End-of-Track Collisions at Terminal Stations
Hoboken, New Jersey, September 29, 2016
and Atlantic Terminal, Brooklyn, New York, January 4, 2017

Special Investigation Report

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National Transportation Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

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Abstract: The National Transportation Safety Board (NTSB) launched investigative teams to two very similar accidents within 13 weeks of one another. In both accidents, the engineers failed to stop their trains before reaching the end of a terminating track at a station. The September 29, 2016, accident on the New Jersey Transit commuter railroad at Hoboken, New Jersey, killed one person, injured 100, and resulted in major damage to the passenger station. The January 4, 2017, accident on the Long Island Rail Road (a subsidiary of Metropolitan Transportation Authority) at the Atlantic Terminal in Brooklyn, New York, injured 108 people. As the NTSB investigations progressed, it became apparent that these accidents had almost identical probable causes and safety issues. The NTSB also realized that these safety issues were not unique to these two properties, but exist throughout the United States at many intercity passenger and commuter passenger train terminals.

The NTSB is issuing two new safety recommendations to the Federal Railroad Administration and two new safety recommendations to New Jersey Transit and the Metropolitan Transportation Authority. In addition, the NTSB is reiterating two safety recommendations to the Federal Railroad Administration.

For more detailed background information on this report, visit http://www.ntsb.gov/investigations/dms.html and search for NTSB accident ID DCA17SR001. Recent publications are available in their entirety on the Internet at http://www.ntsb.gov. Other information about available publications also may be obtained from the website or by contacting:

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Acronyms and Abbreviations

ACS	automatic cab signal
ACSES II	Advanced Civil Speed Enforcement System
AHI	apnea/hypopnea index
Amtrak	National Railroad Passenger Corporation
ANPRM	advance notice of proposed rulemaking
APTA	American Public Transportation Association
ASES II	Advanced Speed Enforcement System
ATC	automatic train control
BLET	Brotherhood of Locomotive Engineers and Trainmen
BMI	body mass index
BNSF	BNSF Railway
CFR	*Code of Federal Regulations*
CPAP	continuous positive airway pressure
CSS	cab signal system
DCO	deputy chief safety officer
DOT	US Department of Transportation
EO	emergency order
FMCSA	Federal Motor Carriers Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
LIRR	Long Island Rail Road
Metro-North	Metro-North Railroad
MTA	Metropolitan Transportation Authority

NJT	New Jersey Transit
NTSB	National Transportation Safety Board
NPRM	notice of proposed rulemaking
OSA	obstructive sleep apnea
PTC	positive train control
RGHS	Railroaders' Guide to Healthy Sleep
RRP	risk reduction program
RSAC	Railroad Safety Advisory Committee
RSIA	Rail Safety Improvement Act of 2008
SMART	International Association of Sheet Metal, Air, Rail, and Transportation Workers
SMS	safety management system
SSPP	system safety program plan
UP	Union Pacific Railroad
USC	*United States Code*

Executive Summary

The National Transportation Safety Board launched investigative teams to two very similar accidents within 13 weeks of one another. In both accidents, the engineers failed to stop their trains before reaching the end of a terminating track at a station. The September 29, 2016, accident on the New Jersey Transit commuter railroad at Hoboken, New Jersey, killed one person, injured 110, and resulted in major damage to the passenger station. The January 4, 2017, accident on the Long Island Rail Road (a subsidiary of Metropolitan Transportation Authority) at the Atlantic Terminal in Brooklyn, New York, injured 108 people.

As the National Transportation Safety Board investigations progressed, it became apparent that these accidents had almost identical probable causes and safety issues. The National Transportation Safety Board also realized that these safety issues were not unique to these two properties, but exist throughout the United States at many intercity passenger and commuter passenger train terminals.

This special investigation report includes discussions of both accidents, examines the common safety issues, and reviews the steps taken by New Jersey Transit and Long Island Rail Road in response to these accidents.

This report addresses the following safety issues:

- **Improving measures to ensure that engineers are fit for duty.** The National Transportation Safety Board has found untreated obstructive sleep apnea to be a causal factor in many highway and railroad accidents.

- **Installing positive train control at terminal tracks.** All passenger railroads that operate terminals with terminating tracks, including New Jersey Transit and Long Island Rail Road, have asked to be excluded from installing positive train control and the Federal Railroad Administration has granted all the requests.

- **Developing and implementing safety management systems.** In these accidents, the National Transportation Safety Board did not find evidence of either New Jersey Transit or Long Island Rail Road having a formal hazard analysis for trains operating into a terminal track, despite earlier accidents on both railroads where trains had struck the bumping post at the end of the track. Although the accidents were significantly less severe than the accidents discussed here, they established that the hazard existed and that another accident could occur.

The National Transportation Safety Board is issuing two new safety recommendations to the Federal Railroad Administration and two new safety recommendations to New Jersey Transit and the Metropolitan Transportation Authority. In addition, the National Transportation Safety Board is reiterating two safety recommendations to the Federal Railroad Administration.

1. Introduction

The National Transportation Safety Board (NTSB) launched investigative teams to two very similar commuter rail accidents within 13 weeks of one another. In both accidents, the engineers failed to stop their trains before reaching the end of a terminating track at a station. The September 29, 2016, accident on the New Jersey Transit (NJT) commuter railroad at Hoboken, New Jersey, killed one person, injured 110, and resulted in major damage to the passenger station. The January 4, 2017, accident on the Long Island Rail Road (LIRR), an entity within the Metropolitan Transportation Authority (MTA), at the Atlantic Terminal in Brooklyn, New York, injured 108 people.

As the NTSB investigations progressed, it became apparent that these accidents had almost identical probable causes and safety issues. NTSB staff also determined that these safety issues were not unique to these two properties, but exist throughout the United States at many intercity passenger and commuter passenger train terminals.

This special investigation report includes discussions of both accidents, examines the common safety issues, and reviews the steps taken by NJT and LIRR in response to these accidents. The report highlights the lessons learned from these accidents to reduce the risk of impairment of safety-sensitive personnel due to undiagnosed and untreated obstructive sleep apnea (OSA), require the use of technology to stop trains before reaching the end of tracks, and provide guidance for improving the effectiveness of system safety program plans (SSPP) to improve railroad safety at stations with terminating tracks. This report also provides recommendations to NJT; MTA, the parent company of LIRR; and the Federal Railroad Administration (FRA).

2. Background

2.1 New Jersey Transit

NJT is a state-owned public transportation system that has served the state of New Jersey, along with portions of the state of New York and the commonwealth of Pennsylvania, since 1979. NJT is the largest passenger and commuter rail line in New Jersey.[1] NJT contracts with the National Railroad Passenger Corporation (Amtrak) for the maintenance of certain NJT rolling stock and the use of Amtrak’s Northeast Corridor. NJT operates 711 trains and 45 light rail vehicles. Covering a service area of 5,325 square miles, NJT is the nation's third-largest provider of bus, rail, and light rail transit, linking major points in New Jersey, New York, and Philadelphia, Pennsylvania. NJT also provides service for some Metro-North Railroad (Metro-North) passenger lines, which, like LIRR, is a part of MTA.

2.2 Long Island Rail Road

LIRR is the largest and oldest commuter railroad in the United States operating under its original name. Chartered in 1834, it extends from three major New York City terminals (Penn Station, Atlantic Terminal, and Hunterspoint Avenue) through a major transfer hub at the Jamaica Station in Queens, New York, to the easternmost tips of Long Island (Greenport and Montauk). The Port Washington branch is the only branch of eleven that does not go through Jamaica. There are 124 stations and 594 miles of track for commuter service. On an average weekday, LIRR runs a total of 743 passenger trains. Annual ridership is nearly 90 million. LIRR is one of three commuter rail systems owned by MTA. The others are Metro-North and the Staten Island Railroad.

2.3 Similarities Between New Jersey Transit and Long Island Rail Road

Both NJT and LIRR service the metropolitan New York City area and its suburbs and carry millions of commuters throughout the year. In some cases, passengers may use both properties on the same trip. Further, the FRA has regulatory and enforcement oversight over both commuter railroads.

2.4 Terminals with Terminating Tracks

According to the FRA, there are at least 35 passenger train terminals in the United States with multiple tracks that end at a bumping post and/or platform. All of the terminal operators have

[1] The other passenger and commuter rail lines in New Jersey are: National Railroad Passenger Corporation (Amtrak); the Port Authority Trans-Hudson Corporation; the Port Authority Transit Corporation Speedline; two Southeastern Pennsylvania Transportation Authority regional rail lines; and some tourist trains in the southern and northwestern parts of New Jersey.

requested an exclusion from applying a positive train control (PTC) system. Without the PTC system, stopping a train on a terminating track depends on the attentiveness of the engineer.

Commuter passenger trains and intercity passenger trains (for example, Amtrak) operate on the same tracks as freight trains, and these tracks are often privately owned.[2] These railroads are regulated by the FRA. Because of the shared territories and ownership, one challenge of implementing positive train control (PTC) has been to ensure that the technology is interoperable. From a safety perspective, the NTSB has recognized the importance of using technology to mitigate human errors and hazards created by single point failures.[3] The NTSB has advocated for the implementation of PTC systems to prevent collisions and overspeed events for more than 45 years. PTC has appeared on the NTSB's Most Wanted List of Transportation Safety Improvements for 23 of the 27 years that the list has been in existence.

The Rail Safety Improvement Act of 2008 (RSIA), required each entity providing regularly scheduled intercity or commuter rail passenger transportation to implement a PTC system by December 31, 2015.[4] In October 2015, Congress extended the PTC deadline by 3 years to December 31, 2018, with the opportunity for an additional 2 years upon approval from the US Department of Transportation (DOT). DOT is prohibited from enforcing PTC regulations during the additional 2-year extension, provided the railroad has met certain milestones, such as installing all PTC hardware, acquiring all necessary radio spectrum, and submitting an alternative schedule and sequence for implementing PTC.[5]

However, due to a regulatory exemption, most terminating tracks on commuter and passenger railroads are not, and will not be, equipped with PTC or other technologies to stop a train should an engineer fail to control its movement. This subject will be discussed in more depth in section 6.

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[2] (a) *Commuter rail*, as defined in Title 49 *United States Code* (*USC*) Section 24102(3), means short-haul rail passenger transportation in metropolitan and suburban areas usually having reduced fare, multiple-ride, and commuter tickets and morning and evening peak period operations. (b) *Intercity rail*, as defined by 49 *USC* 24102(4), is rail passenger transportation, except commuter rail passenger transportation. (c) *Host railroads*, as defined in Title 49 *Code of Federal Regulations* (*CFR*) 236.1003, is a railroad that has effective operating control over a segment of track.

[3] A *single point failure* is part of a system that, if it fails, will stop the entire system from working.

[4] Title 49 *USC* 20156. Public Law 110–432, Division A, October 16, 2008, 122 Stat. 4848, 4853-56.

[5] Title 49 *CFR* 236.1005.

3. The Accidents

The following sections summarize the accidents and outlines the similarities that precipitated the development of this Special Investigation Report.

3.1 Hoboken, New Jersey

On September 29, 2016, about 8:38 a.m. eastern daylight time, NJT train 1614 failed to stop, overrode a bumping post at the end of track 5, and struck a wall of the Hoboken Terminal. Figure 1 shows an exemplar bumping post at the Hoboken Terminal. This bumping post is a rigid structure that is level with the train’s coupler at the end of the track.

Figure 1. Photograph of an exemplar bumping post at the Hoboken Terminal.

Train 1614 consisted of one controlling passenger car (cab car), three passenger cars, and one locomotive at the rear of the train. The train was traveling about 21 mph at the time of the accident.

About 250 passengers and 3 crewmembers (engineer, passenger car conductor, and assistant conductor) were on the train. One person on the passenger platform was struck by falling debris and died; 110 passengers and crewmembers were injured. Total damage to the train, track, and facility is estimated at $6 million. Figure 2 shows the controlling cab car, which was damaged by a falling a roof structure beam from the Hoboken Station.

Figure 2. Damaged controlling cab car.

The NTSB accident brief on this accident investigation is found in its entirety in appendix B.

3.1.1 Probable Cause

The National Transportation Safety Board determined that the probable cause of the Hoboken, New Jersey, accident was the failure of New Jersey Transit train 1614's engineer to stop the train after entering Hoboken Terminal due to the engineer's fatigue resulting from his undiagnosed severe obstructive sleep apnea. Contributing to the accident was New Jersey Transit's failure to follow its internal obstructive sleep apnea screening guidance and refer at-risk safety-sensitive personnel for definitive obstructive sleep apnea testing and treatment. Further contributing to the accident was the Federal Railroad Administration's failure to require railroads to medically screen employees in safety-sensitive positions for obstructive sleep apnea and other sleep disorders. Also contributing to the accident was the lack of either a device or safety system that could have intervened to stop the train before the collision.

3.2 Atlantic Terminal, Brooklyn, New York

On, January 4, 2017, about 8:18 a.m. eastern standard time, LIRR passenger train 2817. consisting of six cars, collided with the platform at the end of track 6 in the Atlantic Terminal in Brooklyn (a borough of New York City, New York).[6] Figure 3 shows the triangular bumping post at Atlantic Terminal, with legs supporting a steel block which is level with the train's coupler.

Figure 3. Photograph of the bumping post at Atlantic Terminal prior to the accident. (Photograph courtesy of LIRR.)

The lead end of the lead car came to rest on top of the concrete platform at the end of the track. (See figure 4.) As result of this accident, 108 people were injured. Total damage was estimated at $5.3 million.

[6] (a) The six LIRR M-7 revenue cars operated in a multiple-unit arrangement that consisted of three semipermanently coupled married pairs with an operating cab at each end. Electric power was provided to the cars from a third rail. (b) Atlantic Terminal, which LIRR shares with New York City Transit, is beneath a commercial building that has restaurants and retail stores.

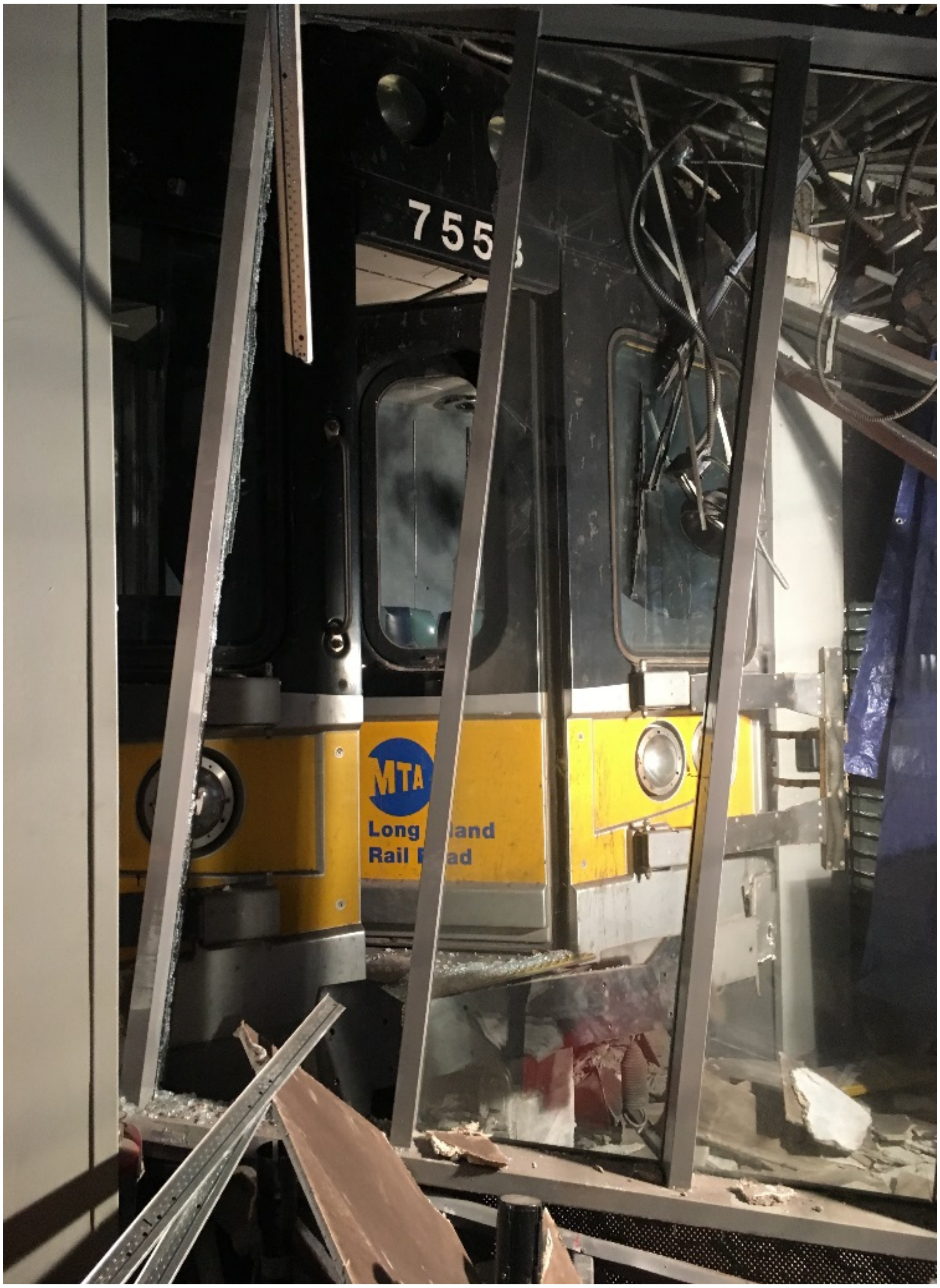

Figure 4. The accident train's lead car.

