Collision of Amtrak Passenger Train 371 and Norfolk Southern Railway Company Freight Train 23M
Chicago, Illinois
November 30, 2007

Accident Report

NTSB/RAR-09/01
PB2009-916301

National Transportation Safety Board

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Notation 7989A
Adopted March 31, 2009

Railroad Accident Report

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National
Transportation
Safety Board

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

National Transportation Safety Board. Year. ***Collision of Amtrak Passenger Train 371 and Norfolk Southern Railway Company Freight Train 23M, Chicago, Illinois, November 30, 2007.*** **Railroad Accident Report NTSB/RAR-09/01. Washington, DC.**

Abstract: On Friday, November 30, 2007, Amtrak (National Railroad Passenger Corporation) passenger train 371, consisting of one locomotive and three passenger cars, struck the rear of a standing Norfolk Southern Railway Company freight train near Chicago, Illinois. The forward portion of the Amtrak locomotive came to rest on top of a container on the rear car of the freight train. Sixty-six passengers and five crewmembers were transported to hospitals; two passengers and one crewmember were subsequently admitted. The weather was clear, and the temperature was 30º F. Estimated damage was $1,299,000

As a result of its investigation of this accident, the Safety Board identified the following safety issues: wayside signal indication training and proficiency programs, crewmember communication and action in response to operating concerns, and inadequate locomotive cab emergency egress and rescue access.

As a result of its investigation of this accident, the National Transportation Safety Board makes recommendations to the Federal Railroad Administration, Amtrak, the Association of American Railroads, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers and Trainmen, the United Transportation Union, and the American Public Transportation Association.

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Contents

Figures

Acronyms and Abbreviations

AAR	Association of American Railroads
Amtrak	National Railroad Passenger Corporation
CFR	*Code of Federal Regulations*
CRM	crew resource management
CSX	CSX Transportation
EMS	Emergency Medical Services
FRA	Federal Railroad Administration
METRA	Northeast Illinois Regional Commuter Rail Corporation
MP	milepost
NORAC	Northeast Operating Rules Advisory Committee
psi	pounds per square inch
PTC	positive train control

Executive Summary

On Friday, November 30, 2007, about 11:23 a.m., Amtrak (National Railroad Passenger Corporation) passenger train 371, consisting of one locomotive and three passenger cars, struck the rear of standing Norfolk Southern Railway Company freight train 23M near Chicago, Illinois. The forward portion of the Amtrak locomotive came to rest on top of a container on the rear car of the freight train. Sixty-six passengers and five crewmembers were transported to hospitals; two passengers and one crewmember were subsequently admitted. The weather was clear, and the temperature was 30º F. Estimated damage was $1,299,000.

The National Transportation Safety Board determines that the probable cause of the November 30, 2007, collision of Amtrak train 371 with the rear of Norfolk Southern Railway Company train 23M near Chicago, Illinois, was the failure of the Amtrak engineer to correctly interpret the signal at Englewood interlocking and Amtrak's failure to ensure that the engineer had the competency to correctly interpret signals across the different territories over which he operated. Contributing to the accident was the relief engineer's failure to immediately communicate to the engineer that he had miscalled the signal at Englewood and to stop the train when he did not respond to her expressed concern. Also contributing to the accident was an absence of effective crew resource management between the relief engineer and the operating engineer which led to their failure to resolve the miscalled signal prior to the collision. Further contributing to the accident was the absence of a positive train control system that would have stopped the Amtrak train when it exceeded restricted speed.

As a result of its investigation of this accident, the Safety Board identified the following safety issues:

- Wayside signal indication training and proficiency programs.
- Crewmember communication and action in response to operating concerns.
- Inadequate locomotive cab emergency egress and rescue access.

As a result of its investigation of this accident, the National Transportation Safety Board makes recommendations to the Federal Railroad Administration, Amtrak, the Association of American Railroads, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers and Trainmen, the United Transportation Union, and the American Public Transportation Association.

Factual Information

Accident Synopsis

On Friday, November 30, 2007, about 11:23 a.m.,[1] Amtrak (National Railroad Passenger Corporation) passenger train 371, consisting of one locomotive and three passenger cars, struck the rear end of standing Norfolk Southern Railway Company freight train 23M near Chicago, Illinois. The forward portion of the Amtrak locomotive came to rest on top of a container on the rear car of the freight train. Sixty-six passengers and five crewmembers were transported to hospitals; two passengers and one crewmember were subsequently admitted. The weather was clear, and the temperature was 30º F. Estimated damage was $1,299,000.

Accident Narrative

The engineer and conductor initially went on duty at Chicago on November 29, 2007, at 4:35 p.m. They were assigned to operate Amtrak train 370 from Chicago to Grand Rapids, Michigan. The crew arrived at Grand Rapids with the train and went off duty at 10:28 p.m. The following morning, November 30, the crew reported for duty at 5:50 a.m. and was assigned to Amtrak train 371, which was destined for Chicago. On the previous day, the crew had been on duty 5 hours 53 minutes; they had a rest period of 7 hours 22 minutes. Although 49 *Code of Federal Regulations* (CFR) Part 228 allows for an interim rest period, a rest period greater than 4 hours but less than 8 hours requires that the hours of the original trip be counted toward the total of 12 hours of limited service. The crew had 6 hours 7 minutes until they would reach their 12-hour limit at 11:57 a.m.

Train 371 was scheduled to depart Grand Rapids at 6:35 a.m.; however, it departed 27 minutes late because the cold weather had hampered the operation of a switch. The train departed New Buffalo, Michigan, the last scheduled passenger stop, at 10:37 a.m., and was an hour behind schedule due to in-transit delays. Concerned that the original crew of train 371 would not have enough duty time to reach Chicago, Amtrak called a relief engineer and a relief conductor to report for duty. This relief crew was transported to Hammond, Indiana, where the train made an unscheduled stop about 10:45 a.m. to pick up the relief crew. (See figure 1.) The relief conductor boarded a passenger car, and the relief engineer rode in the cab of the locomotive.

The original engineer was permitted to work until 11:57 a.m. and opted to continue operating the train after the relief engineer came on board. The relief engineer sat in a seat on the left side of the locomotive cab. The relief engineer said that she did not specifically ask whether the engineer wanted her to operate the train. However, she did recall that the engineer had said he was going to be able to "run all the way into the terminal" and had added, "let's hurry up and get on" and "let's go."

[1] All times are central standard time unless otherwise noted.

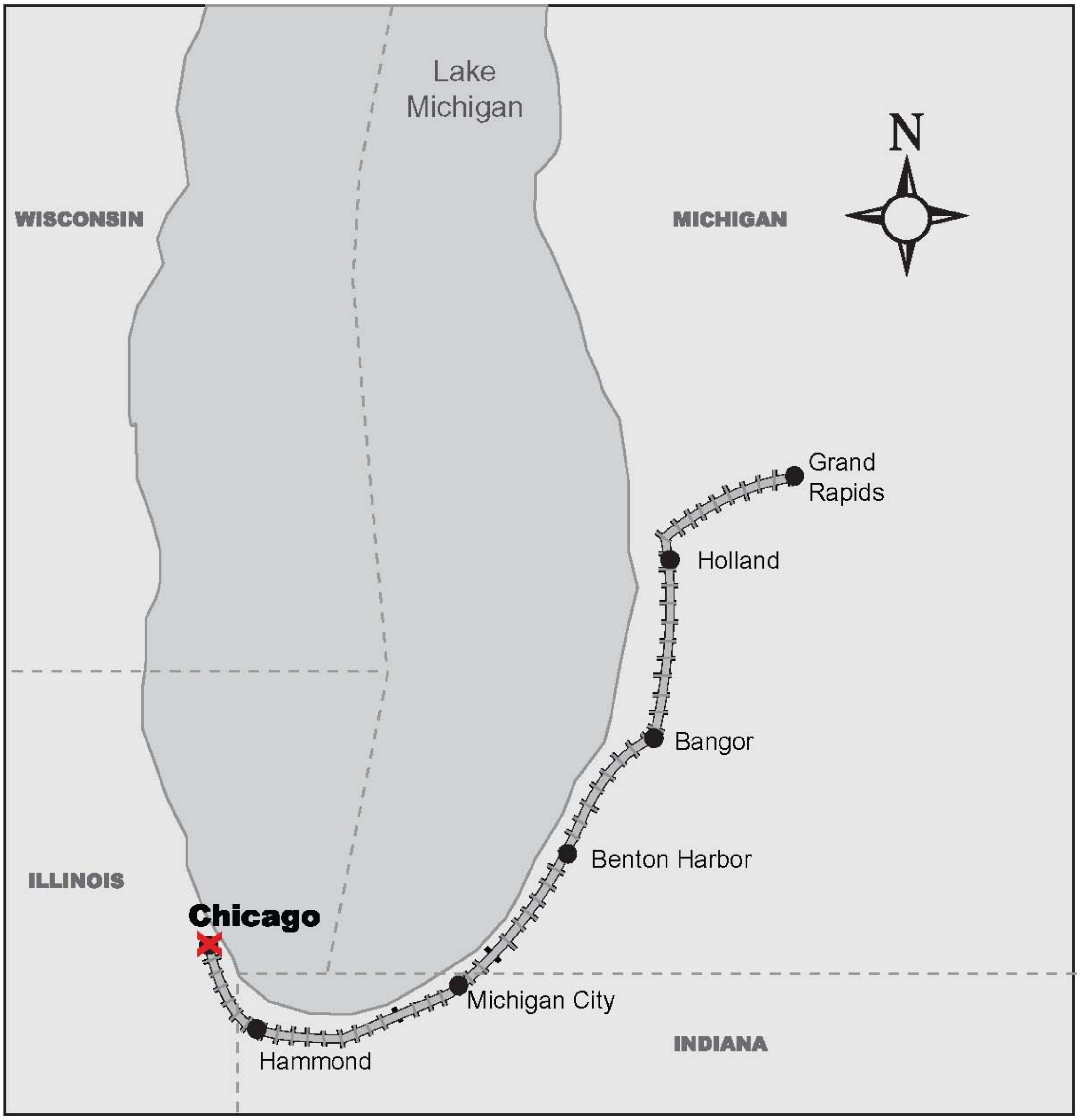

Figure 1. Map of Amtrak Train 371's route and stops. ("X" indicates location of accident.)

As the Amtrak train approached Chicago, it entered an area that had a large number of freight trains. Approaching Englewood interlocking, which is milepost (MP) 516 and 7 miles from Union Station in Chicago, the Amtrak train was operating on track 1 when it passed another westbound train (Norfolk Southern freight train 667) that was stopped on track 2 east of Englewood interlocking.

