NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

April 9, 2018

Locomotive Event Recorders

Specialist's Factual Report
By Sean Payne

1. EVENT SUMMARY

Location:	Cayce, South Carolina
Date:	February 4, 2018
Company:	Amtrak/ CSX Transportation
Train ID/Locomotive:	Amtrak Train 91/Locomotive 47/Lead[1]
Train ID/Locomotive:	CSXT Train F777 03/Locomotive 130/Lead[2]
Train ID/Locomotive:	CSXT Train F777 03/Locomotive 36/2nd behind lead Locomotive[3]
NTSB Number:	RRD18MR003
Summary:	Refer to the Accident Summary report, within this docket.

2. LOCOMOTIVE EVENT RECORDER GROUP

A locomotive event recorder group was not convened.

3. DETAILS OF RECORDER INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division downloaded the following locomotive event recorders on-scene:

Device:	**Wabtec Pulse PCM04**
Serial Number:	**0163411**
Locomotive ID:	**Amtrak 47**
Device:	**Wabtec Pulse PCM04**
Serial Number:	**0133999**
Locomotive ID:	**CSXT 130**
Device:	**Wabtec Pulse PCM04**
Serial Number:	**0218532**
Locomotive ID:	**CSXT 36**

3.1. Locomotive Event Recorders Condition

The recorders for Amtrak 47 and CSXT 36 were in good condition. The recorder for CSXT 130 was damaged from impact. Figure 1 shows the recorder from Amtrak 47, figure 2 shows the

[1] Locomotive 47 will be referred as Amtrak 47.
[2] Locomotive 130 will be referred as CSXT 130.
[3] Locomotive 36 will be referred as CSXT 36.

recorder from CSXT 36, and figure 3 shows the recorder from CSXT 130. Note in figure 3 the damage to CSXT 36's cannon style plug receptacle.

Figure 1. The event recorder from Amtrak 47.

Figure 2. The event recorder from CSXT 36.

Figure 3. The event recorder from CSXT 130.

The data from Amtrak 47 were extracted normally using the Wabtec Railway Electronics Event Recorder Data Analysis Software and Amtrak equipment at an Amtrak facility in Raleigh, North Carolina on February 5th, 2018.

The data from CSXT 36 were extracted normally using the Wabtec Railway Electronics Event Recorder Data Analysis Software and CSX equipment on-scene by a CSX employee on February 4th, 2018. Later, the recorder was re-downloaded and the initial data verified by an NTSB specialist at an Amtrak facility, using Amtrak equipment in Raleigh, North Carolina on February 5th, 2018.

The recorder from CSXT 130 was extracted from the destroyed locomotive. The recorder was found bolted in it's normal mounting position (aft of the engineer's station), however, most of the cab area and other electronics around the recorder were destroyed. The recorder's canon plug was broken, but individual electrical pins associated with the canon plug remained. Individual pins were able to be inserted into the manufacturer's download cable for the device. The data from CSXT 130 were extracted normally using the Wabtec Railway Electronics Event Recorder Data Analysis Software on February 5th, 2018.

3.2. Locomotive Event Recorder Recording Description

Amtrak Locomotive

Using the wheel sizes of 39.25 inches for Amtrak 47, event recorder data were extracted using the Wabtec Railway Electronics Event Recorder Data Analysis Software. This software outputted the locomotive event recorder parameters including distance and speed. The exported data have a sampling rate of one second; therefore, both sets of data have an accuracy of +/- 1 second. Only the data relevant to this event are provided in this report.

CSX Locomotives

Using the wheel sizes of 39.628 inches for CSXT 130 and 37.875 inches CSXT 36 as provided by investigators, both locomotive event recorder data were extracted using the Wabtec Railway Electronics Event Recorder Data Analysis Software. This software outputted the locomotive event recorder parameters including distance and speed. The exported data have a sampling rate of one second; therefore, both sets of data have an accuracy of +/- 1 second. Only the data relevant to this event are provided in this report.

3.3. Parameters

Table A-1 lists the parameters verified and provided in this report for Amtrak 47. Table A-2 lists the parameters verified and provided in this report for both CSXT 130 and CSXT 36. Additionally, table A-3 contains the unit and discrete state abbreviations for all parameters.

