Final report RO-2016-101: Signal passed at danger leading to near collision, Wellington Railway Station, 28 May 2016

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

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Final Report

Rail inquiry RO-2016-101
Signal passed at danger leading to near collision

Wellington Railway Station

28 May 2016

Approved for publication: December 2017

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (the Commission) is a standing Commission of inquiry and an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector and the public, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

Commissioners

Chief Commissioner	Jane Meares
Commissioner	Peter McKenzie, QC
Commissioner	Stephen Davies Howard
Commissioner	Richard Marchant
Commissioner	Paula Rose

Key Commission personnel

Chief Executive	Lois Hutchinson
Chief Investigator of Accidents	Captain Tim Burfoot
Investigator in Charge	Christopher Asbery
General Counsel	Cathryn Bridge

Email	inquiries@taic.org.nz
Web	www.taic.org.nz
Telephone	+ 64 4 473 3112 (24 hrs) or 0800 188 926
Fax	+ 64 4 499 1510
Address	Level 16, 80 The Terrace, PO Box 10 323, Wellington 6143, New Zealand

Important notes

Nature of the final report

This final report has not been prepared for the purpose of supporting any criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

Ownership of report

Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1982 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.

Verbal probability expressions

The expressions listed in the following table are used in this report to describe the degree of probability (or likelihood) that an event happened or a condition existed in support of a hypothesis.

Terminology (adopted from the Intergovernmental Panel on Climate Change)	Likelihood of the occurrence/outcome	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

Location of incident

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Abbreviations

ETCS	European Train Control System
LED	light-emitting diode
m	metres
NTS	non-technical skills
SPAD	signal passed at danger
TXO	Train Examiner Operations

Glossary

A Box	informal local name for the manually operated electro-mechanical signalbox controlling signals and points between Wellington Railway Station and Ngāūranga. Also known as the Wellington Signalbox
ETCS	an integrated automatic signalling system that alerts drivers to the status of signals ahead, moderates train approach speeds automatically for specific locations and automatically applies the train brakes in a SPAD (does not prevent SPADs but does minimise the possible distance a train can go past a Red-STOP signal)
Non-Technical Skills	formerly known as Crew Resource Management, these skills complement technical skills and include the interpersonal skills of communication, leadership and teamwork and the cognitive skills of decision making, situational awareness and task management. NTS are part of human factors and bolster the success of threat and error management
relay	a train movement from a station platform to another platform, or between a station platform to a storage yard or maintenance facility
route indicator	an illuminated display typically found below the signal heads that tell the driver which route the train is taking, displayed with one or two characters. The meaning of the characters is specific to each signal, but usually follows conventions such as '**D**' for Down Main
safety overlap	the section of track beyond a signal that is considered to be part of the track before the signal, and acts as a safety buffer in which a SPAD train can safely stop
SPAD A	when a train passes a perfectly displayed STOP signal without authorisation
Tranzlog	an on-board data recorder that logs details of a train's speed, location, control settings, etc (see www.otari.co.nz)
Train Examiner Operations	the role responsible for coupling, uncoupling, brake testing of trains and shunting duties around rail depots and stations
white arrows	white, non-reflective and non-illuminated diagonal arrows on the uprights of signal posts pointing to the track the signal is controlling. These are unique to signals 99 and 100 in Wellington and assist signal identification

Data summary

Vehicle particulars

Train type and number:	Matangi
Classification:	electric multiple unit
Manufacturer:	Hyundai Rotem, Korea
Operator:	KiwiRail until July 2016[1]
Date and time	28 May 2016 at 0007[2]
Location	Wellington Railway Station – Signal 100
Persons involved	relay train driver and Train Examiner Operations,[3] Upper Hutt train with 79 passengers, signalman
Injuries	none
Damage	none

Figure 1
A Matangi train at Wellington Railway Station

[1] On 3 July 2016, five weeks after this incident, the operation of the Wellington Region commuter services on behalf of Greater Wellington Regional Council transferred from KiwiRail Tranz Metro to Transdev.
[2] Times in this report are New Zealand Daylight Saving Time (Co-ordinated Universal Time +13 hours) and are expressed in the 24-hour mode.
[3] Train Examiner Operations duties include coupling and uncoupling electric multiple units (EMUs), brake testing, shunting duties and manually setting points in/out of storage yards.

1. Executive summary

1.1. Shortly after midnight on Saturday 28 May 2016, an empty passenger train was being moved from Platform 7 at Wellington Railway Station (Wellington Station) to the West Storage Yard for overnight storage. At about the same time a passenger train with 79 passengers on board departed from Platform 5 bound for Upper Hutt. Their respective routes would cross within a short distance from the platforms. It was dark and raining.

1.2. The signal box controller had set a clear (Green) route for the Upper Hutt train and had set a Red Stop signal to hold the empty train just short of the cross-over point until the Upper Hutt train had cleared that section of track.

1.3. However, there was another signal showing Green, adjacent to the Red signal meant for the empty train. The driver confused the two signals, and thinking the Green signal was meant for his train, he continued past the Red signal towards the cross-over point.

1.4. The driver realised his mistake just as his driving cab passed between the Red and Green signals and immediately stopped his train just 12 metres short of the cross-over point. The Upper Hutt train passed through the cross-over 13 seconds later. Both trains were restricted to a maximum speed of 20 kilometres per hour. There was no collision and nobody was injured.

1.5. Noting that train drivers failing to stop their trains at Red signals is a known and foreseeable risk, the Commission found that there should have been more checks or defences built into the system to prevent this near collision when the driver confused the two signals.

1.6. The Commission also found that due to the geographically constrained and congested nature of the Wellington Station area, there are fewer fail-safe back-up systems than would normally be associated with a modern track and signalling system. Consequently, there is an elevated risk of trains colliding in the area that will need to be managed now and in future.

1.7. Safety issues identified during the inquiry included:

- the heightened risk of trains colliding within the approaches to Wellington Station because limited space makes the track layout congested
- a number of reasonable measures had not been taken to further reduce the risk of trains colliding in the approaches to Wellington Station. These include the provision of providing better recognition of signals, standard procedures for signalling trains through the area, and better communication between train drivers and persons controlling the trains

1.8. The Commission refers to a previous recommendation to address issues with communication, and makes two new recommendations to address immediate and long-term solutions for managing the risk in the Wellington Station area.

1.9. Key safety lessons arising from this incident are that:

- all safety-critical systems should have checks and defences designed into them that mitigate against human error resulting in incidents or accidents
- there should be sufficient clear and concise communication between persons responsible for controlling trains and train drivers so that all parties are aware of the situation and alert to any threats to safe train operations.

2. Conduct of the inquiry

2.1. The incident occurred at 0007 on Saturday 28 May 2016. The NZ Transport Agency notified the Transport Accident Investigation Commission (the Commission) soon after the incident occurred. The Commission opened an inquiry under section 13(1) of the Transport Accident Investigation Commission Act 1990 to determine the circumstances and causes of the occurrence and appointed an investigator in charge.

2.2. The Commission investigators travelled to Wellington Station on Monday 30 May to commence the site investigation.

2.3. On 10 June, Commission investigators, KiwiRail and representatives from NZ Transport Agency, re-enacted the incident under controlled conditions. Two Matangi trains departed from Platforms 7 and 5 of Wellington Station. The front of the simulated relay[4] train was stopped on the paint mark made after the incident, and the simulated Upper Hutt train was stopped across the points in front of the relay train. Measurements and photographs were taken to determine the relative positions of the two trains.

2.4. Commission investigators interviewed the:

- relay train driver
- Train Examiner Operations (TXO) who accompanied the relay driver in the cab at the time of the incident
- driver of the Upper Hutt service
- signalman on duty at the time of the incident
- KiwiRail's signalling engineers.

2.5. The Commission obtained the following documents and records for analysis, including:

- closed-circuit television recordings from the cameras on board the relay and Upper Hutt trains
- signals data from the Wellington Station signalling system
- training records and medical details
- KiwiRail's Crew Resource Management documentation
- historical signal passed at danger (SPAD) data for the Wellington Station area
- roster details for the relay driver
- Tranzlog[5] data from both the relay train and the Upper Hutt service train
- KiwiRail signalling design and operation principles documents
- the Commission requested the recordings of the Wellington Signalbox Channel 1 radio communications for the time period of this incident but the radio recording system had not been functional at the time.

2.6. On 27 September 2017, the Commissioners considered a draft report and approved it to be sent to interested persons for consultation.

2.7. The Commission received submissions from five interested persons and these were considered in the preparation of the final report.

2.8. On 13 December 2017, the Commission approved the publication of its final report.

[4] A relay train is one that is being moved into or out of service either to or from a storage or servicing facility to deal with differences in peak and off-peak demands.
[5] On-train data recorder that logs speeds, control settings etc (similar to an aeroplane's black box).

3. Factual information

3.1. Background

3.1.1. The train storage yard and the train maintenance facilities are close to Wellington Station. Consequently, the track layout with the required cross-over points between the main lines on the approaches to the station are congested due to the limited area available. The close proximity of the train storage yard and train maintenance facility contribute to a high number of train 'relay' movements passing through this congested area.

3.1.2. The majority of relay movements around Wellington Station are empty train movements into and out of the train storage yard to facilitate the demands of peak and off-peak times. However, other types of relays include moving trains from one platform to another, taking a train into or out of a maintenance facility, or taking the train through the automatic train wash system.

3.1.3. This incident involved an empty train that was being moved from Platform 7 into the train storage yard for the night (route depicted in green on Figure 2 below).