At Englewood interlocking, there was a red over yellow wayside signal aspect for Amtrak train 371, and the crossover switch was lined for the train to cross from track 1 to track 2. Beyond the interlocking, the engineer and relief engineer saw that an approaching freight train was stopped on track 1.

The track was owned by Norfolk Southern, and according to the Norfolk Southern operating rules, the red over yellow aspect was a *restricting* signal that required the Amtrak train to be operated at restricted speed. A Norfolk Southern freight train that was stopped ahead on the track was the reason for the *restricting* signal. Norfolk Southern's operating rules for restricted speed required, in part, that the train not exceed 15 mph and that the train be operated so that it could be stopped within one-half the range of vision short of either a stop signal or a train that might be encountered on the track beyond the signal.

The engineer said that when he saw the red over yellow signal, he called out *slow approach*[2] in the cab and announced *slow approach* on the radio[3] to the conductor riding in one of the passenger cars. A *slow approach* signal would have required the engineer to not exceed 30 mph and to be prepared to stop short of the next signal; a *slow approach* signal also would have conveyed that the section of track beyond the signal was not occupied.

The relief engineer told investigators that after the engineer had miscalled the signal at Englewood, she had thought to herself, "… maybe [the engineer] just called it wrong but he knew it was a *restricting*." She said that she had "wanted to see what he was going to do." She also said,

> … when the vision came clearer, I could see it was a red over yellow which is a *restricting*, and when the engineer called *slow approach*, I started questioning what I knew of signals, and I started going through my head what all the signals are in the NS [Norfolk Southern] and what their aspects are.

In the postaccident interview, the Amtrak relief engineer also said, "… [the] speed was still low while I was going through signals in my head." The locomotive's event recorder indicated that the engineer had slowed the train to 10 mph while traveling through the crossover switches from track 1 to track 2. When the train cleared on track 2, it accelerated to 25 mph until it cleared a permanent speed restriction (due to curved track) at MP 516.3. (See figure 2.)

During the postaccident interviews, the crew noted that when the train was traveling through the crossovers, they had started a conversation about the job assignments they had received while working the extra board.[4] Once the train cleared the curved track at MP 516.3, the engineer accelerated the train to more than 40 mph. The relief engineer said that she had become uneasy about the speed of the train and that she had challenged the engineer. She said that she had asked the engineer what signal he had called at the Englewood interlocking. She said that he responded that it was a *slow clear*. (A *slow clear* signal would have allowed the engineer to accelerate to a maximum authorized speed of 40 mph after clearing the crossovers and the curve restrictions.) During postaccident interviews, the relief engineer said that she told the engineer,

[2] Postaccident signal testing determined that this signal had displayed a red over yellow aspect, which was a *restricting* signal, not a *slow approach* signal.

[3] During postaccident interviews, the conductor on the train confirmed that he had heard the engineer's announcement but, having not seen the signal, had no reason to doubt its accuracy.

[4] The *extra board* is a group of employees, usually with low seniority, that fill open work assignments when needed.

"You called a *slow approach* at Englewood, right? … Even if it's a *slow approach*, you have to be down to 30."[5]

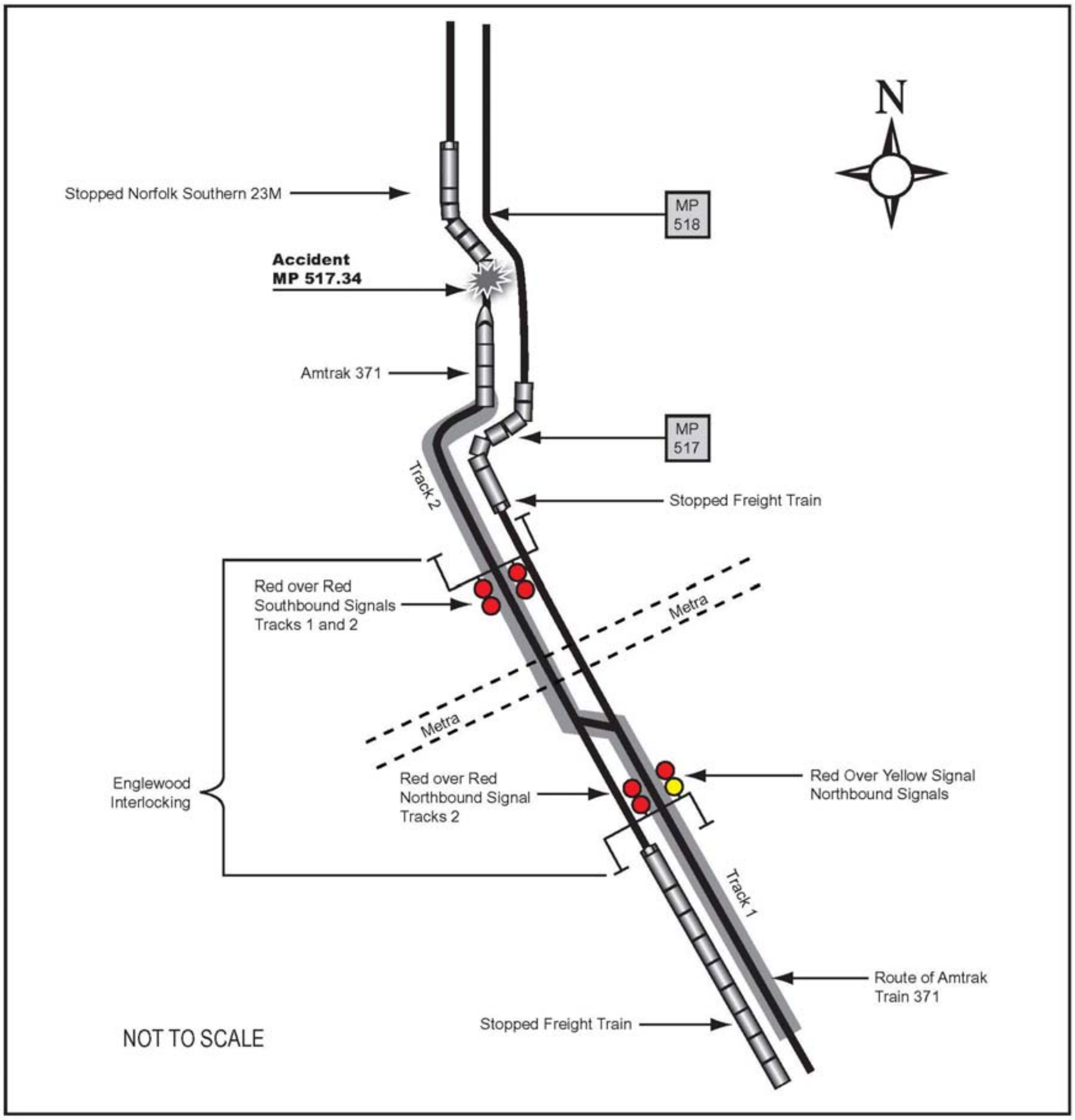

Figure 2. Path of accident train.

Based on the event recorder data and the postaccident crew interviews, the rear of the standing Norfolk Southern freight train on track 2 came into view about a minute after the train was accelerated to 40 mph and while the crew was debating the last signal indication. The engineer reacted and started applying the brakes 8 seconds before the collision. The event

[5] In the Northeast Operating Rules Advisory Committee's (NORAC's) *Rules, Terminology, Definitions, and Authorized Abbreviations*, medium speed means not exceeding 30 mph.

recorder showed that the brakes were quickly applied at several stages until the emergency application, which was made about 1 second before the Amtrak train struck the stopped Norfolk Southern train. The Amtrak train had slowed to 36 mph at impact. Almost 2 miles and about 3 1/2 minutes after crossing from track 1 to track 2, the Amtrak train struck the rear car of the stopped Norfolk Southern train at MP 517.34.

Injuries

The Chicago Fire Department transported 66 passengers and 5 crewmembers to hospitals; 111 passengers on the scene declined treatment. Of the 71 people transported, two passengers and one crewmember were admitted. The two admitted passengers sustained serious injuries as a result of the collision. The day after the accident, the crewmember was released from the hospital. According to Emergency Medical Services (EMS) records, 10 hospitals received the injured passengers and crewmembers. (See table 1.)

Table 1. Injuries.

Injury Type[a]	Train Crew	Passengers	Others	Total
Fatal	0	0	0	0
Serious	0	2	0	2
Minor	5	64	0	69
Total	5	66	0	71

[a]Title 49 CFR 840.2 defines fatality as the death of a person either at the time an accident occurs or within 24 hours thereafter. Title 49 CFR 830.2 defines serious injury as “an injury which: (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes or nose); (3) causes severe hemorrhages, nerve, or tendon damage; (4) involves any internal organ; or (5) involves second or third-degree burns, or any burn affecting more than 5 percent of the body surface.”

Damage

When the Amtrak train struck the rear of the Norfolk Southern freight train, the Amtrak locomotive lifted off its leading truck and rode up onto the rear car, sliding over and crushing the rear corner of a container on the car. The locomotive came to rest on top of the container. (See figure 3.)

The derailment did not damage the signals or track structure, except for two crossties that were marked by the wheels during the re-railing process; however, these crossties did not require replacement.

The Amtrak locomotive was the only derailed piece of equipment. The leading truck assembly[6] ruptured the left front section of the fuel tank, and about 300 gallons of diesel fuel

[6] A locomotive truck assembly includes the wheels, the axles, the side frames, and the traction motors.

spilled from the tank. Both front windows of the cab were dislodged during the collision. The rear window on the right side of the cab was shattered but still in its frame.

Figure 3. Amtrak locomotive resting on top of container on rear car of Norfolk Southern freight train.

Just inside the rear door to the cab from the engine room, the floor was lifted 7 inches and was arched upward in the cab. The engineer's seatback was about 5 1/2 inches from the roof of the cab, the center seatback was about 2 1/2 inches from the roof, and the left seatback was touching the roof. Normally, the seatbacks are 23 inches from the roof.

The three trailing Amtrak passenger cars—35008, 34054, and 34002, in order after the locomotive—remained on the rail, and the exteriors and undersides of the coaches were undamaged. The batteries, battery boxes, power cables, and side and end doors were intact and operable. The emergency lighting remained on in Amtrak car 35008 about 3 1/2 hours after the collision. The public address system was tested after the accident and determined to be functioning in all of the Amtrak cars.

