National Transportation Safety Board
Office of Railroad, Pipeline & Hazardous Materials Investigations
Washington D.C.

Factual Report of Investigation
Railroad Signals

NTSB Number:
DCA-08-MR-007

A. EVENT

Location:	Newton, Massachusetts
Date:	May 28, 2008
Time:	5:51 p.m. eastern daylight time (EDT)[1]
Carrier:	Massachusetts Bay Transportation Authority
Trains:	Trolley Train 3667 (3667 lead unit, 3706 articulated unit) Trolley Train 3681 (3681 lead unit, 3703 articulated unit)

B. GROUP

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[1] All time is eastern daylight time unless otherwise noted.

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C. SUMMARY

On May 28, 2008; at about 5:51 p.m., westbound MBTA trolley train 3667 collided with the rear end of MBTA trolley train 3681 between Waban station and Woodland station. The collision occurred on the MBTA D Branch of the Green Line at station marker 438+78 near wayside signal H66 which is located ⅓ mile west of Waban station. Trolley train 3681 was stopped at signal H66 prior to the collision. Trolley train 3667 was operating between 37 and 40 mph at the time of the impact.

Both trolley trains consisted of two articulated passenger trolley cars. The crew for each train had two motorpersons. One motorperson operated the train from a forward position seated on the left side of the lead car. MBTA estimated there were a total of 185 to 200 passengers on the two trains. At the point of collision, the lead trolley of train 3667 sustained severe damage. The collision resulted in a fatality to the operating motorperson of train 3667. A total of seven passengers were injured. One passenger was seriously injured and was medivaced to a local hospital. Local emergency response personnel provided on-scene treatment and transportation of the injured.

The weather at the time of the incident was clear skies with 68º Fahrenheit and winds from the southwest at 15-20 mph. The initial damage estimates are $8.6 million.

D. DETAILS OF THE INVESTIGATION

Description of Railroad Signal & Catenary Power Systems

The MBTA, D Branch (Highland Branch) of the Green Line runs in a geographic east-west direction between Cambridge (Lechmere Station) and Newton (Riverside Station) in Massachusetts. In the vicinity of the accident, the track structure consists of double track territory. The maximum authorized speed on the double tracks is 40 mph with a posted 25 mph speed restriction over the crossover switches.

Train movements on the Highland Branch are governed by the MBTA light rail rule book for operators and the signal indications of an automatic block signal (ABS) system. The ABS system utilizes five aspect US&S colorlight type signals and US&S hand operated switch machines operating in conjunction with 25 hertz AC track circuits.

Signal heads are illuminated using dual filament, 10 volt lamps. Signals in this territory are arranged for single-direction running on each track. The ABS system is configured to display the aspects listed in Table 1. MBTA designates the northern track as the westbound track or outbound track from Boston. The southern track is designated as the eastbound track or inbound track into Boston.

Table 1. Signal Aspects and Indications

Aspect	*Indication*
Red over Red	Stop
Red	Stop. Proceed after 1 minute at restricted speed. (Proceed, prepared to stop short of a train, car or other obstruction and watch for broken rail or switch not properly lined, not exceeding 10 mph to next signal).
Yellow	Proceed prepared to stop at next signal.
Green	Proceed at authorized speed.

