Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

# RAILWAY INVESTIGATION REPORT R16E0051

## Main-track train collision

Canadian National Railway Company
Freight trains Q11251-03 and M30251-02
Mile 34.9, Edson Subdivision
Carvel, Alberta
04 June 2016

Canada

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## *Summary*

On 04 June 2016, at about 0748 Mountain Daylight Time, Canadian National Railway Company freight train Q11251-03 was proceeding eastward on the Edson Subdivision when it collided at 18 mph with the tail end of train M30251-02 at Mile 34.9 near Carvel, Alberta. No cars derailed as a result of the collision. There was minor damage to 1 empty hopper car on train M30251-02. There were no injuries.

*Le présent rapport est également disponible en français.*

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# 1.0 Factual information

## 1.1 The accident

On 04 June 2016, Canadian National Railway Company (CN) freight train M30251-02 (train 302) was to depart eastward from Edson, Alberta, to Edmonton, Alberta (Figure 1). The train consisted of 2 locomotives, 72 loaded cars, 74 empty cars, and 23 residue cars; it weighed 11 289 tons and was 11 489 feet long. The train was operating in a conventional power configuration, meaning that the locomotives were on the head end.

On the same day, CN freight train Q11251-03 (train 112) was also to depart eastward from Edson, en route to Edmonton. It consisted of 2 locomotives and 167 loaded cars; it weighed 9484 tons and was 9250 feet long. Train 112 was also operating in a conventional power configuration, with the locomotives on the head end.

The operating crews of both trains consisted of a locomotive engineer (LE) and a conductor. The crew members of trains 112 and 302 were qualified for their respective positions, were familiar with the territory, and met established rest and fitness requirements.

When the crew took over train 302 in Edson, the previous crew told them that there was considerable slack[1] in the train, and that the train had experienced a train separation and an undesired emergency brake application (UDE) at Jasper, Alberta. During this exchange, it was suggested that limited use of air brakes and dynamic brakes with incremental throttle manipulation would help limit the slack action and could prevent another UDE.

The crew of train 302 informed the rail traffic controller (RTC) of the state of the train, and the RTC consequently notified the opposing trains en route that train 302 was being operated under throttle modulation and could be delayed at meeting points. In addition, a General Bulletin Order was issued to train 302, containing the following information and instructions:

- Train 302 had incurred a train separation.
- Forward plan, make only incremental adjustments, avoid air applications and maximizing dynamic brake for speed control.
- Do not exceed 40 mph in 3 different locations on the Edson Subdivision.

The trains departed eastward from Edson 53 minutes apart: train 302 at 0422,[2] and train 112 at 0515. They remained relatively close to each other as they proceeded east. Each crew was able to hear some of the other crew's radio communications on the train standby channel, including some of the radio communications with the RTC.

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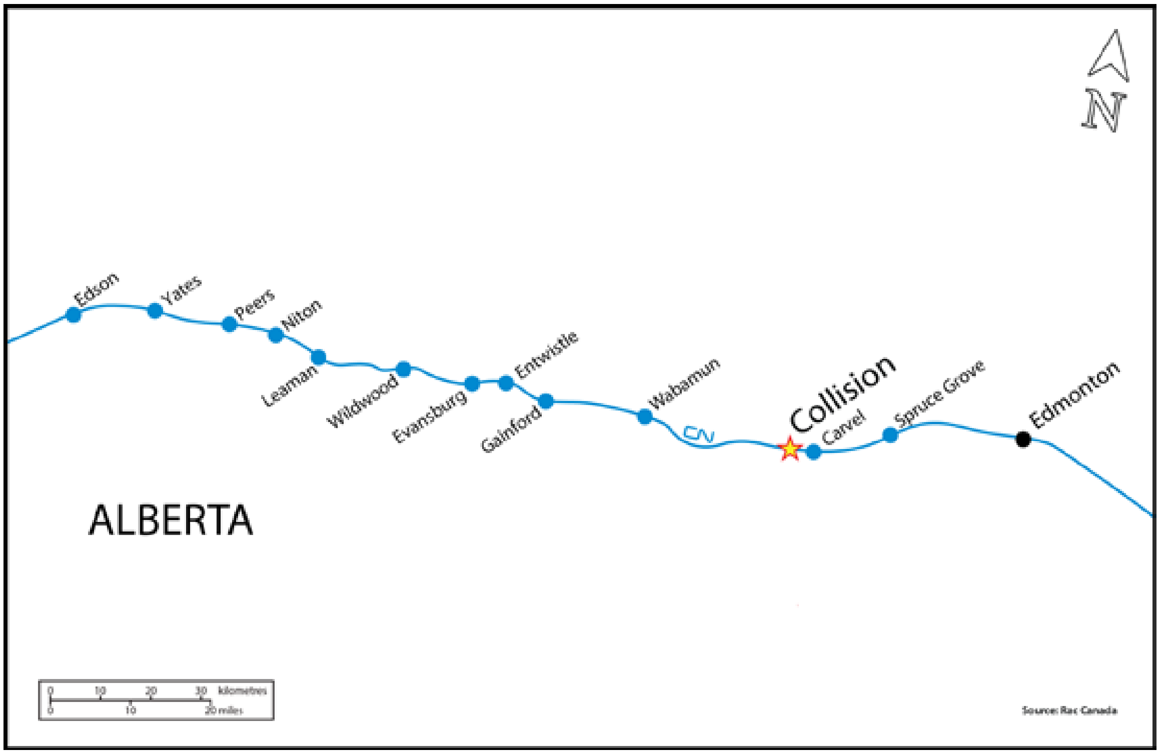
1 "Slack" refers to the amount of lateral travel between rail cars at each coupler. Many couplers are designed with dampened cushioning to prevent damage to the products being transported. In a long train with cushioned couplers, the total amount of slack can be several hundred feet in length.

2 All times are Mountain Daylight Time.

**Figure 1. Map of the occurrence location (Source: Railway Association of Canada, *Canadian Railway Atlas*, with TSB annotations)**




Approaching Carvel on the north track, the crew members of train 302 heard a radio conversation indicating that westbound train 301 was stalled[3] on the north track near Spruce Grove at Mile 19.9 of the Edson Subdivision (Figure 2). They also heard the RTC say that a permissive signal indication was on request[4] for westbound train 725 on the south track, which would allow it to proceed ahead of train 301.

The RTC's plan was for train 302 and train 112 to wait at Carvel until train 725 passed.

Approaching Carvel, the crew of train 302 observed and announced a Clear to Stop signal indication on Signal 346N, and adjusted the train's speed accordingly so that it would not block the public crossing at Mile 31.8.

At 0744:42,[5] train 302 came to a stop, with its head end just west of the public crossing (as was normal practice), about a mile from the Stop signal (Signal 318N) at Carvel.

Train 112 was close enough behind train 302 for the train 112 crew to hear train 302's crew calling signals on the standby channel, as they were required to do under Rule 578 of the *Canadian Rail Operating Rules* (CROR). While en route, the crew of train 302 had been

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3 A train stalls when it has insufficient horsepower to overcome the track gradient.

4 In centralized traffic control territory, the RTC can request a permissive signal indication at controlled block signals. The signal system circuitry will determine the progression of signal indications to be displayed.

5 All times and speeds come from the locomotive event recorder, unless otherwise specified.

informing the crew of train 112 when their train was stopped or stopping for meets (e.g., at Peers, Mile 109.8; and at Evansburg, Mile 69.0), but the crew of train 112 did not know the exact location of train 302 (i.e., that it was stopped at Carvel), or its overall length. As well, on the approach to Carvel (Signal 346N), the crew of train 112 overheard incorrectly that the crew members of train 302 had announced a Clear signal, when they had actually announced a Clear to Stop signal.

At approximately 0742, the crew of train 112 correctly identified a Restricting signal indication[6] on Signal 370N at Mile 37. The train passed the signal while operating at 25 mph, which exceeded the 15 mph limit set by CROR Rule 436. The conductor did not say anything to the LE about the train's speed into the block governed by the Restricting signal.