3.3.1. Distance Traveled

The default output for the distance traveled is the distance decreasing in time. Therefore, the distance traveled began with a very large value and continually decreased to 0 feet.

3.3.2. Milepost

Milepost was derived by the Wabtec Railway Electronics Event Recorder Data Analysis Software by using the following information for each locomotive: a known milepost location (entered into the software), selecting if the milepost was either ascending or descending depending on the train's direction of travel,[4] the movement of the locomotive (either moving forward or reverse), and miles traveled.

The known milepost location used for Amtrak 47 was 350.6 when Amtrak 47 was stopped at the Columbia Station, Columbia, South Carolina and was increasing. The known milepost location used for CSXT 130 and CSXT 36 was the accident location 367.12 and was decreasing.

3.4. Time Correlation

The recorded time from all locomotive event recorder data and the on-board forward facing image recorders[5] are independently time stamped and, consequently, the times may not reflect the actual time of day.

The event recorder data from Amtrak 47 was compared to Amtrak's Train Communications Data (TCD) which contains both GPS location and GPS time stamp information. Amtrak TCD data showed Amtrak 47 leaving Columbia station at 2:03:42 A.M. Eastern Standard Time (EST). To align Amtrak 47's event recorder to this time, three seconds were added.

Amtrak 47 Event Recorder + 3 seconds = EST

Amtrak 47's event recorder indicated a loss of data at 02:27:27 A.M. EST. The milepost information at this time was compared to the accident site and found to match. It was determined that 02:27:27 A.M. EST was the impact time.

The event recorder from CSXT locomotive 36 was then compared to the accident time. To align CSXT 36's event recorder to the accident time, one second was added.

CSXT 36 Event Recorder + 1 second = EST

The event recorder from CSXT 130 stopped recording information prematurely.[6] Using train movements common to the CSX train prior to the accident, CSXT 130's event recorder was aligned to CSXT 36's event recorder. Two seconds were subtracted from CSXT 130's event recorder to bring it into time alignment. After review, it was determined that CSXT 130's event recorder ceased recording at 2:26:24 A.M. EST. A total of 1 minute and 3 seconds of data were lost in the device's buffer as a result of the high impact accident.

CSXT 130 Event Recorder – 2 seconds = EST

[4] For this case, trains traveling southbound have increasing milepost and trains traveling northbound have decreasing milepost. Therefore, since Amtrak 47 was traveling southbound, its milepost were increasing. And since CSX was traveling northbound, its milepost were decreasing.
[5] Refer to the National Transportation Safety Board's On Board Image Recorder Factual Report.
[6] High impact scenarios often cause premature data loss.

3.4.1. Speed Validation

A speed validation was performed for the CSX train as it consisted of two locomotives. Each set of locomotive event recorder data from CSXT 130 and CSXT 36 is independently time stamped. In order to validate the speed data, the time between the two sets of locomotive event recorders needed to be correlated. Using the given wheel sizes for both CSXT 130 and CSXT 36, the difference in speed was negligible.

3.5. Plots and Corresponding Tabular Data

Figures 4 to 8 contain locomotive event recorder data from Amtrak 47 and CSXT 36 recorded during the event on February 4, 2018. All the parameters listed in tables A-1 and A-2 were plotted except milepost. Locomotive event recorder data from CSXT 130 were not plotted since the data stopped prior to the event.

Figures 4 to 6 contain locomotive event recorder data from Amtrak 47. Figure 4 covers 30 minutes of data from 2:00:00 A.M. EST to 2:30:00 A.M. EST. Figure 5 covers 8 minutes of data from 2:20:00 A.M. EST to 2:28:00 A.M. EST. Figure 6 covers 30 seconds of data from 2:27:00 A.M. EST TO 2:27:30 A.M. EST.

Figure 7 contains locomotive event recorder data from CSXT 36 and covers 7 hours of data from 20:00 A.M. EST on February 3, 2018 to 2:30:00 A.M. EST on February 4, 2018. During this time the train made approximately 120 forward and back motions.

Figure 8 contains locomotive event recorder data from CSXT 36 and covers 1 hour of data from 1:30:00 A.M. EST to 2:30:00 A.M. EST on February 4, 2018.

