Report 07-105: push/pull passenger train sets overrunning platforms, various stations within the Auckland suburban rail network, between 9 June 2006 and 10 April 2007

Report 07-105

(incorporating reports 06-105 and 06-107)

push/pull passenger train sets overrunning platforms

various stations within the Auckland suburban rail network

between 9 June 2006 and 10 April 2007

Figure 1
Location of incidents

Contents

Figures

Abbreviations

ARTA	Auckland Regional Transport Authority
DMU	diesel multiple unit(s)
EMU	electric multiple unit(s)
GPS	global positioning system
km	kilometre(s)
km/h	kilometre(s) per hour
kPa	kilopascal(s)
m	metre(s)
NAL	North Auckland Line
NIMT	North Island Main Trunk
NRSS	National Rail System Standard
OJT	on-the-job training
t	tonne(s)
TAMM	Toll Auckland Metro Maintenance
Toll Rail	Toll NZ Consolidated Limited
UTC	universal coordinated time
Veolia	Veolia Transport Auckland Limited

Data Summary

Rail occurrence	Train	Set	Date	Time[1]	Location	Line
06-105	3114	2	9 June 2006	0707	Homai	North Island Main Trunk
06-105	3321	3	13 June 2006	1905	Manurewa	North Island Main Trunk
06-107	3169	9	11 August 2006	1640	Ellerslie	North Auckland Line
07-105	2116	11	10 April 2007	0825 0901	Te Mahia Meadowbank	North Island Main Trunk

Train type: push/pull passenger train sets

Vehicle classes: SA passenger carriages and SD driving trailers

Year of original manufacture: 1972 by British Rail as mk2 passenger carriages

Year of conversion to New Zealand operations: from 2003

Designer and builder of the push/pull sets Original concept was initiated by Tranz Rail Limited and construction of the push/pull sets began during 2003 in the Hillside workshops in Dunedin. Tranz Rail Limited was bought out by Toll NZ Consolidated Limited (Toll Rail) in 2004. Toll Rail was subsequently bought out by the New Zealand Government in 2008 and branded as KiwiRail.

Motive power: DC class diesel electric locomotives rebuilt between 1978 and 1980 by Clyde Engineering of Australia from DA class locomotives originally built in late 1950s/early 1960s by General Motors of Canada

Licensed train operator: Veolia Transport Auckland Limited (Veolia)

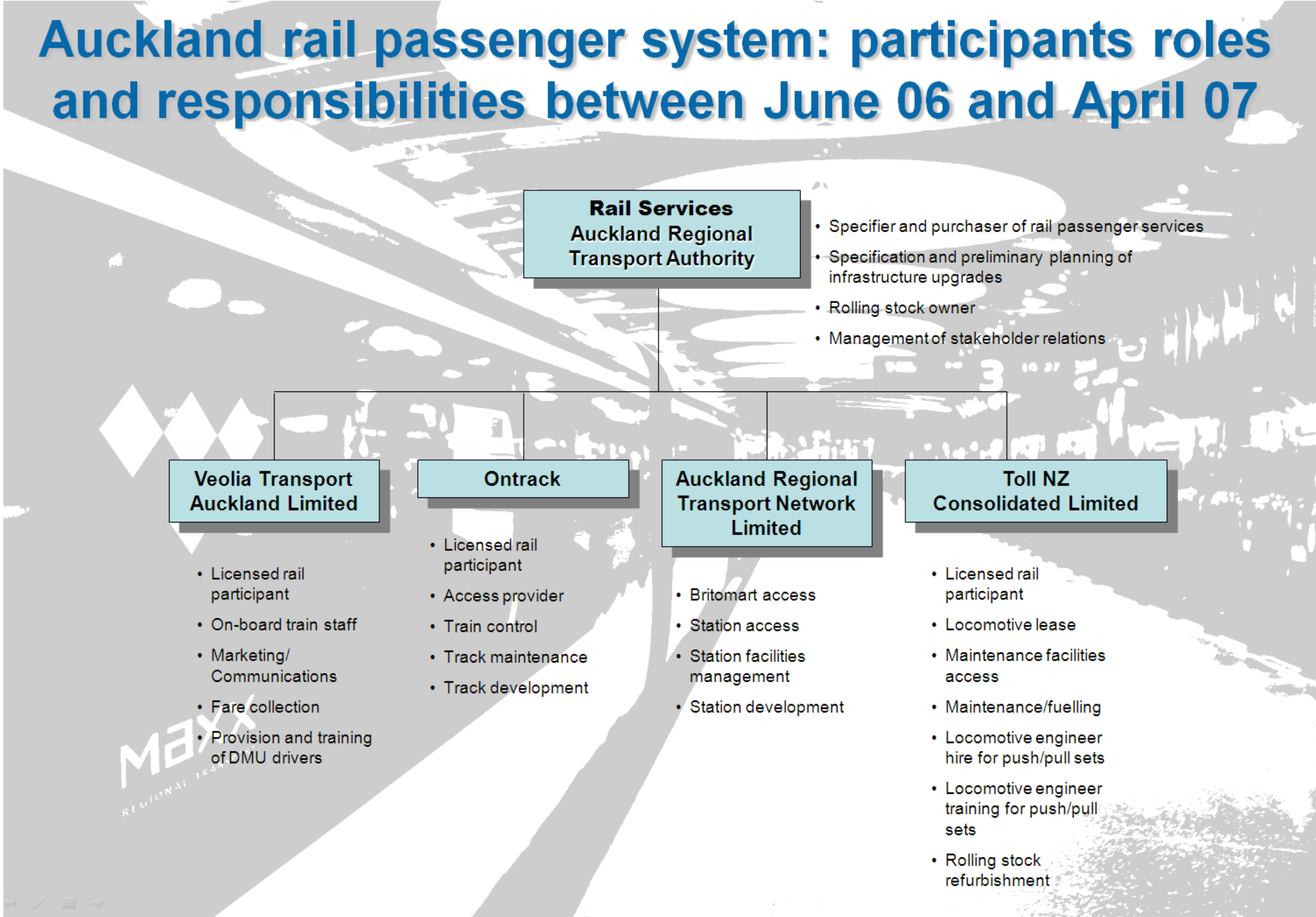
Persons on board each train:
Toll Rail: up to 2
Veolia: up to 2
passengers up to 328 seating and standing

Injuries: nil

Damage: nil

Investigator-in-charge: Vernon Hoey

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


Auckland rail passenger system: participants roles and responsibilities between June 06 and April 07
Rail Services Auckland Regional Transport Authority
• Specifier and purchaser of rail passenger services
• Specification and preliminary planning of infrastructure upgrades
• Rolling stock owner
• Management of stakeholder relations
Veolia Transport Auckland Limited
• Licensed rail participant
• On-board train staff
• Marketing/ Communications
• Fare collection
• Provision and training of DMU drivers
Ontrack
• Licensed rail participant
• Access provider
• Train control
• Track maintenance
• Track development
Auckland Regional Transport Network Limited
• Britomart access
• Station access
• Station facilities management
• Station development
Toll NZ Consolidated Limited
• Licensed rail participant
• Locomotive lease
• Maintenance facilities access
• Maintenance/fuelling
• Locomotive engineer hire for push/pull sets
• Locomotive engineer training for push/pull sets
• Rolling stock refurbishment

Executive Summary

Between June 2006 and April 2007 the Transport Accident Investigation Commission (the Commission) launched inquiries into 5 separate platform overrun events on the Auckland suburban rail network. Because there appeared to be a number of common factors contributing to the overruns, they have been combined into this one report.

All overruns involved push/pull train sets designed and modified in New Zealand from 2003 to cater for the growing needs of the Auckland transport network, pending expansion and modification of the rail infrastructure to cater for new electric train sets within 7 to 9 years. In all cases the trains were being driven by Toll Rail locomotive engineers in the push mode.

There were no injuries and no damage resulting from any of the 5 incidents. In 4 of the 5 incidents the procedures for dealing with a platform overrun were followed correctly. In one of the incidents, the driver reversed his train to the platform without the required authority from train control.

The driving technique of the Toll Rail locomotive engineers was a significant factor leading to the platform overruns. In particular, there was no standardised methodology taught for braking and other train-handling techniques. Trainer drivers were not taught how to teach trainee drivers and were themselves not subject to minimum levels of experience and competency before undertaking trainer duties.

The Commission found that the brake system design was not ideally suited for outer-urban commuter train operations, but it was considered fit for the trains' intended purpose of outer-urban, limited-stop operations that existed in Auckland at the time.

The Commission determined that the National Rail System Standard for passenger train braking distance was not relevant to the design of the network at the time, so the fact that the trains did not comply with that Standard for stopping distance was not in itself a significant safety issue. However, the fact that the trains were signed off as being compliant while they technically did not meet the Standard was a safety issue that needs addressing by the industry.

The Commission has also determined that the National Rail System Standard needs to be reviewed to ensure it is consistent with good rail operating practice and is applicable to the New Zealand rail industry, and that the regulator needs to maintain a tight control over the Standard that are currently governed by the industry.

This report should be read in conjunction with the Commission's previous Report 05-123, Empty passenger Train 4356, overrun of conditional stop board without authority, following an automatic air brake valve irregularity at Meadowbank on 6 October 2005. In that report the Commission commented on the design, performance and maintenance of the brake system on the push/pull fleet. Some of the findings and recommendations in Report 05-123 are equally applicable to this report.

Toll Rail's interpretation of the National Rail System Standard and its decision to test the stopping performance of the push/pull sets based on single-car breakaway tests, rather than as a complete train, resulted in the Standard as written not being complied with.

There was, however, an error within the Standard that had not been detected by either the operating company or the regulator until the trains had been in service for 4 years.

The report makes comments on what level of regulatory oversight should be applied to the design, build and sign off for the push/pull train sets.

Two recommendations have been made to the Chief Executive of the New Zealand Transport Agency to address the safety issues identified in this report about the standards of driver training and compliance with the National Rail System Standard.

Three recommendations have been made to the Secretary for Transport about the status of the National Rail System Standard.

Conduct of the Inquiry

On 6 October 2005, the Commission opened an inquiry into an empty push/pull train overrunning a conditional stop board protecting a work site at Meadowbank in Auckland (Report 05-123). While the Commission was enquiring into the design, performance and maintenance of the push/pull brake system, the first of a series of platform overruns was reported in June 2006.

On 9 June 2006, the Commission opened an inquiry into the first platform overrun, then in the following 10 months opened inquiries into 4 other platform overruns. These 5 events were later combined into one inquiry.

Further platform overruns were notified in the following 3 years; these events were noted, but not investigated separately by the Commission.

On 20 August 2009, the Commission approved the first draft final report to be sent to interested persons for comment. Submissions were received from the regulator and the main industry participants, together with some submissions from individuals.

The submissions received showed that views on key matters discussed in the first draft final report differed among the main rail participants, and showed that information around those key matters was not transparent across the industry. In order to better understand the issues, and to improve the transparency of information, the Commission decided to hold a hearing that included meetings with Veolia Transport Auckland Limited (the operator), KiwiRail Limited (the builder and maintainer), the Auckland Regional Transport Authority (the rolling stock owner), the New Zealand Transport Agency (the regulator), the Ministry of Transport and individuals representative of the push/pull set drivers.

On 24 February 2010, a second draft final report was approved for circulation to interested persons, and the above organisations and individuals made their submissions in writing and presented their submissions during the hearing that was held between 21 and 23 April 2010.

The key matters heard at the hearing included:

- the driver training system, including standards for trainer drivers
- the design and performance of the brake system on the push/pull sets
- the push/pull sets' compliance with the National Rail System Standard at the time they were signed off as compliant
- the appropriateness of the National Rail System Standard at the time
- the status of the National Rail System Standard at the time
- the level of regulatory oversight of the rail industry
- poor communication between the main rail participants (including the regulator) and the Commission.

As a result of the hearing the Commission was satisfied that the matters of design and performance of the push/pull train brake system and compliance with the standards of the day had been clarified and addressed, as had the issue of communication between the main rail participants.

The remaining matters, including driver training, the National Rail System Standard and the regulatory oversight of the rail industry, are key matters that the Commission believes have yet to be resolved.

On 24 June 2010, a re-drafted and third draft final report was approved for circulation to interested persons. Submissions were received from KiwiRail Limited, Veolia Transport Auckland Limited, the New Zealand Transport Agency, the Auckland Regional Transport Authority and a locomotive engineer, and their submissions have been considered in this final report.

1 Factual Information

1.1 Background information

1.1.1 Between Friday 9 June 2006 and Tuesday 10 April 2007, the Commission opened inquiries into 5 occurrences where push/pull passenger train sets overran platforms while making scheduled stops at various stations within the Auckland suburban rail network. At the time of the occurrences, the push/pull sets were all operating in the push mode, with SD driving trailers being the lead vehicles in the direction of travel (see lower image in Figure 2).

Figure 2
Push/pull train sets

1.1.2 The push/pull sets were mostly made up of 4-carriage sets and one DC locomotive. At the time of the incidents, there were a small number of 3-carriage sets and one DC locomotive. A 3-carriage set was 74.24 metres (m) long (including the locomotive) and was designed to convey a maximum of 240 passengers. A 4-carriage set was 95.60 m long (including the locomotive) and was designed to convey a maximum of 328 passengers. The designed maximum passenger capacity included both sitting and standing passengers and was referred to as "crush loading".

1.1.3 Veolia operated the push/pull sets under its rail safety licence. The locomotive engineers who drove the sets were provided by Toll Rail[2]. Other onboard train staff was provided by Veolia Transport Auckland Limited (Veolia).

1.1.4 All of the occurrences happened on a section of the North Island Main Trunk (NIMT) between Papakura and Britomart and a section of the North Auckland Line (NAL) between Westfield and Newmarket (see Figure 3). For passenger reference purposes, these sections of track were referred to as the eastern and southern lines in the public timetable.

[2] Toll Rail was purchased by the New Zealand Government in July 2008 and was rebranded KiwiRail.

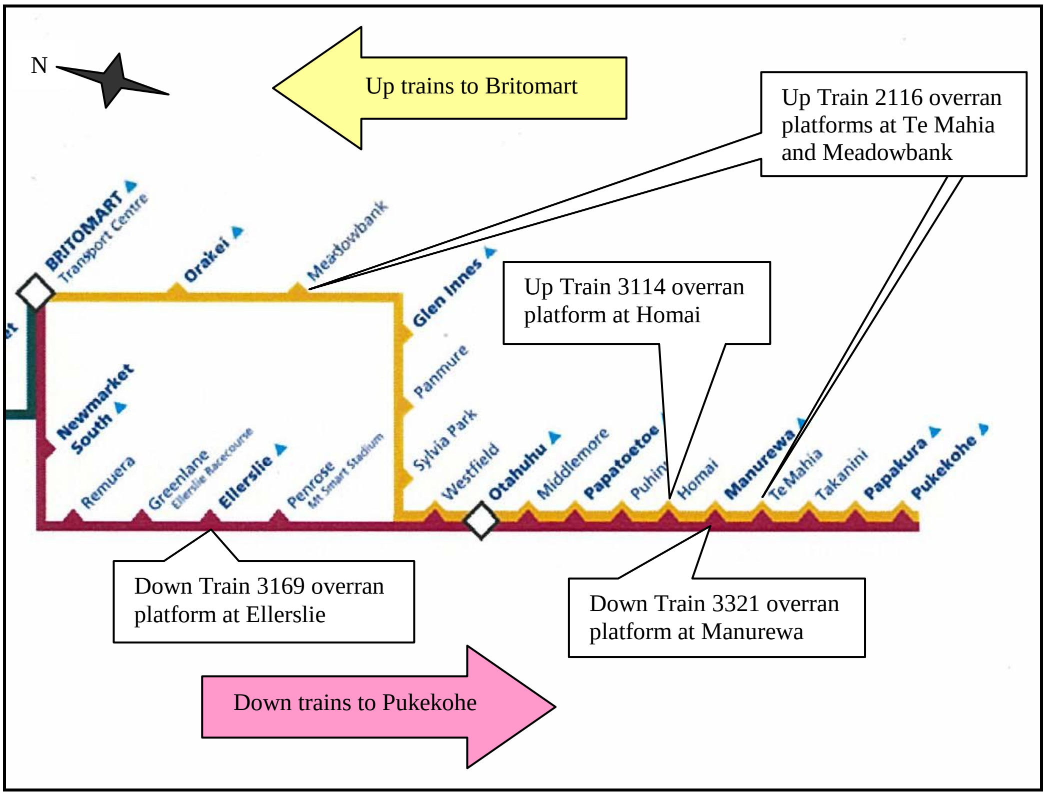


Figure 3
The Auckland suburban rail (southern lines) network (not to scale)

1.1.5 Both the NIMT and NAL were double tracked with separate Up Main and Down Main lines. Trains travelling towards Britomart were classified as Up trains and were identified with even running numbers. Trains travelling away from Britomart were classified as Down trains and were identified with odd running numbers. Trains ran on the left-hand track in the direction of travel.

1.1.6 The DC locomotives and SD driving trailers were each fitted with a computerised "Tranzlog"[3] type of event recorder. The system recorded the following data:

- train speed
- direction of travel
- throttle position
- brake pipe air pressure
- main reservoir air pressure
- headlight, ditch light and train whistle operation
- locomotive engineer response to the vigilance system
- some aspects of the engine performance.

1.1.7 After each occurrence, data from the Tranzlog fitted to the DC locomotives and SD driving trailers was downloaded. In each instance, the Tranzlog was noted as working correctly and the time stamps were consistent with train control time. During the examination of the data, some discrepancies were noted in the accuracy of the recorded speed information and this has been allowed for when analysing the event sequences.

[3] The brand name of the standard event recorder installed on most vehicles in the rail fleet.

Concept and development of the push/pull sets

1.1.8 Between 1996 and 1998, Tranz Rail purchased 69 redundant British Rail mk2 carriages from the United Kingdom for conversion to New Zealand passenger train operations. Stage one of a project to re-engineer the stock started in 1999 when 9 carriages (classified as S cars) were converted and renovated for use on a daily locomotive-hauled passenger service scheduled to run between Palmerston North and Wellington.

1.1.9 In March 2003, a Heads of Agreement, and an Amending Agreement on 5 June 2003, were signed between Tranz Rail and the Auckland Regional Council for the refurbishment of 12 of the British Rail mk2 carriages into 8 SA passenger carriages and 4 SD driving trailers. These 12 vehicles would be configured into 4 three-vehicle push/pull sets for delivery between 31 December 2003 and 30 September 2004. The project was identified as stage 2 in the development of the British Rail mk2 carriages and the SA/SD vehicles had a design life of 25 years.

1.1.10 The project consisted of the drawing up of a detailed design, followed by the construction of a prototype push/pull set. During the re-engineering work, the 1435-millimetre gauge bogies and some of the British Rail air brake equipment that arrived with the carriages from the United Kingdom (not compatible with the New Zealand equipment) were discarded. Bogies suitable for the New Zealand track gauge of 1067 millimetres were installed. DC class locomotives were selected and modified to provide motive power.

1.1.11 The push/pull sets were designed to be used on limited-stop, outer-suburban routes and were not intended to be used on inner-urban, high-capacity, frequent-stop services as the Auckland suburban rail system was considered at the time. The reasons for opting for push/pull sets were as follows:

- there had been a 4-fold increase in ridership during the early 2000s (refer paragraph 1.1.17)
- the existing fleet of second-hand diesel multiple units (DMUs) was struggling to cope with the increasing demand for passenger capacity
- there was a high financial outlay to acquire new DMUs, which had been considered as an option at the time
- decisions on the electrification of the Auckland suburban rail system had still to be made.

1.1.12 During October 2004, Toll Rail subjected the prototype push/pull set to an initial testing programme for type approval, followed by testing for operational commissioning. At the end of that process and after formal approval had been obtained from the Land Transport Safety Authority[4], Toll Rail issued on 12 November 2004 a statement of compliance in accordance with section 6, Engineering Interoperability Standards in the National Rail System Standard (NRSS) for the prototype set to start commercial operations.

1.1.13 The Auckland Regional Transport Authority (ARTA) was formed in December 2004 from the Auckland Regional Council to plan, fund and develop Auckland's regional transport system. In a strategy document of 2005, ARTA reported that there was capacity within the rail network to cater for additional passenger traffic, and that the current under-utilisation of the rail mode represented an inefficient use of resources when taking into account the capital expenditure (both past and present) on infrastructure associated with the rail network. In addition to the existing network, there was potential to expand the rail network to provide for additional passenger services. Expansion of the rail network would assist in providing for additional alternatives to road-based modes and improving the safety and efficiency of those modes.

[4] Predecessor to Land Transport New Zealand, which has since been renamed the New Zealand Transport Agency.

1.1.14 The construction of further push/pull sets was subsequently authorised. A small number of the early sets were fitted with solid drawbar couplings between the carriages, but this arrangement was discontinued and the British Rail automatic coupling equipment that came fitted to the carriages was retained.

1.1.15 ARTA owned the push/pull sets. The DC locomotives were leased from Toll Rail. ARTA contracted Veolia to operate the various classes of rail vehicle used on the Auckland suburban rail system, including the push/pull sets. Veolia subsequently had a contract with Toll Rail for the mechanical maintenance of the sets, which was carried out at the Toll Auckland Metro Maintenance (TAMM) facility in Westfield.

1.1.16 The push/pull sets were permitted to travel at a maximum speed of 100 kilometres per hour (km/h). There were speed-restricted areas within the Auckland suburban rail system where all types of train were required to travel at lower speeds because of track curvature, track junctions and track engineering requirements. For a full description of the locomotive, SD driving trailer and SA carriages and their associated braking systems, refer section 6.1 in the Appendix.

1.1.17 The following table shows the actual and projected ridership of the Auckland suburban rail system and the number of push/pull sets introduced in response to these numbers.