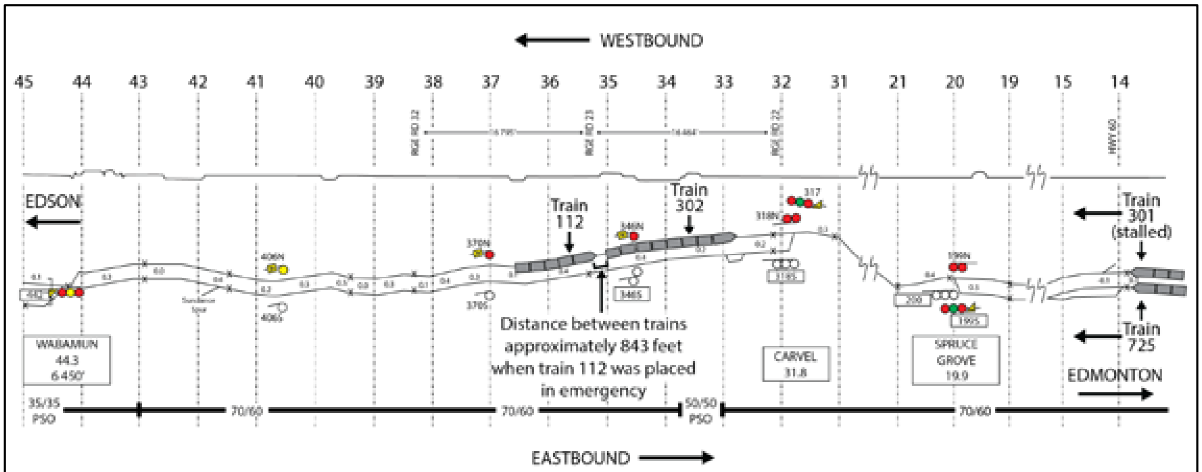
As train 112 entered a right-hand curve and was about 840 feet from the tail end of train 302, the crew saw that a train was stopped ahead (Figure 2).

**Figure 2. Image from train 112's forward-facing video just prior to collision (Source: CN)**

[6] Transport Canada, *Canadian Rail Operating Rules* (14 October 2015), Rule 436, states "Restricting - Proceed at RESTRICTED speed." Restricted speed is defined as "[a] speed that will permit stopping within one-half the range of vision of equipment, also prepared to stop short of a switch not properly lined and in no case exceeding SLOW speed. When moving at RESTRICTED speed, be on the lookout for broken rails." Slow speed is defined as "[a] speed not exceeding 15 miles per hour."

At 0747:16, operating at 27 mph, the conductor (and immediately after that, the LE) initiated an emergency application of the train brakes (Figure 3).

**Figure 3. Site diagram at time train 112 was placed in emergency**




Note: Eastbound coloured signal indications on diagram were as displayed in the field prior to train 112 passing them. Westbound coloured signal indications as seen by train 725.

At 0747:37, while in emergency and travelling at about 18 mph, the lead locomotive of train 112 collided with the tail end of train 302.

No cars derailed as a result of the collision. There was minor damage to an empty hopper car on train 302. There were no injuries.

At 0748:10, train 112 transmitted an emergency radio broadcast on the train standby channel and, subsequently, on channel 4 to the Edson Subdivision RTC, but did not indicate that a collision had occurred.

When train 302 had come to a stop, it was in a stretched state, or slack-out, and the train brakes were released. The collision was not felt by the crew of train 302 at the head end. The crew of train 112 did not tell the crew of train 302 that there had been a collision.

At the time of the occurrence, it was light, the sky was clear, and the temperature was 16 °C.

### 1.1.1 *After the collision*

At 0747:38, alarms sounded in the lead locomotive of train 302 to indicate a loss of brake pipe pressure. The LE observed the end of train air pressure at 0 psi, indicating that the train was in emergency. Recalling their conversation with the incoming crew at Edson, the crew of train 302 believed that a UDE had likely occurred as a result of the slack rolling back.

At 0748:10, while the train was recovering from the emergency brake application,[7] the LE of train 302 initiated an emergency radio broadcast on the train standby channel and repeated

[7] After an emergency brake application and the train has come to a stop, the LE must follow the required steps to recover/release and recharge the train brakes.

the emergency call on the RTC call-in channel. While the crew of train 302 were on the RTC call-in channel, they heard the crew of train 112 making an emergency broadcast.

At 0748:11, the conductor of train 112 conducted a visual inspection of the 10 cars at the tail end of train 302. Noting that no cars had derailed and that there was no damage, the conductor returned to his train.

Item 5.7 (Inspection of Standing Equipment) of CN's *General Operating Instructions* (GOI) specifies (in part):

> (e) Equipment will, as a minimum, be inspected for the following conditions.
> - brake cut out tag affixed to cut out cock,
> - car body leaning or listing to the side,
> - car body sagging downward,
> - car body positioned improperly on truck,
> - object dragging below car body,
> - object extending from the side of the car body,
> - door insecurely attached,
> - any object which is not secured and could fall off,
> - open Plug door,
> - broken or missing safety appliance,
> - lading leading from a placarded dangerous goods car,
> - overheated, broken or extensively cracked wheel,
> - hand brake that fails to release,[8]

At 0751:20, the crew of train 112 made a reverse movement to separate from train 302. The crew made the reverse movement without requesting or receiving authorization.

At 0752, when the RTC responded to the emergency radio broadcast from train 112, the crew did not indicate that there had been a collision. During this exchange, the LE of train 112 indicated that the brake handle had been moved inadvertently, causing the emergency application. The conductor did not question the LE after the decision was made not to report the collision.

At 0756, train 302 recovered from the emergency brake application and was then operated eastward, as instructed by the RTC. The crew of train 302 followed the instructions in CN's GOI, namely:

> When a train other than a passenger train is stopped as the result of an emergency brake application, it need not be inspected if:

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8 Canadian National Railway Company, *General Operating Instructions*, item 5.7: Inspection of Standing Equipment (15 December 2015), p. 18 of section 5.

(i) The brake pipe pressure on the rear car (as indicated on the IDU [input and display unit]) recovers,

(ii) Head-end crew observation indicates no visual evidence of a derailment, and

(iii) Movement does not require excessive tractive effort when restarting.[9]

The RTC informed the crew of train 725 that train 302 had experienced an emergency brake application at Carvel, and requested them to inspect train 302 while passing.

At 0800, the conductor discussed the need to report the collision but was unable to convince the LE to do so.

At 0835, train 725, operating on the south track, passed train 302 and then train 112. From the cab of the locomotive, the crew of train 725 visually inspected the 2 trains and reported to their crews that they had not observed any defects.

Train 302 departed Carvel at 0824, followed by train 112 just 13 minutes later at 0837.

At 0855, while operating through the wayside inspection system at Mile 14.8, train 302 received an alarm and was stopped. Dragging equipment was discovered near the head end of the train, and was repaired. Then, at 1024, as train 302 was entering Walker Yard in Edmonton and the train brakes were being applied, it experienced a UDE. After they had stored the train in the yard, the crew members of train 302 were instructed to meet with local supervisors before they went off duty.

At 1030, the crew members stored train 112 in the yard at the CN McBain Intermodal Terminal in the Greater Edmonton Terminal. They then met with a company supervisor to discuss the events at Carvel. Just prior to this conversation, the supervisor was able to confirm using remotely downloaded video and locomotive event recorder data that train 112 had collided with the tail end of train 302. The collision was then re-confirmed with the crew.

At 1440, the crew members of train 302 were informed that their train had been involved in a tail-end collision earlier in the day.

