TRAIN TELEMETRY GROUP -
ANALYSIS REPORT

Rear-End Collision between
Eastbound UP Freight Train MGRCY 04 and
Eastbound UP Freight Train MPCNP 03 near
Granite Canyon, Wyoming on
October 4, 2018

RRD 19 FR 001

(8 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF RAILROAD, PIPELINE & HAZ-MAT INVESTIGATIONS
WASHINGTON, D.C. 20594

TRAIN TELEMETRY GROUP-
FACTUAL REPORT OF INVESTIGATION

A. ACCIDENT

Type:	Rear-End Train Collision
Date and Time:	October 4, 2018 at 7:40 p.m. MDT
Location:	Granite Canyon, Wyoming
Carrier:	Union Pacific Railroad
Train #1:	Eastbound Freight Train MGRCY 04
Train #2:	Eastbound Freight Train MPCNP 03
Fatalities:	2
Injuries:	0

B. TRAIN TELEMETRY - INVESTIGATIVE GROUP

R. Payan
Electrical Engineer
NTSB
Office of Railroad, Pipeline, and
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K.D. Johnson
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C. ACCIDENT SUMMARY

For a summary of the accident, refer to the Accident Summary in the docket for this investigation.

D. DETAILS OF THE INVESTIGATION

1. Head-of-Train Device (HTD)

1.1 Description of HTD on Locomotive UP 5412

Locomotive UP 5412 was equipped with a Wabtec, LCU-08 HTD (serial number 0380306). The device was manufactured on May 9, 2004 and assembled with a Wabtec RE382 radio configured to operate in half duplex mode. The HTD was designed to operate at AAR assigned UHF frequencies. The device was transmitting at 452.9375 MHz and

receiving at 457.9375 MHz. Software version 6.1 was installed and the device required a nominal operating voltage of 15 volts (DC) for 8-watt transmissions.

Wabtec sold the HTD to GE Locomotives on May 27, 2004. The HTD was installed on a BNSF locomotive. In October 2011, BNSF contracted DPS Electronics to have radios from a Wabtec locomotive HTD's retrofitted with Ritron DTX-454 radios. The Ritron radio was a narrow-band radio that complied with the AAR wireless communication committee 40-71 specifications. BNSF transferred the HTD to the UP Railroad and installed on locomotive UP 5412.

1.2 Postaccident HTD Testing

The HTD was taken to Wabtec facilities for further examination and bench testing. A visual examination determined the LSI/Serial connector on the front panel was severely bent. Internal components did not indicate any damage.

Functional testing determined the device was operating within manufacturer specification and with no malfunctions noted (see Wabtec 10/17/2018 test report in docket). Operational testing determined the behavior of the device during an emergency radio transmission as follows:

- Retry every second when HTD does not receive emergency command acknowledgment from ETD, (unsolicited pressure updates from ETD do not count as emergency command acknowledgements)
- Retry every 4 seconds when HTD receives emergency acknowledgement but ETD brakepipe pressure does not drop below 5psi
- During normal operation, an emergency command is received from the locomotive computer and transmitted to the HTD. The HTD then it sends the command to the ETD. During bench testing the "front-to-rear, no communication" was received in the prescribed 15 second time frame
- From the initial signal from the locomotive computer, the signal will be transmitted for two minutes to then it will stop sending the signal until another command for emergency is received. If an engineer initiates another emergency during the two-minute time frame, the two-minute window is not extended. After the two-minute window the HTD will not send a signal unless directed again by the locomotive computer. A locomotive engineer would have to initiate another emergency application attempt to initiate an ETD emergency command.

2. End-of-Train Device (ETD)

2.1 Description of ETD on UP Train MGRCY-04

Train MGRCY-04 was equipped with a two-way Wabtec, Trainlink ETD (ID number 65471). The ETD was designed to operate at AAR assigned UHF frequencies. The device was designed to transmit at 457.9375 MHz and receive at 452.9375 MHz.

Enabled two-way ETDs provide a safety advantage over one-way ETDs because the two-way feature allows train crews to use radio telemetry to initiate an emergency brake application from the rear of the train. Emergency braking, employing the train brakes, moves from the locomotive through the train and is enhanced with an ETD because similar braking can be concurrently activated from the rear of the train. The rapid reduction of

brakepipe air pressure from the two opposite ends of a train should cause the brakes on all cars to engage up to and including any point where a restriction in the train brakepipe might be located.

2.2 Postaccident ETD Testing

Following the accident, the two-way ETD on UP Train MGRCY-04 was to the UP Telecom Service Center in Council Bluffs, Iowa. The device was examined and tested by FRA, UP and NTSB investigators. A physical examination of the device did not identify any items that prevented the device from operating properly.

The ETD was powered up and operational testing of motion, turbine voltage, battery voltage, GPS and air pressure was completed with no malfunctions identified. The ETD enclosure was opened and further testing of the battery voltage, radio specifications and physical components was completed. The radio transmit/receive function were within manufacturer specifications and the battery was measured at 12.5 volts. The device was determined to be functioning with no malfunctions identified.