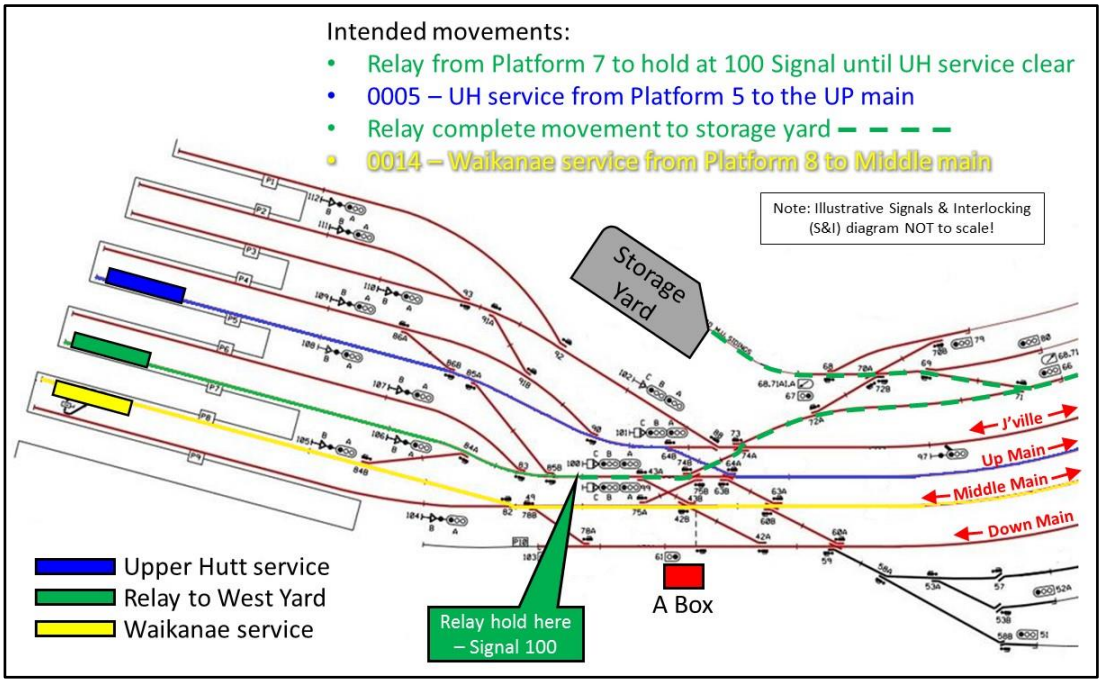


Figure 2
Diagram of planned train movements

3.1.4. Around the same time as the relay movement, an Upper Hutt service (depicted in blue on Figure 2 above) was scheduled to leave Platform 5 at 0005 for the Up Main, passing ahead of the relay train. Also a Waikanae service (depicted in yellow on Figure 2 above) was scheduled to depart Platform 8 at 0014 for the Middle Main, by which time the relay should have been completed.

3.1.5. The trains were all being controlled by a signalbox controller (the signaller) from the Wellington Signalbox, locally know as 'A Box' (depicted in red on Figure 2 above).

3.2. Narrative

3.2.1. A driver who had just completed his shift was asked to drive a relay train to the train storage yard. This type of request was not unusual and the driver could say no without repercussion. Just after midnight on 28 May, the driver and a TXO boarded the relay train. The TXO was present to set the manual points into the storage yard. Once in the driving cab the TXO took the left-hand seat but played no part in the relay train movement.

3.2.2. It was dark at the time and light rain was falling. The driver was using the windscreen wipers on the train, which he reported were working well.

3.2.3. The signaller had pre-set the signals for all three trains departing Wellington. For the Upper Hutt service from Platform 5 all signals were set to 'Green – Proceed' to the Up Main. The Relay was signalled to leave Platform 7 with a 'Yellow – Caution-to-Stop' signal while the next signal (100) was set to 'All Red – Stop'. The Waikanae service was held on Platform 8 by an 'All Red – Stop' signal, but the next signal (99) was pre-set to 'Green – Proceed' with its route indicator displaying 'M' for the Middle Main (see Figure 3).

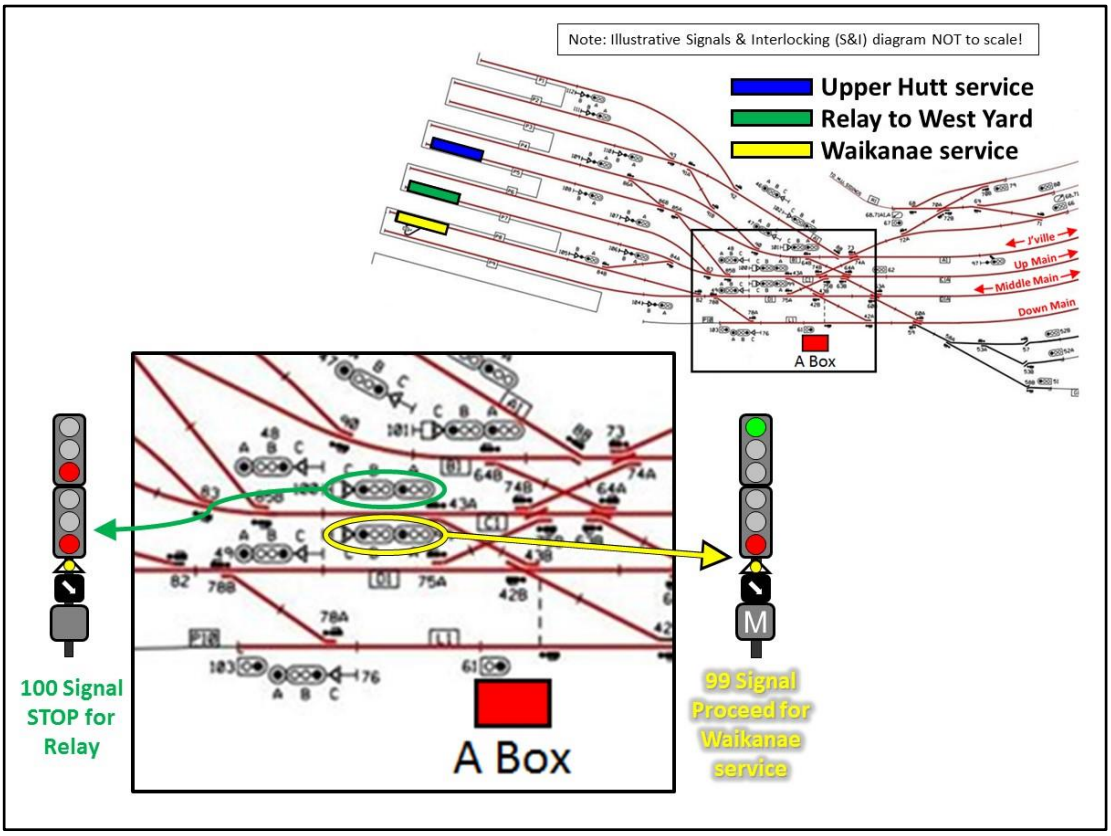


Figure 3
Signal set-up for signals 99 and 100 that the relay driver saw
(for full image of signal set-up for all three trains see Appendix 1)

3.2.4. The relay departed from Platform 7 authorised by the signal displaying a 'Yellow over Red – Caution-to-Stop' indication. This meant the next signal at that time was set at 'All Red – Stop'.

3.2.5. Within seconds of the relay departing the platform, the passenger service destined for Upper Hutt departed Platform 5 with 79 passengers on board.

3.2.6. At 0007, the relay approached signal 100 on the left-hand side of the track, which was still displaying an 'All Red – Stop' indication. However, signal 99 on the right-hand side of the track was displaying a 'Green – Proceed' indication. Although it had a route indicator displaying an 'M' for the Middle Main, the relay driver mistook the signal on his right to be for his relay and

did not stop his train, passing signal 100 at 'All Red – Stop' (see Figure 4). Passing a signal displaying this indication is classed as a SPAD A[6] (signal passed at danger category A).

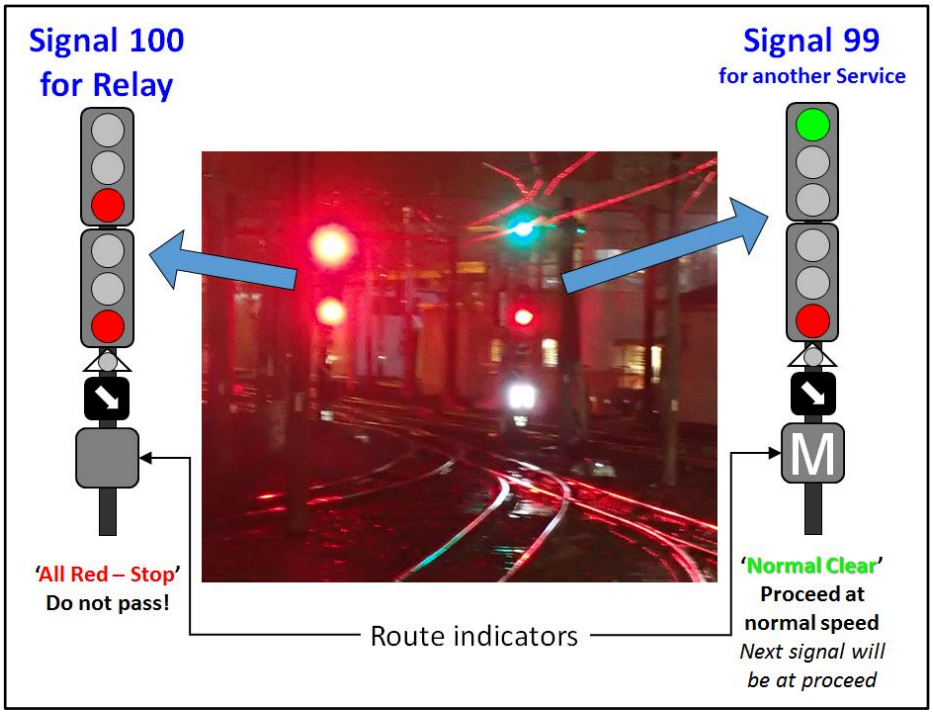


Figure 4
Signal 100 (left) and 99 (right) as seen by the relay driver

3.2.7. The relay driver realised his mistake as he drew level with the 'Stop' signal and applied the train brakes, bringing the relay movement to a full stop 30 metres (m) beyond the signal.