## 1.2 *Reporting of contraventions or safety hazards*

Transport Canada's *Railway Safety Management Systems Regulations, 2015* set out the following 12 components for a safety management system (SMS):

(a) a process for accountability;

(b) a railway safety policy;

(c) a process for ensuring compliance with regulations, rules and other instruments;

(d) a process for managing railway occurrences;

9 Ibid., item 7.3 (c): Emergency Application Procedures, p. 3 of section 7.

> (e) a process for identifying safety concerns;
>
> (f) a risk assessment process;
>
> (g) a process for implementing and evaluating remedial action;
>
> (h) a process for establishing targets and developing initiatives;
>
> (i) a process for reporting contraventions and safety concerns;
>
> (j) a process for managing knowledge;
>
> (k) a process for establishing schedules; and
>
> (l) a process for continual improvement of the SMS.[10]

The Railway Association of Canada (RAC) has stated the following:

> [A] safety management system [is] not effective unless accompanied by a "good" safety culture.
>
> […]
>
> The safety culture of an organization is the result of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management system (SMS).[11]

On 23 November 2015, CN issued System Notice No. 919, Non-punitive Reporting of Contraventions or Safety Hazards, a document linked to the company's SMS. System Notice No. 919 stated (in part):

> Transport Canada's Safety Management Systems regulations [i.e., the *Railway Safety Management Systems Regulations, 2015*] require that all federal railways have a process and policy that allows employees to report without fear of reprisal, a contravention of the Railway Safety Act or any of its regulations, rules, certificates, orders or emergency directions in relation to safety or a safety hazard.
>
> […]
>
> CN will be using the office of the CN Ombudsman for such reports.
>
> […]
>
> The office of the Ombudsman will investigate the matter and provide a response if requested.
>
> This does not relieve employees of the requirement to report any and all accidents, incidents, injuries or occupational illnesses to a supervisor prior to leaving company property, as required by CN Rules.
>
> […]

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10 Transport Canada, SOR/2015-26, *Railway Safety Management System Regulations, 2015* (last amended 01 April 2015), Part 1: Railway Companies, paragraphs 5(a) to (l).

11 Railway Association of Canada, "RAC Safety Culture Initiative" (slide presentation), presented to Transportation Safety Board of Canada (29 September 2015).

> The harassment or intimidation of any employee, or retaliation against any employee, or action to prevent such person from reporting a perceived hazard, incident, or unsafe condition will not be permitted or tolerated.
>
> […]
>
> This policy does not provide reprieve from discipline, where warranted […].

In addition, as prescribed by CROR General Rule A:

> Every employee in any service connected with movements, handling of main track switches and protection of track work and track units shall;
>
> […]
>
> (iii) provide every possible assistance to ensure every rule, special instruction and general operating instruction is complied with and shall report promptly to the proper authority any violations, thereof;
>
> (iv) communicate by the quickest available means to the proper authority any condition which may affect the safe movement of a train or engine and be alert to the company's interest and join forces to protect it;[12]

Once the contravention or safety hazard is reported to the railway, the railway must then report the occurrence to the TSB if the event is a reportable occurrence as specified by the *Transportation Safety Board Regulations*.

In this occurrence, the crew members for train 112 did not follow the requirements for reporting contraventions and safety hazards. The reporting of these events is a fundamental requirement that supports the railway's SMS.

The TSB investigated a risk of collision between a Goderich-Exeter Railway Company freight train and a VIA Rail Canada Inc. (VIA) passenger train that occurred near New Hamburg, Ontario, on 06 June 2006,[13] and found a similar situation. The VIA train had exceeded its limits of authority and stopped short (within approximately 1 mile) of a head-on collision with the freight train. The incident was not reported by either crew. That investigation determined the following:

- Similar recent incidents were not reported by employees.
- A number of employees indicated that if they were not directly involved in an incident, but were aware of it, they might not report it—either for fear of discipline or because of the lack of direct knowledge.
- The inappropriate use of disciplinary measures creates a safety culture based on fear of reprisal rather than one based on the advancement of safety through communicating and learning from mistakes.[14]

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12 Transport Canada, *Canadian Rail Operating Rules* (14 October 2015), General Rule A, p. 14.

13 TSB Railway Investigation Report R06H0013.

14 J. Reason, *Managing the Risks of Organizational Accidents* (Ashgate Publishing, 2006).

- In contrast to the railway industry, other high-consequence industries (e.g., aviation, medicine) have developed voluntary, protected safety information reporting systems as a means of increasing the availability of key information about the safety of their industry. [15] Such non-jeopardy reporting systems provide protection against disciplinary action or other negative repercussions, provided that the employee reports the incident that he or she was involved in. These systems can lead to both an increase in reporting and a more thorough understanding for all parties of the cause and remedial actions required to prevent the type of occurrence from happening again.

## 1.3 *Crew information*

### 1.3.1 *Crew information for train 112*

The conductor for train 112 was hired by CN in 2008, working for the Engineering Services Department on a tie gang. He qualified for the conductor position in 2009 and qualified as an LE in 2011.

The LE for train 112 qualified for his position in 2007. From 1987 to 1993, before becoming an LE, he worked for CN as a switchtender in Edmonton. He was a switchman and yard foreman from 1993 to 2007. Over about 30 years of employment at CN, the LE had been subject to some disciplinary action following violations of rules or company operating policies. This disciplinary action included demerit points[16] and written reprimands. The majority of these discipline events had occurred before 2007 (i.e., prior to his qualification as an LE). In the previous 3 years, the LE had not been subject to any disciplinary action.

## 1.4 *Signals displayed to train 112*

The signals that were displayed in progression for train 112 were as follows (Figure 4):

- At controlled Signal 442 (Wabamun), the signal was Limited[17] to Stop (red/yellow/red with an L plate).
- At intermediate Signal 406N, the signal was Clear to Stop (single indication yellow).
- At intermediate Signal 370N, the signal was Restricting (single indication red with an R plate).

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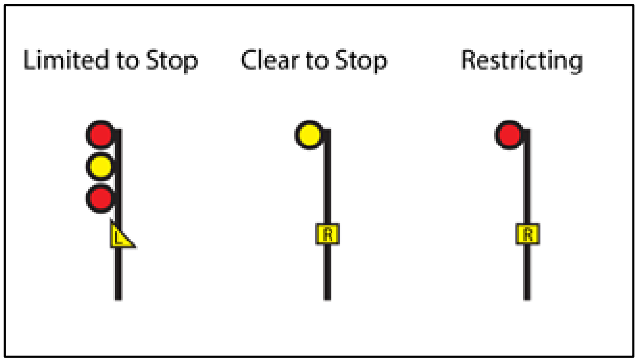
15 M. L. Harper and R. L. Helmreich, "Creating and Maintaining a Reporting Culture," Proceedings of the 12th International Symposium on Aviation Psychology, The Ohio State University, Dayton, OH (2003), pp. 496-501.

16 When railway operating employees are involved in a violation of the CROR (or of company operating policy) and the violation contributes to an accident, the operating employee is typically given a number of demerit points. Once the employee accumulates a certain number of demerit points, the employee can be subject to dismissal.

17 Limited speed is a speed not exceeding 45 mph.

These signals were properly identified and communicated by the train crew.

**Figure 4. Limited to Stop, Clear to Stop, and Restricting signals displayed to train 112**




## 1.5 *Edson Subdivision*

The Edson Subdivision, which extends between Mile 4.2 (West Junction, just west of Walker Yard in Edmonton) and Mile 235.7 (Jasper), has both single main track and double main track. Train movements on this subdivision are governed by the centralized traffic control (CTC) method of train control, as authorized by the CROR; it is supervised by an RTC in Edmonton.

The authorized timetable speed in the vicinity of the occurrence was 60 mph for freight trains and 70 mph for passenger trains. At the time of the occurrence, no temporary slow orders were in effect there.

The typical daily traffic on this portion of the Edson Subdivision was 1 passenger train and 27 freight trains, which entered the main track at different locations. In the vicinity of the occurrence, the Edson Subdivision was double main track in an east–west direction ascending slightly toward the east at 0.4 °. There was a right-hand curve in the direction of travel.

The rail was 136-pound continuous welded rail manufactured in 2015 that was laid on 8-foot 6-inch hardwood ties. The rail was fastened with double-shouldered 14-inch tie plates, with 3 spikes per tie. The ballast was crushed rock (2½ inches) with full shoulders and cribs. The track had good drainage.

The track was last inspected on 02 June 2016, 2 days before the occurrence. No defects were reported in the vicinity of the occurrence.

## 1.6 *Traffic control systems*

Railway traffic control systems are used to direct the movement of trains so that they operate safely. CTC is the method of traffic control generally used by railways on main track in Canada.

The CTC system uses track circuitry and associated software to display signal indications (lights) in the field, and the corresponding track occupancies are shown on the rail traffic control display. In the field, the system displays a combination of red, yellow, and green signals; it is the combination of lights that governs the speed and the limits within which trains may operate. The signals can also indicate whether the block ahead is occupied.