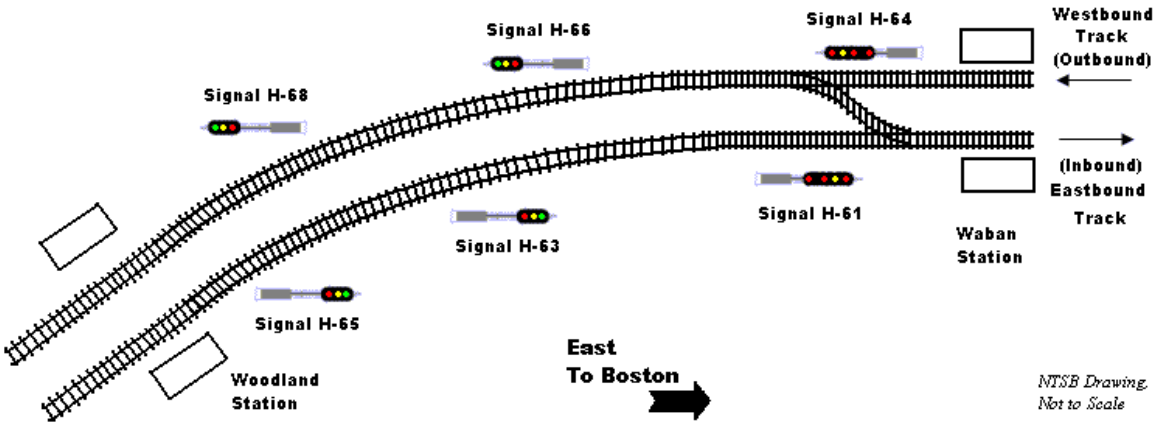
The MBTA dispatch center is located in downtown Boston and coordinates train movements. The dispatch center uses an automatic vehicle identification (AVI) system to aid the tracking of train movements. The AVI system uses transponders located along the wayside on the Highland Branch. As trains traverse past a transponder location, the train identification and time is displayed to dispatchers at the MBTA dispatch center. Additionally, the MBTA dispatching center maintains a record of dispatcher radio and telephone communications.

On the Highland Branch, train propulsion power is supplied through a 600 volt DC catenary system. The power dispatcher system is equipped with a SCADA data logger that maintains a record of the status of the catenary system. The SCADA log records changes in parameters such as circuit breaker conditions.

Given the primacy of the MBTA dispatch center in terms of operational monitoring on the Highland Branch and that all catenary control, AVI information and radio and telephone communications from the dispatch office are recorded, the clock time from the MBTA dispatch center was regarded as the standard time. Clock times relevant to this incident are derived from the MBTA dispatch center clock[2] and are referenced in this report unless otherwise noted.

[2] MBTA Dispatch Center equipment is synchronized to UTC time.

Signal Layout



Data Logs

AVI data captured the time of the two trains involved in the accident as they traveled past the Reservoir AVI location prior to the accident. Reservoir was the last AVI location traversed prior to the accident. Train 3681 was recorded at Reservoir at 5:41:05 p.m. and Train 3667 was logged at 5:43:12 p.m.

The data download from the SCADA system indicates that at 5:51:38 p.m., the H-2 section circuit breaker opened and that at 5:51:41 p.m., the H-1 section circuit breaker opened. The H-2 section designates the outbound track and the H-1 section designates the inbound track.

Postaccident Inspection/Testing of Signal System

Representatives from MBTA, the Commonwealth of Massachusetts - Department of Public Utilities and NTSB participated in the field inspection and testing of the signal system. As a result of the collision, the trains came to rest occupying track circuits both in approach to and in advance of signal H-66. With the trains located in that position, signal H-66 and H-64 were displaying an appropriate red aspect at each signal location. The postaccident inspection found all signal units, signal cases and switches locked and secured with no indications of tampering or vandalism that would interfere with the operation of the signal system. Relay positions were found to be in accordance with the physical location of the accident trains and the displayed signal aspects. None of the signal units or switches incurred damage as a result of the collision.

Upon removal of the train wreckage, signal H-66 remained at red with no trains occupying the track circuits governing that signal. A visual inspection identified two locations with broken rail bonds[3]. The rail ends had been double bonded, and some of the broken bonds had indications of being recently broken during the removal of the wreckage. Some of the bonds were rusted over indicating they were in that condition prior to the

[3] Connection between ends of sections of rail to maintain electrical continuity.

accident. The broken bonds were replaced in order to conduct postaccident testing. With the broken bonds replaced, signal H-66 cleared with no trains on the track circuits.