The NTSB accident brief on this accident investigation is found in its entirety in appendix C.

3.2.1 Probable Cause

The National Transportation Safety Board determined the probable cause of the Brooklyn, New York, accident was that the engineer of Long Island Rail Road train 2817 fell asleep due to his chronic fatigue. Contributing to his chronic fatigue was the engineer's undiagnosed severe obstructive sleep apnea, and Long Island Rail Road's failure to initiate obstructive sleep apnea screening for safety-sensitive personnel and refer at-risk safety-sensitive personnel for definitive obstructive sleep apnea testing and treatment before the accident. Further contributing to the accident was the Federal Railroad Administration's failure to require railroads to medically screen employees in safety-sensitive positions for obstructive sleep apnea and other sleep disorders. Also contributing to the accident was the lack of either a device or a safety system that could have intervened to stop the train before the collision.

4. End-of-Track Collisions

When operating a train into a terminating track, the engineer’s actions (or lack thereof) solely determine whether the train stops before the end of the track. According to the FRA, in the United States, there are currently no mechanisms installed that will automatically stop a train at the end of the track if the engineer is incapacitated, inattentive, or disengaged. There are some railroad properties that have overspeed capabilities, including NJT and LIRR. However, as shown in these two accidents, once the engineer slowed the train to the prescribed speed, the system did not stop the trains before they reached the end of the track. To reduce the likelihood of end-of-track collisions, the following sections will discuss: (1) ensuring that safety-sensitive employees are adequately screened, diagnosed, and treated for OSA; (2) preventing collisions between trains and the ends of tracks in terminals; and (3) developing and implementing robust safety management system (SMS) programs.

5. Obstructive Sleep Apnea

5.1 New Jersey Transit

The 48-year-old male NJT engineer had no documented acute or chronic medical conditions. His most recent occupational medical examination, on July 7, 2016, failed to measure his weight and a required NJT OSA screening form was not located. Although he met referral criteria in the 2006 Tri-Medical Society Task Force Recommendations, NJT protocol at the time left the decision of whether to refer the employee for a sleep study to the discretion of the doctor (Hartenbaum 2006).[7] There was no evidence that he was ever referred. The engineer's FRA-required postaccident toxicology sample, collected after he was administered oxycodone in the hospital, was positive for oxycodone and its metabolite but negative for alcohol and other tested-for drugs.

The NJT engineer underwent a postaccident sleep study on October 4, 2016, 5 days after the accident. At that time, he was found to be 6 feet-tall and morbidly obese with a postaccident weight of 322 pounds, a body mass index (BMI) of 43.67 kg/m^2, and a greater than 90-pound weight gain within the past 5 years.[8] The sleep study identified the engineer's severe OSA with an apnea/hypopnea index (AHI) of 89.6 episodes/hour.[9]

Untreated OSA causes frequent interruptions in sleep resulting in increased fatigue, daytime sleepiness, and may result in microsleeps and "lapses". The engineer was alone in the cab of the train and solely responsible for its operation. The engineer made several errors during the trip, including delayed or missed horn signals during grade crossings. Additionally, the engineer had no identified reason for distraction. It also appears he had adequate opportunity for rest, and no other causes of fatigue were identified. Furthermore, during entry into the station, the engineer advanced the throttle rather than slowing the train prior to hitting the terminal bumping post. These errors are consistent with lapses in alertness that can result from fatigue, including fatigue induced by untreated OSA. The NTSB concludes that lapses in the engineer's alertness prior to the accident resulted from his undiagnosed and untreated severe OSA.

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[7] (a) Some of the referral criteria include: sleep history suggestive of OSA, hypertension, a high BMI, and a large neck circumference. (b) *Tri-Medical Society Task Force* consists of members from the American College of Chest Physicians, the American College of Occupational and Environmental Medicine, and the National Sleep Foundation.

[8] (a) According to the National Institute of Health, a BMI of over 40 kg/m^2 indicates severe or morbid obesity and increase the risk of Type II diabetes, high blood pressure, cardiovascular disease, and obstructive sleep apnea. (b) The engineer's weight gain resulted in a steady increase of his calculated BMI, which increased the engineer's risk of a number of medical conditions, including OSA. (c) Neck circumference is used in conjunction with BMI to help determine whether or not to refer a safety-sensitive employee for definitive OSA testing. Although the neck circumference is a required part of the NJT OSA screening form, the engineer's neck circumference was not recorded during his past three occupational medical examinations.

[9] An *apneic episode* is the complete absence of airflow though the mouth and nose for at least 10 seconds. A *hypopnea episode* is when airflow decreases by 50 percent for at least 10 seconds or decreases by 30 percent if there is an associated decrease in the oxygen saturation or an arousal from sleep. The AHI sums the frequency of both types of episodes per hour. An AHI of less than 5 is considered normal. An AHI of 5-15 is mild; 15-30 is moderate and more than 30 events per hour is considered severe sleep apnea.

A review of NJT physical examination requirements revealed guidance for physicians examining safety-sensitive personnel, including engineers and conductors.[10] It stated that the physician "shall complete an OSA screening during periodic examinations." Additionally, the OSA screening form guidelines have specific guidance for referral for additional OSA testing. At the time of the accident, referral for additional testing was based on a combination of physician discretion and the 2006 Tri-Medical Society Task Force screening and referral recommendations. Since the accident, NJT has started a program to ensure OSA screening forms are completed and centrally reviewed, and that safety-sensitive employees meeting referral criteria are removed from service until appropriately tested and successfully treated.

Had the medical personnel from the NJT OSA screening program completed the screening forms and followed the Tri-Medical Society Task force guidance for referral, the engineer would have been referred for a sleep study, diagnosed with OSA, and treated prior to the accident. Therefore, the failure of the NJT OSA screening program to adequately screen the engineer and refer him for definitive diagnostic testing and subsequent treatment contributed to the accident.

A review of the 55-year-old male conductor's and 62-year-old male brakeman's occupational records found that they were both medically certified for the safety-sensitive positions they held.[11] Their postaccident toxicology testing was negative for alcohol or other drugs. The conductor had a BMI of 40 kg/m^2 and a neck circumference 20.5 inches while the brakeman had a BMI of 36.3 kg/m^2, but his most recent neck circumference was not recorded.[12] While both employees met the referral criteria in the 2006 Tri-Medical Society Task Force Recommendations, NJT protocol at the time left the decision of whether to refer the employee for a sleep study to the discretion of the doctor. Neither employees' records contained documentation that they were referred for further OSA testing. The NTSB concludes that the failure of NJT to follow internal guidance and refer at-risk safety-sensitive personnel including the engineer and other at-risk crewmembers for OSA screening is evidence of a systemic failure of a critical safety system to ensure these personnel were fit for duty.

5.2 Long Island Rail Road

At the time of the accident, the 50-year-old male LIRR engineer had no documented acute or chronic medical conditions. Postaccident toxicology was negative for alcohol or other tested-for drugs. However, a postaccident sleep evaluation documented his height as 5 feet 10 inches, weight as 275 pounds, BMI as 39.5 kg/m^2, and neck circumference as 18.5 inches. Additionally, he scored 12 of 24 points on the Epworth sleepiness scale (Johns 1992).[13] On January 16, 2017, he underwent

[10] These guidelines were in accordance with 49 *CFR* 240.121 and 49 *CFR* 242.117.

[11] A *brakeman* is a job title for railroad workers who are subordinate to a conductor. In freight service, they often operate hand-throw track switches, couple and uncouple cars, apply manual brakes on freight cars, and assist with maintaining compliance with the operating rules. In passenger service, they may perform the traditional duties, but also assist the conductor in fare enforcement and attending to the needs of passengers.

[12] According to the National Institute of Health, a BMI of between 35 and 39.9 kg/m^2 indicates obesity and places the patient at very high risk of Type II diabetes, high blood pressure, and cardiovascular disease.

[13] The *Epworth sleepiness scale* is a subjective measure of the potential to fall asleep. It is administered as a questionnaire. Generally, a score of 10 or higher is considered an excessive amount of sleepiness depending on the situation.

a noninvasive polysomnographic evaluation (sleep study) in a sleep center. Testing documented an AHI of 101.3 episodes per hour with an average oxygen saturation during testing of 95 percent, dropping to as low as 73 percent. The sleep medicine specialist diagnosed severe OSA and prescribed continuous positive airway pressure (CPAP) as treatment.[14]

The engineer had an erratic sleep schedule, including chronic sleep debt with an average of less than 5 hours of sleep a night with a rotation in his sleep period from sleeping during the day to sleeping at night then back to sleeping during the day during the week prior to the accident. Further, the errors in train speed control and the engineer's failure to stop the train were consistent with a lapse in alertness or falling asleep. The NTSB concludes it was likely that fatigue from a variety of factors—including a rotating schedule, insufficient nightly sleep, poor sleep habits, and impaired sleep quality due to frequent arousals during his available sleep periods from undiagnosed and untreated severe OSA— resulted in the engineer falling asleep during entry into the terminal, causing the collision.

MTA developed an OSA screening program as a result of NTSB safety recommendations made to one of its subsidiary properties, Metro-North, following a string of accidents that were examined in a 2014 special investigation report (NTSB 2014c). MTA was in the process of implementing a similar program at each of its other properties, including LIRR, at the time of this accident.

Under MTA's guidance, LIRR had begun the initial planning for an OSA screening program, but it had not yet been implemented at the time of the accident. Since the accident, MTA/LIRR has initiated a program to screen safety-sensitive personnel for OSA. This program is discussed in more detail in the next section.

5.3 Discussion

OSA is a chronic disease in which patients experience episodes of airway obstruction while sleeping. During each episode, the person stops breathing for a period of time which causes oxygen levels to drop and carbon dioxide levels to rise. When the buildup of carbon dioxide gets too high, the brain detects it and the person arouses or awakens to breathe. The end result is fragmented sleep and subsequent daytime sleepiness and fatigue. Risk factors for OSA include: male gender, age, obesity, hypertension, large neck circumference (greater than 16 inches in women and 17 inches in men), a waist-to-hip circumference ratio of greater than 1 for men and 0.85 for women, and snoring (Peppard and others 2013; Seidell 2010; Young and others 2002; Olson and others 1995; Young and others 2004).

The Adult Obstructive Sleep Apnea Task Force, created by the American Academy of Sleep Medicine, developed guidelines for the evaluation, management, and long-term care of OSA in 2009. The task force determined that certain characteristics put patients either at increased risk of having OSA, having serious complications of OSA, or having "high-risk" situations. These characteristics include: obesity, congestive heart failure, atrial fibrillation, treatment refractory hypertension, type 2 diabetes, stroke, nocturnal dysrhythmias, pulmonary hypertension, being a

[14] *CPAP* is a treatment for OSA that uses a machine to generate positive air pressure that is delivered though a mask that covers the nose or nose and mouth to keep the airways open during sleep.

member of high-risk driving populations (such as train engineers, conductors, and commercial truck drivers), and those being evaluated for bariatric surgery (Adult Obstructive Sleep Apnea Task Force 2009). Persons with OSA have a significantly increased risk of motor vehicle accidents and other occupational injuries (Mulgrew and others 2008; Lindberg and others 2001; Basoglu and Tasbakan 2014).

5.3.1 NTSB Recommendation History of OSA Screening

Table 1 below shows NTSB investigations since 2000 that identified OSA as a contributing factor to the accident.

Table 1. NTSB Accident Investigations Involving OSA and FRA-Regulated Railroads.[a]

Location	Date	Report Date	Fatalities	Injuries	Report No.
Clarkston, Michigan	November 15, 2001	November 19, 2002	2	2	RAR-02/04
Red Oak, Iowa	April 17, 2011	April 24, 2012	2	0	RAR-12/02
Chaffee, Missouri	May 25, 2013	November 17, 2014	0	2	RAR-14/12
Bronx, New York	December 1, 2013	October 24, 2014	4	61	RAB-14/12
Hoxie, Arkansas	August 17, 2014	December 19, 2016	2	2	RAR-16/03
Hoboken, New Jersey	September 29, 2016		1	110	
Atlantic Terminal, New York	January 4, 2017		0	108	
Total			**11**	**285**	**7 accidents**

[a] (NTSB 2002a; 2012a; 2013; 2014a; 2014b; 2016b; 2018a; 2018b)

On November 15, 2001, two Canadian National/Illinois Central Railway trains collided near Clarkston, Michigan, killing two crewmembers and seriously injuring two other crewmembers. Although one of the signals at the turnout for the siding displayed a stop signal, one of the trains failed to stop before proceeding onto the main line. The NTSB investigation revealed that the two crewmembers who passed that stop signal had both been informed by their private physicians that they had or possibly had OSA, which is a potentially incapacitating medical condition. However, neither crewmember had informed the railroad, and neither had received sufficient treatment to mitigate the problem. NTSB determined that the probable cause of the accident was the “crewmembers’ fatigue, which was primarily due to the engineer’s untreated and the conductor’s insufficiently treated obstructive sleep apnea” (NTSB 2002).[15]

During the investigation, NTSB determined that the sleep disorders were part of a broader issue of medical fitness of employees in safety-sensitive positions. As a result of this investigation, the NTSB made the following recommendation to the FRA:

<u>R-02-24</u>

> Develop a standard medical examination form that includes questions regarding sleep problems and require that the form be used, pursuant to 49 *Code of Federal Regulations* Part 240, to determine the medical fitness of locomotive engineers; the

[15] Throughout this document, quotes from transcripts and other materials are not edited for grammatical errors.

> form should also be available for use to determine the medical fitness of other employees in safety-sensitive positions (NTSB 2002a).

Following this investigation, FRA initiated a Railroad Safety Advisory Committee (RSAC) working group on medical standards. Based on this encouraging action, NTSB classified safety recommendation R-02-24 as *Open—Acceptable Response*.

Following the Goodwell, Oklahoma, accident, the NTSB recognized the need for all employees in safety-sensitive positions to be medically certified. Therefore, safety recommendation R-02-24 was subsequently classified as *Closed—Unacceptable Action/Superseded* and superseded by R-13-21.

> <u>R-13-21</u>
>
> Develop medical certification regulations for employees in safety-sensitive positions that include, at a minimum, (1) a complete medical history that includes specific screening for sleep disorders, a review of current medications, and a thorough physical examination; (2) standardization of testing protocols across the industry; and (3) centralized oversight of certification decisions for employees who fail initial testing; and consider requiring that medical examinations be performed by those with specific training and certification in evaluating medication use and health issues related to occupational safety on railroads (NTSB 2013).

However, in subsequent years, the RSAC never proposed any medical standards or educational materials and the FRA made no improvements to its medical standards. Moreover, the FRA indicated that future products from the medical standards working group would be "guidelines for the railroad industry, rather than information to support improved regulations" (NTSB 2013).

The NTSB specifically addressed safety concerns resulting from sleep disorders in the investigation of the collision of two BNSF Railway (BNSF) trains in Red Oak, Iowa, on April 17, 2011. The accident occurred because the engineer and conductor had fallen asleep due to fatigue resulting from their irregular work schedules and their medical conditions. Those medical conditions were likely undiagnosed and untreated OSA. The NTSB made the following recommendation to the FRA:

> <u>R-12-16</u>
>
> Require railroads to medically screen employees in safety-sensitive positions for sleep apnea and other sleep disorders (NTSB 2012a).