3. Locomotive Data Logs

Event recorder data from locomotive UP 5412 indicates that just before the collision when the train engineer of the accident train bunched the train with dynamic braking to go down a hill, the recorded air flow dropped below 20 CFM. The train started to accelerate, and the engineer tried to compensate for the increase in speed by increasing the brake application. Before the train reached the railroad's 30-mph speed limit, the engineer made an emergency brake application, but the brake pipe pressure reduction did not propagate to the rear of the train.

The HTD in the lead locomotive transmits a radio message to the ETD to initiate an emergency brake application after the train engineer activates emergency braking. According to locomotive event recorder data, the ETD did not initiate an emergency application of the brakes from the rear of the train. The event recorder data indicates a Front-to-Rear, No Comm at 7:35:11 pm (see Locomotive Event Recorder Factual Report).

The locomotive computer log was downloaded from the UP 5412. The locomotive computer data logs captured additional HDT/EDT loss of communication events. See Table 1 for a summary.

Table 1 Locomotive UP 5412 computer log

Occur Time(GMT)	Reset Date	Fault Code	Incident Description	GPS Latitude	GPS Longitude	Speed
10/05/18 01:35:11		32-0005	ETD Front to Rear Comm Loss	41:5:59.2	-105:12:1.1	29.9
10/05/18 01:34:55	10/05/18 01:35:11	32-0009	ETD Emergency Commanded	41:5:56.6	-105:12:9.3	28.89
10/05/18 00:51:33	10/05/18 00:51:34	32-0006	ETD Front to Rear Comm Loss Restored	41:4:53.0	-105:25:39.0	25.6
10/05/18 00:47:48	10/05/18 00:51:32	32-0005	ETD Front to Rear Comm Loss			
10/05/18 00:25:19	10/05/18 00:25:20	32-0006	ETD Front to Rear Comm Loss Restored	41:6:51.2	-105:29:46.9	5.86

10/05/18 00:24:51	10/05/18 00:25:18	32-0005	ETD Front to Rear Comm Loss	41:6:53.6	-105:29:47.0	5.83
10/04/18 23:43:58	10/04/18 23:43:59	32-0006	ETD Front to Rear Comm Loss Restored	41:10:0.2	-105:32:39.4	12.83
10/04/18 23:38:52	10/04/18 23:43:57	32-0005	ETD Front to Rear Comm Loss	41:10:52.7	-105:32:54.9	12.86
10/04/18 22:56:21	10/04/18 22:56:22	32-0006	ETD Front to Rear Comm Loss Restored	41:18:31.5	-105:35:48.8	0.43
10/04/18 22:53:17	10/04/18 22:56:20	32-0005	ETD Front to Rear Comm Loss	41:18:31.5	-105:35:48.8	0
10/04/18 21:18:21	10/04/18 22:08:14	32-0010	ETD Emergency Confirmed			
10/04/18 21:18:19	10/04/18 21:18:21	32-0009	ETD Emergency Commanded	41:18:23.4	-105:35:51.1	0
10/04/18 19:56:05	10/04/18 19:56:06	32-0006	ETD Front to Rear Comm Loss Restored	41:27:58.7	-105:37:51.1	29.64
10/04/18 19:53:00	10/04/18 19:56:04	32-0005	ETD Front to Rear Comm Loss	41:29:13.0	-105:38:35.6	31.79
10/04/18 11:34:42	10/04/18 11:34:44	32-0006	ETD Front to Rear Comm Loss Restored	41:41:40.9	-107:49:36.7	21.28
10/04/18 11:33:14	10/04/18 11:34:42	32-0005	ETD Front to Rear Comm Loss	41:41:53.2	-107:50:9.9	22.57
10/04/18 10:52:44	10/04/18 10:52:45	32-0006	ETD Front to Rear Comm Loss Restored	41:37:27.2	-108:19:46.7	36.2
10/04/18 10:52:18	10/04/18 10:52:44	32-0005	ETD Front to Rear Comm Loss	41:37:23.2	-108:20:4.2	36.94

4. Federal Regulations

4.1 Federal Communications Commission (FCC)

The FCC published new rules to more efficiently use certain crowded frequency spectrums and required a change to the separation between radio transmission frequencies. Radios operating at frequencies below 512 MHz had to begin moving from the default 25 KHz bandwidth to a 12.5 KHz bandwidth within 10 years and then finally to a 6.25 KHz bandwidth within 18 years. The reduced transmission frequency separation is referred to as narrow-band frequencies.

The FCC issued several stays to the migration rules. In December 2004, the FCC issued a 3rd Memorandum Opinion and Order which set a deadline of January 1, 2013 for radios operating at frequencies below 512 MHz to be converted to the 12.5 KHz bandwidth.

4.2 Federal Railroad Administration (FRA)

Minimum safety standards regarding ETDs can be found in Title 49 Code of Federal Regulations, Part 232 "Brake System Safety Standards For Freight And Other Non-Passenger Trains And Equipment; End-Of-Train Devices."

> §232.405, Design and performance standards for two-way end-of-train devices
> (3)(a) An emergency brake application command from the front unit of the device shall activate the emergency air valve at the rear of the train within one second.