Amtrak Car 35008

On the upper level of the car, two emergency windows on the right side had been removed. The snack area of the lower level of Amtrak car 35008 had both a microwave oven and an empty coffee pot that were found out of their holders and on the floor. The coffee pot's dimensions matched its bracket; however, the microwave's did not. The microwave oven was 13 inches tall. Its bracket was 15 7/8 inches tall, and its holder was 14 1/4 inches tall.

Amtrak Car 34054

The upper level of Amtrak car 34054 had two emergency windows on the right side that had been removed. A seat pair is attached to the car via a wall mount and a pedestal, which is on the aisle side. The pedestal is attached to the floor track with two mount studs. The frame of seat pair 7-8 was not secured to the floor track; the two mount studs on the pedestal securing the seat frame to the track had been fractured. The seat frame was still secured to the wall mount. The frame of seat pair 19-20 was not secured to either the floor track or the wall mount. (See figure 4.) One mount stud on the pedestal securing the seat frame to the track had been fractured. Fractured mount studs were examined in the Safety Board's Materials Laboratory as described later in this report. The rear connection from the wall mount was sheared. The forward connection had been pulled intact from the wall bracket.

Amtrak Car 34002

On the upper level of the car, two emergency windows (one on either side of the car) were open. The mirror in the dressing room of Amtrak car 34002 had shattered, and pieces were lying on the floor. The Americans with Disabilities Act ramp was stored and secured. In the seating portion of the lower level, one light cover was on the floor.

The frame of seat pair 41-42 was not secured to the floor track. The forward mount stud stayed intact with the pedestal, but the rear mount stud had been fractured. The wall mount was still intact.

The damage was approximately $1,299,000. (See table 2.)

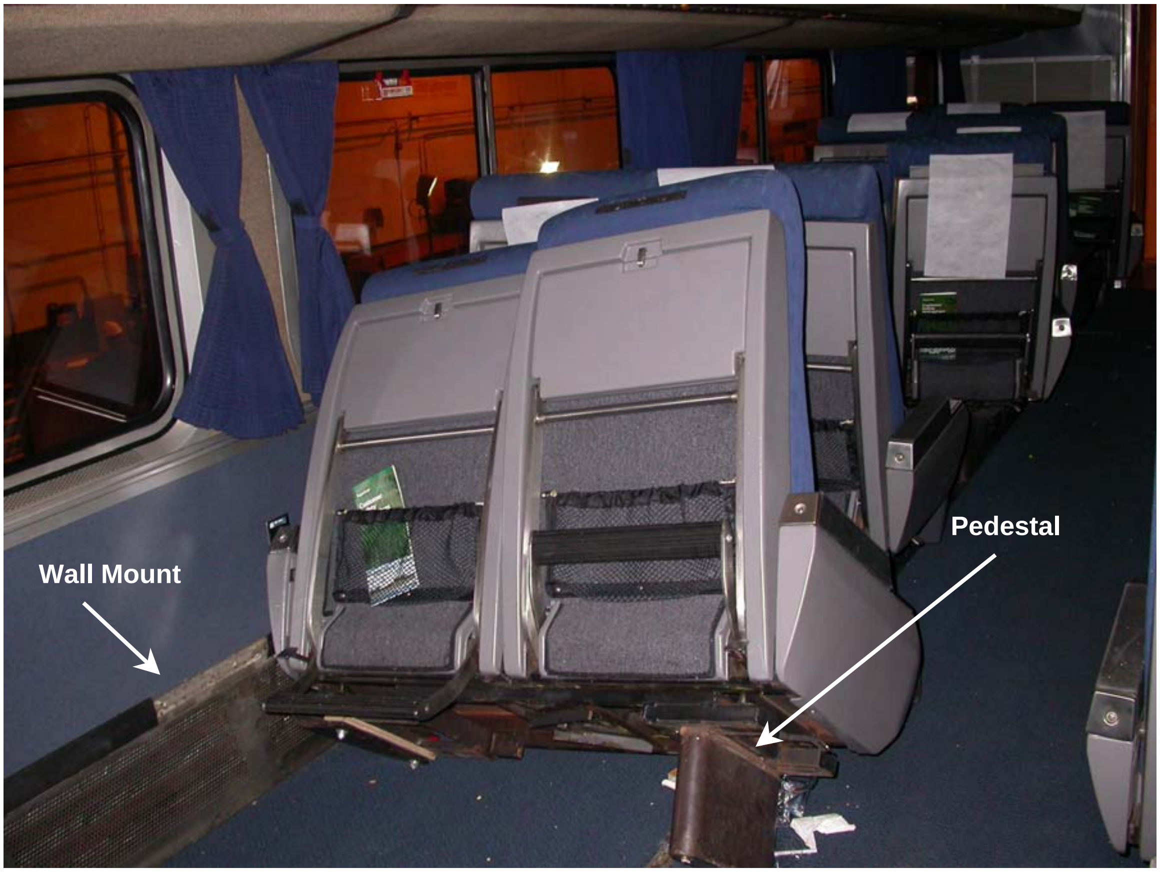

Figure 4. Seat pair 19-20.

Table 2. Damage Estimates.

Item	Damage
Amtrak Equipment	$1,200,000
Lading	80,000
Container	12,000
Freight Car	7,000
Total	$1,299,000

Personnel Information

Engineer

Training/Experience. The Amtrak engineer began his railroad career with the Norfolk Southern as a brakeman in October 2002. He was promoted to conductor on February 28, 2003. He left the Norfolk Southern on November 13, 2003, to pursue his own business. He never worked as an engineer while with the Norfolk Southern.

On September 8, 2006, Amtrak hired him. He began an 8-week locomotive engineer training program at the Amtrak training facility in Wilmington, Delaware. He completed the training with an average score of 91 percent.

He then took the on-the-job training, which consisted of operating trains under the supervision of a certified engineer. This on-the-job training typically lasts about 10 months. His supervisors noted on different occasions that he needed to make smoother station stops and that "[he] needs to stay focused on blowing the whistle for crossings even when other things are going on (radio)." On his final evaluation ride, a supervisor noted that he "exhibits good train handling skills." He became a certified locomotive engineer on September 6, 2007.

The engineer was qualified to operate between Grand Rapids and Chicago on June 15, 2007.[7] He estimated that during his on-the-job training period he had taken 20 to 30 trips to Grand Rapids. From September 25, 2007, through November 30, 2007, he primarily worked railroad yard jobs in Chicago. On November 10 and 11, 2007, he made a round trip from Chicago to Grand Rapids. Then he returned to work on yard jobs. On November 27 and 28, 2007, he completed a round trip to Grand Rapids.

After completing his on-the-job training and prior to receiving his certification as a locomotive engineer, the engineer attended Amtrak's annual refresher training in early September 2007. During this training, he was examined several times on railroad rules and signals. On September 4, 2007, he passed the rules examinations related to the General Code of Operating Rules, the Canadian National Railway, and CSX Transportation (CSX). However, he failed his examination on Northeast Operating Rules Advisory Committee (NORAC)[8] rules. The examination was a 15-question multiple-choice examination on the operating rules. He answered correctly 8 of the 15 questions. The next day, he retook the examination and passed with a score of 93 percent (that is, 14 out of 15).

The engineer was also given his annual refresher signal examinations on September 4, 2007. All operating employees must obtain a perfect score (100 percent) on the annual signal examination before operating or continuing to operate on that railroad. He failed both the Norfolk Southern and the Amtrak terminal signal tests.

On the 10-question multiple-choice examination that covered Norfolk Southern signals, the engineer failed to correctly identify two signals. He gave the same incorrect response for a signal as he did on the day of the accident. In both instances, he misinterpreted a *restricting* signal as a *slow approach* signal. After his examination, the instructor reviewed the questions with the engineer and verified that he understood the correct answers. The engineer was not allowed to work on the Norfolk Southern until he passed the signal examination. The following day, September 5, he retook and passed the Norfolk Southern signal examination.

[7] "Certification" and "qualification" have different meanings. Certified locomotive engineers are in compliance with 49 CFR Part 240 and have displayed the skills and knowledge necessary to operate a train. "Qualified" is a term used to signify that an individual has the skills and knowledge about a specific territory and has the necessary knowledge of that specific route to operate without assistance. Engineers even when certified are not allowed to operate on specific routes until qualified.

[8] Norfolk Southern used NORAC for its operating rules in the Chicago area.

On the Amtrak signal examination for the Chicago Terminal, the engineer missed 4 of the 10 questions on his first attempt. He incorrectly identified an *approach* indication, a *stop* indication, a *medium approach* indication, and a *medium approach medium* indication. The following day, he took the Amtrak signal examination for the second time. On this examination, he missed 2 of the 10 questions. He incorrectly identified an *approach slow* indication and a *stop* indication. Later that same day, the engineer retook the signal exam and passed. The Safety Board notes that the engineer's incorrect answers on the examinations typically identified signal aspects as less restrictive than what the signal indicated. For example, during the engineer's examinations, he had misinterpreted a *stop* indication as a *stop and proceed*.

Work/Rest. The engineer's activities during the 72 hours that led to the accident were reconstructed through interviews, company records, and information provided by the engineer following the on-scene investigation. The engineer had gone on duty the previous Tuesday, November 27, 2007, at 4:35 p.m. in Chicago. He had been assigned to operate a train to Grand Rapids. He arrived at Grand Rapids on Tuesday evening about 10:29 p.m. and then went off duty. He said that he went to bed soon after 11:00 p.m. and awoke the next morning, Wednesday, November 28, 2007, around 5:00 a.m. He went on duty at 5:50 a.m., and his train departed Grand Rapids for Chicago about 6:00 a.m. The train arrived in Chicago about 11:30 a.m., at which time he went off duty. He said that he performed some chores in the afternoon and took a 90-minute nap. He went to bed about 11:30 p.m. He awoke on Thursday, November 29, 2007, at 5:00 a.m., exercised, and did chores. Between 10:00 a.m. and noon, he took a nap. He said that when he awoke, he ate lunch. He left for work at 2:00 p.m. He went on duty in Chicago at 4:35 p.m. and was again assigned to a train that was headed for Grand Rapids. He went off duty in Grand Rapids at 10:28 p.m., and he went to bed about 11:00 p.m. On the day of the accident, he awoke about 5:00 a.m. and went on duty at 5:50 a.m. When he was asked about his alertness level at the time of the accident, he said that his alertness had been about 4 1/2 on a scale from 1 to 5.[9]

Health. The 50-year-old engineer told investigators that before the accident he was in good health. A review of his medical records indicated that his last medical examination with Amtrak had been on September 7, 2007. He was found to be medically fit for duty without restriction. However, he had been taking prescription drugs to control his high blood pressure.