Amtrak 47

In summary, Amtrak 47's event recorder data indicated the following:

- The event recorder showed the train departing Columbia Passenger Station 2:03:42 A.M.
- The train came to a stop at 2:09:17 A.M. at milepost 362.42.
- The train began movement again at 2:21:17 A.M. at milepost 362.42. Milepost began increasing toward the accident site.
- The train reached a maximum speed of 57 miles per hour (mph) around milepost 366.5.
- At 2:27:21 A.M., the train's horn transitioned from off to on. At this time, the train's speed was 56 mph.
- At 2:27:24 A.M., the throttle changed from throttle position 8 (T8) to idle.
- At 2:27:25 A.M., the train entered emergency braking via an "engineer induced emergency" through the EAB handle. The train's speed was 53 mph.
- End of data occurred at 2:27:27 A.M.. The train's speed was 50 mph as the train's air braking system was approaching maximum braking effort. The last milepost was 367.12.

CSXT 36

Approximately 7 hours of data was reviewed from 20:00 A.M. EST on February 3, 2018 to 2:30:00 A.M. EST on February 4, 2018. Around 21:00 on February 3, 2018, the train began conducting operations consistent with servicing the autorack facility in the vicinity of the accident. Data showed that between approximately 21:00 on February 3, 2018, until the accident at 2:27:27 on February 4, 2018, the locomotive made approximately 120 forward and back movements near milepost 367.[7].

At 01:30 A.M. EST, the locomotive was still performing series of moves near milepost 367. Movement continued until 1:46:27 A.M. at which time the train came to a stop after a reversing move. The train was idle for the next 41 minutes. At 2:27:27 A.M., the recorder indicated that the pneumatic control switch (PCS) opened and electronic air brake - brake pipe pressure (EAB BP) dropped quickly to 0 pounds per square inch (psi). A 2 mph and 5 mph sample were recorded within the next two seconds, though the value for milepost remained unchanged. The event recorder continued to record without any other remarkable changes.

All of the corresponding tabular data from Amtrak 47's locomotive event recorder used to create figures 4 to 6 including milepost are provided in .CSV format as attachment 1 to this factual report. Additionally, all of the corresponding tabular data from CSXT 36's locomotive event recorder used to create figure 7 including milepost are provided in .CSV format as attachment 2 to this factual report. Tabular data from CSXT 130 locomotive event recorder are provided in .CSV format as attachment 3 for all the parameters listed in table A-1 from 20:00 EST on February 3, 2018 to 02:30 EST February 4, 2018.

[7] Derived milepost for CSXT 36 may not be accurate throughout as the train was servicing a siding.

Figure 4: Amtrak 47 event recorder parameters from 2:00:00 AM EST to 2:30:00 AM EST