3.2.8. Simultaneously, the signaller noticed that the relay train had passed the signal at 'Stop' and waved vigorously out of the window in an attempt to get the relay movement to stop.

3.2.9. The Upper Hutt service crossed through the set of points directly in front of the relay train 13 seconds after it had stopped. (see Figure 5)

3.2.10. The distance between the relay train and the passing Upper Hutt service was 12 m.

3.2.11. The incident was reported to Train Control and the driver was relieved of the relay train and taken for drug and alcohol testing.

[6] SPAD means passing a STOP signal without authorisation. A 'SPAD A' is passing a perfectly displayed STOP signal without authorisation.

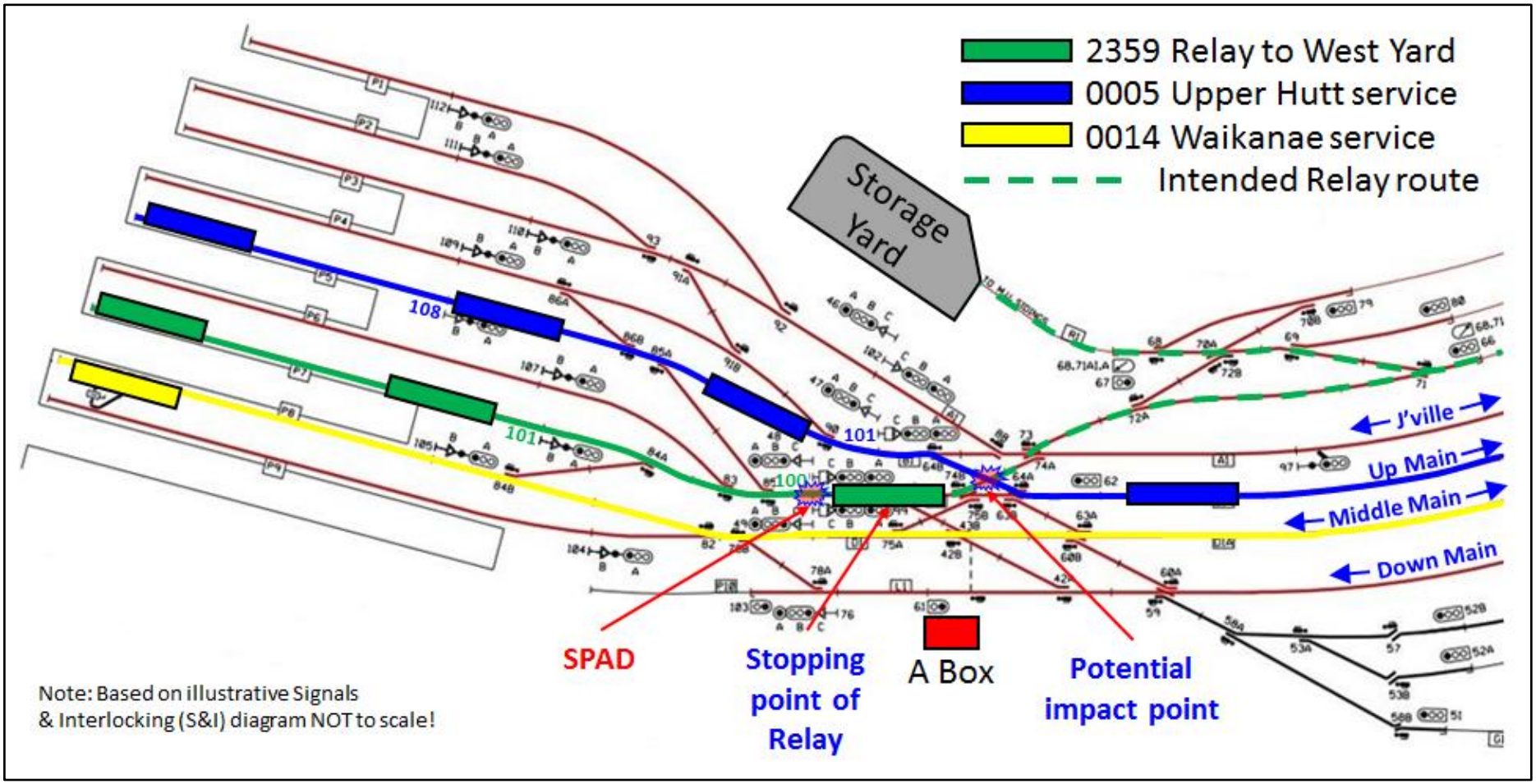


Figure 5
Schematic of train movements

3.3. Personnel information

3.3.1. Both the relay and Upper Hutt service drivers, plus the signaller and TXO, were all certified for their respective roles at the time of the incident.

3.3.2. The relay driver had been certified to drive Matangi units 12 months prior to the incident.

3.3.3. The relay driver was not familiar with the Wellington driver adage used by some that is 'left leaving – right arriving'. This means that when leaving Wellington Station the signals for the route will be on the left-hand side of the track, and when arriving into Wellington the signals are on the right-hand side of the track. However, when leaving platform 7 both signals 99 and 100 appear from the left hand side of the driver until approximately 30 m away, when it becomes clear the train will pass between the two signals and signal 100 is on the left hand side of the train.

3.3.4. The signaller had a total of 41 years' experience in Wellington rail, completing the last 11 years as a signaller in Wellington Signalbox, after four years as a signaller in Taita Signalbox.

3.3.5. Following the incident, the relay driver underwent a KiwiRail post-incident drug and alcohol test, which returned a negative (clear) result.

3.4. Track layout

3.4.1. The signals between Wellington Station through to Ngāūranga are manually controlled from the Wellington Signalbox known locally as A Box.

3.4.2. Part of the track layout just north of Wellington Station is congested due to a lack of available land (see Figure 6), There are multiple sets of points and possible direction or track changes available over a short distance.

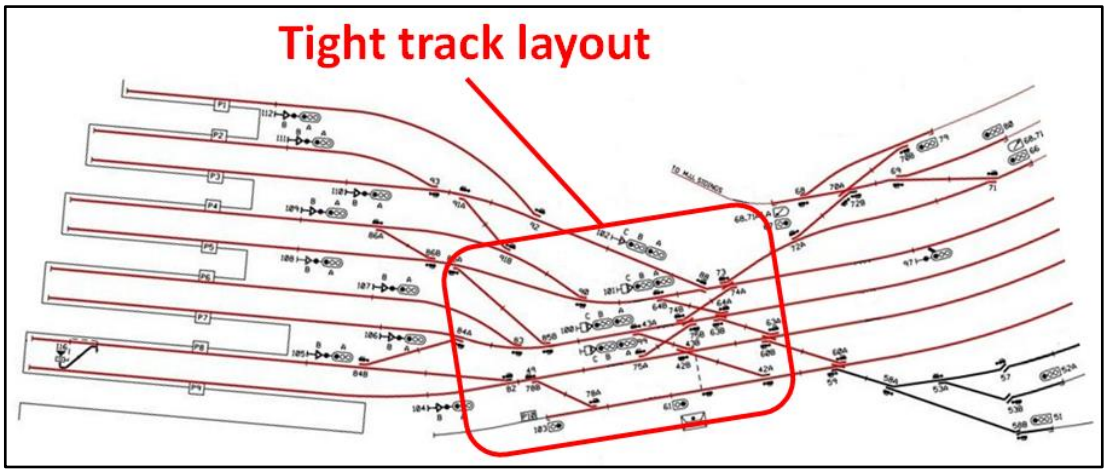


Figure 6
Congested track area north of Wellington Station

3.4.3. The track layout and its associated signalling system was originally built in 1937. A number of improvements to the track and signalling infrastructure have been made over time, including:

- the upgrading of individual signals from the older searchlight type to modern LEDs (light-emitting diodes) (see Figure 7)

Figure 7
Old searchlight vs modern LED signals

- the placement of route indicators (see Figure 8) to Directing Signals in the area to identity the route which has been set, indicated by illuminated characters

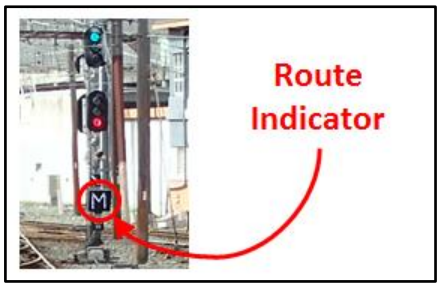


Figure 8
Route Indicator

- the addition of non-reflective white arrows to the uprights of signals 99 and 100 in 2005, to assist drivers to identify which signal is controlling which track

- the introduction of a third bi-directional main line into and out of Wellington in July 2010 (see Figure 9) to improve flexibility into and out of Wellington Station.