Workload. He told investigators that his trip from Grand Rapids to Chicago had been mostly typical. He indicated that his workload had been somewhat more demanding than usual because he had about 23 temporary speed restrictions during the trip. He said that he had taken his cellular telephone with him but had used it only after the collision. The cellular telephone records confirmed his statement.

Relief Engineer

Training/Experience. In 1987, Amtrak hired the relief engineer as a clerk. In October 2003, she became a yardmaster. In October 2005, she left Amtrak and entered the dispatcher training program at CSX. In February 2006, she returned to Amtrak as a yardmaster.

[9] The scale was explained to the engineer as follows: 1 is a low level of alertness, and 5 is a high level of alertness.

In June 2006, she entered Amtrak's locomotive engineer training program in Wilmington, Delaware; she completed the training with an average score of 97 percent.

During her on-the-job training, she spent about 3 months operating trains out of St. Louis, Missouri. The remainder of the time, she worked out of Chicago. She said that as a student she had made 12 round trips through the area where the accident occurred.

On June 12, 2007, she became a certified locomotive engineer. She was qualified to operate trains between Chicago and Grand Rapids and between Chicago and Battle Creek, Michigan. She also worked in the Amtrak rail yard at Chicago. On October 23, 2007, she passed her last operating rules examination.

In the 2 months before the accident, the majority of her time was spent operating in the Amtrak rail yard at Chicago; she also made an occasional trip from Chicago to Butler, Indiana.

Work/Rest. At 10:00 p.m. on the Tuesday before the accident, the relief engineer had gone on duty when she was assigned to a yard job in Chicago. On Wednesday morning at 6:00 a.m., she went off duty. When she had checked with Amtrak, she was told that it was unlikely she would be called for work until at least the next day. She said that she had stayed up on Wednesday. During the day, she did routine chores and activities. About 8:00 p.m. on Wednesday evening, she went to bed. On Thursday about 7:00 a.m., she awoke and did chores; Amtrak did not call. On Thursday evening between 9:00 and 10:00 p.m., she went to bed. On Friday about 6:30 a.m., she awoke. During interviews, she said that she had felt "very alert" when Amtrak called at 8:30 a.m. and told her to report to work at 10:31 a.m.

Health. The 43-year-old relief engineer told investigators that her overall health was good. On May 10, 2007, she had her last medical examination with Amtrak. At that time, she was found to be medically fit for duty without restriction. She said that she wore prescription lenses when operating trains. At the time of the accident, she was wearing prescription contact lenses.

Workload. When first boarding the train, she read the applicable operating instructions issued for the train on this specific trip. Since the engineer did not leave the engineer's seat, she understood that he would operate the train until either reaching his time limit or reaching Union Station, whichever occurred first. During the postaccident interview, she said that she had been a working crewmember of the locomotive cab. She said that one of her duties was to call aloud the wayside signals together with the engineer; however, at Englewood interlocking, she did not call out this signal. She said that she had taken her cellular telephone with her but had used it only after the collision.

Equipment Information

Amtrak train 371 consisted of one locomotive and three Amtrak Superliner I passenger cars (35008, 34054, and 34002). The standing Norfolk Southern freight train 23M consisted of two locomotives and 20 multi-platform intermodal cars. The Norfolk Southern train was 5,055 feet long and, excluding the locomotives, weighed 4,062 tons. The Amtrak train, including the locomotive, was 338 feet long and weighed 358 tons.

Preaccident Inspections and Maintenance

Amtrak train 371 was mechanically inspected and the air brakes were tested before the train's departure from Grand Rapids. The records on the locomotive indicated that the predeparture air brake test and mechanical inspection were completed successfully. No exceptions were noted in the records concerning the predeparture condition of the train. All periodic inspections were within the prescribed limits for each car and the locomotive.

Postaccident Inspections

Because of the damage to the Amtrak locomotive in the accident, the air brake system could not be tested. While operating the train, the engineer had not reported a defective condition. The air brake system of the three Amtrak cars was tested using a Norfolk Southern locomotive. The air brake system was charged, and the brakes were applied and released in both service and emergency applications. During the tests, no binding or fouling was observed in the foundation rigging; the brakes performed as designed.

Signal Information

The Englewood interlocking had interlocking signals and power-operated switches, which were controlled by the Consolidated Control Facility in downtown Chicago. The facility was owned and operated by Northeast Illinois Regional Commuter Rail Corporation (METRA). The Amtrak train was traveling on Norfolk Southern tracks, but the Norfolk Southern tracks crossed two METRA main tracks at the Englewood interlocking. Typically, when railroads cross each other at an interlocking, one of the two railroads will control the crossing location. In this case, a METRA control operator controlled the train movements from track 1 and track 2 on the Norfolk Southern track.

On the day of the accident, a data log was recorded at the METRA facility that captured the signal events and train movements at Englewood interlocking. The control operator had requested that the power-operated switches line for a movement from track 1 to track 2 at 11:08:54 a.m. Five seconds later, the data showed, the switch reversed and the signal cleared[10] for the approaching Amtrak train 371. At 11:19:09, the interlocking track circuit was occupied. At 11:20:32, the interlocking track circuit showed the interlocking was unoccupied. These times matched the times of Amtrak train 371's event recorder, which had recorded the train's westbound movement through Englewood interlocking.

[10] The dispatching system will not indicate the specific aspect given in the field. It can only display if the signal has cleared for a movement or the signal is a stop signal.

The signal maintenance records were examined. Postaccident testing of the applicable signals was performed. No condition was identified that would have prevented the signal system from functioning as designed. A test was performed to simulate the movement of Amtrak train 371.

Operations Information

CSX Transportation

Between Grand Rapids, Michigan, and Michigan City, Indiana, Amtrak train 371 operated on the CSX's Chicago Division, Grand Rapids subdivision. The operations were governed by the NORAC rulebook. The signal aspects and indications are described in CSX Signal Aspects and Indications Rules.

Norfolk Southern

Between Michigan City and 21st Street in Chicago, Amtrak train 371 operated on Norfolk Southern track. The operations were governed by the same NORAC rulebook. For specific instructions, information was available in the Norfolk Southern's Dearborn Division, Northern Region Timetable No. 4. The red over yellow aspect at Englewood interlocking had a *restricting* indication. According to Norfolk Southern's signal rules, this signal indication required the train to be operated at a restricted speed into the next block. The restricted speed meant that the train must not exceed 15 mph and that it must be prepared to stop within one-half the range of vision of another train.

Amtrak Yard

In Chicago, between 21st Street and Union Station, the Amtrak rules for the Central Division, Chicago Terminal, governed Amtrak train 371. The signal aspects and indications were in Amtrak's Timetable No. 3. The Central Division, Chicago Terminal General Order No. 3-S16, added a rule governing a red over yellow signal. The red over yellow aspect between 21st Street Chicago to the Chicago Terminal Union Station had a *slow approach* indication, which meant the following: the engineer should proceed but be prepared to stop at the next signal and, when the entire train clears the interlocking or control point limits, proceed at a speed not exceeding 30 mph and be prepared to stop at next signal. Unlike the Norfolk Southern red over yellow signal aspect, there would be no expectation of a train on the track beyond the signal.

Management Oversight

Amtrak has to prepare its employees to operate on many different railroads throughout the United States. The railroads use different rulebooks and different signal systems. Because a particular Amtrak train can operate on several different railroads, the instructions covering a single trip can be scattered among multiple operating rulebooks. An Amtrak official told investigators that one of the greatest challenges in engineer training is dealing with the signals of two different railroads that have similar aspects but different indications. For example, identical signal aspects for different railroads may specify different speeds. Managers are responsible for signal training and tests. An employee must obtain a perfect score (100 percent) on the annual signal examination before he or she is allowed to operate or continue to operate on that railroad.

Engineer Training

All prospective Amtrak engineers begin their formal locomotive engineer training at Amtrak's training center in Wilmington, Delaware. This portion of the training, which is primarily classroom instruction, lasts 8 weeks. Student engineers are taught the duties and responsibilities of being an engineer. Training includes operating rules (including signals), equipment (locomotives and troubleshooting equipment problems), airbrakes, train handling, and emergency procedures. The Amtrak system general road foreman said that the railroad uses train simulators to expose students to the basics of train handling and the application of the operating rules.

The student engineers take written examinations during this part of their training. Most of the tests are multiple choice. In signal examinations, students select the indication that matches a corresponding color drawing of the signal aspect. A passing percentage for the operating rules examination is 85 percent, but 100 percent is required for the signal section. To achieve a passing score during the engineer training, students are allowed to take the tests twice. If they fail on their second attempt, they are terminated from the training program.[11]

Upon successful completion of the training at the training center, prospective engineers are sent to different regions and assigned to local engineer instructors. This on-the-job-training phase generally lasts about 10 months, depending on the routes on which the engineer will be qualified. The purpose of this training is to provide student engineers with direct supervision as they learn the physical characteristics, signals, and operating rules particular to territories and railroads.

The engineer trainees and certified engineers also take annual refresher training, in which they spend 2 or 3 days in a classroom reviewing policies, procedures, regulations, operating rules, physical characteristics, customer service, and emergency procedures. The training includes case studies involving operating rules violations and previous incidents or accidents involving Amtrak trains.[12] The training ends with a 15-question multiple-choice examination on operating rules and a 10-question examination on signals. If the participant fails to answer any of the signal questions correctly, the instructor hands the examination back without any notations

[11] To pass the annual signal examination in the field, an engineer must score 100 percent; however, an unlimited number of attempts are allowed.

[12] Amtrak officials said that most of the operating violations committed by its locomotive engineers cited in the case studies are not due to confusion over a rule (that is, misinterpretation of a signal aspect) but to other factors, including operator distraction and inattention.

and asks whether the engineer would like to change any answers.[13] If the participant cannot correct the examination, the instructor marks the incorrect answers, and the employee will not be in service until completing the exam with a perfect score. An Amtrak supervisor said that most employees who fail the test wait at least 1 day before retaking the test.

Crew Resource Management Training

Amtrak based its crew resource management (CRM) program on the CRM principles that are applied in the aviation industry, as well as on those principles that are already used in the railroad industry. Amtrak's CRM training, which was developed in 2002, was initially a separate program that was given to engineers during their initial classroom training in Wilmington and was reinforced during their annual refresher training. A few years after its development, Amtrak's CRM training was integrated with a review of operating rules violations and a discussion of how CRM tools could have been used to avoid incidents and operating violations.

Similar to other CRM programs in the transportation industry, Amtrak's CRM program addressed such principles as situation awareness, workload distribution, and effective communication. Crewmembers are instructed to assert themselves when they determine that proper procedures or safe practices are not being exercised.

