Report 07-113, express freight Train 239, wagons left in section at 514.9km, between Te Awamutu and Te Kawa, 22 September 2007

Report 07-113

express freight Train 239

wagons left in section at 514.9km between Te Awamutu and Te Kawa

22 September 2007

Abstract

At about 1915 on Saturday 22 September 2007, southbound express freight Train 239 parted between the 22nd and 23rd wagons while the train was travelling on the North Island Main Trunk line between Te Awamutu and Te Kawa. The emergency brakes applied automatically as the air pressure in the brake pipe reduced and both portions of the train rolled to a stop, some distance apart.

The locomotive engineer went back to examine the train and saw that there was no train end monitor attached to the last wagon. Thinking this was the last wagon on the train and that the loss of the train end monitor was responsible for the loss of air in the brake pipe, he advised train control and continued, leaving behind the rear 10 wagons. These wagons were found some time later by the locomotive engineer of a following train who was following at caution on instruction from train control, because the section of track was showing as occupied on the train control centralised traffic control panel.

There were no injuries and no damage to the train or infrastructure.

The safety issues identified included:

- the manual overriding of a correctly operating signalling system
- failure to establish beyond reasonable doubt the cause of the brake pipe air loss
- failure to ensure beyond reasonable doubt that the Te Awamutu – Te Kawa block section was unoccupied before a train was authorised to enter the block section
- the poor level of training in and application of crew resource management within the rail industry
- the response of train controllers to operating incidents.

One safety recommendation covering these issues has been made to the Chief Executive of the New Zealand Transport Agency.

Contents

Abbreviations ii

Data Summary ii

1 Factual Information 1

- 1.1 Narrative 1
- 1.2 Site and signalling information 2
- 1.3 Track and signal indication data 3
- 1.4 Mis 59 Authority to Pass Departure Signal at Stop 9
- 1.5 Train end monitor 9
- 1.6 Head end display unit 10
- 1.7 Locomotive event recorder 11
- 1.8 Personnel 11
  - Locomotive engineer Train 239 11
  - Locomotive engineer Train 243 11
  - Train controller 11
- 1.9 Train control audio recorder 12
- 1.10 ZL and ZH class wagons 12
- 1.11 Crew resource management 14
  - Toll Rail 14
  - Ontrack – train controllers 14
  - Ontrack – track workers 15
  - Extracts from *Rail Crew Resource Management (CRM): the Business Case for CRM Training in the Railroad Industry*, published by US Department of Transportation Federal Railroad Administration, September 2007 15
  - Introduction 15
  - Initial awareness training 15
  - Practice and feedback 16
  - Continuing reinforcement 16
  - Conclusions 17
- 1.12 Crew resource management occurrences investigated by the Commission 17
  - Introduction 17
  - Rail occurrence report 05-102, track warrant control irregularities, Woodville and Otane, 18 January 2005 18
  - Rail occurrence report 07-108, express freight Train 720 track warrant overrun, Seddon – Vernon, 12 May 2007 18
  - Rail occurrence report 07-110, collision express freight Train MP2 and Work Train 22 at Ohinewai, 19 June 2007 19
- 1.13 A crew resource management occurrence brought to the Commission's attention 19
- 1.14 Tonnage left in section incident, Camden Road Tunnel, Camden Town, London, 19 July 2007 20
- 1.15 Maritime CRM case study in New Zealand 21

2 Analysis 21

- Introduction 21
- Prior to departure from Te Rapa 22
- Train parting at 514.9 km 22
- After departing 514.9 km 23
- Train control 24
- The signalling system 24
- Issue of the Mis 59 25
- Track warrant control 26
- Human factors 26
- Crew resource management 27

3 Findings 28

4 Safety Recommendations 29

Figures

Figure 1	Site diagram (not to scale)	2
Figure 2	Track indications prior to departure of Train 239 from Te Awamutu	2
Figure 3	Track indications as Train 239 departed Te Awamutu	2
Figure 4	Track indications as Train 239 occupied A1 Track	6
Figure 5	Track indications as Train 239 occupied A2 Track	6
Figure 6	Track indications as Train 239 occupied H2 Track	7
Figure 7	Track indications as Train 239 vacated A2 Track	7
Figure 8	Track indications as Train 239 occupied H1 Track	8
Figure 9	Track indications as Train 239 occupied G Tracn and vacated H2 Track	8
Figure 10	Trainlink ATX train end monitor attached to the wagon coupling	9
Figure 12	ZL class wagon	13
Figure 13	ZH class wagon	13

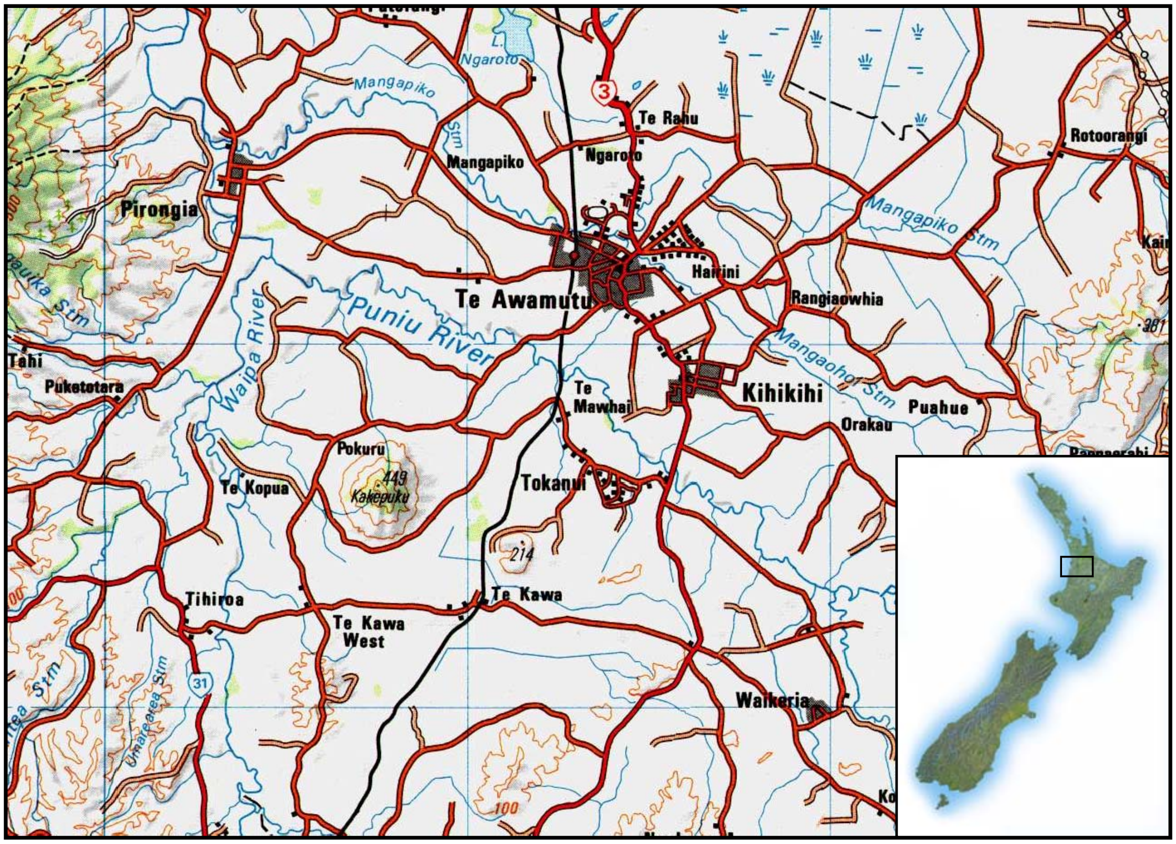
Abbreviations

CTC	centralised traffic control
km	kilometre(s)
km/h	kilometre(s) per hour
m	metre(s)
Toll Rail	Toll NZ Consolidated Limited
UTC	coordinated universal time

Data Summary

Train type and number:	express freight Train 239
Date and time:	22 September 2007, at about 1915[1]
Location:	514.9 km between Te Awamutu and Te Kawa, North Island Main Trunk
Persons on board:	crew: 1
Injuries:	nil
Damage:	nil
Operator:	Toll NZ Consolidated Limited (Toll Rail)
Investigator-in-charge	D L Bevin

[1] Times in this report are New Zealand Standard Time (UTC+12) and are quoted in the 24-hour mode.



Location of Incident

1 Factual Information

1.1 Narrative

1.1.1 On Saturday 22 September 2007, Train 239 was a scheduled Auckland to Wellington express freight train. The train consisted of 2 EF class locomotives in multiple and 32 wagons, with a gross weight of 1321 tonnes and a total train length of 536 metres (m). Train 239 was crewed by one locomotive engineer.

1.1.2 Train 239 had arrived at Te Rapa from Auckland at 1753. After the train examiner operations had reduced 5 wagons and completed the brake test, he notified the locomotive engineer by radio of the number of the rear (32nd) wagon on the train. The locomotive engineer acknowledged the call and checked the wagon number on his train documentation. Usually he highlighted this number by writing it on his train list but he did not on this occasion. Train 239 departed at 1841.

1.1.3 At about 1915, shortly after passing through Te Awamutu on the North Island Main Trunk line, the locomotive engineer heard a sudden loss of air from the train brake pipe. He suspected that either an air hose had burst or the train end monitor had disconnected and fallen from the rear wagon and allowed the air to escape through the unconnected air tap at the rear. The train came to a stop and, after he had advised train control of the situation, the locomotive engineer collected his bag of equipment and proceeded back along the train, checking it as he went, to establish a cause for the loss of air. It was dark and had begun to rain.

1.1.4 When the locomotive engineer reached the last wagon he saw there was no train end monitor attached to the buffer. He closed the air tap to stop the further loss of air and advised train control of what he had found, before he started to walk back to the locomotive. The locomotive engineer had walked about 2 wagon lengths when he realised that he had forgotten to identify the number of the last wagon so he shone his torch back onto the number plate. He could not decipher the actual number but thought he could make out the letter "Z" so he concluded the wagon was the ZL class he knew was on the rear of the rain when he departed from Te Rapa. He advised train control that he would confirm the number when he got back to the locomotive cab.

1.1.5 Once back in the locomotive cab, the locomotive engineer had referred to his train documentation before advising the train controller that the number of the last wagon on the train was ZL462. The train controller confirmed on his computer that the number corresponded to that of the train information before him. The locomotive engineer also confirmed that the train end monitor was missing and suggested that he continue on to Te Kawa and wait for a replacement train end monitor. The train controller instructed him to continue to Otorohanga instead and wait there for the replacement, which the train controller had arranged to be brought by road from Te Rapa.