A functional operational test of signal H-64 was performed, all aspects were checked using a 0.06 ohm shunt and voltage readings were recorded on each lamp of the signal heads (See Table 2). Track circuit levels were tested and documented including a ground reading at the signal case. All tests were repeated at the H-66 signal location. Insulation resistance tests were performed on the cables between signals H-64 and H-66 and recorded.

Full functional operational tests were conducted at the conclusion of the testing between signal locations H-68 and H-64. The relays from signals H-64 and H-66 were then removed from the two signal locations for additional bench testing. A visual inspection of the relays after removal identified a terminal on the H-relay of signal H-66 with indications of corrosion on one of the terminals. The relays were taken to the MBTA relay shop where they were bench tested and operating values were recorded. All relays were operating within specifications.

No exceptions were identified with either the design or operation of the MBTA signal system. All tests indicated the signal system was working as designed.

Table 2. Lamp Voltages

Signal	*Aspect*	*Voltage*
H-64	Red	8.83 volts AC
	Yellow	7.92 volts AC.
	Red	7.90 volts AC
	Red	9.10 volts AC
H-66	Green	9.90 volts AC
	Yellow	9.55 volts AC
	Red	9.93 volts AC

Signal Maintenance Records

MBTA signal maintenance reports were reviewed for signal locations H-64 and H-66, including switches 27 and 28 (crossover switches). The maintenance records indicate all signal tests and inspections were conducted in accordance with MBTA requirements.

A switch obstruction test on both switches was performed in April, 2008. Ground test records indicate it was last tested in April, 2008. The previous monthly tests were performed in April 2008. A wayside signal inspection was conducted in April 2008. The previous insulation resistance testing was performed in 1993. Relays were tested in 2006. All test records indicate the signal system was functioning as designed. A request for reports of signal malfunctions, reported by train operators, indicated that none were reported in the vicinity of the accident.

Additional Information

MBTA signal rules for train operators require certain actions when a motorperson encounters a defective signal. The procedures are contained in Rule 59, which states:

(a) *An interlocking signal imperfectly displayed, such as where there is no light or a white light, is a defective signal, the indication is to STOP. Under no circumstances are operators to pass through interlocking signals imperfectly displayed except under personal direction by an Authorized person.*

(b) *An automatic block signal imperfectly displayed such as when there is no light or a white light, or more than one light at points where one light normally shows, is a defective signal. The indication is STOP. Wait one (1) minute, then proceed at restricted speed. (Proceed, prepared to stop short of a car, train, or other obstruction and watch for broken rail or switch not properly lined, not exceeding ten (10) miles per hour).*

(c) *At locations where there is a crossover with facing point switches you will find on the automatic block signal a multiple number of aspects. With no aspect, Motorpersons must wait for orders from an authorized person to proceed. It's the Moterperson's responsibility to see that the switches are properly set before passing on its points and proceed at a speed no greater than ten (10) mph.*

(d) *The conditions described in (a), (b) and (c) above must be reported at once to the first Official reached or the OCC dispatcher.*

MBTA signal rules do not require motorpersons operating trains to report red signals where the length of the block governing that signal can be determined to be unoccupied. During postaccident interviews, the motorperson operating train 3681 stated seeing a red aspect at signal H-66 with no other trains in the block ahead. The motorperson stated the train was stopped for the required one minute and was proceeding to resume movement when the train was struck from behind. The motorperson was not required and did not report the red aspect encountered at signal H-66.

Because there were no reports regarding the red aspect at signal H-66, the signal group was not able to determine the length of time that signal H-66 was at stop or if this was an intermittent event. The signal group did however determine that signal H-66 was displaying the correct aspect based on the conditions detected by the signal system in the block governing signal H-66. The signal group also determined that signal H-64 was also displaying a proper red aspect on account of train 3681 occupying the block governing signal H-64.

END OF REPORT