When questioned on how to intercede when an employee is not following the procedures properly, an Amtrak system general road foreman whose duties include CRM training told investigators that "appropriate assertiveness" should be exercised. The official said,

> If somebody is not willing to accept your direction or you[r] input sometimes you have to take action… if you have to pull the air, you pull the air….[14] Part of the thing about speaking up is just questioning. You don't have to be alarmed and say, 'Hey, shouldn't we be stopping?' but you could say, 'Hey, wasn't that signal this or shouldn't we be doing 15 [mph] …' the action may be simply to speak up. If that doesn't trigger the appropriate reaction or the engineer says, 'Oh, no, I'm pretty sure it was a green' and then the appropriate assertiveness, you may have [to] say, 'No, listen, I'm directing you to stop and sort this out' or whatever it takes. And, you know, it's an easy thing to say. It's hard to put into practice, but we encourage appropriate action…. I mean my mantra in class is, if in doubt, use the air, slow down. I bring up stories and relate incidents that I've been involved in and that prove that's the way to go and that can save the day.

During the training, the instructors may intentionally communicate a wrong signal to an engineer trainee while operating a train to observe whether the trainee uses the appropriate assertiveness in responding.

[13] Amtrak's senior director, System Operating Practices, said that this "second look" on an examination was discontinued in 2008.

[14] *Pulling the air* means placing the train into emergency braking. A brake handle that is accessible to the employee in the locomotive cab is on the fireman's side.

At the time of the accident, the employees in the cab of the locomotive were governed by four NORAC rules that pertain to observing signals. The first rule is the following:

> 94. Responsibilities of Employees: Signals and Restrictions
>
> a. General Requirements
>
> Employees qualified on the operating rules and located on the leading engine or car must be on the lookout for signal affecting the movement of their train. They must communicate to each other in a clear manner the name of each signal as soon as it becomes clearly visible. After the name of a signal has been communicated, employees must observe it until passed. Any change in the signal must be communicated in the required manner.
>
> If a train is not operated in accordance with the requirements of a signal indication or restriction, qualified employees located in the leading engine or car must communicate with the Engineer immediately. If necessary, they must stop the train.

The second applicable rule is the following:

> 956. Observing Signals; Moving Engine
>
> Engine Service Employees will be responsible for the observance of all signals and for controlling movements accordingly. To prevent injury to persons, to prevent damage to property and lading, and to avoid collisions and derailments they must:
>
> 1. Regulate the speed of their train,
>
> AND
>
> 2. Exercise discretion, care and vigilance in moving their train.

The third applicable rule is the following:

> 958. Visibility Compromised: Regulation Speed
>
> If anything distracts attention from a constant lookout ahead or if weather conditions make observation of signals in any way doubtful, Engine Service Employees must at once regulate the speed of their train to ensure safety.

The fourth applicable rule explains how to resolve a situation in which more than one speed is authorized. The fourth rule, Rule 40, is the following:

> Train speeds may be authorized by the rules, special instructions, signal indications, dispatcher messages or other means. When there is a difference in the speeds, the lowest speed will govern.

Amtrak’s operating crews are required to adhere to the rules that govern the territory on which they are operating trains. Amtrak does not have written rules that specifically require an engineer to either make an immediate brake application or slow the train when another crewmember raises concerns about the train’s operation.

Meteorological Information

At 10:51 a.m., at the Midway Airport, which is approximately 6 miles west of the accident site, the winds were from the northwest at 17 mph with gusts of up to 25 mph. The visibility was 10 miles with partly cloudy skies. The temperature was 30º F, and the dew point was near 9º F.

Toxicological Information

The Amtrak crewmembers (engineer, relief engineer, conductor, relief conductor, and assistant conductor) provided postaccident toxicological specimens that were tested for the presence of alcohol and drugs.[15] Results for all crewmembers were negative for alcohol and drugs.

Emergency Response

Local Emergency Response

A passenger aboard the Amtrak train placed the first 911 call at 11:23 a.m. The passenger reported the collision but was unsure of the train’s location. After discussions with the passenger, the 911 dispatcher determined the location and assured the passenger that ambulances were responding. At 11:27 a.m., the Amtrak conductor called 911.

The initial dispatch, at 11:32 a.m., included four engine companies, four truck companies, one heavy rescue squad, four battalion chiefs, one deputy district chief, one mobile command and communications vehicle, seven ambulances, two EMS chief officers, one EMS assistant deputy chief paramedic, and an advanced life support engine. The conductor reported that the first fire department official arrived at 11:37 a.m. The first of the engine companies arrived at 11:38 a.m.

The commissioner of the Chicago Fire Department was the incident commander. The operations command post for the fire department was established at 312 West 52nd Street, the EMS treatment and triage area was established at 5200 South Princeton Avenue, and the EMS transport area was established in the 5200 to 5300 block of South Princeton Avenue. The nearby

[15] Substances tested for included cannabinoids, cocaine, opiates, amphetamines, methamphetamines, phencyclidine, barbiturates, and benzodiazepines.

Parkman Elementary School was used as a shelter and as an additional treatment and transport area for passengers.

A unified command post was established at 5220 South Shields Avenue. Representatives of the Chicago Fire Department, the Office of Emergency Management and Communications, Amtrak, the Red Cross, and the Chicago Police Department were at this location. The Chicago Police Department assisted with the evacuation of the passengers and provided security at the accident site and school. Norfolk Southern police and personnel also responded. (See figure 5.)

Hose lines were run as a precaution because the locomotive's fuel tank had been breached. However, the leaking diesel never ignited. Triage was started immediately on the train. Passengers were evacuated from the train to an area near a fence between the rail yard and a street east of the accident site. After firefighters had cut down parts of the fence, passengers were led down an embankment to a secondary triage and treatment area. Firefighters placed ladders along the embankment to help the passengers walk down the embankment.

At 11:48 a.m., four additional ambulances, another advanced life support engine, and a mass casualty unit[16] were dispatched. At 11:50 a.m., a heavy rescue unit and a collapse unit were requested. At 11:51 a.m., five advanced life support engines were dispatched to assist with triaging the patients. At 11:52 a.m., six ambulances and two additional mass casualty units were dispatched. At 11:53 a.m., four additional truck companies were requested. At this time, 182 firefighters were on scene. At noon, two additional battalion chiefs and one EMS chief officer were requested.

The transportation of patients to hospitals began at 12:05 p.m. At 12:13 p.m., the final search of the train was complete, and all passengers were off the train. At 12:19 p.m., two additional advanced life support engine companies were dispatched. One of these engines responded to Parkman School. Four additional ambulances were sent to Parkman School at 12:28 p.m.

[16] A mass casualty unit is capable of treating 50 critical patients.

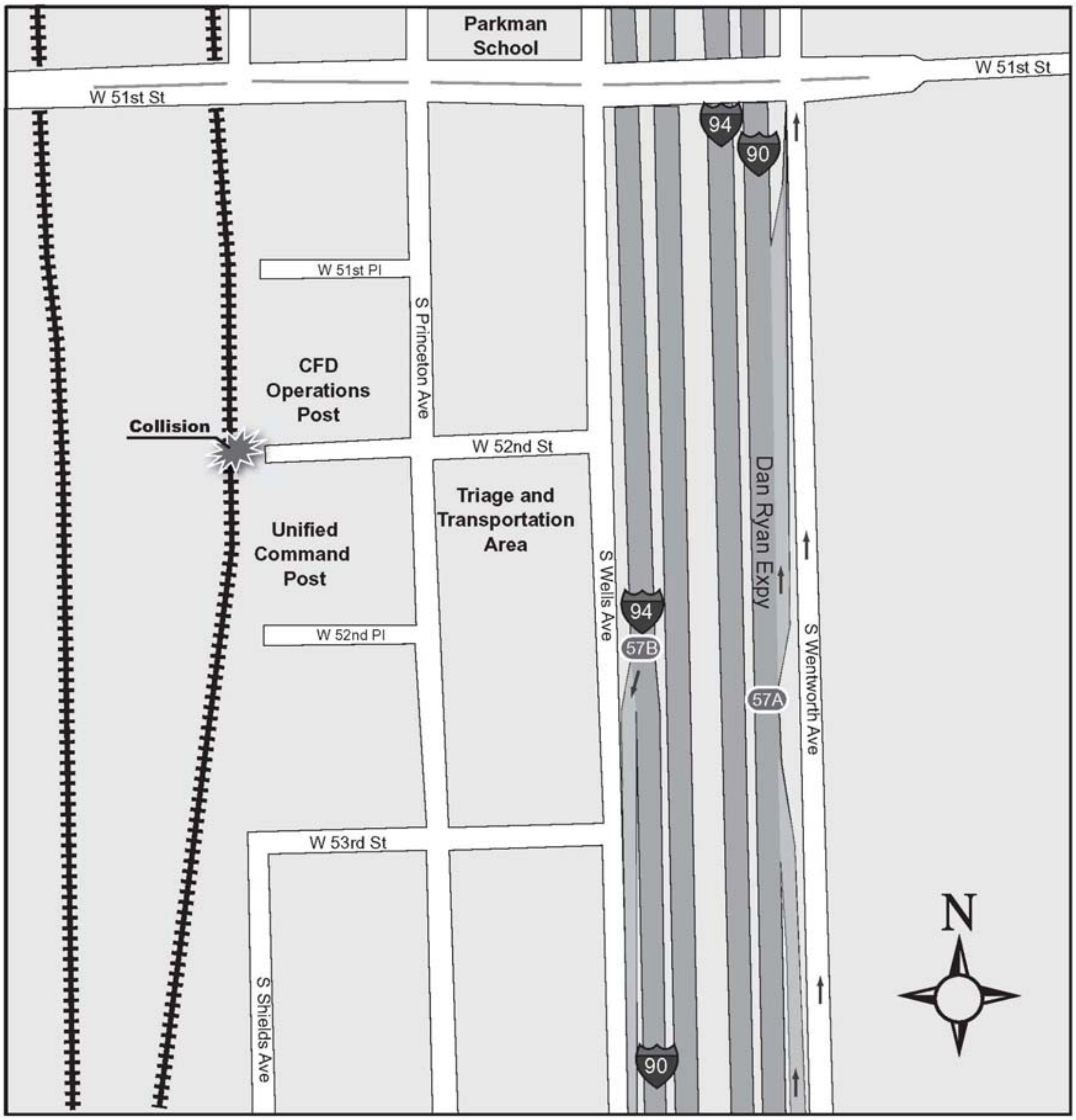

Figure 5. Emergency response locations.