1.1.6 After Train 239 had vacated the Te Awamutu – Te Kawa centralised traffic control block section[2], the track indication lights[3] on the centralised traffic control visual display unit in front of the train controller remained illuminated. This suggested to him that the section was still occupied so he called the locomotive engineer by radio and asked him if his train was complete. The locomotive engineer confirmed that the air was coupled through his train and he had no reason to believe it was not complete.

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[2] The section of single line in centralised traffic control which extended between the Departure signals of any 2 stations equipped for crossing trains.

[3] Track indications shown on the centralised traffic control visual display unit were normally "blacked out" in the section between stations and yellow in the vicinity of points within station limits. In both cases these changed to red when the track was occupied by a train.

1.1.7 Train 239 arrived at Otorohanga at 2002 and when the taxi conveying the replacement train end monitor arrived at the locomotive cab, the locomotive engineer got in and rode back to the rear wagon, where he attached the replacement train end monitor. He was talking to the taxi driver as he did so, and did not check the number of the last wagon. The train departed from Otorohanga at 2029.

1.1.8 About 100 minutes after Train 239 had departed the Te Awamutu – Te Kawa centralised traffic control block section, the track indication lights in the block section were still illuminated. This prevented the train controller from clearing Departure Signal 4LA at Te Awamutu (see Figure 1) to "proceed" for southbound express freight Train 243 to enter the section so he contacted the locomotive engineer by radio and warned him to expect to receive a Mis 59[4] authority on arrival at Te Awamutu.

1.1.9 The train controller advised the locomotive engineer of Train 243 that Train 239, the preceding train, had lost its train end monitor between Te Awamutu and Te Kawa and was waiting at Otorohanga for a replacement. He asked him to keep a lookout for it as he travelled through the section. The locomotive engineer could not see a correlation between the lost train end monitor and the need for a Mis 59, especially as he knew from experience that the train end monitor was not sufficiently long to make contact with both rails, as required to hold the Departure signal at Te Awamutu at "Stop" so did not believe that the "Stop" indication was caused by the lost train end monitor, rather that something else was the cause. He jokingly said to the train controller that he hoped there were no wagons in the section.

1.1.10 After receiving the Mis 59 authority, the locomotive engineer of Train 243 proceeded cautiously past Signal 4LA and entered the block section. Shortly after passing the signal he saw a red reflector in the distance. He pulled up slowly to the reflector and saw it was a train end monitor which was attached to a stationary rake of wagons in front of him. He immediately notified train control.

1.1.11 Train 239 was approaching Kopaki, about 60 km south of where the train had initially stopped, when the locomotive engineer was advised by train control that a rake of wagons had been found in the Te Awamutu – Te Kawa block section by the locomotive engineer of a following train. Train 239 was stopped at Kopaki and the locomotive engineer was relieved of duty.

1.2 Site and signalling information

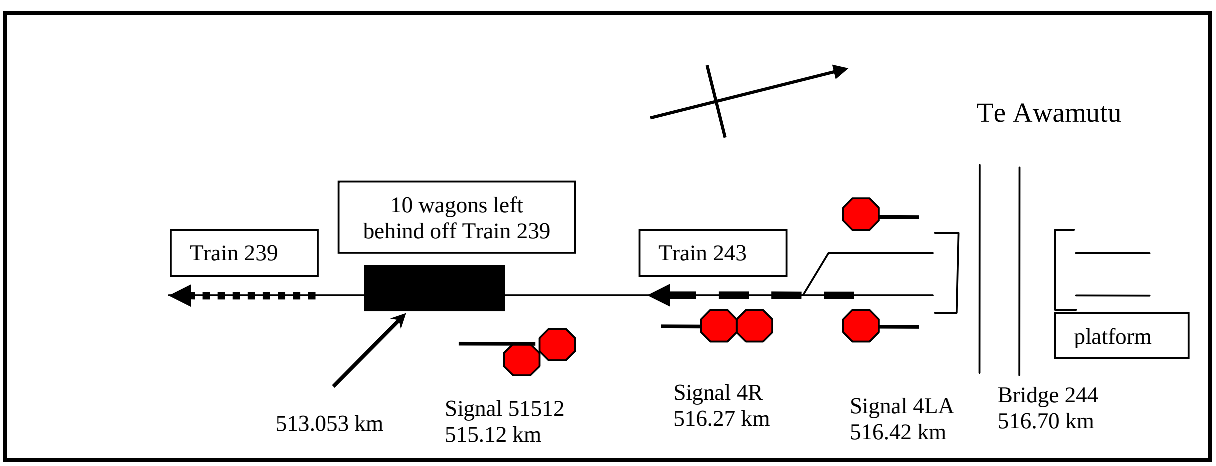

Figure 1
Site diagram (not to scale)

[4] Train control authorised the passing of a Departure signal at "Stop" by issuing a Mis 59 authority.

1.2.1 The track from Te Awamutu to Te Kawa was single line with centralised traffic control signalling. The signalling and interlocking was remotely controlled from the train control centre in Wellington.

1.2.2 A departure signal displaying a "proceed" indication was the authority for a train to enter a block section. Circumstances which prevented the departure signal being placed at "proceed" included:

- a train or vehicle already in the section
- any metallic or other conducting substance so placed as to form a connection between the rails
- a broken or misplaced rail
- any bond wire becoming detached or broken.

1.2.3 The distance between Signals 4LA and 4R at Te Awamutu was 154 m.

1.2.4 The track south of the platform at Te Awamutu entered a 500 m radius left-hand curve then a reverse 820 m radius right-hand curve before running straight from 516.321 km for about 3 km. The track descended on a ruling grade[5] of 1 in 75 from Bridge 244 for about 1000 m to 515.500 km, where it levelled out.

1.2.5 The train controller was able to monitor the progress of trains by track indications on the CTC (centralised traffic control) visual display unit positioned in front of him. The visual display unit showed not only the location of trains but also the indications being displayed by controlled signals in the field.

1.2.6 There were 6 separate track circuit sections displayed on the visual display unit between Te Awamutu and Te Kawa (see Figure 2); 3 between Te Awamutu and Intermediate Signal 55217; and a further 3 between that signal and Te Kawa. A1 and A2 track circuits were not labelled on the main CTC overview screen on the visual display unit and were only separately labelled when the train controller selected the zoom view option. As Train 239 travelled through the track circuit sections, the track indications displayed red on the visual display unit as each was occupied, and reverted to black when the section was vacated.

1.2.7 The track joint between B Track and A1 Track was located at 514.326 km, 2099 m from Signal 4LA at Te Awamutu. The track joint between A1 Track and A2 Track was located at 513.053 km, 3372 m from Signal 4R (see Figure 1). The occupied track indications covered a distance of 3218 m from Signal 4R at Te Awamutu south to 513.053 km.

1.3 Track and signal indication data

1.3.1 The track indication data log recorded the times when trackside signals were cleared to proceed for the passage of a train, when the signal reverted to "Stop" after the passing train had entered the section ahead, and the times the train occupied and vacated each section.

1.3.2 Data from the track indication log was provided for analysis. The data showed:

19:09:26 – Train 239 occupied B Track (see Figure 3)

19:10:58 – Train 239 occupied A1 Track; B Track remained illuminated (see Figure 4) [1915 Train 239 stops due to parting]

19:39:41 – Train 239 started moving again and occupied A2 Track; A1 Track and B Track remained illuminated (see Figure 5)

[5] The steepest part of the gradient.

19:40:45 – Train 239 occupied H2 Track; A1 Track and B Track remained illuminated (see Figure 6)

19:41:26 – Train 239 vacated A2 Track; A1 Track and B Track remained illuminated (see Figure 7)

19:42:01 – Train 239 occupied H1 Track; A1 Track and B Track remained illuminated (see Figure 8)

19:42:26 - Train 239 vacated H2 Track; A1 Track and B Track remained illuminated

19:42:52 – Train 239 occupied G Track; A1 Track and B Track remained illuminated (see Figure 9).

1.3.3 Ontrack's standards for reporting defects in signals stated that all instances of dropped track circuits[6] were to be immediately advised to the help desk and signals staff called out to investigate.

1.3.4 Ontrack's standards for maintenance crew attending to callouts were detailed in The New Zealand Rail Ltd: Railnet[7] Code Supplement CSS/PZ 071 dated 1 June 1992 and still in effect as a guide to callouts for Railnet (now Ontrack) staff. Acceptance guidelines for callouts stated that callouts should be accepted for failures of all Departure signals giving entry to a block section except when "there will be few trains before the fault can be attended to during normal working hours".

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[6] Term for track indications remaining illuminated after the block section has been vacated.
[7] Railnet was a business group of New Zealand Rail Limited with responsibilities for infrastructure renewal and maintenance.