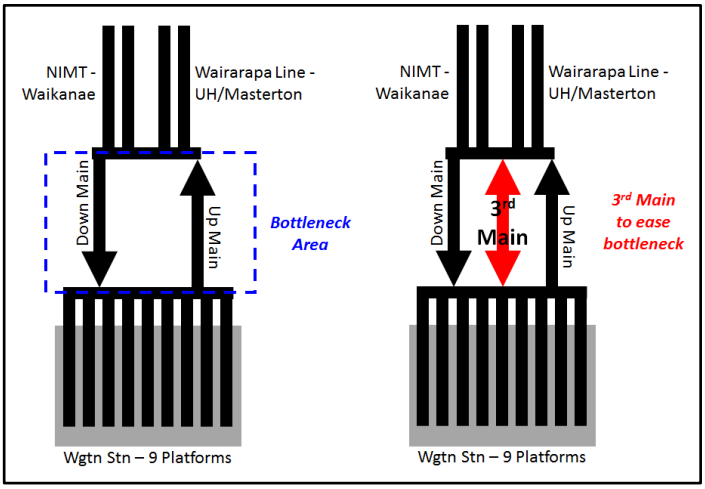


Figure 9
Addition of third main line – bi-directional in 2010

4. Analysis

4.1. Introduction

4.1.1. The following analysis discusses the circumstances that resulted in the relay train passing signal 100 when it was at Red Stop and setting up a potential collision with the departing Upper Hutt service.

4.1.2. The analysis also discusses the following safety issues, identified during the inquiry:

- there is a heightened risk of trains colliding within the approaches to Wellington Station because limited space makes the track layout congested
- there are a number of reasonable measures that had not been taken to further reduce the risk of trains colliding on the approaches to Wellington Station, such as: providing better recognition of signals; standard procedures for signalling trains through the area; and better communication between train drivers and persons controlling the trains
- the standard of non-technical skills (NTS), formerly known as Crew Resource Management, between the driver, the TXO and the signaller were ineffective.

4.2. What happened

4.2.1. There had been no radio communication between the signaller and the relay driver before the relay train departed Platform 7. He was unaware of what other train movements were happening at the time. He just knew what the destination for his train was and departed the platform in accordance with the signal. The signal was at that time showing Yellow over Red, which meant that the next signal ahead (signal 100) was displaying Red.

4.2.2. The next signal ahead was displaying Red because the signaller had set a route for the Upper Hutt train, which would cross ahead of the relay train. The cross-over point was approximately 43 m ahead of signal 100 which was showing Red.

4.2.3. In line with signal 100, on the opposite side of the track, was signal 99. The signaller had pre-set signal 99 to Green in anticipation of routing the Waikanae train that was still sitting at Platform 8 taking passengers on board.

4.2.4. Instead of stopping his train at the Red signal 100 on his left, the driver of the relay train mistook the Green signal 99 on his right as being for his train and continued past it. Both signals had a placard with a white arrow on a black background pointing towards the track to which they applied (see Figure 4). However, the arrows are not illuminated or reflective and are difficult to see in the dark and the rain.

4.2.5. Additionally, the signal required to get from the platform to the storage yard would be a ‘Red over Red light with a Low Speed Yellow light’, so the driver should not have taken a ‘Green Proceed’ indication on either signal (see Figure 10).

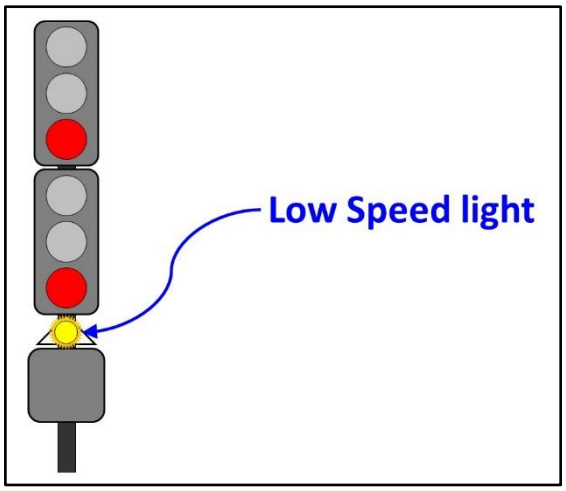


Figure 10
A low speed light below two Red lights

4.2.6. The driver quickly realised his error and stopped his train 12 m short of the cross-over points, thereby narrowly averting a collision with the Upper Hutt train, which passed through the cross-over 13 seconds later.

4.2.7. No conversation is reported to have taken place between the relay driver and the TXO once in the cab of the relay train, so the TXO's presence in the cab did not directly contribute to the incident. While in the cab, the TXO could have helped prevent the incident had he been calling the signals.

4.2.8. The relay train driver had completed similar relay movements before and was familiar with the signals that were applicable to the possible routes. Evidence of this was his immediate recognition of his error as he passed the Red signal.

4.2.9. In human factor terms the driver's mistake is considered a lapse, possibly attributable to him being past the end of his shift late at night, with a less heightened sense of awareness because he was performing the additional task of storing an empty train for the night.

4.2.10. The incident highlights the importance of having checks or defences in a system to counteract the known risk of human error. This is discussed in more detail in the following sections.

4.3. Suitability of the track layout facilitating a modern timetable

Safety issue – There is a heightened risk of trains colliding within the approaches to Wellington Station because limited space makes the track layout congested.

4.3.1. The track layout and associated control system between Wellington Station platforms, and the lines into and out of Wellington and those to the surrounding storage yards or maintenance depots, have remained relatively unchanged since 1937 (see Appendix 2).

4.3.2. The control of the various signals and points in this area is achieved by operating the lever mechanisms inside the Wellington Signalbox. Mechanical interlocks[7] prevent the signaller from being able to set conflicting train movements.

4.3.3. A number of signals and points around New Zealand are controlled via Computer Based Interlocking from the National Train Control Centre within Wellington Station. This system links signals and points by using software interlocking to prevent possible conflicting train

[7] Interlocking is an arrangement of signal apparatus that prevents conflicting movements through an arrangement of tracks such as at junctions or crossings.

movements. Computer Based Interlocking allows complex logic to be implemented, whereas this is considerably more difficult for lever and relay based interlocking.

4.3.4. The Wellington Signalbox controlled area is based on 1930s' vintage signalling principles and the associated interlocking is appropriate for a lever based system of this vintage, and remains fit for purpose, although it does not meet modern design standards[8]. The fundamental principles are the same as those deployed today with the exception that more modern computer based interlocking equipment allows more complex logic to be developed. The existing layout means there are no safety overlaps[9] designed into this area and few fail-safe back-up systems in place in the event of a SPAD. The current system is highly reliant on drivers always stopping at a Red light.

4.3.5. However, changing control of the area from the Wellington Signalbox to a National Train Control Centre would not have prevented this incident. The issue is with the congested layout of the track and signalling system.

4.3.6. Any increases in commuter train services into and out of Wellington through this tight track layout increases the pressure on this bottleneck area, and in turn increases the underlying risk of relying on train drivers to stop at Red lights.

4.3.7. Between the 2001/02 and 2015/16 financial years there has been a 26% increase in patronage on the Wellington commuter network (see Figure 11). To meet this demand there has to be a corresponding increase in the length of trains or an increased service frequency, which has therefore increased the pressure on this congested area.

4.3.8. Using longer trains to accommodate an increase in patronage does not increase the likelihood of collisions, but the potential consequence is elevated. Alternatively, a more frequent service means the likelihood of collisions is increased, but the potential consequence is not.

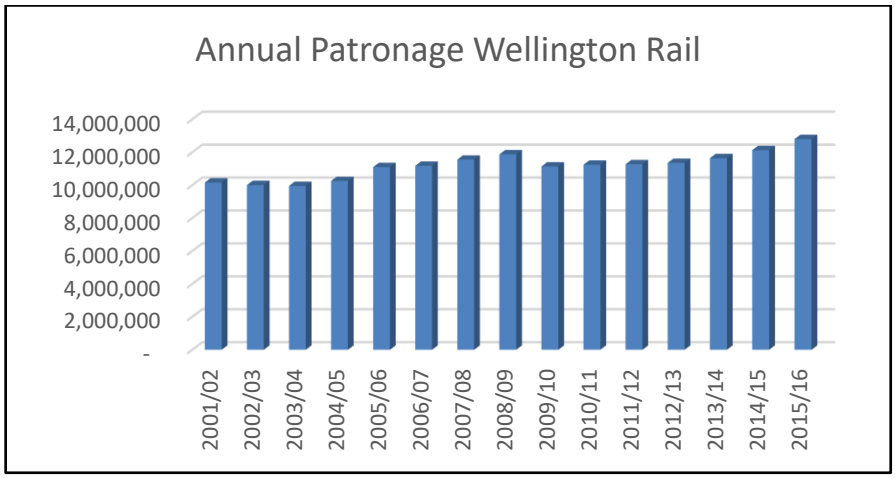


Figure 11
Annual patronage Wellington rail commuter network

4.3.9. Comparing the relatively modern 2010 Britomart Auckland design to the 1930s'-designed Wellington Signalbox controlled area shows some similarities and differences between the two. Both are terminating stations and have the highest patronage in their respective areas.

4.3.10. Operationally, Britomart Auckland has five platforms fed from two tracks compared to Wellington's four tracks feeding nine platforms. Additionally, Britomart has maintenance depots located some distance away, there are no requirements for relays, the signals and

[8] Modern design features could include safety overlaps, Automatic Train Protection and the European Train Control System.
[9] Safety overlap is the distance beyond a signal that is still considered to be part of the track before the signal, and is the safety buffer in which a SPAD train could stop where no other train should be.

points are controlled by the computerised Train Control system, safety overlaps are built in, and the European Train Control System (ETCS)[10] is installed, which can moderate train speeds approaching signals and automatically apply train brakes in the event of a SPAD.