Passengers who were not taken by ambulance to hospitals were taken to Parkman School. After additional triage and treatment at this location, 24 passengers were transported by bus, accompanied by an advanced life support engine company, to Stroger Hospital at about 1:25 p.m. They were the last to be transported to hospitals. Additional buses were used to take uninjured passengers to the train's final destination, Chicago's Union Station. The scene was secured and released to the railroad at 1:30 p.m., a little more than 2 hours after the collision.

At one time during the response, Chicago Fire Department personnel at the scene numbered 250. At the scene, the following were present: 23 companies (engines, trucks, and squads), 6 battalion chiefs, 4 EMS chief officers, 3 mass casualty units, 2 heavy rescue squads, 2 collapse rescue units, a command and communication unit, a support logistics division vehicle with 100 stairchairs, a helicopter, and additional chief officers.

Crew Extrication

Because of the damage to the Amtrak locomotive, the two Amtrak engineers were trapped in the cab compartment. The locomotive cab had three doors. Each side of the cab had a door with a ladder on the outside. The third door was behind the engineer's seat and led to the engine room toward the rear of the locomotive. The crew was not pinned within the cab but could not exit through the doors. Firefighters tried to force open the cab door on the right, but they were unsuccessful. Instead, they broke a window on the right rear door for access. There were no roof access panels or structural weak point to provide additional quick access for emergency personnel; nor were they required.[17] Once inside the locomotive, they found that the door from the engine compartment leading into the cab was jammed closed by the raised floor. This door had to be forced open. To reach the trapped engineers, the firefighters also removed a panel of the right-side cab window.[18] The relief engineer exited the locomotive through the right-side cab window and climbed down the ladder to the ground. The operating engineer walked back through the engine to the rear door, was placed in a rescue basket,[19] and was lowered to the ground. A review of a rail yard video shows that the relief engineer was extricated about 12:05 p.m. and the operating engineer was extricated about 12:16 p.m.[20]

Disaster Preparedness

Crew Training

Amtrak has an emergency preparedness training program for its crewmembers. This training is required by 49 CFR Part 239. A refresher course is required every 2 years. Amtrak's training program is called PREPARE (Passenger Railroad Emergency Preparedness and Response Education). The purpose of the course is to prepare operating and on-board crews for managing train emergencies. The course includes topics such as rail equipment familiarization, passenger evacuation, and emergency care. All of the crewmembers were current with their training.

[17] For passenger train operations with speeds in excess of 125 mph, 49 CFR 238.441 requires roof access panels or a structural weak point to provide quick access for emergency personnel. This accident train operated at less than 125 mph.

[18] The side cab windows were approximately 45 inches wide with one 22-inch panel and one 23-inch panel.

[19] A *rescue basket* is a rigid body-sized platform on which a stretcher can be secured for transporting patients.

[20] These times were adjusted from the video time stamp to match the accurate time provided by the 911 call-in emergency system.

Emergency Responder Training

Title 49 CFR Part 239 also requires passenger railroads to maintain liaison with local emergency responders. Amtrak provides a training program for emergency responders called Passenger Train Emergency Response. This training includes railroad operations, equipment familiarization, and types of train service emergencies. In August 2007, Amtrak had held an emergency incident management meeting, which included the emergency response training, with the Chicago Fire Department, the Chicago Police Department, and the Office of Emergency Management and Communications at Union Station in Chicago. The purpose of the meeting was to identify areas that emergency responders could use for command posts, treatment and triage areas, and field hospitals.

Testing and Examination of Seat Mount Studs

Two different types of mount studs were discovered during the postaccident examination of the Superliner cars. All the mount studs that fractured were of the same type; Amtrak searched its inventory of replacement mount studs and reported that it could find no evidence of this type in its inventory. Amtrak also reported the presence of lead in the type of mount studs that fractured; however, no lead was found in the type of mount studs that did not fracture.

The two fractured mount studs from seats 7-8 and the fractured mount stud from seats 19-20 from car 34054 were sent to the Safety Board’s Materials Laboratory. The Materials Laboratory compared the accident mount studs that failed with an exemplar mount stud of the type that did not fail. The head profile of each mount stud was measured and the material was tested for hardness. Minor differences in head profiles and average hardness values were noted.

The fractures on two of the mount studs contained crack arrest marks that are typical of fatigue cracking emanating from the relief radius between the shank and head portion of the mount stud. The fractures on the head of the third mount stud had fine-grained features that are typical of overstress separation with no evidence of fatigue cracking. The exposed fracture faces showed metal flow that is consistent with the mount stud pulling up relative to the floor-mounting track. The upper side portion[21] of the heads in areas that corresponded to a fatigue crack had fretting[22] damage.

Event Recorder Information

The event recorder captured data through the trip up to the collision. According to the recorder, the train had decelerated to 10 mph near the crossover at the railroad crossing at Englewood interlocking, the train started to accelerate to 25 mph while within the curve restrictions, and finally the train reached a speed of 43 mph. The data showed several brake

[21] This was the portion of the head that was in contact with the floor-mounting track.

[22] *Fretting* is damage that is induced under load and in the presence of repeated relative surface motion.

applications just before the collision, including an engineer-initiated emergency application. The last recorded train speed was 36 mph.

Analysis

Exclusions

Safety Board investigators reviewed the signal system data logs and performed postaccident signal testing. The logs and tests indicated that the signals were functioning properly at the time of the accident. Investigators examined the Amtrak train equipment and recovered the maintenance records. The equipment that was tested, including the braking systems, had worked as intended. The track and structures had been maintained within tolerances and Federal regulations. Both Amtrak operating crewmembers (engineer and relief engineer) indicated that until the Englewood interlocking nothing about the accident trip was abnormal or created an unmanageable workload. There is no evidence that their performance was affected by the use of prescription or non-prescription medication. Postaccident toxicological testing for all the crewmembers was negative for drugs and alcohol. Their work/rest schedules were regular; it does not appear that operator fatigue was a factor in this accident. Neither crewmember was using a cellular telephone or radio before the accident. Nothing in the environment (that is, rain, fog, or direct sunlight) affected the visibility of the signals. Therefore, the Safety Board concludes that the following were not factors in this accident: the functioning of the signal system, the condition of the equipment and the track, drug and alcohol use, fatigue, cellular telephone or radio use, and the visibility of signals.

Train Crew’s Actions

As westbound Amtrak train 371 approached Englewood interlocking on track 1, the operating crew observed two stopped Norfolk Southern freight trains. Both trains were stopped to give the Amtrak train priority on the track.

Train crews understand that Amtrak trains are often given a higher priority than the host railroad's freight traffic. It would have been normal for the train dispatcher to route the Amtrak train around the freight trains by changing tracks and threading the passenger train through the congestion caused by a large number of freight trains. Because of its delayed departure from Grand Rapids, the Amtrak train was running about 1 hour behind schedule when it reached Englewood. From Englewood, the Chicago passenger terminal was about 15 minutes away. It would have been reasonable for the Amtrak engineer, who had just seen two freight trains yield to him, to believe that he would continue to receive priority over other trains ahead of him, thereby preventing additional delays. He was interested in not being delayed, which was evident when he said, “let’s hurry up and get on” and “let’s go” to the relief engineer when she boarded the train. The engineer was likely trying to reach the Chicago Terminal before he ran out of work time at 11:57 a.m.

As the train traveled closer to the first signal at Englewood interlocking, the engineer made a significant error when he misinterpreted the meaning of the red over yellow signal aspect. The red over yellow aspect was a *restricting* indication, requiring the crew to operate the train at a maximum speed of 15 mph and to be prepared to stop for any trains or obstructions ahead. The aspect should have alerted the crew to the possibility of a train on the track ahead of them. However, the engineer misinterpreted the signal as a *slow approach*, which would have allowed him to operate through the interlocking at a maximum speed of 30 mph while being prepared to stop at the next signal. Of even more importance, a *slow approach* signal indication would have meant that there was no train within the next block.

As the westbound Amtrak train approached Englewood, the engineer slowed his train and then crossed over from track 1 to track 2. This action routed his train around the eastbound freight train that was directly ahead of him on track 1. Once the Amtrak train was on track 2, the eastbound freight train was neither a concern nor a source of additional delay. From that point, based on his misinterpretation of the meaning of the signal, the engineer may have had no expectation of operating the train at a reduced speed, at least until the train reached the next signal.

The Amtrak engineer, believing he had just received a *slow approach* indication, operated his train at 25 mph around the curves and at 30 mph on tangent track, which is consistent with the timetable speed for this territory. The crew observed nothing in front of them at that time to suggest that slowing the train below track speed was necessary. Consequently, the engineer likely felt comfortable about increasing the train's speed to the next timetable speed of 40 mph. Moments later, when questioned by the relief engineer about the signal they had passed, he stated that it was a *slow clear* indication, which would have permitted him to operate at the higher speed (40 mph). This second misinterpretation was different from his first misinterpretation and, in fact, was even less restrictive. The engineer and relief engineer continued to discuss the signal while the engineer maintained the train speed at 40 mph. When the engineer saw the stopped Norfolk Southern freight train on the track in front of him, the speed and distance did not allow enough time for him to stop his train short of the Norfolk Southern train.

The relief engineer told investigators that she had immediate concerns about the engineer's misinterpretation of the signal indication at Englewood. However, because of their conflicting interpretations of the signal, she began doubting her own knowledge of that signal and, she said, she thought that initially the engineer had understood the signal but had misspoken. Consequently, she delayed voicing her concerns until she gave it additional thought and felt more confident with her position.[23] She communicated her concerns about 3/4 mile before the collision and as the Amtrak train's speed reached 40 mph, which exceeded both the maximum authorized speed (30 mph) of the signal indication that the engineer had erroneously called and the maximum authorized speed (15 mph) that she correctly believed the signal indication allowed. The relief engineer said that she asked the engineer, "You called a *slow approach* at Englewood, right? ... Even if it's a *slow approach*, you have to be down to 30." The discussion about the previous signal between the engineer and the relief engineer lasted for

[23] Lack of confidence is one of several barriers to communication identified in CRM research. Other factors, some of which might have been present in this accident, include gender differences, lack of credibility, rapport, or authority, experience, rank, and fear of reprisal. R. Baron, "Barriers to Effective Communication: Implications for the Cockpit," 2005, <http://www.airlinesafety.com/editorials/BarriersToCommunication.htm>.

several moments, and the engineer, believing that he was operating the train appropriately, maintained the train's speed.

