Collision of Two Canadian National Railway Freight Trains near Two Harbors, Minnesota September 30, 2010

Accident Summary Report

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National Transportation Safety Board

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Railroad Accident Report

Collision of Two Canadian National Railway Freight Trains near Two Harbors, Minnesota September 30, 2010

National
Transportation
Safety Board

490 L'Enfant Plaza, SW
Washington, DC 20594

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Abstract: On September 30, 2010, about 4:05 p.m. central daylight time, a southbound Canadian National Railway freight train collided head on with a northbound Canadian National Railway freight train near Two Harbors, Minnesota. The collision occurred near milepost 13.5 on Canadian National Railway's Iron Range Subdivision. The trains were operating in nonsignaled territory. The northbound train had 118 empty iron ore railcars and had authority to operate on the single main track. The southbound train had 116 railcars loaded with iron ore and did not have authority to operate on the single main track. The crew of the southbound train entered the main track after failing to properly execute an after-arrival track authority. A total of three locomotives and 14 railcars derailed. All five crewmembers on the two trains were injured and transported to hospitals. Four crewmembers were treated and released; one crewmember remained hospitalized for further treatment. Canadian National Railway estimated damages at $8.1 million.

As a result of its investigation of this accident, the National Transportation Safety Board (NTSB) makes recommendations to the Federal Railroad Administration, Canadian National Railway, the Brotherhood of Locomotive Engineers and Trainmen, the United Transportation Union, Canadian Pacific Railway Limited, Kansas City Southern Railway Company, Norfolk Southern Railroad, and Union Pacific Railroad. The NTSB also reiterates previous recommendations to the Federal Railroad Administration, BNSF Railway, and the American Short Line and Regional Railroad Association. The NTSB also reiterates and reclassifies recommendations to the Federal Railroad Administration.

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Abbreviations and Acronyms

BRM	bridge resource management
CFR	Code of Federal Regulations
CN	Canadian National Railway
CP	Canadian Pacific Railway Limited
CRM	crew resource management
DM&IR	Duluth, Missabe and Iron Range Railway Company
FRA	Federal Railroad Administration
KCS	Kansas City Southern Railway Company
NS	Norfolk Southern Railroad
NTSB	National Transportation Safety Board
PED	portable electronic device
PTC	positive train control
RSAC	Railroad Safety Advisory Committee
RSIA	Rail Safety Improvement Act
RTC	rail traffic controller
SMS	safety management system
UP	Union Pacific Railroad
WCL	Wisconsin Central Ltd.

Executive Summary

On September 30, 2010, about 4:05 p.m. central daylight time, a southbound Canadian National Railway freight train collided head on with a northbound Canadian National Railway freight train near Two Harbors, Minnesota. The collision occurred near milepost 13.5 on Canadian National Railway's Iron Range Subdivision. The trains were operating in nonsignaled territory. The northbound train had 118 empty iron ore railcars and had authority to operate on the single main track. The southbound train had 116 railcars loaded with iron ore and did not have authority to operate on the single main track. The crew of the southbound train entered the main track after failing to properly execute an after-arrival track authority. A total of three locomotives and 14 railcars derailed. All five crewmembers on the two trains were injured and transported to hospitals. Four crewmembers were treated and released; one crewmember remained hospitalized for further treatment. Canadian National Railway estimated damages at $8.1 million. The weather was clear and the temperature was 72°F.

The National Transportation Safety Board determines that the probable cause of the accident was the southbound train crew's error in departing the Highland siding before the northbound train had passed. Contributing to the accident was the Canadian National Railway's use of after-arrival track authorities in nonsignaled territory, a procedure that is vulnerable to human error and lacks inherent safety redundancies necessary to ensure consistent, safe operation. Also contributing to the accident was crew fatigue and inadequate crew resource management.

This report discusses the following safety issues:

- use of after-arrival track authorities for train movement on nonsignaled tracks
- prohibited use of portable electronic devices
- fatigue
- crew resource management
- management and regulatory oversight

1 Investigation and Analysis

1.1 Accident Narrative

On September 30, 2010, about 4:05 p.m. central daylight time,[1] Canadian National Railway (CN)[2] freight train U78982-30 (southbound train), consisting of three locomotives and 116 railcars loaded with iron ore, collided head on with CN freight train U78983-30 (northbound train), consisting of three locomotives and 118 empty iron ore railcars. Prior to the collision, the southbound train was traveling about 15 mph and the northbound train was traveling about 39 mph. Three locomotives and 14 railcars derailed. The five crewmembers on both trains were injured and transported to hospitals. Four crewmembers were treated and released, while the fifth crewmember required additional treatment in the hospital.

The collision occurred near milepost 13.5 on the Iron Range subdivision of the CN North division near Two Harbors, Minnesota (see figure 1). The estimated property damage was $8.1 million. At the time of the accident, the sky was clear, and the temperature was about 72°F.

The accident occurred on a single main track where the northbound train had track authority[3] to operate. The southbound train entered and operated on the single main track without authority. Table 1 provides information on the two trains.

Table 1. Train information.

Data type	Southbound train	Northbound train
Train designation	U78982-30	U78983-30
Operational ID[a]	IC 6258 South	IC 6265 North
Railcars	116 loaded ore railcars	118 empty ore railcars
Train length	2,982 feet	3,035 feet
Train weight	11,974 tons	2,596 tons

[a] Operational IDs use one locomotive unit number (typically the lead locomotive) and direction of travel. Trains are referred to by their operational IDs on track authorities. The initials “IC” refer to Illinois Central, a railroad previously acquired by CN.

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

[2] The track upon which the accident occurred was owned by the Duluth, Missabe and Iron Range Railway Company (DM&IR), which was a subsidiary of CN. After the accident, DM&IR was merged into CN subsidiary Wisconsin Central Ltd. (WCL). DM&IR, WCL, and all of the other railroads indirectly or wholly owned by CN are collectively referred throughout this report as CN.

[3] *Track authority* is a movement instruction issued by some railroad dispatchers/rail traffic controllers, including those at CN for a train to proceed on a designated segment of track. Some railroads use the term *track warrants* instead.

Figure 1. This is an aerial photograph of the train collision.

1.2 Events Preceding the Accident

The northbound train crew consisted of an engineer and a conductor. They reported for duty at Two Harbors Yard at 2:30 p.m. on the day of the accident. The northbound train crew departed Two Harbors at about 3:20 p.m. The crew initially received a track authority at 3:23 p.m. to operate on the single main track to the north end of the Highland siding. They then received a second track authority at 4:00 p.m. to operate on the single main track beyond the Highland siding to Allen Junction. These track authorities allowed the northbound crew to operate the train at the maximum authorized speed of 40 mph on the single main track as it approached the south end of the Highland siding. The engineer told investigators that as he was coming out of a curve just south of the Highland siding, he saw the headlight of the southbound train and applied emergency braking.

The southbound train crew consisted of an engineer, a conductor, and a student engineer. They are referred to as such throughout this report. They reported for duty at Two Harbors Yard at 4:30 a.m. on the day of the accident. The southbound train departed Two Harbors at 6:40 a.m. The student engineer was operating[4] the train and the engineer was with him in the cab of the controlling locomotive. The conductor elected to ride in the second locomotive during most of

[4] CN allows a qualified student engineer to operate a train while under the direct supervision of a qualified engineer.

the trip. There were two seats on the left side of the lead locomotive, but the conductor said that, in his view, seating was inadequate for two people. One of the two seats on the left side of the leading locomotive was well padded and was equipped with armrests. The second seat had less padding and did not have armrests. Neither the engineer nor the student engineer objected to his decision to ride on the second locomotive. The second locomotive was located immediately behind the controlling (lead) locomotive and was facing in the same direction.

The southbound train initially proceeded north about 77 miles to US Steel's Minntac Mine, at Mt. Iron, Minnesota, to be loaded with iron ore. The train arrived at Minntac Mine about 9:52 a.m. During loading operations, the conductor contacted the Two Harbors yardmaster to let him know the train was unlikely to be able to return to Two Harbors Yard before the crewmembers reached their 12-hour time limit[5] at 4:30 p.m. The yardmaster advised the conductor that they would be relieved by another train crew at the Highland siding. Around 1:14 p.m., after the 116 railcars were loaded, the crew began the southward return trip along the same route toward Two Harbors (see figure 2).

During the southbound return trip, the student engineer operated the train from the mine to Allen Junction (a distance of about 31 miles) by the signal indications of a traffic control system that was controlled by a rail traffic controller (RTC)[6] at Homewood, Illinois. Between Allen Junction and Two Harbors (a distance of about 46 miles), the track was in nonsignaled territory and the train movement was controlled with track authorities issued to trains via radio by the RTC. The conductor copied[7] a track authority from the RTC authorizing movement from Allen Junction to South Fairbanks and, later, another authority to South Brimson[8] authorizing movement to the north end of Highland with an instruction to enter the siding. The conductor moved to the lead locomotive before reaching South Brimson to align a track switch. The conductor told investigators: "I gave it (the track authority form) to the engineer." He also said that he had written out a second copy[9] for himself before returning to the second locomotive, where he stayed for the duration of the trip.

Upon arriving at the Highland siding, the student engineer stopped the train on the main track and the conductor aligned the hand-operated switch for the siding. As the train entered the siding at about 3:38 p.m., the conductor returned to the second locomotive. The student engineer operated the train into the Highland siding where he stopped north of the Highland Road grade crossing at about 3:42 p.m. From the second locomotive, the conductor informed the RTC by radio that the train was clear of the main track. The conductor released the track authority back to the RTC. The RTC informed the conductor that, instead of being relieved in the siding as originally planned, the Two Harbors yardmaster wanted the crew to bring the train as far as possible toward Two Harbors Yard (about 14 miles from Highland). Hearing this conversation on the radio, the locomotive engineer told the student engineer to start moving the train south in

[5] Federal regulations limit train crews to 12 hours on duty per shift.

[6] CN refers to train dispatchers as RTCs.

[7] *Copying* occurs when a train crewmember dictates information from the RTC onto a form and successfully repeats the information verbatim back to the RTC.

[8] Brimson and Fairbanks are sidings. Authorities are issued for movement to one end of a siding; in this case, the south end.

[9] CN provides pads of blank track authority forms and carbon paper to the conductors. The conductor of the southbound train stated he did not use carbon paper on this trip.

the siding because they did not have much work time left and they needed to weigh[10] the train before departing the Highland siding.

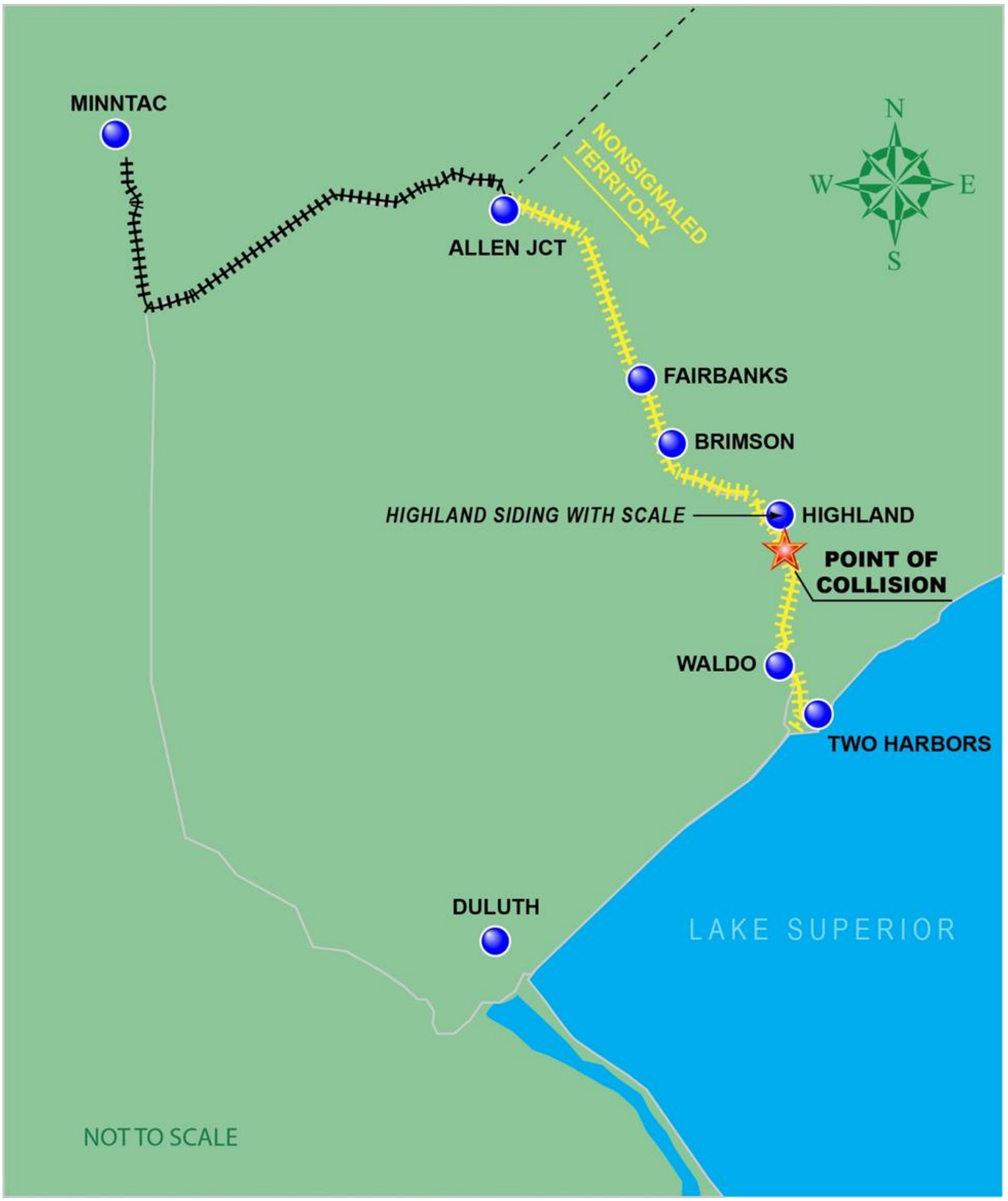

Figure 2. This is a map of the CN rail line between Two Harbors and the Minntac mine.

The student engineer moved the train south and changed the locomotive cab radio to the scale's channel. The scale had an automated radio system to announce if the speed was too high for the weighing mechanism. Even though the radio was on the scale's channel, the radio system was designed so that transmissions from the RTC would override the scale channel.

[10] The Highland siding had a weigh-in-motion scale that required the train to move at about 3 mph until the entire train had cleared the scales.

While the student engineer moved the train toward the scale, the RTC transmitted a new track authority to the conductor authorizing train movement south from Highland on the single main track to Two Harbors. This track authority was conditional, containing an after-arrival restriction. The southbound train was not to act on this authority until the northbound train had arrived.[11] The conductor was on the second locomotive when he copied this authority. On his first read-back attempt, the conductor made an error in the repeat process. The RTC caught the error and the conductor repeated the track authority correctly on his second attempt. The conductor completed the track authority form at 3:47 p.m. The southbound locomotive engineer, who was located in the lead locomotive, heard the RTC's message and copied it onto a second track authority form.