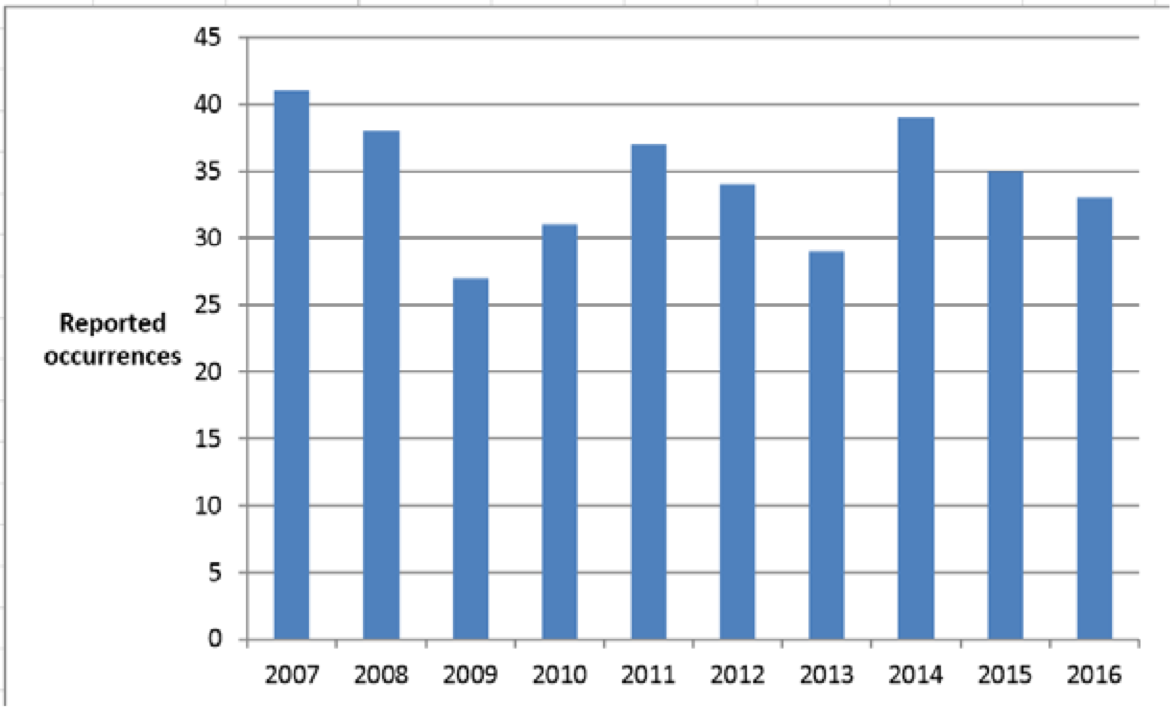
On the rail traffic control display, a track occupancy generally indicates the presence of a train. However, other operational situations, such as a broken rail, an open switch, or an object completing the track circuit between the two rails, can also show as a track occupancy on the rail traffic control display.

When an RTC requests the route for a train in the CTC system, the system determines the normal progression of signals, and allows the RTC to monitor the train's progress along blocks of track in a subdivision. However, the system does not display the train's exact location within a block: only the block that the train occupies is identified on the display. Furthermore, the CTC system does not give any indication that a train may be about to pass beyond a restricted point, nor does it slow or stop the train in these situations.

## 1.7 *Other related occurrences*

Between January 2007 and December 2016, there were 344 occurrences (Figure 5) where trains exceeded their limits of authority as a result of crews not responding appropriately to signal indications displayed in the field. Since 1998, the TSB has investigated 13 occurrences where a train exceeded its limits of authority, of which 11 resulted in a collision or a derailment (Appendix A). In each of these investigations, an operating crew member's misperception of wayside signal indications was determined to be a cause or a contributing factor.

Figure 5. Occurrences reported to the TSB from 2007 to 2016 where a train exceeded its limits of authority due to inappropriate crew response to signal indications




## 1.8 *Defences for signal indications*

Train operations in signalled territory require strict compliance with the rules. Train crews are expected to react appropriately to wayside signal indications. The signal system—in terms of its technology and its safety—has not advanced significantly since it was designed more than 100 years ago.

In a complex system such as rail transportation, even the most rigorous set of rules may not cover every contingency or be uniformly interpreted by individuals. In addition, operating crew members—no matter how motivated or experienced—are subject to the normal slips, lapses, and mistakes that characterize human behaviour. The defence-in-depth approach advocated by safety specialists for complex systems seeks multiple and diverse lines of defence to mitigate the risk of normal human errors. Following the investigation into the 1998 train collision involving 2 Canadian Pacific Railway (CP) trains near Notch Hill, British Columbia,[18] it was determined that backup safety defences for signal indications were inadequate. The Board recommended that

> the Department of Transport and the railway industry implement additional backup safety defences to help ensure that signal indications are consistently recognized and followed.
>
> **TSB Recommendation R00-04**

[18] TSB Railway Investigation Report R98V0148.

Following the investigation into the 2012 derailment and collision of a VIA passenger train at Aldershot, near Burlington, Ontario,[19] the Board recommended that

> the Department of Transport require major Canadian passenger and freight railways implement physical fail-safe train controls, beginning with Canada's high-speed rail corridors.
>
> **TSB Recommendation R13-01**

In its March 2017 reassessment of TC's responses to recommendations R00-04 and R13-01, the Board stated that both recommendations were related to the TSB Watchlist issue of "following signal indications," where there is a risk of serious train collision or derailment if railway signals are not consistently recognized and followed. The Board assessed these responses as follows:

> The Working Group concluded its mandate and presented its findings on train control technologies to the Advisory Council on Railway Safety (ACRS) on 20 September 2016. The final report of the Working Group recommended a targeted, risk-based and corridor-specific implementation of enhanced train control (ETC) technologies as the best option for Canada. On 25 January 2017, TC and the RAC hosted a workshop that was focused on understanding ETC systems and on the status of existing ETC implementations. The workshop brought together experts from Canada and the United States.
>
> Building on the output of the Working Group, TC has scoped out the next phase of work which will be conducted by the Canadian Rail Research Laboratory (CaRRL). This work will include more in-depth analysis of relevant occurrence data, development of a methodology for risk prioritization and ranking corridors in the Canadian rail network and a case study to apply the methodology on a particular rail corridor.
>
> The Board is encouraged that VIA has successfully completed a proof of concept system (GPStrain) that demonstrates the effectiveness of this technology to mitigate human factors. In addition, the Board is encouraged that TC will continue working with stakeholders in industry and labour to further study options to define an ETC implementation concept for Canada, taking into consideration the conclusions and recommendations of the Working Group report. However, despite the significant work on these research initiatives, there still remains no short-term plan to address the risk of train collision or derailment in the absence of additional backup safety defences.
>
> With respect to LVVR [locomotive voice and video recorder] technology, the Board cautions that any defence in-depth concept of system safety design cannot be satisfied solely through additional layers of crew monitoring. Additional layers of physical defences are still required so that the risk of serious train collision or derailment can be effectively mitigated.
>
> The Board considers the response to the recommendation to be **Satisfactory in Part.**

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[19] TSB Railway Investigation Report R12T0038.

## 1.9 Train control systems to prevent train collisions

On the Edson Subdivision, there were a number of safety defences in place to help prevent these types of occurrences. Some of the defences were associated with the train control system and some were associated with the CROR. However, all of the defences can be categorized as administrative: even wayside signals that include a physical signal installation are combined with the administrative requirement to follow the signal indication. Administrative defences rely on the crew's observing a signal and taking the appropriate actions, but if the crew does not take these actions, the defence as a whole fails—and there is little or no backup defence.

In recent years, the railway industry has developed technology to help mitigate the risk of train collisions when a train exceeds limits of authority. The technologies that are in use or under development include proximity detection and positive train control.

### 1.9.1 Proximity detection

A proximity detection device was developed and implemented by Quebec North Shore & Labrador Railway after a 1996 collision involving 2 of its trains.[20] The device is designed to trigger penalty braking if a train crew (or a track unit operator) does not acknowledge the alert warning when coming within a predetermined distance of another movement. No similar systems (except limited trials) have been implemented on other Canadian railways.

### 1.9.2 Positive train control

Positive train control (PTC) is a train control technology that is designed to prevent

- train-to-train collisions;
- overspeed derailments;
- incursions into work zone limits; and
- movement of a train through a switch left in the wrong position.

If the operating crew does not initiate an adequate response, the PTC system would automatically slow or stop the train. In the United States, PTC technology has been under development for many years.