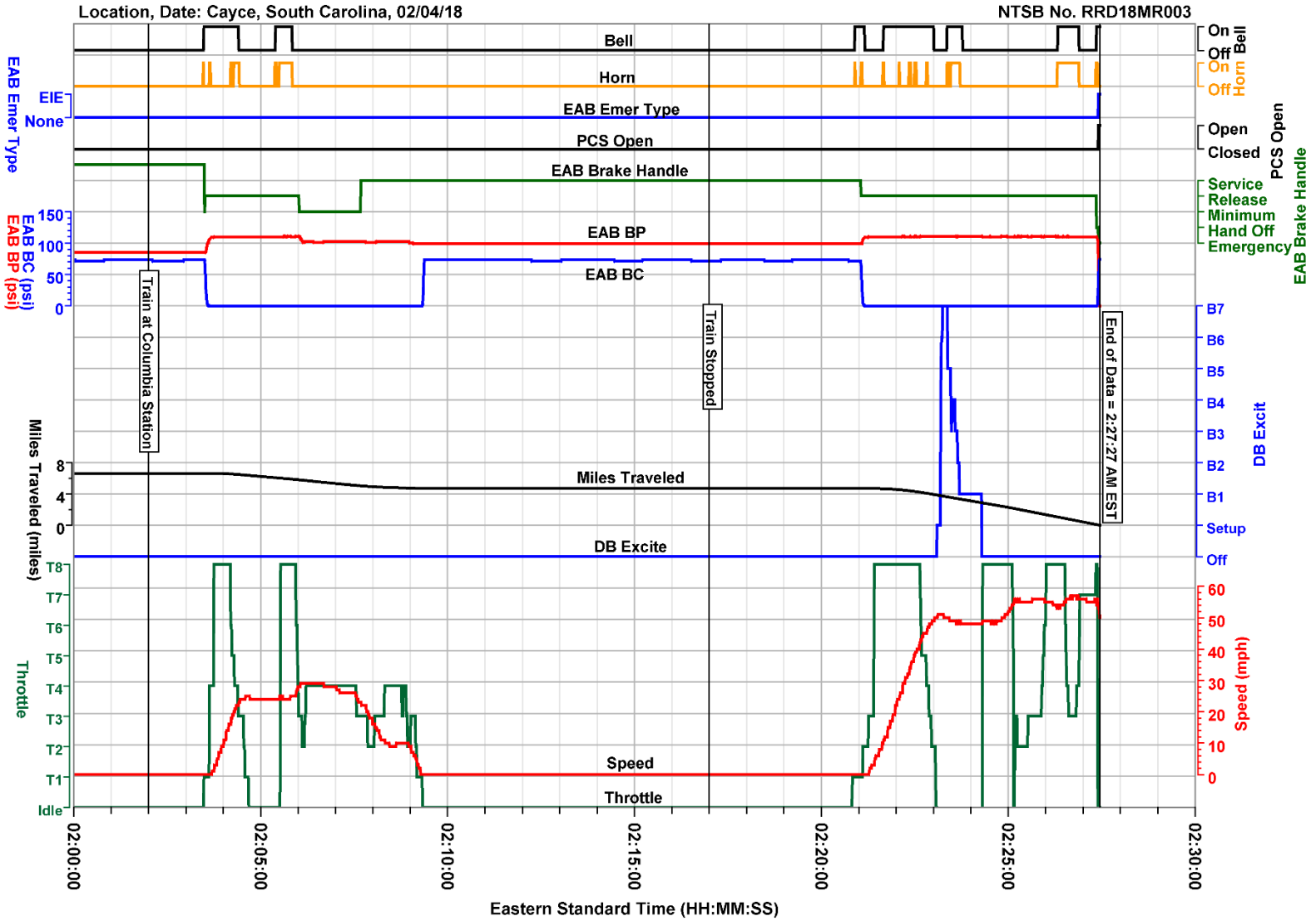


Figure 5: Amtrak 47 event recorder parameters from 02:20 AM EST to 02:28 AM EST

