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

June 6, 2017

Electric Multi-Unit (EMU) M7 Event Recorders

Specialist's Factual Report
By Bill Tuccio, Ph.D.

1. EVENT SUMMARY

Location:	Brooklyn, New York
Date:	January 4, 2017
Company:	Long Island Rail Road (LIRR)
Train:	2871
MU[1] Pair ID:	7553-54 (lead)
MU Pair ID:	7067-68 (2nd)
MU Pair ID:	7073-74 (3rd)
NTSB Number:	DCA17FR002

For a summary of the accident, refer to the Accident Summary report, within this docket.

2. ELECTRIC MULTI-UNIT (EMU) CAR EVENT RECORDER GROUP

An electric multi-unit (EMU) car event recorder group was not convened.

3. DETAILS OF RECORDER INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received event recorder files from the following MU pairs:

MU Pair ID:	7553-54 (lead)
MU Pair ID:	7067-68 (2nd)
MU Pair ID:	7073-74 (3rd)

3.1. EMU M7 Event Recorder Recording Description

Files were downloaded from a crash hardened Bach-Simpson M7 Event Recorder System (ERS). [2] Each LIRR M7 car is part of a paired set referred to as an "A" and "B" car; the recorder was installed in the A car and recorded data from the A and B car. In agreement with the Investigator-in-Charge, only data from A car 7554 was used in this report.

[1] MU means "Multiple Unit." MU cars are semi-permanently coupled and share some components. In this report, the MU pairing is referred to by a dashed reference, for example, "7553-54" meaning "7553" (B car) and "7554" (A car). A further description of the operating design of EMU M7 cards is provided elsewhere in the investigative docket.

[2] As described in "LIRR/MNR M-7 Passenger Cars Event Recorder System (ERS) System Functional Description (SFD) Network Downloading" (Document 878-BSC-0000, Revision K), May 5, 2008.

Using 7554's wheel size of 34.25 inches as provided by investigators, 7554's event recorder data were extracted using the Bach-Simpson WinDAS Software version 4.06. The software outputted the event recorder parameters including speed.

The ERS uses a change-based algorithm to record data, based on an underlying sampling rate between 20 to 125 milliseconds. This algorithm records a baseline of all parameters and, if a parameter's value changes, then that parameter is recorded. If another parameter's value changes within the same period, then that parameter is recorded along with all other parameters. A consequence of this algorithm is that the exported data has repeated times.

3.2. Parameters

Table A-1 lists the parameters verified and provided in this report for MU 7553-54's recorded data. Additionally, table A-2 contains the unit and discrete state abbreviations for the parameters.

3.2.1. Distance Traveled (Feet Remaining)

It was not possible to export distance traveled from the WinDAS software; as such, speed was discretely integrated over each time interval to determine total distance traveled. Using this method, the final distance traveled was 627,834.25 feet. This final distance was subtracted from all values, and the absolute value was used, resulting in distance traveled being expressed as feet remaining and continually decreasing to 0 feet.[3]

3.2.2. Master Controller Position

The Master Controller and Train P-Wire were recorded in values of milliamps. Figure 1 shows a drawing from a LIRR-supplied document that relates milliamps to Master Controller Position.[4] In figure 1, "MC Output Current" refers to Master Controller current from the car controlling the train, which for this investigation was 7553 ("B" Car) (parameter symbol MCB in table A-1). "Trainline Output Current" refers to the Train P-Wire (parameter symbol TPW in table A-1).

Figure 1 contains discrete ranges of MCB and TPW current values; for example, a MCB value of 255 milliamps is an undefined value. According to LIRR, these undefined values may occur during normal operations when the master controller is being moved by the train operator and/or due to slight calibration errors in the MCB/TPW sensors for the recording system. In this report, the undefined values are specifically labelled relative to the interval where they appear; for example, 255 is reported as "Undef-Max2MinBrake" (see table A-2 for definitions of all values).

[3] This report did not determine the physical location of 0 feet relative to the accident.
[4] Bombardier drawing Ref 045-551-10-1006-01 Rev B.

Figure 1. Master Controller Position relationship.