Year	Annual ridership in millions		Comment
	Forecast	Actual	
1993		1.0	
1994		1.2	fleet of second-hand DMUs replaces old carriage sets
1995		1.6	
1996		2.1	
1997		2.2	
1998		2.1	
1999		2.1	
2000		2.3	
2001	1.7	2.2	
2002	1.8	2.3	The Auckland Regional Council considers new DMU fleet acquisition*
2003	1.9	2.5	
2004	2.8	3.2	first push/pull set introduced
2005	3.9	3.8	5 further sets introduced
2006	4.5	4.8	4 further sets introduced
2007	5.0	5.7	4 further sets introduced
2008	6.1	6.8	2 further sets introduced
2009	9.1	7.7	all sets re-engineered to increase crush loading and improve braking capability
2010	9.9	8.4	4 further sets introduced and 3 planned to be introduced
2011	12.1		Rugby World Cup
2012	12.3		
2013	12.9		electrification now planned for 2013
2014	14.1		
2015	14.7		
2016	15.2		
2017	15.8		

*This proposal was later cancelled in favour of the push/pull sets.

1.2 Occurrence 06-105, Train 3114, Homai, 9 June 2006

1.2.1 On Friday 9 June 2006, Train 3114 had SD5761 (leading), SA3171, SA3193, SA3195 and DC4922. This set was identified as No.2 and had been commissioned to service in January 2005. Train 3114 was the scheduled 1350 Papakura to Britomart via Glen Innes service. The locomotive engineer driving Train 3114 was a trainee undertaking on-the-job training (OJT) under the guidance of a Toll Rail "minder driver". Veolia's staff consisted of a train manager and passenger operator.

Homai station had a 138 m long island platform. The Up main line through the station was contained within a 1111 m radius right-hand curve on the 1 in 690 descending gradient (see Figure 4).

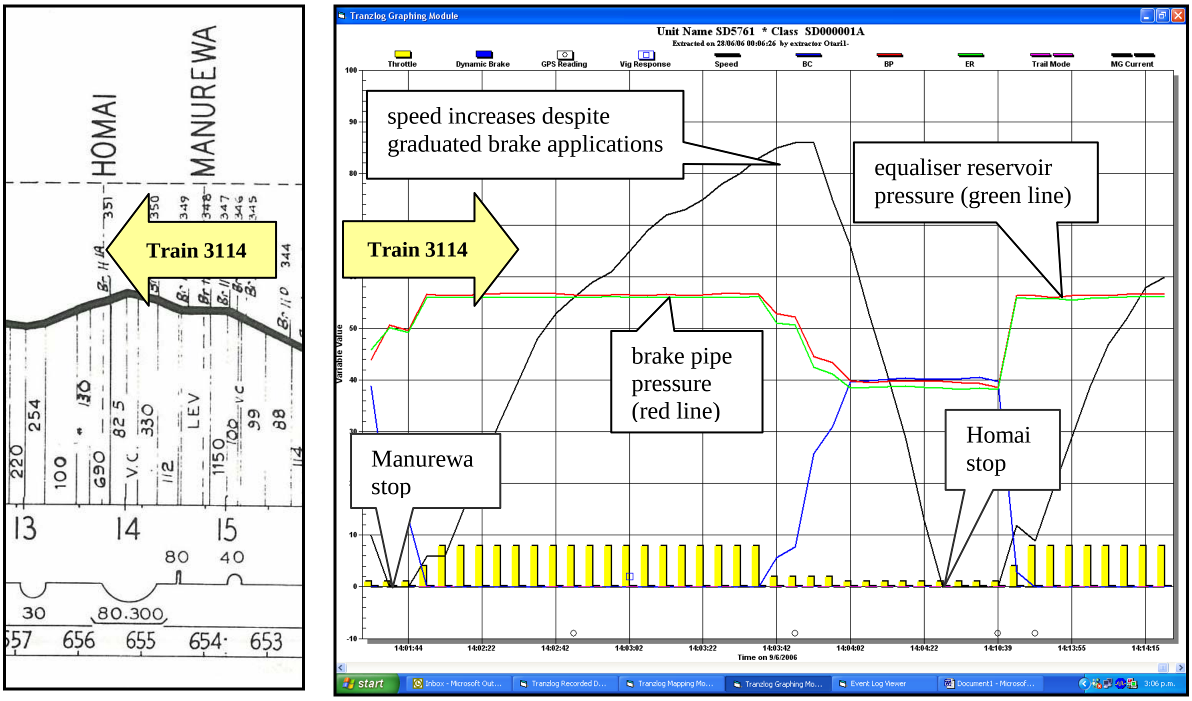


Figure 4
Homai station track alignment/gradient detail (left)
and (right) event recorder data from SD5761 (neither graph is to scale)
(refer appendix section 6.6 for a larger scale of the event recorder data)

1.2.2 The trainee locomotive engineer and minder driver had been rostered on the same shift for the previous 4 days. They booked on at Westfield at 1230 and travelled as passengers to Papakura to take up the running of Train 3114, their first service for the day. Train 3114 was scheduled to stop at all stations and left Papakura on time.

1.2.3 The trainee locomotive engineer said that he approached Manurewa at about 60 km/h. He reduced speed and stopped the train alongside the platform without incident.

1.2.4 The locomotive engineer said that, after the stop at Manurewa, he accelerated the train and attained a speed of about 90 km/h between Manurewa and Homai. He made an initial brake application at its normal location and the train speed had reduced to about 40 km/h by the time the train reached the start of the Homai platform. The entire train set overran the platform and stopped with the locomotive about 20 m beyond the other end of the platform.

1.2.5 The minder driver thought that the brakes had been slightly ineffective as the train approached Takanini, the first stop after Papakura, but not to such an extent that it should be withdrawn from service. He said that he advised the trainee locomotive engineer to adjust his braking when approaching station platforms. Subsequent stops at Te Mahia and Manurewa were carried out satisfactorily.

1.2.6 The minder driver added that the trainee locomotive engineer made the first brake application slightly further back and let the train drift on that application towards the platform at Homai. He thought the train speed was maintained at about 40 km/h along the platform and when the last application was made it took a fair while to be effective, by which time the train had overrun the platform.

1.2.7 The trainee locomotive engineer and the train manager conferred and discounted the option of obtaining the necessary authority from train control to set back to the platform. The train left for the next station after a delay of about 11 minutes.

1.2.8 Event recorder data output from SD5761 (refer Figure 4) showed the following:

- the distance between Manurewa and Homai was 2 kilometres (km)
- during a 10-second period and while travelling at 83 km/h, an initial brake application was made and the throttle setting was moved from notch 8 (the highest power setting) to notch 2, but the speed increased to 86 km/h
- during the next 20 seconds the speed reduced to 66 km/h, the throttle setting was moved to idle (the lowest power setting) and the brake application was increased. During that time, the train travelled 413 m
- the overall stopping distance from when the train reached 86 km/h and the actual stop was 753 m
- the speed recording system was operating within design limits, although when the train was travelling at a true speed of 56 km/h the speed displayed on the console in SD5761 was 61 km/h.

1.2.9 Twelve days previously, on 29 May 2006, a locomotive engineer had reported details of poor braking performance in the 54D fault recording log book when operating the same set in push mode. The subsequent maintenance report stated that the braking system had been checked and the brake blocks on all the passenger cars had been within tolerance limits.

1.2.10 On the same date (29 May 2006) another locomotive engineer had also reported poor brake performance on the same set when operating in the pull mode. The nature of the failure was described as "poor brakes on this train which required full service to bring the speed down at all, on approach to platforms". Maintenance staff reported that adjustments had been made to the travel of brake pistons on DC4922 and some brake blocks on the SA/SD vehicles had been replaced where necessary.

1.2.11 On the morning of the incident (9 June 2006), another locomotive engineer had reported "very poor braking performance, even in full service there is no bite" on the same set.

1.3 Occurrence 06-105, Train 3321, Manurewa, 13 June 2006

1.3.1 On Tuesday 13 June 2006, Train 3321 had SD3197 (leading), SA3265, SA3201, SA3212 and DC4254. This set was identified as No.3 and had been commissioned to service in February 2005. Train 3321 was the scheduled 0623 Britomart to Papakura via Glen Innes service. The Toll Rail locomotive engineer driving Train 3321 was a trainee undertaking OJT under the guidance of a Toll Rail minder driver. They were the same 2 crew members who had been driving Train 3114 on 9 June 2006, described in section 1.2. Veolia staff consisted of a train manager and passenger operator.

1.3.2 Manurewa station had a 79 m long island platform. The Down main line through the station was contained within straight and level track (see Figure 5). Note: Wiri station was closed to passenger traffic.

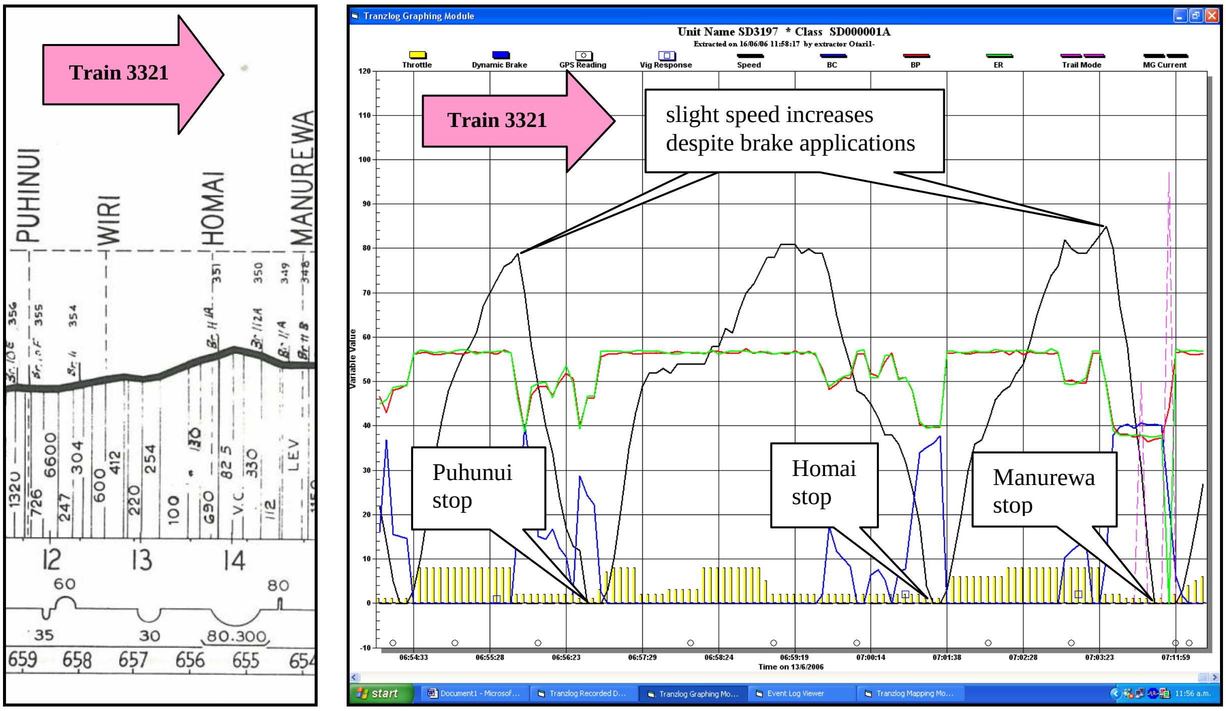


Figure 5
Manurewa station track alignment/gradient detail (left)
and (right) event recorder data from SD3197 (neither graph is to scale)
(refer appendix section 6.6 for a larger scale of the event recorder data)

1.3.3 Train 3321 was the first service the trainee locomotive engineer and minder driver were rostered to crew that day. Train 3321 was scheduled to stop at all stations and left Britomart on time with the trainee locomotive engineer driving the train.

1.3.4 The minder driver noticed that the train was travelling at about 80 km/h approaching Manurewa station in continuous heavy rain. The minder driver said that he had earlier discussed with the train locomotive engineer the need for him to adjust his braking technique when approaching platforms under such conditions.

1.3.5 The minder driver said the trainee locomotive engineer made the initial brake application at about the same location as he had done on previous trips. The minder driver instructed the trainee locomotive engineer to "put everything on" when he realised that the train was going to miss the platform. Most of the train overran the platform and it stopped with only the rear portion of the last carriage and the locomotive on the platform.

1.3.6 Combined event recorder data outputs from SD3197 and DC4254 (refer Figure 5) showed the following:

- the distance between Homai and Manurewa was 2 km
- the speed of Train 3321 was 82 km/h and the throttle was in notch 8 when the brake application was initiated
- during the next 4 seconds the throttle was moved to notch 2 but speed increased to a peak of 85 km/h
- during the next 6 seconds, the brake pipe and brake cylinders reached full service pressure reductions

- 4 seconds later, the throttle setting was moved from notch 2 to idle
- the overall stopping distance from the initiation of the brake application and the actual stop was 536.46 m
- an examination of the accuracy of the Tranzlog fitted to SD3197 showed that when travelling at 80 km/h, the true speed of the train was 2 km/h less than the speed displayed on the locomotive engineer's console.

1.3.7 Fifteen days previously on 29 May 2006, a locomotive engineer had reported that the brakes on SD3197 were operating less than optimally. TAMM depot staff reported that brake blocks on the locomotive had been replaced, the brake blocks on all passenger carriages had been inspected and adjustments made to the length of some of the brake cylinder piston travel.

1.4 Occurrence 06-107, Train 3169, Ellerslie, 11 August 2006

1.4.1 On Friday 11 August 2006, Train 3169 had SD5648 (leading), SA5729, SA5633, SA5637 and DC4536. This set was identified as No.9 and had been commissioned to service in December 2005. The train was the scheduled 1704 Britomart to Papakura via Newmarket service. The crewing of the train consisted of a Toll Rail locomotive engineer and a Veolia train manager and passenger operator.

1.4.2 Ellerslie station had a 71 m long island platform. The Down main line platform was contained within straight track on a descending gradient of about 1 in 200 (see Figure 6).

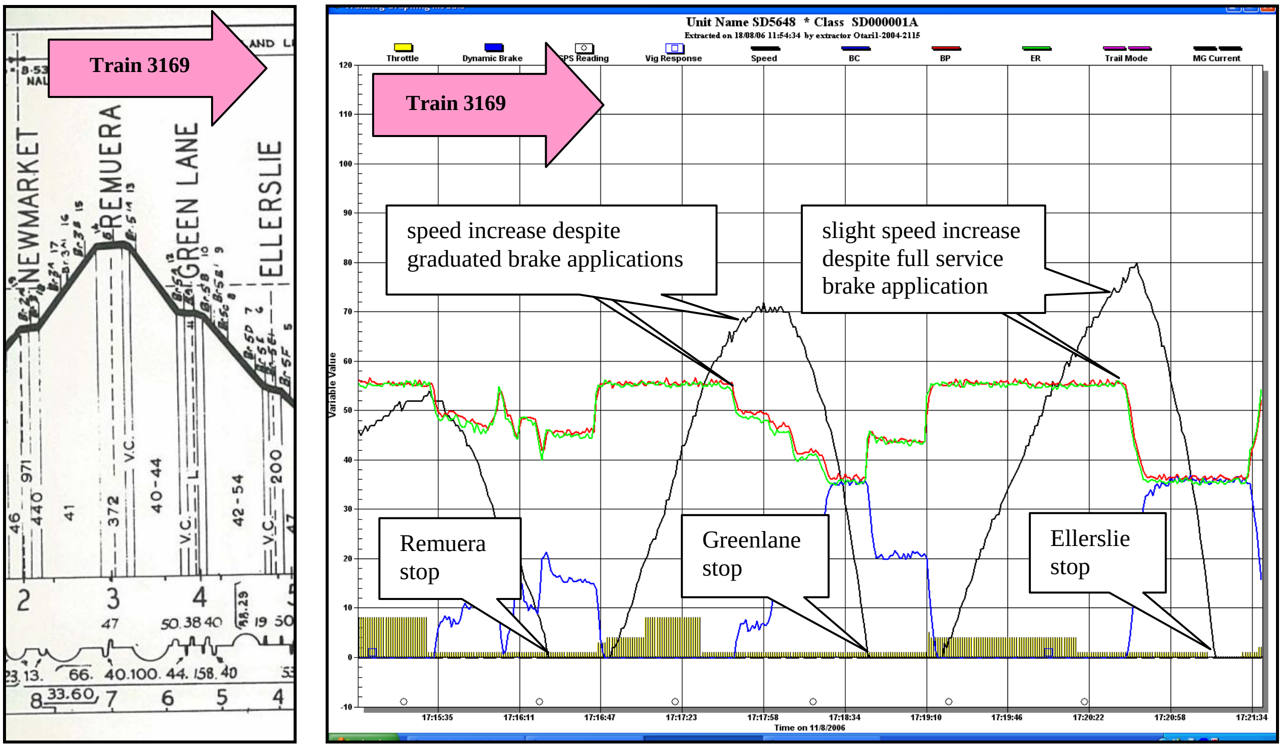


Figure 6
Ellerslie station track alignment/gradient detail (left) and (right) event recorder data from SD5648 (neither graph is to scale) (refer appendix section 6.6 for a larger scale of the event recorder data)

1.4.3 The locomotive engineer booked on for duty at Westfield at 1100 and drove a push/pull set to Britomart. After driving a round trip from Britomart to Papakura and return, he undertook alternative duties for the next 2 hours.

1.4.4 The locomotive engineer's final duty for the day was Train 3169, which was a different push/pull set from the one he had driven earlier in his shift. Train 3169 was scheduled to stop at all stations and it left Britomart on time. The stops at Newmarket, Remuera and Greenlane were achieved without incident. Because it was an evening peak-hour service, the service was carrying a capacity load of passengers from Newmarket.

1.4.5 The locomotive engineer said that he thought the train got up to about 70 km/h between Greenlane and Ellerslie. Initially he made a minimum brake application, then he increased the brake application from minimum to service when the train neared Ellerslie station. He made a further brake application followed by a full service application when he realised that the train was not pulling up in time. He felt the train was sliding but the wheels didn't lock because the speedometer continued to display speed information. The entire train overran the platform with the locomotive beyond the end of the platform.

1.4.6 The locomotive engineer looked back and saw that the passengers waiting on the platform were not moving. He felt that it was safe to set back to get one or more carriages on the platform because he hadn't released the door control to the train manager. He then set the train back without communicating with either the train manager or the train controller. Operating rules required the locomotive engineer to obtain specific authority from train control for such a movement.

1.4.7 The locomotive engineer said that during similar events in his native country and where there were no fixed signals present, the operating rules allowed the locomotive engineer to set back without the need to obtain authority. He said he thought about obtaining specific authority from train control, but because he knew there were no signals between where the train had stopped and the platform he thought that it would be okay to set back the short distance.

1.4.8 The train manager was travelling in the lead vehicle when the train stopped, but walked back to the driving trailer when he felt the train moving backwards. After the train had stopped, the train manager, conscious of passenger safety, opened only the local door on the driving trailer.

1.4.9 The locomotive engineer said that he didn't have a predetermined location where he initiated his brake applications approaching Ellerslie. He varied his braking technique to account for brake performance, passenger loading and the prevailing weather conditions. He said that every train set had its own characteristics, but he usually got an early feel if it was a good braking train set or not. He thought the braking performance on the set was good on the day of the incident.

1.4.10 Train control was not informed that the set-back movement had occurred and the incident was not reported by the train crew. Details of the incident were brought to the attention of Veolia some time later.

1.4.11 Combined event recorder data outputs from SD5648 and DC4536 (refer Figure 6) showed the following:

- the distance between Greenlane and Ellerslie was 1.91 km
- the speed of Train 3169 was 70 km/h when a full service brake application was made
- 9 seconds later the speed of the train had risen to 76 km/h
- the overall stopping distance from the initiation of the brake application and the actual stop was 646 m and this was achieved in 35 seconds
- the speedometer reading of 61 km/h displayed in the driving car of SD5648 was 4 km/h faster than the true speed of 57 km/h.

1.4.12 The 54D books from DC4536 and SD5648 for the 3 months leading up to the incident were examined to identify any entries relating to braking performance. On 1 August 2006, 10 days before the incident, a locomotive engineer had identified poor braking performance when driving from DC4536. The automatic brake valve had been replaced that day and subsequent testing confirmed that the braking system was code compliant. There were no reports in SD5648's 54D book relating to braking performance issues within the 3 months prior to the incident.

1.5 Occurrence 07-105, Train 2216, Te Mahia and Meadowbank, 10 April 2007

1.5.1 On Tuesday 10 April 2007, Train 2216 was made up of a 3-car set and had SD5652 (leading), SA5878, SA5861 and DC4536. This set was identified as No.11 and had been commissioned to service in July 2006. The train was the scheduled 0817 Papakura to Britomart via Glen Innes service. The crewing of the train consisted of a Toll Rail locomotive engineer and a Veolia train manager and passenger operator.

1.5.2 Te Mahia station had a 75 m long island platform. The Up main line platform was contained within a 1227 m radius right-hand curve on an ascending gradient of 1 in 100 (see Figure 7). Note: Tironui station was closed to passenger traffic.