The September 2008 collision between a Metrolink passenger train and a Union Pacific freight train in Chatsworth, California, prompted the passage of the U.S. *Rail Safety Improvement Act of 2008*. This legislation mandated that PTC be installed on the higher-risk rail lines in the U.S. by 2015. However, owing to technical challenges, it is anticipated that the implementation of PTC will not meet the 31 December 2018 deadline.

In Canada, no PTC systems are in use by freight or passenger railways, and no PTC installations on federal railways are planned. However, to meet the U.S. requirements, both

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20 TSB Railway Investigation Report R96Q0050.

CN and CP have PTC implementation plans for their U.S. routes. The plan for CP includes 505 locomotives equipped with the required on-board systems and approximately 2112 miles of track with PTC. CN's plan includes 586 locomotives equipped with the required on-board systems and approximately 3563 miles of track with PTC. For both CN and CP, the PTC system will be based on the Interoperable Electronic Train Management System (I-ETMS). I-ETMS is a locomotive-centric train-control system that uses a combination of locomotive, office, and wayside data that is integrated using a radio network. CN will install it on 39 subdivisions, and CP will install it on 22 subdivisions, corresponding respectively to 62% and 89% of their total U.S. route miles (excluding yard limits).

The PTC systems will have functions that

- alert train crews to pending authority and speed limit violations, including passing a Stop signal;
- stop trains before exceeding authority and speed limits, including Stop signals;
- interrogate upcoming wayside signals and switches in a train route when operating in territory using I-ETMS; and
- protect work-zone limits by enforcing compliance with work-zone restrictions.

The U.S. Federal Railroad Administration must certify the technology and its application for each railroad prior to use in revenue service.

## *1.10 Situational awareness*

Situational awareness develops in 3 stages:

1. The person perceives situational elements from information displays, communications, or other references.
2. This information is integrated into an overall understanding of the situation by the application of past experience and knowledge of how the system works, often referred to as a mental model.
3. The person then projects this acquired information into the future to make and modify plans as tasks are completed or delayed.

Information about the situation (cues) can vary from clear to ambiguous. The clearer the cues, the less effort required to interpret them, leading to a more accurate mental model of the situation.

Mental models are internal structures that allow individuals to describe, explain, and predict events and situations in their environments.[21] They are generated by several factors, notably experience, knowledge, perception, and comprehension of external cues available in the working environment. For train crews, these external cues could be radio transmissions, crew-to-crew conversations, or a message received from a wayside inspection system. Other

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21 E. Salas, F. Jentsch and D. Maurino, *Human Factors in Aviation*, 2nd Edition (Academic Press, 2010), p. 66.

sources of information that can influence a crew member's mental model include signal indications and RTC information; in-cab information displays; a crew's view of the track from the cab; landmarks; environmental conditions; written information such as timetables and other operating bulletins; and railway rules and operating instructions, such as those in the CROR and the GOI that operating crews are either permitted or required to use.

Once a mental model is adopted, it is very resistant to change. For one's thinking to change, the existing mental model has to be superseded by another model, which requires compelling new information to be both available and absorbed. However, the human working memory has a limited capacity, so not all the cues available in the work environment are retained, resulting in a simple and incomplete mental model used to understand and make sense of a dynamic and complex work environment.[22]

## 1.11 *Crew resource management and authority gradients*

The cab of a locomotive with multiple crew members is a dynamic, challenging workplace in which crew members are constantly interacting with the train, elements of the operating environment, and each other. Crew resource management (CRM) is a method of making effective use of available resources (human, hardware, and information) to manage the threats and challenges that can arise during any trip. CRM training can help reduce accidents related to human factors. CRM training can provide crews with strategies to improve communication and interactions in order to align mental models and increase crew situational awareness. These strategies can also help ensure that crew interactions are effective in situations in which the command and decision-making power hierarchy (the authority gradient) is unclear or unbalanced.[23]

For crew interactions to be effective, each crew member has to feel comfortable providing input and being receptive to input from other crew members. This can be a challenge, particularly because train crews typically consist of people with different personalities, levels of experience, and seniority. In addition, during train operations, the LE physically operates the train by manipulating the locomotive controls. In many circumstances, the conductor would not have the same skill sets to operate a train and may not have the experience or confidence to question the LE's train control actions and decisions.

Under these circumstances, CRM training is particularly important for ensuring effective crew interactions and effective train operations. CN does not offer CRM training as a part of its conductor training, although CP and VIA do.

In this occurrence, the conductor, who was also a qualified locomotive engineer but with less experience than the LE, did not say anything to the LE about the train's speed through the

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22 J. A. Wise, V. D. Hopkin and D. J. Garland, *Handbook of Aviation Human Factors*, 2nd Edition (CRC Press, 2016), p. 12-6.

23 Skybrary, "Authority Gradients," at https://www.skybrary.aero/index.php/Authority_Gradients (last accessed on 01 November 2017).

Restricting signal. In addition, the conductor did not initially question the LE after the decision was made not to report the collision. In a 2007 main-track train collision between 2 CN trains,[24] the investigation determined that the conductor had deferred to the LE's experience and did not challenge his actions. The investigation also determined that, in the absence of procedures that recognize the risks inherent in an authority gradient, intra-cab communication can fail.

CRM has been employed in the commercial aviation industry for several decades, and has been credited with contributing to a marked decrease in human factors–related accidents. In the marine industry, bridge resource management training has been adopted for ships' officers. A U.S. Federal Railroad Administration study found that CRM training can be expected to improve crew coordination and have net positive benefits for the railways by reducing costs associated with human factors–related accidents.

The TSB has investigated 3 other main-track train collisions in which ineffective CRM practices were identified:

- R07E0129 (Peers) – On 27 October 2007, westbound CN train 417 was unable to stop prior to passing a stop signal near Peers, Alberta, on the Edson Subdivision and collided with eastbound CN train 342, which was entering the siding. Train 417's locomotives and 22 cars derailed. Five cars on train 342 derailed. The investigation determined that the conductor had deferred to the locomotive engineer's experience and did not challenge his actions. It was also stated that, in the absence of procedures that recognize the risks inherent in an authority gradient, intra-cab communications can fail.
- R98V0148 (Notch Hill) – On 11 August 1998, CP train 463 collided with the rear end of CP train 839 at Mile 78.0 of the Shuswap Subdivision, near Notch Hill, British Columbia. One car on train 463 and two cars on train 839 derailed. The investigation determined that neither the conductor nor the locomotive engineer challenged each other's identification of signals; the authority gradient between the 2 crew members probably prevented the conductor from challenging the locomotive engineer and expressing his concerns.
- R96Q0050 (Mai) – On 14 July 2010, Quebec North Shore and Labrador Railway (QNS&L) train FCS-45 collided with the tail end of stationary QNS&L train PH-475 at Mile 131.48 of the Wacouna Subdivision near Mai, Quebec. The last 3 cars of the stationary train derailed. The locomotive of the moving train was extensively damaged. The locomotive engineer of the moving train sustained minor injuries. The investigation determined that there is currently no established crew resource management program in use on the railway that would ensure that all persons involved are aware of the most up-to-date, accurate information concerning the movement of trains and engines.

The U.S. National Transportation Safety Board (NTSB) has made a number of recommendations relating to crew resource management.

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24 TSB Railway Investigation Report R07E0129.

Following the investigation into the 1998 collision between a Norfolk Southern freight train and a Consolidated Rail Corporation (Conrail) freight train near Butler, Indiana, the NTSB recommended that the U.S. Federal Railroad Administration,

> In cooperation with Class I railroads, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, and the United Transportation Union, develop and require, for all crewmembers, crew resource management training that addresses, at a minimum:
>
> - crewmember proficiency,
> - situational awareness,
> - effective communication and teamwork, and
> - strategies for appropriately challenging and questioning authority.
>
> **(R-99-13)**

Following the investigation into the 2012 collision between 2 Union Pacific Railroad freight trains near Goodwell, Oklahoma, the NTSB recommended that the Union Pacific Railroad

> Develop and implement a plan to establish a safety management system that incorporates crew resource management.
>
> **(R-13-29)**

## 1.12 *Work/Rest Rules for Railway Operating Employees*

The *Work/Rest Rules for Railway Operating Employees*[25] (Work/Rest Rules) are based on the principle of shared responsibility for fatigue management. Specifically, Section 2 of the Work/Rest Rules establishes that companies must take a flexible approach to managing fatigue. Companies are responsible for establishing and maintaining working conditions that allow operating employees to obtain sufficient rest between tours of duty and to maintain alertness throughout duty periods. Employees have a responsibility to use the rest opportunity so that they can report for work rested and fit for duty. The Work/Rest Rules define “fit for duty” as “reporting for duty rested and prepared to maintain alertness for the duration of the tour of duty.”[26]

Section 2.2 of the Work/Rest Rules states that

> Railway companies shall establish and maintain working conditions that allow:
>
> a) operating employees sufficient opportunity to obtain adequate rest between tours of duty; and
>
> b) alertness to be sustained throughout the duty period.[27]

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25 Transport Canada, *Work/Rest Rules for Railway Operating Employees*, TC O 0-140, effective 23 February 2011.