Although the conductor was close by in the second locomotive, he did not walk up to the lead locomotive to deliver the engineer a copy of the track authority form and to ensure that the engineer and student engineer understood it, as required by CN rules and Federal Railroad Administration (FRA) regulations. Instead, the conductor said that he asked the engineer over the radio, "did you copy?" and that the engineer responded affirmatively. The engineer had copied the information onto a track authority form but had not read it back to the RTC. The crewmembers said that they never discussed this track authority among themselves. The engineer did not give the track authority to the student engineer to read and the student engineer did not ask him about it.

The student engineer told National Transportation Safety Board (NTSB) investigators that when he had completed weighing the southbound train, the locomotive engineer instructed him to depart the Highland siding while making no mention of the after-arrival requirement contained in the track authority. The southbound train departed the Highland siding and entered the single main track at the Highland south siding switch without waiting for the arrival of the northbound train. Meanwhile, the northbound train crew had already received a track authority authorizing them to proceed at the maximum track speed of 40 mph past the Highland south siding switch on the main track. The southbound engineer said that he first saw the oncoming northbound train as it rounded a curve and that he told the student to apply the emergency brakes. Figure 3 shows the Highland siding and the point of collision.

NTSB investigators downloaded the event recorders from the lead locomotives of both accident trains and sent the files to the NTSB's Vehicle Recorder division for evaluation and analysis. Both locomotive event recorders recorded 13 parameters, including throttle and braking information.

According to the event recorders, the southbound train was traveling at about 15 mph when, about 12 seconds before the collision, the pneumatic control switch was opened and the automatic brake pressure began to decrease. The southbound train's speed decreased slightly, to about 13 mph, at the time of collision. The northbound train was traveling at about 39 mph prior to a reduction in its automatic brake pressure, about 10 seconds before the collision. The northbound train's speed decreased to about 29 mph at the time of the collision. Sight distance

[11] In this case, the northbound train is not considered to have "arrived" at the Highland siding until the entire train had passed the south switch and the main track was clear for the southbound train to enter.

observations conducted after the accident indicated that the crews of the two trains would have first been able to see the other train when they were about 1,295 feet apart.

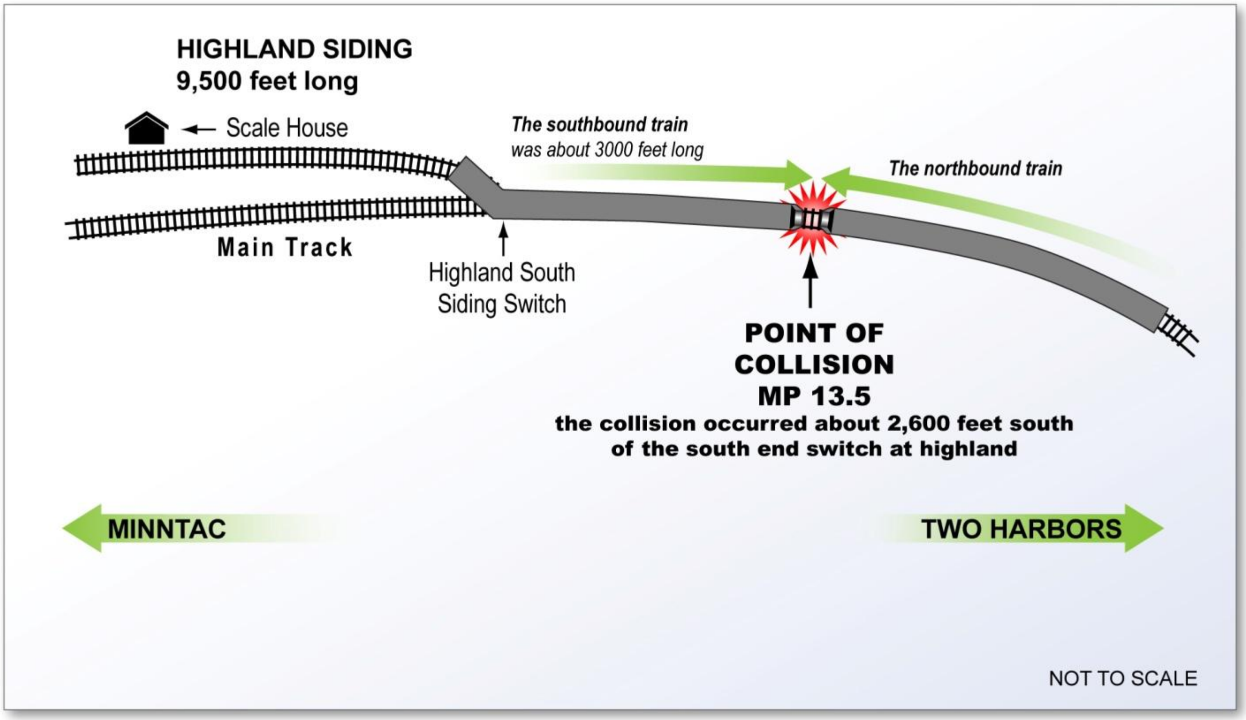

Figure 3. This map depicts the point of collision.

Table 2 provides a timeline—based on event recorder data and crew interviews—of the southbound train's movement and its crew's actions upon reaching the Highland siding.

Table 2. Approximate timeline of southbound train at the Highland siding.

Time	Events
3:37 p.m.	Train stops short of the Highland north siding switch. Conductor aligns the switch for the siding and boards the second locomotive.
3:38 p.m.	Train begins moving into the Highland siding.
3:42 p.m.	Train stops in the siding north of the Highland Road grade crossing.
3:45 p.m.	Train begins moving toward the scale after the RTC advises the conductor to get ready to copy another movement authority.
3:47 p.m.	RTC issues complete (OK) time[a] for track authority with an after-arrival track authority condition.
3:48 p.m.	Train speed reduced to a steady 3 mph (scale speed).
4:01 p.m.	Train speed and throttle increase after the last railcar is weighed.
4:05 p.m.	Student engineer applies train emergency brakes.

[a] The time the train crewmember successfully repeats the track authority information back verbatim to the RTC.

1.3 Factors Not Contributing to This Accident

The locomotives and the train railcars passed postaccident mechanical inspections. A review of preaccident testing and maintenance records for both trains did not reveal any problems. The weather at the time of the accident was clear, with no visual impairments. The postaccident toxicological tests for crewmembers of the two trains were negative for drugs or alcohol. Finally, the northbound train was where it was authorized to be and operating at the allowable speed. The NTSB concludes that the mechanical condition of the trains, the weather, drug or alcohol impairments, and the actions of the northbound train crew were not factors in this accident.

1.4 After-Arrival Track Authorities on Nonsignaled Tracks

Track authorities are movement instructions issued by a train dispatcher or RTC. The FRA classifies track authorities as mandatory directives and, when issued by radio, they fall under regulations found at Title 49 *Code of Federal Regulations* (CFR) section 220.61. Track authorities authorize a train to move from one designated point to another designated point. Railroads use track authorities on both nonsignaled tracks and on tracks equipped with automatic block signals.[12] When trains are enroute, track authorities typically are issued to crews by radio. On CN and most other railroads, a crewmember (usually the conductor) receives the radio transmission from the RTC, makes entries on a preprinted form, and then repeats the information back to the RTC verbatim. This is known as a read back. The read back step allows the RTC to verify that the information was copied correctly. If the read back is correct, the RTC acknowledges by issuing a complete (OK) time[13] and then states his or her name. The employee copying the authority must repeat the complete time and the name of person issuing it.

One condition that an RTC may attach to a track authority is as an "after arrival." With an after-arrival track authority, the permission to occupy a designated portion of single main track does not become effective until after the arrival of one or more opposing trains. In the Two Harbors accident, the last track authority received by the southbound train contained an after-arrival condition. This meant that the southbound train was not authorized to enter the single main track until after the arrival of the northbound train. In the Two Harbors case, this meant that the crew of the southbound train would have visually identified the northbound train by locomotive number (IC 6265) and then confirmed by radio contact with the passing train that it was the correct train, as listed on the track authority form.

The use of after-arrival track authorities allows RTCs to preestablish meeting points[14] in advance of actual train arrivals at those locations. Reasons frequently cited for the use of after-arrival track authorities are that they allow better movement planning, save fuel, improve efficiency, minimize train delays, and reduce the time that road crossings are blocked.

[12] *Automatic block signals* provide information to trains about the occupancy of the signal block (track segment) ahead. They do not authorize train movement.

[13] *Complete (OK) time* is the time the train crewmember successfully repeats the track authority information back verbatim to the RTC.

[14] *Meeting points* are locations where trains will pass.

NTSB investigators asked all Class I railroads about the number of after-arrival track authorities issued during a typical 12-month period. The findings are shown in table 3.

Table 3. Approximate numbers of after-arrival track authorities issued.

Railroad	After-arrival track authorities issued in signaled territory	After-arrival track authorities issued in nonsignaled territory
BNSF Railway[a]	118,353	35
CN	1,249	2,755
Canadian Pacific Railway Limited (CP)	675	23,250
CSX Transportation[b]	0	0
Kansas City Southern Railway Company (KCS)	number not provided	number not provided
Norfolk Southern Railroad (NS)	106,723	14,594
Union Pacific Railroad (UP)	80,069	11,680

[a] As a result of a head-on collision near Gunter, Texas, BNSF made a policy decision to reduce the number of after-arrival track authorities in nonsignaled territory to only those needed to (1) avoid blocking grade crossings or (2) set up meets during a dispatcher turnover.

[b] As a result of a head-on collision near Smithfield, West Virginia, CSX made a policy decision to discontinue the use of after-arrival track authorities.

1.4.1 Human Error and After-Arrival Track Authorities

Human performance literature describes many principles related to the nature of human errors.[15] Many of these principles apply to the execution of after-arrival track authorities by train crews.

For example, when people must complete multiple steps to accomplish a task, they are more likely to miss the later steps in the sequence, rather than the earlier steps.[16] Two of the most critical steps of the after-arrival track authority process are toward the end of the sequence: waiting until after the arrival of one or more opposing trains listed in the authority and then verifying that the train being met is the correct train.

When people encounter unexpected task interruptions during a sequential process, the procedural steps that follow are more prone to errors.[17] This occurs because a person can lose his or her place in the required sequence and then restart the task actions at a point further along than appropriate. In the Two Harbors accident, the southbound train crew had expected to complete the trip at the Highland siding. After plans changed, they were required to copy another track authority, weigh the train, await the arrival of the northbound train, verbally confirm the train ID and, then, proceed. There was about a 15-minute period between the time the southbound train

[15] David D. Woods, Sidney Dekker, Richard Cook, Leila Johannesen, Nadine Sarter, *Behind Human Error*, 2nd ed. (Burlington: Ashgate, 2010); (b) J. Reason, "Combating Omission Errors Through Task Analysis and Good Reminders," *Quality and Safety in Health Care* 11 (2002): 40–44, 2002.

[16] Woods, Dekker, Cook, Johannesen, Sarter, *Behind Human Error*; (b) Reason, "Combating Omission Errors," 40–44.

[17] Reason, "Combating Omission Errors," 40–44.

crew received the track authority and the time when the train reached the end of the Highland siding, where it should have stopped. During this time the crew needed to move the train to the scale, weigh the cars, and then move to the south end of the siding. This provided the opportunity for the crewmembers to lose their place in the process and neglect actions in the sequence, such as the after-arrival track authority.

The communication involved in issuing and executing an after-arrival track authority occurs in several stages: verbally from the RTC to the conductor, in writing when the conductor completes the form, verbally by the conductor reading the contents of the form back to the RTC, in writing when the conductor hands the engineer a copy of the form, and verbally among the conductor and crewmembers, preferably in person, during the briefing. Timeliness, accuracy, and comprehension must be accomplished without error by all participants at each stage of the communication process. If one or more participants fail to understand or properly execute the requirements, the after-arrival element of the track authority risks being misunderstood or overlooked.

Leading up to the Two Harbors accident, there were multiple communication errors and omissions. At the Highland siding, the conductor misstated the northbound train engine number during the first read-back dialogue. The RTC caught and corrected his error. When copying an earlier authority at Brimson, the conductor was on the lead locomotive with the engineer and student engineer as he copied, which facilitated face-to-face communication. However, at the Highland siding, the conductor did not walk to the lead locomotive for a briefing with the rest of the crew. The engineer did not discuss the track authority with the student engineer who was operating the train nor did he provide him with a copy. The student engineer did not ask to see a copy of the track authority or ask for a briefing on the contents.

In addition to potential communication failures in issuing or receiving after-arrival track authorities, there is also the risk of improper execution of these authorities. Execution of the track authority occurs through several stages. The crew must wait at the location named in the track authority. The crew must maintain a vigilant lookout for the train listed on the track authority. The crewmembers must visually identify the train being met as the one they are waiting for and verbally contact that train, confirming it is the correct train. Only after these steps are complete can the crew begin the movement. These stages of behavior require sustained vigilance, accurate visual detection, effective verbal communication, and correct cognitive decision making to execute the track authority properly. Throughout these steps, the crewmembers may be involved in other work tasks that demand their attention and/or physical capabilities, such as operating the train slowly over a scale to weigh the cars. If fatigue, distraction, or work demands compete for the crew’s cognitive resources, there is a risk that the after-arrival track authority will be executed improperly. In the Two Harbors accident, all of these factors may have been at play. The potential for error increased when none of the crewmembers took steps to hold a briefing to discuss the track authority.

1.4.2 Risks of After-Arrival Authorities on Nonsignaled Track

The use of after-arrival track authorities in nonsignaled territory involves greater risk than in signaled territory. This is because automatic block signals provide redundancy by displaying indications about the track segment beyond the signal. Had there been a signal system in this accident, the southbound train would have seen a red signal aspect at the south end of the Highland siding because the northbound train was approaching. This would have served as a reminder to the crewmembers that they had to meet a northbound train. In the absence of a signal system, there is nothing to remind a crew that there may be a train approaching and there is no restricted speed requirement. Although head-on collisions following train crew errors in executing after-arrival track authorities are uncommon, when they occur, they have catastrophic consequences.

The NTSB has previously expressed concerns regarding after-arrival track authorities in nonsignaled territory:[18]

> Non-signaled (dark) territory presents a unique problem for rail safety. In dark territory, there are no signals to warn trains as they approach each other, and the avoidance of collisions relies solely on dispatchers and train crews adhering to operating procedures. Issuing after-arrival track warrants under these conditions only exacerbates an already potentially tenuous and contingent work situation. While the railroad industry contends that after-arrival track warrants facilitate the expedient and efficient movement of trains and reduce the amount of wasted resources, and the FRA sees merit in the industry's logic, ultimately, the role of human error and the cost of human casualties also must be considered in this equation. The FRA acknowledges that, "until positive train control can be fully achieved, we need to take those steps that will decrease the risk of collisions that may occur as a result of employee error."[19] Yet, the FRA has not taken the proactive steps to address this issue as the Safety Board has recommended.