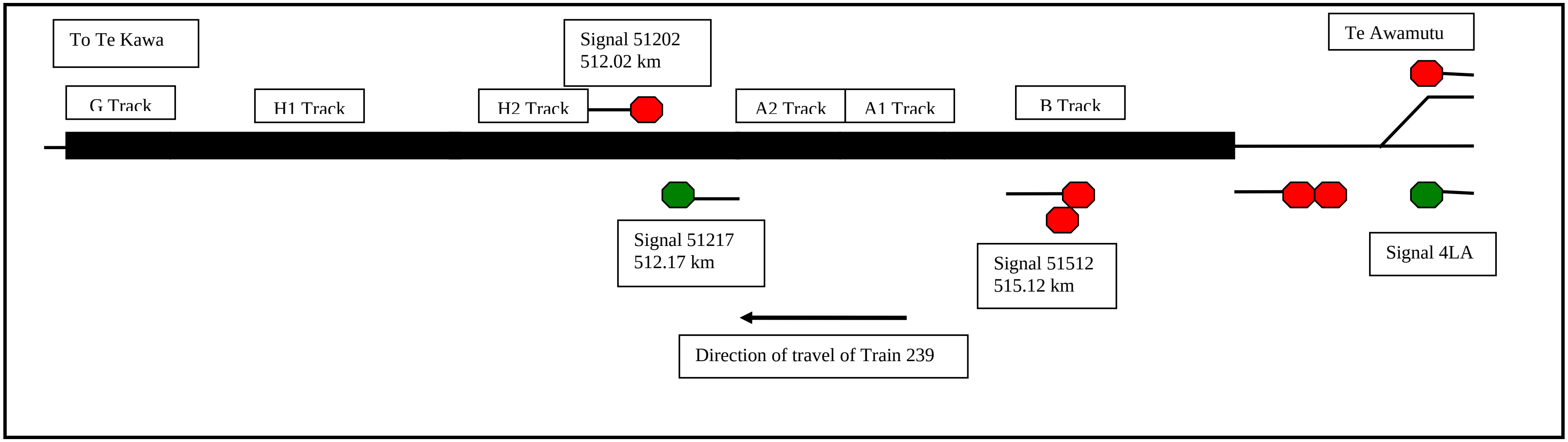

Figure 2
Track indications prior to departure of Train 239 from Te Awamutu

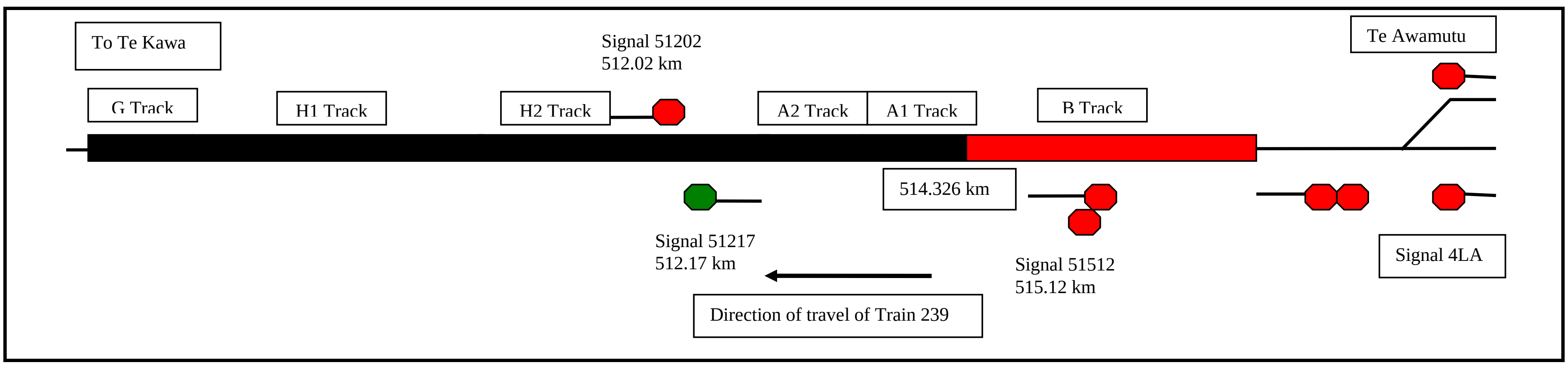

Figure 3
Track indications as Train 239 departed Te Awamutu

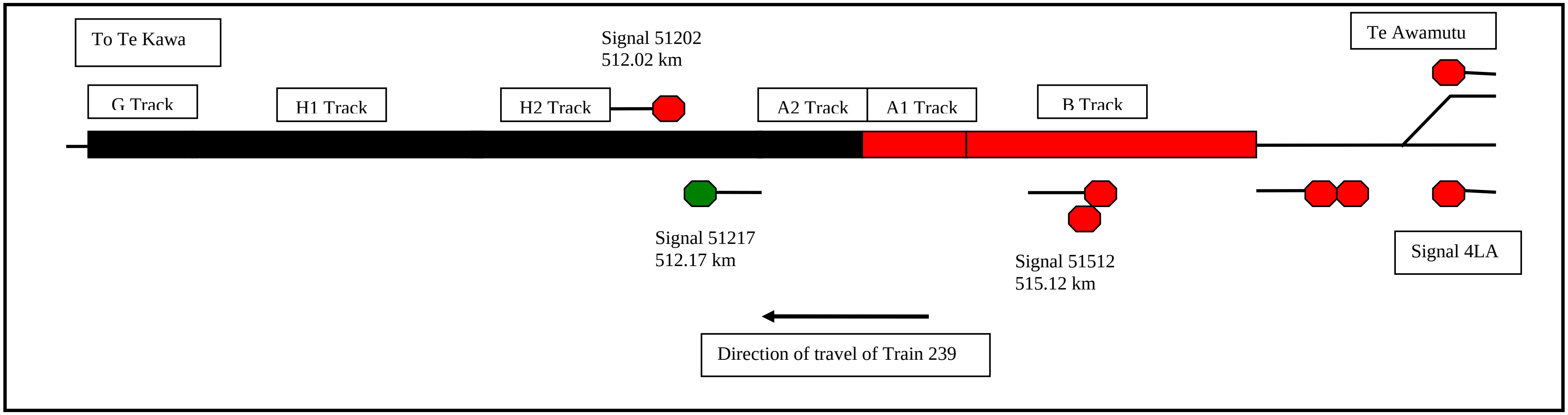

Figure 4
Track indications as Train 239 occupied A1 Track

Te Awamutu

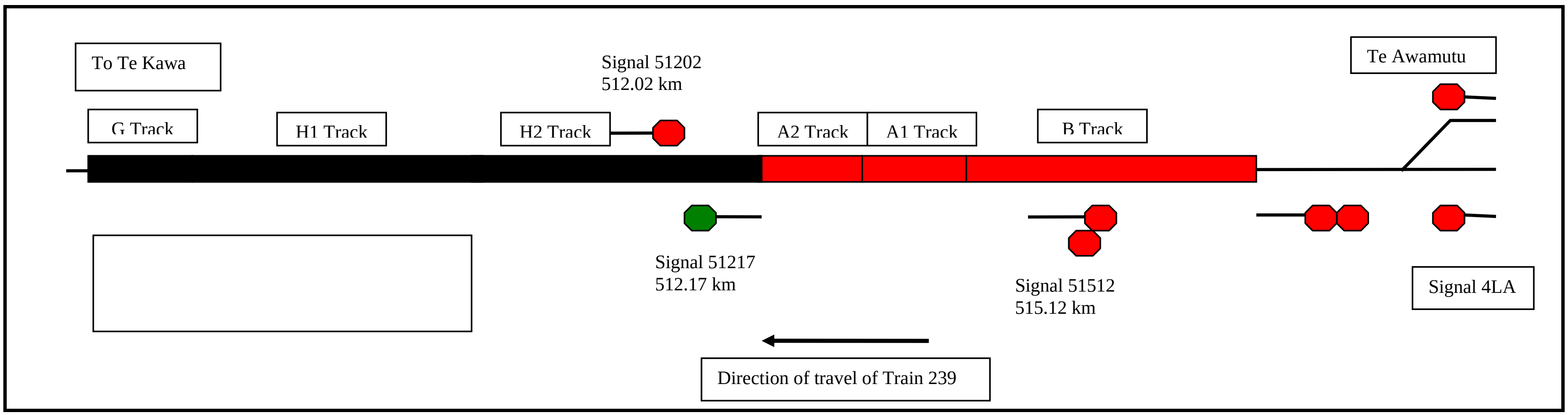

Figure 5
Track indications as Train 239 occupied A2 Track

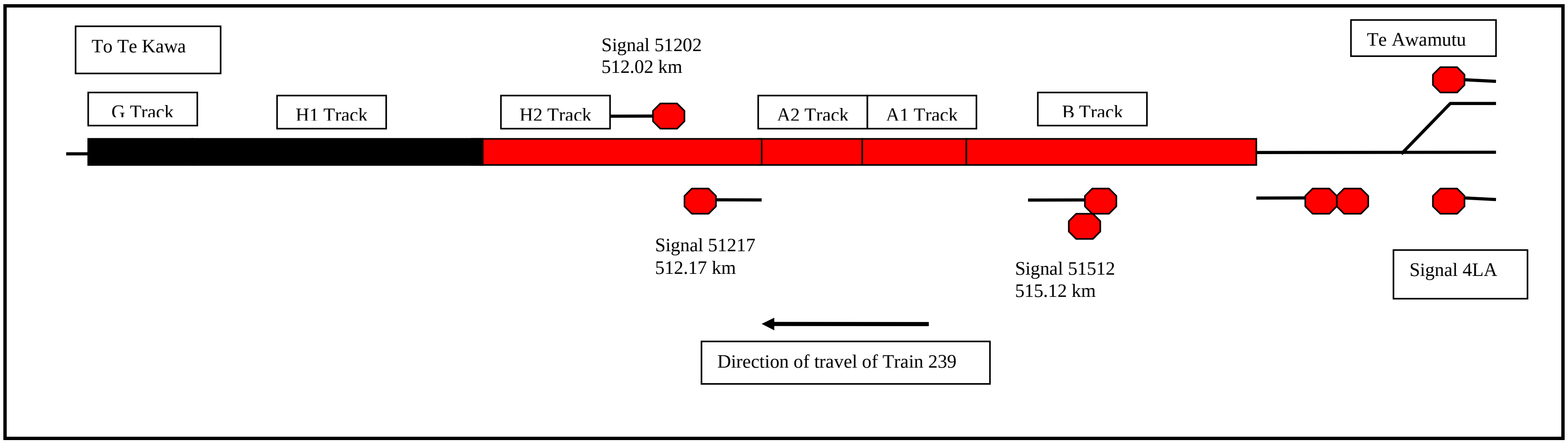

Figure 6
Track indications as Train 239 occupied H2 Track

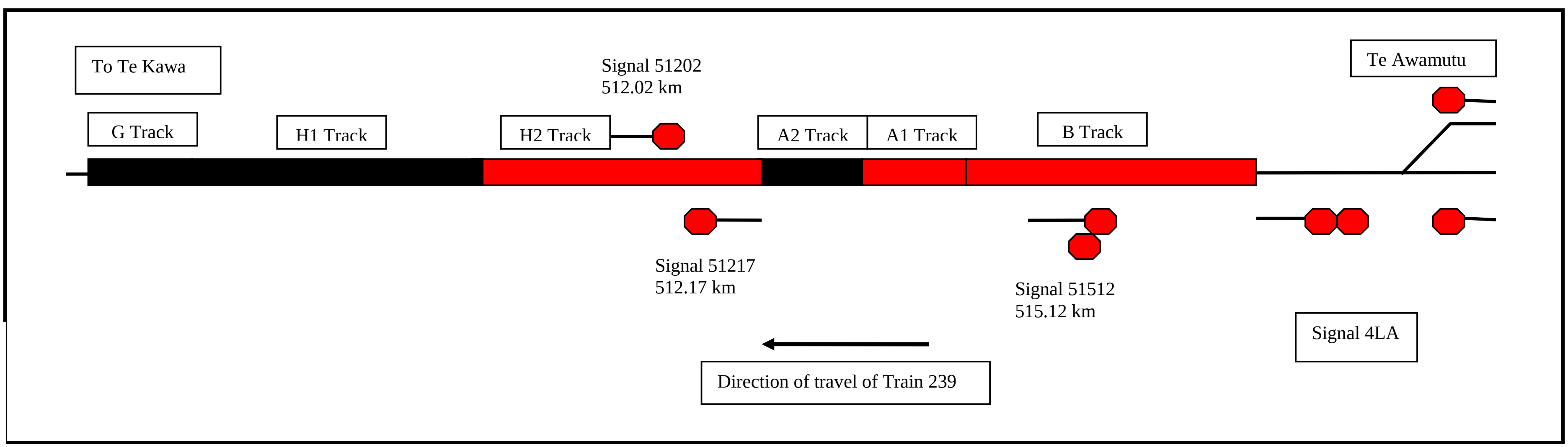

Figure 7
Track indications as Train 239 vacated A2 Track

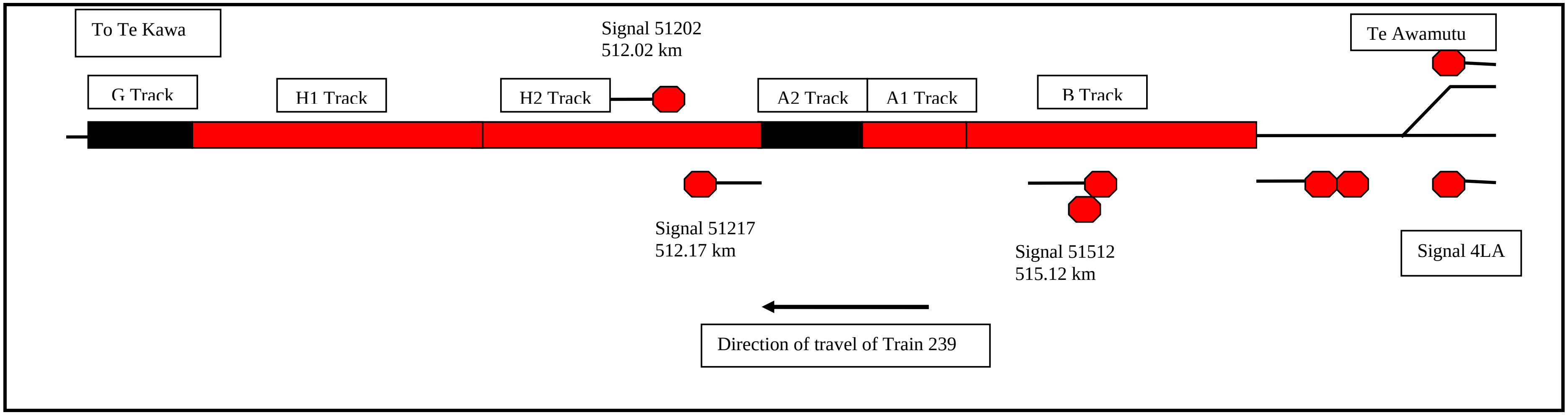

Figure 8
Track indications as Train 239 occupied H1 Track

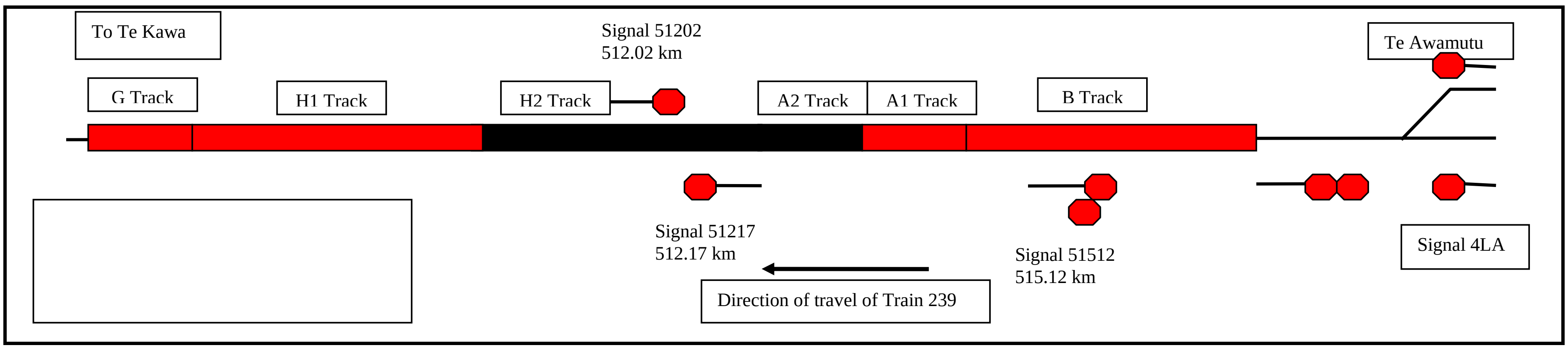

Figure 9
Track indications as Train 239 occupied G Track and vacated H2 Track

1.4 Mis 59 Authority to Pass Departure Signal at Stop

1.4.1 If a Departure signal could not be cleared to "proceed" the train controller could authorise passing the signal at "Stop" by the issue of a Mis 59 authority. It was the responsibility of the train controller to ensure the section was unoccupied prior to issuing a Mis59.

1.4.2 Before issuing a Mis 59 the train controller was required to establish that the most recent train that had travelled through the affected section was clear and confirm with the locomotive engineer that this train was complete.

1.4.3 Once in receipt of a Mis 59 the locomotive engineer was required to travel cautiously, being prepared to find the section obstructed, a displaced rail or points not correctly set and was not to assume that any obstruction was protected.

1.5 Train end monitor

1.5.1 The train end monitor was a Trainlink ATX[8] system made up of 2 components: the train end monitor, and the head end display unit located in the locomotive cab. The system monitored brake pipe pressure and whether the last wagon was moving. A built-in radio transmitted this information for processing and display on the head end unit in the locomotive cab.

1.5.2 The train end monitor was fastened to the rear wagon by a bracket, which was fitted to the drawbar pin within the coupling. The train end monitor was secured to the bracket (see Figure 10) and could not become detached from the coupling unless the drawbar pin worked loose.

Figure 10
Trainlink ATX train end monitor attached to the wagon coupling

[8] Trade name of the train end monitor.

1.5.3 The Trainlink ATX train end monitor with bracket attached extended 950 millimetres above the drawbar.

1.5.4 Rail Operating Rules and Procedures (Signals) Rule 69 "Signals Displayed by Trains" provided that train end monitors were an approved end of train marker. The tail light of the train end monitor operated while the train end monitor was in the upright position, except during daylight conditions when a photo-electric cell turned the marker off. There was also a reflector fitted to the train end monitor.

1.5.5 Ontrack standards required that when a train end monitor was used as an end of train marker the following methods were used to confirm that the train was complete:

- when the train end monitor was fitted to the rear of the train and the head end unit indicated normal brake pipe pressure
- an employee confirmed that the train end monitor was on the rear wagon
- the wagon to which the train end monitor was attached was confirmed as being on the train by a member of the train crew
- the train was stopped and an inspection confirmed that the end of train signal was present at the rear of the train.

Should the end of train signal be missing, the number of the last wagon must be checked against that shown on the relevant train documentation to confirm that the train was complete.

1.6 Head end display unit

1.6.1 The head end unit displayed data transmitted from the train end monitor for the locomotive engineer. This data included:

- last vehicle – MOVING/STOPPED
- marker light – ON/OFF
- battery low
- brake pipe pressure in 10 kPa intervals
- radio break.