The FRA responded on July 31, 2012, and stated that the RSIA requires that railroads develop a risk reduction program (RRP) that must contain a fatigue management plan. The FRA said that this action would address sleep disorders when implemented. In 2012, FRA said that they were also developing a fatigue management regulation responsive to the requirements set forth in the RSIA in conjunction with an RSAC working group.[16] However, these actions cannot occur until the FRA develops regulations directly addressing OSA screening and treatment.

Safety Recommendation R-12-16 was reiterated to the FRA twice in 2014, in response to the investigations of two accidents: the collision of a Union Pacific Railroad (UP) train and a BNSF train near Chaffee, Missouri, on May 25, 2013, and a Metro-North derailment in Bronx, New York, on December 1, 2013 (NTSB 2014a; 2014b).

On March 10, 2016, FRA, along with the Federal Motor Carrier Safety Administration (FMCSA), published an advance notice of proposed rulemaking (ANPRM) requesting data concerning the prevalence of moderate-to-severe OSA in individuals occupying safety-sensitive positions in rail transportation and the potential consequences for rail safety. The intent was to gather the data necessary to prepare a rulemaking that would develop regulations for sleep disorder screening.

In its March 23, 2016, response regarding the reiteration of Safety Recommendation R-12-16, the FRA mentioned the ANPRM and concluded with the following proposal, "Once FRA has fully considered how to address obstructive sleep apnea, FRA will next consider strategies to address other medical conditions that are also contributing causes to accidents."[17]

As a result of the investigation into the August 17, 2014, collision of two UP freight trains in Hoxie, Arkansas, the NTSB reiterated Safety Recommendation R-12-16, and issued a new safety recommendation to ensure that employees diagnosed with sleep disorders were fit for duty:

> <u>R-16-044</u>
>
> Develop and enforce medical standards that railroad employees in safety-sensitive positions diagnosed with sleep disorders must meet to be considered fit for duty (NTSB 2016b).

On February 16, 2017, the FRA responded to both Safety Recommendations R-12-16 and R-16-044 and said, "FRA is working to respond to the recommendations in NTSB's letter and will respond as soon as possible."[18]

FRA provided a second response on March 30, 2017, and said it was "actively working to achieve the intent of the recommendation." The FRA added:

> FRA is currently developing a regulation, consistent with input from an RSAC working group, responsive to the RSIA's FMP requirements. FRA, with the Volpe Center, fatigue researchers, and medical professionals, developed the Railroaders' Guide to Healthy Sleep (RGHS) website at www.railroadersleep.org, as an educational resource.[19]

[16] Letter from FRA administrator to NTSB, July 31, 2012.
[17] Letter from FRA administrator to NTSB, March 23, 2016.
[18] Letter from FRA director of safety analysis to NTSB, February 16, 2017.
[19] Letter from FRA executive director performing the duties of the administrator to NTSB, March 30, 2017.

As of January 18, 2018, Safety Recommendation R-16-044 is currently classified *Open—Unacceptable Action.*

However, on August 8, 2017, the FRA and FMCSA announced that they were withdrawing the 2016 ANPRM and would not continue developing a regulation to address sleep disorders by safety-sensitive railroad employees (*Federal Register* 2017e). This is particularly disappointing because the NTSB has recommended improvements to the medical screening and fitness-for-duty standards for railroad employees in reports since the investigation of the 2001 Clarkston, Michigan, accident. After 16 years, the railroad industry is still under no obligation to screen employees for sleep disorders. The NTSB concludes that the unwillingness of the FRA to address the issue of employee fatigue due to OSA and other sleep disorders, most recently evidenced by the August 2017 withdrawal of the ANPRM, jeopardizes public safety.

In both of these accidents, the engineers were later diagnosed with severe OSA. The NTSB concludes that these accidents demonstrate the need for effective screening programs to reduce the risk of safety-sensitive employees with OSA operating trains.

The NTSB further concludes that since the FRA did not implement Safety Recommendation R-12-16 or comply with the legislated time limit in the RSIA to require railroads to develop and implement fatigue management plans, NJT and LIRR were not required to have a screening and treatment program for OSA. Therefore, NTSB reiterates safety recommendations R-12-16 and R-16-044.

Despite FRA's failure to create robust OSA screening and treatment regulations, some railroads have attempted to improve their screening process for OSA and other sleep disorders. As a result of the Red Oak, Iowa, accident, NTSB issued the following recommendation to BNSF, which was parallel to Safety Recommendation R-12-16.

<u>R-12-26</u>

> Medically screen employees in safety-sensitive positions for sleep apnea and other sleep disorders (NTSB 2012a).

Safety Recommendation R-12-26 is currently classified *Open—Acceptable Response.*

BNSF explained the challenges to implementing the recommendation and expressed the need for regulatory standards to require a sleep disorder screening process in its August 23, 2012, response:

> Previous attempts by BNSF to require additional medical information about certain safety related medical conditions, specifically including attempts to obtain medical information on sleep apnea, met with stiff resistance from our labor organizations… Simply stated, until there are some federal standards on medical qualification for such conditions as sleep apnea, other sleep disorders or, medical conditions that

> affect an employee's ability to work safely, it will be difficult to obtain and use such information without facing a variety of legal challenges.[20]

As mentioned in section 5.1, NJT had a sleep disorder screening process in place at the time of the accident. However, the engineer's medical provider failed to complete the form and follow the procedures that would have identified his risk factors for OSA. Further, the conductor and brakeman had risk factors for sleep apnea that were also not being addressed. Since the accident, NJT has modified its screening and treatment protocols to ensure at-risk safety-sensitive personnel are appropriately screened and treated. Following the revision of the program several engineers have been identified with OSA, referred for treatment, and successfully returned to duty, demonstrating the importance of comprehensive OSA screening and treatment programs. The NTSB concludes that the NJT OSA screening and treatment program should reduce the risk safety-sensitive employees with undetected and untreated OSA pose to rail safety.

After multiple accidents at Metro-North over a 10-month period, NTSB published *Organizational Factors in Metro-North Railroad*.[21] Over the course of the investigation, NTSB recognized the similarities between the commuter railroads within the MTA, and as a result, recommended the following to LIRR:

> R-14-65
>
> Develop and implement protocols to routinely screen and fully evaluate your safety-sensitive employees for sleep disorders and ensure that such disorders are adequately addressed, if diagnosed (NTSB 2014c).

LIRR responded in a February 11, 2015, letter and stated that it was currently addressing sleep disorders with new employees and current employees who had a job change. LIRR added that it was working with Metro-North (a sister property under MTA) to develop a medical protocol related to sleep disorders. However, the railroads had not begun to routinely screen all employees.[22]

NTSB considered these to be steps to further safety, but noted that LIRR did not fully implement the recommendation. On August 20, 2015, NTSB notified LIRR that the status of Safety Recommendation R-14-65 would be classified *Open—Acceptable Response*, but requested that LIRR keep NTSB informed about LIRR's efforts to complete the recommended actions.

At the time of the Atlantic Terminal accident, LIRR had limited OSA screening efforts (only for hiring and job changes). However, these screening efforts failed to diagnose the engineer. LIRR also provided training for all employees on preventing fatigue. During its investigation, the NTSB determined that although the MTA training stated that employees should get 8 hours of sleep in a 24-hour period, it did not specify that these 8 hours should be contiguous. This training also contained no warnings against desynchronizing sleep patterns on days off duty. Since the accident, MTA has revised the fatigue training and corrected these issues.

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[20] Letter from BNSF vice president to NTSB, August 23, 2012.
[21] Metro-North is a subsidiary of MTA, as is LIRR.
[22] Letter from LIRR president to NTSB, February 11, 2015.

Meanwhile, MTA started an OSA screening-program trial at a sister company, Metro-North. In April 2016, MTA announced it planned to integrate other subsidiary agencies, including LIRR, into its occupational health program and initiate OSA screening for all MTA safety-sensitive employees. However, the integration did not begin until March 2017 and, therefore, the OSA screening program for safety-sensitive employees had not yet begun at the time of the January 2017 accident. The LIRR engineer had the risk factors which, if identified in the MTA OSA screening program, would likely have resulted in his referral for a sleep study. A sleep study likely would have identified his severe OSA.

Since the accident, LIRR has implemented the MTA OSA screening program to ensure that safety-sensitive personnel are appropriately screened and that referral guidance is followed. MTA and LIRR are currently identifying engineers with OSA and referring those engineers for extra testing and possible treatment. Several engineers have been identified with OSA since this policy has been implemented, demonstrating the importance of comprehensive OSA screening programs. The NTSB concludes that the MTA OSA screening and treatment program should reduce the risk safety-sensitive employees with undetected and untreated OSA pose to rail safety.

6. Collision Avoidance/Mitigation

6.1 Positive Train Control

RSIA required each Class I railroad over which poison- or toxic-by-inhalation hazardous materials are transported and each entity providing regularly scheduled intercity or commuter rail passenger transportation to implement a PTC system by December 31, 2015.[23]

The Positive Train Control Enforcement and Implementation Act of 2015 extended the deadline for PTC implementation until December 31, 2018, and contained provisions for railroads to request an additional 24-month extension.[24] The act also prohibits the FRA from imposing monetary fines on railroads that do not meet the extended deadline until 2021. Additionally, the act requires each railroad to file a revised implementation plan and annual progress reports detailing the extent to which they are meeting the schedule set forth in those plans with the DOT. DOT is required to make the annual progress reports available to the public within 60 days of receiving them.

6.1.1 New Jersey Transit

NJT expects to complete its PTC system in December 2018. NJT will implement a PTC system identical in function to that provided by Amtrak on the Northeast Corridor, referred to by Amtrak as the Advanced Civil Speed Enforcement System (ACSES II) with cab signal system (CSS). This PTC package is referred to by NJT as the Advanced Speed Enforcement System, second generation (ASES II). It provides identical features and functions and is fully compatible and interoperable with Amtrak's ACSES II. The existing CSS continues to provide train separation and signal speed enforcement while the ASES II system complements the CSS and provides the other required PTC functions. The two systems (CSS and ASES II) are functionally independent, although they do report status and transfer certain data between them.

Federal regulation permits certain main line tracks to be excluded from PTC requirements.[25] NJT designated certain line segments, including the terminal interlocking at Hoboken, in its January 2016 *Positive Train Control Implementation Plan*, (PTCIP), as "other-than-main line track", thus exempting them from PTC requirements. The Hoboken terminal area includes 20 track terminus points. The terminal consists of 17 passenger-platform tracks, each with an eastbound fixed inoperative stop signal at the end of the terminating tracks; and 3 additional tracks at the southern limits of the terminal. Although the train speeds will be slower, no technology will prevent the train from colliding with the end of the track.

6.1.2 Long Island Rail Road

On August 10, 2010, LIRR filed its *Positive Train Control Implementation Plan* (rev 2.1). After some revisions, the FRA granted provisional approval of the LIRR *Positive Train Control*

[23] Public Law 110-432, section 104, October 16, 2008.
[24] Public Law 114-73, section 1302, October 29, 2015.
[25] Title 49 *CFR* 236.1019.

Implementation Plan (rev 2.2) on July 7, 2011. According to the 2016 fourth quarter update report, LIRR reported to FRA a planned timeline for full implementation of PTC by December 2018.

However, LIRR requested and FRA approved an other-than-main line exception for PTC at Atlantic Terminal station. LIRR operating rules will limit the authorized track speeds to 5 mph, although no technology will automatically enforce this limit and no technology will prevent the train from colliding with the end of the track.[26]

6.1.3 Federal Railroad Administration

In summary, all passenger railroads—including NJT and LIRR—that operate terminals with terminating tracks have asked to be excluded from the requirement to install PTC, and the FRA has granted all the requests. The NTSB concludes that, as evidenced by these two accidents, relying solely on an engineer's ability to stop his or her train before reaching the end of these tracks does not provide the level of safety necessary to protect the public. Further, the NTSB recommends that the FRA require intercity passenger and commuter railroads to implement technology to stop a train before reaching the end of tracks.

6.2 Bumping Posts

The bumping posts were destroyed in both the Hoboken and Atlantic Terminal accidents. The bumping posts at these accident locations could only provide protection for low-speed impacts. Further, according to a representative from a bumping post manufacturer, "Everything is designed on the assumption that there is no power at the point of impact."[27] In both accidents, the trains were still under power when they struck the end of the track. Currently, without PTC installed there are no mechanisms to prevent intercity passenger trains or commuter trains from being under power when they reach the end of a track.

Some bumping posts can absorb more energy than those in these accidents, but they require more space at the end of the track and/or retarding mechanisms. Bumping posts other than stationary barriers are normally designed with either high-speed impacts or low-speed impacts in mind. Friction mechanisms are suited to reducing high speeds, whereas hydraulic systems can mitigate slower impacts. The friction mechanisms slide along the track after being struck by a train. The higher the speed, the longer the distance needed to slow and stop the train. Most railroad terminals and their terminating tracks have been in place for many years, and do not have the physical space needed to expand the tracks to a size necessary to install these friction mechanisms. Further, if the friction mechanisms are installed on existing tracks, the platform area would be reduced and could only allow access to several cars at the front of the train. This is counter to the needs at a terminating station where normally the passengers need to enter and exit all of the cars of the train.

Even with these upgrades, there is an upper limit of the allowed impact speed and train weight that can be absorbed by either kind of bumping post. Both the speed and weight of the train contribute to the force that must be absorbed by the bumping post. Also, the speed of the train

[26] See NTSB Docket, Brooklyn, New York, DCA17FR002, "Bulletin 1038-B 5 mph Speed Restriction."
[27] See NTSB Docket, Brooklyn, New York, DCA17FR002, "Interview with Bumping Post Manufacturer."

must be slowed at an acceptable rate so that the passengers are not abruptly thrown forward, which could cause injuries. Train weights can vary greatly. Railroads can add cars to trains in response to changes in ridership. Without PTC, the current speed control systems allow the train speeds to exceed the majority of bumping post designs. The NTSB concludes that bumping posts, of the type used at Hoboken and Atlantic Terminals, alone do not provide adequate protection at the end of a track.

7. System Safety

For over three decades, the NTSB has expressed concern about the lack of safety management and preventative maintenance. More recently, NTSB investigations have often revealed that SMS programs or system safety programs could prevent injuries and the loss of life. Many factors could be involved in a transportation accident. However, there is often evidence of a continuous safety program long before the accident occurred.[28] These programs are intended to protect against the development of unsafe conditions. Upon examination, however, some programs have proven ineffective.

The system safety program plan (SSPP) outlines the systematic procedures and policies of an organization's system safety. The SSPP is the first element of a formal process for applying safety management principles and is the basis for identifying all hazards. SSPPs are designed as roadmaps to aid in monitoring operations and collecting appropriate data to identify emerging and developing safety problems before they result in death, injury, or significant property damage. Risk identification, assessment, and appropriate mitigation are critical elements in an effective SMS.

SMS is the formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls and includes systematic procedures, practices, and policies for the management of safety risk. An SMS is an organized approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures (NTSB 2012c). The SMS structure process obligates organizations to manage safety with the same level of priority that other core business processes receive.

SMS can indicate the status of an organization's safety culture. Noted researcher Dr. James Reason has indicated that organizations with weak safety culture will have more active failures, as well as latent conditions that undermine safety. Active failures are the errors and violations committed by those in direct contact with the system. Latent conditions can lie hidden and dormant for many years before they combine with active failures and lead to an accident. According to Reason, perhaps the most insidious and far-reaching effects of a weak safety culture are shown by an organization's reluctance to proactively address known safety shortcomings (Reason 2013).

NTSB addressed SMS in its investigation into an April 3, 2016, accident in which an Amtrak train struck a backhoe near Chester, Pennsylvania. An important concept related to safety culture is safety management, which is one component of a safety program. Generally, safe organizations have a system in place to manage safety, which is called an SMS. It includes systematic procedures, practices, and policies for the management of safety risks (NTSB 2017).

Further, an SMS is a structured process that obligates organizations to manage safety with the same level of priority that other core business processes are managed. Safety culture and SMS programs are interconnected. A safety culture is a manifestation of the internalization of the SMS program on the part of the employees in the organization. The SMS program should take account

[28] *Safety Management Systems*, National Transportation Safety Board website, 2012, accessed September 18, 2017.

of and shape the safety culture of the organization. Effective SMS programs instill and reinforce a safety culture among employees, and that safety culture ensures the effective implementation of the policies, principles, and practices set forth by the management system (NTSB 2017).