Although the relief engineer voiced her concerns in time for the engineer to make a brake application and safely stop the train, her actions were not immediate and were not adequate. She asserted herself after the engineer accelerated the train to 40 mph rather than asserting herself immediately after she first believed that the engineer had miscalled the signal, and she never asserted to the engineer that she believed that the Englewood signal was a *restricting* signal that limited their speed to 15 mph. After the relief engineer first voiced her concern, the process by which the two crewmembers attempted to resolve their differences was to discuss the indication of the previous signal: the engineer did not immediately slow the train, and the relief engineer, seeing that the engineer did not immediately slow the train, did not herself apply the brakes to stop the train. The engineer applied the brakes only after he saw the stopped Norfolk Southern train in front of them. Therefore, the Safety Board concludes that the engineer misinterpreted and miscalled the signal at Englewood which resulted in the operation of the Amtrak train at a speed greater than authorized, and when challenged by the relief engineer, the engineer failed to slow or stop the train while he and the relief engineer discussed their differences in understanding the signal displayed at Englewood. The Safety Board also concludes that the relief engineer failed to communicate effectively and in a timely manner to the engineer that he had miscalled the restricting signal at Englewood interlocking and failed to then take action herself to stop the train after the engineer did not slow or stop the train when challenged.

The process by which train crews should identify and strategically respond to unsafe situations is addressed in Amtrak's Crew Resource Management (CRM) program. Modern railroads emphasize both the application of CRM principles and crewmember proficiency to establish and maintain safe train operations. The purpose of CRM is to help operating crews use all of the available resources (information, personnel, and equipment) at their disposal effectively. The role for crewmembers is to perform their assigned tasks responsibly, to know about or participate in determining the plans for movement of the vehicle, to be alert to departures from plans or from the expected performance of others, and to make those departures known in time to avert an operational error. If properly applied, CRM will increase the likelihood that human operation errors will be detected in time for action to be taken to prevent an accident. Although Amtrak's CRM program emphasizes the importance of crewmembers immediately voicing their concerns after recognizing potentially unsafe situations, this accident clearly demonstrates the importance of crewmembers implementing the principles of CRM to prevent accidents. Therefore, the Safety Board believes that Amtrak, the Association of American Railroads, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers and Trainmen, the United Transportation Union, and the American Public Transportation Association should use the circumstances of the November 30, 2007, accident in Chicago, Illinois, during crew resource management training to reemphasize the necessity of any qualified person on the leading locomotive or car to immediately communicate any disagreement on a called signal and to immediately take action necessary to ensure that the train is operated safely.

Amtrak Crew Training and Qualifications

Amtrak operating crews are often assigned to operate over multiple railroads, sometimes during a single trip, as was the case in this accident. This type of operation requires the crew to be competent in multiple signal systems. Generally, Amtrak has been successful in preparing its crewmembers for these challenges.

However, on the accident trip, the engineer appeared to have misinterpreted the meaning of a signal aspect found on different railroad properties. The signal displayed a red over yellow aspect, yet it had different meanings on different railroads. At Englewood interlocking on Norfolk Southern territory, a red over yellow aspect is a *restricting* indication. During his on-the-job training, the engineer had operated on this territory several times under the supervision of an on-board foreman. It is unknown, however, whether the engineer had been exposed to a *restricting* indication during his training.[24] In contrast, a red over yellow aspect in the Amtrak yard indicates a *slow approach*. Since receiving his certification, the engineer had spent most of his time working yard jobs. His experience with this Amtrak signal aspect and its associated indication would have been more recent and frequent and, as a result, more likely committed to his memory.

In the December 27, 2007, proceedings of Amtrak's internal investigation of this accident, the engineer stated, "I looked at the signal [the Norfolk Southern signal at Englewood], and I saw our signal, Amtrak's signal. And I called that signal a *slow approach*." Certain fallibilities of human memory may have contributed to his misinterpreting or forgetting the meaning of the signal at Englewood. His forgetting may have been related to *retroactive interference,*[25] which happens when new information affects the recall of somewhat similar material that had been previously learned. In this case, the engineer could have easily confused the red over yellow (*slow approach* indication) signal in the train yard, which was a signal indication that currently was more salient to him, with the red over yellow (*restricting* indication) signal at Englewood, which had been more relevant to him months earlier. Furthermore, his last experience of the red over yellow *restricting* signal indication may have been during his written examination, which occurred a few months before the accident. He had operated infrequently over the accident territory since then, and this lack of exposure to and rehearsal of the signals in their true context may have made it more difficult for him to accurately retrieve from his memory the meaning of signal aspects while he was operating in this territory.

The Safety Board also is concerned about the Amtrak engineer's proficiency with signal identification when he received his engineer certification. Specifically, after completing several months of training on the accident territory, he nonetheless misinterpreted the meaning of several signals on the examinations just before his certification on the Norfolk Southern territories. During his signal examination, he made the same misinterpretation of a *restricting* signal as he

[24] His certification was 3 months before the accident, and the engineer had operated only twice on the route from Chicago to Grand Rapids.

[25] This type of interference is retroactive in the sense that current tasks are interfering with the retrieval of memories of learning that took place earlier in time.

did on the day of the accident. He took this exam only several days before he received his engineer certification.

On the same testing day, he also missed 4 of the 10 questions related to the signals that are found on the Amtrak territories on which he had been qualified to operate. He made a significant mistake when he misinterpreted a *stop* indication for a *stop and proceed* indication. Further, he not only missed this question on his first attempt but also on his second attempt.

Amtrak reported that engineers with limited operating experience may not be exposed to all signal aspects for a significant period, but stated that most of its operating violations are due to factors unrelated to the crew's knowledge of the signal indications.[26] Although the Safety Board understands this, the Board also recognizes that newly certified engineers, whose knowledge and skills related to their craft are still being developed, are most vulnerable to errors that might be attributed to a lack of rehearsal or experience. The Amtrak engineer struggled on his last signal examinations immediately before he received his engineer certification. While engineer trainees occasionally miss some signal exam questions, the accident engineer's multiple mistakes during the latter part of his training demonstrate a lack of mastery of this essential skill. His failure to correctly interpret critical signal indications of territories on which he had been qualified to operate should have raised concerns about his readiness to operate a locomotive independently and may have warranted additional preparation.

Signal interpretation is a skill that should be *overlearned* (that is, practiced beyond the point of mastery). Information that is overlearned is more resistant to disruption and is retained longer in memory. Since his last signal examination, it is unlikely the engineer had engaged in this type of learning for those signals that he had difficulty remembering. Because his work assignments had been predominantly yard jobs since his certification, his experience with the signals that he had mistaken would have been extremely limited and would have provided few opportunities to reinforce his signal interpretation memories. The Safety Board concludes that the engineer did not show the signal recognition proficiency level necessary to operate on the territories where the accident occurred. Consequently, the Safety Board believes that Amtrak should identify engineers and engineer trainees who have not consistently demonstrated competency in interpreting signals and provide them with enhanced training, supervision, testing, and evaluation necessary to determine that signal proficiency has been achieved and maintained.

Train Signals

Over the years, privately owned railroads have designed and installed signal systems on their properties to control their train movements. As previously noted, in this accident the red over yellow signal aspect on Norfolk Southern's signal system had a different meaning from the red over yellow signal aspect on Amtrak's signal system within the Chicago Terminal. Currently, there are various railroad signal system configurations across the United States. Hence, the same signal aspect may have different meanings or indications, depending on which railroad a train is operating.

[26] A review of Amtrak employee operating violations over the last few years indicates that unfamiliarity with the signal system does not appear to be a common problem.

The Federal Railroad Administration (FRA) issued regulations in 49 CFR 236.23 that provide some standards for signal systems. The FRA regulations allow signal aspects to be displayed by the color of lights, the position of lights, and the flashing of lights.[27] Signal aspects may also be qualified by a marker plate, a number plate, a letter plate, and a marker light. Each aspect displayed by a signal must be identified by a name and must indicate the action to be taken; however, only one name and one indication can apply to each aspect, and the same aspect cannot be used with any other name and indication on the same railroad.

While these regulations apply to each railroad individually, two adjoining railroads may have signals with the same aspects and different indications, as in this accident. A signal with the same aspect and two different indications or requirements can be confusing. Although railroads may use the same aspect to communicate a different meaning, some fundamental conditions must apply across all railroads. These regulations address the use of four colors of lights (that is, red, green, yellow, and lunar) and their meanings. A red light or a series of horizontal lights must be used to indicate stop; a yellow light or a lunar light must be used to indicate that speed is to be restricted and a stop may be required; and a green light or a series of vertical lights must be used to indicate proceed. The railroads combine colors in numerous arrangements to create signal aspects, such as a red light over a yellow light.

Even though the FRA requires each railroad to define each signal aspect used on its property and to provide a meaning for that aspect, the regulations do not prohibit different railroads from having different meanings for the same aspect. As seen in this accident, a red over yellow signal aspect on the Norfolk Southern's signal system was *restricting*; hence another train may be occupying the block of track beyond the signal. A red over yellow signal aspect on Amtrak's signal system within the Chicago Terminal was a *slow approach*; hence the block of track beyond the signal was not occupied.

While engineers and conductors operated predominately on the same railroad territories in the past, today's train crews may operate over several territories in a single day, and train crews must be proficient on more than one signal system. The Safety Board concludes that the lack of uniform meanings of signal aspects can lead to misinterpretation, as demonstrated in this accident. Therefore, the Safety Board believes that the FRA should establish uniform signal aspects that railroads must use to authorize a train to enter an occupied block and prohibit the use of these aspects for any other signal indication. The Safety Board also believes that the FRA should study the different signal systems for trains, identify ways to communicate more uniformly the meaning of signal aspects across all railroad territories, and require the railroads to implement as many uniform signal meanings as possible.

Positive Train Control

Over the last 4 decades, the Safety Board has investigated many railroad accidents in which crewmembers failed to operate their trains effectively and in accordance with operating

[27] These regulations also allow the signal aspect to be displayed by the position of semaphore blades, which are signals equipped with a large mechanical arm that raises and lowers to provide different aspects. The use of semaphore blades has been discontinued by most railroads.

rules for a variety of reasons, including fatigue, sleeping disorders, use of medications, or distractions within the operating cab. The Board has advocated the implementation of positive train control (PTC) systems that compensate for human error and that incorporate collision avoidance to prevent train collisions. The Board believes that PTC is particularly important in places where passenger trains and freight trains both operate. Because of the Board's longstanding interest in this issue, PTC remained on the Board's Most Wanted Transportation Safety Improvements list from 1990 to 2008.