1.6.2 A movement sensor on the tail end monitor provided data that showed whether the last wagon of the train was stopped or moving, but was designed to be an aid rather than a guarantee that the last wagon was moving.

1.6.3 If there was no transmission from the train end monitor for 5 minutes the radio break indicator on the head end unit flashed continuously and 6 beeps sounded. After a further 5 minutes without transmissions the display went blank.

1.6.4 When Train 239 parted, the head end unit would have shown brake pipe pressure reducing, and subject to any discrepancy, that eventually the last wagon had stopped.

1.6.5 The train end monitor had a transmitting range of about 2 km. Once the head end unit exceeded that distance, transmissions usually ceased and the radio break indication would display to advise the locomotive engineer. As the front portion of Train 239 pulled away, the train end monitor would continue to transmit data relating to the detached portion of the train until the battery failed or the locomotive moved out of range.

1.7 Locomotive event recorder

1.7.1 The recorder was the older Kaitiaki type. On-site personnel omitted to isolate the recorder once Train 239 had been stopped at Kopaki. Consequently the short-term data had been overwritten and was not available.

1.8 Personnel

Locomotive engineer Train 239

1.8.1 The locomotive engineer had 32 years' driving experience with Toll Rail and its predecessors and was qualified for express freight services. He had been booked on duty at 1445.

Locomotive engineer Train 243

1.8.2 The locomotive engineer had 28 years' driving experience with Toll Rail and its predecessors and was qualified for express freight services.

Train controller

1.8.3 The train controller had 4 years' train controlling experience and held current certification for the position he was operating. Prior to becoming a train controller he had worked in signal boxes in the Auckland area.

1.8.4 He had commenced duty at 1850 and was to finish at 0700 the following morning, a shift of 12 hours. His duties included controlling trains on the East Coast Main Trunk, the North Auckland Line, the North Island Main Trunk line from Marton to Auckland, and the Auckland metropolitan area. Although this covered a large geographical area, he did not consider the workload to be excessive.

1.8.5 The train controller had received a radio call from the locomotive engineer of Train 239 between Te Awamutu and Te Kawa, advising that his train had lost air and had come to a stop and that he was going to try and find the cause. A short time later the train controller received another call from the locomotive engineer, this time telling him that the train end monitor was missing from the last vehicle. The train controller asked him what the number of the rear vehicle was but the locomotive engineer said he was walking back to the locomotive and would advise the number when he got back in the cab.

1.8.6 When the locomotive engineer advised that the number of the rear wagon was ZL462, the train controller checked this number against his computerised train list and confirmed it to be the number of the last wagon on the train. He then instructed the locomotive engineer to continue on to Otorohanga and wait for a replacement train end monitor.

1.8.7 As Train 239 moved through the Te Awamutu – Te Kawa block section the train controller noticed that 2 track indications immediately south of Te Awamutu had remained illuminated so he called the locomotive engineer to confirm that his train was complete. The locomotive engineer assured the train controller that the train was complete and that the air was through.

1.8.8 The train controller said that after he had confirmed the rear wagon number given to him by the locomotive engineer of Train 239 he thought he had no reason to doubt that the train was complete. He did however suggest to the locomotive engineer that he recheck the train while at Otorohanga but the locomotive engineer was adamant that the train was complete and that there was no need to check it again.