SMS programs have four functional characteristics:

1. Corporate policies and procedures for safety and safe operations
2. Safety assurance controls that serve as checks and balances for the implementation of safety policies and practices and also as a feedback mechanism to inform management about the effectiveness of the safety programs
3. Risk management, a formal system of hazard identification, analysis, and mitigation, which informs employees about safety hazards and provides sufficient insights to control risks to acceptable levels
4. Safety promotion which conveys to all workers that safety is a core value of the organization (which has established practices that support safety and in which management participates) (NTSB 2017)

An SSPP is a primary component for applying the principles of system safety.[29] The American Public Transportation Association (APTA), describes SSPPs as follows:

> System safety is the management and engineering discipline that addresses these needs and the System Safety Program Plan (SSPP) is the first element of a formal process for applying its principles.
>
> A well-written SSPP will provide the basis for identifying any and all hazards that might interfere with customer and employee safety, as well as the public at large. It will provide for safety reviews of capital improvements, changes in equipment, and changes in operating practices and will include or refer to concrete methods for eliminating, minimizing, and otherwise mitigating these hazards. A SSPP also defines the lines of responsibility and authority for addressing potential hazards in an organization, and establishes safety and security tasks for departmental units that have a lead or a support role in implementation of those responsibilities (APTA 2006).

The APTA *Manual for the Development of System Safety Program Plans for Commuter Railroads* identifies 23 elements for commuter railroads to consider when developing an SSPP. The section on hazard management process pertains to the issues involved with a train colliding with the end of a track. The APTA guide states:

> The hazard identification/resolution process is perhaps the heart of the System Safety Program. While there has been much written about the level of formality needed for this section of the program, it remains an individual matter for each transit system to fit the proper process to its respective organization. The important

[29] According to the American Public Transportation Association (APTA), a *system safety program* "provides consistent, comprehensive safety guidance in a form that ensures continuity during changes in staff, infrastructure, and operating practices and conditions. Such a program must be adequately planned, organized, documented, and staffed" (APTA 2006).

> element that must be included in a fully developed System Safety Program is the mechanism, accessible to all levels of the organization, by which hazards are identified, analyzed for potential impact on the operating system, and resolved in a manner acceptable to general management. The entire Hazard Management process is nothing more than a formalized procedure for risk acceptance by the commuter railroad management staff. It allows for a systematic hazard identification process and a coordinated hazard effects minimization process. The Hazard Management process usually resides with the safety unit of the commuter railroad organization, which is responsible for all supporting documentation and coordination (APTA 2006).

FRA describes system safety as a structured program with proactive processes and procedures to identify then mitigate or eliminate hazards and the resulting risk to the railroad's system (*Federal Register* 2012).[30] The FRA further states that the main components of an SSPP are the risk-based hazard management program and risk-based hazard analysis to identify risks and mitigate or eliminate those hazards.

Both the FRA and APTA recognize the importance of hazard management as part of an SSPP. The NTSB agrees that "the hazard identification/resolution process is perhaps the heart of the System Safety Program" and recognizes the importance of a formal documented process that shows a deliberate decision-making process to either reduce or eliminate a hazard (APTA 2006).

7.1 New Jersey Transit System Safety

NJT implemented its current SSPP, *Rail System Safety Program Plan,* on October 31, 2011, and it was in effect at the time of this accident (NJT 2011).[31] NJT voluntarily adopted the guidelines of the APTA *Manual for the Development of System Safety Program Plans for Commuter Railroads* as guidance in developing this plan and included APTA's elements in its SSPP (APTA 2006). NJT took this action in anticipation of federal rulemaking requiring commuter railroads to develop and implement SSPPs.

From 1997 until 2012, APTA audited NJT's SSPP every 3 years. The 2012 APTA audit focused on the SSPP and did not comment on the property's physical characteristics. NJT had an outside consultant audit the program in 2015, and plans to have the next audit in 2018. Although NJT's SSPP states that one of NJT's safety objectives is to update its SSP annually, NJT had not revised its SSPP in the 5 years prior to the accident.

The NJT SSPP describes system safety as follows:

> System Safety is an overall, integrated, coordinated effort on the part of all managers and the rail Safety Department and is designed to:
>
> - Preserve life and property.

[30] Title 49 *CFR* Part 270.
[31] NJT developed its first *Rail System Safety Program Plan* in 1997.

- Control, eliminate or reduce hazards to the lowest possible level.
- Reduce and prevent accidents.
- Minimize and control the effects of accidents and incidents.
- Maintain the safe operation of the system.
- Ensure that safety is an integral part of all personnel decisions, plans, specifications, designs, tests, procedures and operations (NJT 2011).

The NJT SSPP outlines its practices for hazard analysis in Section 3 *Hazard Management Processes*, based on the United States Department of Defense Standard Practice, "System Safety."[32] The NJT SSPP states that it also identifies hazards via safety committees through scheduled inspections, code compliance, and adherence to various governmental regulations. Lastly, the appropriate departments mitigate customer concerns about safety issues (NJT 2011).

The NJT SSPP describes the mechanism used to formally identify, analyze, and resolve hazards as critical elements. NJT performs a hazard analysis when the corrective action of a safety issue or root cause of an accident is not obvious or the designated reviewing committee cannot agree with the determination. In this situation, hazards are identified in terms of severity and probability of occurrence (NJT 2011).

NJT defines hazard severity as a "subjective measure of the worst result possible from an event that can result from personal error, environmental conditions, design inadequacies and/or procedure inefficiencies of the system" (NJT 2011). One of the tools NJT uses to determine hazard severity and responses is a matrix found in APTA's *Manual for the Development of System Safety Program Plans for Commuter Railroads.* The risk matrix is described further in section 7.4.

NTSB investigators interviewed NJT safety employees to gain insight into the NJT safety processes, particularly regarding measures for the prevention of single point failures. The employees said that the SSPP did not address such measures:

> The SSPP provides a guideline to rail operations for consideration of certain safety-oriented related activities. Its rulebook and special instructions that accompany it or complement it, there is where you would find the specific rule that speak to many, if not all operating environments.

When asked if the SSPP addressed whether there was redundancy for an operator failing to adhere to restricted speed rule requirements and if it contained mitigation strategies to address

[32] Although United States Department of Defense Standard Practice, MIL-STD-882E, effective May 11, 2012, is the current standard, a previous version, MIL-STD-882C, dated January 1993, was used by NJT in developing the SSPP and serves as the reference document for this section.

it, the NJT chief safety officer said, "it's more of a high-level document that would encourage the placement of rules that were more specific."[33]

The NJT system safety manager stated there was not a hazard analysis that would evaluate the potential for a collision between a train entering a stub end track and the bumping block because "it was never a major issue before."

The NJT SSPP section on safety data analysis states that NJT performed periodic analysis of employee and nonemployee injuries to determine injury trends and underlying causes. There is no mention of incorporating the hazard management procedures to determine, categorize, rank, and mitigate any risk associated with these events. The NJT risk management department also analyzes and categorizes information regarding the cost of accidents/incidents reported by external agencies.

NJT routinely used a checklist for inspections and audits. The SSPP discusses how to identify hazards and uses a Risk Matrix Hazard (similar to those found in section 7.4); however, when asked what method NJT uses to identify hazards and add those hazards on the checklist, as well as if there was a group seeking to identify hazards, NJT relied on rules as a mitigation for that risk.[34] NJT's system safety manager stated:

> This particular item [bumping post collision] was not on the checklist because it was not identified as a hazard as the other issues. … So, this issue about the collision with the bumpers, as I said—it was not a major issue experience-wide by the committee before. And we look—we depend upon the rules for the operations department to discuss that issue. For example, speed restriction, that kind of thing, they look at.[35]
>
> Further, NJT uses technology to supplement human performance.
>
> So, there's on-train technology and there's field technology that we rely on, trackway technology, that acts as an interface to the locomotives and to the lead cars, which will under the right circumstances slow and/or stop the train. … So, we rely on, obviously, the engineer. We rely on the on-board technology. We will, or communicate to the trains, to on-board equipment to slow and/or stop trains. … we also rely on that and not just the human being.[36]

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[33] (a) According to the *NORAC Operating Rules*, 10th edition, movements made at restricted speed must (1) control the movement to permit stopping within one-half the range of vision short of: (a) other trains or railroad equipment occupying or fouling the track, (b) obstructions, (c) switches not properly lined for movement, (d) derails set in the derailing position, (e) any signal requiring a stop; and (2) look out for broken rail and misaligned track; and (3) do not exceed 20 mph outside interlocking limits and 15 mph within interlocking limits. This restriction applies to the entire movement, unless otherwise specified in the rule or instruction that requires restricted speed. See NTSB Docket, Hoboken, New Jersey, DCA16MR011, "NORAC Operating Rules." (b) See NTSB Docket, Hoboken, New Jersey, DCA16MR011, "Interview with System Safety Managers."

[34] See NTSB Docket, Hoboken, New Jersey, DCA16MR011, "NJT System Safety Program Plan."

[35] See NTSB Docket, Hoboken, New Jersey, DCA16MR011, "Interview with System Safety Managers."

[36] See NTSB Docket, Hoboken, New Jersey, DCA16MR011, "Interview with System Safety Managers."

The Internal Safety Management Assessment Process section of the SSPP outlines the process for assessing the implementation level of the SSPP program elements where NJT objectively examines evidence to determine its own compliance with the SSPP.

The objectives of the internal safety assessment are:

- To verify that the safety programs have been developed and implements per the plan's requirements.
- To assess the effectiveness of the Rail System Safety Program.
- To identify program deficiencies.
- To identify potential hazards at NJ Transit Rail and to enhance the current safety programs.
- To verify corrective actions are being tracked.
- To recommend improvements to the Rail System Safety Program.
- To provide management with an assessment of the status and the adequacy of the Rail System Safety Program Plan (NJT 2011).

7.1.1 NJT End-of-Track Collisions

During the 10-year period between January 1, 2007, and December 31, 2016, in addition to the accident on September 29, 2016, NJT had seven reported accidents in which a train hit a bumping post. Three of those collisions happened at Hoboken Terminal.[37]

Hoboken Terminal has 17 stub end passenger train tracks. Visual evidence indicates that most of these bumping posts had been struck by trains or maintenance-of-way equipment during their life cycles. However, more incidents may or may not have been reported, based on their severity.

As a result of this accident, NJT issued instructions requiring the conductor to occupy the head end of the train for trains approaching the Hoboken and Atlantic City Terminals (NJT 2016a). On January 28, 2017, NJT extended this requirement by issuing instructions requiring the conductor to occupy the head end of trains approaching Penn Station in New York (NJT 2017).

Following this accident, NJT created a rule reducing the maximum authorized speed at Hoboken Terminal from 10 mph to 5 mph. NJT is also researching improving technology or modifying existing technology to augment the human performance aspect of operating a train into a terminating track. In addition, NJT began an analysis of bumping posts and a risk assessment of all stub end tracks at Hoboken Terminal.

[37] See NTSB Docket, Hoboken, New Jersey, DCA16MR011, "Previous NJT Bumping Post Accidents."

7.1.2 NJT Fitness for Duty

The NJT SSPP outlined the medical services department responsibilities, including ensuring the physical fitness of safety-sensitive employees associated with train movement. NJT required periodic physicals to determine physical fitness. The medical services department also administers special testing necessitated by state and federal mandates such as the Hearing Conservation Program and other programs associated with potential occupational hazards. NJT offered wellness and educational programs for its employees to promote a healthier workforce. It also had a screening program for undetected and untreated OSA, but had no discussion of that program in its SSPP.

As explained in section 5.1, NJT had a screening program for undetected and untreated OSA, but the program was not effectively managed. The investigation found evidence of systemic failures to follow program guidelines to screen individuals at risk for OSA and refer them for definitive diagnosis and treatment. Further, the SSPP program was not designed to monitor medical oversight of safety-sensitive employees and, as a result, was unable to identify potential shortcomings in the OSA screening program.

7.2 Long Island Rail Road System Safety

LIRR implemented its SSPP, effective May 14, 1986, and last revised the plan in February 2014. LIRR voluntarily used the APTA *Manual for the Development of System Safety Program Plans for Commuter Railroads* as guidance in developing the current plan (APTA 2006).

Every 3 years until 2014, APTA audited LIRR's SSPP. LIRR planned on having an outside consultant audit its safety program, including the SSPP, beginning in 2017. The state of New York Department of Transportation Public Transportation Safety Board recertified LIRR in its Resolution #2098, dated May 15, 2014.

LIRR outlines the hazard identification, resolution process, and mechanisms available for all levels of its organization in Section 5.1, *Hazard Management Process* of its SSPP (LIRR 2014). This process is the means LIRR uses to identify hazards, analyze the potential impact of them on the operating system, and provide guidance on how to resolve the issues caused by those hazards in a manner acceptable to management. LIRR stated:

> Just as a hazard can result in an accident, the risk is related to the probability that frequency, intensity and duration of a stimulus that will be enough to transfer the hazard to the state of loss. Risk is the probability of a mishap in terms of hazard severity and hazard probability (LIRR 2014).

The LIRR SSPP describes the risk index—a process to generate a hazard rating by combining severity and probability in its section on the hazard management process. LIRR would then prioritize hazards based on the risk index.[38]

[38] The APTA SSPP provides guidelines for hazard analysis and refers to the United States Department of Defense Standard Practice, "System Safety", MIL-STD-882 E, which has become the foundation for the majority of customized matrixes and tables for identifying the level of risk associated with a hazard.

The greater the risk, the more complex the mitigation to reduce the risk and eliminate the hazard. The following four methods are described and listed in order of preference:

1. Design for minimum hazard
2. Safety devices
3. Warning devices
4. Procedures and instructions (LIRR 2014)

The SSPP also provided guidance if a hazard was identified with an unacceptable risk. In that case, LIRR would stop operations until correction or control of the identified hazard was reduced to an acceptable level (LIRR 2014).

In its section on safety data acquisition analysis, the LIRR SSPP discussed hazard management, referencing hazard identification as a principle for preventing errors before they happen. This section used a statistical analysis approach to describe how data from accidents, risk and risk ratings, and trends are elements of hazard management. LIRR gathered data from multiple sources including accident investigations, employee and passenger injury reports, employee and customer forms, customer letters, police reports, notices of claims, the employee "Safety One-Call Number," and external agency data from the federal government and the railroad industry to develop its analysis.[39]

The LIRR Deputy Chief Safety Officer (DCO) said in an interview with NTSB investigators that the LIRR SSPP was based on an APTA standard, stating:

> The APTA standard is a consensus standard. There are discrete elements that are identified therein. We use—we put those elements into our plan and then we expound upon them to describe the basis for the flag hazards on the Long Island Rail Road and resolving those.[40]

When asked how the LIRR SSPP and the APTA elements addressed the Atlantic Terminal, he responded:

> There's various sections that would apply. Mostly the sections on emergency response would describe how we plan for and train on emergency response actions. There are sections for various departments and how they deal with the hazards down at the facility. So, the transportation folks specific to the incident. There's various descriptions on how [to] qualify our train crews, how we train them. There are standards that they are expected to hold, the tests and audits that the department does in order to ensure that those standards are upheld.

The DCO was asked whether the Atlantic Terminal, through either the walks or through the APTA standards, been identified as a potential hazard with the possibility of a single point failure of a trainman losing control of the train coming into the station." The DCO responded:

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[39] The *Safety One-Call Number* is a method for LIRR employees to report safety issues.

[40] See NTSB Docket, Brooklyn, New York, DCA17FR002, "System Safety Managers Interview."

> I don't know that the plan specifically identifies that particular issue. It identifies the methods by which we identify those hazards. So, in the past, when the signal system was designed, those—and rules that were put into effect were probably considered.
>
> We use the plan in order to prioritize the hazards that we encounter for mitigation. That specific hazard was not identified in the plan, [it] was not the document for that.

However, during the accident investigation, LIRR provided the following explanation addressing the hazard of a train operating into a terminating terminal track:

> LIRR implemented mitigations, such as restricted speed and bumping posts, based on historical data of incidents at this location.[41] As a result of an FRA Safety Advisory issued December 2016, we instituted a second qualified person in the cab. This was to go into effect the day of the incident. The SSPP describes the process used to identify and mitigate risks. It is not intended to describe the specific risks and mitigations for each location.

NTSB noted that LIRR used "procedures and instructions"—the LIRR's least-preferred method—to mitigate the hazard. Even though the bumping post was shown as a mitigation, NTSB does not agree that railroads should rely on a bumping post to prevent collisions or to reduce the severity of collisions.

7.2.1 LIRR End-of-Track Collisions

LIRR provided data on 15 collisions between LIRR trains and bumping posts between 1996 and 2010, two of which happened at Atlantic Terminal.[42] These accidents were relatively minor—in total, two employees and no passengers were injured. LIRR determined that in 14 of the 15 collisions, the accident was caused by the crew failing to control the train movement.