MASTER CONTROLLER POSITION	MC OUTPUT CURRENT (mA)	TRAINLINE OUTPUT CURRENT (mA)
EMERGENCY BRAKE	94-106	0
MAX. BRAKE	124-140	0
MIN. BRAKE	256-277	256-277
COAST	290-310	290-310
MIN. POWER	323-343	323-343
MAX. POWER	485-515	485-515

3.2.3. Emergency Brake Trainline (EBT)

When the train is in motion, the Emergency Brake Trainline (EBT) is charged and recorded as "On." When EBT transitions to "Off," a valve opens allowing Brake Pipe Pressure to exhaust to the atmosphere, reducing Brake Pipe Pressure, and resulting in brake application.

3.3. Event Recorder Timing

The ERS records three times: (a) an elapsed recorder time per record, which started at 0 for the 7553-54 data; (b) a date/time per record, which corresponds to local time; and (c) a sampling of network time taken at irregular intervals. Using this information, it was determined that time (b) (without respect to calendar day), was slow by 3-hours, 32-minutes, and 35-seconds. Further, elapsed seconds (a) of 44,400.90 corresponded to time (b) on the accident day of 00:01:41.1. Using this information, -31,645.9 seconds was subtracted from elapsed time to convert to local, eastern standard time (EST). Therefore, for the rest of this report times are expressed as EST.

3.4. Plots and Corresponding Tabular Data

Figures 2 through 5 contain event recorder data from MU 7553-54 recorded during the event on January 4, 2017, by car 7554. All the parameters listed in table A-1 were plotted, as summarized in table 1.

Table 1. Figures 2 through 5 data descriptions.

Time Period/Parameters	Basic	Master Controller
07:10:00 to 08:30:00 EST	Figure 2	Figure 4
08:11:30 to 08:20:30 EST	Figure 3	Figure 5

Collectively the figures show (feet remaining is relative to the final calculated distance of 0 feet, as described in section 3.2.1):

- Car 7553 ("B" car) was activated at approximately 07:18 EST on the day of the accident, consistent with Train 2871 being operated from Car 7553 ("B" Car). The Brake Pipe Pressure was above 125 pounds per square inch until the time of the accident.
- The Master Controller settings changed throughout the recording period.

- At 08:17:23 EST (447 feet remaining), MU 7553-54 slowed to 2 mph before starting to accelerate.
- At 08:17:27 EST (436 feet remaining), MU 7553-54 began to accelerate.
- At 08:17:57 EST (12 feet remaining), EBT transitioned from “On” to “Off,” with corresponding change in Brake Pipe Pressure and Brake Cylinder Pressure. At this time, MU 7553-54 was traveling at 13 mph.
- By 08:17:59 EST (0 feet remaining), MU 7553-54 had stopped.

All of the corresponding tabular data used to create figures 2 through 5 are provided in electronic separated value (.csv) format as attachment 1 to this factual report.

Figure 2. 7553-54 basic parameters from 7:10 EST through and including the accident.