4.3.11. By contrast, in Wellington the passenger train and freight maintenance depots are both located within the Wellington Signalbox controlled area. Relays are required from platform-to-platform, and into and out of the storage yards or maintenance depots, with all movements controlled by the electro-mechanical system in the signalbox. To install an ETCS type system in Wellington a substantial remodel of the current layout to facilitate the required safety overlaps would be required. See Appendix 3 for a tabular comparison between Auckland Britomart and the Wellington Signalbox controlled areas.

4.3.12. Currently, Greater Wellington Regional Council, in partnership with KiwiRail and Transdev, has developed and maintains a Wellington Network Management Plan. This is a three-yearly document used for budgeting and operational delivery within a 10-year planning period. The current planned signalling work programme addresses reliability issues and life-expired equipment.

4.3.13. Decongesting and modernising the track and signal infrastructure at Wellington Station will require significant resources, and is unlikely to occur in the near future. However, with the increasing rail patronage and a corresponding capacity-increase demand, the Commission is recommending that KiwiRail and Greater Wellington Regional Council develop a long-term strategy for the metropolitan rail system, with a view to addressing the issues described above. Meanwhile, there is a need to further mitigate the risks that the current system poses, and this issue is discussed in the following sections.

4.4. Risk management

Safety issue – There are a number of reasonable measures that had not been taken to further reduce the risk of trains colliding within the approaches to Wellington Station, such as: providing better recognition of signals; standard procedures for signalling trains through the area; and better communication between train drivers and persons controlling the trains.

Signalling procedures

4.4.1. One way to reduce the risk of trains colliding in the Wellington Station area is to develop signalling procedures that could reduce the number of potential conflicts or points of possible confusion for drivers.

4.4.2. For example, the advantage in pre-setting signal 99 to Green for the Waikanae bound train, so that only one lever movement was required to release the Waikanae service for the whole movement out of the Wellington Station area, was offset by the increased risk of the relay train driver confusing it as his signal. Signal 99 was the signal that the relay train driver mistook as applying to his train.

4.4.3. Another example is the relay train being signalled to depart the platform, knowing that it would likely only travel 150 m before needing to stop at signal 100 to allow the passage of the Upper Hutt train through the cross-over. In this scenario, probably the safest solution would have been to keep the relay train at its platform until the Upper Hutt train had cleared the section, thereby eliminating the potential for conflict.

4.4.4. It had become accepted practice for signallers to advance trains the short distance from the platforms up to signals held at red. This helps clear trains from the platforms more quickly and therefore contributes to keeping services on schedule at peak service times. This incident occurred shortly after midnight, during a quiet period with fewer trains operating. While there may be marginal time gains in some cases, such gains are likely to be offset by there being few technical interventions for preventing collisions should a driver fail to stop at a Red signal.

[10] The ETCS alerts drivers to the status of signals ahead, moderates approach speeds automatically for specific locations, and automatically applies train brakes in a SPAD (it does not prevent SPADs but minimises the possible distance of a SPAD).

4.4.5. It had also become accepted practice for signallers to pre-set part of the route ahead for a service and hold the train at the platform on a Red signal to help spread the signaller's workload.

4.4.6. KiwiRail had no written guidelines, instructions or procedures on how early a signaller can pre-set part of the route prior to a planned departure.

4.4.7. Without procedures or guidelines, signallers can achieve the same movement multiple different ways. There is therefore a lack of consistency about how signallers should signal and route a given movement.

Communication

4.4.8. Good positive communication is the key to safe operational transport systems, and train operation is no different from other modes of transport. As mentioned earlier, the relay train driver boarded his train and moved off with no knowledge of what other movements might be affecting the movement of his train or what the route to his destination would be.

4.4.9. The holding of a relay at the platform with a Red signal until the driver is on board and ready to depart would ensure the driver would need to call the signaller to request a light to depart. This would give the signaller the opportunity to confirm with the driver his train's destination, the route it will take and any priority constraints. In this case, if it was deemed necessary to move the relay train off the platform and up to signal 100, typical information could read 'cleared to depart Platform 7 for the yard in accordance with signals – likely hold at signal 100 for passage of the Upper Hutt Service departing Platform 5'. Such communication would put the driver on alert that there was a conflicting movement in parallel and crossing his train.

4.4.10. KiwiRail's 'Local Instructions – Operating Procedures Tranz Metro Wellington' (Rev 9 dated 2/9/15) document states in section '5.4 Platform/Platform Relays':

Before taking a relay movement from the platform, the Locomotive Engineer must call A Box for the intended movement.

It is unclear why there is a requirement for a driver to interact with the signaller only for platform-to-platform relays and not for all relay train or unusual train movements.

4.4.11. The TXO was sitting in the driving cab of the relay train for operational reasons. He was allowed to be there provided he was directly involved in matters related to the running of the train. The TXO was trained and experienced in the various routes and signals within the Wellington Station area. There was a lost opportunity for him to work with the driver by calling the relevant signals along the route. It is feasible that had he been doing so, he would have prompted the driver to focus on the correct signal, thereby averting the incident.

4.4.12. Finally, when the signaller realised there had been a SPAD, his spontaneous reaction was to wave out of the window of the Wellington Signalbox to try and attract the attention of the relay train driver in the dark and rain. A more effective way to have communicated the problem would have been to use the available radio and call 'stop, stop, stop', thereby stopping both trains.

Signal definition

4.4.13. The potential for a driver to confuse signals 99 and 100 was partially addressed in 2005 by the addition of non-reflective arrows on the signal poles, pointing to the respective track the signal is controlling (see Figure 12). The arrows are effective during daylight hours, but they are not illuminated or reflective and are difficult to see at night.

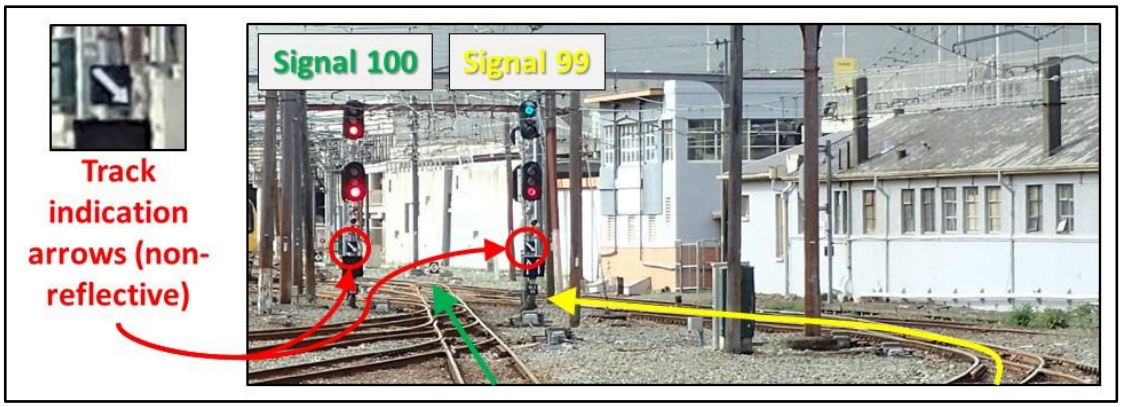


Figure 12
Track indication arrows

4.4.14. In Figure 12, signal 100 controls the track depicted by the green arrow, which is the track the relay train was travelling on. Signal 99 controls the track to the right depicted by the yellow arrow, which was the track the Waikanae bound train was scheduled to travel on.

4.4.15. Illuminating the arrows may have assisted the relay train driver in recognising which of the two signals applied to his train. The Commission has recommended that the Chief Executive of KiwiRail conduct a review of current arrangements and take any opportunities they can to reduce the risk of unsafe train operations in the area.

4.4.16. In an automatic signalling area like Wellington Station, if a train passes a Red signal the surrounding signals governing potential conflicting movements automatically change to Red as a safety feature. This happens because the rogue train has occupied an unauthorised section of track beyond the Red signal, which then activates the associated track circuits to change all other signals to Red to prevent a potential collision.

4.4.17. In this section of Wellington Station the complexity of possible movements and the congested nature of the area mean that the insulated joint[11] where the track circuit detection happens is not directly adjacent to signal 100. The relay train proceeded 30 m past signal 100 and stopped 1 m short of the insulated joint. Consequently, the signals for the Upper Hutt bound train remained Green even though the relay train had passed the Red signal by 30 m.

4.4.18. To allow simultaneous parallel train movements through adjacent sets of point on adjacent lines with the relatively simple electro-mechanical logic system in the existing Wellington Signalbox, sections of track have been linked to form zones (see Figure 13). This limits the sensitivity of the system and was the reason why the insulated joint was not located immediately adjacent to signal 100.

[11] An insulated joint separates two adjacent pieces of rail track so that sensors can detect when a train moves from one section across the insulated joint to the other piece of track.