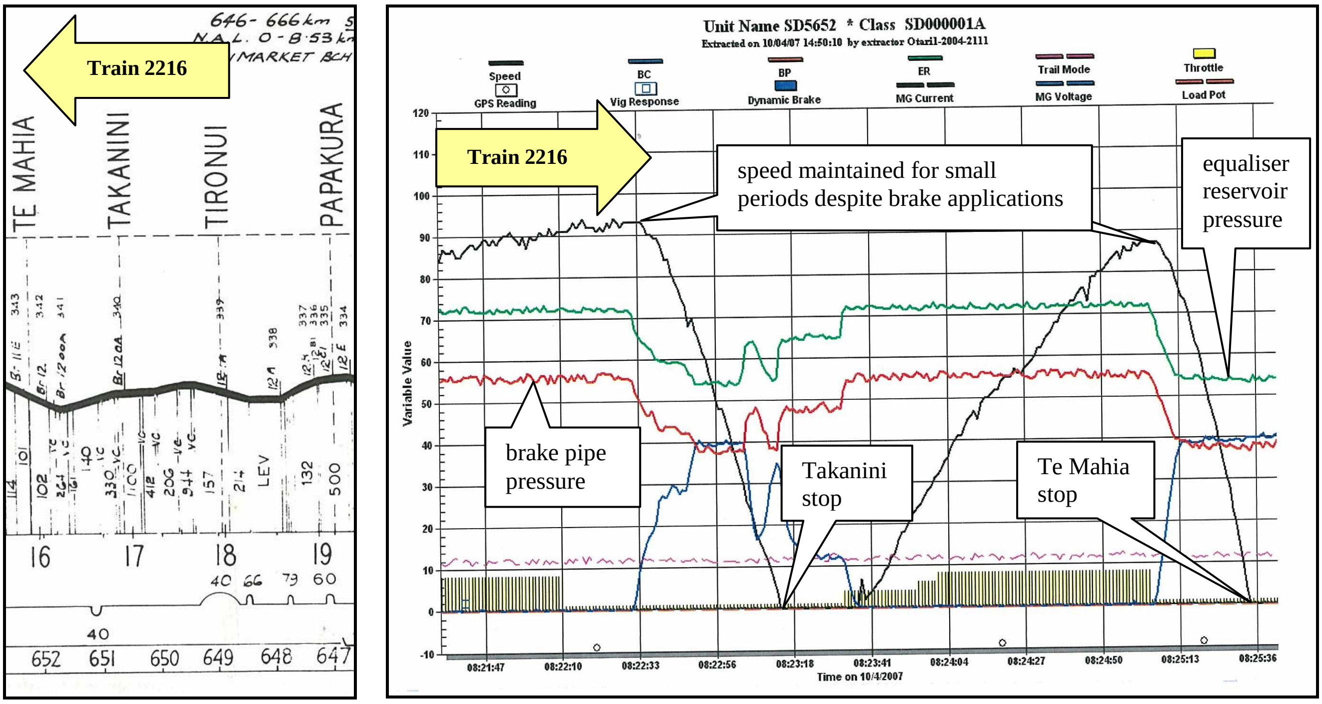


Figure 7
Te Mahia station track alignment/gradient detail (left) and (right) event recorder data from SD5652 (neither graph is to scale) (refer appendix section 6.6 for a larger scale of the event recorder data)

1.5.3 The locomotive engineer had booked on for duty at Papakura at 0400 and driven a 4-carriage set on a round trip between Papakura and Britomart. There had been no reported incidents on these 2 journeys. The locomotive engineer changed train sets on his arrival at Papakura and boarded a 3-carriage set programmed to operate Train 2216. Train 2216 was scheduled to stop at all stations on the journey to Britomart and left Papakura on time.

1.5.4 The locomotive engineer said that he made a normal brake application approaching Te Mahia station. He then advanced the brake application to full service when he realised that the train was not stopping in time. Only the last carriage remained on the platform when the train stopped. After the train manager conferred with the locomotive engineer, he arranged for the passengers to alight and board through the last carriage.

1.5.5 The event recorder data output from SD5652 (refer Figure 7) for the stop at Te Mahia showed the following:

- the distance between Takanini and Te Mahia was 1.6 km
- the throttle was closed for 19 seconds before a brake application was made for the previous stop at Takanini
- during a 6-second period and with Train 2216 travelling steady at 87 km/h, the throttle was moved from notch 8 to idle at the same time as the brake application was initiated for the stop at Te Mahia
- the equalising reservoir pressure and brake pipe pressure dropped uniformly straight from release to full service over an 8-second period and the full service brake cylinder pressure was achieved within 9 seconds of the brake application being initiated
- the overall stopping distance from the initiation of the brake application and the actual stop was 385.3 m.

1.5.6 The locomotive engineer said that after that incident he "took it a bit easier". He said that further into the journey he reverted to his normal braking practices when he felt the train was responding normally to his brake applications. Having stopped at several stations after Te Mahia, the train approached Meadowbank.

1.5.7 Meadowbank station had a 100 m long island platform. The Up main line was contained within a 563 m radius right-hand curve on a descending gradient of 1 in 157 (see Figure 8).

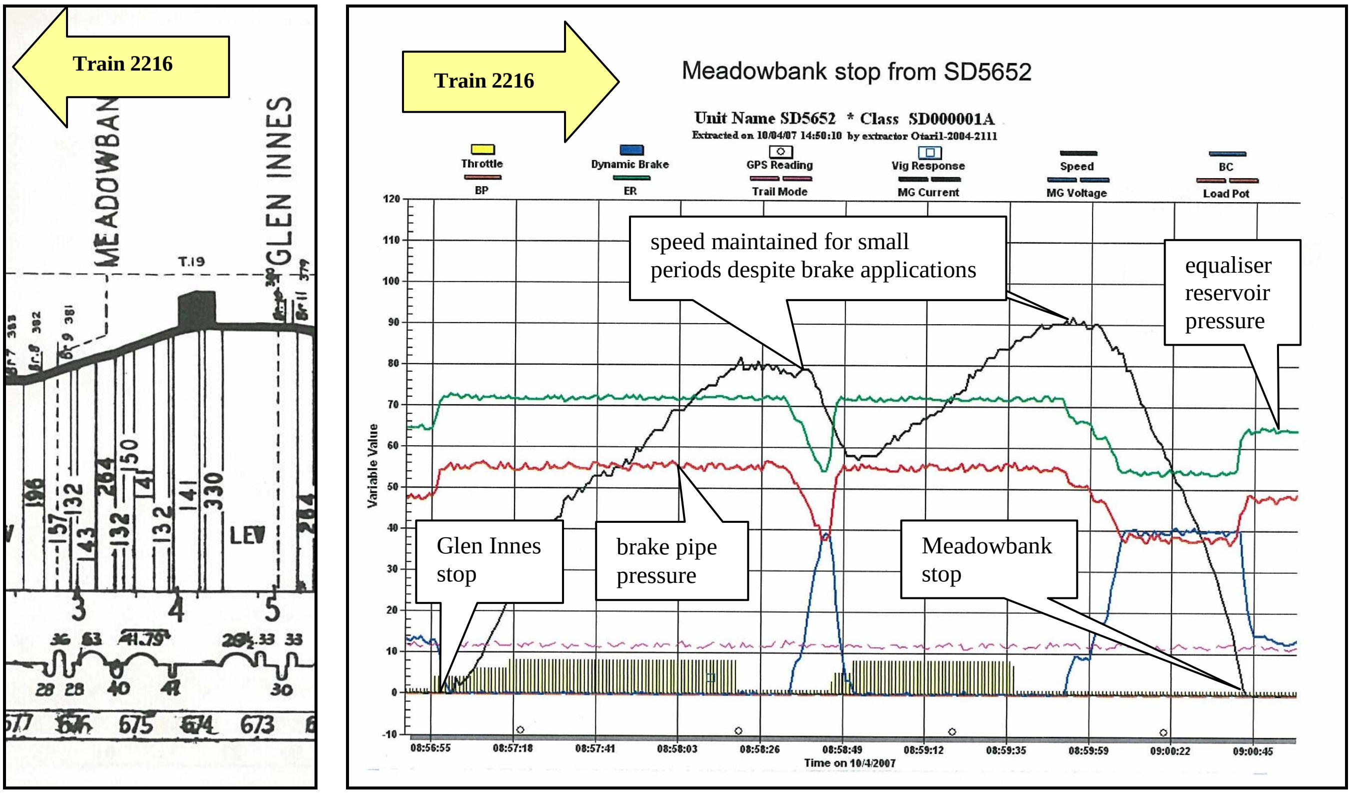


Figure 8
Meadowbank station track alignment/gradient detail (left) and (right) event recorder data from SD5652 (neither graph is to scale) (refer appendix section 6.6 for a larger scale of the event recorder data)

1.5.8 The locomotive engineer said that he made a normal brake application when the train approached Meadowbank station, followed by a full service application when he realised that the brakes were not responding as he expected. The train finally stopped 45 seconds later and had completely overrun the platform.

1.5.9 Because there would be delays in obtaining specific train control authority to set back to the platform, the train manager and the locomotive engineer agreed to continue the journey and leave the 5 waiting passengers on the platform to join a following service.

1.5.10 The event recorder data output from SD5652 (refer Figure 8) for the stop at Meadowbank showed the following:

- the distance between Glen Innes and Meadowbank was 3.62 km
- 14 seconds after the throttle was reduced to idle, the speed of Train 2216 approaching Meadowbank was 90 km/h and the automatic brake application was initiated
- during the next 4 seconds, the speed peaked at 92 km/h before speed began to drop in response to the throttle reduction and brake application
- the brake application was made in 3 steps: minimum reduction, then down to 470 kilopascals (kPa) and then a full service reduction
- the brake cylinders on DC4536 and SD5652 both responded correctly to each step of brake pipe reduction selected by the locomotive engineer
- the overall stopping distance from the initiation of the brake application and the actual stop was 868.3 m.

1.5.11 The train manager recorded the details of the 2 incidents on his running sheets and also telephoned details to a supervisor in Britomart station. The locomotive engineer logged details of the problem in the 54D book. The set was taken out of service after arrival at Britomart.

Post-incident mechanical examination of Train 2216

1.5.12 Following the occurrence at Te Mahia and Meadowbank, a data-verification process concluded that the speedometer on SD5652 from where the train was driven was reading 7.5% slower than true speed. The speedometer on DC4536 was reading 12% slower than true speed.

1.5.13 It was found that the verification process was deficient in that during sharp deceleration events, such as occurred in this instance at Te Mahia and Meadowbank, there was a lag between the information recorded by the global positioning system (GPS), radar and speedometer equipment. It was determined that the taking of one time stamp during the rapid decelerations produced unreliable results.

1.5.14 Further research concluded that an average of 10 system messages would provide a more reliable measurement of any GPS, radar and speedometer differential. Using this new procedure, it was found that the speedometer on SD5652 was reading 2% faster than true speed and on DC4536 was reading 1.3% faster than true speed.

1.5.15 Given these discrepancies, Toll Rail said that it was changing its maintenance check procedures to the averaging method. A software change to the Tranzlog system was necessary to support this new method and on 2 July 2008, KiwiRail advised that the appropriate technical committee had approved the changed maintenance check process in issue 3 of M9120 Tranzlog qualification tests for locomotives and driving trailers.

1.5.16 Following the commissioning of the set to service, the following faults relating to the braking problems on DC4536 were recorded in the 54D book:

Date	Nature of fault	Nature and comment on repair
7 September 2005	Bad flats on trail bogie as found.	Flats checked, Depot advised.
13 June 2006	Braking on this service starting to fade.	Loco serviced, new block fitted.
21 June 2006	Phantom penalty brake application at Remuera.	Checked operation of VD, cancels with everything.
1 August 2006	SD unit booked poor braking, found ABV not making 40 kPa reduction in minimum. Replaced ABV in SD. 40 kPa reduction now being made and SD brake cylinders showing 100 kPa but loco cylinders only showing 50 kPa.	Have been told this is in code but will investigate further.
28 November 2006	Piston travel excessive, brakes require adjustment.	All blocks adjusted.
6 March 2007	Brakes are starting to fade on this unit, at its worst when driving from loco. SD car not too bad to re-pad etc.	Brake efficiency test carried out to code. Brake travel and blocks are OK. ABV to change*. Minimum reduction out of code.

*The auto brake valve was subsequently changed out on 8 March 2007. The extent of the out-of-code pressure reduction was not recorded.

1.5.17 Between its re-commissioning and the date of the incident, DC4536 passed 5 scheduled air brake code checks. The results of all of the tests were recorded in the locomotive check sheet. There were no brakes cut out on set No.11 on the day of the incident.

1.6 Subsequent reported platform overrun incidents

1.6.1 In the 13-month period between the date of the Te Mahia/Meadowbank overrun incidents on 10 April 2007 and June 2008, the following platform-overrun incidents involving push/pull sets were reported:

Date	Station	Up or Down train	Push or pull mode
19 June 2007	Middlemore	Down	not recorded
26 June 2007	Middlemore	Down	not recorded
9 July 2007	Sylvia Park	Up	push
4 January 2008	Sylvia Park	Up	not recorded
28 February 2008	Orakei	Down	not recorded
12 March 2008	Sunnyvale	Down	not recorded
14 March 2008	Panmure	Down	not recorded
4 June 2008	Puhunui	Up	pull
6 June 2008	Meadowbank	Down	pull
11 June 2008	Orakei	Down	pull
21 June 2008	Middlemore	Down	pull

1.6.2 During June 2009, 2 further notifications of platform-overrun incidents involving push/pull sets were reported to the Commission. These incidents are summarised as follows:

Date	Station	Up or Down train	Push or pull mode
3 June 2009	Boston Road, Mount Eden and Mount Albert	Up	push
8 June 2009	Meadowbank	Up	push

1.7 National Rail System Standard

1.7.1 The NRSS was a series of 11 standards or “manuals” designed to provide guidance and set minimum standards for rail access providers and rail operators using the national rail system. The overview of NRSS/2 (Safety Management) described the NRSS as documents designed to be integrated into the rail safety systems of individual access providers and operators, and to provide guidance on implementation of the requirements of the Railways Act 2005 (NRSS/2, 11 June 2007).

1.7.2 The status of the NRSS could not be found within the standards themselves, or within the Railways Act 2005. NRSS/2 (Safety Management) contained a reference to an NRSS executive and 2 joint technical committees; Rail Operating Rules and Procedures, and Engineering Interoperability.

1.7.3 The membership of the NRSS executive comprised senior technical experts from general manager/executive and senior management level from key access providers and rail operators. The purpose of the executive was to review and approve proposed changes to the NRSS, and to discuss the future development of the NRSS (including reviewing recent overseas trends and aligning standards with international best practice).

1.7.4 The 2 joint technical committees were to manage the ongoing development of standards in their respective areas and to provide technical advice to the NRSS executive. They were made up of senior technical experts from the same key access providers and rail operators.

1.7.5 The Railways Act required each rail access provider and rail operator to hold a rail licence, which was issued by the regulator. Each licence holder was required to have a safety case also approved by the regulator, and an underpinning rail safety system. When asked about the status of the NRSS, the NZ Transport Agency said that it would not approve a rail participant's safety case unless that safety case referenced and adopted the NRSS. That was how it established a link between the Railways Act and the NRSS.

1.7.6 At the time of the inception of the NRSS in July 2004 (Issue 1), the regulator had no involvement in the NRSS executive, meaning the industry was effectively regulating its own standards. At the time of Issue 2 in June 2007, this situation remained. At the time of publishing this report, NZ Transport Agency had been given observer status on the NRSS executive, but did not have voting rights on any amendments, but that status had yet to be formalised within the NRSS or in any legislation.

1.7.7 KiwiRail's safety case referred to the NRSS as providing a generic framework for the management of the critical elements within KiwiRail's safety system and the systems of other rail participants. The safety case adopted the NRSS and stated it should be read in conjunction with the safety case and other relevant standards.

1.7.8 NRSS/6 Engineering Interoperability Standards contained the "Important Note" as follows:

> IMPORTANT NOTE: This document forms part of any "Access Agreement" between the Access Provider and any Operator, and should be read in conjunction with any such Access Agreement. In particular, the Access Agreement sets out certain procedures relating to vehicle, operational and safety audits, and the rights of the Access Provider in respect of any breach of that Agreement or the standards contained in this document. To the extent of any inconsistency between any Access Agreement and this document, the Access Agreement prevails.

1.7.9 Toll Rail had entered into an access agreement with the access provider at the time, Ontrack.

1.7.10 Section 2 of NRSS/6 specified that rail operators must ensure that their rail vehicles were designed, constructed, maintained and operated with good sound railway engineering practice, and the requirements of their licences and all NRSS standards.

1.7.11 NRSS/6, Engineering Interoperability Standards, detailed in part:

> **9 BRAKING AND ACCELERATION**
>
> **9.4 Rail Vehicle Braking Performance**
>
> 9.4.1 The braking system must achieve the following stopping distances from 80 km/h or line speed, whichever is greater:
>
> (a) the train within 885 m
> (b) a single vehicle (in a break-away test) within 650 m
> (c) passenger rolling stock must stop from 100 km/h within 600 m as per 9.4.2, individually or as a train, and in wet and dry conditions
> (d) EMU's within the Wellington suburban area must stop within 460 m from 100 km/h or be subject to Working Timetable speed restrictions.

9.4.2 This performance must be achieved under the following conditions:

(a) at all combinations of block or wheel wear and block material variation;
(b) on straight and level track;
(c) in any load condition;
(d) under normal climatic conditions;
(e) with individual car brakes cut out in accordance with Rules and Regulations;
(f) no tractive power applied to the locomotive;
(g) a full service brake application;
(h) brake system fully charged before application.

9.7 Air Brake System Type

The braking system fitted to rail vehicles are to be compatible with the single pipe direct release "Westinghouse" type automatic continuous brake system which has been traditionally used on the National Rail System.

The air brake system has the following parameters:

- Passenger and scheduled unit freight trains may operate on either "direct release" or "graduated release".

9.8 Compliance with Braking Standards

In general, the simplest way of meeting this brake standard is to provide a braking system that is compatible with the "Westinghouse" system with brake pipe pressure set at 550 kPa.

1.8 Licensing and monitoring of the rail industry participants

1.8.1 In 1993, the Land Transport Safety Authority (predecessor to the NZ Transport Agency) was mandated by the Government to administer railway safety legislation, oversee its application to railway operations and monitor ongoing compliance and performance.

1.8.2 A document called the Rail Safety Licensing and Safety Assessment Guidelines (the guidelines), first published in 2000, was updated in April 2006 following the passing into law of the Railways Act 2005. The 2006 guidelines (from which the information in this section was extracted) related to the safety management of railways in New Zealand and set out requirements of the Government with respect to safety. The guidelines placed the onus on each rail participant to take all practicable steps to ensure that none of the rail activities for which it was responsible caused, or was likely to cause, death or serious injury to individuals.

1.8.3 In defining its policy and designing the applicable legislation, the Government adopted a co-regulatory approach, meaning that the technical and operating standards that formed a rail participant's safety system were the responsibility of the rail industry. To gain a licence, each applicant had to show, through the submission of a safety case, that it had taken all practicable steps to ensure that all rail activities were safe. Reference needed to be made to the safety system and, in particular, comprehensive risk assessments. The risk creators (the rail participants and licence holders) carried the responsibility for managing their operations safely.

1.8.4 The NZ Transport Agency, as the Government's nominated rail safety monitoring agency, administered the legislation that required the application of an integrated safety management systems/safety assessment (audit) approach. This placed the Agency in a regulatory role that included approving the minimum requirements for the scope and contents of a safety case and underlying safety system. The Agency did not set technical or operating standards.

1.8.5 The NZ Transport Agency maintained its responsibility by monitoring railway participant performance. This was achieved by monitoring key performance indicators and accident and incident occurrence data and by performing safety assessments. The Agency, through the Government, had the power to intervene and make rules regarding technical and operating standards to ensure safety was maintained across the rail industry. In doing so the Minister would rely on the Agency for technical expertise in drafting rules and consulting the industry. As of 2010, no rules had been made for regulating the rail industry.

1.8.6 The NZ Transport Agency tailored the safety assessment[5] programme to match the nature and extent of rail participants' rail activities, taking into account their safety records. Initially it was assumed that only annual safety assessments would be needed for existing participants. The scope of safety assessments could vary so that annual safety assessments looked at one part of the business (in a cycle), with the whole business being covered every 2 years.

1.9 Safety system standard and practices

Minimum train braking/stopping distances

1.9.1 In 1966, New Zealand Government Railway mechanical engineers produced a research report that espoused the theory of train braking dynamics following a series of actual tests. The report outlined the limitations of the data used in calculating braking distances and the results gained were compared with theoretical results. The paper included a series of graphs showing the calculated stopping distances of the various types of train (in normal operation at that time) travelling at various speeds over level, ascending and descending gradients. The research referenced overseas tests conducted in India and the United Kingdom. The report remained relevant and was part of KiwiRail's safety system.

1.9.2 During the tests passenger trains were found to be able to stop within 600 m and freight trains took 885 m to stop. From this information, signal engineers developed a minimum intermediate signal spacing policy for the future installation or expansion of automated signalling systems on the New Zealand network. As most of the network carried both passenger and freight trains, the 885 m standard was exclusively adopted.

Signalling system design parameters

1.9.3 On railway systems worldwide, the capacity of a line was usually determined by customer requirements that stipulated the types of train (passenger and or freight) and frequency (trains per hour) envisaged to run on the line. Having reached that understanding, signal engineers then considered the following fixed infrastructure needs when designing signal placement:

- track layout and other track infrastructure requirements, such as:
  - maximum line speed
  - track curvature and gradient limitations
  - signal sighting requirements
  - turnouts leading to other signalled tracks
  - station platforms
  - tunnels
  - bridges
  - level crossings
  - train braking parameters
- headway. This parameter was the minimum time taken by a second (passenger or freight) train to traverse the distance running on green signals at maximum line speed behind a preceding (passenger and or freight) train also travelling at maximum line speed on green signals. In Auckland, for example, when designing the track duplication work and associated re-signalling work on the western line, ARTA had requested the ability to run 6 passenger trains per hour in each direction and KiwiRail needed to retain the ability to run a small number of long/heavy freight trains throughout the day.

1.9.4 The result of this planning led to signal aspect sequencing design that enabled both passenger and freight trains to stop within the erected signals. Normal signal aspect sequencing design is shown in Figure 9.