1.8.9 When the train controller saw the track indications had remained illuminated after Train 239 had moved off, he initially thought that there might have been a wagon left behind but then thought it more likely that the train end monitor had fallen off and was making contact with both rails, thereby causing the illuminated track indications. He said that if he had been uncomfortable with the reason given by the locomotive engineer he could have called a maintainer out to establish the cause of the fault, or else he could have instructed the locomotive engineer to walk the train again which, he felt, might have resulted in an argument. He thought the locomotive engineer had walked the train again while it was stopped at Otorohanga anyway and after it had departed he was satisfied that it was just a coincidence that the track circuit had remained illuminated. There was only one other train to go through the section that night so he decided against calling out maintenance staff until he was satisfied it was not just a "ghost" indication.

1.9 Train control audio recorder

1.9.1 The train control audio recorder was downloaded and a disk was supplied for analysis which revealed:

- 1915:21: the locomotive engineer of Train 239 advised that his train had lost all its air and stopped and he would need to investigate
- 1916:42: a portable radio test was undertaken prior to the locomotive engineer leaving the cab
- 1926:15: the locomotive engineer of Train 239 advised train control that the train end monitor was missing from the rear of his train. In response to the train controller's question about whether there was any sign of it, the locomotive engineer responded that there wasn't and that it was probably no longer in one piece. The locomotive engineer advised that he would confirm the number of the last wagon on the train when he returned to the locomotive cab. The train controller acknowledged this
- 1939:21: the locomotive engineer confirmed that the last wagon on the train was ZL462, which was acknowledged by the train controller, who then instructed the locomotive engineer to proceed to Otorohanga and wait for the arrival of a taxi which was conveying a replacement train end monitor
- 1945:53: the train controller contacted the locomotive engineer and asked him to confirm that the last wagon was on the train on arrival at Otorohanga, as after the train had left the Te Awamutu – Te Kawa block section some track circuit indications had remained illuminated. The locomotive engineer responded that he still had air through his train so was sure his train was complete. The train control acknowledged that and said the track indications might be caused by the train end monitor being in contact with the rails. The locomotive engineer thought this was the most likely cause.

1.10 ZL and ZH class wagons

1.10.1 The wagon on the rear of Train 239 when it departed Te Rapa was ZL462. These wagons were used for carrying general freight traffic.

1.10.2 The wagon on the rear of Train 239 to which the replacement TEM was attached at Otorohanga was ZH53. These wagons were used for conveying palletised bulk product such as milk powder and urea, as well as palletised general freight.

Figure 12
a ZL class wagon

Figure 13
a ZH class wagon

1.11 Crew resource management

1.11.1 Toll Rail and Ontrack provided details of their respective approaches to crew resource management training and application.

Toll Rail

1.11.2 The initial development of the crew resource management training for trainee locomotive engineers involved a member of the training centre team, line managers of locomotive engineers and Tranz Metro's[9] training facilitator. The training module took about 2 hours to facilitate.

1.11.3 Facilitators involved in the training of trainee locomotive engineers, existing locomotive engineers and managers, together with those involved in re-certifications, all had railway operating experience at frontline and management/supervisory level. Managers involved in facilitating crew resource management training were themselves trained by the operational risk and compliance manager.

1.11.4 Training consultants based at the training centre undertook facilitation to trainee locomotive engineers. Current locomotive engineers were trained by local managers and locomotive engineer team leaders.

1.11.5 The crew resource management revalidation process, which was part of the locomotive engineer's biennial recertification process, included a crew resource management module incorporating case studies as well as the application of crew resource management principles during the human factors and fatigue management aspects of the recertification process.

1.11.6 Toll Rail said it had also started training all operational managers in "line manager crew resource management" to ensure the principles were understood and embraced at all levels.

1.11.7 Toll Rail's information pamphlets which were distributed to staff identified 3 basic rules/actions of crew resource management:

- correct – listen/observe carefully to ensure facts are correct
- intercede – be prepared to intercede, even if you are a third party
- challenge – be prepared to challenge and accept a challenge.

Ontrack – train controllers

1.11.8 Crew resource management was presented during train control school training as a communication standard, closely associated with radio procedure training. It identified the behavioural elements of individuals and teams to focus on the wider issues of clarification, challenge and cross-checking to ensure the accuracy of information transfer.

1.11.9 The training was given by the train control school trainer who was a certified and experienced train controller as well as a qualified New Zealand Qualifications Authority assessor.

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[9] Tranz Metro was the group within Toll Rail with responsibility for the operation of suburban train services in Wellington.

Ontrack – track workers

1.11.10 New track worker employees received one day's training as part of the manager's induction before being sent out with the track gang. The ganger was then responsible for all operating environment training. The ganger was trained by his previous ganger and area managers.

1.11.11 Crew resource management refreshers for both train controllers and track workers were not currently undertaken but these were being added to the refresher training list that was being compiled.

Extracts from *Rail Crew Resource Management (CRM): the Business Case for CRM Training in the Railroad Industry*, published by US Department of Transportation Federal Railroad Administration, September 2007

Introduction

1.11.12 Based largely upon the successful implementation of Crew Resource Management (CRM) in the commercial aviation, military aviation, and the marine transportation industry, NTSB [National Transportation Safety Board] recommended that CRM be introduced in the railroad industry following its investigation of the 1998 accident in Butler, Indiana, between Norfolk Southern (NS) and Conrail (NTSB, 1999). In this accident NTSB found that a lack of coordination, communication, and teamwork among the members of the NS crew was the primary cause of the crash. An examination of the factors involved showed that the human factors issues leading up to this crash were quite similar to those involved in numerous aviation and marine accidents previously investigated by NTSB. Because CRM had been attributed with reducing human factors-caused accidents in those industries, NTSB saw its potential as a countermeasure for similar rail accidents as well.

1.11.13 CRM researchers assert that trainees must have the knowledge and understanding of concepts related to CRM before starting to practice CRM techniques in the field (Helmreich et al., 1990). Because trainees are most often unfamiliar with CRM and its concepts, the cognitive training methods through which knowledge is transferred to the trainees is of the utmost importance. Called initial indoctrination or awareness training, knowledge transfer normally takes place in a classroom setting, where the initial CRM concepts are taught (Salas et al., 2001).

Initial awareness training

1.11.14 The subject matter experts [experts] interviewed, as well as published reviews of aviation CRM, suggest that classroom/awareness training lasts between 1 to 2½ days. Furthermore, experts state that CRM content domain includes topics such as coordination, situational awareness, communication, judgment and decision making, threat and error management, assertiveness, stress and fatigue management, and command leadership.

1.11.15 Specifically, during classroom instruction, a heavy reliance exists on discussion and analysis of case studies of real life accidents caused by the failure of the crew to work together. Instructors of airline CRM training are actual pilots who have qualified to facilitate CRM training. This qualification entails participating in classes on how to facilitate CRM classes specifically. Before instructors can facilitate a class by themselves, they must be observed and signed off by a qualified CRM facilitator.

1.11.16 Railroad RM experts suggest that the CRM awareness and indoctrination training in the railroad industry is equivalent to that of the aviation industry in terms of length, content, and methods used. Specifically experts state that initial railroad CRM lasts 1-2 days and covers content related to communications, human factors, conflict resolution, technical proficiency (as it relates to CRM), situational awareness, teamwork, coordination and assertiveness. Like the aviation industry, awareness training takes place in a classroom setting, using group discussion, exercises, and case studies.

1.11.17 The characteristics and qualifications of the facilitators themselves are also similar to the airline industry. They are former conductors or locomotive engineers who have gone through facilitation training.

Practice and feedback

1.11.18 Practice and feedback is seen as a necessary component of skill acquisition[10]. The practice and feedback phase of CRM training initiatives gives trainees an opportunity to perform work activities while obtaining feedback from the instructor and/or other trainees. The research team's experts and the current literature suggest that the most common method for practicing and receiving feedback on CRM skills in the airline industry is in cockpit simulators or through actual flight audits using Line Operations Safety Audit (LOSA)[11].

1.11.19 Railroad experts suggest that less practice and feedback of CRM skills in their particular organization exist. Practice and feedback that occurs is during yearly on-the-job CRM training/assessments, which are similar to that of LOSA. Specifically, instructors or coaches observe road and yard crew's CRM skills while riding along with them during normal operations. The instructor takes notes on a standardized appraisal form; following these ride-alongs, instructors provide feedback to the crewmembers. Like LOSA, its effectiveness is largely dependent on the skills, attitudes, and motivation of the trainers/mentors. These trainers are selected based both on their skills and abilities to be effective instructors. In addition they receive special training as observers so that they can more readily identify all crew actions or inactions related to CRM skills.

1.11.20 In summary, the results of this research study suggest that the practice and feedback phase of CRM is more in depth in the airline industry than in the railroad industry. Although both have active ride-along programs that include feedback, the amount of practice and feedback in a simulated environment, which is considered to be an important component of effectiveness (Jacob et al., 1990), is far more extensive in the airline industry.

Continuing reinforcement

1.11.21 Research has determined that training effectiveness depends not only on training content, methods used, the degree of practice and feedback, or the instructor's ability, but also on factors beyond the immediate training environment (Helmreich et al., 1990). Taking a systems view of training helps trainers understand how organizational, situational, and trainee characteristics influence training effectiveness by their influence on pre-training and post-training motivation (Salas et al., 2000). The third phase of CRM training comes from this systems perspective, which looks at training in the larger context of the organization and its environment. Thus, this phase of training is not specific to the training program itself but instead represents variables related to the continuing reinforcement of CRM outside formal practice and feedback. Although this phase of training is separate from the training itself, it is considered an essential

[10] Cannon-Bowers, Rhodenizer, Salas, & Bowers, 1998; Pescuric & Byham, 1996.
[11] LOSA involves trained observers riding along in actual aircraft cockpits to observe threatening situations encountered by the crews, errors made by the aircrew, and how crews handle the threatening situations (Helmreich, Klinect, Wilhelm, & Sexton, 2001).

component because it is vital in making the awareness and practice/feedback phases of training come to fruition and affect job performance (Salas et al., 2000).

1.11.22 Variables related to continuing reinforcement include a variety of post-training organizational, situational, and trainee characteristics that can influence the degree to which trainees are motivated to use what they learned in training on the job. For example, consistent with the general literature (e.g., Rodger & Hunter, 1991), airline experts participating in this study suggested that a high level of institutional support is necessary for CRM to have an effect on organizational performance measures. Other organizational characteristics included supervisor support and participation (Baldwin & Ford, 1988), a reward system that reinforces safety compliance along with on-time performance (Hackman, 1990), an environment conducive to the positive transfer of the training skills in the work space (Tracey, Tannenbaum, & Kavanagh, 1995), and a continued commitment to use CRM to enhance an overall safety culture (Helmreich, in press). In summary, the relevant literature and the team's experts suggested that for CRM to be effective, it needs to take place in an organization that has a good overall safety climate.