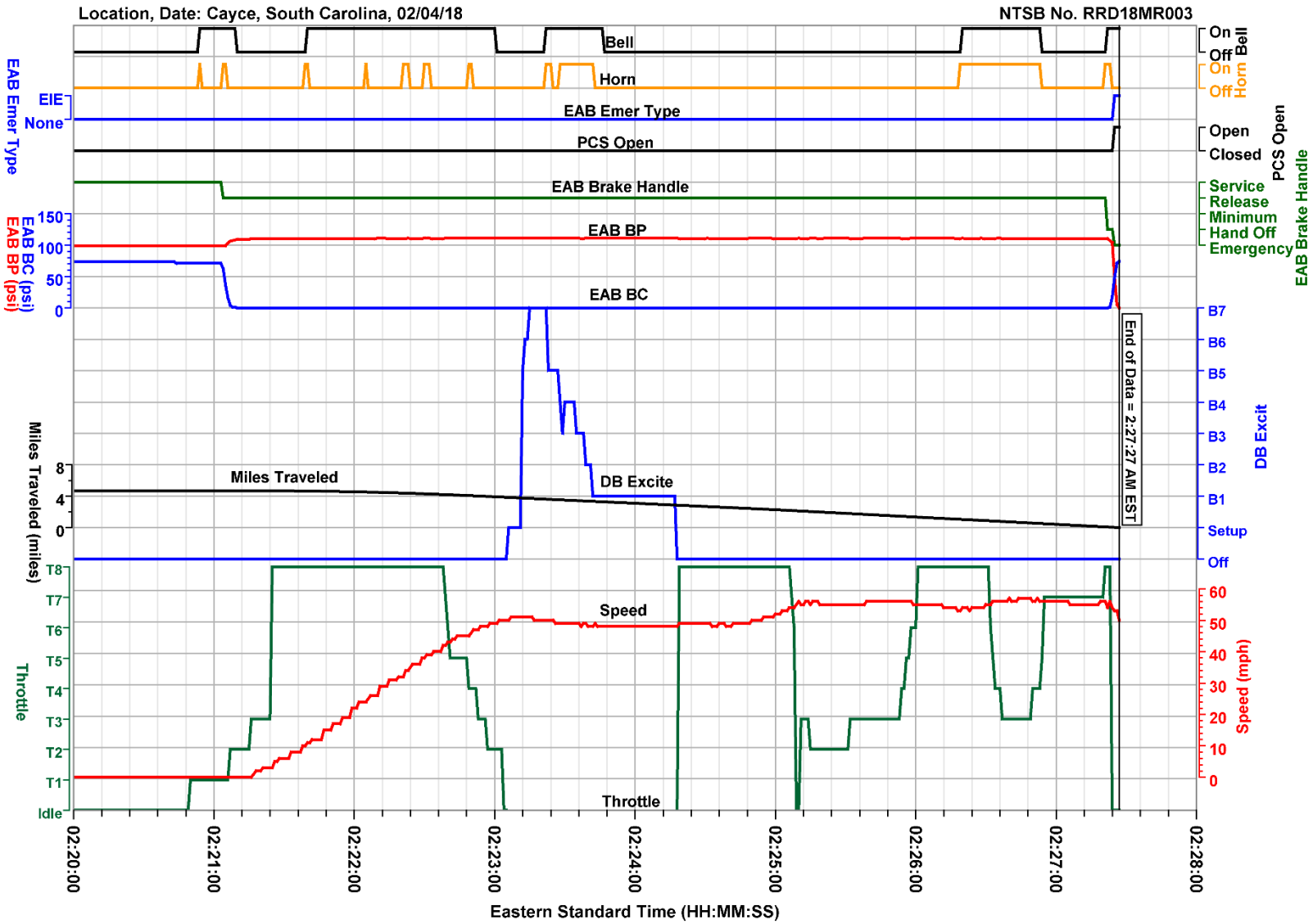


Figure 6: Amtrak 47 event recorder parameters from 02:27:00 AM EST to 02:27:30 AM EST