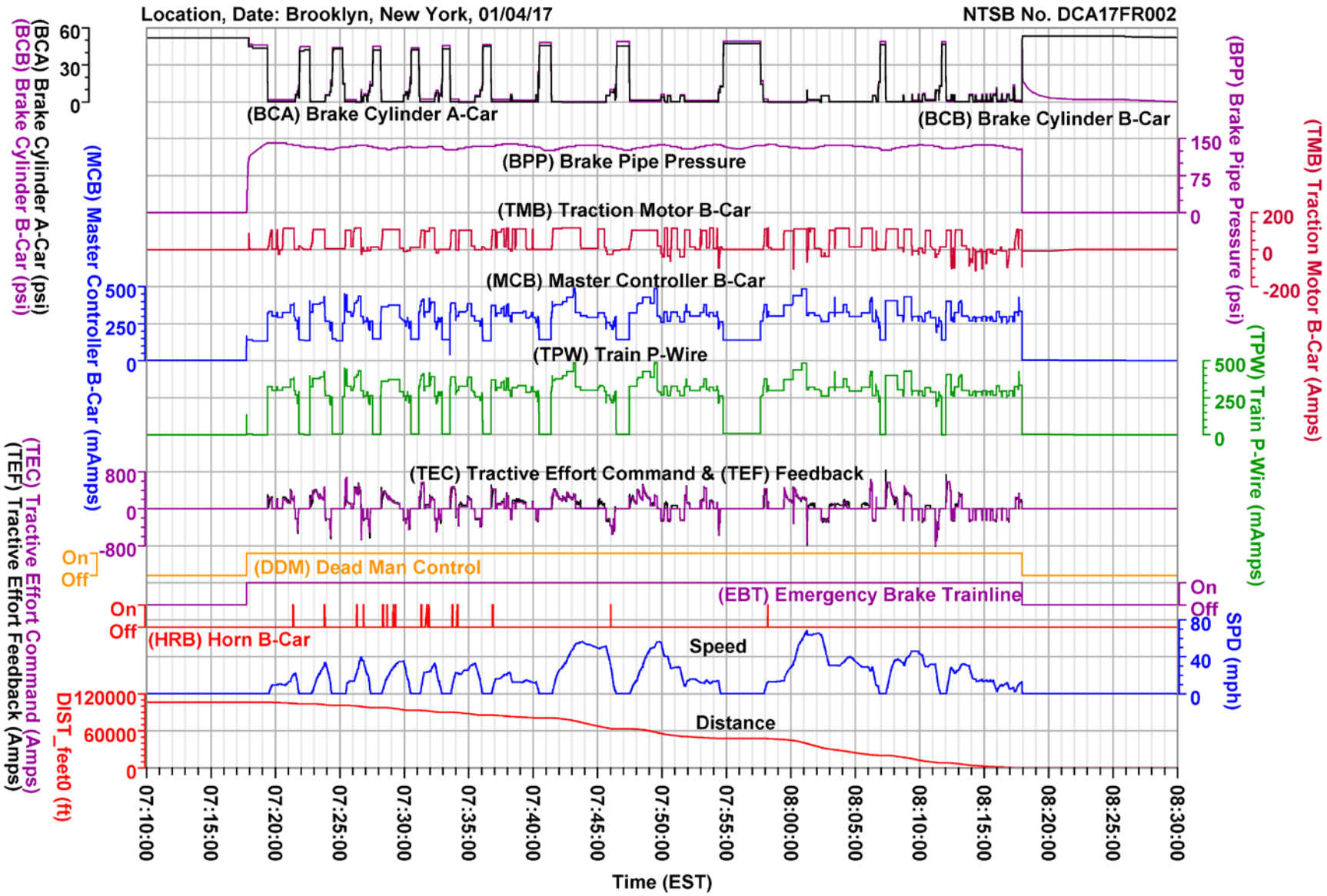


Figure 3. 7553-54 basic parameters from 8:11:30 EST through and including the accident.

