBRAKE APPLIED	(Note D)	Yes (Note B)	No	None	Normal	2.18	CCD
10025	STUCK BRAKE	3	Yes	Yes	None	Normal	2.19	CCD
10026 to 19999	Reserved for Future ECP Exception Growth							
DP Exceptions (Not Used by APTA)								
20000	Not used							
20001	DISTRIBUTED POWER SUBSYSTEM DATA INVALID	2 or 3 (Note C)				Normal	3.1	LCM
20002	AIR BRAKE SUBSYSTEM DATA INVALID	6				Normal	3.2	LCM
20003	PROPULSION SUBSYSTEM DATA INVALID	2 or 3 (Note C)				Normal	3.3	LCM
20004	PROPULSION MODE COMMAND MISCOMPARE	2 or 3 (Note C)				Normal	3.4	LCM
20005	DIRECTION MISCOMPARE	2 or 3 (Note C)				Normal	3.5	LCM
20006	THROTTLE STEP MISCOMPARE	4 or 5 (Note C)				Normal	3.6	LCM
20007	DYNAMIC BRAKE STEP MISCOMPARE	4 or 5 (Note C)				Normal	3.7	LCM
20008	BV MISCOMPARE	7				Normal	3.8	LCM
20009	HIGH BC PRESSURE DETECTED	6				Normal	3.9	LCM
20010	CRITICAL DISTRIBUTED POWER SUBSYSTEM FAILURE	2				Normal	3.10	LCM
20011	CRITICAL AIR BRAKE SUBSYSTEM FAILURE	6				Normal	3.11	LCM
20012	CRITICAL PROPULSION SUBSYSTEM FAILURE	2				Normal	3.12	LCM
20013	WHEEL SLIP	(Note D)				Normal	3.13	LCM
20014	DYNAMIC BRAKE WARNING	2				Normal	3.14	LCM
20015	GROUND RELAY FAULT	4 or 5 (Note C)				Normal	3.15	LCM
20016	UNIT ALARM BELL	(Note D)				Normal	3.16	LCM
20017	LOW MR	7				Normal	3.17	LCM
20018 to 29999	Reserved for Future WDP Exception Growth							

TABLE 4
Exception Codes

Exception Number	Exception Description	Priority	Display	Operator Ack Req'd	Brake App	Msg Type	Msg Ref	Source Device
30000 to 65534	Reserved for Future Growth							

Notes:
A. HEU fault handling as defined in M-024 shall override the defaults listed in this table.
B. If the fault condition requires the engineer to take action, then the exception message shall be displayed.
C. First priority shown applies to controlled units. The second priority shown applies to monitored units.
D. The prioritization method does not apply to these exceptions.

2. All manufacturer ECP brake system exceptions

This section provides a description and definition of supporting data fields for each ECP brake exception message listed in **Table 4**.

2.1 Loss of HEU Beacon

Version: 0x00
Description: This message is transmitted by a CCD, Trail HEU or EOT when it detects a loss of HEU beacon as defined in M-024. This exception is cleared as defined in M-024.
Supporting Data: None

2.2 Loss of Brake Pipe Pressure

Version: 0x00
Description: This message is transmitted by a CCD, Trail HEU or EOT when it detects loss of BPP as defined in M-024. This exception is cleared as defined in M-024.
Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
BRAKE PIPE PRESSURE	1	0 to 250 psi	(LSB = 1 psi)		
BPP SETPOINT	1	0 to 250 psi	(LSB = 1 psi)		

2.3 Low Brake Pipe Pressure

Version: 0x00
Description: This message is transmitted by an EOT when it detects low BPP as defined in M-024. This exception is cleared as defined in M-024.
Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
BRAKE PIPE PRESSURE	1	0 to 250 psi	(LSB = 1 psi)		
BPP SETPOINT	1	0 to 250 psi	(LSB = 1 psi)		

2.4 Low Reservoir

Version: 0x00
Description: This message is transmitted by a CCD when it detects low reservoir charge as defined in M-024. This exception is cleared as defined in M-024.
Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
RESERVOIR PERCENT CHARGE	1	0 to 250%	(LSB = 1%)		
RES. PRESSURE	1	0 to 250 psi	(LSB = 1 psi)		
BPP SETPOINT	1	0 to 250 psi	(LSB = 1 psi)		

2.5 Low Train Line Voltage

Version: 0x00
Description: This message is transmitted when low trainline voltage is detected by the EOT or a PSC as defined M-024. This exception is cleared as defined in M-024.
Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
ACTUAL TRAINLINE VOLTAGE	1	0 to 250 VDC	(LSB = 1 VDC)		