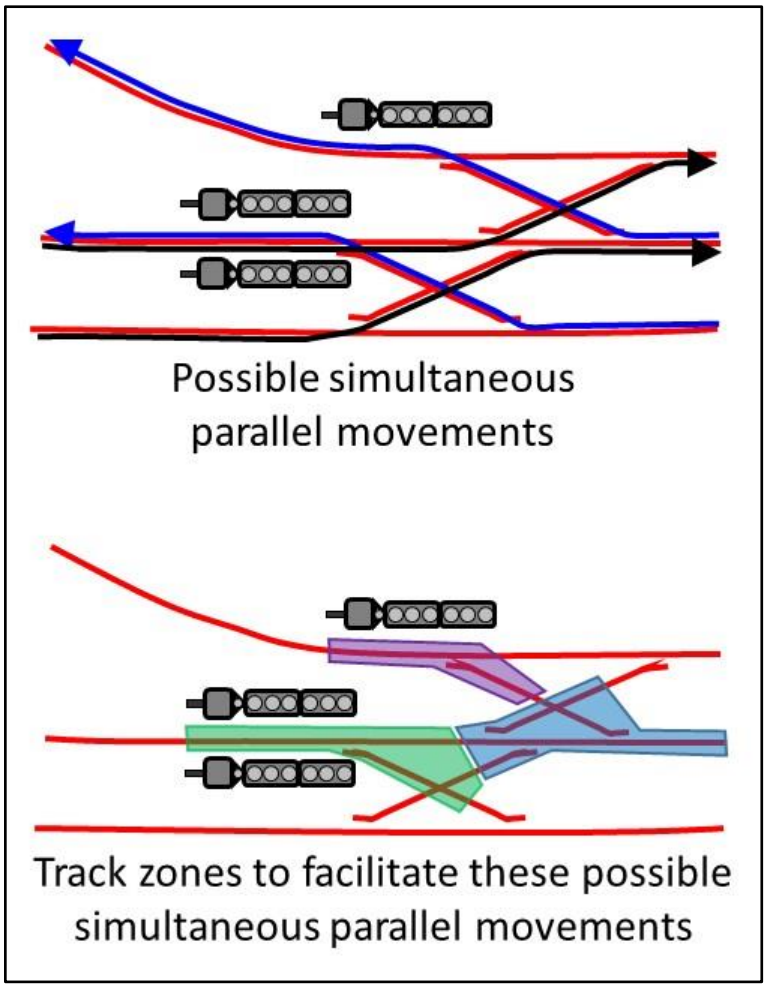


Figure 13
Possible parallel movements and associated track zones

4.4.19. This meant that the signal for the Upper Hutt service, displaying a 'Green – Proceed' indication, did not revert to 'All Red – Stop' despite the incursion of the relay movement towards the same convergence of points. It is debatable whether the Upper Hutt service would have had time to stop before colliding with the relay train if the relay had continued into the conflict area. However, had the signals for the Upper Hutt bound train reverted to Red as soon as the relay train passed the Red signal 100, the driver of the Upper Hutt bound train would have had more opportunity to slow his train before both trains reached the convergence points.

4.4.20. A number of key signals in the Wellington Station area are fitted with signal trips[12] (see Figure 14). However, there are no automatic signal trips fitted to signals 99, 100 or 101, which would automatically engage the train brakes in the event of a SPAD. The reason given for signal trips not being fitted to these signals is that the signals are too close to the conflict zone for a train to stop before it occupies the points area. However, in this case the driver was able to stop his train just short of the conflict zone and avoid a potential collision. There may therefore be some safety benefit from having such devices installed in some cases.

[12] A signal trip is an arm which automatically raises when a signal is at 'All Red – Stop'. It catches on the brake trip lever mounted low on the side of a train and automatically applies the train brakes if the train passes a signal at red.

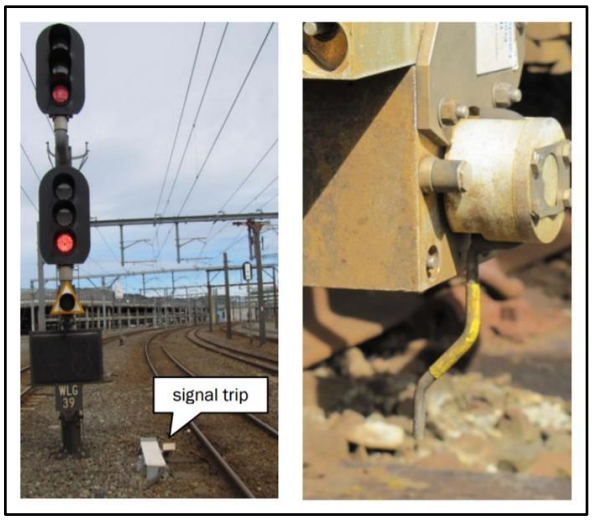


Figure 14
A signal trip installed at Signal 39 (left) and the brake trip lever on a Matangi train (right)

4.4.21. KiwiRail has said that the current mitigation actions against train collisions and minimising damage to passengers and rolling stock in the event of a collision in this area are:

- for the driver to always stop at an 'All Red – Stop' signal
- a 20 kilometre-per-hour speed restriction in the area to ensure any collision is at a relatively low speed
- the crashworthiness of the various train vehicle designs to minimise impact damage and vehicle incursion into the passenger compartment in the event of a train-to-train impact.

Only one of the three measures would actually prevent a collision, and that measure relies solely on human performance. The other two measures do not prevent collisions, but minimise the consequences instead.

4.4.22. There have been 10 recorded relay movement SPADs within the Wellington Signalbox controlled area between January 2006 and May 2016, so this area could be considered a relatively high-SPAD and high-risk area. This incident has shown that more work is required by KiwiRail to reduce the risk of train collisions within the Wellington Station area. The Commission is recommending that the Chief Executive of KiwiRail liaise with Greater Wellington Regional Council to develop a long-term strategy for the metropolitan rail system, with a view to identifying and addressing the current safety issues with the track and signalling infrastructure in the Wellington Station area.

5. Findings

5.1. The empty relay train passed a signal at Red (Stop) and nearly collided with a loaded passenger train because the driver of the relay train mistakenly thought a Green signal that was adjacent to his Red signal was applicable to his train.

5.2. Train drivers failing to stop their trains at Red signals is a known and foreseeable risk. There should therefore have been checks or defences built into the system to prevent this near collision when the driver confused the two signals.

5.3. The congested nature of the Wellington Station track layout means there are fewer fail-safe back-up systems than would normally be associated with a modern track and signalling system. Consequently, there is an elevated risk of trains colliding in the area that will need to be managed in future.

5.4. The measures relied on to mitigate the risk of trains colliding in the Wellington Station area did not reduce the risk as far as reasonably practicable.

5.5. Better communication and sharing of information between the signaller who was controlling the trains and the train drivers involved could have prevented the incident occurring.

6. Safety actions

General

6.1. The Commission classifies safety actions by two types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation; and

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

Safety actions addressing safety issues identified during an inquiry

- KiwiRail held a Signal's Sighting Committee review of signals in this A Box controlled area (see Appendix 4)
- Transdev Wellington has:
    - undertaken some retraining of the relay driver
    - added the relay driver to the 'at-risk register' for increased frequency of safety observations and supervision
    - reminded all staff of the requirements of Rule 117 (October 2017 staff briefing – see Appendix 5).

7. Recommendations

General

7.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, recommendations have been issued to KiwiRail, with notice of these recommendations given to Greater Wellington Regional Council, New Zealand Transport Agency and Transdev Wellington.

7.2. In the interests of transport safety, it is important that these recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

Previous recommendations to the NZ Transport Agency

7.3. Good positive communication is key to the safety of the train operations. In this case, the relay train driver boarded his train and moved off with no knowledge of what other movements might be affecting the movement of his train. This incident emphasises how important NTSs are in preventing incidents and accidents.

In 2012, as part of Inquiry RO 2011-101, the Commission issued a recommendation (002/12) to the Chief Executive of the NZ Transport Agency that he require: the Executive of the National Rail System Standards (NRSS) to develop standards to ensure all rail participants meet a consistently high level of Crew Resource Management (now NTS); and communication to staff which includes the use of standard rail phraseology.

On 31 March 2017, the NZ Transport Agency updated the Commission as follows:

> It is noted that the Commission issued its most recent recommendation on non-technical skills to the Transport Agency in 2012 and that this is still open. The recommendation required that the practice of non-technical skills be recognised in the National Rail System Standards. The Transport Agency continues to work with KiwiRail on this issue, and in December 2016 issued a Safety Improvement Plan Notice in accordance with section 36 of the Railways Act 2005 requiring KiwiRail to prepare a Safety Improvement Plan to address the implementation of non-technical skills into its rail operations.

On 1 November 2017, the NZ Transport Agency updated the Commission as follows:

> The Transport Agency approved KiwiRail's Safety Improvement Plan regarding non-technical skills in April 2017. In their most recent update on the Non–Technical Skills project KiwiRail reported that the project is on time, within budget and meeting the project specifications. As of 13 October 2017, the Transport Agency has also agreed to the integration of stabilised approach and risk-triggered commentary driving into the scope of the Safety Improvement Plan requirements.

Recommendations made to KiwiRail

7.4. There is a heightened risk of trains colliding within the approaches to Wellington Station because limited available space makes the track layout congested. The existing layout means there are fewer safety overlaps designed into this area and fewer fail-safe back-up systems in place in the event of a driver failing to stop at a red light.

Any increases in commuter train services into and out of Wellington through this tight track layout increases the pressure on this bottleneck area, and in turn increases the underlying risk of relying on train drivers to stop at red lights.

To decongest and modernise the track and signal infrastructure at Wellington Station will require significant resources, which is unlikely to occur in the near future. However, there will likely be future increases in rail patronage and the system is already congested.

On 15 December 2017, the Commission recommended that the Chief Executive of KiwiRail liaise with Greater Wellington Regional Council to develop a long-term strategy for the metropolitan rail system, with a view to identifying and addressing the current safety issues with the track and signalling infrastructure in the Wellington Station area. [033/17]

7.4.1. On 23 January 2018, the Chief Executive of KiwiRail replied:

> KiwiRail accepts the recommendation as presented and will be engaging with the Greater Wellington Regional Council (GWRC) for developing a long-term strategy for improving the safety of the track and signalling infrastructure in the Wellington Station area.

7.5. There are a number of reasonable measures that had not been taken to further reduce the risk of trains colliding within the approaches to Wellington Station, such as:

- providing better recognition of signals
- standard procedures for signalling trains through the area
- better communication between train drivers and persons controlling the trains.