[5] Safety assessments confirmed whether or not rail licence holders were operating in accordance with their approved safety cases and supporting safety systems.

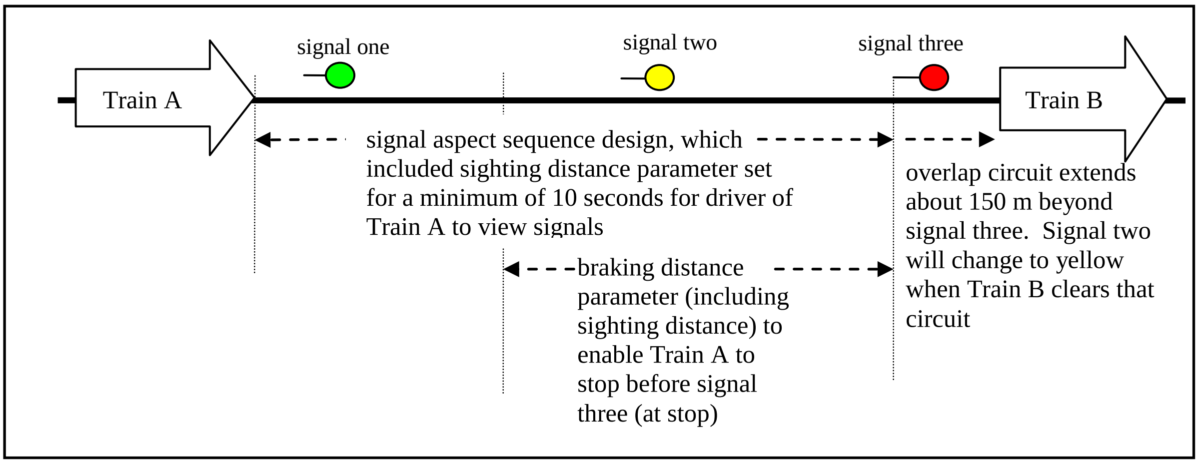


Figure 9
Signal aspect sequence design using 3 signal spacing (not to scale)

1.9.5 In the event that braking distance for the worst-performing train (usually a long/heavy freight train) that could not stop in the distance from the instant the steady yellow signal was sighted to the red signal, signal engineers incorporated a fourth aspect capability (flashing yellow) on the signal preceding the steady yellow to provide for greater braking distance (see Figure 10).

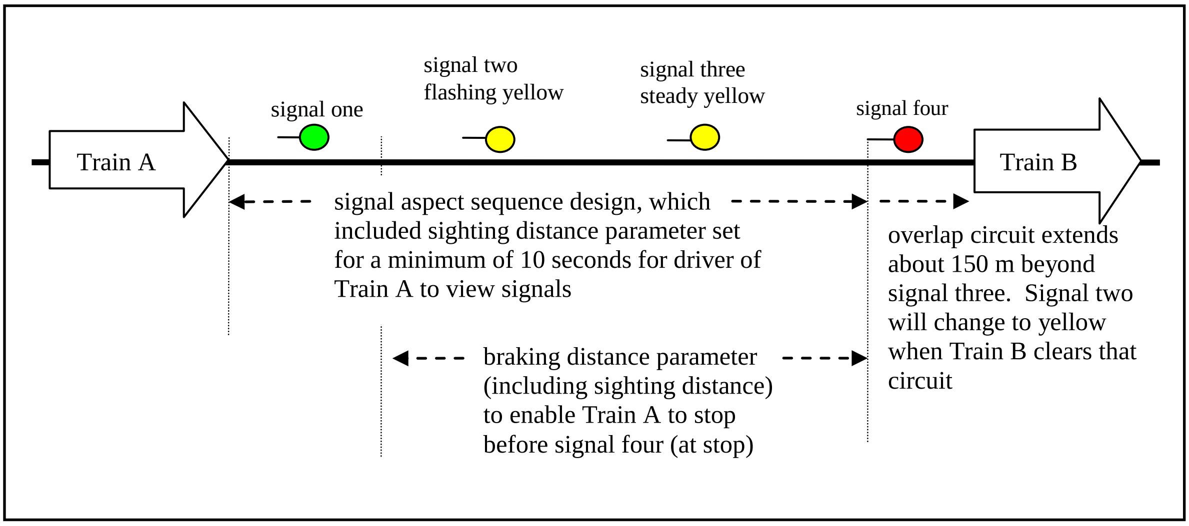


Figure 10
Signal aspect sequence design using 4 signal spacing (not to scale)

Comment on regulatory oversight from a previous report

1.9.6 A previous Commission investigation (Report 05-123, published on 20 September 2007) found that a number of significant decisions made during the building and commissioning of the push/pull concept increased the risk of the safety-critical brake system failing. One such decision included Toll Rail deciding not to conduct a dynamic brake test of a complete push/pull set as required by the NRSS, prior to signing off the prototype.

Toll Rail/KiwiRail interpretation of the NRSS/stopping distances

1.9.7 Toll Rail refuted the Commission's interpretation of the NRSS at the time of publishing Report 05-123 as follows:

> As a final comment, NRSS/6 is largely based on Tranz Rail document Q910, which applied entirely to enthusiast operated "heritage vehicles" and where it was required (based on experience) that each individual vehicle be specially verified as being compliant. Toll believe Clause 2.2 has not been properly developed to reflect the universal role of this new document and as such it does not differentiate clearly enough the requirements for "Type Acceptance", where the design and compliance of a first of kind is verified (requiring extensive activity) and the more routine verification of production examples of a series design. Currently Toll certifies to Ontrack that new designs are compliant but Ontrack quite rightly relies on Toll's Land Transport approved systems to ensure that each subsequent production vessel also complies. Toll will raise this matter at the Joint Technical Committee – Engineering Interoperability with a view to having the situation recognised in the wording of 2.2.

Mechanical engineering design manual

1.9.8 Separate sections of KiwiRail's M3000 mechanical engineering design manual, dated 9 June 2000 (which formed part of its safety system), stated in part:

> **3.2.3 Stopping Distances and Braking**
>
> The policy for the design stopping distances for all trains on level track is 885 m from 80 km/h.
>
> An additional 10% stopping distance margin is allowed for operational contingencies and is built into signal spacings.
>
> The design policy for new rail passenger vehicles is that they shall stop in the shortest distance possible without wheel-slide. Currently the maximum stopping distance for Electric Multiple Units in the Wellington suburban area is 460 m from 100 km/h.
>
> **18.14.3 Brake performance Requirements – Locomotive Hauled Vehicles, Locomotives and Power Cars**
>
> A fully loaded train must stop from 100 km/h in a maximum of 600 m on straight level track in wet or dry conditions, as demonstrated in actual stopping test with individual vehicles.

1.9.9 The completed Commission investigation (Report 05-123, referred to in paragraph 1.9.6) concluded that an appropriate level of regulatory oversight and intervention would have resulted in a more robust programme for commissioning the new concept of push/pull suburban passenger train operations in New Zealand. It also concluded that the rail regulatory system in New Zealand, where the rail participants set, owned and measured their own compliance with minimal intervention from the regulator, posed a risk to public safety because vested commercial interests were potentially in conflict with the public's right to a safe rail system.

1.9.10 As a result of this investigation, on 26 September 2007 the Commission recommended to the Director of Land Transport New Zealand that he:

> Note the failures of the regulatory system to detect shortcomings in the maintenance of infrastructure (as presented in the Commission's report 05-116: collapse of the Nuhaka Bridge under a work train) and shortcomings in the construction and commissioning process for newly modified rolling stock (as presented in Report 05-123), and;
>
> Take a more strategic approach to risk management of the rail industry, and in particular take more of a leadership role in setting, changing and monitoring compliance with national standards for rail infrastructure and rolling stock, and the interaction between these components of the rail system. (035/07)

1.9.11 On 26 September 2007, the Director of Land Transport New Zealand replied in part:

> Land Transport NZ has recently reviewed its regulatory activities within the co-regulatory New Zealand rail system and plans to take a more strategic, proactive and risk based approach in its monitoring of, and involvement with, the rail industry. Land Transport NZ notes the failure of the maintenance system that led to the collapse of the Nuhaka Bridge and in the commissioning and construction process associated with the construction of SD passenger cars, as outlined in the TAIC reports.

Brake testing

1.9.12 During the course of the investigation, the Commission posed a number of questions on the subject of the NRSS stopping distance to KiwiRail. It responded on 6 October 2008 in part as follows:

> **Testing Requirements**:
>
> A research report of 1966 has served as the basis for identifying calculated stopping distances to underpin setting of signalling distances in New Zealand. The following requirements have been derived from this report.
>
> National Rail System Standard/6, Clause 9.4 (c) specified the braking performance parameter for passenger rolling stock on the New Zealand rail network.
>
> The NRSS/6 requirement was "must stop from 100 km/h within 600 m as per 9.4.2, individually or as a train, and in wet or dry conditions".
>
> Note: 9.4.2 outlined the test procedure. Stopping was to be by means of a "Full Service" brake application.
>
> M3000 Design Manual, Section 18 Passenger Rolling Stock, Clause 18.14.3 also specified braking performance requirements.
>
> The M3000 requirement was "A fully loaded train must stop from 100 km/h in a maximum of 600m on straight level track in wet or dry conditions, as demonstrated in actual stopping tests with individual vehicles".
>
> The above confirm a need to conduct testing to ensure new passenger train consists comply with the specified stopping distances or, if unachievable, provide a basis for any variation that may be sought through the regulatory framework.
>
> The method used by KiwiRail (and predecessors) has been to complete a single car test and use this information to calculate the train stopping distance. This fitted within the NRSS/6 and M3000 requirements which provided for stops "individually or as a train" and "as demonstrated in actual stopping tests with individual vehicles" respectively.
>
> However, as can be seen in the test results and comment on braking performance criteria below, it has since been recognised there is a case for completing train stopping distance tests if there are conditions that had potential to negate the validity of using calculations based on single car tests.
>
> We are considering adding a qualification in M3000 covering the issue raised in the previous paragraph, with a view of also submitting a case for this to be included in NRSS/6.
>
> **Braking Performance**:
>
> The braking performance testing is not an exact science. There are a number of variables that will influence the outcome:
>
> - Rail condition.
> - Wheels and brake blocks heating during testing leading to fade and increasing stopping distances.
> - Track access to repeat tests over the same section of level track leads to a variation of gradient.

Apart from the May 2006 test (567 metres-SD leading) the stopping distances exceeded specified criteria. It is likely testing of unmodified train sets would produce a similar result.

Braking Performance Criteria:

The specified criteria appears to have some flaws when applied to SA/SD trains.

Converting the formulae from this report the specified stopping distance was 597 metres from 60 mph for express passenger trains. 100 km/h is actually 62.5 mph which would extend the stopping distance to 640 metres.

The research paper used eight car and eleven car JA [class of steam locomotive] hauled passenger trains to establish stopping distances. This must be a critical consideration when attempting to use this criteria for “short” diesel locomotive hauled trains.

Compared to wagons or carriages, locomotives have lesser self braking capability. This results in the attached vehicles contributing to braking the locomotive as well as the vehicles themselves. For the JA hauled trains each vehicle “carries” about 6.4 - 8.8 tonnes of locomotive. In the case of a four car SA/SD train each car carries about 20.5 tonnes of locomotive recognising that a DC locomotive has two axles undriven and unbraked.

It should be noted that the basic design requirement is to stop within signal headways. Given the stopping distance for freight trains, which are authorised to operate over the same territory, is 885 metres from 80 km/h it follows that a safe stopping distance for a passenger train would also be 885 metres from 100 km/h.

Nevertheless, it is conceded this anomaly would have been identified had the train sets braking performance been assessed against the M3000 and NRSS/6 criteria and a case prepared, taking into account any residual risk, for either an amended criteria or exemption if need be.

1.9.13 Information detailing single-car breakaway and complete-train braking tests was provided to the Commission in March 2009. Detail in part of that information is shown in the following paragraphs.

Single-carriage test results

1.9.14 Toll Rail mechanical engineers conducted extensive single-carriage breakaway testing using 2 SD driving trailers from different push/pull sets. The breakaway tests involved the uncoupling of the SD driving trailer from a test train, and on-board sensors/instruments measuring the distance travelled until the uncoupled vehicle had come to a complete stop. The SA/SD vehicles were fitted with the 4741 type of composite brake block at the time of the tests. The results of the tests were:

Date of test	Vehicle used	Speed range at time of vehicle separation	Achieved range of stopping distance	Average stopping distance
March/April 2004	SA carriage	99-100 km/h	458-499 m	479 m
September 2004	SD driving trailer	100-103 km/h	377-421 m	399 m

Note: The triple valve was modified and the brake rigging pins lubricated for the September 2004 tests.

It was calculated from these test results, using the formula from the 1966 research paper that a 4-carriage set operating in the pull mode would stop at 517 m from 100 km/h.

Complete-train test results

1.9.15 A series of braking tests was performed on 2 different complete 4-carriage train sets following the single-carriage tests. Note: tests were not completed for train set Nos.1 to 8 and Nos.11 to 14.

1.9.16 The initial series of tests used train set No.9. The tests took place on straight track but gradients varied because of distances required to attain braking speed. In comparison with the standard braking system on the other train sets, the SA/SD carriages on set No.9 were fitted with the 4741 type of brake block and a "Vercoelen link" was fitted to the brake rigging. The Vercoelen link was a modification that moved the slack adjuster stop from the body of the vehicle to the brake rigging. The modification retained brake force within the brake rigging instead of the previous transfer of some of the force into the vehicle body. The braking system also had a few pneumatic "tweaks" to speed up application and recharge times.

1.9.17 The following results were recorded in November 2005 and January 2006:

Push or pull mode	Speed	Time to stop in seconds	Achieved range of stopping distance	Average stopping distance	Deceleration rate
push	100 km/h	49	711-734 m	723 m	5.7%*
pull	100 km/h	49	785 m	785 m	5.7%*
push	not recorded		700 m	700 m	could not be calculated
pull			624 m	624 m	

*The deceleration rate of the train set was calculated by speed in metres per second divided by the time to stop, divided by the deceleration rate of gravity (g) established at 9.81 m per second squared. In comparison, the deceleration rate of passenger trains operating in the United Kingdom is approximately 9%g.

1.9.18 The second series of tests used train set No.10 and was conducted during May 2006. In comparison with train set No.9, the SA/SD vehicles on train set No.10 had the same braking system modifications, but were fitted with the LT14 type of composite brake. The following results were recorded:

Push or pull mode	Achieved range of stopping distance	Average stopping distance
push	567 m	567 m
pull	619-623 m	621 m

1.9.19 The tests conducted up to January 2006 were documented by KiwiRail in an internal report dated the same month. Land Transport New Zealand (the rail regulator at the time) said that prior to this it had not been formally advised that there were braking problems on the push/pull sets but that there may have been some discussions about perceived issues of braking consistency.

1.9.20 On 8 December 2005, Land Transport New Zealand received an email from Toll Rail just prior to set No.9's introduction to service, commenting on the enhanced braking system being supplied and advising that further testing would be done. The email said further:

> Train Set 9 is programmed to enter commercial service in Auckland this Friday, 9/12[2005]. As previously discussed 'soft' improvements that provide better brake system responsiveness / feel for drivers have been made.
>
> These changes are made within code compliance issues such as satisfying stopping distance requirements.
>
> Testing has now been completed by PSG [professional services group] to ensure that the train set is fully code compliant. The Christchurch testing last week achieved all our objectives without any problems being highlighted. A visiting Westfield RMTU driver rep was in attendance and was happy for the train set to enter service.

> Once in commercial use accurate in-service braking performance comparisons of TS9 against other non-modified sets will be prepared, this will include driver feedback before a definitive conclusion can be reached on the benefits of the modified system. It is our expectation that the train will enter service on or about Friday 9/12/05 and this being the case, its performance should be clear by early January.
>
> In summary, brake improvements have been developed as a result of increased experience with growing fleet size (earlier SA, SD incorporated improvements as a result of experience with the S car, SX and ADL vehicles) and, our efforts to continuously improve the product while making those improvements available to the customer as soon as possible.
>
> We must re-iterate the current brake system is safe and compliant, what we have done with TS 9 is offer improvements to the product by engineering refinement.

SD driving trailer control volume reservoirs

1.9.21 On 18 March 2009, KiwiRail said that a manufacturing error had been found when the control volume reservoir on the SD driving trailer produced a braking timing difference of about 2.5 seconds when compared with that achieved from the DC locomotive. This would mean that when operating in the push mode, trains were travelling some distance between brake application and brake engagement.

1.9.22 The following table shows the effect of the time lag between the brake application initiated by the locomotive engineer and the instant that speed began to decrease after the brake block engaged the wheel. The Tranzlog event recorder system recorded events at one-second data points with the exception of the Tranzlog fitted to Train 3369 at Ellerslie:

Station	**Comment on overrun distance from paragraphs 1.2 to 1.5 inclusive**	**Train speed at brake application**	**Train speed at brake engagement**	**Elapsed time between brake application and brake engagement**	**Calculated distance travelled between brake application and brake engagement**
Homai	Locomotive about 20 m beyond platform	83 km/h	86 km/h	5 seconds	117.03 m
Manurewa	Rear portion of last carriage and locomotive on the platform	82 km/h	85 km/h	4 seconds	92.52 m
Ellerslie	Whole train past the platform	70 km/h	76 km/h	9 seconds 4.5 seconds	181.99 m 91.00 m
The Tranzlog fitted to Train 3369 at Ellerslie recorded events at 5-second data points. The data recorded over the 9 seconds was halved to align with the average over the other 4 incidents.					
Te Mahia	Last carriage and locomotive on the platform	87 km/h	calculated to be 87 km/h	5 seconds	120.50 m
Meadowbank	Whole train past the platform	90 km/h	92 km/h	4 seconds	100.83 m
Average over the 5 incidents				4.5 seconds	104.37 m
Average distance travelled due to known 2.5-second delay from the incorrectly sized control volume reservoir					57.98 m
Average distance travelled during the remaining 2-second period					46.39 m

Note: The calculated distance travelled was determined by averaging the train speeds recorded at brake application and brake engagement.

1.9.23 The incorrectly sized control volume reservoir error was detected by Hillside workshop personnel during the construction of further push/pull sets midway through 2008. It was noted that the volume dimensions on official drawings did not match the size of the reservoirs as installed. A simple test to confirm actual volume confirmed there had been a discrepancy.

1.9.24 Replacement components were procured and were being fitted when the vehicles were taken out of service for major checks in Westfield. As at April 2009, about half of the fleet had been completed and it was anticipated the balance would be fitted by June 2009. When the error was detected, the push/pull sets had been in service for about 3½ years. Because locomotive engineers had already identified the difference in braking characteristics in driving between the DC locomotive and the SD driving trailer, KiwiRail decided that no further action was necessary.

Maintenance of a locomotive's air brake system

1.9.25 Toll Rail's mechanical code M9103, effective 1 September 2005, required that the air brakes on DC class diesel locomotives, including those leased to ARTA for the push/pull sets, be subjected, in part, to the following standard tests and servicing schedule:

> **1. Servicing**
> Carry out servicing test as per M9103, Section B.
>
> **2. A Check**
> Test operating efficiency of brakes, M9103, Section B.
>
> **3. B check**
> Change Compressor air filter. Check all brake rigging, piping, hoses and fittings for leakage and fouling. Test operating efficiency of brakes, M9103, Section B.
>
> **4. C Check**
> Clean compressor air suction strainer. Check all brake rigging, piping, hoses and fittings for leakage and fouling. Full Air Brake Code Test to the relevant section of the Air Brake Code M9103.
>
> **5. D & E Check**
> Clean compressor air suction strainer. Change compressor oil and test oil pressure. Clean out all dirt collectors and drain valves. Check all brake rigging, piping, hoses and fittings for leakage and fouling. Full Air Brake Code Test to the relevant section of the Air Brake Code M9103.
>
> **6. Air brake check**
> - Every 4 years
> - Remove the following brake equipment and replace with refurbished units:
>   26-F brake valve
>
> Full Air Brake Code Test to the relevant section of the Air Brake Code M9103.

1.9.26 The servicing test was an elementary test that occurred every time a locomotive was serviced, nominally about every 24 hours. The A and B checks were simpler brake efficiency tests and occurred at about 18 000 km, or after 2 months in service.

Maintenance of a carriage's air brake system

1.9.27 Toll Rail's mechanical code M9352, effective 19 October 2006, specified types of air brake inspection and test procedures for SA single-carriage brake test and an SD brake test. The code also contained a procedure for a complete push/pull set air brake operating efficiency test.

1.9.28 The sets were subjected to an annual brake efficiency tests during the scheduled "C" check with an upper limit of 14 months. Brake efficiency tests could also occur following reports from locomotive engineers containing information on defective braking performance, and whenever there was an operating incident in which the train's braking system might have been a contributory factor. Additionally, a brake efficiency test could be carried out on a set that had been under repair in the TAMM facility for more than 24 hours.

1.10 Personal accounts of the incidents

Locomotive engineer trainee, Trains 3114 and 3321

1.10.1 The locomotive engineer trainee began his conversion training for overseas-sourced locomotive engineers on 12 September 2005. About one month later, he started theory and OJT on freight trains over all routes serviced from Westfield. The locomotive engineer achieved his Certificate of Competency on 10 March 2006 after completing practical assessments driving freight trains as far as Helensville, Mission Bush, Te Rapa and Mount Maunganui.

1.10.2 A formal safety observation had been carried out on the locomotive engineer, covering both mainline and yard activity, on 2 May 2006. There were no areas of concern recorded.

1.10.3 The locomotive engineer completed a formative conversion training programme on the push/pull sets 4 days later. The training included the location of equipment in the passenger carriages, the operating instructions for the graduated release braking system and correctly positioning an empty set alongside station platforms including Homai, Ellerslie and Puhunui.