2.6 High Train Line Voltage

Version: 0x00
Description: This message is transmitted when high trainline voltage is detected by the EOT or a PSC as defined in M-024. This exception is cleared as defined in M-024.
Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
ACTUAL TRAINLINE VOLTAGE	1	0 to 250 VDC	(LSB = 1 VDC)		

2.7 Train Line Short Circuit

Version: 0x00
Description: This message is transmitted when a PSC detects a short circuit condition on the trainline. This exception is cleared by resetting fault logic.
Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
ACTUAL TRAINLINE VOLTAGE	1	0 to 250 VDC	(LSB = 1 VDC)		
ACTUAL TRAINLINE CURRENT	1	0 to 25.0 A	(LSB = 0.1 A)		

2.8 Low Input Voltage

Version: 0x00
Description: This message is transmitted when an active PSC detects voltage at the input of its associated trainline power supply less than the low-battery fault threshold. This exception is cleared when the input voltage is greater than the low-battery fault clear threshold.

Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
ACTUAL INPUT VOLTAGE	1	0 to 250 VDC	(LSB = 1 VDC)		
LOW BATTERY FAULT LEVEL	1	0 to 250 VDC	(LSB = 1 VDC)		
LOW BATTERY CLEAR LEVEL	1	0 to 250 VDC	(LSB = 1 VDC)		

2.9 Low Battery

Version: 0x00
Description: This message is transmitted by a CCD or EOT when it detects low battery charge as defined in M-024. This exception is cleared as defined in M-024.

Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
ACTUAL BATTERY VOLTAGE	1	0 to 25.0 VDC (LSB = 0.1 VDC) 255 = unknown			

2.10 Incorrect BC Pressure

Version: 0x01
Description: This message is transmitted by a CCD when it detects incorrect BCP as defined in M-024. This exception is cleared as defined in M-024.

Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
ACTUAL BCP	1	0 to 250 psi	(LSB = 1 psi)		
TARGET BCP	1	0 to 250 psi	(LSB = 1 psi)		
RESERVOIR PRESSURE	1	0 to 250 psi	(LSB = 1 psi)		
BPP SETPOINT	1	0 to 250 psi	(LSB = 1 psi)		
INCORRECT BCP REASON CODE	1	Bits 0–3:	0 = Unknown 1 = Low Reservoir Charge 2 = Cylinder Leaking 3 = Pressure Transducer Failure 4 = Cylinder & Reservoir Connected 5 = Cylinder Not Venting 6 = Other CCD BCP Control Fault 7 = BP Connected to Cylinder 8–15 = Not used	0	A
		Bits 4–5:	0 = Unknown 1 = BCP High 2 = BCP Cannot Apply 3 = BCP Stuck Brake		
		Bits 6–7:	Not used (set to 0)		

Note:
A. Incorrect BCP reason codes (bits 0–3) may be implemented at manufacturer's discretion. Bits 4–5 are mandatory and shall be set according to AAR M-024, paragraph 4.4.12.

2.11 Car ID Fault

Version: 0x00
Description: This message is transmitted by a CCD when it detects a fault with the car ID function. This exception is cleared when the fault condition is no longer detected or fault logic is reset.

Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
CAR ID FAULT STATUS FLAGS	1	Bits 0–2:	0 = Unknown Car ID Fault 1 = Car ID Not Responding 2 = Car ID Reporting Fault 3 = Car ID Data Not Loaded 4 = Car ID Data Out of Range 5–7 = Not used	0	A
		Bits 3–7:	Not used (set to 0)		

Note:
A.   Car ID fault status flags may be implemented at manufacturer's discretion.

2.12 Locomotive ID Fault

Version: 0x00
Description: This message is transmitted by an HEU or PSC when it detects a fault with the locomotive ID function. This exception is cleared when the fault condition is no longer detected or fault logic is reset.

Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
LOCOMOTIVE ID FAULT STATUS FLAGS	1	Bits 0–2:	0 = Unknown Loco ID Fault 1 = Loco ID Not Responding 2 = Loco ID Reporting Fault 3 = Loco ID Data Not Loaded 4 = Loco ID Data Out of Range 5–7 = Not used	0	A
		Bits 3–7:	Not used (set to 0)		

Note:
A.   Locomotive ID Fault Status Flags may be implemented at manufacturer's discretion.

2.13 CCD Cutout

Version: 0x00
Description: This message is transmitted by a CCD when it cuts out as defined in AAR M-024. This exception is cleared as defined in M-024.

Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
STATUS	1	Bit 0:	1 = CUTOUT	1	A
		Bit 1:	1 = HEU Cutout Commanded		
		Bit 2:	1 = Isolated Critical Loss		
		Bit 3:	1 = CCD Fault Detected		
		Bit 4:	1 = Stuck Brake Protection Active		
		Bits 5–7:	Not used (set to 0)		

Note:
A. For this message, Bit 0 is always 1. Bits 1–3 indicate the reason for it being cut out. Bit 4 indicates whether or not the CCD has stuck brake protection available when it is cut out.

2.14 Compatibility Error

Version: 0x00
Description: This message is transmitted by a device when it detects a compatibility version in the train configuration data that it is unable to support.

Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
MANUFACTURER ID	1	0 to 250 (from paragraph 1.1.4.1)		
DEVICE TYPE	1	0 to 250 (from paragraph 1.1.3)		
M-024 COMPATIBILITY VERSION	1	0 to 255 (Device Version)	2	
Error! Reference source not found. COMPATIBILITY VERSION	1	0 to 255 (Device Version)	2	

2.15 Multiple Lead HEUs

Version: 0x00
Description: This message is transmitted by a device when it detects more than one Lead HEU operating on the trainline.
Supporting Data: None

2.16 Critical Loss Relay

Version: 0x01
Description: This message is transmitted by a CCD or Trail HEU when it detects a TBC in the HEU beacon that is not consistent with a system-critical loss as defined in AAR M-024, latest version. This exception is cleared as defined in M-024, latest version.

Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
UNIQUE ID (first device reporting critical loss)	6	0 to 0xFFFFFFFFFFFF		A, B, C

Notes:
A. This is the Unique ID of the first device that caused the sending device to be in a "critical loss" state. It could be the ID of the sending device if the sending device had sensed a "critical loss" before receiving a critical loss message from another device.
B. If the sending device is in a "critical loss" state as a result of having received a critical loss relay message, then these fields shall be the same as in the critical loss relay message received.
C. The EOT function uses a fixed Unique ID (see paragraph 2.2.3).

2.17 PSC Enable Fault

Version: 0x00
Description: This message is transmitted by a PSC after it receives an ENABLE as Primary or Secondary command and is not able to activate as defined in M-024, paragraph 4.3.3.2.3, "Disable Train Line Power." It also shall send this exception when it detects voltage outside the range of 22.8 to 30 VDC on its output within 5 s after it receives an ENABLE Low Voltage command. This fault is cleared upon transition into or out of Initialization mode and upon the receipt of a Reset PSC Exceptions command.

Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
MOST RECENT POWER SUPPLY COMMAND	1	Bits 0–1:	0 = DISABLE Output 1 = ENABLE Output as Primary 2 = ENABLE Output as Secondary 3 = ENABLE Low Voltage Output		
		Bit 2:	1 = Reset PSC Exceptions		
		Bits 3–7:	Not used (set to 0)		
TRAINLINE VOLTAGE	1	0 to 250 VDC	(LSB = 1 VDC)		

2.18 Handbrake Applied

Version: 0x00
Description: This message is transmitted by a CCD on a car that is equipped with handbrake-sensing capability that detects that its handbrake is in the applied state upon receiving an HEU beacon where the TBC transitions to 0%.
Supporting Data: None

2.19 Stuck Brake

Version: 0x00
Description: This message is transmitted by a CCD when it cannot vent the brake cylinder to below 5 psig as required.

Supporting Data:

Field Name	Size	Value/Range (Resolution)		Default	Notes
ACTUAL BCP	1	0 to 250 psi	(LSB = 1 psi)		
TARGET BCP	1	0 to 250 psi	(LSB = 1 psi)		
RESERVOIR PRESSURE	1	0 to 250 psi	(LSB = 1 psi)		
BPP SETPOINT	1	0 to 250 psi	(LSB = 1 psi)		
INCORRECT BCP REASON CODE	1	Bits 0–3:	0 = Unknown 1 = Low Reservoir Charge 2 = Cylinder Leaking 3 = Pressure Transducer Failure 4 = Cylinder & Reservoir Connected 5 = Cylinder Not Venting 6 = Other CCD BCP Control Fault 7 = BP Connected to Cylinder 8–15 = Not used	0	A
		Bits 4–7:	Not used (set to 0)		

Note:
A. Bits 0–3 may be implemented at manufacturer's discretion.

3. All manufacturer WDP system exceptions

This section provides a description and definition of supporting data fields for each WDP exception message listed in **Table 4**, "Exception Codes."