This incident has shown that more work is required of KiwiRail to further reduce the likelihood of trains colliding within the Wellington Station area.

On 15 December 2017, the Commission recommended that the Chief Executive of KiwiRail conduct a review of current arrangements and take any opportunities it can to further reduce the risk of train operations in the area until a more suitable longer-term solution can be made. [034/17]

7.5.2. On 23 January 2018, the Chief Executive of KiwiRail replied, in part:

> KiwiRail, GWRC and Transdev Wellington already co-operate closely on operating and strategic matters. This is required by the Wellington Network Agreement and is supported by an MOU between the three organisations.
>
> KiwiRail are in agreement to conduct a review of current arrangements in order to try to identify opportuniites for attempting to reduce the risk to train operations in the Wellington station area.

Notice of recommendations given

7.6. On 15 December 2017, the Commission **gave notice** to the Chief Executive of Greater Wellington Regional Council that the Commission had recommended that KiwiRail:

> … liaise with Greater Wellington Regional Council to develop a long-term strategy for the metropolitan rail system, with a view to identifying and addressing the current safety issues with the track and signalling infrastructure in the Wellington Station area [033/17].

7.7. On 15 December 2017, the Commission **gave notice** to the Chief Executive of the NZ Transport Agency that the Commission has recommended that KiwiRail:

> … conduct a review of current arrangements and take any opportunities it can to reduce the risk of train operations in the area until a more suitable longer-term solution can be made [034/17].

7.8. On 15 December 2017, the Commission **gave notice** to the Chief Executive of Transdev that the Commission had recommended that KiwiRail:

> … liaise with Greater Wellington Regional Council to develop a long-term strategy for the metropolitan rail system, with a view to identifying and addressing the current safety issues with the track and signalling infrastructure in the Wellington Station area [033/17].

7.9. On 15 December 2017, the Commission **gave notice** to the Chief Executive of Tranzdev that the Commission had recommended that KiwiRail:

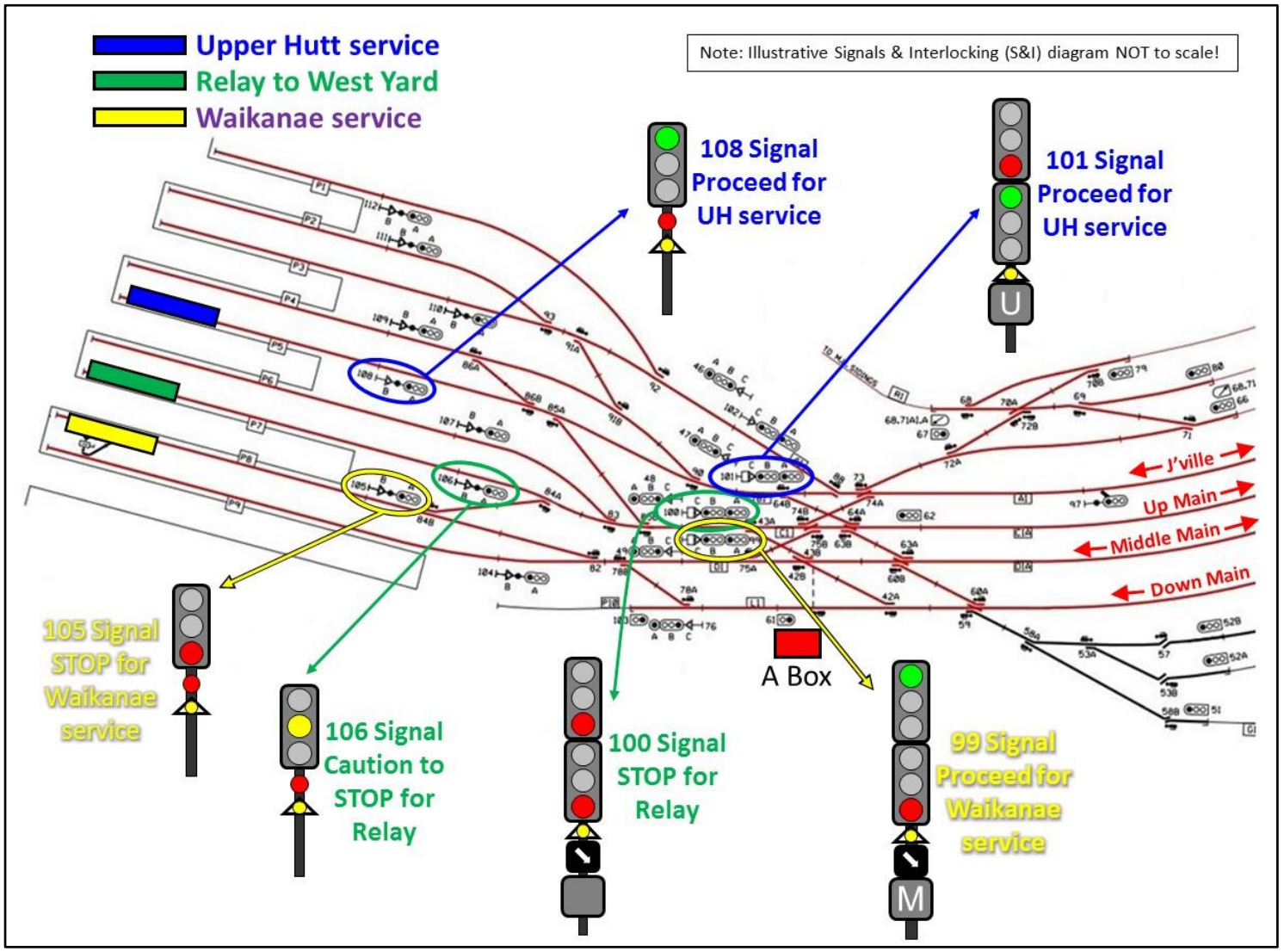
… conduct a review of current arrangements and take any further opportunities it can to reduce the risk of train operations in the area until a more suitable longer-term solution can be made [034/17].

8. Key lessons

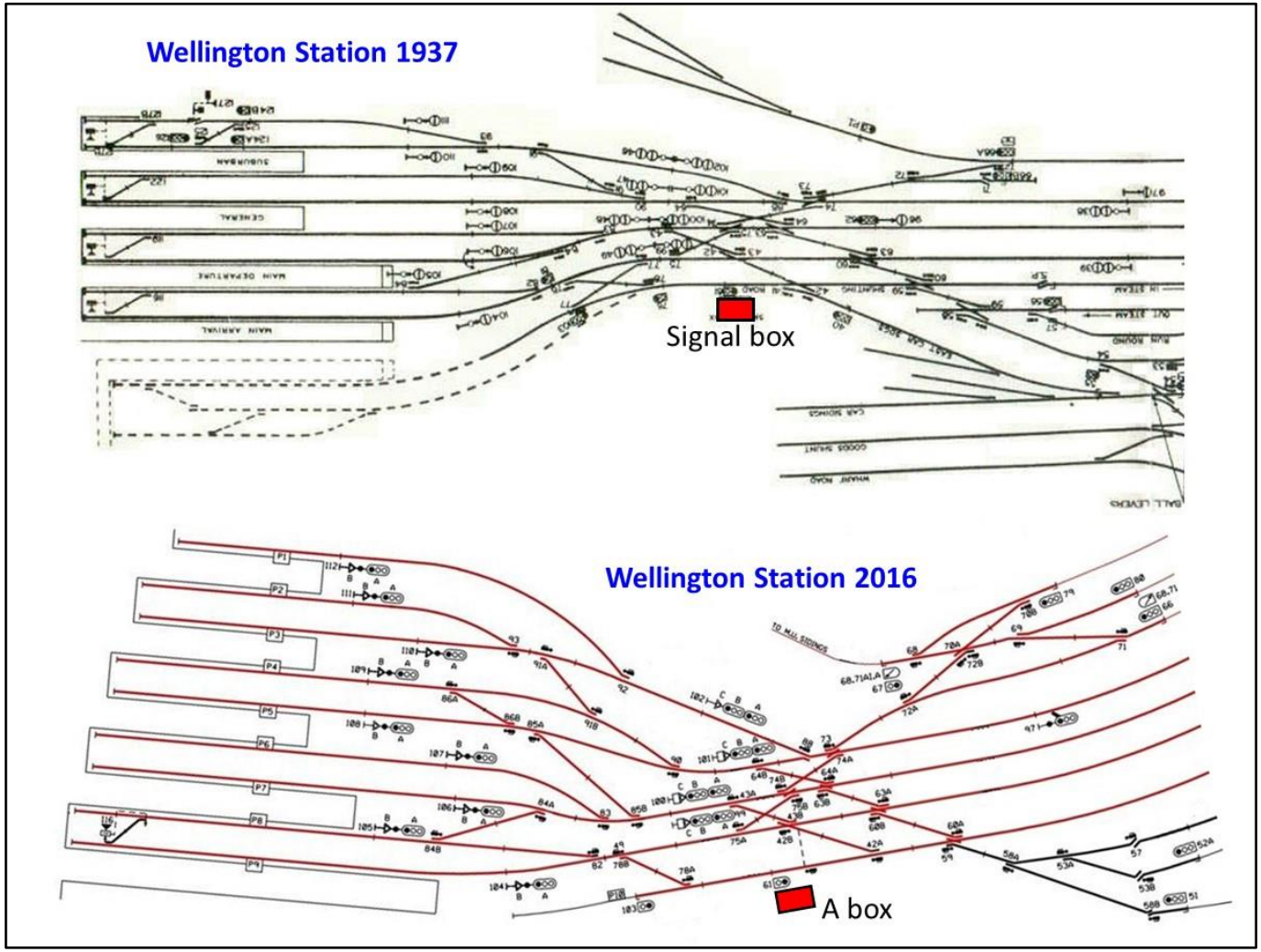
8.1. All safety-critical systems should have checks and defences designed into them that prevent human error from resulting in accidents.