Conclusions

1.11.23 Research findings indicate that in addition to traditional technology-based and regulatory approaches, [the regulator] should encourage railroads to more fully implement specific human factors training programs, such as CRM, which can improve compliance with existing or even improved procedures/rules. Beyond this, it can increase the coordination and efficiency of railroad operations by engendering improved teamwork across many different levels and crafts.

1.12 Crew resource management occurrences investigated by the Commission

Introduction

1.12.1 Although the principles of crew resource management have application to certain rail operating environments, crew resource management training has not been adopted in the New Zealand rail industry to the same extent as in some international rail industries or within the air and marine industries.

1.12.2 Examples of common crew resource management deficiencies are preoccupation with minor technical problems, failure to delegate tasks and assign responsibilities, inadequate monitoring, failure to use available data, failure to communicate intent and plans, and failure to detect and challenge deviations from standard operating procedures.

1.12.3 In 1998, this failure of the industry within New Zealand to adopt crew resource management techniques was identified in the Commission's Rail Occurrence Report 98-107, Train 411, wrong line running, Ngaruawahia, which included the following safety recommendation directed to the Managing Director of Tranz Rail that he:

> introduce formalised crew resource management training for Train Control Operators, Signalmen and LEs[12] based on the training available in the aviation and marine industries. (001/99)

Tranz Rail replied:

> Service Delivery will review the crew resource management training available within New Zealand for the aviation and marine

[12] Locomotive engineers.

industry to assess its suitability to meet the requirements of our operation. If accepted such training would be linked into our current training requirements for Locomotive Engineers, Signalbox and Train Control staff. (001/99)

1.12.4 In 2000, the issue was raised again in Rail Occurrence Report 00-106, track warrant overrun at Mataura by shunt Y35, when the earlier safety recommendation was expanded to include remote-control operators operating main line shunts and reissued as:

> introduce the formalised crew resource management procedures recommended in safety recommendation number 001/99, and ensure that such procedures include remote-control operators operating main line shunts. (006/01)

Tranz Rail replied:

> Tranz Rail accepts this recommendation. This is presently being evaluated to determine the best way to facilitate these principles to staff. Tranz Rail expects to complete this evaluation by end of June 2001. (006/01)

1.12.5 On 26 March 2008, Toll Rail advised that it had introduced a number of initiatives to facilitate crew resource management principles to all operating personnel and provided copies of pamphlets published in 2006 which were distributed to all staff as one of those initiatives.

1.12.6 On 24 April 2008, the Commission wrote to the Chief Executive of Toll Rail advising that the Commission was satisfied that the recommendation had been acted on and the status of the safety recommendation was now "closed acceptable".

Rail occurrence report 05-102, track warrant control irregularities, Woodville and Otane, 18 January 2005

1.12.7 On Tuesday 18 January 2005, a track warrant irregularity occurred when a track warrant was issued to the locomotive engineer of Train 627 at Otane authorising his train to proceed to Takapau to cross opposing Train 626.

1.12.8 Train 626 was scheduled to shunt at Takapau and, while berthed on the loop waiting to commence the shunt, the locomotive engineer heard the train controller issue a track warrant to the locomotive engineer of Train 627 at Otane authorising him to travel to Takapau to cross Train 626. The locomotive engineer of Train 626 knew that he was already in possession of a track warrant authorising him to advance to Waipukurau to cross Train 627 and realised that a conflicting track warrant had been issued. He notified the train controller immediately.

1.12.9 Had the locomotive engineer of Train 626 not challenged the train controller, Train 627 would have departed from Otane with the locomotive engineer in possession of a track warrant authorising him to cross Train 626 at a station beyond that to which Train 626 was already authorised to travel for the same crossing, creating a potential head-on collision situation.

Rail occurrence report 07-108, express freight Train 720 track warrant overrun, Seddon – Vernon, 12 May 2007

1.12.10 On Saturday 12 May 2007, express freight Train 720 travelled from Seddon to Vernon on the Main North Line without the authority of a track warrant issued from train control. The incident occurred when the locomotive engineer did not stop on the main line at Seddon, as required, to obtain a track warrant to travel beyond Seddon. Southbound Train 723 was sitting on the loop at Seddon at the time.

1.12.11 The locomotive engineer of Train 723 sitting on the loop was aware that Train 720 was required to stop and obtain a new track warrant, but did not say anything. Train 720 then travelled about 15.5 km towards Vernon before the train controller radioed the locomotive engineer to enquire about his whereabouts. By chance in this case there was no conflicting movement.

1.12.12 Among the findings of this investigation was that good crew resource management between the locomotive engineers of Train 720 and Train 723 could have prevented or minimised the extent of the track warrant overrun when the trains crossed at Seddon.

Rail occurrence report 07-110, collision express freight Train MP2 and Work Train 22 at Ohinewai, 19 June 2007

1.12.13 On Tuesday 19 June 2007, express freight Train MP2 was travelling between Huntly and Te Kauwhata when it struck a gantry crane from Work Train 22, which was stationary and working on the adjacent Down Main line with its cranes fouling the Up Main line. The gantry rotated on impact and struck the operator, knocking him from the wagon and into the passing train. The operator was fatally injured.

1.12.14 The accident occurred when the cranes they were operating were fouling the adjacent Up Main line in the path of the approaching MP2 because the person-in-charge was under the erroneous belief that protection for Work Train 22 had been arranged covering both main lines.

1.12.15 Although 2 persons associated with the Work Train 22 rail recovery operation were aware that Train MP2 was due to pass on the adjacent main line, which the work train was fouling during the rail recovery, neither had communicated this to the person-in-charge or taken defensive action to prevent the collision.

1.12.16 Among the findings from this investigation was that the quality of crew resource management, including management of resources at different locations such as the train control centre, locomotive cabs and track work sites, was of an inconsistent standard across the rail industry and contributed to the accident.

1.12.17 Arising from this investigation it was recommended to the Chief Executive of the New Zealand Transport Agency on 6 October 2008 that he address the following safety issue:

> The quality of crew resource management to achieve outcomes in this case, including the management of resources at different locations such as the train control centre, locomotive cabs and track work sites, sometimes using different communication methods, was of a poor standard, and previously published occurrence reports, as well as other, still open investigations, indicate that the standard of crew resource management across the rail industry is not adequate. (026/08)

1.13 A crew resource management occurrence brought to the Commission's attention

1.13.1 On Tuesday 25 September 2007, the train controller was contacted by a member of the public who reported sparks coming from the rear of a train that had just passed through Mangaweka. The train controller identified the train as express freight Train 222 and contacted the locomotive engineer by radio to advise him of the circumstances. The train controller said he had not considered that the train might have been derailed at that time but rather that one of the wagons at the rear had a defective wheelset.

1.13.2 When the train controller spoke to the locomotive engineer, he offered him the options of stopping where he was or continuing on to Utiku, where there was a train waiting for him to pass, the locomotive engineer of which could assist with the inspection. The locomotive engineer decided on the second option and continued towards Utiku.

1.13.3 The locomotive engineer said that he had not sensed any problems with the handling of the train and his first thought when he was told of the sparks was that one of the wagons probably had dragging brakes or a handbrake secured. Because of the poor underfoot conditions in the area he decided to continue on to Utiku, where he would inspect the train. However, before reaching Utiku his train lost air pressure in the brake pipe and came to a stop. He went back to determine the cause of the loss of air pressure and found that 2 wagons near the rear of the train had derailed and the train had parted behind the second derailed wagon. Damage to the track was extensive over several kilometres.

1.13.4 The train controller said that had the derailed wagons been identified and notified to him by a dragging equipment detector[13], he would have instructed the locomotive engineer to stop his train and check it. The locomotive engineer confirmed that if he received a message from the train controller which had originated from a dragging equipment detector he would have stopped immediately and checked his train.

1.13.5 When questioned about his training in crew resource management, the locomotive engineer said he could recall something from his bi-annual certification and safety observations but it was nothing specific, just part of the ongoing courses.

1.14 Tonnage left in section incident, Camden Road Tunnel, Camden Town, London, 19 July 2007[14]

1.14.1 When English, Welsh & Scottish Railway Train 7M59 from Angerstein Wharf to London St Pancras Churchyard Sidings started from Signal WH204 at the south end of Camden Road Tunnel, the screw coupling[15] broke between the second and third wagons from the back of the train. This resulted in an uncommanded application of the air brakes.

1.14.2 The driver examined the rear of the front portion of the train and concluded that while the train was stopped at Signal WH204, vandals had opened the brake pipe and main reservoir cocks and had removed the tail lamp. He did not realise that the train had divided and did not see the 2 detached wagons which were in the tunnel.

1.14.3 After the front portion had worked into Churchyard Sidings, the 2 detached wagons ran away southwards for 200-300 m, reversed direction and came to rest about 140 m from where the runaway started.

1.14.4 Two minutes after the front portion of the train had moved away from Signal WH204, the signaller noticed that the track circuit covering the southern end of Camden Road Tunnel was still occupied. He contacted the train driver, who checked his train at Churchyard Sidings and found that the 2 rear wagons were missing.

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[13] Dragging equipment detectors were installed to provide network protection by ensuring trains detected as having dragging equipment could be stopped before causing too much damage to the infrastructure. When activated, an alarm was sent to the train control and a voice message was activated over the local radio channel for immediate advice to any trains in the immediate vicinity.
[14] Information courtesy of Rail Accident Investigation Branch (RAIB), Department for Transport, United Kingdom, Report 12/2008.
[15] A type of coupling used to connect rail vehicles together.

1.14.5 Findings from this investigation included:

- the driver assumed that vandals were responsible for the missing tail lamp and open brake pipe and main reservoir cocks
- the driver's thinking was influenced by the amount of graffiti in the area of Camden Road Tunnel indicating frequent trespass of individuals onto the railway
- the driver did not take his train list with him when he went to examine the train following the automatic brake application on starting from Signal WH204
- the driver did not see the detached wagons standing in the darkness about 24 m apart from the front portion of the train
- the signaller did not challenge the driver's explanation of the cause of the brake application on starting from Signal WH204 and did not consider the possibility that Train 7M59 had divided.

1.15 Maritime CRM case study in New Zealand

1.15.1 The Interislander was a division of Toll New Zealand (also the rail operator). The division operated a passenger, rail and vehicular ferry service between the North and South Islands of New Zealand.

1.15.2 In response to a number of operating incidents that were linked in some way to inadequate CRM, the division decided to conduct a review of its CRM training programme. Most deck officers had attended a 2 day CRM training workshop and all masters had in addition attended a one week advanced training CRM workshop. Both workshops had been facilitated by a recognised training organisation specialising in CRM, yet the practical aspects of CRM were only being applied in a limited way and were not effective, as evidenced by the number of operating incidents.