CSX Transportation, a large Class I railroad, discontinued the use of after-arrival track authorities in nonsignaled territory following an accident that occurred in 1996. CSX has been operating successfully without using after-arrival authorities in nonsignaled territory for well over 10 years. BNSF Railway, another large Class I railroad, discontinued the use of after-arrival authorities in nonsignaled territory in 2004 in all but a small handful of cases.[20] The NTSB concludes that the use of after-arrival track authorities in nonsignaled territory presents unacceptable and unnecessary safety risks. CSX discontinued the use of after-arrival track authorities with no reported decrements to operational efficiency. As a result, CSX has not experienced an accident similar to the Smithfield, West Virginia, collision.

1.4.3 Previous NTSB Investigations Involving After-Arrival Track Authorities

This is not the first accident the NTSB has investigated in which a train crew did not adhere to the provisions of an after-arrival track authority in nonsignaled territory. Since 1996, the NTSB has investigated five high-consequence accidents that occurred due to human errors in executing after-arrival track authorities (see table 4).

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[18] *Collision of Two Burlington Northern Santa Fe Freight Trains Near Clarendon, Texas, May 28, 2002*, Railroad Accident Report NTSB/RAR-03/01 (Washington, DC: National Transportation Safety Board, 2003).

[19] FRA letter to the NTSB dated October 3, 2003.

[20] There have been 36 after-arrival track authorities issued in nonsignaled territory by BNSF during a recent 12-month period.

In 1996, in Smithfield, West Virginia,[21] the NTSB investigated a head-on collision between two CSX Transportation freight trains. As a result of this accident, CSX Transportation discontinued the use of after-arrival track authorities in nonsignaled territory. There were no recommendations resulting from this investigation.

Table 4. NTSB investigations involving after-arrival track authority.

Accident	Date	Injuries	Damages	Human performance factors involved
Smithfield, WV CSX	8/20/96	2 fatal, 1 injured	$4.8 million	Inadequate Crew Resource Management (CRM)
Devine, TX UP	6/22/97	4 fatal	> $6 million	Dispatcher – Crew Communication
Clarendon, TX BNSF	5/28/02	1 fatal, 3 injured	> $8 million	PED Use, Inadequate CRM
Gunter, TX BNSF	5/19/04	1 fatal, 4 injured	> $2 million	PED Use, Dispatcher – Crew Communication, Inadequate CRM
Two Harbors, MN CN	9/30/10	5 injured	> $8 million	PED Use, Potential Fatigue, Crew Communication, Inadequate CRM
Total		**8 fatal, 12 injured**	**> $28.8 million**	

In 1997, the NTSB investigated a collision between two UP freight trains in Devine, Texas.[22] Because of this investigation, the NTSB issued Safety Recommendation R-98-27 to the FRA to require that railroads permanently discontinue the use of after-arrival track authorities in nonsignaled territory. The FRA responded by issuing a recommendation that railroads add a statement that the track authority contains a requirement to meet another train when a track authority contains an after-arrival condition. The FRA also recommended that railroads review their practices with a goal of reducing the number of after-arrival authorities issued. The NTSB responded that it was "disappointed with FRA's decision not to prohibit the use of after-arrival orders." Safety Recommendation R-98-27 was classified "Closed—Unacceptable Action" on June 29, 1999.

In 2002, the NTSB investigated a collision between two BNSF freight trains in Clarendon, Texas.[23] From this investigation, the NTSB recommended that the FRA limit the use of after-arrival orders in nonsignaled territory to trains that have stopped at the location at which they will meet the opposing train (Safety Recommendation R-03-2). The FRA did not implement Safety Recommendation R-03-2 and the FRA advised the NTSB that it found merit in the industry's assertion that requiring a train to be stopped at the meeting point before issuing an after-arrival track authority would reduce dispatcher (or RTC) flexibility and potentially increase the amount of time grade crossings were blocked; delay trains; and increase fuel usage, air and noise pollution, brake shoe wear, and crew fatigue. The NTSB responded on August 6, 2004:

[21] *Head-On Collision, Trains Q317-19 and Q316-18, CSXT Railroad, Smithfield, West Virginia, August 20, 1996,* Railroad Accident Brief NTSB/RAB-98/13 (Washington, DC: National Transportation Safety Board, 1998).

[22] *Collision and Derailment of Union Pacific Railroad Freight Trains 5981 North and 9186 South in Devine, Texas on June 22, 1997,* Railroad Accident Report NTSB/RAR-98/02 (Washington, DC: National Transportation Safety Board, 1998).

[23] NTSB/RAR-03/01.

"FRA staff indicated that the agency was planning no further action in response to this recommendation. Given the FRA's position and the Safety Board's continued belief in the recommendation's merit, the Board has no alternative but to classify Safety Recommendation R-03-2 "Closed―Unacceptable Action." The NTSB notes that several Class I railroads have voluntarily adopted this practice.

In 2004, the NTSB investigated a collision between two BNSF freight trains near Gunter, Texas.[24] The NTSB determined that the probable cause of the accident was the southbound train (BNSF 6789 South) crew's failure to adhere to an after-arrival track warrant requiring them to stay at Dorchester until the northbound train (BNSF 6351 North) arrived. From this accident investigation, the NTSB made the following safety recommendation to the FRA:

> Prohibit the use of after-arrival track warrants for train movements in dark (non-signaled) territory not equipped with a positive train control system. (R-06-10) (Open—Unacceptable Response)

In the Gunter, Texas, report, the NTSB noted:

> The FRA has declined to implement the NTSB's safety recommendations to prohibit the use of after-arrival track warrants. The FRA has indicated that disallowing after-arrival authorities in non-signaled territory would reduce flexibility and hinder the efficient movement of trains. The FRA also has stated that it expects that railroad employees will adhere to all applicable operating rules. The NTSB has investigated too many accidents in which the avoidance of the accident depended on the use of an operating rule or standard practice that proved to be insufficient to prevent accidents caused by human error. The NTSB is concerned about the FRA's failure to prohibit the use of after-arrival track warrants in non-signaled territories, as previously recommended.

In the Gunter, Texas, report, the NTSB expressed concern about the FRA's failure to act and cited a meeting of NTSB and FRA staff that occurred before the Gunter, Texas, collision, on March 17, 2004. During discussions of Safety Recommendation R-03-2, staff from the FRA stated that although they shared concerns about the risks of after-arrival orders, they were reluctant to prohibit their use at that time. However, the FRA staff did state that if another accident occurred because of an after-arrival order, the FRA would issue an emergency order. Two months later, on May 19, 2004, the Gunter, Texas, accident occurred. Now, after nine years, the FRA still has not taken any specific action to require railroads to discontinue the use of after-arrival track authorities.

The CN rule on issuing track authorities that was in effect at the time of the Two Harbors accident met all FRA regulatory requirements except for the specific requirement that the conductor and engineer ensure that all crewmembers have read and understand the directive. CN had Operating Rule 104 in effect at the time of the accident, which required engineers and conductors to "ensure their subordinates were familiar with their duties." CN officials stated that they felt this addressed the regulatory requirement. After the accident and on the advice of

[24] *Collision Between Two BNSF Railway Company Freight Trains Near Gunter, Texas, May 19, 2004,* Railroad Accident Report NTSB/RAR-06/02 (Washington, DC: National Transportation Safety Board, 2006).

the FRA, CN added language to the rule explicitly requiring the conductor and engineer to ensure that all crewmembers read and understand the track authority.

1.4.4 Class I Railroad Actions to Improve After-Arrival Authority Processes

Several Class I railroads have implemented procedural safeguards on the use of after-arrival track authorities, above FRA minimum requirements. For example, NS requires the engineer on a train restricted by an after-arrival track authority to contact the engineer on the other train to determine that they are, or will be, clear one mile in advance of approaching the meeting point. NS also requires the conductor to remind the engineer of the meeting point two miles before reaching it. Both BNSF and NS require dispatchers to advise crews that they will be receiving an after-arrival track authority and to provide the identification of the train being met. Both BNSF and UP require that the restricted train be stopped at the meeting location before the after-arrival track authority can be issued.[25]

BNSF has significantly reduced the use of after-arrival track authorities in nonsignaled territory. It has also added several additional levels of safety redundancy on the use of after-arrival track authorities in nonsignaled territory. The following are key elements of this process for issuing after-arrival track authorities in nonsignaled territory:

- The issuance of after-arrival track authorities in nonsignaled territory is restricted to (1) locations where public grade crossings would otherwise be blocked for extended periods of time and (2) train meets that would occur during the train dispatcher shift change.
- The crew of the train that would be receiving the after-arrival track authority must make radio contact with the crew of the train it will meet and advise the train dispatcher that the contact was made.
- The crew of the train to receive the after-arrival track authority must notify the dispatcher when it has stopped at the meeting point.
- The dispatcher may issue the after-arrival track authority only after the previous steps have been completed.
- The crew of the train that is to receive the after-arrival track authority must make radio contact for the second time with the crew of the train it has been waiting for to confirm that it has actually passed the meeting point.
- Following that confirmation, the train crew must document the met train's ID, the meeting point, and the meeting time on the form.

[25] NTSB recommended that the FRA require that trains be stopped at the meeting point before an after-arrival track authority was issued. The FRA did not act on this recommendation and it is classified "Closed—Unacceptable Action."

BNSF also installed recording equipment in radio towers covering nonsignaled territory to allow auditing of compliance with the more stringent radio communication protocols. BNSF advised NTSB investigators that every after-arrival authority used for nonsignaled track is reviewed against the recorded audio to verify communication requirements were completed successfully. Appendix B contains a comparative summary of the BNSF and CN railroad after-arrival track authority processes.

1.4.5 NTSB Position on After-Arrival Track Authorities in Nonsignaled Territory

Errors in communication, judgment, and action resulted in noncompliance with the after-arrival track authority procedures. The limits of human cognition and behavior provide a basis to expect continued errors with after-arrival track authorities unless additional safeguards are implemented. Successful execution of after-arrival track authorities depend on error-free human performance, which is unlikely without additional safeguards since fatigue, distraction, and competing tasks may interfere with the after-arrival track authority communication and execution process. The NTSB concludes that the use of the after-arrival track authorities in nonsignaled territory presents unacceptable and unnecessary safety risks to railroad operational safety, because the procedure is vulnerable to human error and lacks inherent safety redundancies ensuring consistent safe operation.

The NTSB recognizes that a positive train control (PTC) system provides the most effective means to avoid train collisions. However, as the NTSB recognized in the investigation of the Gunter, Texas, collision:[26]

> …even if PTC becomes more widely adopted, the current non-signaled areas of the U.S. railroad network will probably be among the last to be outfitted with PTC for the same reasons they remain non-signaled now—train volume and type of traffic.

The NTSB is disappointed that the FRA has not implemented Safety Recommendation R-06-10. However, the NTSB is encouraged that CSX Transportation recognized the significant risk of after-arrival track authorities in nonsignaled territory and voluntarily discontinued their use. BNSF has also recognized the higher risk of after-arrival track authorities on nonsignaled track and has implemented policies that substantially limit their use in nonsignaled territory. The NTSB concludes that, in the absence of a PTC system, discontinuing the use of after-arrival track authorities in nonsignaled territory will mitigate future accidents involving authority overruns.

Many miles of the US railroad network will not fall under FRA PTC mandates, and CN officials verified that PTC would not be installed in the Two Harbors accident area when PTC requirements take effect. Therefore, the NTSB reiterates Safety Recommendation R-06-10 to the FRA and encourages the FRA to take immediate and appropriate action. The NTSB also recommends that CN discontinue the use of after-arrival track authorities in nonsignaled territory not equipped with PTC.

[26] NTSB/RAR-06/02.

As a result of the Gunter, Texas, accident, the NTSB made the following safety recommendation to BNSF Railroad:

> Discontinue the use of after-arrival track warrants for train movements in dark (non-signaled) territory not equipped with a positive train control system. (R-06-12)

BNSF responded that the railroad had implemented procedures to significantly reduce the number of after-arrival track authorities used in nonsignaled territory and implemented additional procedural safeguards. NTSB classified safety recommendation R-06-12 "Open―Unacceptable Response" on September 7, 2007. NTSB appreciates that BNSF has recognized the risks of using after-arrival track authorities in nonsignaled territory and has taken steps to reduce the frequency of their use on BNSF, as well as clarified and tightened communication protocols. However, NTSB remains convinced that the use of after-arrival track authorities in nonsignaled territory is a flawed process with inherent risks that will inevitably result in future accidents. Therefore, NTSB reiterates safety recommendation R-06-12 to BNSF.

As a result of the Devine, Texas, collision, NTSB made the following safety recommendation to UP:

> Discontinue permanently the use of after-arrival orders in dark (nonsignalized) territory. (R-98-25)

UP advised NTSB that the railroad had discontinued the use of after-arrival track authorities in nonsignaled territory shortly after the Devine, Texas, accident and that they had no intention of reestablishing the practice. Based on this assurance, Safety Recommendation R-98-25 was classified "Closed―Acceptable Action" on July 23, 2001. However, at some point later, UP did, in fact, reestablish the use of after-arrival track authorities in nonsignaled territory. The NTSB is disappointed that UP made the choice to resume the use after-arrival track authorities in nonsignaled territory and that, other than CSX, no Class I railroads have discontinued their use. Therefore, NTSB recommends that UP, CP, KCS, and NS discontinue the use of after-arrival track authorities for train movements in nonsignaled territory not equipped with a PTC system.

While the Class I railroads account for the bulk of train movements in the United States, various short line and regional railroads may also use after-arrival track authorities in their operations; however, these roads are too numerous to address individually. As a result of the Gunter, Texas, accident, the NTSB made the following safety recommendation to the American Short Line and Regional Railroad Association.

> Encourage your members to discontinue the use of after-arrival track warrants for train movements in dark (non-signaled) territory not equipped with a positive train control system. (R-06-13)

Because Safety Recommendation R-06-13 is over six years old, and the NTSB has received no indication that the American Short Line and Regional Railroad Association has taken action on it, the recommendation was recently classified "Open―Unacceptable Action." The NTSB reiterates Safety Recommendation R-06-13 to the American Short Line and Regional

Railroad Association to inform its members of the circumstances of this accident and urge them to discontinue the use of after-arrival track authorities for train movements in nonsignaled territory not equipped with a PTC system.

1.5 Fatigue

The NTSB investigation reviewed CN work records for the five crewmembers involved in the accident. Table 5 presents the work histories for the five crewmembers, based on CN records. For the crewmembers of the southbound train, the accident occurred in the final hour of their 12-hour work shift; whereas, for the northbound train crewmembers, the accident occurred about 2 hours after the start of their work shift.

Table 5. Crew work history.

Crewmember	Monday 9/27	Tuesday 9/28	Wednesday 9/29	Thursday 9/30
Southbound engineer	On duty: 6:20 a.m. Off duty: 9:10 a.m. On duty: 10:00 p.m.	Off duty: 8:45 a.m.	On duty: 3:30 a.m. Off duty: 3:30 p.m.	On duty: 4:30 a.m. Off duty: accident
Southbound conductor	Did not work	Did not work	On duty: 3:30 a.m. Off duty: 3:30 p.m.	On duty: 4:30 a.m. Off duty: accident
Southbound student engineer	On duty: 8:50 p.m.	Off duty: 8:45 a.m.	On duty: 3:30 a.m. Off duty: 3:30 p.m.	On duty: 4:30 a.m. Off duty: accident
Northbound engineer	Did not work	Did not work	On duty: 11:30 a.m. Off duty: 11:10 p.m.	On duty: 2:00 p.m. Off duty: accident
Northbound conductor	On duty: 10:45 a.m. Off duty: 10:41 p.m.	Did not work	On duty: 8:00 a.m. Off duty: 6:20 p.m.	On duty: 2:00 p.m. Off duty: accident

All crewmembers had received at least the minimum amount of time off duty as required by federal regulations. However, the NTSB recognizes that simply meeting regulatory requirements for time off duty does not ensure that crewmembers arrive and remain alert throughout their on-duty work shifts. The causes, symptoms, and consequences of fatigue are varied. As discussed below, the human factors of physiological fatigue, disruption to circadian rhythms, and continuous hours of wakefulness affected the alertness of crewmembers.