3.1 Distributed Power Subsystem Data Invalid

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it has lost communication with the distributed power system. It indicates that parameters usually reported from this system are not known. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.2 Air Brake Subsystem Data Invalid

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it has lost communication with the air brake system; it indicates that parameters usually reported from this system are not known. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.3 Propulsion Subsystem Data Invalid

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it has lost communication with the propulsion system; it indicates that parameters usually reported from this system are not known. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.4 Propulsion Mode Command Miscompare

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the WDP system is not able to transition into the command contained in the WDP beacon. This exception is reported cleared only via the WDP Remote Status response.

Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
ACTUAL PROPULSION MODE	1	0 = Throttle Mode 1 = Dynamic Brake Mode 2 = Engine Stop 3 = Slow Speed 4 = Invalid Mode		
ACTUAL THROTTLE/DYNAMIC BRAKE EFFORT/SLOW SPEED TARGET	1	0–100% (LSB = 0.5%) or 0–12.70 mph (LSB = 0.05 mph)		

3.5 Direction Miscompare

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the propulsion system has not been able to transition into the command contained in the WDP beacon. This exception is reported cleared only via the WDP Remote Status response.

Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
ACTUAL DIRECTION	1	0 = Neutral (Centered) 1 = Forward 2 = Reverse 3 = Invalid		

3.6 Throttle Step Miscompare

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the propulsion system has not been able to transition into the command contained in the WDP beacon. This exception is reported cleared only via the WDP Remote Status response.

Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
ACTUAL THROTTLE STEP	1	0–100% (LSB = 0.5%)		

3.7 Dynamic Brake Step Miscompare

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the propulsion system has not been able to transition into the command contained in the WDP beacon. This exception is reported cleared only via the WDP Remote Status response.

Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
ACTUAL DYNAMIC STEP	1	0–100% (LSB = 0.5%)		

3.8 BV Miscompare

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the air brake system has not been able to transition into the command contained in the WDP beacon. This exception is reported cleared only via the WDP Remote Status response.

Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
ACTUAL BV IN/OUT STATUS	1	0 = BV In 1 = BV Out		

3.9 High BC Pressure Detected

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the air brake system has not been able to fully release the brakes as directed in the WDP Beacon and that the brakes may be dragging. This exception is reported cleared only via the WDP Remote Status response.

Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
ACTUAL BC	1	0 to 254 (LSB = 1 psi)		

3.10 Critical Distributed Power Subsystem Failure

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the distributed power system has failed. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.11 Critical Air Brake Subsystem Failure

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the air brake system has failed. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.12 Critical Propulsion Subsystem Failure

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that the throttle system has failed. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.13 Wheel Slip (not used by APTA)

Version: 0x00
Description: This message is transmitted by a controlled LCM when it detects that it is in a wheel slip condition in accordance with AAR S-4250. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.14 Dynamic Brake Warning (not used by APTA)

Version: 0x00
Description: This message is transmitted by a controlled LCM when it detects that it is in a dynamic brake warning condition in accordance with AAR S-4250. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.15 Ground Relay Fault (not used by APTA)

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that a ground relay fault condition exists in accordance with AAR S-4250. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.16 Unit Alarm Bell (not used by APTA)

Version: 0x00
Description: This message is transmitted by a controlled LCM when it detects that it has a local alarm bell condition in accordance with AAR S-4250. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data: None

3.17 Low MR (not used by APTA)

Version: 0x00
Description: This message is transmitted by a controlled or monitored LCM when it detects that it has a low main reservoir condition in accordance with AAR S-4250. This exception is reported cleared only via the WDP Remote Status response.
Supporting Data:

Field Name	Size	Value/Range (Resolution)	Default	Notes
ACTUAL MAIN RESERVOIR	1	0 to 254 (LSB = 1 psi)		

4. Manufacturer-specific exceptions

All manufacturer-specific exceptions shall include the manufacturer ID defined in paragraph 1.1.4.1 as the first data field in supporting data. Additional supporting data shall be manufacturer specific and have a length

of 0 to 9 bytes. Each manufacturer-specific exception message shall support the Exception Update message as described in paragraph 2.7.5 with a meaningful text description of the exception.