1.10.4 The locomotive engineer started his OJT with a minder driver on commercial push/pull train set operation on 22 May 2006. During the OJT period the minder driver recorded that he could not fault the locomotive engineer's train handling.

1.10.5 On 6 June 2006, the locomotive engineer was assigned a replacement minder driver because of annual leave commitments. The locomotive engineer commented that the 2 minder drivers promoted different driving styles when approaching station platforms. The first minder driver encouraged him to attack the platform and make a full brake application then reduce the braking effort as the train slowed. The second minder driver encouraged a cautious approach to the station platform by progressively increasing the braking effort until the train stopped.

Minder driver Train 3314

1.10.6 The minder driver undertaking training responsibilities on Train 3314 at Homai was a Grade 1 certified locomotive engineer and had experience driving the DMUs and locomotive-hauled passenger trains. He had taken up his minder driver responsibilities, initially on freight trains, in May 2001.

1.10.7 The minder driver had gained certification to drive the push/pull sets in April 2005. His minder driver responsibilities extended to OJT training on the push/pull sets from that date. The locomotive engineer on Train 3314 was his third OJT candidate.

Locomotive engineer, Trains 3169 and 2216

1.10.8 The locomotive engineer driving Trains 3169 and 2216 was the same person. He had overseas experience driving diesel-hauled freight trains for 5 years and driving electric multiple unit passenger train for 9 years. After being selected by Toll Rail, he had immigrated to New Zealand in June 2005 and shortly afterwards had started his induction training as a trainee locomotive engineer in Wellington.

1.10.9 At the completion of the induction training, the trainee locomotive engineer moved to Westfield and started a period of theory and OJT. He progressively gained competencies to drive freight trains over all lines serviced from Westfield between 15 March and 25 March 2006. On 25 March 2006 he received a certificate of competency as a locomotive engineer.

1.10.10 Two weeks later on 8 April 2006, the locomotive engineer underwent and passed a 4-hour training induction to start OJT on the push/pull sets. His OJT was overseen by a minder driver and he was required to complete a number of trips throughout the Auckland suburban rail network on the push/pull sets.

1.10.11 The locomotive engineer said that during his OJT he was trained by 3 different minder drivers. He added that he built up knowledge from other locomotive engineers' reference points for starting brake applications. He said that once during the early part of his OJT he had overrun the platform at Penrose station, with the front portion of the train past the platform. His minder driver had instructed him to stay where he was because those passengers wanting to alight could do so from a rearmost carriage. The locomotive engineer said that the minder driver had not discussed the process for setting back.

1.10.12 At the completion of his OJT on 13 June 2006, the locomotive engineer gained certification of competency to drive push/pull sets.

1.10.13 The locomotive engineer said that from his training, when aiming to stop a train at a platform, he positioned the locomotive off the platform when in pull mode, but in push mode he positioned the SD driving trailer at the end of the platform. Irrespective of the direction of travel, he said that he normally made a 200 kPa brake cylinder pressure reduction and, depending on whether the train was stopping too quickly, or not quickly enough, he would decrease or increase the brake reduction as he aimed for the end of the platform.

1.10.14 The locomotive engineer said that about 90% of his driving time since gaining certification had involved driving the push/pull sets. On 10 July and 21 July 2006 the locomotive engineer underwent A-Level safety observations while driving the push/pull sets. No areas of concern were recorded by the assessor during those observations.

1.10.15 In December 2006 and after the incident at Ellerslie, the locomotive engineer relocated to a depot in Papakura. This depot had been created to cater for the increasing frequency of push/pull train services between Papakura and Britomart. From that date and up to the time of the incidents on Train 2216, the locomotive engineer drove push/pull sets only and did not drive any freight trains.

1.10.16 During his time in Papakura, the locomotive engineer was assessed by 3 different assessors, on 9 February, 22 February, 27 February and 29 March 2007. The assessment records showed that the locomotive engineer had met requirements for train handling technique and correct use of the throttle and brakes in addition to a large number of associated activities associated with the operation of push/pull sets. The assessor had recorded that the locomotive engineer's train handling was "very smooth" during the assessment on 9 February 2007.

1.10.17 The locomotive engineer said that it was not normal to drive a 3-carriage set on Train 2216 because the service was normally programmed with a 4-carriage set. He considered that his inability to stop the train on the platform at Te Mahia was because of a problem in the brake system. He said that he "used certain spots such as a house, a building, a bridge, a km peg, a signal or an old tree that had been cut down and left lying in a field" as a reference point to start his brake application when approaching stations. He added that he used these same reference points in foggy conditions, during darkness and when driving 3- or 4-carriage sets.

1.10.18 Another factor that the locomotive engineer considered when driving either 3- or 4-carriage sets was the number of passengers being conveyed. He said that he had to apply the brake earlier when the train was full of passengers because of the additional weight.

1.10.19 The locomotive engineer said that he felt comfortable driving the push/pull sets because he had driven passenger trains over a lengthy period of time in his native country. He added that the conversion training was sufficient and he had received positive feedback from the training facilitators regarding his braking techniques approaching station platforms.

Other locomotive engineers

1.10.20 At the Commission's invitation, 6 locomotive engineers with careers ranging from one year to 48 years shared their experiences with driving the push/pull sets. Although these are personal accounts only, the Commission considers them persuasive because, collectively, they provide a consistent profile of the problems experienced by these locomotive engineers when driving the push/pull sets. The comments of the 6 locomotive engineers are summarised as follows. Note: 2 locomotive engineers gave evidence orally during the hearing.

- senior locomotive engineers received conversion training on the push/pull sets but did not receive OJT
- one locomotive engineer said that after he had received his conversion training, he spent the next 4 months driving freight trains
- braking qualities were different between the DC locomotive and SD driving trailer on each push/pull set
- braking qualities also varied between the push/pull sets
- no textbook, detailing best driving practices for the push/pull sets, was available
- a newly recruited locomotive engineer said that, without a textbook during his OJT, he felt he was learning to some extent by the seat of his pants
- senior locomotive engineers rated the SX train[6] braking qualities as superior to those of the SA/SD push/pull sets. The reason provided was that the SX train had 4 brake cylinders per carriage versus 2 cylinders per carriage on the SA/SD sets
- one locomotive engineer noted that there were 7 pivot points in the brake rigging under the SA/SD carriages
- experienced locomotive engineers conducted an "in-motion" test in order to get a feel of the braking power immediately after leaving the starting station on each train journey
- if brakes were not so good, experienced locomotive engineers consequently made earlier and greater braking reductions approaching stations
- trains with high crush loads required a more cautious approach to braking techniques
- braking techniques also had to be adjusted for wet weather conditions, autumn leaf fall and wintry conditions
- one locomotive engineer engaged the dynamic brake with help from air brake applications when descending gradients between Newmarket and Britomart and between Avondale and New Lynn
- the ability to use dynamic brake on other descending gradients was hampered by a 12-second time delay between dynamic brake application and energisation
- locomotive engineers were conscious of delivering a smooth arrival at stations because passengers would have stood up from their seats and walked to the door wells in readiness for the opening of the doors. They were also conscious of delivering a smooth departure when leaving the stations
- senior locomotive engineers related that they had to call on all their experience to deliver the best timekeeping performance and passenger comfort needs on the push/pull sets
- senior locomotive engineers said unanimously that the maximum speed attained between stations was between 80 km/h and 90 km/h, with one locomotive engineer targeting a speed of 85 km/h

[6] The SX train was a one-off push/pull set made up of different vehicles powered by 2 locomotives, one at each end of the train.

- after driving the trains for some time, senior locomotive engineers said that the best technique to stop a push/pull train was to make a 100 kPa reduction following an increasing series of graduated releases/reapplications on the brake. During the reapplications, the brake handle was restored within seconds to the previous position
- if the brakes were not so good, the locomotive engineers would make a full service application, followed by a series of graduated releases/reapplications
- experienced locomotive engineers aimed to have the train speed in the vicinity of 40 km/h or 50 km/h when the lead vehicle they were driving reached the start of a platform
- braking power was not so good at some subsequent station stops on a train journey
- senior locomotive engineers identified the following stations as requiring extra care when stopping: Meadowbank, Takanini, Te Mahia, Penrose, Greenlane, Otahuhu, Ellerslie, Remuera, Puhunui and Sunnyvale
- stopping trains at short platforms required complete focus from the locomotive engineers
- maintaining timekeeping required full cooperation between the locomotive engineer, train manager and signal box controllers/train controllers
- after a train journey, water sprayed on a DC locomotive's brake blocks turned to steam, while water spayed onto an SA/SD carriage's brake blocks did not vaporise
- the braking modifications should help in improving braking quality and consistency across the sets
- overall, the senior locomotive engineers enjoyed driving the push/pulls sets in spite of the braking inconsistencies they described.

Comparison of train timekeeping to timetable

1.10.21 In December 2009, the Commission researched Tranzlog data from 5 push/pull sets that ran services across the network on Friday 11 December 2009. This was done to test whether the timetable was realistic or whether the drivers had to drive aggressively to achieve the timetable. The data, shown in detail in Section 6 of the report, is summarised as follows:

- the review of train performance covered the running of 54 trains throughout the Auckland suburban rail system, representing 16% of the total number of services operated by Veolia
- Veolia reported in its executive summary for Friday 11 December 2009 that punctuality across all services achieved 85.2%. Its target is 82.5% of trains arriving within 5 minutes of schedule at destination
- dwell time at terminal stations allowed for most of the late-running trains to be turned round and leave on time
- there was evidence of infrastructure activity in 3 areas: between Fruitvale Road and Avondale (New Lynn trench), between Boston Road and Newmarket and between Papakura and Pukekohe
- the fastest speeds the trains achieved were between 80 and 90 km/h
- there was evidence that power braking was being used extensively in both push and pull modes when the trains were being slowed and stopped at stations
- there was no evidence that locomotive engineers were speeding to regain lost time
- the average time lost on those services that arrived late at destination, with the exception of Train 8111 (delayed by signalling failure) and Train 9154 (delayed by Police incident) was 3 minutes
- the evidence showed that circumstances not attributable to locomotive engineers and the timetable were the reasons for the scrutinised trains being delayed.

Professional services group comment

1.10.22 The professional services group was where engineering design, standards and overall management of mechanical practices in the rail system were centred.

The manager of the group was interviewed to gain an understanding of why KiwiRail's understanding of stopping distances differed from that of the Commission. The following comments are a précis of the group's understanding.

> The 1966 research paper remained relevant because it referred to basic physical constants of a train stopping on a piece of track. The sole purpose of the research paper was to set the minimum distances between signals and the basic physical principles haven't changed in the 42 years since the report was completed. One reason was that maximum train speed had not increased during that period.
>
> There were no inherent differences in train braking characteristics for a push/pull train, irrespective of direction of travel. The laws of physics had not changed, and if during 1966 test, the test train only had 4 carriages, then the carriages would have had to exert more braking effect to compensate for the reduced effort the locomotive was able to provide. Under those circumstances, the test train would have taken longer than 600 m to stop.
>
> The 600 m stopping distance was not a standard but a statement of what a JA-hauled passenger train of 11 carriages was able to achieve in 1966. The 600 m standard had become a gold standard whereas the real standard should have been the 885 m achieved by a freight train at the same time. The 885 m has been used by the signal design engineers to set the minimum distance between signals.
>
> Using a proven formula, it was mathematically possible to calculate the stopping distance of a train of any number of vehicles from the stopping distance achieved by one vehicle used within that train consist. For example, if one carriage could stop in a distance of about 400 m from a speed of 100 km/h in a breakaway test, being able to stop in about 600 m for a train of such carriages was achievable.
>
> It was physically impossible to stop a train within 600 m without the wheels going into wheel-slide. The 600 m was an arbitrary figure and had no relationship to a safe stopping distance within operational constraints.
>
> Feedback from a group of locomotive engineers to Toll Rail included comment that the brakes were not always consistent in their application and they were struggling to drive the push/pull sets reliably. The straight air brake system used on the sets required a little more care and planning in its use because of its slower application in comparison with an electro-pneumatic brake system fitted on purpose-built multiple units that operated in Auckland and Wellington.
>
> Because the push/pull sets were considered to be a train of separate vehicles and were different from a multiple unit design, there was no requirement for the trains to be subjected to complete train testing. Another reason why the sets were not required to be tested was that they could not achieve a speed of 100 km/h anywhere in Auckland.
>
> Resulting from an upgrade programme, the push/pull trains were being equipped with load-variable braking that should provide lower braking effort when a train was running empty and a higher braking effort when a set was running with a full crush load. The upgrade programme reflected the longer-than-forecast in-service usage of the sets and that they are carrying "a huge, increasing load".

1.11 Training

Internationally sourced locomotive engineers

1.11.1 The training programme for locomotive engineers with more than 2 years' driving experience recruited from overseas began with an induction programme as follows:

Pre requisites:

- Good English skills written and spoken.

Formative Training Period - Freight:

- Five pre-entry level unit standards:
  - demonstrate basic knowledge of railway signals
  - demonstrate knowledge of rail service operator
  - demonstrate knowledge of rail transport in New Zealand
  - demonstrate knowledge of rail network centres used to control the movement of rail service vehicles.
- train inspection freight rules and procedures - one week
- train examiner freight OJT - 3 weeks
- advanced railway signals - 2 weeks
- centralised traffic control - one week
- track warrant control - one week
- double-line automatic signalling - one week
- examinations - one week
- locomotive (mechanical) - 2 weeks
- train handling (simulator based) - 6 days.

1.11.2 At the completion of the induction phase, the locomotive engineer returned to their allocated depot location to undertake a conversion on the locomotive types operating in that depot together with a site familiarisation over all the main lines and yards serviced from the depot. The recruit then started a minimum of 500 footplate hours' OJT, supervised by a minder driver together with other training requirements peculiar to the area. The candidate was required to demonstrate:

- prepare the train for departure
- operate a locomotive-hauled freight train on all network routes serviced from the depot
- use all braking systems on the train
- demonstrate the use of emergency procedures.

1.11.3 Full certification for a locomotive engineer (freight) was achieved after the successful completion of the OJT and the passing of practical competency tests. There was no specified requirement for a post-freight OJT period to be completed before commencing the push/pull train set training.

Conversion to driving the push/pull sets

1.11.4 Internationally recruited locomotive engineers who had completed their initial training, and locally recruited locomotive engineers who chose to drive the push/pull train sets, underwent a conversion training programme. The programme included familiarisation training covering the procedures for and operation of:

- graduated braking system
- start-up and stabling
- door operation and door fault finding
- diesel alternator set start up and shut down
- solid bar connection between vehicles
- train handling instructions
- vigilance device, event recorder and radio instructions
- safety equipment and emergency procedures
- air conditioning system
- public address system.

1.11.5 At the completion of the conversion training, a practical competency test was carried out under the direction of an assessor. During the competency test the candidate was required to demonstrate:

- prepare and drive the set
- knowledge and use of the graduated braking system
- position the set correctly on at least 3 station platforms
- change driving ends between the SD driving trailer and the locomotive
- identify the emergency equipment.

1.11.6 The candidate, having the appropriate certification for the signalling categories for the area of operation, then underwent a 4-hour formative training period on all classes of push/pull train set:

- location of equipment on the sets
- operating instructions contained in associated M9349 and M9343 manuals to drive the sets equipped with a graduated release brake valve.

1.11.7 After a successful practical test, a candidate started the OJT content on commercial services under the guidance of a minder driver. The OJT included all Auckland suburban routes and at least 15 return trips from Britomart to Waitakere on the NAL and 10 return trips from Britomart to Papakura on the NIMT.

Minder driver selection

1.11.8 KiwiRail had no requirements for minder drivers to have specified minimum driving hours on the push/pull sets before they could perform tutorials on locomotive engineers driving such trains. The only formal requirement was that minder drivers were themselves subjected to a standard safety observation within each 8-month period. Apart from this requirement, minder drivers could be called upon to undertake some push/pull train set driving if called out for a shift that did not include any training component.

1.12 Train handling

1.12.1 KiwiRail's Operating Code, Section 4, Operating instructions for locomotive running personnel contained a 52-page instruction that detailed train handling. It said in part:

> **General Procedures**
>
> Good train handling is dependent upon 3 major factors, the most important being the judgement and skill of the locomotive engineer. To properly control the train the locomotive engineer must anticipate and plan ahead, so that no matter what problem arises it is the locomotive engineer's prompt assessment and reaction that ensures smooth and proper train handling rather than damage customers customer' s freight, a parting or a derailment. The skill of the locomotive engineer will be enhanced if the locomotive engineer adheres to the following procedures on proper use of the air brakes (both automatic and independent), dynamic brake, and combinations of air and dynamic braking and judicious use of the throttle.
>
> The second factor is the condition of the locomotive and vehicle's equipment, particularly in regard to braking system.
>
> The third but very important factor is the locomotive engineer to have a thorough knowledge of the physical characteristics of the territory to be traversed.
>
> A train is a complex mechanical system of vehicles, loads and springs and interacts with itself and the track in many ways. These interactions are in turn dependent various factors including the arrangement of vehicles with the train (particularly the placing of empty or lightly loaded vehicles in the train), length of the train, and characteristics of the locomotive consist.

Because no two trains handle the same, the locomotive engineer must pre-plan brake and throttle handling so that speeds established by timetable or bulletin are not exceeded.

Preplanning is of particular importance when approaching curves, turnouts or restricted speed areas so that authorised speeds are not exceeded and in-train forces are minimised while traversing these areas.

Locomotive Brake Efficiency

If the brakes on a locomotive are allowed to apply during brake applications, the deceleration rate for a locomotive for a given brake reduction is generally quicker than the deceleration rate for freight wagons, particularly loaded ones.

Engaging dynamic brake to slow train

While the speed of the train is relatively slow, place the throttle in the "idle" position, pause for a minimum of 10 seconds to allow the traction motor magnetic fields to decay, then move the dynamic brake controller to "set up" to establish dynamic brake circuits. Allow sufficient time for the train to settle.

The dynamic brake controller can now be moved slowly away from the "set up" position as required to control the speed of the train.

1.12.2 KiwiRail's Operating Code, Section 4, Operating instructions for locomotive running personnel contained a 3-page section covering the handling of passenger trains. It said that:

In handling a passenger train the problem of slack control is much the same as with freight trains. Most rough handling occurs at slow speeds and extreme care must be used to avoid heavy brake applications at the lower speeds.

Most passenger trains consist of only a few vehicles. In this case the locomotive brake must be allowed to apply; if not, the few vehicles on the train will be asked to do an undue share of braking. If the locomotive weight is 80 tonne and if there are only 4 vehicles on the train then each vehicle would need to brake 20 tonnes of locomotive as well as itself, and in this case very heavy reductions would be needed, resulting in high brake block wear and rough stops. With such short trains the locomotive must do some of the braking either with the air brake or dynamic brake where this can be used.

1.12.3 The same instructions contained a one-page instruction headed Power and prolonged braking that said that:

Power braking is where the train brakes are applied while the locomotive is still in power. This is wasteful as more braking effort is required to slow the vehicle than if power was shut off, resulting in greater heat being generated by friction causing the wheels to heat up excessively.

Power braking can result in overheated tyres and solid disc wheels. Power braking situations have resulted in:

- loose tyres – in a number of cases, the tyre came off and a derailment resulted
- solid disc wheels becoming loose on the axle and moving resulting in derailment
- cracked tyres
- spalled treads
- burned out brake blocks and brake shoes.

Locomotives hauling passenger trains must not use power braking above notch 2.

1.12.4 KiwiRail's mechanical engineering document M9349 SA/SD car operating instructions stated in part:

> **18 SA/SD Train Handling instructions**
>
> **Graduated Release**
> All SA/SD carriages are fitted with WG1 triple valves. The WG1 triple valves have a graduated release capability which means that in addition to the brakes being able to be applied gradually in steps, they can be released gradually in steps.
>
> The MAXX branded Passenger locomotives assigned to haul the SA/SD train sets have the 26C brake valve cut off valve set up for 3 positions, Out, Freight and Passenger. The Passenger position must be used on these locomotives when hauling the SA/SD sets
>
> **18.1 Key points for handling SA/SD train sets**
>
> **Operation as a Three Car + 1 SD car consist with a locomotive Working At One End** (Push – Pull Configuration)
>
> - **Important**: when being driven from the SD cab and while in the turnouts between Britomart and Newmarket branch and in the Otahuhu triangle **the locomotive throttle must not be used above notch 4**. This is to avoid a risk that the rear carriage will derail under excess push forces.
> - The locomotive will comprise 1/3rd the total train weight. Therefore to avoid skids on the carriages or overheating of the wheels, the independent release should not be used to bleed off any automatic brake application on the locomotive.
> - The locomotive and carriage brakes are capable of being applied, then partially released to any point between full service and release and can then be reapplied a further number of times. The air supply that feeds the brake cylinders is constantly topped up out of the Main Reservoir pipe, to ensure brake cylinder air is always available.
> - If a brake application is made and then the brake handle is moved part way back towards release the brake cylinder pressure will reduce according to the new handle position.
> - With the graduated release brakes on both the locomotives and carriages, there will always be air pressure in the brake cylinders after a brake reduction, until the brake pipe is fully recharged again. If the locomotive automatic brake application is left applied as recommended, the locomotive brake cylinder pressure will mimic the brake cylinder pressure on the carriages.
> - The emergency brake cylinder pressure on the SA/SD carriages is the same as the full service brake cylinder pressure. In emergency the speed of the brake application is faster due to the faster brake pipe discharge rate.

2 Analysis

2.1 The overrun incidents

2.1.1 Initially the Commission started monitoring platform overrun incidents in the Auckland passenger train network, not because each incident on its own was seen as a high risk, but because the statistics showed the frequency of platform overruns was trending up. To keep the matter in perspective though, the frequency amounted to less than one overrun for every 25,000 scheduled platform stops around the time when 13 of the push/pull sets were in operation. The potential for injury to passengers through slips, trips and falls would have existed if the passengers had tried to alight or board away from the platform once the overrun occurred, but this would only have happened if the outcome had not been effectively managed by the on-board train staff.