FRA published Safety Advisory 2016-03 on December 5, 2016, in response to the Hoboken accident, urging railroads to "take more robust action to address human factors that may cause accidents and to enhance protection of railroad employees and the public" (*Federal Register* 2016b). The advisory recommended, among other actions, that railroads require crews to communicate with one another:

> Adopt procedures requiring communication between crew members and the locomotive engineer before and during operation into a station or terminal and/or

[41] According to the *Long Island Rail Road Rules of the Operating Department, (Second Edition)*, *restricted speed* is a mode of operation, at which a train can be stopped within one-half the range of vision, short of the next signal, another train, obstruction, derail, or switch improperly lined, looking out for broken rail or crossing protection not functioning, while not exceeding 15 mph.

[42] See NTSB Docket, Brooklyn, New York, DCA17FR002, "Bumping Post Incidents at Passenger Terminals from 1997 to January 2017."

> implement technology to appropriately control and/or stop the train short of the stub end track.

LIRR distributed FRA Safety Advisory 2016-03 to its workforce and developed General Notice No. 2-52 with specific instructions to its train crews.[43] The notice was developed in response to the NJT accident in Hoboken, New Jersey, and went into effect on January 4, 2017, at 5:01 p.m., following the 8:18 a.m. accident at Atlantic Terminal. The new instructions required that a qualified and authorized crewmember be positioned on the head end of the train with the engineer when approaching stations with stub end tracks, including the stations at Long Island City, Greenport, Montauk, Atlantic Terminal, Far Rockaway, Long Beach, Port Washington, Hempstead, and West Hempstead (LIRR 2017). The added crewmember would assist the engineer in complying with all applicable rules and/or special instructions including, but not limited to, calling out signals, checking switch points for proper positioning, and confirming the engineer complied with the maximum authorized speed for the train. The notice required that the engineer stop the train prior to entering the yard or interlocking before one of the named stations if the added crewmember was not on the head end of the train (LIRR 2017). In an interview with NTSB investigators, the DCO said that prior to this notice requiring another qualified employee to be with the engineer when entering stations, LIRR had been concerned that an additional crewmember in the head end of the train may create a distraction to the engineer. The DCO said that LIRR had held the philosophy that the "locomotive engineer cab was to be kept sterile."

During the investigation into the May 12, 2015, derailment of Amtrak Train 188 in Philadelphia, Pennsylvania, NTSB explored the potential safety improvements involved in adding a second qualified crewmember in a locomotive cab:

> The NTSB agrees that relying on a single person to make correct decisions can result in a single point failure. This single-point failure will be substantially addressed by full PTC implementation since that system will provide an independent automated means of compliance with speed and signal restrictions in case of human error. In areas where PTC is not implemented, other ways of addressing this single point failure may be necessary. It is unclear if a two-person crew would satisfactorily address this issue because there is insufficient data to demonstrate that accidents are avoided by having a second qualified person in the cab. In fact, the NTSB has investigated numerous accidents in which both qualified individuals in a two-person crew made mistakes and failed to avoid an accident (NTSB 2016a).

As a result of this investigation, NTSB made several recommendations to the FRA, including the following two recommendations regarding the number of crewmembers in a locomotive cab.

[43] See NTSB Docket, Brooklyn, New York, DCA17FR002, "General Notice No. 2-52."

<u>R-16-33</u>

Modify form 6180.54 (Rail Equipment Accident/Incident Report) to include the number of crewmembers in the controlling cab of the train at the time of an accident.

<u>R-16-34</u>

After form 6180.54 is modified as specified in Safety Recommendation R-16-33, use the data regarding number of crewmembers in the controlling cab of the train at the time of an accident to evaluate the safety adequacy of current crew size regulations.

The FRA responded to these recommendations in August 2017, and as of November 2017, the response is currently being evaluated. These recommendations are currently classified *Open—Initial Response Received*.

Although there are benefits to adding a second crewmember to a locomotive cab, these benefits cannot be quantified until the FRA accident database is analyzed and can reflect the presence of a second crewmember.

7.2.2 LIRR Fitness for Duty

The LIRR SSPP outlined the processes used by its human resources department employees for pre-employment background checks, pre-employment drug screening and FRA- and FMCSA-required random drug testing.[44] The LIRR medical facility also performed physical ability screening to assess applicants' and employees' ability to perform the essential functions of the job. This also included provisions for disability management and employee services.

The LIRR fitness for duty program included the LIRR drug and alcohol program that covered all LIRR employees. This section included the intention and description of this program to prevent accidents, incidents, and losses resulting from alcohol and drug use. It also defined alcohol and drug-testing requirements and outlined applicable employee assistance program services.

The LIRR SSPP identified its medical department as responsible for employees' fitness for duty following an accident or incident. However, the LIRR SSPP did not outline any process for managing fitness for duty other than as part of its disability management program and postaccident or incident.

The LIRR SSPP did not have a section to address fatigue management; however, it had a training course that focused on fatigue and alertness for employees in the railroad industry. Although LIRR had begun the initial planning, under MTA's guidance, for an OSA screening program at the time of the accident, it had not yet been implemented. The SSPP was silent on the

[44] LIRR SSPP Section 3.5.1.2 *Human Resources*.

hazards associated with undiagnosed and untreated OSA and did not specifically include this hazard in its hazard management plan (LIRR 2014).

7.3 Discussion

The NTSB recognizes that NJT and LIRR voluntarily implemented system safety programs prior to the accidents and followed the suggested *Manual for the Development of System Safety Program Plans for Commuter Railroads.* Further, both railroads used the audit process to evaluate and improve their programs. However, when investigating these accidents, NTSB did not find evidence of either of the railroads having a formal hazard analysis for trains operating into a terminal track, despite both railroads having experienced earlier accidents where trains had struck the bumping post at the end of the track. Although the accidents were significantly less severe than the accidents discussed in this report, they established that the hazard existed and another accident could occur. The NTSB concludes that both the NJT and the LIRR SSPPs were ineffective in identifying operational hazards associated with operating trains into terminal tracks.

Table 2 shows the risk matrix hazard categories from the *Manual for the Development of System Safety Program Plans for Commuter Railroads.*

Table 2. Risk Matrix Hazard Categories from *Manual for the Development of System Safety Program Plans for Commuter Railroads*.

	Hazard Categories			
Frequency of Occurrence	**I Catastrophic**	**II Critical**	**III Marginal**	**IV Negligible**
A – Frequent	1A	2A	3A	4A
B – Probable	1B	2B	3B	4B
C – Occasional	1C	2C	3C	4C
D – Remote	1D	2D	3D	4D
E – Improbable	1E	2E	3E	4E

Using the matrix from the *Manual for the Development of System Safety Program Plans for Commuter Railroads*, the collisions at Hoboken and Atlantic Terminals had catastrophic or critical outcomes. For example, using the left side of the table above, the frequency of occurrence for these accidents would be B – Probable, because both railroads had previous collisions with the end of tracks.[45] Moving to the right of the table after selecting B – Probable, these accidents would either be classified as a 1B or 2B within the hazard categories because the accident at Hoboken resulted in one fatality and caused major structural damage and the accident at Atlantic Terminal caused major structural damage.

[45] According to MIL-STD-882, the qualitative definition of probable is that it will occur several times in the lifecycle of a particular item, whereas the qualitative definition of occasional is that it is likely to occur at some point in the lifecycle of the item.

The APTA publication provides suggested actions for each of the hazard categories. According to Table 3, the hazard of colliding with the end of the track classified as a 1B or 2B hazard category, should have been identified as an unacceptable risk and eliminated (APTA 2006).

Table 3. Suggested Responses to Risk Matrix Hazard Categories.

Risk Matrix Hazard Category	Suggested Action
1A, 1B, 1C, 2A, 2B, 3A	Unacceptable, eliminate hazard.
1D, 2C, 2D, 3B, 3C, 4A, 4B	Undesirable, upper management decision to accept or reject risk.
1E, 2E, 3D, 3E	Acceptable with management review.
4C, 4D, 4E	Acceptable without review.

Even though both railroads had system safety programs that included hazard management, neither NJT nor LIRR recognized the unacceptable risk of an end-of-track collision. Further, in both of these accidents, the railroads relied on standard operating procedures and compliance with operating rules (speed restrictions) by the locomotive engineers to prevent a collision. However, in both cases the engineers were impaired due to fatigue and failed to effectively control the trains. These single point failures resulted in catastrophic damage, injuries, and death. The NTSB concludes that the use of operating rules and procedures to mitigate end-of-track collisions was an inadequate method for preventing these accidents because it failed to eliminate the possibility of a single point failure. As stated in section 6.1.3, the NTSB recommends that the FRA require intercity passenger and commuter railroads to implement technology to stop a train before it reaches the end of tracks. Further, the NTSB concludes that NJT and LIRR did not consider that the previous end-of-track collisions represented an increased risk of future accidents. Therefore, the NTSB recommends that NJT and MTA review and revise the hazard management portion of their SSPPs to ensure that they document previous incidents and use them when identifying and assessing operational hazards.

Both NJT and LIRR had extensive descriptions of their drug and alcohol policies in their respective SSPPs. The NJT SSPP speaks briefly to fatigue management, but LIRR's does not. Both railroads' SSPPs are silent on the need for mitigation of OSA awareness, identification, and treatment to prevent accidents. Neither railroad included undiagnosed or untreated OSA in their hazard management programs or identified it as a hazard in their SSPPs. The NTSB concludes that if both the NJT and the LIRR SSPPs had identified OSA screening as a risk-reduction action when evaluating employees for fitness for duty, it would have been unlikely that these employees would have been operating trains with undiagnosed and untreated OSA. Therefore, the NTSB recommends that NJT and MTA ensure that operator impairment due to medical conditions, including OSA, is part of the hazard management portion of their SSPPs.

7.4 Federal Railroad Administration System Safety

The FRA issued Emergency Order No. 20, on February 20, 1996 (FRA 1996). This document was issued in response to February 1996 accidents involving NJT and Maryland Rail Commuter Service trains (NTSB 1997a; 1997b). Part of the order required commuter and intercity passenger railroads to develop an interim system safety plan addressing the safety of operations that permit passengers to occupy the leading car in a train. Specifically, it said, "this order will require railroads operating scheduled intercity or commuter rail service to conduct an analysis of their operations and file with FRA an interim safety plan indicating the manner in which risk of a collision involving a cab car is addressed." According to the FRA, the initial plans that were submitted were inadequate (*Federal Register* 2012).

The FRA issued an ANPRM for passenger equipment safety standards on June 17, 1996, which included information for the proposed system safety program and details on proposed SSPPs (*Federal Register* 1996).

In the past, APTA had primarily provided guidance for transit properties and not FRA-regulated railroads. When the FRA issued a notice of proposed rulemaking (NPRM) for the system safety regulation in September 2012, they provided the following history of APTA's involvement with the commuter railroads:

> On June 24, 1996, the chairman of APTA's Commuter Railroad Committee sent a letter to FRA to announce that APTA commuter railroads were in compliance with the requirements of EO [Emergency Order] 20 and agreed to adopt additional safety measures, including comprehensive system safety plans. These comprehensive system safety plans were broader in scope than the interim plans had been and were modeled after the Federal Transit Administration's (FTA) [Title 49] Code of Federal Regulations (CFR) Part 659 system safety plans, which were being successfully used by rapid transit authorities and include a triennial audit process. (*Federal Register* 2012)[46]

In 1997, within a year of EO 20 and the submission of the ANPRM, APTA, the commuter railroads, FRA, and DOT developed the *Manual for the Development of System Safety Program Plans for Commuter Railroads*. Using the manual, commuter railroads, including NJT and LIRR, developed or updated their SSPPs. The triennial audit process of these plans began in early 1998 with the FRA's participation (*Federal Register* 2012).

In March 1996, the FRA established an RSAC subgroup, which "provides a forum for collaborative rulemaking and program development" (*Federal Register* 2012). Through participation in an RSAC, railroads, labor organizations, suppliers, and manufacturers can openly discuss the impact of potential regulations and provide the FRA with insights necessary to develop more effective safety regulations. Within the full RSAC, there are working groups that study and discuss a broad topic such as passenger safety. In some cases, the working groups form a subgroup (task force) to address a particular subject.

Soon after the RSAC was formed, the Passenger Safety Working Group was established, with LIRR as a member, to review passenger equipment safety needs and programs. Over the years, this group has proposed recommendations for the full RSAC to consider (*Federal Register* 2012).

In 2006, the Passenger Safety Working Group established the General Passenger Safety Task Force to study the issues pertaining to door securement, passenger safety in train stations, and SSPPs. LIRR and NJT were members of the task force.

[46] FTA's system safety plans are outlined in 49 *CFR* Part 659.

At the second meeting of the task force in April 2007, the System Safety Task Group was created. This group maintained the same membership as the General Passenger Safety Task Force, and was charged with identifying the core elements and features of a system safety program and prepare draft language for a potential system safety regulation to present to the full RSAC.

The group met seven times between June 2008 and March 2012 and eventually produced recommended draft language for a system safety regulation.

Meanwhile, Congress passed the RSIA, which directed the secretary of transportation to issue a regulation requiring certain railroads to develop, submit for review and approval, and implement a railroad safety risk reduction program.[47] The secretary of transportation delegated the responsibility for issuing the necessary regulation to the FRA administrator (*Federal Register* 2012).

The RSIA also contained instructions to identify information the railroads gather while preparing their hazard assessments that should be protected from use in civil proceedings. The FRA contracted a law firm to analyze this directive. On October 21, 2011, the law firm produced a final report, *Study of Existing Legal Protections for Safety-Related Information and Analysis of Considerations For and Against Protecting Railroad Safety Risk Program Information*, giving the FRA guidance in preparing the regulation.

On May 21, 2012, the RSAC adopted regulation language that was proposed by the System Safety Task Group and forwarded through the Passenger Safety Working Group.

The FRA used most of the language from the RSAC recommendation and added the protection from public release of specific information. On September 7, 2012, the FRA published an NPRM, which included the draft regulation in 49 *CFR* Part 270: *System Safety Program*. The NPRM stated:

> An SSP would provide a railroad with the tools to systematically and continuously evaluate its system to identify the hazards and risks that result from gaps in safety and to mitigate or eliminate these hazards and risks (*Federal Register* 2012).

In the introduction to the NPRM, FRA said, although it has "issued safety regulations and guidance that address many aspect of railroad operations, gaps in safety exist, and hazards and risks may arise from these gaps." They further expressed the belief that railroads are better positioned to identify some of the gaps and take the necessary action to mitigate or eliminate the arising hazards and resulting risks (*Federal Register* 2012).

On August 12, 2016, the FRA published its final rule for 49 *CFR* Part 270: *System Safety Program*, with an effective date of October 11, 2016. The FRA said that "A[n] SSP provides a railroad with the tools to systematically and continuously evaluate its system to identify hazards

[47] (a) Title 49 *USC* 20156, 20118, and 20119. Pub. Law 110-432, October 16, 2008. (b) Those certain railroads were (1) Class 1 railroads; (2) railroad carriers with inadequate safety performance, as determined by the secretary of transportation; and (3) railroad carriers that provide intercity rail passenger or commuter rail passenger transportation (passenger railroads).

and the resulting risks gaps in safety and to mitigate or eliminate these hazards and risks” (*Federal Register* 2016a).

FRA published a stay of the regulation on February 13, 2017, delaying the effective date of this rule from February 10, 2017, until March 21, 2017 (*Federal Register* 2017a). On March 21, 2017, FRA published another stay of the regulation from March 20, 2017, until May 22, 2017 (*Federal Register* 2017b). FRA again stayed the regulation until June 5, 2017 (*Federal Register* 2017c). FRA published another stay of the regulation, effective June 2, 2017, until December 4, 2017 (*Federal Register* 2017d). Most recently, effective November 30, 2017, the FRA published a stay of the regulation until December 4, 2018 (*Federal Register* 2017f). The FRA provided supplementary information in the latest stay of regulation saying that “the stay was consistent with the new Administration’s guidance issued January 20, 2017, intended to provide the Administration an adequate opportunity to review new and pending regulations.”

By issuing Emergency Order 20 in 1996, the FRA introduced the concept of system safety. Although the passage of the RSIA and the creation of RSAC and the General Passenger Safety Task Force have been positive steps to improve system safety, more than 20 years later, there is still no formal rule to implement system safety on our nation’s passenger railroads.