8.2. There should be sufficient clear and concise communication between persons responsible for controlling trains and train drivers, so that all parties are aware of the situation and alert to any threats to safe train operations.

Appendix 1: Signal set-up for intended movements



Appendix 2: Wellington Station 1937 and 2016



Note: Illustrative signals and interlocking (S&I) diagrams are not drawn to scale. Instead, they are a simple representation of the relative positions of signals and points to each other.

Appendix 3: Comparison of Auckland and Wellington rail networks

	Commuter Network	
	Auckland	**Wellington**
CBD terminal station	Britomart	Wellington
Platforms & tracks	2 tracks feeding 5 platforms	4 tracks feeding 9 platforms (*really 3 feeding 8 with Platform 1 dedicated to Johnsonville line*)
	All lines signalled bi-directional	Johnsonville & Middle Main bi-directional
Maintenance depots	Located remotely	EMU and Freight depots next to terminal station - meaning extra relay movements
Relays	No relays	Relays from platform to platform, to storage yards and to maintenance depots
Signals and Points	Controlled from the computer controlled National Train Control Centre - ***Computer Based Interlocking***	Manually controlled by 'A Box'
Safety overlap	Designed around 150m	Track layout too tight for any safety overlap in some areas
ETCS - European Train Control System	Automatically moderates train speed approaching a RED light	No plan to install at this stage
	Applies brakes automatically in a SPAD	Would need remodel of tight layout to be installed

Appendix 4: Signal Sighting Committee review notes for signal 99

KiwiRail

Signal Sighting Form		RevXX	
Serial Number: SSF-		**Plan No:**	
Recommendations of meeting held on :			
Interlocking Area	WLG	**Signal Number**	**99 ABC**
Direction/Line	Up	**Existing Position (Km)**	
Proposed Position (Km)		**Agreed Position (Km)**	
Line Speed:	20km/h	**Reason for movement from Proposed Position**	
Required Min Distance at 12 Sec (@ 110km/hr)		**Maximum Sighting Distance available**	
Background Interference	See note (1	**Confusion with other signals/Read through risk**	See note (2
Obstructions affecting approach view	See note (3	**Distance to signal ahead, visible?**	Yes
Aspect requirements (e.g. hot spot, long hoods)		**Re-inspection required, reason/when?**	

Special Requirements / Remarks:

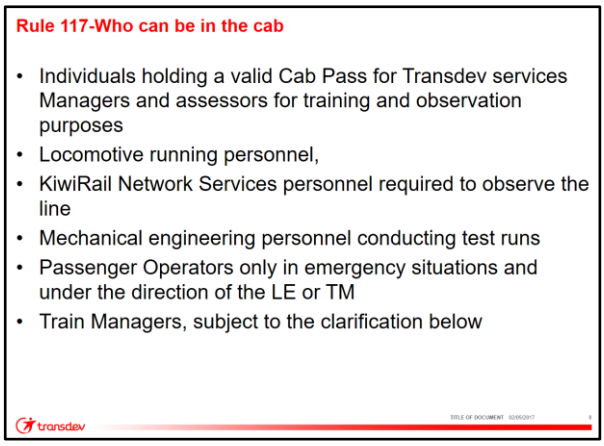
1) Further discussion on a signal shroud for the A & B unit to help prevent confusion
2) A & B unit to be slightly rotated
3) Note this signal is right next to signal 100ABC
4) A few seconds of loss due to traction pole on approach from platform.

Attendance

Name	Company	Signature	Contact No.
[redacted]			

Issue 2	KiwiRail Holdings Ltd (New Zealand Railways Corporation)
Revision 1	This document is uncontrolled when printed.
December 2014	Page 1 of 2

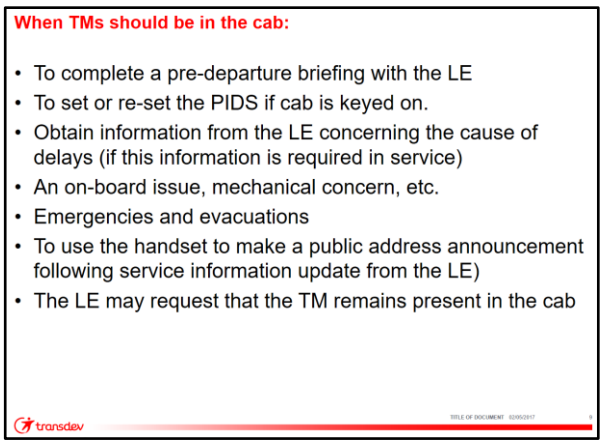
Appendix 5: Transdev staff briefing on Rule 117



Rule 117-Who can be in the cab

- Individuals holding a valid Cab Pass for Transdev services Managers and assessors for training and observation purposes
- Locomotive running personnel,
- KiwiRail Network Services personnel required to observe the line
- Mechanical engineering personnel conducting test runs
- Passenger Operators only in emergency situations and under the direction of the LE or TM
- Train Managers, subject to the clarification below

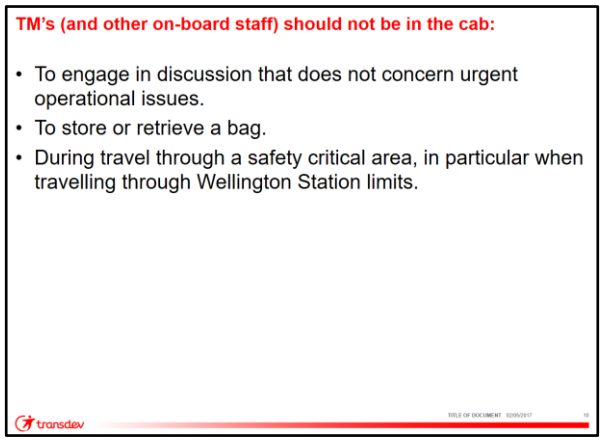
transdev



When TMs should be in the cab:

- To complete a pre-departure briefing with the LE
- To set or re-set the PIDS if cab is keyed on.
- Obtain information from the LE concerning the cause of delays (if this information is required in service)
- An on-board issue, mechanical concern, etc.
- Emergencies and evacuations
- To use the handset to make a public address announcement following service information update from the LE)
- The LE may request that the TM remains present in the cab

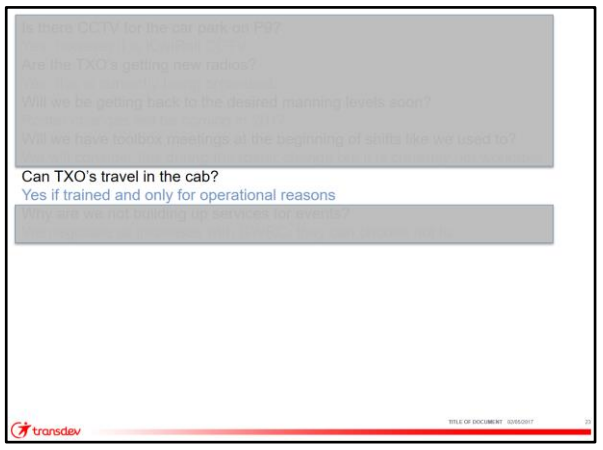
transdev



TM's (and other on-board staff) should not be in the cab:

- To engage in discussion that does not concern urgent operational issues.
- To store or retrieve a bag.
- During travel through a safety critical area, in particular when travelling through Wellington Station limits.

transdev



Can TXO's travel in the cab?

Yes if trained and only for operational reasons

transdev

Recent railway occurrence reports published by the Transport Accident Investigation Commission (most recent at top of list)

RO-2016-102	Train 140 passed Signal 10R at 'Stop', Mission Bush Branch line, Paerata, 25 October 2016
RO-2015-103	Track occupation irregularity, leading to near collision, between Manunui and Taumarunui, 15 December 2015
RO-2014-105	Near collision between train and hi-rail excavator, Wairarapa Line near Featherston, 11 August 2014
RO-2013-101	Derailment of freight Train 345, Mission Bush Branch line, 9 January 2013
RO-2015-102	Electric locomotive fire at Palmerston North Terminal, 24 November 2015
RO-2014-104	Express freight train striking hi-rail excavator, within a protected work area, Raurimu Spiral, North Island Main Trunk line, 17 June 2014
RO-2013-103 and RO-2014-103	Passenger train collisions with Melling Station stop block, 15 April 2013 and 27 May 2014
RO-2015-101	Pedestrian fatality, Morningside Drive pedestrian level crossing, West Auckland, 29 January 2015
RO-2014-101	Collision between heavy road vehicle and the Northern Explorer passenger train, Te Onetea Road level crossing, Rangiriri, 27 February 2014
RO-2012-103	Derailment of freight Train 229, Rangitawa-Maewa, North Island Main Trunk, 3 May 2012
RO-2012-105	Unsafe recovery from wrong-route, at Wiri Junction, 31 August 2012
RO-2013-107	Express freight MP16 derailment, Mercer, North Island Main Trunk, 3 September 2013
RO-2012-104	Overran limit of track warrant, Parikawa, Main North line, 1 August 2012
RO-2013-104	Derailment of metro passenger Train 8219 , Wellington, 20 May 2013
Urgent Recommendations RO-2015-101	Pedestrian fatality, Morningside Drive level crossing, West Auckland, 29 January 2015

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