1.15.3 The Interislander engaged experts from a cruise ship operator which at the time was considered one of the leaders in good CRM. A review was completed, which identified that although the concept of CRM was understood by the crew, it was not being practised.

1.15.4 A programme was designed which included putting all deck officers through a one-week workshop that focused on how to apply CRM, rather than what it is. The workshop was followed by a rigorous programme of operational audits where bridge teams were observed on the job, scored and given feedback. This follow-up programme continued for some time until the practice of good CRM became normalised; that is, inadequate CRM became the exception rather than the rule and was quickly corrected within the bridge teams without external input.

1.15.5 The intention was to extend the programme to other departments on board, but what was observed was that other departments naturally adopted the practices merely by interacting with the deck department. The success of the CRM programme was attributed not only to the training method, but to the commitment from management and the realisation that the programme never ends; it will always require monitoring and improvement.

2 Analysis

Introduction

2.11 Freight train partings were not an uncommon occurrence on the New Zealand rail network. There were 180 incidents reported during 2007 alone, but only one missing train end monitor during the same period. Instructions to be followed in such cases were contained in the operating rules and procedures. Had the procedures been followed properly by all parties concerned, then the risk of conflict would have been low because the true picture would have been realised immediately. As it was, a collision was averted by the last defence, the locomotive engineer of Train 243 proceeding cautiously as required under a Mis 59. This report examines why other safety defences in place to manage such a situation failed.

2.12 The investigation highlighted some human behavioural patterns as having contributed to the incident, together with an absence of crew resource management practices. Crew resource management as an aid to minimising operational human error has been raised by the Commission in previous occurrence reports.

2.13 Although actions have been taken by Ontrack and Toll Rail to raise the profile of crew resource management within the operating environment in response to previous safety recommendations, this investigation has revealed that the principles of crew resource management, even though they are included in staff training as well as other initiatives, are not being well practised within the rail industry in New Zealand.

Prior to departure from Te Rapa

2.14 The wagon to which the train end monitor had been attached prior to the departure of Train 239 from Te Rapa was ZL462. The wagon number had been notified to the locomotive engineer by the train examiner operations as he stood beside the wagon. The locomotive engineer had checked the wagon number against his train documentation and confirmed the wagon number as that of the rear wagon with the train examiner operations. The locomotive engineer had not highlighted the wagon number on his train documentation at this time, as he usually did, but the ZL classification of the rear wagon, if not the actual number, had obviously remained in his mind. Up to this point standard operating procedures were being followed.

Train parting at 514.9 km

2.15 Following the loss of air on Train 239, the locomotive engineer had walked back along the train expecting to find either a burst air hose or a missing train end monitor. When he arrived at the last wagon he found that the train end monitor was not there. He immediately concluded that the train end monitor had fallen off, become disconnected from the air pipe and allowed the air to escape through the open air tap.

2.16 Thinking that he had found the cause of the loss of air, he closed the air tap and started to walk back to the locomotive. He had walked about 2 wagon lengths when he realised that he had not checked the number of the rear wagon, so he shone his torch back towards the wagon number plate and saw the letter “Z”.

2.17 Once the locomotive engineer was back in the locomotive cab he referred to his train documentation and assumed that the letter “Z” he had seen in his torchlight was part of the number ZL462 and that his train was otherwise complete, and he advised the train controller accordingly.

2.18 Had the locomotive engineer referred to his train work order to confirm the number of the last wagon before leaving the cab he may also have registered that there were 32 wagons on the train. He could then have counted the number of wagons as he walked the train, which would have confirmed once he arrived at the rear of the train that there were 10 wagons missing, one-third of his train.

2.19 The ZH class wagon was a distinctive version of the "box car" in common use and was easily recognisable by its profile and smooth, white, fibreglass sides, compared with the ribbed steel sides of the less common red-oxide coloured ZL class. The difference in the wagons should have been obvious to the locomotive engineer, who had 5 opportunities to recognise the wagon was a ZH class:

- when he walked past the wagon on his way to the rear of the train
- when he closed the air pipe tap
- when he walked past the wagon on his way back to the locomotive cab
- when he shone the torch back at the wagon
- when he attached the replacement train end monitor at Otorohanga.

2.20 When the replacement train end monitor arrived at Otorohanga, the locomotive engineer travelled in the taxi to the rear wagon and had not walked the train as the train controller understood. Even so, he could still have realised from the colour and distinctive end profile of the rear wagon as he attached the replacement train end monitor that it was not a ZL class wagon.

2.21 The locomotive engineer may have been distracted by talking to the taxi driver at that time, but if there was any doubt in his mind that the wagon he was fitting the train end monitor to was not the last bonafide end of his train, it would have been immediately obvious. The locomotive engineer's actions, including his discussion with train control, made it obvious that he was satisfied that he had not left tonnage behind and it was going to take a lot to convince him otherwise.

After departing 514.9 km

2.22 Train 239 had been stationary at 514.9 km for about 30 minutes and as it moved away the train controller had been able to monitor its progress on the centralised traffic control visual display unit. At that time, and for a short time afterwards, the train end monitor was probably transmitting to the head end unit that there was no air pressure where the train end monitor was still attached to the brake pipe on ZL462 and also that ZL462 was not moving.

2.23 This same information would have been transmitted to the head end unit if the train end monitor had actually disconnected from the air hose and was lying undamaged on the ground. If the locomotive engineer had referred to the head end unit as he pulled away, the information it displayed would probably have only reinforced his notion that the train end monitor had become detached. Similarly, once the locomotive exceeded the transmitting range of the train end monitor, the radio break indication on the head end unit would have been the same whether the train end monitor had been left behind while attached to a rake of wagons or had become disconnected and fallen from the train. Because the locomotive engineer believed that the train end monitor had been lost, these head end monitor indications would not have challenged that belief or suggested to him that there may have been another reason for the loss in air brake pressure.

2.24 The train controller was aware that the number of the supposed rear wagon had been given to him from the locomotive cab and not from alongside the wagon. When told that the locomotive engineer would advise the train controller of the number of the last wagon on return to his locomotive cab, the train controller should immediately have insisted that the number instead be given from the rear wagon. This would have immediately established from his train list that at least one wagon was missing from the rear of the train.

Train control

2.25 After Train 239 had departed from Te Kawa, B Track and A1 Track indications in the Te Awamutu – Te Kawa block section, where the train had been stationary, remained illuminated on the centralised traffic control visual display unit. This had alerted the train controller that something may be wrong and he contacted the locomotive engineer and asked if his train was complete. The locomotive engineer had confirmed that there was air through the train and that it was complete, but of course there would be air through his train because he had closed the air tap on the last wagon.

2.26 The illuminated track indications in the Te Awamutu – Te Kawa block section after Train 239 had departed the section provided good grounds for the train controller to instruct the locomotive engineer to stop his train and carry out another check of the rear wagon number to confirm that the train was complete. Up until this time the number of the last wagon of the rake attached to the locomotive had not been physically sighted and Train 239 should not have moved beyond Te Kawa until such a physical check had been done.

2.27 The train controller was sufficiently experienced to have realised that the illuminated track indications represented an unusual situation, particularly as Train 239 had made an uncommanded stop in the vicinity. His suspicions should have been raised because there had been no signalling defects prior to this situation that he was aware of and it should therefore have been logical that the illumination of the track circuits was highly likely to have been related to the stopping of Train 239.

2.28 Even if the train end monitor had become detached from the rear wagon, it was not long enough to have made contact across both rails, and even if it had been it would only have affected one track indication, not 2. That 2 track indications remained illuminated after Train 239 moved away does not appear to have been noticed by the train controller, or, if it was, he did not consider it warranted further investigation. Although the train end monitor could have come to rest across a track joint, or damaged a bond wire, causing the track circuits to remain illuminated as though occupied, these scenarios were unlikely.

The signalling system

2.29 The centralised traffic control signalling system was operating as designed. Both B and A1 Tracks were illuminated because they were still occupied by the rear 10 wagons which straddled the track joint. The safety defence in centralised traffic control signalling to prevent another train entering an already occupied or potentially unsafe block section was that in this instance the Departure signals at either end of the block section could not be cleared to “proceed”. The manual overriding of the “Stop” indication on the Departure signal at Te Awamutu by the issue of a Mis 59 to allow Train 243 to enter the block section effectively removed the safety defence to prevent potential conflicts, and it was of concern that the safety defence of a correctly operating signalling system could be so easily bypassed.

2.30 The train controller had 2 options available to him to verify the conflicting information regarding the completeness of Train 239: either instruct the locomotive engineer to stop the train and carry out a physical check, or arrange for Ontrack staff to be called out to run the section. Either option would have established the reason for the illuminated track indications much sooner and before the issue of the Mis 59 to Train 243. There was a requirement for the train controller to report the alleged Departure signal “failure” to Ontrack’s signals staff, but there was no requirement for staff to accept the callout if there would be few trains affected before the fault could be rectified in normal work hours. As this incident occurred at the weekend, when rail traffic was light, it was unlikely that callout staff would have responded immediately had they been called.

2.31 There was sufficient time after Train 239 cleared the Te Awamutu – Te Kawa block section and before Train 243 arrived at Te Awamutu for Ontrack staff to have been notified and to have commenced a patrol of the section before the arrival of Train 243. However, the train controller chose instead to advance Train 243 through the section on a Mis 59 authority to satisfy himself that the cause of the illuminated track indications on the centralised traffic control visual display unit was not a "ghost" indication. The use of Train 243 for this purpose was inappropriate, given the conflict between information from the locomotive engineer of Train 239 and that displayed on the visual display unit. This conflict should have been resolved before any train was authorised to enter the affected block section.

2.32 The length of the 10 wagons left at the 514.9 km was 150 m and the section of track covered by the illuminated B Track and A1 Track indications measured 3218 m. It had not been possible to establish how much of the rake straddled each side of the track joint between Tracks B and A1. Based on the worst-case scenario of 9 of the 10 wagons being positioned on the Te Awamutu side of the track joint, and therefore closest to the end of the section from which Train 243 would approach, 135 m of B Track would have been occupied from the track joint back towards Te Awamutu. In this case the locomotive engineer of Train 243 could have been able to see the train end monitor reflector from about 2000 m away when his train entered the straight section of track at 516.321 km. This distance would increase depending on how many wagons were physically positioned on each side of the track joint, but in any case the distance was sufficient for him to see the obstruction in plenty of time and react accordingly, because he was driving his train as required, with caution.