2.1.2 It soon became apparent that the level of risk was dependent on the reasons for the overruns occurring. For example, if the overruns were occurring simply through errors in judgement by locomotive engineers attempting to position their trains at platforms where there was little margin for error, the risk could be considered low. If, however, other factors such as substandard brake design and maintenance were contributory, that raised other potential safety issues when considering the worst credible scenario.

2.1.3 Trains were required to stop within a defined distance for a number of reasons. One key criterion used for setting a maximum stopping distance was signal spacing. A train must be able to stop before reaching a signal at red. The distance available to stop would be governed by when a locomotive engineer could sight the preceding caution signal(s) indicating an upcoming red signal. Considering a credible scenario where a signal might be at red because a train was stopped in the next section ahead, just on the other side of that signal, any failure to stop the train before that signal could result in a rear-end collision. The consequence of that collision would depend on the speed of the following train at the point of collision, or put another way, the extent of the overrun beyond the signal at stop.

2.1.4 During the inquiry into these platform overruns, a serious overrun incident occurred in Auckland where a passenger train overran the platform and ran through a busy level crossing, having passed a signal protecting the level crossing that was most likely still displaying a red (stop) aspect. The reasons for the train overrunning the platform and signal will be reported on separately in an upcoming report, but from information gathered so far, had it not been for an opposing train approaching the station on the other main line, the flashing lights and bells and half-arm barriers protecting road and pedestrian traffic would not have been activated before the overrunning train travelled over the level crossing. While that incident was likely to have been related to a platform overrun rather than a signal sighting issue, it does show that a train overrunning a platform or a signal can be a serious safety issue.

2.1.5 Driver technique and training is one area examined and is considered to be the main factor contributing to the overruns. Other obvious aspects to examine when a train fails to stop include train braking systems, train design, train scheduling and maintenance of brake systems. All of these factors are discussed herein.

2.2 Locomotive engineer training

2.2.1 The training the Toll Rail/KiwiRail locomotive engineers underwent was mainly focused on freight trains, although much of the knowledge learned during this phase was transferable to driving the push/pull sets. The focus on freight train driving was principally to meet the operational needs of Toll Rail/KiwiRail and was a consequence of the locomotive engineer hire contract that existed between those organisations and Veolia. Locomotive engineers who were trained in both types of operation could be assigned to either roster by Toll Rail/KiwiRail. While this did make for a flexible workforce, locomotive engineers were disadvantaged because they could be moved between the 2 operations and would have to adjust driving styles to suit. In particular, a key difference between freight and push/pull operations described in the training documents was braking technique.

2.2.2 A locomotive engineer who was going to be permanently assigned to driving the push/pull sets would have benefited from a training programme dedicated to that operation. All training for braking technique would then have been relevant to the push/pull sets that came equipped with the graduated braking system and how to use it to good effect to place the sets accurately alongside each platform. The concept of OJT under the tuition of a minder driver has some merit. A trainee gains first-hand knowledge of the operating environment and train handling. There were, however, 2 key elements missing from the training system that contributed to the platform overruns.

2.2.3 The first missing element was that there were no standards relating to the minder drivers. Toll Rail/KiwiRail did not select minder drivers for their skills in training and tuition, nor were they trained in training techniques, often referred to as "train-the trainer". Minder drivers were sought then assigned simply on the basis that they were qualified to drive the trains themselves. It was feasible that a new locomotive engineer could gain certification then immediately be placed on minder driver duties overseeing the training of the next trainee locomotive engineer. The risk with this type of approach was that skills and experience passed down to trainee locomotive engineers could diminish at each transfer.

2.2.4 The second missing element was the lack of common driving standards and techniques. This was evident from discussions with various experienced and new locomotive engineers. The technique for approaching and bringing a train to a stop at the right place alongside a platform differed depending on the minder driver with whom the trainee was placed. In some cases trainee locomotive engineers were taught 2 completely different techniques, one telling the trainee to "attack" the station aggressively, another telling the trainee to approach cautiously. Some locomotive engineers were told to focus on the far end of the platform where they wanted to stop, while others were told to focus on the near end as a "landing point" then proceed along the platform under control. The former was likened to the pilot of an aircraft incorrectly focusing on the far end of the runway when landing, rather than the runway threshold at the near end.

2.2.5 An analysis of the timekeeping by a randomly selected sample of 54 SA/SD train journeys (16% of the total) on the Auckland network in one normal weekday was made to gain an idea of how the trains were being driven and the resultant timekeeping. Veolia's executive summary for all train journeys on that day showed that 85.2% achieved the target of arriving within 5 minutes of their scheduled arrival times. The performance target was for 82.5%. The data from the Tranzlog verifies the comments mentioned by drivers to the Commission in the early part of the inquiry regarding power-braking, top speeds reached and the need to drive the trains reasonably hard to achieve the timetable.

2.2.6 There were a number of variables with which a locomotive engineer had to contend when braking a push/pull set to stop in position alongside the platform. These included:

- the length of the train in relation to the length of the platform and the accuracy required to position the train correctly
- passenger loading and the effect on stopping distance
- wet or dry track and the effect on stopping distance
- the gradient and curvature of the track on approach to and at the station
- the end from which the push/pull set was being driven and the effect on stopping distance.

These variables were not dissimilar to those encountered with other transport vehicles, and operators were taught and learnt through experience to adjust technique to make allowance for them.

2.2.7 There were, however, 2 performance standards that should have been achieved with regard to brake system performance. The first was that the vehicle should have been designed to stop within the constraints of the operating environment. The second was that the maintenance system should have been designed to ensure a consistency in braking performance with vehicles of the same type. If either one or both of these standards had not been met, the risk of an operating overrun would have been much higher because the locomotive engineer had the above variables to consider along with those inherent to the operation.

2.3 Push/pull set braking performance and the National Rail System Standard

2.3.1 In their submission, KiwiRail argued that discussion devoted to the push/pull set braking system performance and the National Rail System Standard was irrelevant as neither of these issues contributed to the platform over run incidents or of themselves raised any safety issues.

The Commission does not agree with KiwiRail for the reasons discussed below.

2.3.2 The brake system installed on the push/pull sets was a variation of that installed on freight trains and locomotive-hauled passenger trains operating across the New Zealand rail system, with the added enhancement of the graduated brake release function installed on the automatic brake valve in the driving cabs. The advantages of the air brake system were that it was cheaper to install, had synergies with the existing maintenance and spare parts systems, and could be installed relatively quickly compared with installing a more modern and efficient brake system that might be better suited to passenger trains required to stop frequently. The relative simplicity of the air brake system and the short development timeframe were in accord with the urgency of the design and build programme to meet the increasing public demand on the Auckland suburban rail network.

2.3.3 Some doubt was expressed by KiwiRail over the suitability of the NRSS (refer paragraph 1.9.7), in that it believed Clause 2.2 of NRSS/6 had not been properly developed to reflect the universal role of the document (the NRSS). The problem was that the brake system as designed and installed did not comply with the NRSS because the trains, when first introduced to service in 2004 and progressively throughout the following 4 years, could not stop within 600 m from a speed of 100 km/h. In Report 05-123, Overrun of conditional stop board due to a faulty automatic air brake valve near Meadowbank, the Commission questioned the "co-regulatory" nature of the rail system that allowed the designer and builder of the push/pull sets to also sign off the trains as compliant with the NRSS, with little intervention or oversight from the regulator. The Commission used the example of how the train sets had not undergone a brake test as a complete train before being signed off as fit for purpose.

2.3.4 KiwiRail argued at the time that the NRSS requirement to test train brake systems "individually or as a train" was an either/or case, and that it had chosen to test individual vehicles and use the data to calculate the complete train stopping distance. This was reflected in its M3000 mechanical engineering manual, where a fully loaded train was required to stop from 100 km/h in a maximum of 600 m on straight and level track in wet or dry conditions, as demonstrated in actual stopping tests with '**individual vehicles'** (Commission emphasis added).

2.3.5 This difference between the KiwiRail M3000 manual and the NRSS is significant, and raises the question as to which document took precedence at the time, an issue that is discussed in more detail later in this report.

2.3.6 The Commission does not accept that the intent of the NRSS was an either/or scenario, but instead that it was a worst case scenario. The calculation of train stopping distance from individual vehicle tests might have been appropriate for freight trains where the ratio of wagons to locomotive(s) was mostly high; but the same cannot be said for train sets designed with only 4 carriages to absorb the lesser brake performance of the locomotive because of its inherent un-braked idler wheel set configuration. For these reasons the Commission believes that the brake performance of these train sets could not be reliably calculated from single-vehicle tests. As well, the brake performance of the push/pull sets might have been different depending on whether the locomotive was pushing or pulling the train.

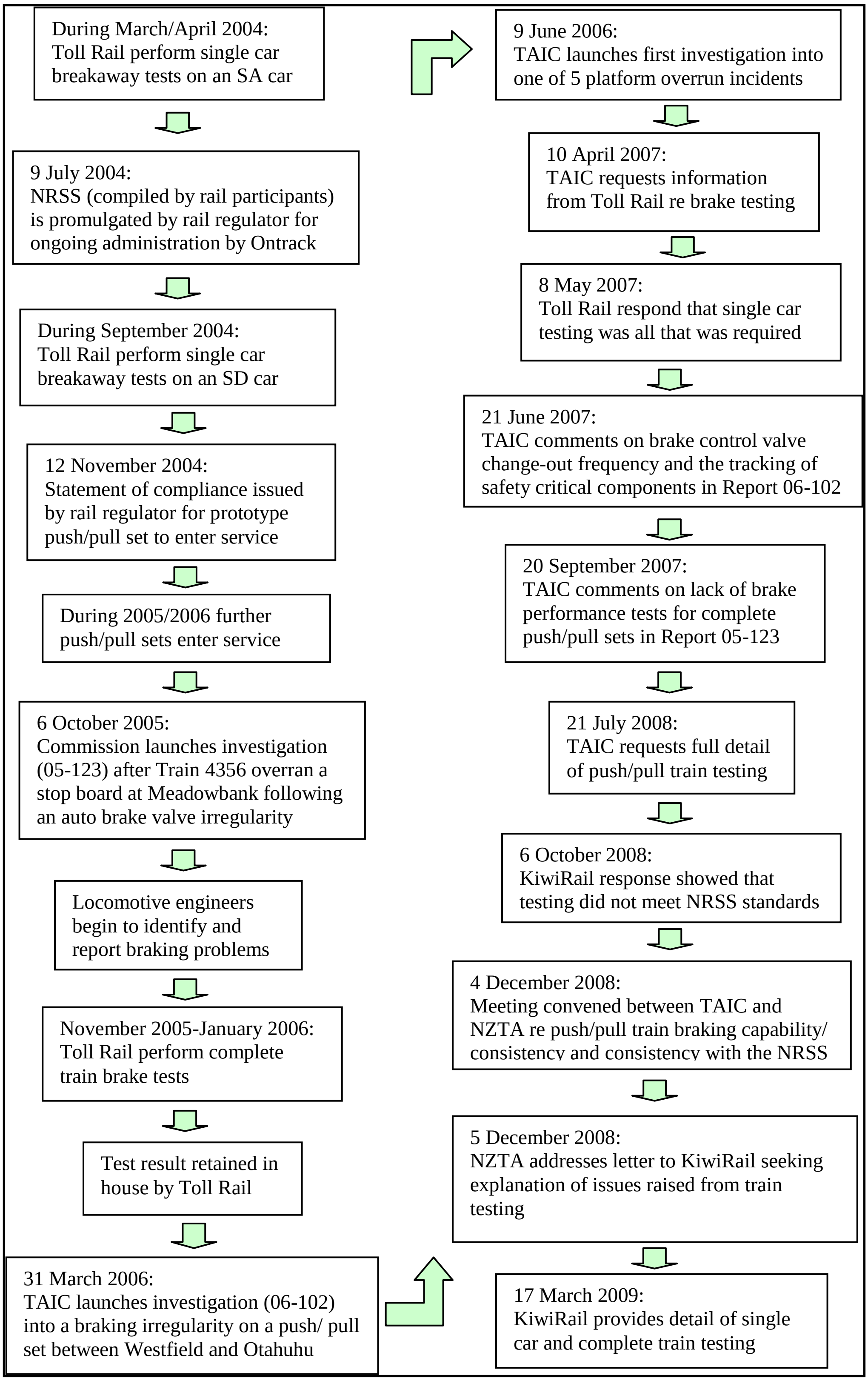
2.3.7 The Commission remains of the view that the push/pull sets should have been tested as a complete train in both push and pull modes and were therefore not adequately tested before being signed off as fit for purpose. This view has been supported by the results of complete-train testing since undertaken by Toll Rail, where all but one of the tests failed to meet the standard, and that was after making several modifications to the brake system and installing the Vercoelen link and a different type of brake block; these being some examples.

2.3.8 Toll Rail/KiwiRail did not at first provide the results of the complete-train brake tests, and only did so to the Commission following several requests. Nor did Toll Rail/KiwiRail provide the information to NZTA; instead it referred to the modifications as "improvements to product by engineering refinement" amid assurances that the modifications were "soft" improvements to a brake system that was "safe and compliant".

2.3.9 What Toll Rail/KiwiRail meant by these statements at the time was that it genuinely believed that the trains complied with the NRSS. This belief was formed out of the design group working to its own M3000 manual, which allowed for single-car breakaway tests rather than complete-train testing. The improvements that were made to the brake system were not in response to a failed test, but in response to 2 requests from the transport provider ARTA; the first asking that the push/pull trains be modified to handle crush passenger loading and the second a request for additional push/pull sets, both to meet the increasing public demand for suburban rail travel in Auckland.

2.3.10 To enable the push/pull trains to carry an increased crush load, modifications had to be made to the bogies, including to the brake system to make it more efficient. The increase in number of trains to be built meant that the supply of second-hand bogies ran dry and new bogies that could already handle the increased crush loads were purchased for the new trains.

2.3.11 The Commission made a further request for information such as loading and rail condition criteria. The information received confirmed that the full-train brake tests did not include a test with the train fully loaded (fully or part loaded, or empty) and did not include stopping distances under different track conditions (wet or dry). The following flow diagram shows the chronology of the various milestones around brake testing on the push/pull trains.



2.3.12 An assessment of the complete-train brake tests conducted on set No.9 (refer paragraphs 1.9.16 and 1.9.17) showed an average rate of deceleration (rate of change of speed) of 5.7% of gravity (9.81 m per second squared) from the time of brake application to the train stopping. According to information provided by the Rail Accident Investigation Branch in the United Kingdom, passenger trains in that country with different types of braking system achieve 9% as a standard in comparison.

2.3.13 An analysis of the event recorder data extracted following the brake tests showed that once the train brake had fully applied, the deceleration rate achieved was as good as, if not better than, that achieved in the United Kingdom. The results were being affected by the 2-second average delay for the mechanical brake rigging to take up any slack before any braking force was achieved at the wheels. In the push mode there was a further 2.5-second delay caused by the incorrectly sized control air volume reservoirs that had been fitted to all push/pull trains prior to August 2008, the date when the problem was first noticed. In the push mode this meant the train travelled for about 100 m before any deceleration was achieved.

2.3.14 The discovery in August 2008 of the incorrectly sized control volume reservoirs causing a delay in the brakes applying when driving in the push mode was an example of missed quality control at the build stage. More importantly though, this omission could and should have been detected during a robust brake-testing regime prior to sign-off of the first push/pull set to service. The delay in the brakes applying was evident from the event recorders in all of the overrun events. In some cases the speed of the train increased after the initial brake application due to track gradient, and in some cases the train travelled about one train length before the speed began to decrease.

2.3.15 There was a view (refer paragraph 1.9.7) within KiwiRail that the NRSS was not appropriate for the current rail industry when the push/pull sets were being designed and built. In some cases it was ignored, even though its safety case required strict adherence to the NRSS, and that this was a condition of its rail licence remaining valid. KiwiRail design engineers at the time of designing and building the push/pull sets were working to the M3000 manual because they had always done so, and did not refer to the NRSS document. They said they did not refer to the NRSS as they believed it had evolved from the M3000 manual and the requirements would therefore be the same. They believed that the inclusion of the words “or as a train” in reference to brake testing was a typographical error made during one of several documented changes in both the M3000 manual and the NRSS. The Commission considered and accepted this explanation.

2.3.16 There were examples where, if the NRSS could not be complied with, the executive committee, on the advice of the joint technical committee, reviewed and altered the relevant standards to reflect an achievable level of compliance. One such case was in 2006 during the Commission’s investigation into an uncontrolled movement of a passenger train in Auckland (Report 06-110). The NRSS set a latest date for fitting event recorders to passenger trains. When that deadline could not be met, the executive committee discussed the matter and changed the NRSS and added another 12 months for compliance without any analysis or input from the regulator. This was eventually resolved once the Commission raised the issue with the regulator.

2.3.17 Comments from within KiwiRail’s professional services group over the applicability of the 600 m stopping standard for passenger trains showed that it placed little credence on that standard because freight trains were given 885 m maximum stopping distance and both types of train were operating on the same network. The group believed that signal spacing was based on a 885 m stopping distance for trains. This was demonstrated in the KiwiRail mechanical design manual M3000, section 3.2.3, Stopping distances and braking, which stated that the policy for design stopping distances for all trains on level track was 885 m from 80 km/h.

2.3.18 The same section commented that an additional 10% stopping distance margin was allowed for operational contingencies and was built into signal spacing. This second statement was true, but failed to recognise that the 10% was applied to 600 m, not 885 m, as inferred. Section 3.2.3 in M3000 manual went on to state that the policy for new rail passenger vehicles was that they should stop in the shortest distance possible without wheel-slide. It was not until section 18.14.3 in the manual that stopping from 100 km/h within 600 m was mentioned, and only then for locomotive-hauled vehicles. Not only was this an inconsistency within the manual, it was at variance with the NRSS, which categorically stated that all passenger trains must stop from 100 km/h within 600 m.

2.3.19 The approach taken by the professional services group to stopping distances was, however, understandable. During this inquiry, it proved very difficult to establish why there were 2 different standards for stopping distances: 600 m for passenger trains and 885 m for freight trains. The reasons varied depending on who was asked, but no-one could say why, that information having been lost from the corporate memory of the organisation. The signal spacing was dependent firstly on the location of fixed structures, then on the required headway distance; that is, the frequency at which trains were required to run on a section of track. This would normally be decided by the designers of the train network in conjunction with the train operating company, in this instance ARTA and Veolia and their predecessors. The signal aspect sequence design would then be calculated based on the frequency and maximum speed at which the trains could travel, and the trains' ability to stop between signals. If the headway needed to be reduced for operational requirements, either the signal spacing would need to be reduced or more signal aspects would need to be introduced.

2.3.20 If freight trains were run on a line where the signal spacing was designed around 600 m (for either train headway or the stopping capability of the trains), additional signals or signal aspects would be needed to give freight train drivers more advance warning that they needed to stop their trains. If signal spacing (including the introduction of more signal aspects) were designed around a freight train stopping distance of 885 m, passenger trains would have no problem stopping in the distance available, but the operator's ability to reduce headway between trains would be compromised. This highlights some of the difficulties of operating freight and passenger trains on the same line; the signalling system could become complex in trying to cater for both.

2.3.21 For example, drivers of passenger trains would need to know how to interpret or how to react to a flashing yellow light. The driver of a freight train would know this meant that the next signal was displaying steady yellow, meaning the next signal in advance of that was displaying red. The flashing yellow light should mean to them that they need to start slowing their train in advance of the steady yellow signal; otherwise they might not be able to stop their train before the red signal because the distance between those signals could be less than 885 m.

2.3.22 A flashing yellow signal would mean the same to a passenger train driver, that the next signal was displaying a steady yellow aspect. The question for those drivers is, what action do we take now? Can the passenger-train driver ignore the flashing yellow signal and be safe in the knowledge that they can start braking at the next steady yellow signal and still stop their train before the following red signal? The answer is not clear, but KiwiRail said that in those circumstances the system was highly reliant on the route knowledge of the drivers. That is to say, the drivers would know what lay ahead, would know the stopping performances of their trains, and drive them accordingly. This philosophy would make route knowledge and train handling critical functions of any training programme.

2.3.23 KiwiRail confirmed that the signalling system across the entire network was based on an 885 m maximum train stopping distance, mostly using additional signal aspects and/or occasionally speed restrictions when the distance between signals was less than 885 m (considering view lines).

2.3.24 The 600 m stopping distance requirement in the NRSS, and the KiwiRail M3000 manual for that matter, would appear to be there for no other logical reason than historical, and nobody can say why. It is perplexing why this requirement remained within KiwiRail's system and within the NRSS for so long without anyone changing it to 885 m. Although KiwiRail design engineers were designing trains to stop based on single-car testing, they were still using the 600 m criterion. It was not until the appropriateness of single-car breakaway testing for push/pull trains was challenged that the 600 m requirement was questioned by KiwiRail.

2.3.25 KiwiRail put forward the argument that the "as a train" requirement in the NRSS was a transcribing error when the requirements of the M3000 manual were being put into the NRSS, and that if it weren't for that error the push/pull sets would have been compliant (based on single-car breakaway tests only).

2.3.26 Regardless of whether the current standard should have been 600 m or 885 m, or whether the trains should have been tested as a single car or as a complete train, 600 m was the documented standard at the time, so the push/pull trains should have been made to show compliance with that standard before being signed off as compliant. Had this been done, any error in the standards would presumably have been discovered.