In its investigation into an April 3, 2016, accident in which an Amtrak train struck a backhoe near Chester, Pennsylvania, the NTSB concluded that “by delaying progressive system safety regulation, the FRA has failed to maximize safety for the passenger rail industry and the traveling public.” Therefore, the NTSB made the following recommendation:

R-17-17

Enact Title 49 *Code of Federal Regulations* Part 270, System Safety Program without further delay (NTSB 2017).

The accidents at Hoboken and Atlantic Terminal further illustrate that FRA’s formal system safety regulation would improve the effectiveness of railroad safety.

7.4.1 Guidelines for Hazard Analysis

In October 2007, the FRA developed and made available the *Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service* to provide a “step-by-step procedure on how to perform hazard analysis and how to develop effective mitigation strategies that will improve passenger rail safety.” These guidelines were based upon and closely followed the hazard management process discussed in APTA’s *Manual for the Development of System Safety Program Plans for Commuter Railroads*, but also gave examples of existing railroad hazard analysis worksheets. It also provided the necessary steps to evaluate hazards, such as a collision at the end of a terminating track (FRA 2007).

The structured hazard management process defined by both APTA and FRA is a significant element of the system safety program to prevent accidents and improve safety. NTSB believes that NJT and LIRR used inadequate mitigating measures because they failed to document the hazard analysis for the terminal tracks.

FRA's *Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service*, is a tool for intercity passenger and commuter railroads to properly identify hazards and determine the probability and severity of risks, thereby assisting them in selecting the appropriate mitigating measures to improve safety. The NTSB concludes that if the FRA, at a minimum, instructed railroads to use the *Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service* when identifying and mitigating hazards, commuter and intercity railroad safety would be improved. Therefore, NTSB recommends that FRA include the *Collision Hazard Analysis Guide for Commuter and Intercity Passenger Rail Service* as part of the regulation or part of a detailed compliance manual to assist railroads in implementing 49 *CFR* Part 270.

8. Conclusions

8.1 Findings

1. Lapses in the New Jersey Transit engineer's alertness prior to the accident resulted from his undiagnosed and untreated severe obstructive sleep apnea.

2. The failure of the New Jersey Transit obstructive sleep apnea screening program to adequately screen the engineer and refer him for definitive diagnostic testing and subsequent treatment contributed to the accident.

3. The failure of New Jersey Transit to follow internal guidance and refer at-risk safety-sensitive personnel including the engineer and other at-risk crew members for obstructive sleep apnea screening is evidence of a systemic failure of a critical safety system to ensure these personnel were fit for duty.

4. It was likely that fatigue from a variety of factors—including a rotating schedule, insufficient nightly sleep, poor sleep habits, and impaired sleep quality undiagnosed and untreated severe obstructive sleep apnea—resulted in the Long Island Rail Road engineer falling asleep during entry into the terminal, causing the collision.

5. The failure of the Federal Railroad Administration to adequately address the issue of employee fatigue due to obstructive sleep apnea and other sleep disorders, most recently evidenced by the August 2017 withdrawal of the advance notice of proposed rulemaking, jeopardizes public safety.

6. These accidents demonstrate the need for effective screening programs to reduce the risk of safety-sensitive employees with untreated obstructive sleep apnea operating trains.

7. Since the Federal Railroad Administration did not implement Safety Recommendation R-12-16 or comply with the legislated time limit in the Rail Safety Improvement Act to require railroads to develop and implement fatigue management plans, New Jersey Transit and Long Island Rail Road were not required to have a screening and treatment program for obstructive sleep apnea.

8. The New Jersey Transit obstructive sleep apnea screening and treatment program should reduce the risk safety-sensitive employees with undetected and untreated obstructive sleep apnea pose to rail safety.

9. The Metropolitan Transportation Authority obstructive sleep apnea screening and treatment program should reduce the risk safety-sensitive employees with undetected and untreated obstructive sleep apnea pose to rail safety.

10. As evidenced by these two accidents, relying solely on an engineer's ability to stop his or her train before reaching the end of these tracks does not provide the level of safety necessary to protect the public.

11. Bumping posts, of the type used in Hoboken and Atlantic Terminals, do not by themselves provide adequate protection at the end of a track.

12. Both the New Jersey Transit and the Long Island Rail Road system safety program plans were ineffective in identifying operational hazards associated with operating trains into terminal tracks.

13. The use of operating rules and procedures to mitigate end-of-track collisions was an inadequate method for preventing these accidents because it failed to eliminate the possibility of a single point failure.

14. New Jersey Transit and Long Island Rail Road did not consider that the previous end-of-track collisions represented an increased risk of future accidents.

15. If both New Jersey Transit and the Long Island Rail Road system safety program plans had identified obstructive sleep apnea screening as a risk-reduction action when evaluating employees for fitness for duty, it would have been unlikely that these employees would have been operating trains with undiagnosed and untreated obstructive sleep apnea.

16. If the Federal Railroad Administration, at a minimum, instructed railroads to use the *Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service* when identifying and mitigating hazards, commuter and intercity railroad safety would be improved.

9. Safety Recommendations

9.1 New Recommendations

As a result of these investigations, the National Transportation Safety Board makes the following new safety recommendations:

To the Federal Railroad Administration:

> Require intercity passenger and commuter railroads to implement technology to stop a train before reaching the end of tracks. (R-18-001)
>
> Include the *Collision Hazard Analysis Guide for Commuter and Intercity Passenger Rail Service* as part of the regulation or part of a detailed compliance manual to assist railroads in implementing Title 49 *Code of Federal Regulations* Part 270. (R-18-002)

To New Jersey Transit and Metropolitan Transportation Authority (parent company of Long Island Rail Road)

> Review and revise the hazard management portion of your system safety program plans to ensure that they document previous incidents and use them when identifying and assessing operational hazards. (R-18-003)
>
> Ensure that operator impairment due to medical conditions, including obstructive sleep apnea, is part of the hazard management portion of your system safety program plan. (R-18-004)

9.2 Reiterated Recommendation

As a result of these investigations, the National Transportation Safety Board reiterates the following safety recommendations:

To the Federal Railroad Administration:

> Require railroads to medically screen employees in safety-sensitive positions for sleep apnea and other sleep disorders. (R-12-16)
>
> Develop and enforce medical standards that railroad employees in safety-sensitive positions diagnosed with sleep disorders must meet to be considered fit for duty. (R-16-044)

Appendix A. Investigations

Hoboken, New Jersey

The National Transportation Safety Board (NTSB) was notified on September 29, 2016, that New Jersey Transit (NJT) train 1614 failed to stop, overrode a bumping post at the end of track 5, and struck a wall of the Hoboken Terminal in Hoboken, New Jersey. National Transportation Safety Board (NTSB) then-Vice Chairman T. Bella Dinh-Zarr launched to the scene with a team consisting of an investigator-in-charge and investigators specializing in human performance, track and power, signals and train control, railroad operations, survival factors and crashworthiness, and mechanical/equipment.

Parties to the investigation included NJT, Federal Railroad Administration (FRA), the Brotherhood of Locomotive Engineers and Trainmen (BLET), the International Association of Sheet Metal, Air, Rail and Transportation Workers – Transportation Division (SMART), and the Brotherhood of Railroad Signalmen.

Atlantic Terminal, Brooklyn, New York

The NTSB was notified on January 4, 2017, of the collision of Long Island Rail Road (LIRR) passenger train 2817 with the end of track within the Atlantic Terminal station. NTSB launched an investigator-in-charge and a team to investigate human performance, track and power, signals and train control, railroad operations, survival factors and crashworthiness, and mechanical/equipment.

A representative from the NTSB Media Relations division was also on scene to provide assistance with press briefings.

Parties to the investigation included LIRR, Metropolitan Transportation Authority (MTA), Federal Railroad Administration (FRA), New York Public Transportation Safety Board, BLET, and SMART.

Appendix B. Hoboken, New Jersey, Accident Brief

National Transportation Safety Board

Railroad Accident Brief

New Jersey Transit Train Strikes Wall in Hoboken Terminal

Hoboken, New Jersey

The Accident

On September 29, 2016, about 8:38 a.m. eastern daylight time, New Jersey Transit (NJT) train 1614 failed to stop, overrode a bumping post at the end of track 5, and struck a wall of the Hoboken Terminal in Hoboken, New Jersey.[1] Train 1614 consisted of one controlling passenger car (cab car), three passenger cars, and one locomotive at the rear of the train. The train was traveling about 21 mph at the time of the accident.

About 250 passengers and 3 crewmembers (engineer, passenger car conductor, and assistant conductor) were on the train. One person on the passenger platform was struck by falling debris and died; 110 passengers and crewmembers were injured. Total damage to the train, track, and facility is estimated at $6 million. At the time of the accident, the sky was overcast, an 18-mph wind was coming from the northeast, and the temperature was 63˚F.

[1] All times referenced in this report are eastern daylight time.

Figure. Damaged controlling cab car.

The Investigation

Train Crew

The engineer began his career with NJT in 1987 as a part-time ticket agent. He became an engineer in March 2000 and worked in that position until the accident. He was qualified to operate on the Pascack Valley Line (where the accident occurred) and all the other lines on the Hoboken Division. On the day of the accident, he went on duty at 6:46 a.m. in Spring Valley, New York. He told investigators that he felt fully rested upon arriving at work. He had been off work 2 days before the accident. In the days leading up to the accident, he said that he had received the amount of sleep he needed to wake up feeling rested. He said that his cell phone was off and stored in his personal backpack. He also said that there were no distractions either inside or outside of the operating compartment.

The engineer said that he had conducted the required brake tests on the train before leaving Spring Valley, and the train operated normally throughout the trip approaching the accident site.[2] He said that the cab alerter was operating properly, and there was clear visibility approaching the terminal.[3]

The engineer said that the train arrived on track 5, which is the normal arrival track for train 1614 at Hoboken Terminal. As the train approached the end of the terminal platform, he said that he sounded the horn, checked the speedometer, and started ringing the bell. He said that he looked at his watch and noticed the train was arriving about 6 minutes late. He said that the speedometer showed the train was moving at 10 mph as it entered the terminal. After the accident, he said that he woke up on the cab floor with no memory of the accident.

The conductor began his career with NJT in 2003 as an assistant conductor and worked as a ticket collector. At the time of the accident, he had worked about 11 1/2 years as a conductor and had worked every line on the Hoboken Division.

On the morning of the accident, the conductor said that he woke at 4:50 a.m. after sleeping 7 to 8 hours; he went on duty at 6:30 a.m. He worked the extra board, filling in on different assignments where needed; he had worked the 3 days before the accident.[4]

The conductor said he had worked with the engineer on other occasions. They spoke the morning of the accident, and the conductor said he did not notice anything unusual about the engineer’s behavior. The preparation for departure was normal. That day, the train had four cars rather than the usual five, which resulted in people standing in the vestibules because of crowding; the conductor was unable to collect fares. The conductor did not notice anything unusual about the speed of the train as it approached the Hoboken Terminal, but he said that his focus was on the crowded conditions. After the accident, the conductor helped evacuate the train. He walked through the train to ensure that all passengers had exited.

The assistant conductor said that he had worked as an NJT brakeman and as a conductor for 20 years. On the morning of the accident, he said that he had woke at 5:15 a.m. and “felt fine” after going to bed at 10:00 p.m. the previous night. He went on duty at 6:31 a.m. and arrived at work a few minutes before his shift was to start. He walked with the engineer to the train; they had a casual conversation. The assistant conductor did not notice anything unusual about the engineer’s behavior.

During the trip, the assistant conductor was responsible for the third and fourth passenger cars. He told investigators that the trip was routine, and the engineer had operated the train properly at each station stop. As the train approached Hoboken Terminal, the assistant conductor was in the

[2] Refer to Title 49 *Code of Federal Regulations* (*CFR*) 232.205 for information on a Class I air brake test.

[3] An *alerter* is a safety device required by 49 *CFR* 229.140 that is installed in the locomotive cab to promote engineer attentiveness by monitoring some engineer-induced control activities. If the engineer’s control activity is not detected in a predetermined time, both audible and visual alarms are activated to prompt a response. Failure to acknowledge the alerter through a manual reset provision results in a penalty brake application that brings the locomotive (or the train) to a stop.

[4] An *extra board employee* does not have a regular job assignment, instead serving as a substitute when a regularly assigned employee is not available. Train and engine employees who work in yards, local freight service, and passenger and commuter operations have jobs with regular start-stop work times.

fourth car preparing to make an announcement over the public-address system. After the train's fourth car crossed over the switches, the assistant conductor noticed the train was not slowing as it normally would; he sensed the train was beginning to accelerate. He decided to try to apply the emergency brakes, which required him to move through a crowd of passengers. Just before he reached the emergency brake switch, he thought he heard the emergency brakes apply; he then felt the collision.

After the collision, he helped to evacuate the passengers. He also got off the train and re-entered at the first car, making his way to the operating compartment where he found the "unconscious" engineer on the floor under some debris.

Toxicology

Quest Laboratory conducted FRA-mandated postaccident toxicology for the engineer, conductor, and assistant conductor in accordance with federal regulations.[5] The results of the toxicology tests for the conductor and assistant conductor were negative for tested-for drugs and alcohol. The engineer's testing was negative for alcohol and all tested-for drugs, but positive for the pain medication oxycodone and its metabolite oxymorphone. The investigation determined that these medications were administered during hospital treatment which occurred before the test. Additionally, the NJT medical review officer reviewed the case and downgraded the results to negative.

Recorders

The video showed the train operating over dozens of crossings, and it recorded the bell and horn sequence as the train approached each grade crossing. The data showed that the engineer did not operate in accordance with train horn regulations at several crossings.[6]

The NJT train's forward-facing audio/video recording showed the cab car colliding with and overriding the bumping post at the end of the track 5 platform. A large flash was visible as the car collided with the panel at the end of the track. About 1 minute before the collision, the forward-facing audio/video recorder recorded one sounding of the train's horn while the train was in the yard leading up to the station. Shortly afterward, the train's bell began sounding, and it continued until the end of the recording.

Locomotive event recorder data indicated that about 38 seconds before the collision, the throttle increased from idle to the number 4 position while the train was traveling about 8 mph. The train speed began to increase, and the speed reached about 21 mph. Just before the collision, the event recorder indicated that the throttle position went from position 4 to idle. Engineer-induced emergency braking occurred less than 1 second before the collision with the

[5] Quest Laboratory tested specimens for alcohol, amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, MDMA/MDA, methadone, opiates/opioids, phencyclidine, tramadol, brompheniramine, chlorpheniramine, diphenhydramine, doxylamine, and pheniramine.

[6] In accordance with the Train Horn Rule (49 *CFR* Part 222), engineers must begin to sound train horns at least 15 seconds, and no more than 20 seconds, in advance of all public grade crossings. Train horns must be sounded in a standardized pattern of two long, one short, and one long blasts. The pattern must be either repeated or prolonged until either the lead locomotive or the lead cab car occupies the grade crossing.

bumping post. Although the authorized speed was 10 mph, the event recorder showed the train speed was about 21 mph at the time of the collision.

Medical Factors

The engineer told investigators that he had not been taking any medications. He said that he had never been diagnosed with either obstructive sleep apnea (OSA) or any other sleep disorder. He said that he needed about 7 hours of sleep to feel rested and he would take a nap "not every day, but sometimes" between assignments in the breakroom. He stated that his quality of sleep was "fine," and he would wake up feeling "fine."

The engineer did not recall ever having a blackout. His last required physical examination at NJT was about 3 months before the accident. He was medically certified for service.

Following the accident, the engineer underwent a home sleep study on October 21, 2016. A board-certified pulmonary and sleep medicine physician evaluated the engineer. The engineer's height was 6 feet, he weighed 322 pounds, and had a body mass index of 43.67 kg/m^2.[7] Additionally, he scored 7 of 24 points on the Epworth sleepiness scale (indicating a normal amount of sleepiness). Testing results included an apnea-hypopnea index (AHI) of 89.6 episodes per hour with an average oxygen saturation during testing of 84 percent, dropping to as low as 53 percent.[8] The sleep medicine specialist diagnosed him with severe OSA with severe sleep fragmentation; the specialist prescribed the use of a continuous positive airway pressure (CPAP) machine.[9]

OSA is a chronic disease in which patients experience episodes of airway obstruction while sleeping. During each episode, the person stops breathing for a period causing the blood oxygen levels to drop and the blood carbon dioxide levels to rise. When the blood carbon dioxide level gets too high, the brain detects it, and the person either arouses or awakens to breathe. The result is fragmented sleep and subsequent daytime sleepiness and fatigue. Risk factors for OSA include: male gender, age, obesity, hypertension, large neck circumference (greater than 16 inches in women and 17 inches in men), a waist-to-hip circumference ratio of greater than 1 for men and 0.85 for women, and snoring.[10]

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[7] According to the National Institute of Health, a body mass index of more than 40 kg/m^2 indicates severe or morbid obesity and increases the risk of type II diabetes, high blood pressure, cardiovascular disease, and OSA.