(g) The availability of the front-to-rear communications link shall be checked automatically at least every 10 minutes.

§232.407, Operations requiring use of two-way end-of-train devices; prohibition on purchase of nonconforming devices
(g) …With regard to two-way end-of-train devices, a loss of communication between the front and rear units is an en route failure only if the loss of communication is for a period greater than 16 minutes and 30 seconds. Based on the existing design of the devices, the display to an engineer of a message that there is a communication failure indicates that communication has been lost for 16 minutes and 30 seconds or more.

5. AAR Industry Standards

The AAR Manual of Standards and Recommended Practices, Locomotive Electronics and Train Consist System Architecture, Standard S-9152.v2.2[1], contains the requirements for communication systems between the lead locomotive and the rear car of freight trains.

Paragraph 2.1 Basic System Rear Unit (End-of-Train Device)
The rear unit shall determine the status of brake pipe pressure value and transmit this information to the cab unit for display to the locomotive engineer. The rear unit shall be designed for continuous duty service on the rear of trains. The design of the rear unit shall consider the nature and consequences of possible system failure modes in such a way that a fault tolerant design results.

Paragraph 2.1.7 Rear Unit Identification Provisions
2.1.7.1 Each rear unit will be assigned a unique identification code that will be transmitted along with the pressure threshold message to the cab unit. This code ensures that only data transmitted from the assigned rear unit will be accepted by the cab unit. In this way, rear unit messages from adjacent trains will be rejected by the cab unit. In order to maintain the interchangeability between rear units and cab units, the identification code must be reported and selected at the cab unit prior to the start of any train trip.

Paragraph 2.2 Basic System Cab Unit (Head-of-Train Device)
The cab unit shall receive data messages from the rear unit and display information to the locomotive engineer. The receiver and cab display unit located in the locomotive cab shall be designed for continuous duty service. The design of the cab unit shall consider the nature and consequences of possible system failure modes so that a fault-tolerant design results.

Paragraph 3.2 Brake Application
The front-to-rear transmission and rear-of-train equipment shall provide for application of train emergency air brakes, upon emergency train brake application by the locomotive engineer.

[1] Last revised 2016

The front-to-rear transmission and rear-of-train equipment shall provide for application of train emergency air brakes upon manual selection by the locomotive engineer.

3.2.1 An emergency brake application command from the front unit must activate the emergency air valve typically within 1 second.

3.2.2 The rear unit shall send an acknowledgment message to the front unit immediately upon receipt of a brake application command. The front unit shall listen for this acknowledgment and repeat the brake application command if the acknowledgment is not correctly received.

3.2.3 The rear unit, on receipt of a properly coded command, will open a valve in the brake line and hold it open for a minimum of 15 seconds. This opening of the valve shall cause the brake line to vent to atmosphere.

Paragraph 3.8.6 Rear-to-Front Communications Failure
3.8.6.1 The cab unit shall declare a rear-to-front communications failure on rear-to-front radio link failures lasting for a duration of 5 minutes or greater. Rear-to-front radio link failures lasting less than 5 minutes shall not be declared as rear-to-front failures. This alarm shall be cleared on receipt of a valid EOT message on the selected ID.

Exception: Rear-to-Front Communications Failure shall not be declared when ID is set to 00000.

3.8.6.2 Display or indication of front-to-rear communication failure shall take precedence over rear-to-front communication failure.

Paragraph 3.8.7 Front-to-Rear Communications Failure
3.8.7.1 The cab unit shall declare a front-to-rear communications failure on front-to-rear radio link failures lasting for a duration of 16 minutes 30 seconds or greater. Front-to-rear radio link failures lasting less than 16 minutes 30 seconds shall not be declared as front-to-rear failures. This alarm will be cleared by the next successful front-to-rear/rear-to-front confirmation cycle (automatically or manually initiated). Minimum polling of at least once every 2 minutes must be maintained or as often as necessary to minimize loss of front-to-rear communications exceeding the 16 minute 30 second limit.

Exception: Front-to-Rear Communications Failure shall not be declared when ID is set to 00000.

3.8.7.2 This warning will be reset by the next successful front-to-rear/rear-to-front confirmation cycle (automatically or manually initiated).

3.8.7.3 A front-to-rear communication failure shall also be tested and declared during an

attempted emergency activation paragraph 3.8.1).

Paragraph 3.8.8 Front-to-Rear Message Retries
The cab unit will handle data message retries as follows:

3.8.8.1 For emergency brake application commands, the retries will continue until a status update indicates that the rear unit has received the command by setting the confirmation bit in the update. Thereafter, if the rear brake pipe pressure has not been reduced to a level below 5 psi within 4 seconds, another retry will be made and again the confirmation bit looked for. This process will repeat up to a maximum time of 2 minutes after the last emergency switch activation. If a confirmation bit has not been received within 15 seconds of the initial or a 4-second retry emergency command, front-to-rear communication failure will be declared.

TRAIN TELEMETRY GROUP
END OF FACTUAL REPORT