Following a head-on collision between a passenger train and a freight train in Chatsworth, California, on September 12, 2008, which resulted in 25 fatalities and more than 130 injuries, the Rail Safety Improvement Act of 2008 was enacted. In addition to other safety improvements, this law mandates the installation of PTC systems by December 31, 2015, on all main-line tracks where intercity passenger and commuter railroads operate and where toxic-by-inhalation hazardous materials are transported. This includes the territory where this accident occurred. After the enactment of the Rail Safety Improvement Act of 2008, the Safety Board's Safety Recommendation R-01-06, which called for PTC to be installed on railroads, was classified "Closed—No Longer Applicable"[28] and was removed from the Board's Most Wanted list in October 2008.

Had a PTC system been in place at Chicago, it would have intervened by stopping the Amtrak train when the engineer failed to comply with the restricted speed. The Safety Board concludes that had a PTC system been in place at the time of this accident, the collision would not have occurred.

Survival Factors

Emergency Response

The first call to 911 was placed by a passenger at 11:23 a.m. The 911 communications center spoke with this passenger until 11:35 a.m. During this time, the 911 communications center identified a street location for the accident using the computer-aided dispatch system. The Chicago Fire Department was dispatched at 11:32 a.m. Fire department units began arriving on scene at 11:37 a.m., which was 14 minutes after the first 911 call was initiated.

The commissioner of the fire department assumed incident command. A command post was established. Representatives from the railroads, the Red Cross, the Office of Emergency Management, and the Chicago Police Department assisted at the command post. Staging, triage and treatment, and transportation operations were established. Specialty equipment, including three mass casualty units, two heavy rescue squads, and two collapse rescue units responded. In total, 250 members of the Chicago Fire Department operated at the scene of the derailment.

[28] *Closed—No Longer Applicable* means the Safety Board's recommended action has been overtaken by events.

Firefighters began triage on the train. Passengers were then led from the rail yard to the treatment area. Transportation of people to hospitals began 28 minutes after the fire department's arrival. All passengers were off the train 35 minutes after the fire departments arrived.

The emergency response was rapid and included enough resources to address the size of the emergency. Once on scene, the responders evacuated the injured individuals from the train and appropriately selected those needing immediate attention and transport. Therefore, the Safety Board concludes that the emergency response was timely and effective.

Extrication of Locomotive Crew

The Amtrak locomotive's fuel tank was breached during the accident, and although no postaccident fire occurred, about 300 gallons of diesel fuel spilled from the tank. Due to the collision forces and structural damage, the cab compartment doors were inoperative. Additionally, because the windows were not designed to be removed by the crewmembers, the two engineers in the cab could not exit the locomotive without assistance.

The relief engineer exited the cab through a window that was removed by firefighters, about 28 minutes after the fire department's arrival. The delay occurred because the windows also were not designed to be rapidly removed by the emergency responders.[29] The engineer was extricated from the cab about 39 minutes after the fire department's arrival. This extended delay occurred because the firefighters had to force open a door into the structurally damaged cab. The Safety Board concludes that because all cab compartment doors were inoperable and the windows were not designed to be easily removable from either the inside or the outside, the engineers could not exit the locomotive nor could the emergency responders enter the locomotive in a timely manner.

In 49 CFR 229.206, the FRA's locomotive design requirements state,

> Each locomotive used in occupied service must meet the minimum … emergency egress … design requirements set forth in AAR [Association of American Railroads] S-580" for locomotives manufactured or remanufactured after January 1, 2009. The AAR sets forth in its S-580 Locomotive Crashworthiness Requirements, subsection 6.3, Emergency Egress that the locomotive cab "must allow for exit through at least one opening (for example, the engineer's side door, nose door, windows) in any locomotive orientation.

After an accident, a train crew may need to quickly exit a locomotive cab, particularly in the event of a fire or a hazardous materials release, and a train crew may require assistance from emergency responders when injured or incapacitated. The need for passengers to quickly exit passenger cars and for emergency responders to be able to enter passenger cars has been previously addressed in 49 CFR Part 238. The FRA's regulations for emergency windows in passenger cars have an "ease of operability" requirement. Title 49 CFR 238.113 states that emergency window exits in passenger cars "shall be designed to permit rapid and easy removal

[29] This engineer was smaller, had minor injuries, and was more agile than the other engineer.

from the inside of the car during an emergency situation without requiring the use of a tool or other implement.” Title 49 CFR 238.114 states that rescue access windows in passenger cars “must be capable of being removed without unreasonable delay by an emergency responder.” While the regulations for emergency egress and access in passenger cars clearly address the need for the rapid evacuation of the cars, the requirements for the emergency evacuation of locomotives do not incorporate similar “rapid and easy removal” systems. Therefore, the Safety Board believes that the FRA should require that emergency exits on new and remanufactured locomotive cabs provide for rapid egress by cab occupants and rapid entry by emergency responders.

Appliance Securement

The microwave oven and the coffee pot in the café car were thrown to the floor during the collision. No injuries were attributed to the microwave or the empty coffee pot in this accident. The restraining bracket was larger than the microwave and could not have secured the microwave to the counter. Since the accident, Amtrak has changed to a new style of microwave on Superliner café cars. The new microwaves match their mounting brackets and are properly secured.

Seat Pedestal Securement

As a result of the collision, three seat pairs were detached from the guides on the floor of the car. The Safety Board’s Materials Laboratory examined the mount studs that attached the seat pedestals to the mounting guides on the floor. The head portions of two mount studs contained preexisting fatigue cracks that contributed to the detachment of each seat pedestal during the accident. The fatigue cracks were a stress riser that reduced the impact resistance of the mount studs.

The Safety Board concludes that some of the seat mount studs experienced fatigue cracking that resulted in seat pedestals detaching from the floor. Amtrak reviewed its existing inventory and found no seat mount studs of the type that fractured in this accident. All mount studs on the seats involved in this accident were replaced before the passenger cars were returned to service. During Amtrak’s ongoing overhaul program, replacement mount studs of the type that did not fracture are being installed in all seat pedestals on Superliner passenger cars. This replacement program will be completed within 4 years.

Conclusions

Findings

1. The following were not factors in this accident: the functioning of the signal system, the condition of the equipment and the track, drug and alcohol use, fatigue, cellular telephone or radio use, and the visibility of signals.

2. The engineer misinterpreted and miscalled the signal at Englewood which resulted in the operation of the Amtrak train at a speed greater than authorized, and when challenged by the relief engineer, the engineer failed to slow or stop the train while he and the relief engineer discussed their differences in understanding the signal displayed at Englewood.

3. The relief engineer failed to communicate effectively and in a timely manner to the engineer that he had miscalled the restricting signal at Englewood interlocking and failed to then take action herself to stop the train after the engineer did not slow or stop the train when challenged.

4. The engineer did not show the signal recognition proficiency level necessary to operate on the territories where the accident occurred.

5. The lack of uniform meanings of signal aspects can lead to misinterpretation, as demonstrated in this accident.

6. Had a positive train control system been in place at the time of this accident, the collision would not have occurred.

7. Because all cab compartment doors were inoperable and the windows were not designed to be easily removable from either the inside or the outside, the engineers could not exit the locomotive nor could the emergency responders enter the locomotive in a timely manner.

8. The emergency response was timely and effective.

9. Some of the seat mount studs experienced fatigue cracking that resulted in seat pedestals detaching from the floor.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the November 30, 2007, collision of Amtrak train 371 with the rear of Norfolk Southern Railway Company train 23M near Chicago, Illinois, was the failure of the Amtrak engineer to correctly interpret the signal at Englewood interlocking and Amtrak's failure to ensure that the engineer had the competency to correctly interpret signals across the different territories over which he operated. Contributing to the accident was the relief engineer's failure to immediately communicate to the engineer that he had miscalled the signal at Englewood and to stop the train when he did not respond to her expressed concern. Also contributing to the accident was an absence of effective crew resource management between the relief engineer and the operating engineer which led to their failure to resolve the miscalled signal prior to the collision. Further contributing to the accident was the absence of a positive train control system that would have stopped the Amtrak train when it exceeded restricted speed.

Recommendations

As a result of its investigation of the November 30, 2007, collision of Amtrak train 371 with the rear of standing Norfolk Southern Railway Company train 23M near Chicago, Illinois, the National Transportation Safety Board makes the following recommendations:

To the Federal Railroad Administration:

Establish uniform signal aspects that railroads must use to authorize a train to enter an occupied block, and prohibit the use of these aspects for any other signal indication. (R-09-1)

Study the different signal systems for trains, identify ways to communicate more uniformly the meaning of signal aspects across all railroad territories, and require the railroads to implement as many uniform signal meanings as possible. (R-09-2)

Require that emergency exits on new and remanufactured locomotive cabs provide for rapid egress by cab occupants and rapid entry by emergency responders. (R-09-3)

To Amtrak:

Identify engineers and engineer trainees who have not consistently demonstrated competency in interpreting signals, and provide them with enhanced training, supervision, testing, and evaluation necessary to determine that signal proficiency has been achieved and maintained. (R-09-4)

Use the circumstances of the November 30, 2007, accident in Chicago, Illinois, during crew resource management training to reemphasize the necessity of any qualified person on the leading locomotive or car to immediately communicate any disagreement on a called signal and to immediately take action necessary to ensure that the train is operated safely. (R-09-5)

To the Association of American Railroads, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers and Trainmen, the United Transportation Union, and the American Public Transportation Association:

Use the circumstances of the November 30, 2007, accident in Chicago, Illinois, during crew resource management training to reemphasize the necessity of any qualified person on the leading locomotive or car to immediately communicate any disagreement on a called signal and to immediately take action necessary to ensure that the train is operated safely. (R-09-5)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Acting Chairman

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Member

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Member

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Member

Adopted: March 31, 2009

Appendix A

Investigation

The National Transportation Safety Board was notified of Amtrak passenger train 371's collision with Norfolk Southern freight train 23M, near Chicago, Illinois, about 1:30 p.m., on November 30, 2007. The investigator-in-charge and the mechanical group chairman were launched from the Safety Board's Los Angeles Regional Office. The track group chairman was launched from the Safety Board's Chicago Regional Office. The operations, human factors, survival factors, and signal/event recorder group chairmen were launched from Safety Board Headquarters in Washington, D.C. Then-Vice Chairman Robert L. Sumwalt accompanied the team to the accident site.

Parties to the investigation included Amtrak, the Norfolk Southern Railway Company, the Federal Railroad Administration, the Illinois Commerce Commission, the Brotherhood of Locomotive Engineers and Trainmen, and the United Transportation Union.