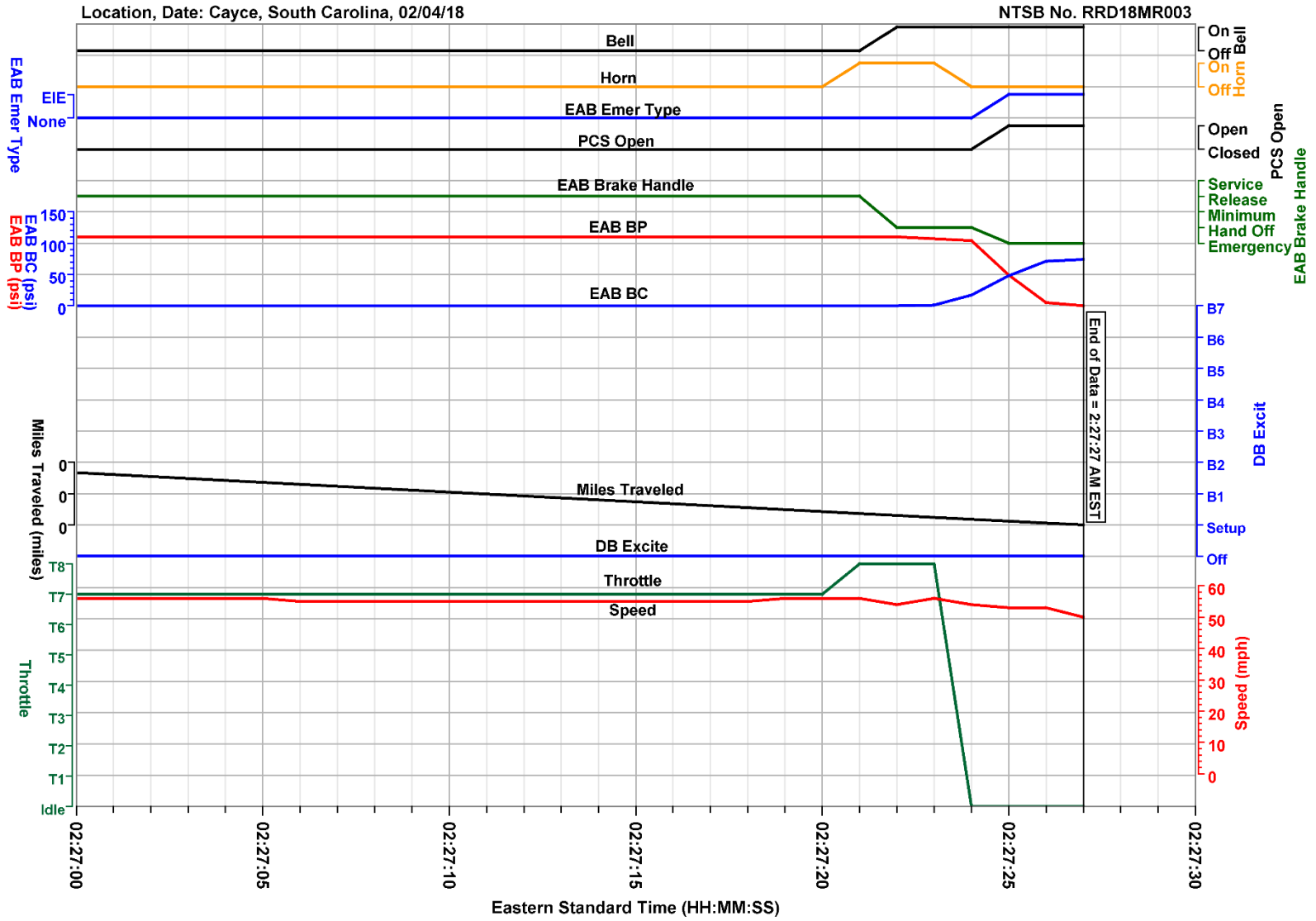


Figure 7: CSXT 36 event recorder parameters from 20:00:00 A.M. EST on February 3, 2018 to 02:30:00 A.M. EST on February 4, 2018.