26 Ibid., p. 5.

27 Ibid., p. 2.

Section 2.3 states that "[o]perating employees have a responsibility to report for work rested and fit for duty."[28]

Section 6 of the Work/Rest Rules requires railway companies to implement a fatigue management plan. At a minimum, the plan must consider education and training, scheduling practices, dealing with emergencies, alertness strategies, rest environments, implementation policies as well as evaluation of fatigue management plans and crew management effectiveness.

Section 7 of the Work/Rest Rules requires that the company file its fatigue management plan with Transport Canada.

In addition, section 28 of the *Railway Safety Management System Regulations, 2015* requires railways to apply the principles of fatigue science[29] and have a method for doing so.[30] When scheduling the work of an employee who is required to work according to a schedule meeting prescribed requirements, railways must consider the following principles:

> (a) that human fatigue is governed by physiology;
>
> (b) that human alertness is affected by circadian rhythms;
>
> (c) that human performance degrades in relation to hours of wakefulness and accumulated sleep debt; and
>
> (d) that humans have baseline minimum physiological sleep needs.[31]

## 1.13 *Scheduling practices for operating employees*

Similar to other Canadian railways, CN normally operates its freight trains on an unscheduled basis, and calls crews for trips as required. Trips are assigned to crew members from subdivision pools based on a first-in, first-out system. When crew members finish a trip, their names are placed back into the pool for assignment to their next trip.

At CN, employees can bid to crew extended-run trains operated from Edmonton to Jasper and return (west pool) and from Jasper to Edmonton and return (east pool). At the time of the occurrence, there were 2 priority extended-run trains a day in each direction, each requiring 1 LE and 1 conductor and typically operating within a regularly scheduled 8-hour window. As these priority trains were more desirable to operate, the more senior employees would bid for these positions. If a priority train's schedule fell outside the 8-hour window and there was no other train or deadhead to which the assigned crew members could be transferred, the crew members would still be paid, but would be able to stay home. Only employees with seniority were eligible to work exclusively on the priority trains.

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28 Ibid.

29 Transport Canada, SOR/2015-26, *Railway Safety Management System Regulations, 2015* (last amended 01 April 2015), Part 1: Railway Companies, subsection 28(1).

30 Ibid., subsection 28(2).

31 Ibid., paragraphs 28(1)(a) to (d).

Train 112's crew members, who had insufficient seniority to work exclusively on the extended-run trains, chose to bid for a west pool job. They would be ordered out of Edmonton and Edson whenever their position in the west pool came up. In the week preceding the occurrence, these crew members had had variable work hours.

## 1.14 Variability in crew start time

Because trains are not specifically scheduled, crews' start times and arrival times at both home and away-from-home terminals have to be estimated on the basis of the latest list of trains the railway expects to operate, known as a train lineup. Train lineups have to be regularly updated for this to be effective.

However, a number of factors—mechanical problems with the train, weather conditions, train congestion, planned or unplanned track work, or crew members who are ahead on the pool list becoming unavailable at short notice—can significantly affect train arrival times and make call times for train crews unpredictable.

Variable and unpredictable start times for a train crew member can make it difficult to plan for and obtain good-quality restorative sleep, particularly if the crew member is anticipating a call for work. To help improve predictability of shift start times, railways have implemented improvements to train lineups, including access to train lineup information such as CN's Crew Assignment and Timekeeping System (CATS). When shift start time is highly variable, the available sleep periods for crew members tend to occur across varying circadian rhythm highs and lows.

On the day prior to the occurrence, the crew of train 112 had arrived in Edson on train 417 and had gone off duty at 1615. At about 2000 that evening, the crew members reviewed the CATS lineup and concluded that they could expect to work again at about 0100. They then went to bed in the company bunkhouse.

Expecting a call near midnight, the crew awoke and checked the CATS lineup again. The most recent information indicated that they were now to start their shift at about 0400. The LE did not fall back to sleep, while the conductor was able to sleep for another hour. The crew was eventually called at 0400 for a shift start time of 0500. Each of the crew members had accrued a sleep debt of 2 to 3 hours.

## 1.15 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer.

**Following railway signal indications is a Watchlist 2016 issue.** As this occurrence demonstrates, railway signals are not consistently recognized and followed, which poses a risk of serious train collisions and derailments.

**Following railway signal indications will remain on the TSB Watchlist until**

- additional physical safety defences are implemented to ensure that railway signal indications governing operating speed or operating limits are consistently recognized and followed.

**Fatigue management systems for train crews is a Watchlist 2016 issue.** As this occurrence demonstrates, the unpredictability of call times for train crews can lead to accumulated sleep debts.

**Fatigue management systems for train crews will remain on the TSB Watchlist until**

- Transport Canada completes its review of railway fatigue management systems; and
- Transport Canada and the railway industry implement further actions to effectively mitigate the risk of fatigue for operating crew members on freight trains.

**On-board voice and video recorders are a Watchlist 2016 issue.** As this occurrence demonstrates, the lack of a locomotive voice and video recorder hindered the investigation with respect to understanding the operating crew's decision not to report the collision.

**On-board voice and video recorders will remain on the TSB Watchlist until**

- voice and video recorders are installed on all lead locomotives operating on main track.

# *2.0 Analysis*

Neither the trains nor the track contributed to the accident. The signal system was operating as designed. Therefore, the analysis will focus on the operation of train 112, the operational risks in centralized traffic control (CTC), mental models, crew resource management (CRM), equipment inspections following high-impact collisions, and the unpredictability of call times.

## *2.1 The accident*

The accident occurred when train 112 collided with the tail end of train 302.

The crew of train 112 proceeded past the restricted Signal 370N, despite having encountered (and correctly called) the restricting signal indication, at a speed that did not allow them to stop within half the range of vision of equipment. Upon entering a curve while travelling at 27 mph, the crew of train 112 observed train 302 stopped about 840 feet ahead. An emergency brake application was initiated, slowing the train to about 18 mph prior to the collision.

The crew of train 112 had heard the signals being called by the crew of train 302 over the standby channel, and believed that the crew of train 302 had announced a Clear signal for Signal 346N on approach to Carvel, but it was actually a Clear to Stop signal that had been announced. Having overheard the signal call incorrectly, the crew of train 112 believed that train 302 was further ahead than it was, and that it had likely passed Signal 318N.

While en route, the crew members of train 302 had been informing the crew of train 112 when their train was stopped or stopping for meets, as they did at Mile 109.8 and Mile 69.0. However, at Carvel, the crew members of train 302 were occupied with other operational tasks, and did not advise the crew of train 112 that they were stopped, nor were they required to do so.

Having overheard the signal call incorrectly, and not being informed that train 302 was stopped, the crew of train 112 developed an incorrect mental model of the location of train 302: they believed that train 302 was further ahead than it was, and that it had passed Signal 318N.

## *2.2 Train control defences for centralized traffic control*

CTC is the traffic control method generally used by railways on main track in Canada. The CTC system determines the normal progression of signals, and allows the rail traffic controller to monitor a train's progress along blocks of track in a subdivision. However, the CTC system does not display the train's exact location within a block, or its speed, and it does not ensure positive train separation. Furthermore, the system does not provide automatic enforcement to slow or stop a train before it passes a Stop signal or other point of restriction. If the crew does not take the appropriate action, the defence as a whole fails.