1.5.1 Physiological Fatigue

The length of sleep that an individual needs each night varies with genetics, circadian timing, sleep debt, and other factors.[27] The National Sleep Foundation believes that adults need 7 to 9 hours of sleep each night.[28] On the day before the accident, the southbound train conductor had the opportunity to obtain about 3 hours, 45 minutes of sleep; on the prior day, he had the opportunity to obtain just over 6 hours of sleep. Likewise, the southbound train student engineer had the opportunity to obtain about 4 hours, 45 minutes of sleep the day before the accident, and

[27] M. Carskadon and W. Dement, “Normal Human Sleep: An Overview,” in *Principles and Practice of Sleep Medicine*, 4th Edition, ed. M. Kryger, T. Roth, and W. Dement (Philadelphia: Elsevier-Sanders, 2005).

[28] "How Much Sleep Do We Really Need?" National Sleep Foundation, accessed November 23, 2010, http://www.sleepfoundation.org/article/how-sleep-works/how-much-sleep-do-we-really-need.

about 8 hours, 30 minutes of sleep over two separate periods on the prior day. Their actual amount of sleep was less than their sleep opportunity time.

While one night of reduced sleep opportunity time may not significantly degrade performance, the southbound train's conductor and student engineer had reduced sleep opportunity time for at least two nights prior to the accident. Chronic partial sleep restriction results from a repeated reduction in the amount of sleep a person gets. Scientific literature has shown that as little as two hours less sleep than normal is associated with impairment of performance and alertness.[29]

1.5.2 Disruption of Circadian Rhythms

Human physiology fluctuates over the 24 hours of a day; that is known as circadian rhythm. Examples of human physiological processes showing circadian rhythms include: body temperature, heart rate, blood pressure, and "sleepiness" or alertness.[30] For alertness, subjective sleepiness and performance degradation are most pronounced during the low phases of the circadian cycle,[31] occurring between midnight and 6:00 a.m., and, again, between 2:00 p.m. and 5:00 p.m.

The review of CN work records also indicated that the southbound train engineer had started his work shifts at different times on several days preceding the accident (i.e., 4:30 a.m. on September 30; 3:30 a.m. on September 29; 8:45 a.m. on September 28; and 6:20 a.m. on September 27). People often require several days to adjust, both physically and psychologically, to shifts in their sleep schedules. Moreover, shifting on-duty and off-duty times can lead to sleep difficulties; that is, irregular work schedules disrupt circadian rhythms and sleep patterns, leading to fatigue. The southbound train engineer was affected by circadian disruptions; and, consequently, likely suffered from fatigue-induced performance impairments. However, the investigation did not reveal detailed information on the southbound train engineer's sleep patterns or off-duty activities, because he was unable to provide any information about his sleep/awakening in the days prior to the accident.

1.5.3 Continuous Hours of Wakefulness

The length of time a person has been awake and their total time-on-task have been associated with increased risk of fatigue. Continuous hours of wakefulness exceeding 16 hours has been found to result in deficits equivalent to those seen in individuals with blood alcohol

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[29] M.A. Carskadon, "Sleep Restriction," *Sleep, Sleepiness and Performance*, ed. T.H. Monk, (Chichester, England: John Wiley & Sons, 1991) 155–167. For comparison, evidence exists showing that a two-hour sleep debt produces performance decrements comparable to those produced by a blood alcohol level of 0.045 percent and that a four-hour sleep debt produces performance decrements comparable to a blood alcohol level of 0.095 percent. T. Roehrs, E. Burduvali, A. Bonahoom and others, "Ethanol and Sleep Loss: A 'Dose' Comparison of Impairing Effects," *Sleep,* 26, no. 8 (2003): 981-985.

[30] Kroemer, K.H.E.; Kroemer, H.J.; and Kroemer-Elbert, K.E., *Engineering Physiology: Bases of Human Factors/Ergonomics*, 2nd ed., (New York: Van Nostrand Reinhold, 1990) 176.

[31] H.P.A. Van Dongen and D. Dinges, "Circadian Rhythms in Sleepiness, Alertness, and Performance," in *Principles and Practice of Sleep Medicine,* 4th Edition, ed. M. H. Kryger, T. Roth, and W.C. Dement (March 2005).

content values between 0.05 percent and 0.1 percent.[32] With respect to time-on-task, studies have shown that the risk of accidents increases exponentially beyond the eighth or ninth hour at work.[33]

Twelve-hour work shifts have been associated with fatigue-related performance decrements. One study found "decreased performance (187 percent more errors) and increased sleepiness (66 percent) for workers of a 12-hour shift during their last 4 hours on shift."[34] Thus, the southbound train crew was at a high risk of fatigue-induced performance problems.

The three southbound train crewmembers had been awake for between 13 and 14 hours at the time of the accident. The accident occurred during the final hour of a 12-hour shift for the crew. Their potential continuous hours of wakefulness ranged from over 13 hours in the case of the student engineer to almost 14 hours in the case of the engineer and conductor at the time of the accident. Since the accident occurred at 4:05 p.m., which corresponds to a low phase in the circadian rhythm, the crew likely experienced reduced alertness and cognitive functioning in the time period leading up to the accident. The consequences of these fatigue-induced performance problems in one's work environment usually results in a reduction in safety, efficiency, and productivity. Specific signs of fatigue-related performance problems include: reduced decision-making ability, reduced ability to perform complex planning, reduced communications skills, reduced reaction time, increased forgetfulness, and increased manual and cognitive errors. These signs of fatigue were identified in the NTSB investigation of this accident. Therefore, based on physiological fatigue, disruption to circadian rhythms, and extended continuous hours of wakefulness, the southbound train crew was fatigued.

1.5.4 Lack of Crew Coordination and Communication

The circumstances of this accident suggest that fatigue played a role in the events leading up to the accident. The conductor elected to remove himself from the lead locomotive and remain on the second locomotive unit for much of the trip, thereby physically isolating himself from the engineer and student engineer. Being located in the second unit by himself would have provided him an opportunity to nap or sleep. When the final track authority before the accident was issued by the RTC, the conductor incorrectly repeated the engine number of the northbound train his train was scheduled to meet, an error that was detected by the RTC. Such an error could be attributed to reduced cognitive functioning associated with fatigue. Furthermore, he did not walk to the first locomotive unit and discuss the contents of the track authority with the engineer and student engineer, as was required by CN rules and FRA regulations. The willful lack of effective communications and coordination among the crewmembers most likely was due to their

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[32] (a) D. Dawson and K. Reid. "Fatigue, Alcohol, and Performance Impairment," *Nature* 388, (1997): 235; (b) A.M. Williamson and A.M. Feyer, "Moderate Sleep Deprivation Produces Impairments in Cognitive and Motor Performance Equivalent to Legally Prescribed Levels of Alcohol Intoxication," *Occupational and Environmental Medicine* 57, (2000) 649-655.

[33] K. Hanecke, S. Tiedemann, F. Nachreiner, and H. Crzech-Sukalo, "Accident Risk as a Function of Hours at Work and Time of Day as determined from Accident Data and Exposure Models for the German Working Population," *Scandinavian Journal of Work, Environment, and Health*, 24 no. 3 (1998): 43-48.

[34] R.R. Rosa, M.J. Colligan, and P. Lewis, "Extended Workdays: Effects of 8-Hour and 12-Hour Rotating Shift Schedules on Performance, Subjective Alertness, Sleep Patterns, and Psychosocial Variables," *Work and Stress* 3 no. 2 (1989): 21-32.

fatigue. Therefore, the NTSB concludes that fatigue-induced performance errors contributed to the accident.

The NTSB has identified fatigue as a factor in numerous transportation accidents, the most recent railroad accident investigation involving fatigue was a rear-end collision that occurred near Red Oak, Iowa, on April 17, 2011, that resulted in fatalities to both crewmembers on the striking train and over $8.7 million in damage. The NTSB's investigation determined that both crewmembers on the striking train had fallen asleep due to fatigue. The NTSB noted that the Rail Safety Improvement Act (RSIA) passed by Congress in 2008 mandated that railroads develop fatigue management plans. The Red Oak, Iowa, accident report described the RSIA requirements and FRA's implementation as follows:

> The RSIA gives railroads 4 years after enactment of the law in which to develop these plans, which must include methods to manage and reduce fatigue experienced by railroad employees in safety-related positions and to reduce the likelihood of accidents, incidents, injuries, and fatalities caused by fatigue. There are several elements to the RSIA's fatigue management plan requirements, many of which are relevant to this accident. Three of these elements are listed here and discussed below:
>
> - Employee education and training on the physiological and human factors that affect fatigue, as well as strategies to reduce or mitigate the effects of fatigue, based on the most current scientific and medical research and literature.
> - Opportunities for identification, diagnosis, and treatment of any medical condition that may affect alertness or fatigue, including sleep disorders.
> - Scheduling practices for employees, including innovative scheduling practices, on-duty call practices, work and rest cycles, increased consecutive days off for employees, changes in shift patterns, appropriate scheduling practices for varying types of work, and other aspects of employee scheduling that would reduce employee fatigue and cumulative sleep loss.

In a December 19, 2011, letter, the FRA advised the NTSB that it is currently in the process of drafting guidance for railroads to develop fatigue management plans as part of a larger railroad risk-reduction program. The guidance is expected to be issued in early 2013. The FRA also has recently formed a Railroad Safety Advisory Committee (RSAC) working group to provide advice on developing fatigue management plans.

On June 11, 2012, in coordination with the Volpe Center; Harvard Medical School, Division of Sleep Medicine; and the WGBH Educational Foundation; the FRA launched a Railroader Guide to Health Sleep website (http://www.railroadersleep.org). The website provides information to train crewmembers about fatigue and its countermeasures. This is an initial step by the FRA and other stakeholders to implement a fatigue guidance resource. Discussions with the FRA disclosed that the FRA is drafting rule text, which it will present to the RSAC in

April 2013. Task teams from the RSAC are working on additional fatigue guidance information. The development and implementation of fatigue management plans will be an important step in improving railroad safety. In the Red Oak, Iowa, investigation, the NTSB recommended that the FRA:

> Establish an ongoing program to monitor, evaluate, report on, and continuously improve fatigue management systems implemented by operating railroads to identify, mitigate, and continuously reduce fatigue-related risks for personnel performing safety-critical tasks, with particular emphasis on biomathematical models of fatigue. (R-12-17)

The FRA responded in a letter dated July 31, 2012, stating that it was working with an RSAC working group to develop a regulation document responsive to RSIA requirements. The letter also advised NTSB that FRA had developed a fatigue risk management systems guidance document. Safety Recommendation R-12-17 is classified "Open―Acceptable Response." The NTSB appreciates that FRA is taking these steps and takes this opportunity to reiterate Safety Recommendation R-12-17 to the FRA.

1.6 Use of Portable Electronic Devices

NTSB investigators obtained cell phone records for the five crewmembers involved in the accident. The records indicated that four of the five crewmembers had used their cell phones while on duty on the day of the accident.

CN operating rules and FRA regulations prohibit the use of cell phones and other portable electronic devices (PED) while on duty when (1) the train is in motion or (2) when a crewmember is on the ground (off the locomotive). CN operating rules prohibit text messaging at any time when on duty. Figure 4 shows the cell phone usage for the southbound and northbound train crews; most of the unauthorized cell phone use involved text messaging or occurred while the trains were moving or while the southbound train conductor was on the ground. In addition, one 33-second call made by the northbound train engineer at 3:39 p.m. occurred while the train was moving and he was at the controls. The records indicate that the northbound train conductor did not engage in any cell phone activity.

The NTSB concludes that the use of cell phones by crewmembers on the southbound train and by the engineer on the northbound train was a distraction to the safe operation of both trains and an indication of a clear disregard for CN rules and FRA regulations.

The NTSB recognizes that PED usage is a significant factor underlying many forms of transportation accidents. Moreover, the NTSB has advocated for the prohibition of unauthorized use of PEDs in railroad operations.

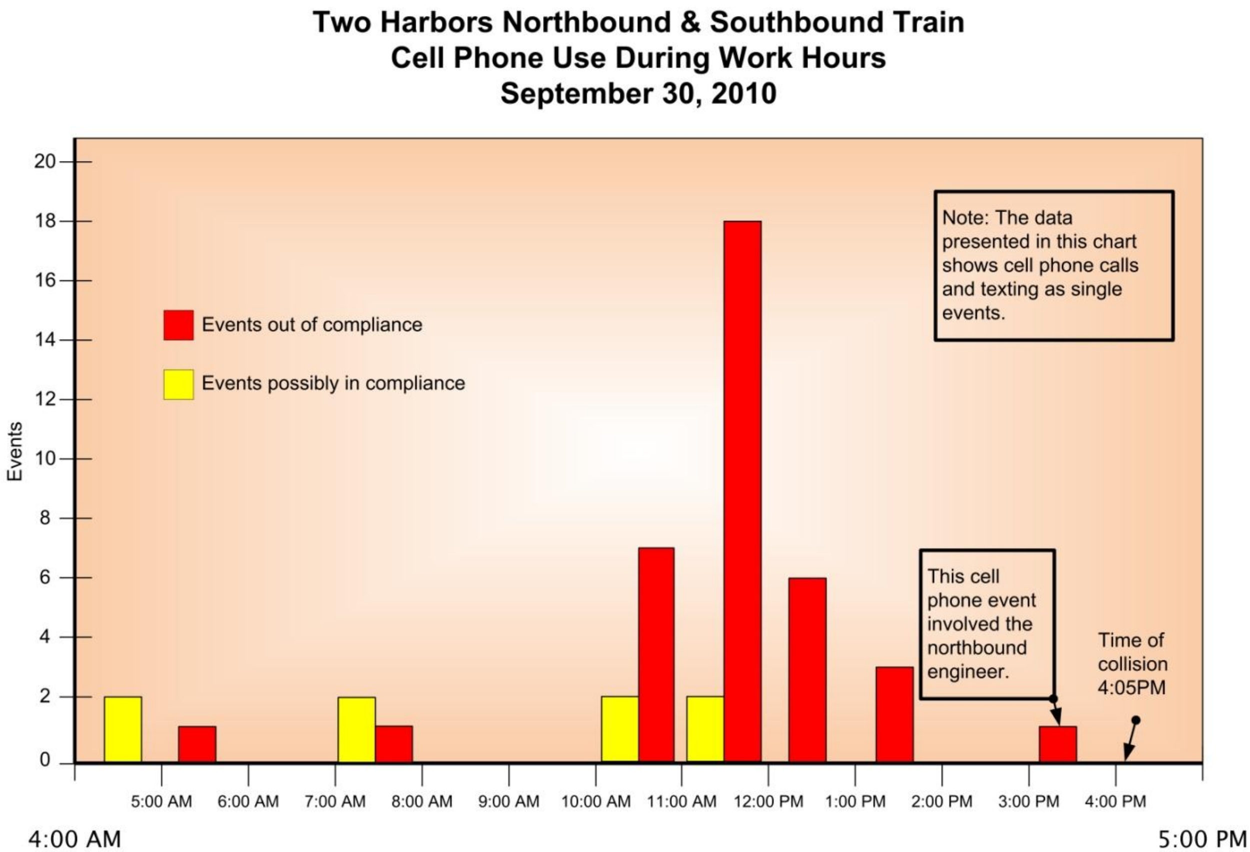

Figure 4. This graphic shows cell phone use by the southbound and northbound train crews during the accident trip.