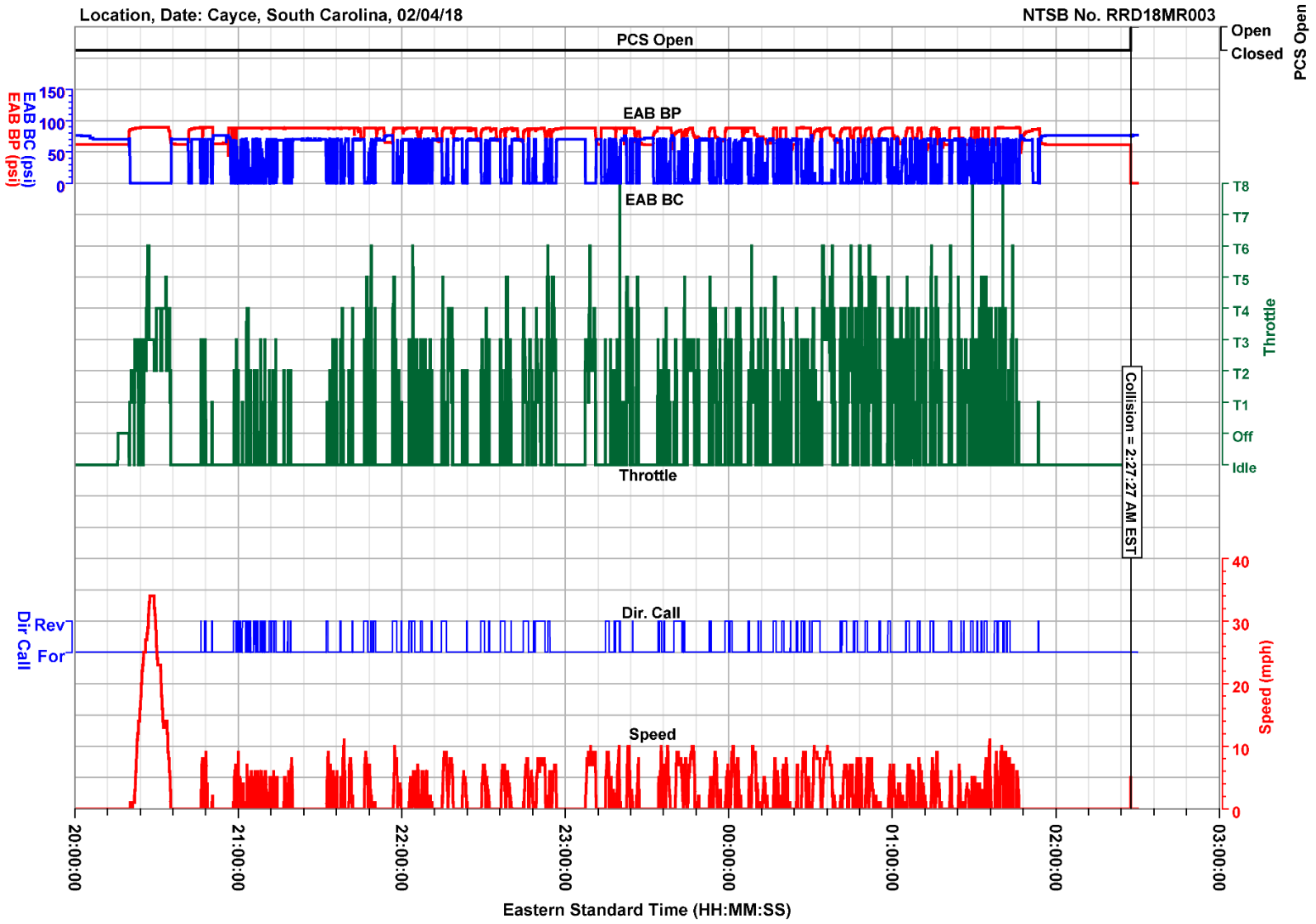
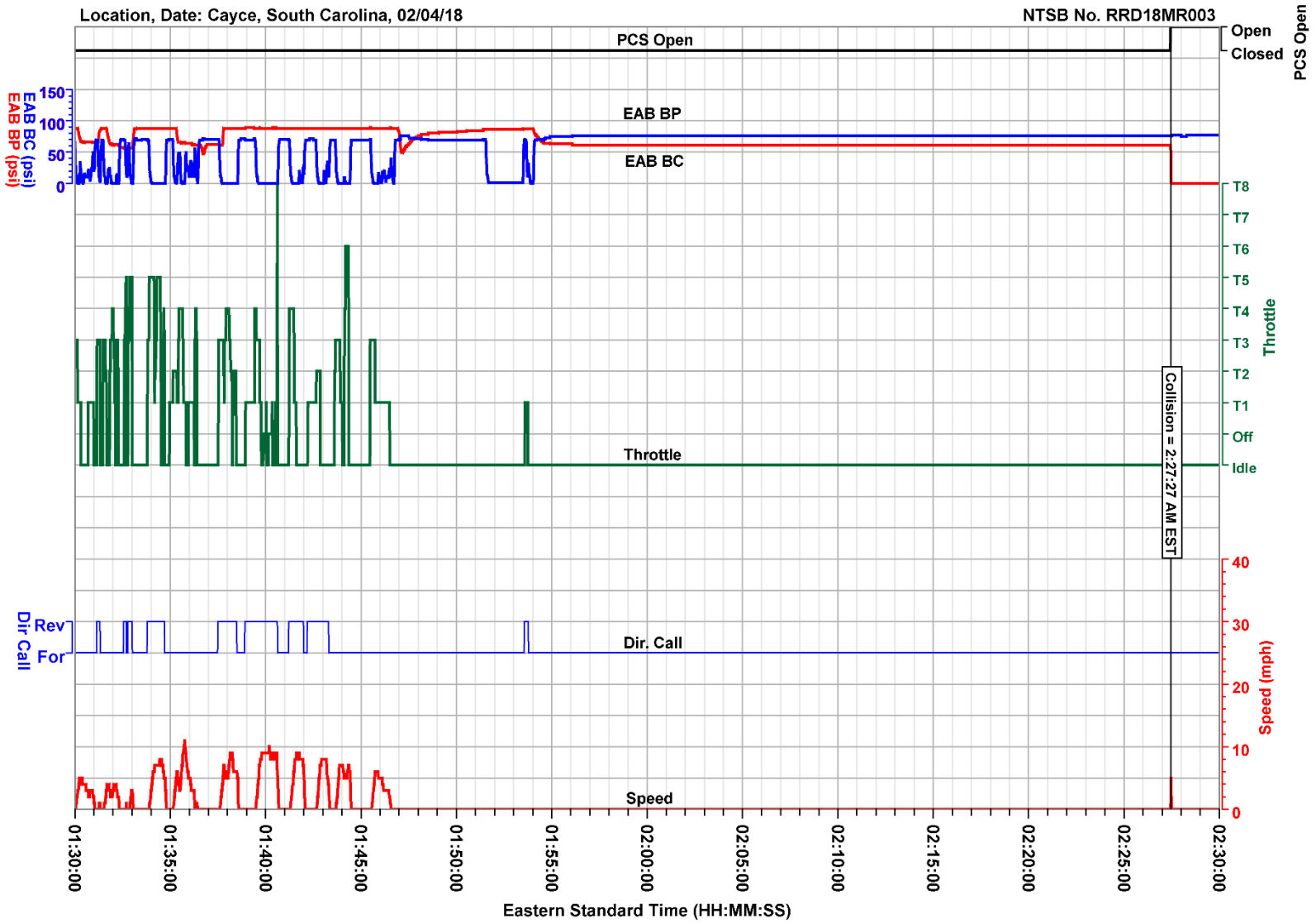