2.3.27 The responsibility for the future planning of the rail system in Auckland lay primarily with ARTA (formerly Auckland Regional Council). The designers of the push/pull trains made it quite clear in the design specification that the trains were only designed for the current Auckland situation of outer-urban, limited-stop service. It seems likely that the true requirements of the push/pull trains became lost in communication between ARTA through KiwiRail down to the professional services group. As soon as the push/pull sets entered service, they were used on the same timetable as the DMU fleet were. It soon became apparent that the push/pull trains were not able to maintain that timetable, so the timetable was relaxed. Although a number of drivers felt that the push/pull trains required all of their skills to stop accurately at platforms and maintain the timetable, the survey conducted over one day of operation showed that the timetable was being achieved within agreed parameters.

2.4 Regulatory oversight

2.4.1 To accept trains for passenger service that did not comply with the stopping distance standards, even for a short period let alone an estimated 9 years and very likely many more years to follow, could have represented an unnecessary risk to the travelling public if the 600 m standard had been relevant. There was no doubt there was some pressure, actual or perceived, to upgrade services on the Auckland suburban passenger network as quickly and cost effectively as possible. There was nothing wrong with that, provided there were robust systems in place to ensure the design and build were subject to appropriate levels of quality control and regulatory oversight to prevent any commercial and social pressures from compromising safety through unnecessary risk.

2.4.2 For reasons said previously, there was some uncertainty within the rail industry over the suitability of the NRSS, and compliance with them. Other people in the industry had expressed dissatisfaction with the NRSS during interviews. KiwiRail's safety system was, in the opinion of the Commission, not compliant with the NRSS regarding train brake testing for new train types.

2.4.3 Had the certification of the push/pull trains been subjected to an appropriate independent check against the standards of the day by the regulator, or even by ARTA (the owner) or Veolia (the operator), the fact that the trains did not comply with the NRSS would have become apparent. Any error in the NRSS and the M3000 manual could have been identified at that time and rectified. That this did not happen is a significant safety issue. Although in this case the braking system on the push/pull trains as designed was fit for its intended purpose, the absence of a truly independent check against the various standards added an unnecessary dimension of risk to the rail operation.

2.4.4 The status of the NRSS was certainly not clear. It was not referred to in the Railways Act, and NZTA relied on its policy of requiring access providers and rail operators to reference the Standard in their respective safety cases in order to have those safety cases approved. KiwiRail expressed a further view in response to the draft of this report that the NRSS was subordinate to NZTA's approved safety cases and was enforceable by KiwiRail as access provider through the rail access agreements.

2.4.5 KiwiRail referred to the NRSS "and other relevant standards" in its safety case. Those other relevant standards were contained within its rail safety system (in the M3000 manual), so to audit compliance of the push/pull trains' braking performance an auditor would need to measure against the NRSS and the M3000 manual, which were not consistent with each other.

2.4.6 The access provider at the time, Ontrack, required rail operators to enter access agreements with it. NRSS/6, which Ontrack administered and for which it made up part of the executive, contained the statement that if there were any inconsistencies between the access agreement and the NRSS, the access agreement would prevail.

2.4.7 The NRSS states that it is designed to "provide guidance and set minimum standards", yet how enforceable those standards were had yet to be tested. The NRSS executive was self-appointed from within the key industry players, and did not seem to have any legal status other than from within the document itself, which the executive controlled. In other words, industry set the standards and relied on a combination of internal and external assessments to comply with them. The regulator had only in recent times been given observer status on the NRSS executive.

2.4.8 The NZ Transport Agency's policy of monitoring KiwiRail's entire safety system within a 2-year cycle based on one annual audit was not practicable given the sheer size of its safety system. The entire rail industry essentially evolved from KiwiRail's safety system, as it was from this system that standards for the industry were derived. What made it even more vital from a regulatory perspective for NZ Transport Agency to understand fully KiwiRail's safety system, was that it was referred to in the NRSS as the default standard in the absence of any other suitable standard.

2.4.9 If the NRSS were to be reviewed, so too would KiwiRail's safety case and underpinning safety system need reviewing to ensure that the 2 systems were and remained compatible. This could be problematic for other rail participants who had to operate on the same network. If the rail industry is to be future-proofed, the logical choice would be to review the NRSS and make it the minimum requirement to which all operators must adhere. That way, should the rail industry fragment again in future, as it did around the time the push/pull trains were designed and built, the NRSS would be the same for any operator entering the system.

2.4.10 The Commission has already made a recommendation (refer to Section 5) to Land Transport New Zealand (the regulatory authority at that time) regarding taking a more strategic approach to regulating the rail industry. For the reasons just given, that recommendation is applicable to this report as well. The Commission makes a new recommendation in this report to address the safety issue whereby there was uncertainty within the rail industry over the suitability of the NRSS as a national rail standard and that it is overdue for a full review. Such a review should be managed by an organisation independent of KiwiRail, the NRSS executive committee and NZTA. Ongoing ownership and control of the NRSS should be included in that review, as should the status of the NRSS and the relationship between its standards and rail participants' safety cases and underlying safety systems.

3 Findings

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

3.1 The platform overruns occurred because of one or a combination of the following errors in driver technique:

- braking was initiated too late for the speed of the train and the gradient of track on which the train was travelling at the time.
- the initial brake application was insufficient to overcome natural tolerances in the brake control rigging and to begin to slow the train effectively
- the over-use of power braking technique led to increased stopping distances.

3.2 The reasons for drivers braking too late included one or a combination of the following factors:

- insufficient transitional training when moving from driving freight trains to push/pull trains that were required to stop more frequently and with more precision at station platforms
- the additional 2.5-second delay in the brakes taking effect when driving in the push mode due to an out-of-specification control volume air reservoir that had been fitted to all train sets prior to 2008, including the prototype
- differences in driver perception of speed, depending on whether they were driving from the locomotive cab or the lower seating position provided in the SD driving trailer cab.

3.3 Reasons for drivers making insufficient or untimely initial brake applications included inadequate knowledge of the mechanics of the push/pull train brake system leading to a false expectation of brake efficiency at low brake applications, and unfamiliarity with the graduated brake release system available on the push/pull sets.

3.4 The reason for push/pull drivers over-using the power braking technique on push/pull trains was that it was condoned in driving instructions that were biased toward driving freight trains, and read by push/pull drivers. No dedicated comprehensive driving instructions for push/pull trains existed.

3.5 The Toll Rail/KiwiRail locomotive engineer training programme for the push/pull train sets was flawed because it did not teach a standardised methodology for driving the push/pull sets, it did not have standard methodology for minder drivers to pass on to trainees, and it did not set minimum levels of service and competency for trainee locomotive engineers.

3.6 The pure Westinghouse air brake system was not ideal for urban passenger train operations due to mechanical inefficiencies causing delays in the brakes taking effect, but in each of the overrun incidents, once a full service brake application had been made, the deceleration rate achieved by each train was comparable with deceleration rates achieved with other train types overseas, and is considered acceptable.

3.7 The requirement in the NRSS for passenger trains to stop within 600 m from 100 km/h as a complete train was not consistent with the design of the rail system, which was designed around accommodating freight trains that were required to stop within 885 m from 80 km/h.

3.8 The push/pull trains would be fit for their intended purpose of operating outer-urban, limited-stop passenger operations, as the current Auckland rail network has been described, provided the scheduled timetable was compatible with train performance and the drivers were adequately trained, and provided that it can be demonstrated that the trains can stop within 885 m in all conditions of loading and all conditions of track.

3.9 When the prototype push/pull set entered service in 2004, it did not comply with the NRSS at the time, which required it to stop as a train from 100 km/h within 600 m, in all conditions of loading and all conditions of track (wet and dry).

3.10 Inconsistencies between KiwiRail's safety system and the NRSS regarding complete-train brake testing resulted in the trains not being properly tested for compliance with the NRSS.

3.11 Single-car breakaway tests were not an appropriate method for assessing the braking performance of short locomotive-powered trains that might have had different handling characteristics depending on direction of travel, and where the brakes on individual carriages were required to absorb a higher percentage of the locomotive weight during the majority of the braking cycle.

3.12 Toll Rail designed and built the push/pull sets to standards within its own safety system with little reference to the NRSS because it had done so historically and because it had viewed the NRSS as a document that had evolved out of its own safety system for the benefit of other operators, rather than as an industry document that must be complied with.

3.13 The process for designing, building and commissioning new train types on the New Zealand rail network did not have an adequate level of quality control, independent review and regulatory oversight to detect that the push/pull train sets in this instance did not comply with the NRSS for braking performance as documented at the time.

3.14 There was sufficient evidence to warrant a full independent review of the NRSS and its status to establish:

- its applicability to the industry as it is today and for its likely direction in the future
- appropriate ownership and control of the standards
- an appropriate level of independent regulatory oversight of the rail industry.

4 Safety Actions

4.1 On 23 July 2010, KiwiRail said that it had developed and implemented a specific standardised driving technique for the push/pull sets to address the primary cause of the platform overruns. Initial results had demonstrated that proper application of the revised technique had significantly reduced the frequency of platform overrun incidents.

5 Recommendations

Previous recommendation

5.1 On 26 September 2007 and arising out of an investigation into an empty passenger train, following an automatic air brake irregularity, overrunning a conditional stop board at Meadowbank (Report 05-123), the Commission recommended to the Director of Land Transport New Zealand that he:

> Note the failures of the regulatory system to detect shortcomings in the maintenance of infrastructure (as presented in the Commission's report 05-116: collapse of the Nuhaka Bridge under a work train) and shortcomings in the construction and commissioning process for newly modified rolling stock (as presented in report 05-123), and;
>
> Take a more strategic approach to risk management of the rail industry, and in particular take more of a leadership role in setting, changing and monitoring compliance with national standards for rail infrastructure and rolling stock, and the interaction between these components of the rail system. (035/07)

5.2 On 26 September 2007 the Director of Land Transport New Zealand replied in part:

> Land Transport NZ has recently reviewed its regulatory activities within the co-regulatory New Zealand rail system and plans to take a more strategic, proactive and risk based approach in its monitoring of, and involvement with, the rail industry. Land Transport NZ notes the failure of the maintenance system that led to the collapse of the Nuhaka Bridge and in the commissioning and construction process associated with the construction of SD passenger cars, as outlined in the TAIC reports.

New recommendations

Arising out of the current investigation, the following new recommendations are made and are listed in order of development and not in order of priority.

5.3 On 19 August 2010, it was recommended to the Chief Executive of the NZ Transport Agency that he address the following safety issues:

5.3.1 The push/pull train sets were signed off as fit for purpose and commissioned to the Auckland passenger train network when they did not comply with the National Rail System Standard with regard to maximum allowable stopping distance as a complete train, and it has not yet been proven that they do so under all conditions of loading and track condition. (031/10)

5.3.2 The training system for drivers of the push/pull sets on the Auckland rail network did not use standard training techniques, did not teach standard best practice methods for train operations, and did not include appropriate standards for minder drivers to achieve before being certified to teach trainee drivers. (032/10)

5.4 On 25 August 2010, the Chief Executive of the NZ Transport Agency replied as follows:

> Discussions on this issue have been ongoing both with the Transport Accident Investigation Commission and various rail industry organisations for some time now since this issue was first raised with the NZTA. SA/SD set braking performance and associated issues also formed an integral part of both the Veolia and KiwiRail assessments this year.
>
> We intend to work closely with KiwiRail with an aim to implementing and closing these recommendations as soon as practicable.
>
> Discussions on them will be ongoing. Any outstanding Transport Accident Investigation Commission (TAIC) recommendations continue to form an integral part of our annual safety assessments of the rail industry.
>
> When these discussions are concluded and the appropriate evidence has been gathered, we will be liaising with TAIC with a view to closing this safety recommendation.

5.5 On 19 August 2010, it was recommended to the Secretary for Transport that he address the following safety issues:

5.4.1 the status of the National Rail System Standard and the relationship between these standards and rail participants' safety cases and underlying safety systems is not clear. For example, it is not clear whether KiwiRail's safety case and its underpinning safety system can be required to comply with the NRSS as a minimum, or whether the NRSS is subservient to KiwiRail's safety system. An approved (by the regulator) change to KiwiRail's safety system could then by default become an approved change to the NRSS. If the latter, then it is also unclear what the relationship between the NRSS and other rail participants' safety cases and underpinning safety systems would be. (033/10)

5.4.2 the status of the NRSS Committee, the rights to membership of that committee and the responsibilities of each Committee member, and the terms of reference of the Committee is currently unclear. (034/10)

5.4.3 the National Rail System Standard has not been fully reviewed since they were established in 2004. Once the status of the standards and its Committee has been established then an independent review of the standards should be conducted to determine if they are still applicable to the New Zealand rail industry, and to ensure if they are representative of standards set in other comparative countries operating modern rail systems. (035/10)

5.6 On 3 September 2010, the Secretary of Transport responded to all 3 recommendations as follows:

> The Ministry accepts this recommendation [035/10].
>
> As the National Rail System Standards are industry standards, which are developed by the NRSS Committee, and approved for inclusion in a rail operator's safety case by the regulator, the Ministry is well placed to carry out an independent review. In carrying out this review, the Ministry will particularly focus on the matters raised in recommendations 033/10 and 034/10.

Approved on 18 August 2010 for Publication

Mr John Marshall QC
Chief Commissioner

6 Appendices

6.1 Push/pull train vehicles and equipment

DC locomotives

6.1.1 The locomotives were originally built by General Motors of Canada and entered service in the 1960s as the DA class. Eighty-five locomotives were reclassified to the DC class after a mid-life conversion/rebuild programme completed in the late 1970s, early 1980s. It was known during the mid-life rebuild that some of the original air brake piping could have been retained on some of the locomotives. The reclassified locomotives' power rating was 1230 kilowatts, or 1650 horsepower in imperial rating.

6.1.2 The DC locomotives have been used to haul all classes of freight and passenger train and they remain the mainstay of the diesel locomotive fleet in New Zealand. During the development of some of the earlier push/pull sets, a number of DC locomotives were selected from storage and refurbished at Woburn workshops near Wellington to provide a 10-year service span powering the push/pull sets.

6.1.3 The locomotives' in-service tare weight was 82 tonnes (t) and they were slightly over 14 m in length. The locomotives rode on 2 bogies that each contained 3 axles (see Figure 11).

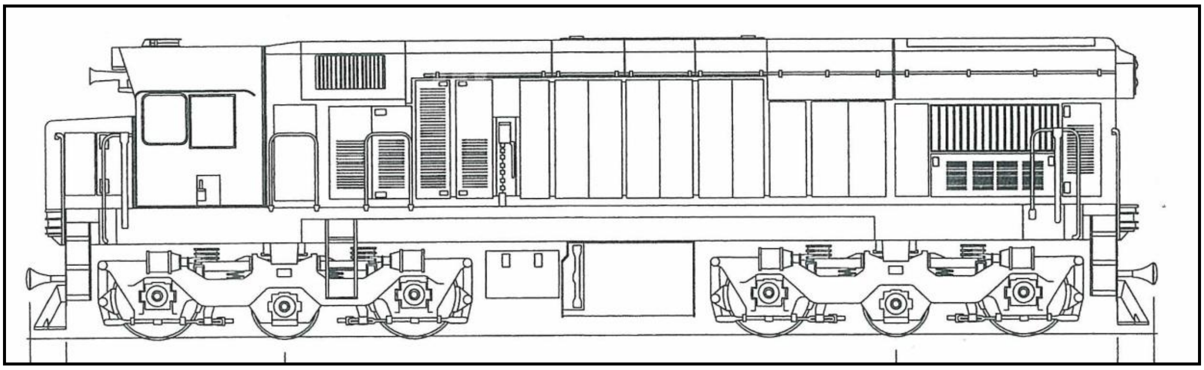


Figure 11
DC locomotive outline

6.1.4 The 2 outer axles on each bogie were driving axles and they carried 16 t each, 2 t less than the maximum permitted axle load on the controlled network. The centre axles had smaller wheels and were referred to as idlers. They were fitted for weight distribution purposes and were non-powered and non-braked. The 2 idler axles carried 9 t each for a combined weight of 18 t. The maximum speed of the locomotives was 100 km/h.

6.1.5 There was a dedicated pool of DC locomotives to operate the push/pull sets in Auckland, and the locomotives were not used on other services. The locomotives were regularly exchanged between the sets to meet scheduled and unscheduled servicing and maintenance requirements.

6.1.6 When operating in the push mode, the locomotive at the rear of the train was controlled from the cab at the outer end of the SD driving trailer via a train line connection. This locomotive-control practice mirrored the method of how 2 or more coupled locomotives were operated in multiple at the front of a train.

Westinghouse air brake system

6.1.7 The Westinghouse air brake system was a standard, failsafe train brake used by railways all over the world. In New Zealand it was referred to as the 26L air brake system. The system was based on the simple physical properties of compressed air (up to a maximum pressure of 550 kPa) as the force to apply and maintain brake block pressure against the wheel treads. The compressed air was transmitted through a brake pipe along the length of the train and the changes in the level of air pressure in the brake pipe caused a change in the state of the brake on each vehicle (see Figure 12).

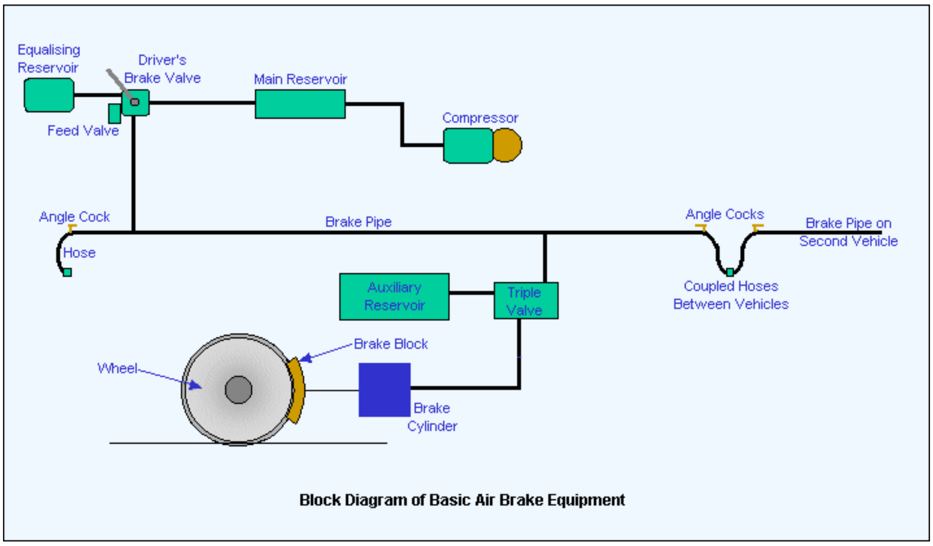


Figure 12
Diagram of a train air brake system (not to scale)

6.1.8 Auto brake valves fitted in the cabs in the DC locomotives and SD driving trailers provided the control mechanism for locomotive engineers to apply and release the brakes. The brake operation was activated by moving a handle on the auto brake valve into one of 6 positions: Release, Initial Reduction, Service, Suppression, Handle Off and Emergency. When a locomotive engineer moved the brake handle into any one of the 6 positions, air pressure escaped in the equalising reservoir. The air pressure reduction in the equalising reservoir then triggered the 26C relay portion of the automatic brake valve to adjust and equalise the air pressure in the brake pipe.

6.1.9 The propagation rate for air pressure loss to travel along the brake pipe only throughout the length of the push/pull train was about 300 m per second. The push/pull set design required no differential in propagation time when operating in either the push or the pull mode. The loss of brake pipe pressure was detected in triple valves fitted to each vehicle. When the pressure on the brake pipe side of the triple valve fell, the auxiliary reservoir pressure on the other side pushed a slide valve over, opening a connection between the auxiliary reservoir and the brake cylinder. Auxiliary reservoir air was then fed into the brake cylinder, forcing lateral pressure through the brake rigging arrangement. When the slack within the rigging was taken up, the rod connected to the brake blocks moved against spring pressure resistance and force was applied against the wheel treads.

6.1.10 Air would continue to pass from the auxiliary reservoir to the brake cylinder until the pressure in both was equal. Emergency brake cylinder pressure on the push/pull sets was the same as the full service brake cylinder pressure, but the speed of an emergency brake application was faster due to the faster discharge rate in the brake pipe.

6.1.11 The auto brake valves on the DC locomotive and the SD driving trailer were also equipped with a graduated release capability that allowed the locomotive engineer to apply and release the brakes, gradually in steps, and thus provided a smoother ride for passengers while the trains were decelerating for station stops.

6.1.12 The brakes on the locomotive could be applied and released in isolation from the rest of the push/pull set using an independent brake function fitted to the auto brake valve in the DC locomotive and the SD driving trailer. However, to avoid run-in of the locomotive when operating in the push mode and placing excess load on the passenger carriage brakes, the independent brake in the SD driving trailer could not be used to release the brakes on the locomotive.

6.1.13 The locomotive engineer operated a cut-out switch in the driving cab being vacated, then cut in the brake operation in the cab from which he was to drive when transferring air brake control of a push/pull set at terminal stations, such as Papakura and Britomart.

6.1.14 The bogies on the SA/SD vehicles were fitted with a clasp brake configuration, which meant that there were 2 brake blocks on each wheel (see Figure 13). In comparison there was only one brake block on each wheel on a standard freight wagon bogie.