Strict rules compliance is required, as train crews are expected to react appropriately to wayside signal indications. However, in a complex system, such as rail transportation, even the most rigorous set of rules may not cover every contingency or be uniformly interpreted by individuals.

Operating crew members are subject to the normal slips, lapses, and mistakes that characterize human behaviour. Since 2007, the TSB has investigated 10 other occurrences involving a collision, a derailment, or movements exceeding limits of authority, in which an operating crew's misinterpretation, misperception, and/or misapplication of wayside signal indications was a cause or contributing factor.

Following the investigation of an accident at Aldershot, near Burlington, Ontario, in 2012,[32] the Board issued Recommendation R13-01, which called for the implementation of physical fail-safe train controls. This defence-in-depth approach advocated by safety specialists for complex systems seeks multiple and diverse lines of defence. If existing signal systems do not include physical fail-safe capabilities, signal recognition or application errors by operating crew members may not be detected, increasing the risk of train collisions and derailments.

## 2.3 *Crew resource management and authority gradients*

The conductor, who was also a qualified locomotive engineer (LE) but with less experience than the occurrence LE, did not initially question the LE on the speed of the train while operating past the Restricting signal. In addition, the conductor did not further question the LE after it was decided not to report the collision. For effective crew interactions, each crew member has to feel comfortable providing input and being receptive to input from other crew members. This can be a challenge, particularly when train crews typically consist of people with different personalities, levels of experience, and seniority.

Training in CRM—the effective use of available resources (human, hardware, and information) to manage the threats and challenges that can arise during any trip—can give crews strategies to improve communication and situational awareness, which can also help ensure that crew interactions are effective in situations in which the command and decision-making power (the authority gradient) is unclear or unbalanced.

CRM training helps crew members give and receive input so that appropriate decisions are made. If operating employees are not trained in CRM, including how to make decisions when authority gradients are present, crew coordination and interaction may not be effective, increasing the risk of human factors–related accidents.

## 2.4 *Reporting of contraventions or safety hazards*

As prescribed by Canadian Rail Operating Rules (CROR) General Rule A, when an accident or incident occurs during train operations, the involved employees must report the

32 TSB Railway Investigation Report R12T0038.

occurrence to the appropriate railway personnel. In addition, at Canadian National Railway Company (CN), System Notice No. 919 (Non-punitive Reporting of Contraventions or Safety Hazards) had been issued, highlighting the company requirement for employees to report all accidents. This notice specifies that employees must "report any and all accidents, incidents, injuries or occupational illnesses to a supervisor prior to leaving company property, as required by CN rules."[33]

Once the contravention or safety hazard is reported to the railway, the railway must then report the occurrence to the TSB if the event is a reportable occurrence as specified by the *Transportation Safety Board Regulations*.

In this occurrence, the crew members for train 112 did not follow the requirements for reporting contraventions and safety hazards. It could not be specifically determined why the crew of train 112 did not report the collision.

The reporting of these events is a fundamental requirement that supports the railway's safety management system (SMS). If relevant railway safety data is not available to help identify safety issues, emerging trends involving unsafe events or conditions may not be identified in a timely manner, increasing the risk of accidents.

## *2.5 Equipment inspections following high-impact collisions*

After the collision, the conductor of train 112 did a visual inspection of the 10 cars at the tail end of train 302. Noting that no cars had derailed and that there was no damage, the conductor returned to his train.

However, shortly after the collision, alarms sounded in the lead locomotive of train 302 to indicate a loss of brake pipe pressure, indicating that the train was in emergency. Train 302 recovered from the emergency brake application and was then operated eastward as instructed by the RTC. No further inspection was required because the following conditions specified in item 7.3 (c) of CN's *General Operating Instructions* were met:

- The brake pipe pressure on the rear car recovered.
- There was no visual evidence of a derailment.
- The train did not require excessive tractive effort when restarting.

Train 302 then continued on to Edmonton without a thorough inspection. While operating through the wayside inspection system at Mile 14.8, train 302 received an alarm and was stopped. Dragging equipment was discovered near the head end of the train, and was repaired. As train 302 was entering Walker Yard in Edmonton and the train brakes were being applied, it experienced another undesired emergency brake application (UDE).

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33 Canadian National Railway Company, Eastern & Western Regions Operating Practices, System Notice No. 919, Non-punitive Reporting of Contraventions or Safety Hazards (23 November 2015).

Although the UDE conditions existed prior to the collision, it is unknown whether the earlier high-impact collision caused the equipment to drag.

The decision by the crew of train 112 not to tell the crew of train 302 that there had been a collision resulted in a cursory inspection of train 302, when a thorough inspection was required.

## 2.6 *Unpredictability of call times for train crews*

Freight trains normally operate on an unscheduled basis, and crews are called for trips as required. Trips are assigned to crew members from subdivision pools based on a first-in, first-out system. This means that crew members have to estimate their call times on the basis of the latest train lineup, which provides the expected arrival time of the anticipated trains. Railways have made improvements to train lineups, including access to train lineup information (e.g., CN's Crew Assignment and Timekeeping System). Train lineups have to be regularly updated for this to be effective.

However, a number of factors—mechanical problems with the train, weather conditions, train congestion, planned or unplanned track work, or crew members who are ahead on the pool list becoming unavailable at short notice—can significantly affect train arrival times and make call times for train crews variable and unpredictable. This can make it difficult for crew members to plan for and obtain good-quality, restorative sleep.

In this occurrence, owing to a change in the train lineup, the crew of train 112 incurred a sleep debt of 2 to 3 hours. They expected a call time near midnight, but the actual call time was 0400. It could not be established whether this short-term sleep debt adversely affected the crew's decision making. If call times for train crew schedules cannot be reliably predicted, operating crew members may not be able to achieve sufficient restorative sleep, which can lead to accumulated sleep debts, increasing the risk of fatigue.

# 3.0 Findings

## 3.1 Findings as to causes and contributing factors

1. The accident occurred when train 112 collided with the tail end of train 302.

2. The crew of train 112 proceeded past the restricted Signal 370N, despite having encountered (and correctly called) the restricting signal indication, at a speed that did not allow them to stop within half the range of vision of equipment.

3. Upon entering a curve while travelling at 27 mph, the crew of train 112 observed train 302 stopped about 840 feet ahead. An emergency brake application was initiated, slowing the train to about 18 mph prior to the collision.

4. The crew of train 112 had heard the signals being called by the crew of train 302 over the standby channel, and believed that the crew of train 302 had announced a Clear signal for Signal 346N on approach to Carvel, but it was actually a Clear to Stop signal that had been announced.

5. While en route, the crew members of train 302 had been informing the crew of train 112 when their train was stopped or stopping for meets. However, at Carvel, the crew members of train 302 were occupied with other operational tasks, and did not advise the crew of train 112 that they were stopped, nor were they required to do so.

6. Having overheard the signal call incorrectly, and not being informed that train 302 was stopped, the crew of train 112 developed an incorrect mental model of the location of train 302: they believed that train 302 was further ahead than it was, and that it had passed Signal 318N.

## 3.2 Findings as to risk

1. If existing signal systems do not include physical fail-safe capabilities, signal recognition or application errors by operating crew members may not be detected, increasing the risk of train collisions and derailments.

2. If operating employees are not trained in crew resource management, including how to make decisions when authority gradients are present, crew coordination and interaction may not be effective, increasing the risk of human factors–related accidents.

3. If relevant railway safety data is not available to help identify safety issues, emerging trends involving unsafe events or conditions may not be identified in a timely manner, increasing the risk of accidents.

4. If call times for train crew schedules cannot be reliably predicted, operating crew members may not be able to achieve sufficient restorative sleep, which can lead to accumulated sleep debts, increasing the risk of fatigue.

## *3.3 Other findings*

1. The decision by the crew of train 112 not to tell the crew of train 302 that there had been a collision resulted in a cursory inspection of train 302, when a thorough inspection was required.

# 4.0 Safety action

## 4.1 Safety action taken

The Board is not aware of any safety action taken as a result of this occurrence.

*This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 16 November 2017. It was officially released on 05 December 2017.*

*Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.*

# Appendices

## Appendix A – TSB investigations involving misinterpretation, misperception, and/or misapplication of wayside signal indications

Since 1998, the TSB has investigated 13 similar occurrences.