In its investigation of a May 28, 2002, collision of two BNSF freight trains near Clarendon, Texas,[35] the NTSB determined the probable cause of the accident was, "the coal train engineer's use of a cell phone during the time he should have been attending to the requirements of the track warrant for his train." As a result of that investigation, the NTSB made the following safety recommendation to the FRA:

> Promulgate new or amended regulations that will control the use of cellular telephones and similar wireless communication devices by railroad operating employees while on duty so that such use does not affect operational safety. (R-03-1)

Following the Chatsworth, California, collision, the FRA published Emergency Order 26 restricting PED use by on-duty operations personnel. As a result of this action, the NTSB classified Safety Recommendation R-03-1 "Closed—Acceptable Alternate Action."

During the investigation of the May 19, 2004, Gunter, Texas, collision,[36] the NTSB noted that the engineer of the train that overran its authority had been on his cell phone at the time that

[35] NTSB/RAR-03/01.
[36] NTSB/RAR-06/02.

the conductor had experienced difficulty in copying an earlier track authority. The Gunter, Texas, investigation found that rules did not deter "frequent use [of cell phones] by all crew members of the two accident trains while the trains were in motion."

On September 12, 2008, a westbound Southern California Regional Rail Authority Metrolink train collided head on with an eastbound UP Railroad freight train near Chatsworth, California.[37] The accident resulted in 25 fatalities, including the engineer of the Metrolink train, and 102 injured passengers. The NTSB noted as part of the probable cause, the locomotive engineer "…was engaged in prohibited use of a wireless device, specifically text messaging that distracted him from his duties." As a result of this investigation, the NTSB made two safety recommendations to the FRA:

> Require the installation, in all controlling locomotive cabs and cab car operating compartments, of crash- and fire-protected inward- and outward-facing audio and image recorders capable of providing recordings to verify that train crew actions are in accordance with rules and procedures that are essential to safety as well as train operating conditions. The devices should have a minimum 12-hour continuous recording capability with recordings that are easily accessible for review, with appropriate limitations on public release, for the investigation of accidents or for use by management in carrying out efficiency testing and systemwide performance monitoring programs. (R-10-1)

> Require that railroads regularly review and use in-cab audio and image recordings (with appropriate limitations on public release), in conjunction with other performance data, to verify that train crew actions are in accordance with rules and procedures that are essential to safety. (R-10-2)

Both safety recommendations were originally classified "Open—Acceptable Response." While the FRA has indicated that it is favorable to the concept of using audio and imaging technology in locomotives and cab cars, it has yet to directly address the implementation of these specific safety recommendations. Pending a concrete action by the FRA to require that all locomotives and cab cars operated under 49 CFR Part 229 be equipped with a crash- and fire-protected inward- and outward-facing audio and image recorders, Safety Recommendations R-10-1 and -2 are classified "Open—Unacceptable Response."

The NTSB urges the FRA to promptly initiate rulemaking activity for the audio and imaging requirements outlined in Safety Recommendations R-10-1 and -2 and reiterates these two recommendations. By taking action now on the NTSB cab audio and image recorder recommendations, the FRA will require locomotive manufacturers to implement important safety improvements. NTSB accident investigations conducted since the issuance of these recommendations further demonstrate how cab audio and image recorders can play a key role in identifying and deterring unsafe acts as well as by providing critical human performance and cab environment information for accident investigations that would otherwise be unavailable. The

[37] *Collision of Metrolink Train 111 with Union Pacific Train LOF65-12, Chatsworth, California, September 12, 2008,* Railroad Accident Report NTSB/RAR-10/01 (Washington, DC: National Transportation Safety Board, 2010).

NTSB, therefore, encourages the FRA to move quickly to implement the NTSB's audio and imaging recommendations.

In its most recent response to the NTSB on July 31, 2012, the FRA advised that it recognized the value of cameras and voice recordings for accident investigations. It also indicated awareness of "significant privacy concerns" and the belief that implementing the recommendations would erode employee morale and might result in selective enforcement and retaliation. The NTSB is disappointed that more than four years after the deadliest passenger train accident in decades, the FRA has not acted on two recommendations that would protect railroad employees, as well as the public. Therefore, the NTSB reiterates Safety Recommendations R-10-1 and -2 to the FRA.

Following the Chatsworth, California, accident and the many others preceding it that involved improper PED usage, the FRA issued Emergency Order 26 on October 7, 2008.[38] In the findings supporting the issuance of the emergency order, the FRA highlighted the need to "eliminate this source of extremely dangerous distraction in the railroad operating environment."

FRA Emergency Order 26[39] contained three major components and included the following requirements:

(1) Each personal electronic or electrical device must be turned off with any earpieces removed from the ear while on a moving train, except that, when radio failure occurs, a wireless communication device may be used in accordance with railroad rules and instructions.

(2) Each personal electronic or electrical device must be turned off with any earpieces removed from the ear when a duty requires any railroad operating employee to be on the ground or to ride rolling equipment during a switching operation and during any period when another employee of the railroad is assisting in preparation of the train (e.g., during an air brake test).

(3) Use of a personal electronic or electrical device to perform any function other than voice communication while on duty is prohibited. In no instance may a personal electronic or electrical device interfere with the railroad operating employee's performance of safety-related duties.

On September 27, 2010, the FRA published a final rule codifying the requirements of Emergency Order 26, prohibiting the unauthorized use of cell phones and other electronic devices by on-duty railroad operating employees at 49 CFR Part 220 Subpart C. The final rule became effective on March 28, 2011. At the time of the accident, CN's operating rules were consistent with the restrictions in Emergency Order 26, with the added restriction that text

[38] Federal Railroad Administration, "Emergency Order To Restrict On-Duty Railroad Operating Employees' Use of Cellular Telephones and Other Distracting Electronic and Electrical Devices," Title 73 *Federal Register* 58702 (October 7, 2008) was in effect at the time of this accident. The FRA has since promulgated a regulation.

[39] Title 73 *Federal Register* 58702 (October 7, 2008).

messaging was not permitted at any time. The CN rules on PED use that were in effect at the time of the accident are shown in appendix C.

On May 8, 2009, Massachusetts Bay Transportation Authority Green Line Train 3612 struck the rear end of a standing train. Sixty-eight passengers and crewmembers were injured, and damages exceeded $9 million. The NTSB again found that PED usage was part of the probable cause, remarking that the train operator was "…engaged in [the] prohibited use of a wireless device, specifically text messaging that distracted him from his duties."[40]

The circumstances of PED misuse in the Two Harbors accident, as well as the series of previous accidents discussed earlier in this report, highlight a persistent and pervasive safety hazard in the rail industry; that is, the unauthorized use of PEDs by on-duty crewmembers is too difficult to prevent by rules, policies, and punitive consequences. The use of PEDs has become, and likely will continue to be, engrained in our daily lifestyles. Consequently, procedural guidelines and enforcement offer little, if any, assurance that all on-duty train crewmembers will refrain from PED misuse. Therefore, additional measures that prevent unauthorized PED use by on-duty train crewmembers are needed. The NTSB concludes that additional measures to prevent unauthorized PED use by train crewmembers is necessary because of the continuing use of these devices by some railroad crewmembers, and the resulting risks to safety caused by distraction.

Commercial technology to detect the presence of cell phone signals is available and suitable for use in locomotive cabs. This technology only detects the presence of electronic signals. It does not record the contents and destination of communications or infringe on personal privacy. This technology could be used to alert railroad management about the presence of an active cell phone or other PED producing a signal in a locomotive cab, allowing railroad management to intervene with the train crew in a timely manner. The NTSB concludes that electronic signal detection technologies in locomotive cabs would enhance safety by deterring inappropriate PED use without affecting crewmember privacy. Therefore, the NTSB recommends that the FRA identify, and require railroads to use in locomotive cabs, technology-based solutions that detect the presence of signal-emitting PEDs and that inform the railroad management about the detected devices in real time.

There are also commercially available and relatively inexpensive handheld cell phone-signal detectors that can be used by railroad management and FRA inspectors to detect the presence of cell phones that are in use or turned on, which could potentially create an unsafe distraction. Such handheld detectors can be put into use quickly and have the advantage of detecting the unauthorized use of PEDs, both on trains in switching operations and at other railroad locations where unauthorized use presents a safety hazard. The NTSB concludes that handheld cell phone-signal detectors can serve as an effective tool for personnel performing inspections and test to deter the unauthorized use of PEDs by railroad personnel. Therefore, the NTSB recommends that the FRA incorporate the use of handheld signal detection devices to aid in the enforcement of 49 CFR Part 220 Subpart C.

[40] *Collision of Two Massachusetts Bay Transportation Authority Light Rail Passenger Trains, Boston, Massachusetts, May 8, 2009,* Railroad Accident Brief NTSB/RAB-11/06 (Washington, DC: National Transportation Safety Board, 2011).

1.7 Communication and Coordination of Southbound Train Crew

Before reaching the Highland siding, the conductor of the southbound train had two radio conversations concerning the amount of time that the crew had remaining to work. In the first conversation, the conductor asked the RTC to call the Two Harbors yardmaster and advise him that the crew would not be able to complete the return trip before the expiration of the 12 hours-of-service limitation and would need to be relieved enroute.

The conductor said he received a radio call from the Two Harbors yardmaster after the conversation with the RTC. In an interview with NTSB investigators, the conductor said, “I told him we’ll make it to Highland and probably get it [the train] weighed.” According to the conductor, the yardmaster’s response was, “Yeah, that’s fine. There’s going to be a van and a crew for you.”

The conductor told NTSB investigators that when the train reached the Highland siding, he understood that the train needed to stop before it blocked the Highland Road grade crossing and, then, he and the crew needed to wait for a relief crew to arrive in a van. Once the train stopped and was clear of the single main track in the Highland siding, the conductor radioed the RTC and released the train’s track authority. The conductor said that the RTC told him, “…I talked to the yard [Two Harbors yardmaster]. They want you to take it further south, try to get to Waldo.”[41]

The conductor told the RTC that his understanding was that the crew would be relieved at the Highland siding. The conductor said that the RTC responded, “No, you have to keep it moving.” The RTC added, “Are you ready to copy? Get ready to copy.”[42] The conductor responded, “Okay.”

The locomotive engineer overheard this conversation between the RTC and the conductor and instructed the student engineer to start moving the train south on the siding to begin the weighing process. While the train was moving toward the scale, the RTC transmitted an after-arrival track authority to the conductor, who was still in the cab of the second locomotive.[43] This after-arrival track authority allowed the southbound train to proceed south toward Two Harbors after the arrival of the northbound train.

CN operating rules in place at the time of the accident required the conductor to copy the authority on a track authority form, using carbon paper to make a second copy; read the form back to the RTC to confirm its accuracy; ensure that the engineer had a copy of the track authority; and ensure that every crewmember had a complete understanding of the track authority’s requirements. The conductor told NTSB investigators that when he rode in the cab of the lead locomotive, he would often make a carbon copy while writing the original track authority, and then physically hand the carbon copy to the engineer. On this trip, he rode in the

[41] Waldo station was 10.4 miles south of the Highland siding and was closer to Two Harbors.

[42] This comment meant that the RTC wanted to issue a new track authority to the conductor for movement beyond the Highland siding.

[43] The conductor chose to ride in the second locomotive and was not in the lead locomotive during most of the trip. The conductor told NTSB investigators that he did so because he did not believe the third seat in the cab of the lead locomotive unit was suitable for him because of his size.

second locomotive and so did not make a carbon copy of the authorities. In copying an earlier authority, he described how he handed the written authority to the engineer and then wrote out a second copy for himself before returning to the second locomotive.

A review of recordings of radio communications revealed that the conductor had initially repeated to the RTC the wrong locomotive number of the train they were supposed to wait for at the Highland siding. The RTC caught the error and had the conductor correct the train ID on the after-arrival portion of the track authority. At 3:47 p.m., the RTC confirmed that the conductor had correctly repeated the after-arrival track authority and issued the complete (OK) time. Then, the conductor asked the locomotive engineer over the radio, “Did you copy?” During interviews with NTSB investigators, the conductor stated that the locomotive engineer responded, “Yes.”

The locomotive engineer told NTSB investigators that he did not recall if he had a conversation with the conductor, but claimed he could hear the conductor receiving the track authority from the RTC and said, “I believe it was clear enough for me to copy.” He also recalled that the track authority included an after-arrival authority instruction and acknowledged that they should not have left the Highland siding until after the northbound train had passed. Copies of these two after-arrival track authority forms are in appendixes D and E. The engineer copied this track authority but did not read it back. CN rules require that when an employee copies a track authority, he or she reads it back to the RTC to ensure accuracy. CN rules also required a job briefing on the new authority among all employees. The job briefing was never held.

The student engineer told NTSB investigators that while the locomotive engineer was copying the track authority, he was operating the train with his attention focused on achieving a controlled, slow train speed.[44] The student engineer said he knew that the engineer was copying a track authority because the engineer had the radio handset against his ear and was writing. However, he added that he was not aware of the contents of the communication between the conductor and the RTC or between the locomotive engineer and the conductor. He did not ask the engineer about the contents of the track authority and he did not ask to see it. When the scale automated radio system announced that the train had cleared the scales (at about 4:01 p.m.),[45] the student engineer told investigators that the locomotive engineer said, “We’ve got one for Two Harbors.”[46] The student engineer said that the locomotive engineer added, “We don’t have much time, we’re not going to get very far. We need to get rolling; you need to be doing 10 (mph) when we get over that switch.”[47] According to the student engineer, the locomotive engineer did not explain to him that the track authority contained an after-arrival requirement and he did not ask.

[44] In order for the scales to be able to weigh the train, the train speed must be maintained at 3 mph.

[45] The collision was at 4:05 p.m., about one-half mile from the Highland south siding switch. If the train was operating at 10 mph (traveling one mile every six minutes) over the switch, the train would have departed the Highland siding at approximately 4:02 p.m.

[46] This statement would have meant that the train had track authority to leave the Highland siding and proceed toward Two Harbors on the single main track.

[47] The engineer was saying the student engineer needed to accelerate the train up to 10 mph (the speed limit through the switch) from 3 mph. The reference to the switch would have been the Highland south siding switch where the train would reenter the main track.