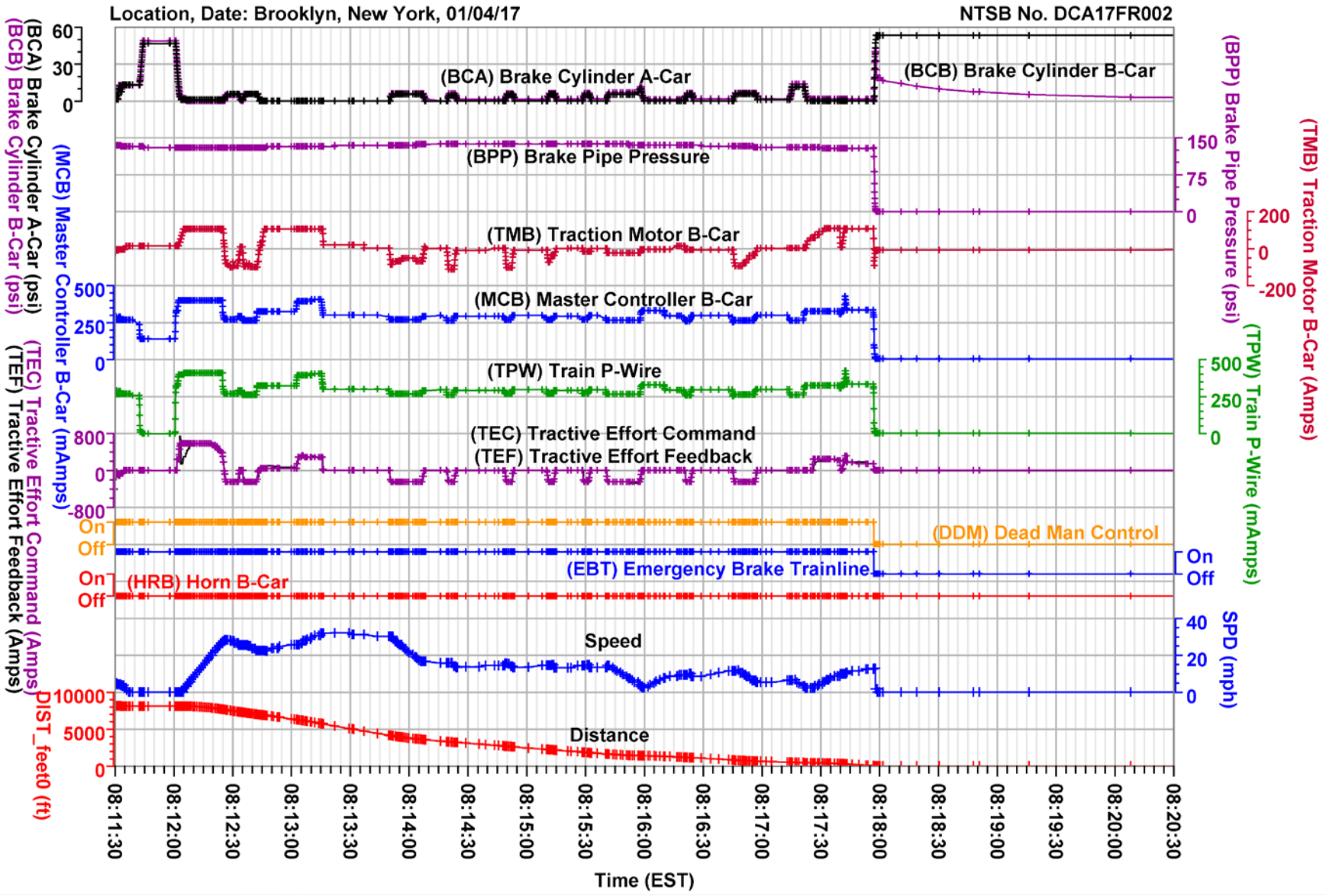


Figure 4. 7553-54 Master Controller from 7:10 EST through and including the accident.