**R15D0118 (Montreal)** – On 11 December 2015, at approximately 0925 Eastern Standard Time, VIA Rail Canada Inc. (VIA) passenger train 605, carrying 14 passengers, was travelling west on the north track of Canadian National Railway Company (CN) Montreal Subdivision. At Mile 6.30, the train derailed while negotiating a crossover at 55 mph, where the authorized speed was 15 mph. About 1600 feet of railway track was damaged. An on-board service employee sustained minor injuries. The investigation determined that if other physical defence methods for controlling trains in signalled territory are not in place, the risks of collision and derailment are increased when signal indications are not correctly recognized or followed.

**R15V0183 (Beavermouth)** – On 06 September 2015, Canadian Pacific Railway (CP) train 602-242 collided with CP train 113-01 near Beavermouth, British Columbia. As a result of the collision, 2 locomotives and the first car behind the locomotives derailed on train 602-242. In addition, the 64th car on train 113-01 derailed 1 set of trucks. The conductor sustained serious injuries. The investigation determined that if existing signal systems are not enhanced to include physical fail-safe capabilities, failures to follow signal indications will continue, and the risk of train collisions and derailments will persist."

**R14T0294 (Newtonville)** – On 28 October 2014, VIA passenger train 62 (VIA 62) was proceeding eastward from Toronto, Ontario, to Montréal, Quebec, on the south track of the CN Kingston Subdivision near Newtonville, Ontario. At 1015 Eastern Daylight Time, while travelling at about 68 mph, VIA 62 passed Signal 2784S, which was displaying a Stop signal. The train was brought to a stop after passing the Stop signal by about 900 feet. There were no injuries, and there was no derailment or track damage. The investigation determined that if additional physical fail-safe train control defences in signalled territory are not available when signal indications are not correctly identified and followed, train movements will not be adequately protected, increasing the risk of collisions and derailments.

**R13C0049 (Dunmore)** – On 18 May 2013, at about 1330 Mountain Daylight Time, CP train 351-424, operating westward on the north main track of the Maple Creek Subdivision approaching Dunmore, Alberta, struck the side of eastward CP train 100-17 that was departing Dunmore from the north main track through the crossover onto the Depot 1 track. As a result of the collision, the 2 lead locomotives and following 2 cars on train 351-424 derailed. On train 100-17, 2 cars derailed and several others sustained damage. The conductor of train 351-424 sustained minor injuries. The investigation determined that if existing centralized traffic control systems are not enhanced to include physical fail-safe capabilities, signal recognition errors will remain undetected, increasing the risk of train collisions and derailments.

**R13Q0001 (Mai)** – On 11 January 2013, at approximately 0018 Eastern Standard Time, Quebec North Shore and Labrador Railway (QNS&L) freight train FCN-05 collided with the rear end of iron ore train BNL-005 at Mile 124.2 of the QNS&L Wacouna Subdivision, near Mai, Quebec. The first locomotive on train FCN-05 was completely destroyed and the second locomotive derailed. Eight cars on train BNL-005 derailed. The crew members of freight train FCN-05 sustained minor injuries. Approximately 40 feet of track was damaged. The investigation determined that in the absence of additional physical fail-safe train controls in signalled territory, the existing defences proved inadequate to prevent the collision.

**R12T0038 (Aldershot)** – On 26 February 2012, VIA train 92 (VIA 92) was travelling east from Niagara Falls to Toronto, Ontario, on track 2 of the CN Oakville Subdivision. Beyond the stop at Aldershot Station, the track switches were lined to route the train from track 2 to track 3. The last signal required the train to proceed at 15 mph. VIA 92 entered the crossover at about 67 mph. The locomotive and all 5 coaches derailed. The 3 operating crew members were fatally injured, and 44 passengers and the VIA service manager were injured. The investigation determined that in the absence of additional physical fail-safe safety defences to reduce the consequences of inevitable human errors in signalled territory, the risk of collisions and derailments persists. As a result of the investigation, the Board recommended that the Department of Transport require major Canadian passenger and freight railways implement physical fail-safe train controls, beginning with Canada's high-speed rail corridors.

**R11E0063 (Bailey)** – On 23 June 2011, at approximately 0625 Mountain Daylight Time, CN freight train Q10131-21, proceeding westward at 25 mph on the Wainwright Subdivision, collided with the tail end of CN freight train A41751-23 at Mile 262.30. As a result of the collision, 2 intermodal flat cars derailed (3 car bodies) and locomotive CN 2234 was damaged. The investigation determined that in the absence of additional back-up safety defences in signalled territory, when signal indications are not correctly identified or followed, existing defences may not be adequate to reduce the risk of collision and derailment.

**R10Q0011 (Saint-Charles-de-Bellechasse)** – On 25 February 2010, VIA train 15 (VIA 15) was proceeding westward from Halifax, Nova Scotia, to Montréal, Quebec. At approximately 0425 Eastern Standard Time near Saint-Charles-de-Bellechasse, Quebec (Mile 100.78 of the CN Montmagny Subdivision), the train entered a siding switch, which had an authorized speed of 15 mph, while travelling at approximately 64 mph. Two locomotives and 6 passenger cars derailed. The 2 operating crew members and 5 passengers were injured. The investigation determined that existing defences, such as 2-man crews and the centralized traffic control (CTC) system, do not ensure that signal indications will always be followed. In the absence of additional defences, the risk of serious train collisions or derailments remains.

**R10V0038 (KC Junction)** – On 03 March 2010, at about 1410 Pacific Standard Time, CP train 300-02, operating eastward on the north track of the Mountain Subdivision approaching KC Junction, British Columbia, side collided with westbound CP train 671-037 when it was departing Golden from the north track through the crossovers onto the south track. As a result of the collision, 3 locomotives and 26 cars derailed. The crew members of train 300-02 were transported to hospital for observation. The investigation determined that in the absence of enhanced protection against signal recognition errors, such as that provided by cab signalling systems or positive train control (PTC), CTC and its current defences do not always adequately ensure that the requirements of signals are followed.

**R09V0230 (Redgrave)** – On 30 October 2009, at about 2225 Pacific Daylight Time, CP train 355-429, operating westward on the signalled siding track at Redgrave, British Columbia (Mountain Subdivision), side collided with eastbound CP train 110-30 that had stopped on the main track. As a result of the collision, 2 locomotives and 6 cars derailed. The investigation determined that CTC defences are not designed to ensure safety in situations in which train crews erroneously perceive signal indications to be more permissive. Intervention from a system such as PTC may have compensated for the signal misidentification and prevented the collision.

**R07E0129 (Peers)** – On 27 October 2007, at 0505 Mountain Daylight Time, the crew on CN train A41751-26 (train 417) operating westward on the main track of the Edson Subdivision initiated an emergency brake application approximately 475 feet from a Stop signal at the west end of Peers, Alberta. The train was unable to stop prior to passing the signal and collided with eastbound CN train M34251-26 (train 342), which was entering the siding. As a result of the collision, train 417's locomotives and 22 cars derailed. Ten other cars sustained damage, but did not derail. Five cars on train 342 derailed and 4 other cars sustained damage, but did not derail. There were no serious injuries. The investigation determined that intervention from a PTC-type system would have compensated for the locomotive engineer's loss of situational awareness and prevented the collision.

**R99T0017 (Trenton Junction)** – On 19 January 1999, VIA train 52 (VIA 52) travelled east passed Signal 2328S at Mile 232.8 of the CN Kingston Subdivision at the Trenton Junction Station while it was indicating Stop. The train subsequently passed through a main-track switch, which was in the reverse position in a trailing movement direction, and came to a full stop at Mile 232.17. There was no derailment, and there were no injuries. There was no damage to property other than the switch that was forced open by the train wheels as it passed. As a result of the Notch Hill accident, the TSB made a recommendation that the Department of Transport and the railway industry implement additional backup safety defences to help ensure that signal indications are consistently recognized and followed (TSB Recommendation R00-04).

**R98V0148 (Notch Hill)** – On 11 August 1998, CP train 463-11 collided with the rear end of CP train 839-020 at Mile 78.0 of the CP Shuswap Subdivision, near Notch Hill, British Columbia. One car on train 463-11 and 2 cars on train 839-020 derailed. There were no injuries. The TSB identified 2 safety deficiencies related to the backup safety defences for signal communication and the impact of noise on the communications of safety-critical information between crew members on locomotive cabs.