Appendix B: Example train makeup messaging

1.	HEU Lead		Device Info Control/Query (UNLOCK ALL)	→	All devices
2.	HEU Lead		Device Info Control/Query (ALL HEU-Send ID)	→	All devices
3.	HEU Lead	←	Device Info (HEU)		HEU 1
4.	HEU Lead	←	Device Info (HEU)		HEU N-1
5.	HEU Lead	←	Device Info (HEU)		HEU N
6.	HEU Lead		Assign Node ID* (LOCK & ID)	→	HEU 1
7.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	HEU N-1
8.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	HEU N
9.	HEU Lead		Device Info Control/Query(ALL PSC-Send ID)	→	All devices
10.	HEU Lead	←	Device Info (PSC)		PSC 1
11.	HEU Lead	←	Device Info (PSC)		PSC N-1
12.	HEU Lead	←	Device Info (PSC)		PSC N
13.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	PSC 1
14.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	PSC N-1
15.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	PSC N
16.	HEU Lead		PSC Dynamic Configuration (On or On 8 sec/Off)	→	PSC X
17.	HEU Lead		Device Info Control/Query (ALL DEVICES)	→	All nodes
18.	HEU Lead	←	Device Info (EOT)		EOT
19.	HEU Lead	←	Device Info (CCD)		CCD 1
20.	HEU Lead	←	Device Info (CCD)		CCD N-1
21.	HEU Lead	←	Device Info (CCD)		CCD N
22.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	EOT
23.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	CCD 1
24.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	CCD N-1
25.	HEU Lead		Assign Node ID$^{a/}$ (LOCK & ID)	→	CCD N

The HEU Lead then repeats the process by sending the Device Info Control/Query (ALL DEVICES) command (step 17) until no devices answer (all are locked and assigned).

* The Assign Node ID step uses the same ID already in the device being assigned as long as it is unique in the train.

Appendix C: Train sequencing messaging

1. Train sequencing message transfer

Preparation phase

1. HEU Lead   Train Sequencing Command (Prepare for Sequencing)   →   All devices
2. HEU Lead   HEU Beacon (T/L Power OFF)   →   All devices

The HEU Lead verifies that trainline voltage is shut down before proceeding to step 3.

3. HEU Lead   PSC Dynamic Config (Enable Low Voltage Output)   →   Any PSC

The HEU Lead verifies that low trainline voltage is present before proceeding to step 4 if a PSC other than the Lead PSC is selected in step 3. Otherwise proceed to step 8.

Lead sense phase

4. HEU Lead   Train Sequencing Command (Enable Lead Sense)   →   All devices
5. HEU Lead   Vehicle Sequence Command (Connect Load)   →   Lead PSC (Note A)
6. HEU Lead   ←   Vehicle Sequence Status (Load Applied)   Lead PSC (Note A)

Lead Locomotive connects its load across the trainline and then disconnects.

7. HEU Lead   ←   Vehicle Sequence Status (Load Removed)   →   Lead PSC (Note A)

Steps 5, 6 and 7 may be repeated twice to reduce error probability.

Sequencing phase

8. HEU Lead   Train Sequencing Command (Reset/Start Pulse Count)   →   All devices
9. HEU Lead   Vehicle Sequence Command (Connect Load)   →   Vehicle(n)
10. HEU Lead   ←   Vehicle Sequence Status (Load Applied)   Vehicle(n)

Vehicle(n) connects its load across the trainline and then disconnects.

11. HEU Lead   ←   Vehicle Sequence Status (Load Removed)   →   Vehicle(n)

Steps 9, 10 and 11 repeat for each vehicle where n=1, #vehicles in train.

12. HEU Lead   Train Sequencing Command (Hold/Stop Pulse Count)   →   All devices

Data collection phase

13. HEU Lead   Vehicle Sequence Info Query (Update Position)   →   Vehicle(n)
14. HEU Lead   ←   Vehicle Sequence Info   →   Vehicle(n)

Steps 13 and 14 repeat for each vehicle where n=1, #vehicles in train.

Evaluate data and display train sequence

Sequencing complete; command end of sequencing and activate normal trainline power control.

15. HEU Lead   Train Sequencing Command (End Sequencing)   →   All devices
16. HEU Lead   PSC Dynamic Config (Disable)   →   Enabled PSC
17. HEU Lead   HEU Beacon (T/L Power ON)   →   All devices
18. HEU Lead   PSC Dynamic Config (Enable as Primary)   →   Any PSC

Note:
A. These messages are not required if the Lead HEU controls the sequencing hardware on the lead locomotive.

Appendix D: Device compatibility

TABLE 5
ECP Device Compatibility Version

ECP Device	M-024 Compatibility Version		Reasons for Current Compatibility Version
	Mandatory	**Current**	
HEU	2	2	Initial version
CCD	2	2	Initial version
PSC	2	2	Initial version
EOT	2	2	Initial version