The student engineer said that he felt a sense of being rushed because of the short amount of time remaining to work. According to the event recorder, once the rear of the train had cleared the scales, the student engineer increased the throttle to position seven.[48] The train accelerated to 10 mph while still on the Highland siding. As the train reached 12 mph, the student engineer then lowered the throttle setting to idle and then applied the dynamic braking. Although the speed limit while moving through the spring switch was 10 mph, the student engineer allowed the train to reach 15 mph. When the crew saw the northbound train, the engineer said "shoot 'em"[49] and the student engineer applied emergency braking. The student engineer said he expressed surprise and he remembered hearing the locomotive engineer respond, "…we had an after."

Leading up to and during the accident sequence, the southbound train crew exhibited a degree of disengagement and a lack of professionalism that fatigue alone would not explain. When the conductor abandoned an available seat in the operating cab because it did not look suitable to him at the beginning of the trip, he chose to take a seat on the left side of the second locomotive. Had the conductor sat on the right side of the locomotive, in the engineer's seat on that unit, he would have been in a better position to observe the signals governing the train's movement when the train was in signal territory. He also would have been able to observe the speedometer and air gauges and better monitor, and be engaged in, the train's operation. When the conductor copied the final track authority, he did not use the provided carbon paper to make copies of track authorities for the engineer, as required. Finally, although there is an easily accessible walkway between the locomotives that does not require getting off the locomotive, the conductor did not walk up to the cab of the lead locomotive to give the engineer a copy of the track authority and/or make sure the engineer and the student engineer understood the requirement to wait for the northbound train.

The southbound engineer's decision not to discuss the track authority with the student engineer (who he was supposed to have under "close supervision")[50] or to give a copy of the document to the student engineer to read was a dereliction of his responsibilities. These actions displayed a lack of professionalism and engagement.

The student engineer, who was qualified and familiar with CN operating rules, did not ask to see the track authority nor did he question its content, thereby demonstrating, similar to his crewmates, a lack of engagement that resulted in the unsafe operation of the train. One element of effective CRM is to encourage subordinates to effectively and appropriately challenge authority in situations deemed by them to be unsafe, or that have the potential for unsafe actions. This element helps overcome problems associated with "authority gradients" within crews, where members of lower position or rank hesitate to voice their concerns and perspectives to members of higher rank or position within the command hierarchy, thereby limiting the quality of teamwork and group decision making.

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[48] The throttle positions run from one through eight, plus idle. Idle is no power, one is the lowest amount of power, and eight is the highest amount of power.

[49] This is a slang term and the command meant to apply the emergency brakes.

[50] Both CN and the FRA told NTSB investigators that "close supervision" required the engineer to be in the operating cab with the student engineer and to be in a position to intervene, if necessary, to ensure safety.

1.8 Crew Resource Management

Many accidents and dangerous situations occur in transportation systems because of poor human decision making,[51] as opposed to technical failures. Consequently, approaches to minimize and avoid these occurrences have received considerable attention over the past two decades across several transportation industries: aviation,[52] maritime,[53] pipeline,[54] and railroad[55] transportation. One of the more successful approaches is CRM, which makes use of equipment, procedures, and people to achieve greater levels of safety and efficiency in system operations. The main principle of CRM is that crewmembers will work together safely when their work climate fosters effective communication, improved situational awareness, and quality leadership. One study found that while the impact of CRM training on learning and behavioral changes suggested mixed results across and within domains, CRM training generally produced a positive reaction from trainees.[56] The behavioral findings of these studies included increases in team relationships, maintaining workload levels, mission information exchange, cross-monitoring performance, managing mission-threatening errors, and completion of mission segments. In the aviation industry, the organizational impact resulted in a decrease in the number of aircraft accidents.

The purpose of CRM is to assure that all crewmembers understand their roles and responsibilities in relation to the tasks being performed. Teamwork and active engagement are important elements of CRM. CRM becomes even more important when one or more members of a crew potentially becomes fatigued or distracted, therefore at higher risk of making errors. Using CRM principles of effective communication, situational awareness, and teamwork can mitigate the adverse effects of fatigue and serve as a countermeasure.

In August 2012, NTSB investigators met with the FRA to discuss some of the issues involved in the Two Harbors accident, including CRM. During the meeting, the FRA provided information on efforts to develop and implement CRM in the rail industry. FRA representatives told NTSB investigators that they will continue to monitor progress regarding CRM with both the Long Island Railroad and UP. NTSB staff will request periodic updates from the FRA in

[51] G.E. Cooper, M.D. White, and J.K. Lauber, "Resource Management on the Flightdeck: Proceedings of a NASA/Industry Workshop," NASA CP-2120 (Moffett Field, California: NASA-Ames Research Center, 1980).

[52] R.L. Helmreich, A.C. Merritt, and J.A. Wilhelm, "The Evolution of Crew Resource Management Training in Commercial Aviation," *International Journal of Aviation Psychology* 9, no. 1 (1999): 19-32.

[53] C. Hetherington, R. Flin, and K. Mearns, "Safety in Shipping: The Human Elements," *Journal of Safety Research* 37 (2006): 401–411.

[54] *Enbridge Incorporated Hazardous Liquid Pipeline Rupture and Release, Marshall, Michigan, July 25, 2010*, Pipeline Accident Report NTSB/PAR-12/01 (Washington, DC: National Transportation Safety Board, 2012).

[55] *Collision of Norfolk Southern Corporation Train 255L5 With Consolidated Rail Corporation Train TV 220, Butler, Indiana, March 25, 1998*, Railroad Accident Report NTSB/RAR-99-02 (Washington, DC: National Transportation Safety Board, 1999).

[56] G. Grubb, N. Crossland, and L. Katz, "Evaluating and Delivering the U.S. Army Aircrew Coordination Training Enhancement (ACTE) Program" *Proceedings of the Interservice/Industry Training, Simulation and Education Conference* (Arlington, Virginia: National Training Systems Association, 2002) 1143-1149; G. Grubb and J.C. Morey, "Enhancement of the U.S. Army Aircrew Coordination Training (ACT) Program," *Proceedings of the 12th International Symposium on Aviation Psychology*, ed. R.S. Jensen (Columbus, Ohio: Ohio State University, 2003) 446-452.

relation to these pilot programs. One FRA-sponsored research study,[57] published in 2007 by the Texas A&M Transportation Institute, developed CRM training curricula for transportation, mechanical, and engineering employees. Another FRA-sponsored research study,[58] also published in 2007, presented the business case for CRM in the rail industry. Additionally, FRA awarded grants to the Long Island Railroad and UP railroad for CRM pilot programs.

Staff reviews of CRM literature support the conclusion that CRM participants have favorable reactions to the training.[59] Specifically, one study[60] found that CRM training produced positive reactions, enhanced learning, as measured through attitude and behavioral changes in the cockpit. While the study could not determine with certainty the effect CRM training had on aviation safety, the authors concluded, "…it may be argued that the current evidence for the effectiveness of CRM training program, as impressive, albeit imperfect."[61]

The Federal Aviation Administration in an Advisory Circular[62] discussed a Fatigue Risk Management System. Page 6 of the document noted that, "Implementing error detection and corrective processes can prevent operational consequences of fatigue. Crew Resource Management (CRM) is a recognized and widely used process to encourage crewmembers to work together to detect and prevent operational errors. From a practical standpoint, CRM programs typically include educating crews about the limitations of human performance, including an understanding of cognitive errors, and how stressors (such as fatigue, emergencies, and work overload) contribute to the occurrence of errors.

The circumstances of the Two Harbors accident draw attention to the importance of CRM—particularly, the need for effective crew coordination and communication. The NTSB is concerned that each member of the southbound train crew was responsible for the safe operation of the train and adhering to CN rules, but did not do so. The southbound train's engineer and conductor did not discuss the specific elements of the track authority issued to them at 3:47 p.m. The engineer, in turn, did not discuss that same track authority with the student engineer. Moreover, the student engineer did not inquire about the track authority before moving the train. Regarding the performance and supervision of the student engineer, an important element of CRM is developing techniques and confidence among junior crewmembers, and encouraging them to challenge their more senior colleagues regarding proper procedures. Further, the engineer and conductor did not speak up or take action when the student engineer entered the single main track without authority. Likewise, they took no action to slow the train when the student engineer exceeded the maximum allowable speed through the Highland south siding

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[57] Federal Railroad Administration, *Rail Crew Resource Management (CRM): Pilot Rail CRM Training Development and Implementation* (Springfield, Virginia: National Technical Information Service, 2007).

[58] Federal Railroad Administration, *Rail Crew Resource Management (CRM): The Business Case for CRM Training in the Railroad Industry* (Springfield, Virginia: National Technical Information Service, 2007).

[59] O'Connor et al., 2002; Salas et al., 2001; Salas, Wilson, Burke & Wightman, 2006 as cited in O'Connor, Campbell, Newton, Melton, Salas, and Wilson, "Crew Resource Management Training Effectiveness: A Meta-Analysis and Some Critical Needs," *International Journal of Aviation Psychology* 18 no. 4 (2008): 353-368.

[60] Salas, E., Wilson, K.A., and Burke, C.S., "Does Crew Resource Management Training Work? An Update, an Extension and Some Critical Needs," *Human Factors* 48 no. 2 (Summer 2006): 392-412.

[61] Salas, E., Wilson, K.A., and Burke, C.S., "Does Crew Resource Management Training Work? An Update, an Extension and Some Critical Needs," *Human Factors* 48 no. 2 (Summer 2006): 410.

[62] Federal Aviation Administration, *Fatigue Risk Management Systems for Aviation Safety*, AC No: 120-103, August 3, 2010.

switch. These events illustrate that effective crew communication and coordination are imperative, especially when a crewmember is receiving on-the-job training. The NTSB concludes that the southbound train crew displayed poor coordination of activities and inadequate communication, which are indicative of poor CRM.

One method of improving crew coordination and communication is through CRM training. The NTSB identified inadequate or nonexistent CRM training as a safety issue in the Marshall, Michigan, pipeline accident,[63] as well as several aviation[64] and marine accidents.[65]

In 1999, the NTSB addressed the lack of railroad CRM in an investigation of the collision between two trains in Butler, Indiana.[66] The NTSB concluded that the accident, as well as other accidents, demonstrated that if crewmembers receive CRM training, railroad safety can be improved.[67] As a result of the Butler, Indiana, accident, the NTSB issued Safety Recommendation R-99-13, as well as other recommendations for the FRA, all Class I railroads, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers and Trainmen, and the United Transportation Union to work together to develop and implement CRM training for train crewmembers.

With regard to R-99-13, the NTSB noted that the FRA had engaged in direct communication with the Association of American Railroads and many of the Class I railroads about CRM training. Furthermore, the NTSB indicated that since that accident, the railroad industry had made great strides to embrace the concept of CRM training. Therefore, based on the industry's voluntary development and implementation of CRM training, on May 6, 2003, the NTSB classified this safety recommendation "Closed—Acceptable Alternate Action."

NTSB investigators requested copies of any CRM training materials used by CN at the time of the accident. CN responded that while it did not have stand-alone formal CRM training, several elements of CRM training, including crewmember proficiency and effective communication, situational awareness, and challenging and questioning authority were in place and addressed Safety Recommendation R-99-13 that resulted from the Butler, Indiana, investigation.

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[63] NTSB/PAR-12/01.

[64] *Loss of Control and Impact With Terrain Aviation Charter, Inc., Raytheon (Beechcraft) King Air A100, N41BE, Eveleth, Minnesota, October 25, 2002*, Aviation Accident Report NTSB/AAR-03/03 (Washington, DC: National Transportation Safety Board, 2003); *Air Florida, Inc., Boeing 737-222, N62AF, Collision with 14th Street Bridge near Washington National Airport, Washington, DC, January 13, 1982*, Aviation Accident Report NTSB/AAR-82-08 (Washington, DC: National Transportation Safety Board, 1982); *Runway Overrun During Rejected Takeoff Global Exec Aviation Bombardier Learjet 60, N999LJ, Columbia, South Carolina, September 19, 2008*, Aviation Accident Report NTSB/AAR-10/02 (Washington, DC: National Transportation Safety Board, 2010).

[65] *Grounding of the United Kingdom Passenger Vessel* RMS Queen Elizabeth 2, *near Cuttyhunk Island, Vineyard Sound, Massachusetts, August 7, 1992*, Marine Accident Report NTSB/MAR-93/01 (Washington, DC: National Transportation Safety Board, 1993); *Grounding of the U.S. Tankship* Star Connecticut, *Pacific Ocean, near Barbers Point, Hawaii, November 6, 1990*, Marine Accident Report NTSB/MAR-92/01 (Washington, DC: National Transportation Safety Board, 1992); *Collision between the Greek Tankship* Shinoussa *and the U.S. Towboat* Chandy N and Tow *near Red Fish Island, Galveston Bay, Texas, July 28, 1990*, Marine Accident Report NTSB/MAR-91/03 (Washington, DC: National Transportation Safety Board, 1991).

[66] NTSB/RAR-99-02.

[67] The investigation revealed that no crewmember in this accident had received formal CRM training.

While the NTSB is encouraged that CN has attempted to address some of the elements that are contained in CRM training, it believes the current CN efforts do not go far enough in developing and implementing a comprehensive and effective CRM training program. For example, CN indicated it did not have specific training that addressed situational awareness, but instead, taught employees why situational awareness was important. Furthermore, the information CN provided that discussed effective peer-to-peer communication consisted of one slide of a presentation that did not specifically explain the principles and dynamics of interpersonal communications. Finally, with respect to challenging and questioning authority, CN cited its rule Z that notes federal law permits an employee "…the right to challenge a directive from a supervisor that the employee feels would violate a railroad operating rule regarding shoving movements, leaving unattended equipment foul of an adjacent track, or handling switches or derails." Rule Z does not specifically address operating personnel, such as engineers or conductors, who function in an operational environment, nor does it delineate how an employee would effectively exercise strategies that would appropriately challenge authority in dynamic situations, such as in the locomotive cab of a train.

The NTSB concludes that had the crewmembers on the southbound train received training in, and practiced the principles of, CRM, they may have demonstrated better coordination and communication. Based on the response and materials received from CN regarding its CRM training, the NTSB believes that CN should develop and implement specific training that will result in operating personnel acquiring and using strategies and skills based on the principles of CRM.

Federal regulations require CRM training for aviation cockpit crews and bridge resource management (BRM) training for mariners. FRA studies show that CRM training can be effective on railroads. The NTSB recommends that FRA require railroads to implement initial and recurrent CRM training for train crews.

2 Management and Regulatory Oversight

2.1 CN Management Oversight

FRA regulations require railroads to establish a program of operational tests and inspections. The CN testing program involves establishing goals for managers based on the number and type of tests they should be administering each quarter. Goals are modified each quarter based on CN management reviews of accidents, incidents, rules violations, and failures from the previous quarter. The manual[68] states that CN's philosophy on rules compliance testing provides:

> ….an opportunity to verify that employees are working safely and in compliance with all company rules, policies, instructions and procedures. Quality Efficiency Testing is one of the most valuable services (managers) can perform to ensure safe, efficient rail operations.

CN provided operational testing data for the accident crews during the 12 months prior to the accident. Table 6 summarizes these data:

Table 6. CN rules compliance testing of crewmembers of the accident trains.