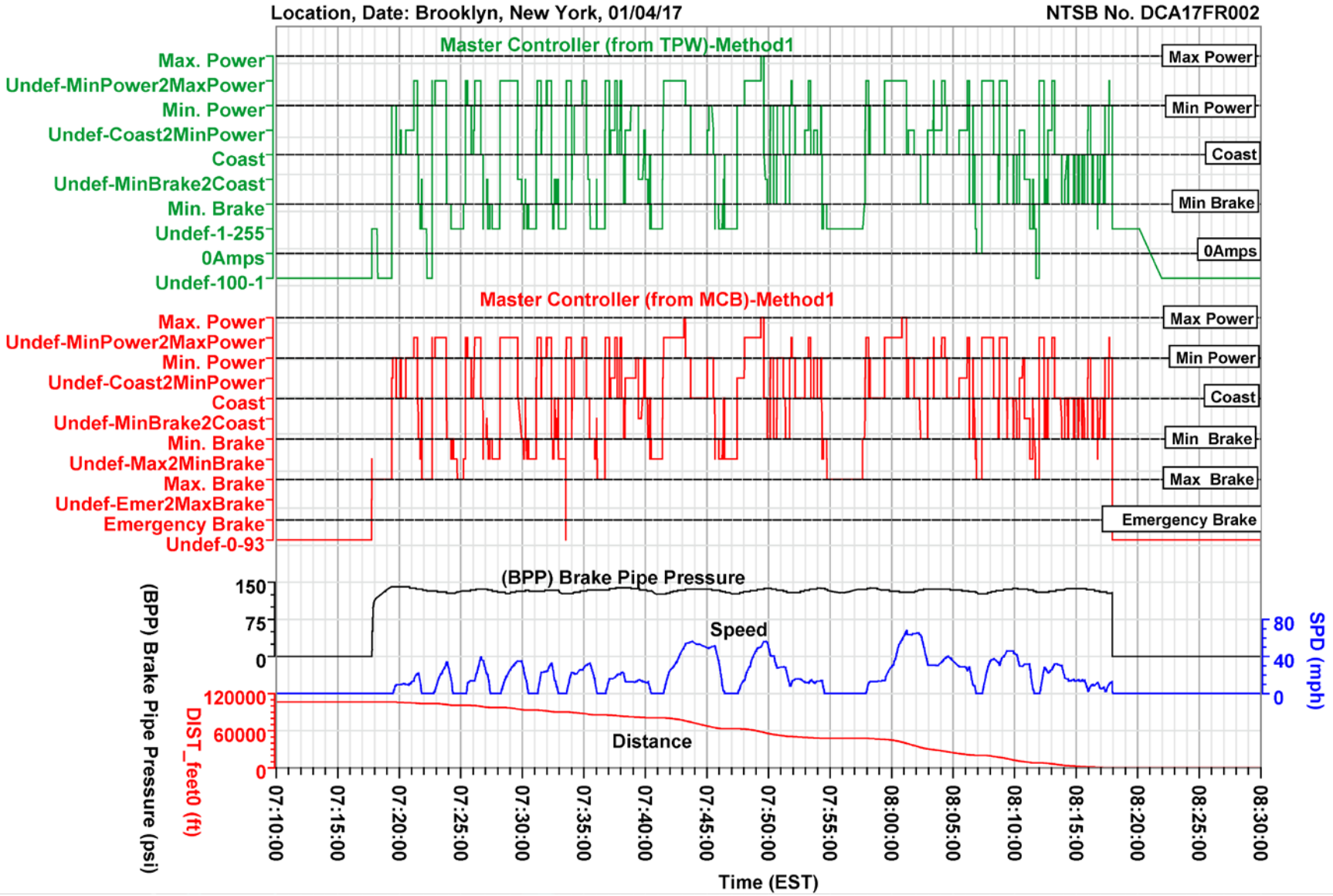
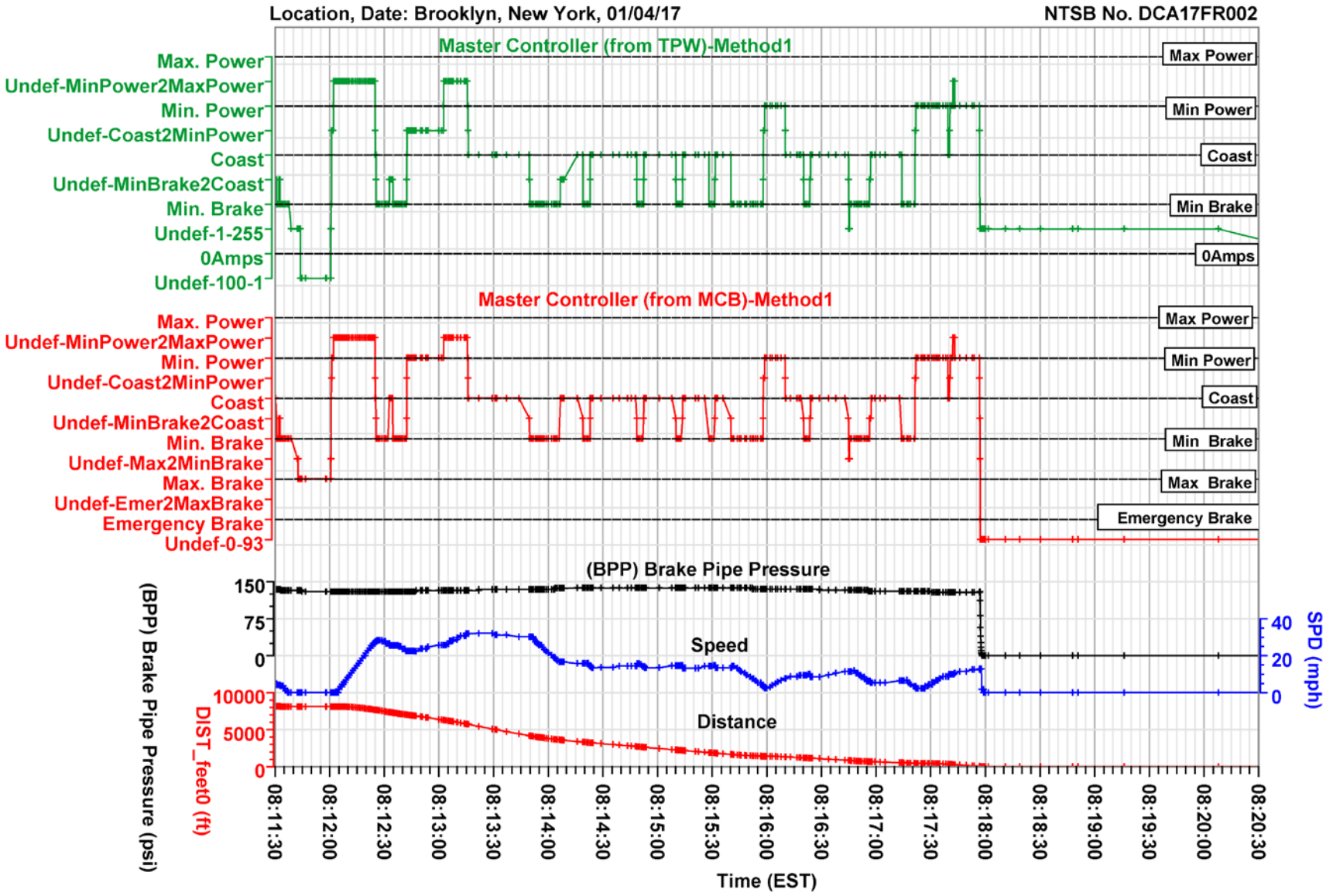