Issue of the Mis 59

2.33 The issue of a Mis 59 will always place a rail vehicle at risk even though the vehicle must proceed cautiously through the block section, expecting to find unsafe conditions ahead. This placed further responsibilities on the locomotive engineer, not only to drive his train safely through the section, but also to be on the lookout for obstructions or other unsafe conditions. The train was authorised to enter a section with potentially unsafe conditions; it was effectively heading into "dark territory" as track warrant territory is commonly referred to.

2.34 The theory of accident prevention in complex and high-risk systems is that there should be a series of measures in place to guard against each significant hazard. Accidents often occur when one of these protective systems is out of operation for some reason, and this is a time when people need to be especially sensitive to risk. Where a signal has "failed to red" and drivers are authorised to pass it, one of the regular safeguards against collisions is not operating. This is a situation of heightened risk, where heightened awareness of risk would be desirable.

2.35 Prior to issuing a Mis 59 for a train to enter a block section, the train controller was required to establish that any preceding train was clear of the section and complete. In his attempts to confirm this, the train controller had twice spoken to the locomotive engineer of Train 239 and both times the locomotive engineer had confirmed his train was complete. The train controller twice accepted the locomotive engineer's affirmation, despite the illuminated track indications on the centralised traffic control visual display unit in front of him.

2.36 The locomotive engineer of Train 243 had operated his train in accordance with the operating rules and procedures implicit with the issue of a Mis 59, specifically that he travel cautiously, being prepared to find the section obstructed. His train handling, together with good visibility and his discomfort with the situation, meant that the risk of a collision was low.

Track warrant control

2.37 Track warrant control was introduced to New Zealand Railways in 1988 as an alternative to a signalling system for train operation on lower traffic density lines. Track warrant control was a method for ensuring that only one train or vehicle had authority to occupy a section of the track at any one time.

2.38 Track warrant control areas contained locations known as warrant stations for the purpose of crossing trains. The majority of warrant stations were equipped with motor points, which allowed opposing trains to cross, with the locomotive engineers manually operating the signalling system and points to enter the loop. Additionally, track circuiting linked to the arrival signals and points indicators provided a degree of interlocking at each end of the warrant station.

2.39 Track warrant control was referred to as "dark territory", because the route was not track circuited and could not therefore be monitored by train control, unlike centralised traffic control. Track circuiting and interlocking applied only in the immediate vicinity of the crossing stations and track detection did not extend beyond 1300 m into the single line section at either end. In centralised traffic control, track circuiting extended through the section to the next crossing station in advance.

2.40 Because track warrant control territories were not track circuited, the location of trains could not be tracked on a visual display unit as in centralised traffic control territories. Therefore, if Train 239 had parted in track warrant control territory, the rake of wagons left in the section would not have illuminated any track indications in front of the train controller nor activated any signals to prevent another train entering the section or warn of the presence of the rake.

2.41 Under this scenario, the consequences could potentially have been more serious because a train could have approached the stationary rake at maximum authorised line speed rather than cautiously as required by the conditions of a Mis 59 and, unless the locomotive engineer had seen the train end monitor reflector and been able to stop in time, a serious collision was a likely outcome. This highlights the importance of following the standard operating procedures at all times.

Human factors

2.42 The locomotive engineer of Train 239 had gone back expecting to find either a burst hose or a missing train end monitor as the cause of the depleted air pressure and uncommanded stop. One of the reasons why false hypotheses can persist is the tendency known as "confirmation bias". Once humans have a theory to explain an otherwise ambiguous situation, they tend to search for information that will confirm what they suspect. People, however, rarely attempt to prove themselves wrong and, in fact, often disregard information that would contradict their ideas. For example, lost pilots will sometimes try to guess where they are, and then look for ground features that are consistent with that idea, ignoring those that are inconsistent[16].

2.43 The locomotive engineer clearly had decided that his train had stopped uncommanded by him due to either a burst air hose or losing the train end monitor. He said that he had thought this before he left the cab once the train had stopped. Why he thought it was one or the other is not explained, but could be related to past experiences or even hearing of others' experiences.

2.44 By the time he reached what was now the back of his train and had not found a burst air hose, he was looking for a missing train end monitor, and that was exactly what he found. His hypothesis was confirmed, notwithstanding the fact that missing also was one-third of his train. The fact that it was dark and had begun to rain may have been an influencing factor.

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[16] "Errors, decision-making and violations"; Alan Hobbs, Australian Transport Safety Bureau Human Factors for Transport Investigators Course, Canberra, 2000.

2.45 Sure in his own mind that his train end monitor had fallen off, he omitted to follow the procedure of identifying the last wagon on his train. When he did remember to do this, the mere sighting of the letter "Z" from a distance was all he needed to confirm that he was looking at what was supposed to be the last wagon, even though the profile and colour of the wagon types were different and even though there are a number of other wagon types with "Z" as their leading identifier.

2.46 Even when questioned by the train controller if he was sure his train was complete, he used the rationale that it must be, because he had air pressure throughout his train, which of course he did have since he had closed off the tap on the last wagon.

2.47 Since he had been advised by the locomotive engineer that the train end monitor was missing but had received confirmation that his train was complete, the train controller also, to a degree, formed a false hypothesis that the monitor must have fallen on the rail and caused the signalling system to show the section as occupied, a possibility also supported by the locomotive engineer. In fact the train end monitor was not long enough to reach between the rails, which the train controller might not have known, but, more importantly, it would have had to land on the top of the rail from a moving train and come to rest across a bonded rail joint to show 2 sections occupied on the CTC video display unit, a possibility but less likely than a train parting..

Crew resource management

2.48 The train controller's reluctance to challenge the locomotive engineer and risk a confrontation may have been based on a perceived authority gradient between himself and the locomotive engineer. This term refers to the balance of decision-making power or the steepness of command hierarchy in a given situation. Expressing concerns, questioning, or even simply clarifying instructions would require considerable determination on the part of team members who perceive their input as devalued or unwelcome.

2.49 The train controller's 4 years' experience in train control, when compared with the locomotive engineer's more than 30 years in locomotive operating duties, could conceivably have influenced him not to challenge further, even though he had doubts about the completeness of the train. For his part, the locomotive engineer had based his responses and actions on his "confirmation bias" that the train end monitor had been lost from the rear of the train. Historical evidence and probably his own experience should have suggested to him that instances of train end monitors falling from trains were now rare and that a train parting was the more likely cause of the uncommanded stop, given the frequency with which they occur.

2.50 The locomotive engineer of Train 243 had concerns surrounding the issue of the Mis 59 and for that reason it would have been better for him to have challenged the train controller regarding the reason for the Mis 59, or else refused to accept and act on it. Toll Rail's crew resource management training identified being prepared to challenge as one of the 3 basic actions of crew resource management yet, despite his misgivings, the locomotive engineer did not challenge the train controller over the issuing of the Mis 59 and instead accepted and acted on it, albeit against his better judgement.

2.51 The 2 hours spent by Toll Rail on crew resource management during the initial induction training of new staff, especially when compared with that of the railroads surveyed in the US Department of Transportation study, showed that the Toll Rail crew resource management training programme was much shorter, included more "self-training" and "tick in the box" activities and was not as extensive as training practised by those railroads. When taken in the context of the total training time, this short and comparatively light training approach taken could signal to staff a "not that important" message, and could be a reason for the lack of effective crew resource management within the operating environment identified in this and other investigations undertaken by the Commission. An example of this was the locomotive engineer's comments in relation to the Utiku derailment, referring to crew resource management training as being "nothing specific, just part of the ongoing courses".

2.52 The derailment of Train 222 near Utiku 3 days after Train 239 had parted could not have been avoided as the wagons were most likely derailed when the train controller was first notified by a member of the public. However, the application of appropriate crew resource management principles between the train controller and the locomotive engineer on receipt of that notification would have resulted in reducing the distance the derailed wagons were dragged, thereby minimising the amount of infrastructure damage and reducing the risk of an even more extensive derailment, and potential damage to other property as well.

2.53 The lack of crew resource management principles applied by staff during this incident suggested that they were not sufficiently trained, lacked understanding or considered crew resource management was "not that important" in such situations. Certainly the level of training offered by both Toll Rail and Ontrack was not as comprehensive as that detailed in the US Department of Transportation report, and still does not appear to meet the requirements of staff, despite enhancements made in response to safety recommendations arising from earlier incidents.

2.54 The challenge for the rail industry will be to create a culture where crew resource management is not only understood, but is practised, and is supported by management at the highest level. Already a division of the rail operator has shown how this can be done within its own crews. The challenge is to have all stakeholders take part – train crews, track staff, train controllers and others who interact with the system operationally. A safety recommendation covering the standard of crew resource management training is made to the Chief Executive of New Zealand Transport Agency.

3 Findings

Findings are listed in order of development and not in order of priority.

3.1 About one-third of Train 239 was left in the Te Awamutu – Te Kawa section when the train parted without the locomotive engineer's knowledge.

3.2 The locomotive engineer did not properly ascertain that the train was complete before resuming the journey.

3.3 The human factors phenomenon of "confirmation bias" contributed to the locomotive engineer believing his train was complete even when information, including challenges from the train controller, suggested otherwise.

3.4 There were enough indicators for the train controller to have reasonably suspected that part of train 239 was still occupying the section after the train resumed its journey. The proper course of action would have been for him to direct the locomotive engineer to stop and recheck his train, or arrange for a track inspection before sending the next train into the section.

3.5 Had the same event occurred in track warrant territory, which is about 54% of the total network, the potential for a high-speed collision was great.

3.6 The inadequate standard of crew resource management displayed in this occurrence, together with that recorded in relation to other occurrences notified to the Commission, is an indication that the rail industry in New Zealand would benefit from a review of how effective the current training programme is in firstly promoting the knowledge of effective crew resource management and secondly putting it into practice.

4 Safety Recommendations

4.1 Because effective crew resource management is a critical component of every rail participant's operational safety system, and is particularly critical to safe outcomes where rail operational systems integrate, on 18 December 2008 the Commission recommended to the Chief Executive of New Zealand Transport Agency that he ensure that a review is undertaken of current crew resource management training by all participants in the rail industry, including how the principles of crew resource management are being implemented. The outcome of the review and any corrective action should ensure that staff are equipped with the skills necessary to effectively use crew resource management techniques to reduce operational occurrences. (033/08)

4.2 Ensuring the completeness of a train following a train parting or similar event is a safety-critical procedure for protecting against wagons being inadvertently left behind and creating the potential for a high speed collision in track warrant territory. The Commission believes that the circumstances where the procedure for ensuring the completeness of the train was so easily by-passed on this occasion is a safety issue. On 7 January 2009 the Commission recommended that the New Zealand Transport Agency address that safety issue. (001/09)

Approved on 18 December 2008 for publication

Hon W P Jeffries
Chief Commissioner

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