Figure 8: CSXT 36 event recorder parameters from 01:30:00 A.M. EST to 02:30:00 A.M. EST on February 4, 2018.



APPENDIX A

This appendix describes the locomotive event recorder parameters provided and verified in this report for Amtrak 47, CSXT 36 and CSXT 130. Table A-1 lists the plot labels, parameter descriptions, and units for Amtrak 47. Table A-2 lists the plot labels, parameter descriptions, and units for CSXT 130 and CSXT 36. Table A-3 contains the unit and discrete state abbreviations for the parameters.

Table A-1. Verified and provided locomotive event recorder parameters for Amtrak 47 and CSXT 36.

Plot Label	Parameter Description	Unit
Bell	Bell[8]	N/A
Horn	Horn[9]	N/A
PCS Open	Pneumatic Control Switch Open	N/A
EAB BP	Electronic Air Brake – Brake Pipe Pressure	psi
EAB BC	Electronic Air Brake – Brake Cylinder Pressure	psi
Throttle	Throttle Position	psi
Miles Traveled	Miles Traveled	miles
Dir Call	Direction Call[9]	N/A
Speed	Speed	mph
EAB Brake Handle	Electronic Air Brake – Emergency Handle Position	N/A
EAB Emer. Type	Electronic Air Brake – Emergency Type	N/A
DB Excite	Dynamic Brake Setting	N/A
Milepost	Milepost	miles
DB Excite	Dynamic Brake Excitement	N/A

8. Parameter is for Amtrak 47 only.

9. Parameters are for CSXT 36 only.

NOTE: Parameters with a blank unit description in table A-1 are discretes. A discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.

Table A-3. Unit and discrete state abbreviations.

Unit and Discrete Abbreviation	Description
B1	Brake Position 1
B2	Brake Position 2
B3	Brake Position 3
B4	Brake Position 4
B5	Brake Position 5
B6	Brake Position 6
B7	Brake Position 7
B8	Brake Position 8
EIE	Engineer Initiated Emergency

APPENDIX A

Unit and Discrete Abbreviation	Description
For	Forward
ft	feet
miles	miles
mph	miles per hour
psi	pounds per square inch
Rev	Reverse
T/E	Train Emergency
T1	Throttle Position 1
T2	Throttle Position 2
T3	Throttle Position 3
T4	Throttle Position 4
T5	Throttle Position 5
T6	Throttle Position 6
T7	Throttle Position 7
T8	Throttle Position 8