Crewmember	Number of tests	Noncompliant tests	Noncompliant test items
SB Engineer	16	1	Test #43: Inspection of Trains
SB Conductor	26	3	Test #22: Radio Use Test #62: Special - Tardiness Test #62: Special - Tardiness
SB Student Engineer	31	0	n/a
NB Engineer	4	0	n/a
NB Conductor	7	0	n/a

CN also provided rules compliance test data for the Iron Range, Keenan, Minntac, and Two Harbors subdivisions[69] covering calendar years 2009, 2010, and 2011. Table 7 summarizes all operational tests conducted on these four subdivisions:

Table 7. CN rules compliance testing on four CN subdivisions.

Year	Noncompliant tests	Tests passed	Total tests
2009	34	424	458
2010	32	694	726
2011	49	863	912

[68] Canadian National Railway, *CN Southern Region Efficiency Tests and Inspections* (Montreal, Canada: Canadian National Railway, 2009).

[69] Ore trains to the Minntac mine operate on these four subdivisions.

Several specific CN operational tests are particularly relevant to this accident. These tests relate to the authority to occupy and move on the main track and the use of PEDs. Table 8 shows the number of tests conducted by CN both before and after the accident. All of these tests were recorded as passed.

Table 8. Summary of five CN tests conducted in 2009, 2010, and 2011, on four CN subdivisions.

CN test	2009	2010	2011	Three-year total
Test 11 – Authority to Occupy Main Track (all passed)	1	1	5	7
Test 17 – Communicating Restrictions (all passed)	3	1	10	14
Test 18 – Copy Manditory Directives (all passed)	6	3	21	30
Test 51 – RTC Issuing Authorities (all passed)	2	8	3	13
Test 56 - Proper Use of PEDs (all passed)	0	0	1	1
Yearly total of all five tests	12	13	40	65

CN describes the purpose of test 11 as follows: "to determine the train or engine has received authority to occupy the main track…" There were several observations listed in CN data for this test for the four subdivisions during the time period between 2009 and 2011; all were recorded as passed.

CN describes the purpose of test 17 as follows: "determines employees practice proper procedures for communicating restrictions and signals affecting train movement." There were 14 observations listed in CN data for this test in the four subdivisions during the time period between 2009 and 2011; all were recorded as passed.

CN describes the purpose of test 18 as follows: "to determine that the employee has copied and/or repeated mandatory directives correctly." There were 30 observations listed in CN data for this test in the four subdivisions during the time period between 2009 and 2011; all were recorded as passed.

In this accident, the southbound train crew would have failed tests 11, 17, and 18. They would have failed test 11 because the train departed from the Highland siding and entered the main track without authority. They would have failed test 17 because no one on the crew communicated the restriction (waiting for the northbound train) to the student engineer who was operating the train. Lastly, they would have failed test 18 because the conductor did not provide a copy of the authority to the engineer, the engineer copied the authority without reading it back to the RTC, and the crew did not hold a job briefing.

CN describes the purpose of test 51 as follows: "Observe the RTC/control operator verbally issuing an instruction or authority, or listen to historical tapes to verify that the RTC/control operator listened to the repetition correctly." There were 13 observations listed in CN data for this test in the four subdivisions during the time period between 2009 and 2011; all were recorded as passed. The RTC issuing the last authority to the southbound train would have passed this test.

CN describes the purpose of test 56 as follows: “determines that employee knows how and when they may use railroad-supplied and personal electronic devices, other than railroad radios.” There was only one observation recorded in the CN data for this test in the four subdivisions during the time period between 2009 and 2011, and it was recorded as passed. Had CN managers been able to overcome the challenges of detecting unauthorized personal PED use, as exhibited by the crewmembers involved in this accident, all three members of the southbound train crew, as well as the northbound train engineer, would have failed this test.

CN conducted limited operational testing of the rules that were not complied with in this accident, prior to this collision. With the exception of the testing of RTCs on issuing authorities, CN’s testing before the accident on these important operational safety areas that were factors in this accident increased after the accident. The unauthorized use of PEDs by four of five crewmembers indicates a serious disregard for CN rules and FRA regulations, yet CN managers recorded only one test observation of PED use on these subdivisions during the time period between 2009 and 2011. CN’s efficiency testing manual describes the purpose of operational testing as:

> …assuring employees an opportunity to demonstrate their command of rules and instructions, while giving supervisors the chance to praise a job well done or to correct operating deficiencies.

The NTSB concludes that given CN’s limited management oversight of track authorities and particularly the infrequent test observations of PED use, CN’s program before the accident was ineffective in ensuring compliance with these operating rules.

The limited observations on PED usage again point out the challenges of detecting unauthorized use. As noted earlier in this report, commercially available handheld cell phone-signal detection devices can be used by managers to better identify and correct improper PED use. The NTSB concludes that CN’s oversight of crew PED use can be improved by equipping managers with cell phone-signal detection technology. Therefore, the NTSB recommends that CN incorporate the use of handheld signal detection devices into its operational efficiency program on the use of PEDs.

The NTSB is a strong advocate for the use of safety management systems (SMS) to improve the safety of transportation operations in all modes. In its report on the derailment of a CN freight train at Cherry Valley, Illinois, on June 19, 2009,[70] the NTSB noted that:

> had an effective SMS been implemented at the CN, the inadequacies and risks that led to the accident would have been identified and corrected…

An effective SMS should at a minimum:

[70] *Derailment of CN Freight Train U70691-18 With Subsequent Hazardous Materials Release and Fire, Cherry Valley, Illinois, June 19, 2009,* Railroad Accident Report NTSB/RAR-12/01 (Washington, DC: National Transportation Safety Board, 2012).

- Define how the organization is set up to manage risk
- Identify workplace risk and implement suitable controls
- Implement effective communication across all levels of the organization
- Implement a process to identify and correct nonconformities
- Implement a continual improvement process

CN operates in both Canada and the United States. In Canada, CN operations fall under the regulatory authority of Transport Canada. Effective since 2001, regulations from Transport Canada required CN develop and implement a SMS. CN officials told investigators that (1) CN introduced SMS to its US operations around October 2010, and (2) the first system audit in the Two Harbors area occurred in April 2011. The NTSB recognizes that implementation of SMS is a long--term effort that requires a strong management commitment to changing and improving the prevailing work culture. The NTSB is encouraged that CN's US operations has started the implementation of SMS.

The 2011 CN audit report included a review of transportation efficiency testing. The report found that managers were "actively" performing efficiency testing. The report noted that historical testing compliance rates were at 96 percent while the audit found a lower compliance rate of 71 percent. The report listed "need to drive efficiency test quality" as an area of opportunity for improvement. CN's internal audit and the NTSB's investigation both found weakness in CN's operational testing program. Moreover, the NTSB notes that four of the five crewmembers involved in this accident demonstrated open and repeated disregard for rules on use of PEDs and that the southbound train crew failed to comply with several safety-critical operating rules and practices. The NTSB is concerned that theses safety issues are not isolated incidents; rather they may be indicators of a larger systemic problem. Similar concerns were expressed in the NTSB investigation of a 2009 CN railroad accident in Cherry Valley, Illinois.[71] The NTSB recommends that CN improve its operational testing program and verify that the testing of track authority procedures and unauthorized PED use is adequate to ensure consistent, safe operation.

Risk identification and mitigation is a key element of SMS. Operational testing is one method of gathering data to help identify risks. The use of peer observers in a nonpunitive program to assess operational safety, perform peer-to-peer counseling and to generate data on trends of risky behaviors that can be used to develop mitigation strategies is an approach with merit. The aviation industry has found success in the Line Operations Safety Audit (LOSA),[72] a voluntary safety program in which trained observers (usually line pilots from the airline) ride on a jump seat during regularly scheduled flights to collect safety-related data on environmental conditions, operational complexity, training efficacy, and flight crew performance. The data collected remains confidential, and pilots are assured of nonpunitive use of those data.

The LOSA program provides a unique and proactive opportunity to study the flight management process—both successful and unsuccessful—by noting the problems crews encounter on the line and how they manage these problems. Such a program would prove equally

[71] NTSB RAR-12/01.
[72] For more information on LOSA, see the Federal Aviation Administration's Advisory Circular 120-90.

valuable to the rail industry, as suggested by the circumstances of the Two Harbors accident. The NTSB is aware that some railroads have begun the implementation of LOSA-like programs. The NTSB concludes that a nonpunitive peer audit program is an important element of effective SMS and would provide CN with the opportunity to better address operational safety issues.

At the time of the Two Harbors collision, CN did not have an active peer audit program in place in the area where the accident occurred. While CN did introduce a Safety For Everyone (SaFE) peer audit program on portions of the North Division before the accident, it was not fully successful and was discontinued. CN advised NTSB investigators that the program continues in successful operation on the Southern portion of CN's US lines (former Illinois Central). The NTSB is encouraged that CN has implemented a LOSA-like program called SaFE on portions of its US lines, but is disappointed that it was not fully successful on the North Division.

The NTSB concludes that a nonpunitive peer audit program would provide CN with the necessary data to address operational safety issues on the North Division and would be consistent with and support CN's implementation of SMS. Therefore, the NTSB recommends that CN work with the Brotherhood of Locomotive Engineers and Trainmen and the United Transportation Union to develop and implement a nonpunitive peer audit program for the North Division, focused on rule compliance and operational safety. Also, the NTSB recommends that the Brotherhood of Locomotive Engineers and Trainmen work with CN and the United Transportation Union to develop and implement a nonpunitive peer audit program for CN's North Division. Further, the NTSB recommends that the United Transportation Union work with CN and the Brotherhood of Locomotive Engineers and Trainmen to develop and implement a nonpunitive peer audit program for the North Division.

2.2 FRA Regulatory Oversight

CN's US operations fall under the safety regulatory authority of the FRA. Regulations found at 49 CFR Part 217 require that CN have in place a program of operational tests and inspections to confirm that crews are operating trains in accordance with CN rules. The FRA also issued Emergency Order 26 restricting the use of PEDs.

FRA operating practices require that inspectors periodically visit all US railroads and make inspections for compliance with specific FRA regulations. In some instances, a small group of inspectors will perform a much more comprehensive in-depth audit of a railroad's operational testing program over a period of several days and will provide the railroad with a written report that summarizes the audit findings and which may contain recommendations for improvement to the railroad's program.

NTSB investigators asked the FRA for any inspection reports related to CN's operations testing program on the North Division. The FRA provided copies of all operating practice reports relating to 49 CFR Part 217 filed for inspections conducted on the CN North Division during 2009, 2010, and 2011. During the 21 months before the collision, FRA inspectors filed nine inspection reports on CN operational rules compliance. These inspection reports noted seven observations for compliance with PED use requirements with one instance of improper use.

During the 14 months following the collision, FRA inspectors filed 23 inspection reports. These reports noted three observations for compliance with PED use requirements, with no improper use observed. The FRA inspection reports also recorded seven observations on the proper execution of mandatory directives (three before the accident and four after).

NTSB investigators also asked the FRA to provide reports on any Part 217 audits performed on the CN North Division either before or after the accident. FRA representatives explained that they analyze accidents, injuries, employee complaints, and railroad operational testing data in order to select locations for in-depth Part 217 audits. Based on an evaluation of these factors, FRA did not conduct a Part 217 audit on the subdivision where this accident occurred. FRA did supply NTSB with four reports on audits performed on CN operations during 2006 and 2007. The last FRA audit on the CN North Division prior to the accident was conducted in Wisconsin in 2007. However, an FRA representative advised that, based on FRA's review of CN safety data, a Part 217 audit was determined not to be needed, and therefore was not conducted on the portions of the CN North Division where the accident crew operated.

The NTSB concludes that railroad safety on the CN North Division would benefit from a FRA audit on CN's program of operational tests and inspections. Therefore, NTSB recommends that the FRA conduct an audit of the CN North Division program of operational tests and inspections to determine if the program is effective in promoting knowledge and compliance with rules on executing track authorities and the appropriate use of PEDs.

2.3 Actions Taken Since the Accident

Representatives from CN told NTSB investigators that they have taken several steps since the accident. These include:

- CN issued Superintendent's Notice L-10-LZ, dated October 5, 2010, mandating that all members of an operating train crew occupy the lead locomotive unless there are no seats available to accommodate them.
- CN retrofitted all locomotives having only two seats with a third seat.
- CN modified Rule 1000 to include the following language: "…before being acted upon, conductor and engineer must each have a copy of all mandatory directives issued for their train, and they must be read and understood by all members of the crew who are responsible for the operation of the train. They will be retained for the duration of the train crew's work assignment."
- CN instituted a policy where it conducts safety awareness meetings[73] for three days immediately following an accident.
- CN increased operational testing of train crews using supervisors of locomotive engineers from other divisions as test administrators.

[73] *Safety awareness meetings* are also known as a "safety blitz" and require that managers contact all affected employees, discuss the circumstances of the accident, and reinforce applicable rules and procedures.

3 Conclusions

3.1 Findings

1. The mechanical condition of the trains, the weather, drug or alcohol impairments, and the actions of the northbound train crew were not factors in this accident.

2. The use of after-arrival track authorities in nonsignaled territory presents unacceptable and unnecessary safety risks to railroad operational safety, because the procedure is vulnerable to human error and lacks inherent safety redundancies to ensure consistent, safe operation.

3. In the absence of a positive train control system, discontinuing the use of after-arrival track authorities in nonsignaled territory will mitigate future accidents involving authority overruns.

4. Fatigue-induced performance errors contributed to the accident.

5. The use of cell phones by crewmembers on the southbound train and by the engineer on the northbound train was a distraction to the safe operation of both trains and an indication of a clear disregard for Canadian National Railway rules and Federal Railroad Administration regulations.

6. Additional measures to prevent unauthorized portable electronic device use by train crewmembers is necessary because of the continuing use of these devices by some railroad crewmembers, and the resulting risks to safety caused by distraction.

7. Electronic signal detection technologies in locomotive cabs would enhance safety by deterring inappropriate portable electronic device use without affecting crewmember privacy.

8. Handheld cell phone-signal detectors can serve as an effective tool for personnel performing inspections and tests to deter the unauthorized use of portable electronic devices by railroad personnel.

9. The southbound train crew displayed poor coordination of activities and inadequate communication, which are indicative of poor crew resource management.

10. Had the crewmembers on the southbound train received training in, and practiced the principles of, crew resource management, they may have demonstrated better coordination and communication.

11. Given Canadian National Railway's limited management oversight of track authorities and particularly the infrequent test observations of portable electronic device use, Canadian National Railway's program was ineffective in ensuring compliance with these operating rules.

12. Canadian National Railway's oversight of crew portable electronic device use can be improved by equipping managers with cell phone-signal detection technology.

13. A nonpunitive peer audit program is an important element of an effective safety management system and will provide Canadian National Railway management with the necessary data to better address operational safety issues.

14. Railroad safety on the Canadian National Railway North Division would benefit from a Federal Railroad Administration audit on Canadian National Railway's program of operational tests and inspections.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the southbound train crew's error in departing the Highland siding before the northbound train had passed. Contributing to the accident was the Canadian National Railway's use of after-arrival track authorities in nonsignaled territory, a procedure that is vulnerable to human error and lacks inherent safety redundancies to ensure consistent, safe operation. Also contributing to the accident was crew fatigue and inadequate crew resource management.