[8] An *apneic episode* is the complete absence of airflow though the mouth and nose for at least 10 seconds. A *hypopnea episode* is when airflow decreases by 50 percent for at least 10 seconds or decreases by 30 percent if there is an associated decrease in the oxygen saturation or an arousal from sleep. The AHI adds the frequency of both types of episodes. An AHI of less than 5 is considered normal. An AHI of 5 to 15 is mild sleep apnea; 15 to 30 is moderate sleep apnea, and more than 30 events per hour is considered severe sleep apnea.

[9] *CPAP* is a treatment for OSA that uses a machine to generate positive air pressure that is delivered though a mask the covers the nose or nose and mouth to keep the airways open during sleep.

[10] (a) P.E. Peppard, and others, "Increased Prevalence of Sleep-Disordered Breathing in Adults," *American Journal of Epidemiology* 177, no. 9 (2013): 1006-1014; (b) J.C. Seidell, "Waist Circumference and Waist/Hip Ratio in Relation to All-Cause Mortality, Cancer and Sleep Apnea," *European Journal of Clinical Nutrition* 64, no. 1 (2010): 35-41; (c) T. Young and others, Sleep Heart Health Study Research Group, "Predictors of Sleep-Disordered Breathing in Community-Dwelling Adults: the Sleep Health Study," *Archives of Internal Medicine* (now *JAMA Internal Medicine*) 162, no. 8 (2002): 893-900; (d) L.G. Olson and others, "A Community Study of Snoring and

NJT OSA Screening

FRA does not mandate OSA screening, however NJT screens safety-sensitive personnel. During physical examinations, a NJT physician was required to complete a NJT form titled "Epworth Sleepiness Scale" which records weight, height, body mass index, and neck circumference, and poses a number of subjective questions to gauge how likely the employee is to doze off or fall asleep during the day. The physicians were provided with the form, as well as the 2006 Tri-Medical Society Task Force screening and referral recommendations, which provided guidance on determining whether to refer an employee for a sleep study. In interpreting the information on the Epworth Sleepiness Scale, the physicians did not rely only on one factor, but used a combination of discretion and the 2006 recommendations to make that determination. The investigation determined that the engineer, conductor, and assistant conductor all met NJT screening criteria for referral for definitive OSA testing but had not been referred. Furthermore, the NJT medical department was unable to locate the engineer's most recent OSA screening form.

Since the accident, NJT has started a program to ensure OSA screening forms are completed, centrally reviewed, and that safety-sensitive employees meeting referral criteria are removed from service until appropriately tested and successfully treated.

Signal and Train Control

Investigators inspected the affected signal equipment and physical layout of train 1614's interlocking route from the automatic signal M06T3 milepost (MP) 0.6 to the train shed track 5 signal at MP 0.0.[11] The signal at the end of track 5 and track circuit A40B were not inspected because of damage to the signal, track, and terminal. The forward-facing video verified that the signal at the end of track 5 was illuminated, and the aspect was red. Track circuits were inspected, verified, and shunted sequentially to simulate a train taking the same route as train 1614. All signal locations were inspected and verified for proper operation. The signal circuits were free of grounds, and all signal lamp units were working as intended with proper voltage levels. The signal route and signal aspect sequence testing were performed between the automatic signal M06T3 at MP 0.6 and terminal interlocking signal 26 E. Investigators found no deficiencies in either the signal aspect or cab signal code rate. The signal preview and signal spacing were of sufficient length to comply with the operating rules. Investigators found no defects in the inspected units. The NJT maintenance, inspections, and tests records for the signal system were in accordance with the Federal Railroad Administration (FRA) requirements. The signal and train control system functioned as designed.

Positive Train Control

A positive train control (PTC) system had not been implemented at the time of the accident. NJT planned to implement a PTC system called the Advanced Speed Enforcement System, which

Sleep-Disordered Breathing Prevalence," *American Journal of Respiratory and Critical Care Medicine* 152, no. 2 (1995): 711-716; (e) T. Young and others, "Risk Factors for Obstructive Sleep Apnea in Adults," *Journal of the American Medical Association* 291, no. 16 (2004): 2013-2016.

[11] The train shed is the signal location at the entrance to the covered portion of the track leading to the Hoboken Terminal.

is second generation (ASES II). The existing cab signal system (CSS) will continue to provide train separation and signal speed enforcement while ASES II complements the CSS and provides other required PTC functions. The two systems—CSS and ASES II—are functionally independent, although both do report status and transfer certain data.

FRA regulations permit the exclusion of certain “mainline tracks” from PTC requirements. NJT designated certain line segments in its January 2016 PTC Implementation Plan as other than main line track. NJT included this terminal interlocking at Hoboken as a designated exemption from the PTC requirements. This terminal included 20 track terminus points (17 passenger platform tracks, extending from each end of track, each with an eastbound fixed inoperative stop signal; and three additional tracks at the southern limits) to the eastbound home signals at the terminal.

Mechanical

Investigators reviewed maintenance records for the locomotive and passenger car equipment and found that NJT’s inspection and maintenance program was comprehensive and met the FRA’s daily and periodic inspection requirements.[12] On September 28, 2016, the controlling cab car, 6036, passed an FRA-required pretrip cab signal inspection. The following day, qualified inspectors completed an FRA Class I air brake test on train 1614 and found no exceptions. Additionally, an FRA-required running air brake test was performed by the engineer with no exceptions.

Investigators examined the controlling cab car to determine whether the brake control system, throttle, and other systems could be repaired to complete the postaccident testing. The cab car electrical communication network necessary for brake, signal, and propulsion control was destroyed in the accident; the functional testing of key controlling components would be necessary to assess the mechanical condition of the train prior to the accident. The accident damage to the cab car’s air brake system was minor and was repaired for testing. A friction brake test was completed using the rear locomotive to apply the brakes; the brakes functioned as designed.

The equipment from cab car 6036 was sent to the manufacturer for a comprehensive qualification test of components according to the manufacturer’s test procedures. The NTSB investigators witnessed the testing. The results of the testing showed that all components functioned as designed.

Track

The tracks in the accident area consisted primarily of four main tracks, designated as tracks 1 through 4, that pass through the Bergen Tunnels and into the Hoboken East End Interlocking. Between the East End Interlocking and the Terminal Interlocking on the NJT Morristown Line, six main tracks were present; these six main tracks were designated as: 1, 2, 3,

[12] These requirements are specified in 49 *CFR* Part 229, Railroad Equipment Safety Standards, and 49 *CFR* Part 238, Passenger Equipment Safety Standards.

4-main, 6-main, and 122. Approaching the terminal, main tracks 1 through 3 were adjacent, and the other three main tracks diverged southward. There were 19 tracks at the Hoboken Terminal.

Entering the terminal, at MP 0.39, the track is designated as FRA Class 1 track, which allows for a maximum operating speed of 15 mph for passenger trains. The NJT timetable further restricted speeds to 10 mph for all trains inside the train shed. The train shed started about 600 feet before the end of the tracks. NTSB investigators did not observe any track conditions that would have affected the operation of the accident train.

Bumping Post

The bumping post at the end of Hoboken Terminal's track 5 was installed in 1908.[13] Its purpose was to help control unintended equipment movement. The bumping post was constructed of steel with thicknesses ranging from 0.5 inch to 0.75 inch. The base of the bumping post was set in concrete. Generally, the visible portion of the bumping post measured 60 inches high and 24 inches wide; and the depth was about 22 inches at the top angling down to 60 inches at the concrete slab base. A 24-inch by 16-inch striking plate was mounted about 42 inches above the running surface of the rail.

Train 1614 was traveling at 21 mph when it struck and destroyed the bumping post at the end of track 5. The bumping post was displaced backward 65 inches toward the station platform. The concrete slab moved 40 inches toward the platform. The base of the bumping post tore from the concrete slab, canted about 55 degrees, and moved 25 inches toward the platform. The strike plate and its mounting post were found beneath the front truck of the lead controlling cab car.

Emergency Response

The NJT police department has offices in the Hoboken Terminal. The emergency response to the accident began immediately. Firefighters and police officers ensured power was removed from the track area, stabilized the scene, and evacuated the train and the terminal. The last passenger was evacuated within 1 hour of the accident.

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[13] *A bumping post* is a braced post, a block, or an obstruction placed at the end of either a stub or a spur track to halt car movement and prevent cars from going off the rails.

Probable Cause

The National Transportation Safety Board determined that the probable cause of the Hoboken, New Jersey, accident was the failure of New Jersey Transit train 1614's engineer to stop the train after entering Hoboken Terminal due to the engineer's fatigue resulting from his undiagnosed severe obstructive sleep apnea. Contributing to the accident was New Jersey Transit's failure to follow its internal obstructive sleep apnea screening guidance and refer at-risk safety-sensitive personnel for definitive obstructive sleep apnea testing and treatment. Further contributing to the accident was the Federal Railroad Administration's failure to require railroads to medically screen employees in safety-sensitive positions for obstructive sleep apnea and other sleep disorders. Also contributing to the accident was the lack of either a device or safety system that could have intervened to stop the train before the collision.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

EARL F. WEENER
Member

T. BELLA DINH-ZARR
Member

Adopted: February 6, 2018

For more details about this accident, visit www.ntsb.gov/investigations/dms.html and search for NTSB accident number DCA16MR011.

The NTSB has authority to investigate and establish the facts, circumstances, and cause or probable cause of a railroad accident in which there is a fatality or substantial property damage, or that involves a passenger train. (49 U.S. Code § 1131 - *General authority*)

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, "accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties . . . and are not conducted for the purpose of determining the rights or liabilities of any person." 49 *Code of Federal Regulations*, Section 831.4. Assignment of fault or legal liability is not relevant to the NTSB's statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report. 49 *United States Code*, Section 1154(b).

Appendix C. Atlantic Terminal, Brooklyn, New York, Accident Brief

National Transportation Safety Board

Railroad Accident Brief

Long Island Rail Road Passenger Train Strikes Platform in Atlantic Terminal

Brooklyn, New York

The Accident

On, January 4, 2017, about 8:18 a.m. eastern standard time, Long Island Rail Road (LIRR) passenger train 2817, consisting of six cars, collided with the platform at the end of track 6 in the Atlantic Terminal in Brooklyn (a borough of New York City, New York).[1] The lead end of the lead car came to rest on top of the concrete platform at the end of the track. (See figure 1.) As result of this accident, 108 people were injured. Damage was estimated at $5.3 million. The accident occurred inside the terminal and was not affected by the weather.

[1] (a) All times referenced are eastern standard time. (b) Atlantic Terminal, which the LIRR shares with New York City Transit, is beneath a commercial building that has restaurants and retail stores. (c) LIRR is part of New York's Metropolitan Transportation Authority.

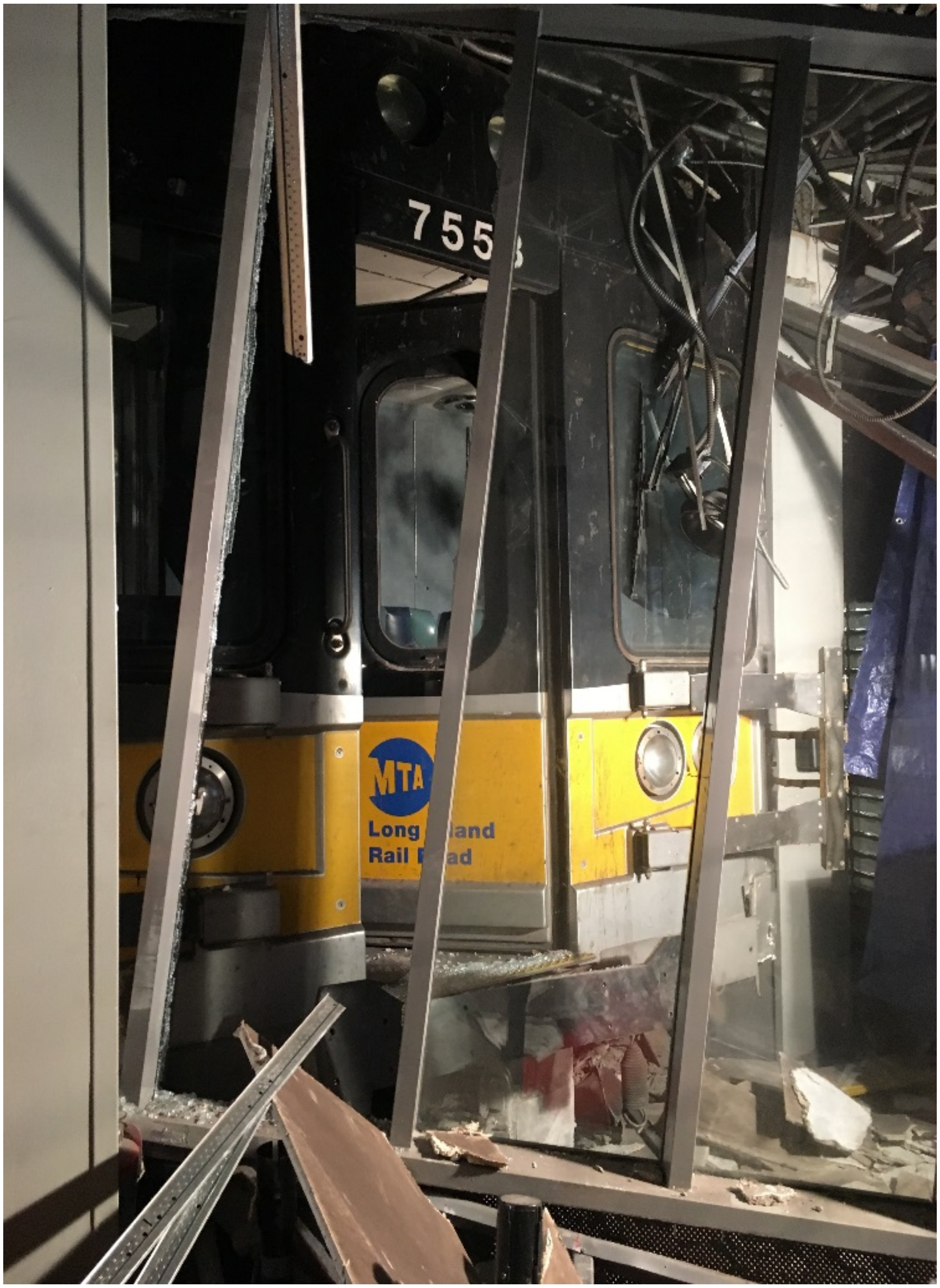

Figure 1. The accident train's lead car.

The Investigation

On the day of the accident, the LIRR engineer, conductor, and assistant conductor were scheduled to go on duty at the West Side Storage Yard in New York City at 12:16 a.m. The engineer commuted by train to work each day from Hicksville, New York, to Penn Station in New York City. On the night of the accident, the commuter train was running late, so the engineer's supervisor told him to disembark at Jamaica Station and wait there for his assigned train. Meanwhile, the supervisor arranged for a temporary replacement to fill in for the delayed engineer on the first scheduled revenue trip (on train 802) to Long Beach Station. On the return trip (on train 805), the regular engineer relieved his replacement at 4:28 a.m. and the regular crew continued running the route. The crew continued to Atlantic Terminal. They arrived at 4:51 a.m. and secured the train on track 1.

The train left Atlantic Terminal at 5:16 a.m. and arrived at Far Rockaway Station in the New York City borough of Queens at 6:10 a.m.; the train made 11 station stops. The crew moved to the cab on the opposite end of the train and changed the train's designation to 2817. They started the return trip to Atlantic Terminal at 7:20 a.m. The engineer and crew performed the required brake tests; the brakes operated as designed.

The engineer said he encountered a restricting signal at the Brook 2 Interlocking on main track 1, which required him to slow to restricted speed (not to exceed 15 mph).[2] (See figure 2.) The train then crossed from main track 1 to main track 2 where it encountered another restricting signal at the Brook 1 Interlocking that also required the train to travel at restricted speed. However, the maximum authorized track speed in the terminal was restricted to 5 mph. In this circumstance, the engineer must still be prepared to stop in one-half his range of vision while not exceeding 5 mph. The train was lined into track 6.