Figure 5. 7553-54 Master Controller from 8:11:30 EST through and including the accident.



APPENDIX A

This appendix describes the event recorder parameters provided and verified in this report for MU 7553-54, recorded by car 7554 (“A” car). Table A-1 lists the parameters and table A-2 contains the unit and discrete state abbreviations for the parameters.

Table A-1. Verified and provided event recorder parameters for MU 7553-54.

Name	Symbol	Description
1. Brake Cylinder A-Car (psi)	BCA	A-Car Brake Cylinder Pressure
2. Brake Cylinder B-Car (psi)	BCB	B-Car Brake Cylinder Pressure
3. Brake Pipe Pressure (psi)	BPP	Brake Pipe Pressure
4. Dead Man Control (discrete)	DDM	Dead Man Control
5. DIST_feet0 (ft)	-	Feet Remaining
6. Emergency Brake Trainline (discrete)	EBT	Emergency Brake Trainline
7. Horn B-Car (discrete)	HRB	B-Car Horn
8. Master Controller (from MCB)-Method1 (discrete)	-	Master Controller Position derived from MCB (see section 3.2.2)
9. Master Controller (from TPW)-Method1 (discrete)	-	Master Controller Position derived from TPW (see section 3.2.2)
10. Master Controller B-Car (mAmps)	MCB	B-Car Master Controller
11. Speed (mph)	-	Speed
12. Traction Motor B-Car (Amps)	TMB	B-Car Traction Motor
13. Tractive Effort Command (Amps)	TEC	Tractive Effort Command
14. Tractive Effort Feedback (Amps)	TEF	Tractive Effort Feedback
15. Train P-Wire (mAmps)	TPW	Train P-Wire

Table A-2. Unit and discrete state abbreviations.

Units Abbreviation	Description
Amps	amperes
mAmps	milliamperes
discrete	discrete
ft	feet
mph	miles per hour
psi	pounds per square inch
Undef-0-93	undefined (see figure 1)
Undef-Emer2MaxBrake	undefined (see figure 1)
Max. Brake	Maximum Brake (see figure 1)
Undef-Max2MinBrake	undefined (see figure 1)
Min. Brake	Minimum Brake (see figure 1)
Undef-MinBrake2Coast	undefined (see figure 1)

Units Abbreviation	Description
Undef-Coast2MinPower	undefined (see figure 1)
Min. Power	Minimum Power (see figure 1)
Undef-MinPower2MaxPower	undefined (see figure 1)
Max. Power	Maximum Power (see figure 1)
Undef-AboveMaxPower	undefined (see figure 1)
Undef-100-1	undefined (see figure 1)
0Amps	TPW 0 mAmps (see figure 1)
Undef-1-255	undefined (see figure 1)

NOTE: For parameters with a unit description of discrete, 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.