4 Recommendations

4.1 New Recommendations

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

To the Federal Railroad Administration:

Identify, and require railroads to use in locomotive cabs, technology-based solutions that detect the presence of signal-emitting portable electronic devices and that inform the railroad management about the detected devices in real time. (R-13-5)

Incorporate the use of handheld signal detection devices to aid in the enforcement of Title 49 *Code of Federal Regulations* Part 220 Subpart C. (R-13-6)

Require railroads to implement initial and recurrent crew resource management training for train crews. (R-13-7)

Conduct an audit of the Canadian National Railway’s North Division program of operational tests and inspections to evaluate their effectiveness for promoting knowledge and compliance with rules regarding the execution of track authorities and the appropriate use of portable electronic devices. (R-13-8)

To Canadian National Railway:

Discontinue the use of after-arrival track authorities in nonsignaled territory not equipped with positive train control. (R-13-9)

Develop and implement specific training that will result in operating personnel acquiring and using strategies and skills based on the principles of crew resource management. (R-13-10)

Incorporate the use of handheld signal detection devices into your operational efficiency program on the use of portable electronic devices. (R-13-11)

Evaluate your operational testing program, and verify that the testing of track authority procedures and unauthorized use of portable electronic devices is adequate to ensure consistent, safe operation. (R-13-12)

Work with the Brotherhood of Locomotive Engineers and Trainmen and the United Transportation Union, to develop and implement a nonpunitive peer audit program for the North Division, focused on rule compliance and operational safety. (R-13-13)

To the Brotherhood of Locomotive Engineers and Trainmen:

> Work with the Canadian National Railway and the United Transportation Union, to develop and implement a nonpunitive peer audit program for the Canadian National Railway's North Division, focused on rule compliance and operational safety. (R-13-14)

To the United Transportation Union:

> Work with the Canadian National Railway and the Brotherhood of Locomotive Engineers and Trainmen, to develop and implement a nonpunitive peer audit program for the Canadian National Railway's North Division, focused on rule compliance and operational safety. (R-13-15)

To Canadian Pacific Railway Limited, Kansas City Southern Railway Company, and Norfolk Southern Railroad, and Union Pacific Railroad

> Discontinue the use of after-arrival track authorities for train movements in nonsignaled territory not equipped with a positive train control system. (R-13-16)

4.2 Previously Issued Recommendations Reiterated in this Report

As a result of this accident investigation, the National Transportation Safety Board reiterates the following previously issued safety recommendations:

To the Federal Railroad Administration:

> Prohibit the use of after-arrival track warrants for train movements in dark (non-signaled) territory not equipped with a positive train control system. (R-06-10)

Safety Recommendation R-06-10 is classified "Open—Unacceptable Response".

> Establish an ongoing program to monitor, evaluate, report on, and continuously improve fatigue management systems implemented by operating railroads to identify, mitigate, and continuously reduce fatigue-related risks for personnel performing safety-critical tasks, with particular emphasis on biomathematical models of fatigue. (R-12-17)

Safety Recommendation R-12-17 is classified "Open—Acceptable Response".

To BNSF Railway:

> Discontinue the use of after-arrival track warrants for train movements in dark (non-signaled) territory not equipped with a positive train control system. (R-06-12)

Safety Recommendation R-06-12 is classified “Open-Unacceptable Response”.

To the American Short Line and Regional Railroad Association:

> Encourage your members to discontinue the use of after-arrival track warrants for train movements in dark (non-signaled) territory not equipped with a positive train control system. (R-06-13)

Safety Recommendation R-06-13 is classified “Open—Unacceptable Response”.

4.3 Previously Issued Recommendations Reiterated and Reclassified in this Report

As a result of this accident investigation, the National Transportation Safety Board reclassifies the following previously issued safety recommendations:

To the Federal Railroad Administration:

> Require the installation, in all controlling locomotive cabs and cab car operating compartments, of crash- and fire-protected inward- and outward-facing audio and image recorders capable of providing recordings to verify that train crew actions are in accordance with rules and procedures that are essential to safety as well as train operating conditions. The devices should have a minimum 12-hour continuous recording capability with recordings that are easily accessible for review, with appropriate limitations on public release, for the investigation of accidents or for use by management in carrying out efficiency testing and systemwide performance monitoring programs. (R-10-1)

Safety Recommendation R-10-1, previously classified “Open—Acceptable Response” is classified “Open—Unacceptable Response” in this report.

> Require that railroads regularly review and use in-cab audio and image recordings (with appropriate limitations on public release), in conjunction with other performance data, to verify that train crew actions are in accordance with rules and procedures that are essential to safety. (R-10-2)

Safety Recommendation R-10-2, previously classified "Open—Acceptable Response" is classified "Open—Unacceptable Response" in this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

DEBORAH A.P. HERSMAN
Chairman

ROBERT L. SUMWALT
Member

CHRISTOPHER A. HART
Vice Chairman

MARK R. ROSEKIND
Member

EARL F. WEENER
Member

Adopted: February 12, 2013

Board Member Statements

Vice Chairman Christopher A. Hart, concurring:

I concur with the findings, probable cause, and recommendations in this report, but I believe that we would have been warranted in going further with three of the recommendations, and perhaps also recommending that the Federal Railroad Administration (FRA) take an active role in implementing the recommended audit programs.

The Three Recommendations. The report contains recommendations to each of three entities, the Canadian National Railway (CN), the Brotherhood of Locomotive Engineers and Trainmen, and the United Transportation Union:

> ... to develop and implement a nonpunitive peer audit program for the North Division, focused on rule compliance and operational safety.

Given what this investigation revealed about the inadequate safety culture at CN, query whether this recommendation should have applied to CN's entire operation rather than being limited to the North Division.

For example, the frequency of the use of cell phones by the train crew while operating the train, in violation of both CN and FRA regulations, indicates inadequate concern by the train crews about the potential safety implications of cell phone use while underway. Unfortunately we have seen far too many fatalities, in all modes of transportation, that resulted from the use of cell phones by people who were not paying adequate attention to their primary operating responsibilities.

Similarly, the openness by the train crews of their cell phone use, in clear view of other crewmembers, shows that the practice is widely ignored and tolerated; and given the amount of cell phone use that was discovered in this investigation of just one accident, it is difficult to conceive that management is not aware of that cell phones are being used inappropriately.

Complicating the issue is that management permits cell phone use for certain work-related reasons. Query what safeguards CN has employed to assure that any permitted use does not unduly distract an operator from his or her primary responsibilities. Given the limited management oversight of cell phone use discussed in the report, this is a critical item for CN to address.

Another example of CN's inadequate safety culture relates to the fact that when the Canadian Government imposed a requirement for the implementation of a safety management system (SMS), CN complied with that requirement for its Canadian operations, but did not systematically extend the SMS program to its US operations until many years later. This clearly suggests a lack of urgency to implement this safety measure.

Notwithstanding these examples, I hope that CN will decide to implement nonpunitive peer audit programs throughout its system, even though our recommendation refers only to its North Division.

FRA Involvement. Also not included in our report is a recommendation to the FRA to play a role in the implementation of the audit program. Aviation industry experience has demonstrated that one of the key issues in the implementation of an audit program is what protections will be applied to the data from the audits, and the ultimate decision on that issue rests with the regulator.

Given that the FRA has attempted to be proactive regarding safety by, for example, establishing a near-miss reporting program for the railroad industry, it seems unlikely that the FRA would do anything that undercuts a proactive audit program, such as attempting to use any of the audit data for enforcement purposes. That said, however, in order for the parties to be willing to participate in an audit program, the FRA will probably need to establish guidelines regarding the protection of audit data, much as the Federal Aviation Administration has done in FAA Advisory Circular 120-90 with respect to the Line Operations Safety Audit (LOSA) program in aviation.

Members Sumwalt and Weener concurred with this statement.

5 Appendixes

5.1 Appendix A: Investigation

The National Transportation Safety Board was notified on September 30, 2010, of the collision of two Canadian National Railway trains near Two Harbors, Minnesota. The National Transportation Safety Board launched an investigator-in-charge and two other investigative team members from its headquarters and from the Los Angeles and Chicago regional offices. The Federal Railroad Administration, the Canadian National Railway, the Brotherhood of Locomotive Engineers and Trainmen, and the United Transportation Union assisted the National Transportation Safety Board in this investigation.

5.2 Appendix B: Comparative Table of BNSF and CN Rule Requirements for After-Arrival Track Authorities in Nonsignaled Territory

Comparative table of BNSF and CN rule requirements for after-arrival track authorities in nonsignaled territory	BNSF	CN
Use of after-arrival track authority in nonsignaled territory is restricted to preventing extended road crossing blockage and train meets during dispatcher shift turnover.	X	
Before transmittal, the dispatcher/RTC advises the train receiving after-arrival track authority that the authority will require a meet with another train.	X	X
Before transmittal, the dispatcher/RTC advises the train receiving the after-arrival track authority that the authority will require a meet with another train and advises the crew of the ID of the train to be met.	X	
The restricted train must make contact with the other train, establish its location, and inform the dispatcher/RTC before the after-arrival track authority is transmitted.	X	
The train receiving the after-arrival track authority must be stopped at the meeting point and advise the dispatcher/RTC of the fact before the after-arrival track authority is transmitted.	X	
The after-hours track authority is transmitted, read back, and okayed.	X	X
The crew must note on the track authority form and read back, "This authority requires a meet with another train at _________."	X	
All train crews must announce their train ID, location, speed, and direction approximately two miles in advance of approaching a junction or siding.	X	
When the train arrives, the restricted train must again communicate via radio to confirm its train ID before proceeding.	X	X
The crew of the restricted train must note on the track authority form the train ID of the train met, the time met, and the location met.	X	
Every after-arrival track authority used for nonsignaled track is reviewed against recorded audio to verify the communication requirements were met.	X	

5.3 Appendix C: Canadian National Rule on PED Use

L. COMMUNICATION AND ELECTRONIC DEVICES. The use of railroad supplied or personal electronic devices must not interfere with operating employees covered by the Federal Hours of Service law during performance of safety related duties. This rule does not apply to railroad radios.

Personal or railroad supplied electronic devices may be used to respond to an emergency involving railroad operations. They also may be used in place of the radio, when radio failure occurs, however all radio rules will apply to electronic devices.

When operating company vehicles or off-track equipment, hands-free technology must be utilized unless vehicle is stopped.

Railroad Supplied Electronic Devices

The use of railroad supplied electronic devices by Engineers is prohibited:

• On a moving train, or

• When any crew member is working on the ground, or riding equipment during a switching operation, or

• During any time when another employee of the railroad is assisting in preparation of the train, i.e. utility employee.

The use of railroad supplied electronic devices by other employees is prohibited:

• On a moving train or on-track equipment, unless authorized for company business, and:

1. A safety briefing is conducted, and all agree it is safe to do so, or

2. Within the body of a passenger train or business car.

• Outside the locomotive cab or on-track equipment, unless:

1. Not fouling the track,

2. No switching is being performed,

3. No other safety related duties are being performed, and

4. All employees have been briefed that operations have been stopped.

Personal Electronic Devices

While on duty, the use of personal electronic devices for other than voice communication is prohibited.

All operating employees must have personal electronic devices TURNED OFF, and if equipped, earpiece removed when:

- On a moving train.

- When duty requires any crew member to be on the ground.

- When a crew member is riding rolling equipment during a switching operation.

- During any time when another employee of the railroad is assisting in preparation of the train.

5.4 Appendix D: Southbound Train After-Arrival Track Authority, Conductor Copy

TRACK AUTHORITY CN

No. 16268 Date 9/30, 20 10

To IC 6258 South At Highland

1. ☐ Track Authority Number ______ is void.

2. ☐ Proceed from ______ to ______ on ______.

   ☐ Proceed from ______ to ______ on ______.

3. ☐ Clear Main Track at ______.

4. ☒ AFTER THE ARRIVAL OF IC 6265 North at Highland

   Proceed from S. Highland SW(Y) to CTC THJct SW (N) on Main.

5. ☐ Clear Main Track at ______.

6. ☐ Work between ______ Switch Yes No and ______ Switch Yes No on ______.

   Work between ______ Switch Yes No and ______ Switch Yes No on ______.

   Work between ______ Switch Yes No and ______ Switch Yes No on ______.

Track released by ______ between ______ and ______ at ______.

Track released by ______ between ______ and ______ at ______.

Track released by ______ between ______ and ______ at ______.

Track released by ______ between ______ and ______ at ______.

7. ☐ DO NOT SET ON AHEAD OF OR PASS PRECEDING TRAIN(S) ______; ______.

8. ☐ JOINT AUTHORITY between ______ and ______.

   with ______ between ______ and ______.

   with ______ between ______ and ______.

   with ______ between ______ and ______.

   with ______ between ______ and ______.

   with ______ between ______ and ______.

9. ☐ STOP at ______ until known the switch is in the normal position.

   STOP at ______ until known the switch is in the normal position.

10. ☐ PERMISSION to leave following switch(es) in reverse position ______, ______, ______, ______.

11. ☐ Additional Instructions ______

12. ☒ This authority requires a meet with another train(s) at S. Highland.

This authority has 2 boxes marked: 4, 12, ___, ___, ___, ___, ___, ___, ___.

OK 1547 RTC JAA Copied by Reimer.

Limits Reported Clear at ______ By ______.

5.5 Appendix E: Southbound Train After-Arrival Track Authority, Engineer Copy

TRACK AUTHORITY CN

No. 16268 Date ________, 20____

To IC 6255S At Highland

1. ☐ Track Authority Number __________ is void.
2. ☐ Proceed from __________ to __________ on __________.
   ☐ Proceed from __________ to __________ on __________.
3. ☐ Clear Main Track at __________.
4. ☒ AFTER THE ARRIVAL OF IC 6265N at S.H. S.Y.
   Proceed from S.H. S.Y. to THE JCT SN on main
5. ☐ Clear Main Track at __________.
6. ☐ Work between __________ Switch Yes No and __________ Switch Yes No on __________.
   Work between __________ Switch Yes No and __________ Switch Yes No on __________.
   Work between __________ Switch Yes No and __________ Switch Yes No on __________.

Track released by __________ between __________ and __________ at __________.
Track released by __________ between __________ and __________ at __________.
Track released by __________ between __________ and __________ at __________.
Track released by __________ between __________ and __________ at __________.

7. ☐ DO NOT SET ON AHEAD OF OR PASS PRECEDING TRAIN(S) __________; __________.
8. ☐ JOINT AUTHORITY between __________ and __________.
   with __________ between __________ and __________.
   with __________ between __________ and __________.
   with __________ between __________ and __________.
   with __________ between __________ and __________.
   with __________ between __________ and __________.
9. ☐ STOP at __________ until known the switch is in the normal position.
   STOP at __________ until known the switch is in the normal position.
10. ☐ PERMISSION to leave following switch(es) in reverse position __________, __________, __________, __________.
11. ☐ Additional Instructions __________
12. ☒ This authority requires a meet with another train(s) at S. Highland S.Y.

This authority has 2 boxes marked: 4, 12, ____, ____, ____, ____, ____, ____.

OK 1547 RTC TAA Copied by Kremer

Limits Reported Clear at __________ By __________.