When the train reached the end of track 6, it struck the bumping post and continued until the first car crashed through a wall of an employee-only area. The train stopped on the concrete at the end of the track, which was level with the platform that runs parallel to the track.

The engineer said he remembered approaching the track 6 platform and then being thrown from his seat. The engineer said track 6 had a slight descending grade. To control the train speed, it was necessary to continually manipulate the master controller between power and braking. Using this technique, the engineer said the train's speed would normally fluctuate between 4 and 6 mph.

The locomotive was not equipped with either inward- or outward-facing cameras. Investigators reviewed event recorder data, which included the speed and master controller positions (and other inputs by the engineer), as the train entered the Atlantic Terminal. On the day of the accident, the train slowed to less than 5 mph near the restricting signal at Brook 1 Interlocking. The train's speed slowed to 2.4 mph, but it then started to accelerate until it reached 10 mph about 1,131 feet from the end of the track. Again, the train's speed slowed to 8.5 mph about 1,000 feet from the end of the track; however, it gradually accelerated to almost 13 mph (with the master controller in the minimum power position) when it struck the bumping post.

[2] According to the *Long Island Rail Road Operations Manual*, *restricted speed* is a mode of operation, at which a train can be stopped within one-half the range of vision, short of the next signal, another train, obstruction, derail, or switch improperly lined, looking out for broken rail or crossing protection not functioning, while not exceeding 15 mph.

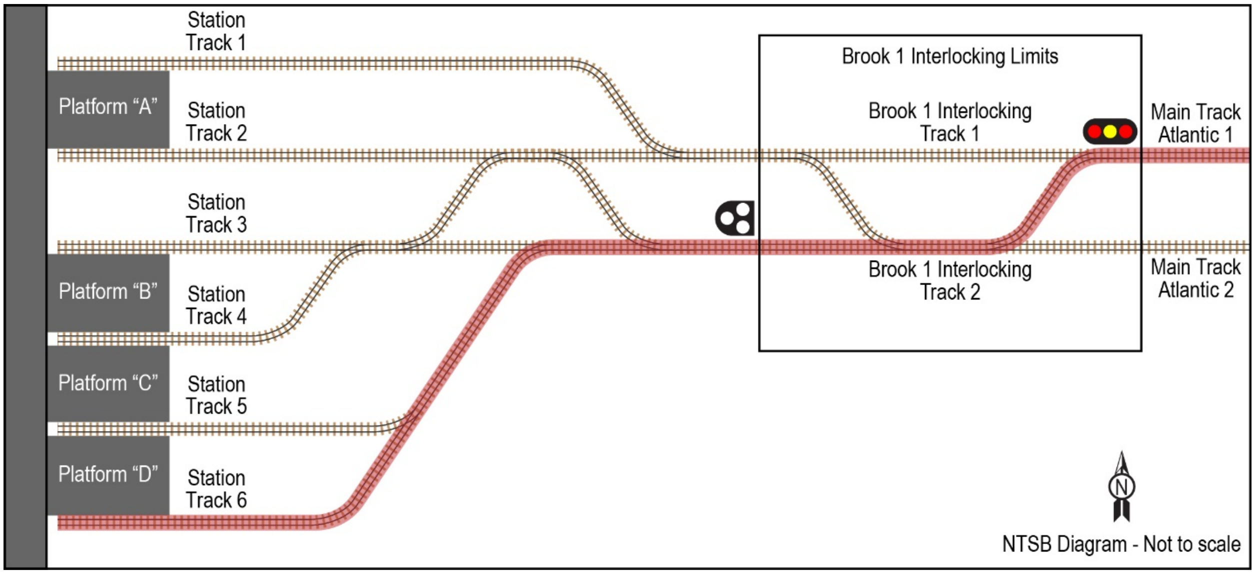

Figure 2. Diagram of tracks at Atlantic Terminal. (Brook 2 is to the right of Brook 1 and is not shown in the figure.)

Equipment

All six LIRR cars were coupled pairs with an operating cab at each end. A 750-volt direct-current third-rail supplied power to the cars, which were equipped with friction and electric brakes.

After the collision, three cars (7067, 7073, and 7074) remained upright and did not derail. The lead car (7553), which was the most damaged, derailed upright with its front end resting on the raised concrete at the end of the track.[3] Its front truck disconnected from the car body and moved about 6 feet backward.

Due to the damage to the lead and second cars, the electric and pneumatic brake systems could not be tested. A National Transportation Safety Board (NTSB) investigator examined the brake systems and running gear, draft components, glazing, signage, electrical components, and car body general condition. No defective conditions were found. When an NTSB investigator tested the brakes of four cars (7067, 7068, 7073, and 7074), he found that the brakes functioned as designed.

Track and Structure

Six LIRR station tracks (tracks 1 through 6) are in the Atlantic Terminal; track 6 was the southernmost track. Each track ended at a bumping post.[4] Walls and a roof enclosed the tracks at Atlantic Terminal. The accident train approached and entered the track in a 14-degree curve to the

[3] The concrete area in front of the train was level with the platform and was a continuation of the platform. However, the term *platform* applies only to the area adjacent to the train where passengers get on and off the train.

[4] A *bumping post* is a braced post, block, or obstruction placed at the end of a stub or spur track that halts car movement and prevents cars from going off the ends of the rails.

right and a 1-percent descending grade. Near the end of track 6, the grade was a 1-percent ascending grade.

LIRR had designated the maximum authorized speed as 5 mph from Brook 1 to the end of the platform tracks.[5] LIRR inspected the station tracks weekly. The last inspection before the accident occurred on January 3, 2017. The postaccident inspections of the track found no deviation from track standards, other than those caused by the accident.

Bumping Post

Train 2817 was traveling about 13 mph when it struck the bumping post at the west end of track 6. The lead car destroyed the bumping post. The car traveled 13 feet 6 inches after making contact with the bumping post. A segment of the rail attached to the bumping post pierced the floor of the lead car and entered the electrical closet directly behind the engineer's control cab.

In 2015, the LIRR engineering management asset group inventoried all bumping posts in passenger yard tracks, including those in the Atlantic Terminal. The bumping post that was struck was a Western Cullen Hays, Inc., model WDC. The manufacturer calculated that the bumping post had a maximum impact capacity of 415,000 pounds force. This capacity equals about six partially loaded M-7 multiple-unit locomotive passenger cars that are moving about 1 mph with no power applied. The accident train consisted of six M-7 cars; according to the event recorder, the train struck the bumping post at about 13 mph with the power shutting off at, or just before, impact.[6]

Signal and Train Control

The LIRR train movements on the Far Rockaway branch were governed by operating rules, general orders, timetable instructions, and the signal indications of a traffic control system supplemented with an automatic train control (ATC) system. Position light and color-light signals displayed the train movement authorities. Train movements into the Atlantic Terminal were coordinated by the Brook 1 tower operator at the terminal. All signals and switches were inspected and tested following the accident. No abnormalities were found, and the system functioned as designed.

The ATC system limited train speeds when encountering specific signals. If the locomotive ATC did not receive a cab signal track code, the train was restricted to 15 mph, and the system would stop the train if it exceeded 15 mph. Cab signal track codes were not transmitted to trains entering Atlantic Terminal. Train 2817 was restricted by the ATC to 15 mph after passing the first restricting signal at Brook 2 and changing from track 1 to track 2. According to the event recorder, train 2817 did not exceed 15 mph.

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[5] LIRR Timetable Special Instruction 1038-B, which was included in General Order 203, was effective November 14, 2016.

[6] M-7 multiple unit locomotives were manufactured by Bombardier, Inc., between 2002 and 2007. M-7 multiple unit locomotives are both locomotives and passenger cars that are powered electrically by use of a third rail.

Positive Train Control

On August 10, 2010, LIRR submitted its Positive Train Control (PTC) Implementation Plan to the Federal Railroad Administration (FRA). Following a plan revision, the FRA granted provisional approval to LIRR on July 7, 2011. In 2016, LIRR submitted a planned timeline to the FRA for full implementation of PTC technology by December 2018.

Under the main track exceptions section of the federal regulations, LIRR requested and the FRA approved a Passenger Terminal Exception for the array of tracks between Brook 1 Interlocking limits and the Atlantic Terminal. In its request, LIRR stated that the 5-mph maximum authorized speed for train movements through this area would remain. Furthermore, a 15-mph maximum speed would still be enforced by the restricting aspect of the ATC. In its request, LIRR stated that no freight trains would operate in this area.

Method of Operations

The LIRR train movements into Atlantic Terminal were primarily governed by signal indications with the ATC enforcing the train speeds appropriate to the wayside signal indication. Written instructions limited the maximum authorized speed for trains within Atlantic Terminal—including track 6—to 5 mph. However, the ATC only enforced the 15-mph limit because of the restricting signal indication entering the terminal.

Personnel Information

Engineer

The 50-year-old engineer was hired as an engineer by the LIRR on April 26, 1999. His engineer certification was current; it was due for renewal on November 17, 2019. The records showed that railroad supervisors observed the engineer's compliance with operating rules 56 times in the 12 months before the accident. The engineer failed to have his timetable and other instructions current and in proper order on November 15, 2016, at Hillside Station.

At the time of the accident, the engineer had no documented acute or chronic medical conditions and was medically certified to perform his duties. Following the accident, several specialists evaluated the engineer for possible impairing medical conditions. The neurology and the cardiology evaluations did not identify any issues; however, a sleep medicine evaluation identified undiagnosed obstructive sleep apnea (OSA).

The sleep specialist documented the engineer's height as 5 feet 10 inches, weight as 275 pounds, BMI as 39.5 kg/m^2, and neck circumference as 18.5 inches, which are the risk factors indicating possible sleep apnea.[7] Further, the engineer scored 12 of the possible 24 points on the

[7] According to the National Institute of Health, a body mass index of over 35 kg/m^2 indicates severe obesity and increases the risk of Type II diabetes, high blood pressure, cardiovascular disease, and obstructive sleep apnea (OSA).

subjective Epworth Sleepiness Scale.[8] Finally, a noninvasive polysomnographic evaluation (sleep study) conducted in a sleep center documented he had an apnea-hypopnea index (AHI) of 101.3 episodes per hour.[9] The sleep medicine specialist diagnosed severe obstructive sleep apnea (OSA) and prescribed continuous positive airway pressure (CPAP) as treatment.[10]

Following a 2013 fatal rail accident in Bronx, New York, in which undiagnosed OSA was implicated, Metro-North Railroad, a subsidiary of Metropolitan Transportation Authority (MTA), began an OSA screening program in January 2015 for its locomotive engineers. Since then, Metro-North Railroad has expanded the program to include its conductors. At the time of this accident, MTA had plans to include LIRR in the OSA screening program, but had not yet implemented the change. After the accident, on April 17, 2017, LIRR started screening locomotive engineers during their FRA recertification testing using the MTA OSA screening program.

The engineer was on the second day of his work week (Tuesday through Saturday); Sunday and Monday were his days off. The engineer shifted his sleep schedule by about 11 hours during his days off to coincide with his family's normal circadian sleep cycle.[11] This twice weekly reversal of his sleep and awake periods causes circadian rhythm desynchronization. According to New York City Transit's *Fatigue Awareness Training Manual*, changing work/sleep schedules back and forth more quickly than body rhythms can adjust will cause desynchronization, which leads to chronic fatigue.

After working the night shift, the engineer said that he usually slept 5 hours after arriving home about 11:00 a.m.[12] He also said he would nap when he had a long layover between assignments.

On Monday evening, the engineer took a 2-hour nap before leaving for work about 11:00 p.m. During his shift, he followed his normal routine and took a few naps when he had the opportunity. After arriving home, he slept for 5 hours. On Tuesday evening, he had a 3-hour nap before leaving for work around 11:00 p.m. Because there was a delay during the engineer's commute, he arrived at work late and was unable to nap during the accident shift.

Although the engineer may have been getting nearly 8 hours of sleep in a 24-hour period, the 8 hours were not uninterrupted. His training failed to adequately convey that uninterrupted hours of sleep in a 24-hour period are needed for people to obtain the full, restorative benefits of

[8] The *Epworth Sleepiness Scale* is a subjective measure of the potential to fall asleep. The scale is administered by questionnaire. Generally, a score of 10 or higher is considered an excessive amount of sleepiness, depending on the situation.

[9] An *apneic episode* is the complete absence of airflow though the mouth and nose for at least 10 seconds. A *hypopnea episode* is when airflow decreases by 50 percent for at least 10 seconds or decreases by 30 percent if there is an associated decrease in the oxygen saturation or an arousal from sleep. The AHI sums the frequency of both types of episodes. An AHI of less than 5 is considered normal. An AHI of 5-15 is mild sleep apnea; 15-30 is moderate sleep apnea and more than 30 events per hour is considered severe sleep apnea.

[10] *CPAP* is a treatment for OSA that uses a machine to generate positive air pressure that is delivered though a mask that covers the nose or nose and mouth to keep the airways open during sleep.

[11] The engineer typically went to sleep about midnight on his days off and about 11:00 a.m. on the days he worked.

[12] Typically, he slept from 11:00 a.m. to 4:00 p.m.

sleep, including feeling rested and having the ability to focus and a sense of emotional well-being.[13]

In summary, the engineer desynchronized his circadian rhythms on his days off, and he did not get 8 hours of uninterrupted sleep on the days he worked. After the accident, he was diagnosed with severe OSA. These factors led to poor sleep quality and resulted in the engineer being chronically fatigued.

Conductor

The 46-year-old conductor was hired by the railroad on September 28, 1998. Her conductor certification was current and was due for renewal on September 16, 2019. The records showed that railroad supervisors observed the conductor's compliance with operating rules 51 times in the 12 months before the accident. No noncompliance entries were found. A review of her occupational records found that she was medically certified for her safety-sensitive position.

Assistant Conductor

The 51-year-old assistant conductor was hired by the railroad July 11, 2007. His conductor certification was current; it was due for renewal on April 29, 2018. The records showed that railroad supervisors observed the assistant conductor's compliance with operating rules 53 times in the 12 months before the accident. No noncompliance entries were found. A review of his occupational records confirmed that he was medically certified for his safety-sensitive position.

Toxicology

Quest Laboratory conducted FRA-mandated postaccident toxicology for the LIRR engineer, conductor, and assistant conductor in accordance with federal regulations. Testing was negative for tested-for drugs and alcohol.

[13] Based on contemporary sleep research findings, such as M. Kahn, G. Sheppes, and A. Sedeh, "Sleep and Emotions: Bidirectional Links and Underlying Mechanisms," *International Journal of Psychophysiology* 89, no. 2 (2013): 218-228; M. Kahn, S. Fridenson, R. Lerer, Y. Bar-Haim, and A. Sadeh, "Effects of One Night of Induced Night-Wakings Versus Sleep Restrictions on Sustained Attention and Mood: A Pilot Study," *Sleep Medicine* 15, no. 7 (2014): 825-832; and P.H. Finan, P.J. Quartana, and M.T. Smith, "The Effects of Sleep Continuity Disruption on Positive Mood and Sleep Architecture in Healthy Adults," *Sleep* 38, no. 11 (2015): 1735-1742.

Probable Cause

The National Transportation Safety Board determined the probable cause of the Brooklyn, New York, accident was that the engineer of Long Island Rail Road train 2817 fell asleep due to his chronic fatigue. Contributing to his chronic fatigue was the engineer's severe undiagnosed obstructive sleep apnea, and Long Island Rail Road's failure to initiate obstructive sleep apnea screening for safety-sensitive personnel and refer at-risk safety-sensitive personnel for definitive obstructive sleep apnea testing and treatment before the accident. Further contributing to the accident was the Federal Railroad Administration's failure to require railroads to medically screen employees in safety-sensitive positions for obstructive sleep apnea and other sleep disorders. Also contributing to the accident was the lack of either a device or a safety system that could have intervened to stop the train before the collision.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

EARL F. WEENER
Member

T. BELLA DINH-ZARR
Member

Adopted: February 6, 2018

For more details about this accident, visit www.ntsb.gov/investigations/dms.html and search for NTSB accident number DCA17FR002.

The NTSB has authority to investigate and establish the facts, circumstances, and cause or probable cause of a railroad accident in which there is a fatality or substantial property damage, or that involves a passenger train. (49 U.S. Code § 1131 - *General authority*)

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, "accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties . . . and are not conducted for determining the rights or liabilities of any person." 49 *Code of Federal Regulations*, Section 831.4. Assignment of fault or legal liability is not relevant to the NTSB's statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report. 49 *United States Code*, Section 1154(b).

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