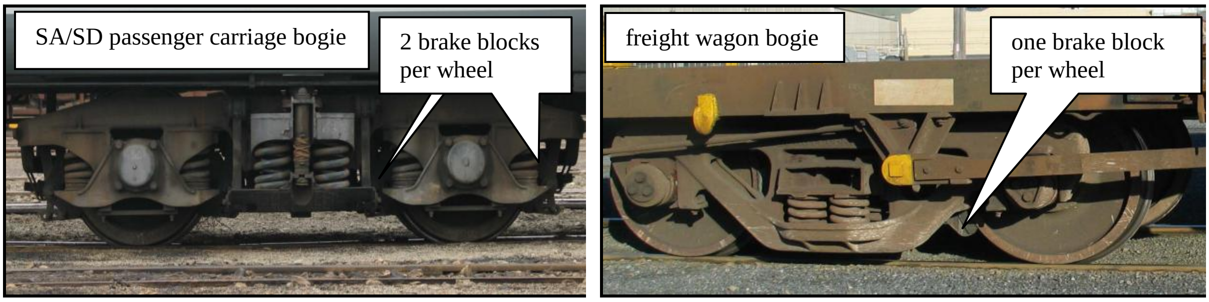


Figure 13
Brake block arrangements

Sanding system

6.1.15 Sand was provided on the DC locomotives powering the push/pull sets. The sand was carried in boxes located in front of the leading wheels at each end of the locomotive. The sand was used to assist with adhesion at the rail/wheel interface during accelerating or braking and could be applied automatically or manually.

6.1.16 Wheel-slip described the situation when there was uncontrolled rotation of the powered axle-wheels while under traction and usually occurred because of wet rail and or heavy train-load conditions. Wheel-slide described the situation when un-powered wheels locked and stopped rotating under braking, usually, but not always, in wet rail conditions.

6.1.17 The sanding function was available on the push/pull sets only when operating in the pull mode. When wheel-slip was detected during acceleration, an automatic system on the locomotive applied sand to the locomotive's leading wheels. Locomotive engineers also had the ability to apply sand using a manual control in the locomotive cab.

6.1.18 There was no automatic or manual sanding function in the SD driving trailer. This meant that sand could not be applied by the locomotive engineer to the rails under the locomotive while the sets were operating in the push mode.

SD driving trailer speedometer system

6.1.19 SD driving trailers were fitted with an integrated GPS/radar/speedometer system. The system, together with the driving controls and gauges on the SD driving trailer, operated independently of the locomotive except for the supply of compressed air (see Figure 14).

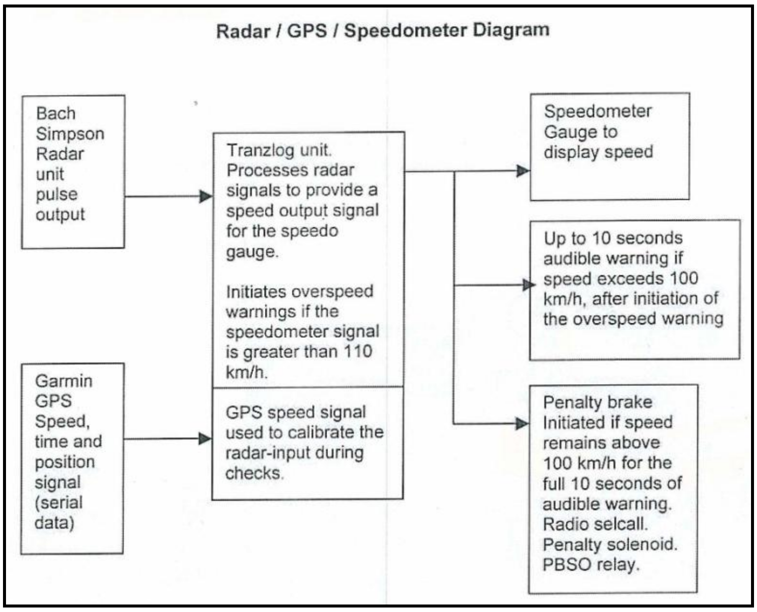


Figure 14
Details of the integrated SD driving trailer speedometer system

6.1.20 Outputs from the speedometer system were recorded on the computerised Tranzlog event recorder system. Testing of the integrated system, incorporating data from the Tranzlog system, was performed during the following check routines:

- A check at 12 000 km
- B check at 24 000 km
- C check done annually.

The process was a snapshot of replay data that compared outputs from the GPS/radar and speedometer systems. Variations of ± 2 km/h required recalibration.

6.2 Post-incident internal inspection and comment

6.2.1 On 3 July 2008, in response to questions posed regarding push/pull train set handling standards, KiwiRail advised as follows:

> A key impediment for Toll Rail's internal investigations into platform overrun incidents was the ability to identify actual causation and in particular isolate vehicle performance and locomotive train handling issues. Following the Train 2216 incidents a project was initiated to enable Tranzlog event recorder data to be used to help distinguish between these two elements. In the case of braking performance the data would supplement post incident brake efficiency checks of the vehicles involved.
>
> The project specification required a "best practice" train handling technique to be identified, taking into account mechanical and operational factors, then confirmed in commercial operation. A master Tranzlog file recording stops at all stations, in both directions, would be compiled for comparative purposes should an overrun occur.

It was also intended that this information be used for training, re-training, competency assessments and review of random Tranzlog extractions.
This project has not been progressed in part because of a number of changes within regional and site management and the need for locomotive operating managers/ team leaders to increase their driving time to cover a shortage of locomotive engineers.

6.2.2 On 17 March 2009, KiwiRail advised in a letter to the New Zealand Transport Agency the following in part:

It was noticeable that trains driven from the SD cab dominated the earlier incidents but there were other factors contributing to the incidents that indicated this was more likely "statistical" as opposed to being a key contributor.

For instance more likely contributors identified for the previous incidents were:

- Platform approach was more aggressive. This was confirmed when event recorder data for the trains/stops involved was compared with other random event recorder data during the internal Fruitvale/Sunnyvale investigation.
- A number of incidents involved trainee locomotive engineers making an error of judgement. In one case the trainee had a different Tutor who requested he try a different technique.
- The length of some platforms involved left a small margin for error. It is considered this has likely influenced an apparent culture of non-reporting of overruns involving multiple units and the SA/SD trains simply because train staff considered periodic overruns were inevitable.

Post-incident inspections of train sets involved in the overruns have typically found no maintenance issues apart from minor code discrepancies that would lead to a significant deterioration in braking effort.

Given their intended role as an "interim" train and the need for urgent delivery, the SA/SD trains are fitted with a "pure air" braking system, which while fit for purpose is arguably not the optimum for the evolving Auckland metropolitan operation. Purpose built metro trains would normally employ an electro-pneumatic braking system.

The key benefit of the electro-pneumatic system is that it provides a faster response by reducing the time the brake application is propagated throughout the train. These braking systems also incorporate a "weighing" feature that automatically adjusts the braking effort when passenger loading increase or decrease.

Although the SA/SD trains would be more suited to services with less passenger stops the reality is introduction of these trains on schedules requiring frequent stopping was the most expeditious option available to meet the Regional Council's [ARTA's] rail public transport needs, albeit less than ideal.

When used exclusively in this environment the braking system is susceptible to the amount of heat created by the kinetic energy of the train. When the vehicle wheels are unable to absorb more heat a brake "fade" situation occurs when the brake blocks and wheel can no longer efficiently absorb and remove the heat of a brake application as fast as it is created.

Importantly, this is a "characteristic" of this braking system when used in this environment, not a "braking failure".

Confirming a brake fade event may have contributed to an incident has presented a challenge during our investigation because:

- Lack of base case event recorder data demonstrating a known controlled stop using appropriate train handling technique, to compare with actual incident data.
- The similarity between a locomotive engineer's perception of braking performance and attempting to stop from a speed that is too high. In both cases there is a feeling of loss of control when the train cannot be stopped as intended.
- The condition is unpredictable and because it disappears within one or two brake applications or when heat is dissipated it cannot be replicated post incident.

Although there is no direct evidence that a "brake fade" event did or did not occur during any of the overrun incidents, KiwiRail's internal investigation has found that locomotive engineers and their immediate managers and trainers have not had an understanding of this braking characteristic.

This has meant that the condition has not been adequately factored into appropriate defensive driving techniques and contributory techniques such as power braking remain prevalent.

It should be noted that before the re-commencement of driver training in the early 2000s a locomotive engineer's driving technique was derived from the technique he/she was exposed to in a two-person crew "on the job training" situation. This predated the introduction of the locomotive simulator and the development of modern event recorder technology.

The investigation has found that although locomotive engineers were provided with training to familiarise them with the graduated brake, this training essentially overlaid the variety of driving styles previously adopted by locomotive engineers.

Based on our conclusions described above, KiwiRail is primarily focusing on the train handling issue as the primary cause of and solution to these incidents.

A project has been initiated to:

- Develop a "model" train handling technique that adopts a more "defensive" approach to station platforms and signals and at the same time reduces exposure to brake "fade" events.
- Re-train locomotive engineers with a view of achieving a more appropriate and consistent train handling technique across the driving workforce. The training will include sufficient background information to acquaint locomotive engineers with the relationship between the braking characteristics of these trains and the revised train handling technique.
- Include evaluation of tranzlog data in Safety Observation assessment process to provide a more robust method of evaluating train-handling technique.
- Similarly, include more effective use of Tranzlog data during the post-incident support process.

The complexity of this task should not be underestimated given it involves modifying driving techniques used by experienced locomotive engineers over a long period of time. Dependent on the degree of individual change needed, there will be some habitual elements and perhaps some traditional viewpoints that will present challenges.

KiwiRail is also strengthening the post-incident investigation process by introducing a standard format to be followed for each incident. This process has been established to ensure the range of likely causes is explored in all cases. Obviously, there will be some variation if issues unique to a specific incident are encountered.

Although we are placing considerable emphasis on the train handling issue, future investigations will continue to focus on both train operational and mechanical elements, as was the case for the recent Britomart collision [this incident is the subject of a subsequent Commission investigation]. In other words our approach will not be pre-conditioned by previous findings.

Although the braking modification is proceeding, KiwiRail believe this will have little or no effect on the root cause of these incidents as inappropriate train handling whether it be late braking decisions, power braking increasing exposure to excessive wheel heat or trainee error.

However, the implementation process included a thorough assessment of the expected change "feel" for locomotive engineers, involving union and local operational management. As a result a formal briefing for locomotive engineers was developed and facilitated prior to implementation.

The opportunity was also taken to introduce the "brake fade" issue and acquaint them with the train handling technique review that is presently in progress.

6.2.3 On 17 April 2009, in response to further questions posed regarding push/pull train set handling standards, KiwiRail advised as follows:

KiwiRail is developing a document and associated procedures intended to move from a historic regime of variable techniques to more consistent train handling.

Meantime a "Train Handling" briefing has been provided to all locomotive engineers providing information on train handling issues associated with these trains, in particular the changes expected following the introduction of the upgraded/load sensing bogies and an introduction to the "brake fade" issue.

6.3 Operating rules

6.3.1 Ontrack's operating rules (general) stated in part:

112. Trains Overrunning or Stopping Short of Platform
When a train conveying passengers overruns or stops short of the platform at an attended station it must not be moved until the crew have conferred with the Officer in charge. If the train is to be moved staff concerned must first ensure that passengers will not attempt to leave the train whilst it is in motion. The Officer in Charge will then give the necessary instructions to the Locomotive Engineer to move the train.

At unattended stations the crew must advise passengers before the train is moved.

6.3.2 Ontrack's double-line automatic signalling rules stated in part:

1. Trains Not to Set Back
(a) Trains must not set back after leaving a station, or run on the right-hand line in the direction of travel except:

(i) When authorised by a Mis 60.

(ii) When at a station and wholly within the Home or Outer Home signals movements may reverse direction on the authority of the Signalman who must first satisfy himself that it is safe for the intended movement.

6.4 Comparative overseas practices

Brake distance testing parameters in the United Kingdom

6.4.1 The following comments emanate from train braking inspectors within the Rail Accident Investigation Branch and Office of Rail Regulation in the United Kingdom. There is a set of standard braking curves that relate to existing signal spacing. Any new or modified passenger trains must be designed so that the trains can brake within the curve that is applicable. This is then confirmed/demonstrated by testing before entry into regular service.

6.4.2 Normally a target stopping distance is set and the tests are conducted to prove that the train can stop in the prescribed distance. During the tests many things are measured, for example the delay and fill times for the air brake system, speed, distance travelled, wheel-slide protection activity, brake cylinder air pressures, and sometimes brake block and wheel temperatures. Usually the tests are done for the mechanical brake system – any rheostatic or regenerative systems (and their brake blending control systems) are tested separately (but in the same series of tests).

6.4.3 The tests usually take place at different speeds and brake application settings over the same stretch of railway. Full passenger load and tare condition are also tested separately. This is especially important for metro operations where tare to full-crush-load ratios could be high.

6.4.4 From then on the maintenance arrangements must include brake tests (static on depot) to show that the application timings and brake pressures are within the limits such that the train will meet its braking curve. Obviously there will be basic depot checks before departure and during initial running on a journey to check the basic functionality of the brake system.

6.4.5 There is one unknown and that is wheel-rail friction or adhesion. There is still much research and debate being done on this topic internationally. Many trials have been run in wet or contaminated conditions to develop and test new technologies for stopping trains in poor adhesion conditions. However, brake curve testing is usually done in dry conditions to prove the capability of the train-borne system. Whole-system testing with different rail-wheel adhesion conditions has been done in the past and still continues, but generally as part of research rather than vehicle acceptance testing.

6.4.6 Wheel-slip protection is a key technology that has come out of this work, as have modern sanders and magnetic track brakes (see Figure 15).

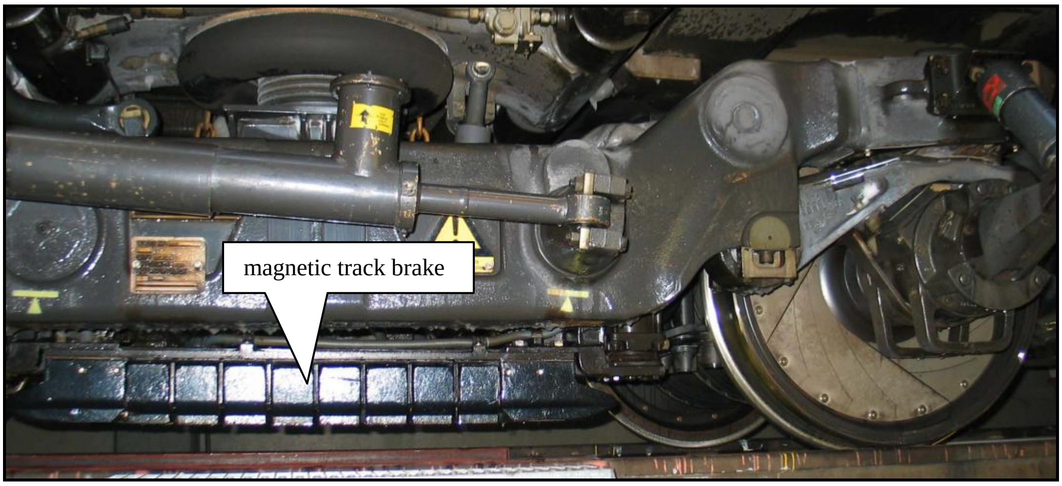


Figure 15
Magnetic track brake on a Norwegian multiple unit vehicle

Operating push/pull passenger train sets in Toronto, Canada

6.4.7 In order to compare the operational issues faced in this investigation with an overseas operator of push/pull trains, the Commission approached GO Transit in Toronto, Canada in order to understand if platform overruns were occurring there. GO Transit operated a fleet of 40 push/pull passenger train sets using 72 locomotives and 457 bi-level passenger carriages. The sets were made up of 10 carriages and had a seating capacity of 1620 passengers per set.

6.4.8 The locomotives used by GO Transit were a General Motors 1988 design. They were classified as F59PH and were purposely built for commuter train operations. Production had reached 146 units by 2002 and the locomotives were in widespread commuter-train-operation use in large cities throughout North America.

6.4.9 The locomotives rode on 2 bogies with 2 axles each and had a power rating of 3000 horsepower. The locomotives were equipped with the 26L straight air brake (the same as the DC locomotive) and had a maximum operating speed of 130 km/h. The tare weight of the locomotives used was 116 tons (imperial measurement), which meant that each axle carried 29 tons. This compared to the 16 t carried on each of driving axles of a DC locomotive.

6.4.10 GO Transit said that it had experienced a higher-than-normal degree of platform overshoots [overruns]. Overshoots referred to the locomotive engineer not stopping at the proper spotting marker to allow the “accessibility coach doors” to line up adjacent to the accessible platform. These overshoots were generally in the order of 5 feet to 30 feet (1.5 m to 9.1 m). The trains were then repositioned in a safe and effective manner following regulated guidelines and instructions. There were minor delays as a result of the overshoots and GO Transit had attributed the overshoots to the inexperience of the new locomotive engineers.

6.4.11 GO Transit had hoped that the frequency of the overshoots would decrease in the near future following specialised “throttle training”. This was a mentoring process facilitated by seasoned locomotive engineers who worked “one on one” with the new locomotive engineers.

6.5 Train performance detail

6.5.1 The following table shows in detail (from paragraph 1.9.21) the train performance data gathered from the Tranzlog downloads:

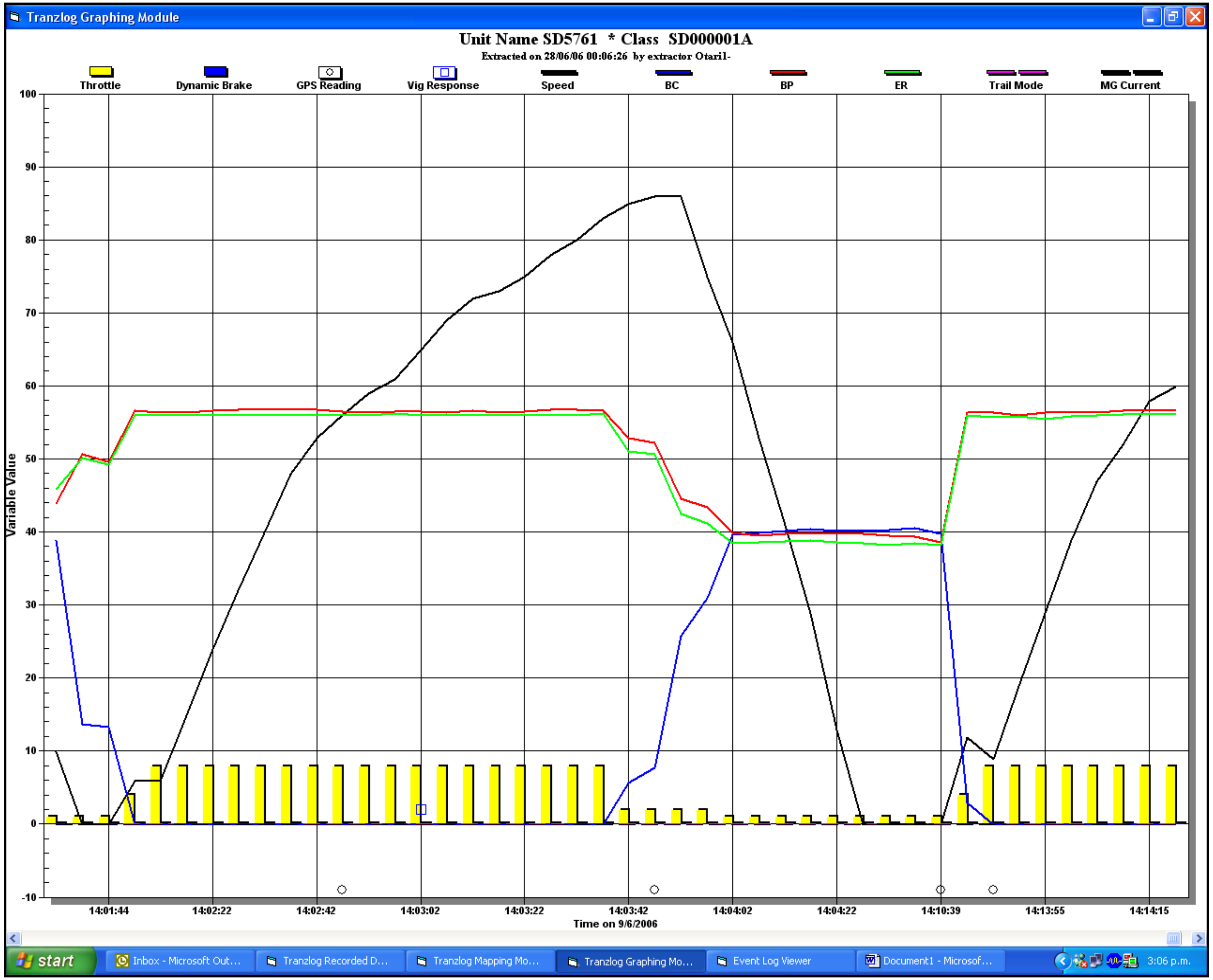
Comparison between actual journey times and schedules taken from Tranzlogs on 5 locomotives running Veolia services on Friday 11 December 2009

Train ID	From	To	Schedule time in minutes	Actual time in minutes	Time lost in minutes	Comment on lost time
DC4248/SD5626						
9101	Waitakere	Britomart	58	58	-	
8106	Britomart	Swanson	52	55	3	Crossing opposing late-running services
8111	Swanson	Britomart	53	74	21	Signalling failure at Avondale
8112	Britomart	Swanson	52	52	-	
8119	Swanson	Britomart	53	57	4	Crossing opposing late-running services
9122	Britomart	Waitakere	58	60	2	Infrastructure activity and heavy passenger loading
9127	Waitakere	Britomart	58	63	5	Crossing opposing late-running services
9128	Britomart	Waitakere	58	61	3	Infrastructure activity and heavy passenger loading
9135	Waitakere	Britomart	58	61	3	Infrastructure activity and heavy passenger loading
9136	Britomart	Waitakere	58	58	-	
9143	Waitakere	Britomart	58	62	4	Crossing opposing late-running services
8150	Britomart	Swanson	52	54	2	Crossing opposing late-running services
8151	Swanson	Britomart	53	53	1	Infrastructure activity and heavy passenger loading
DC4275/SD5860						
3210	Pukekohe	Britomart	63	64	1	Not apparent

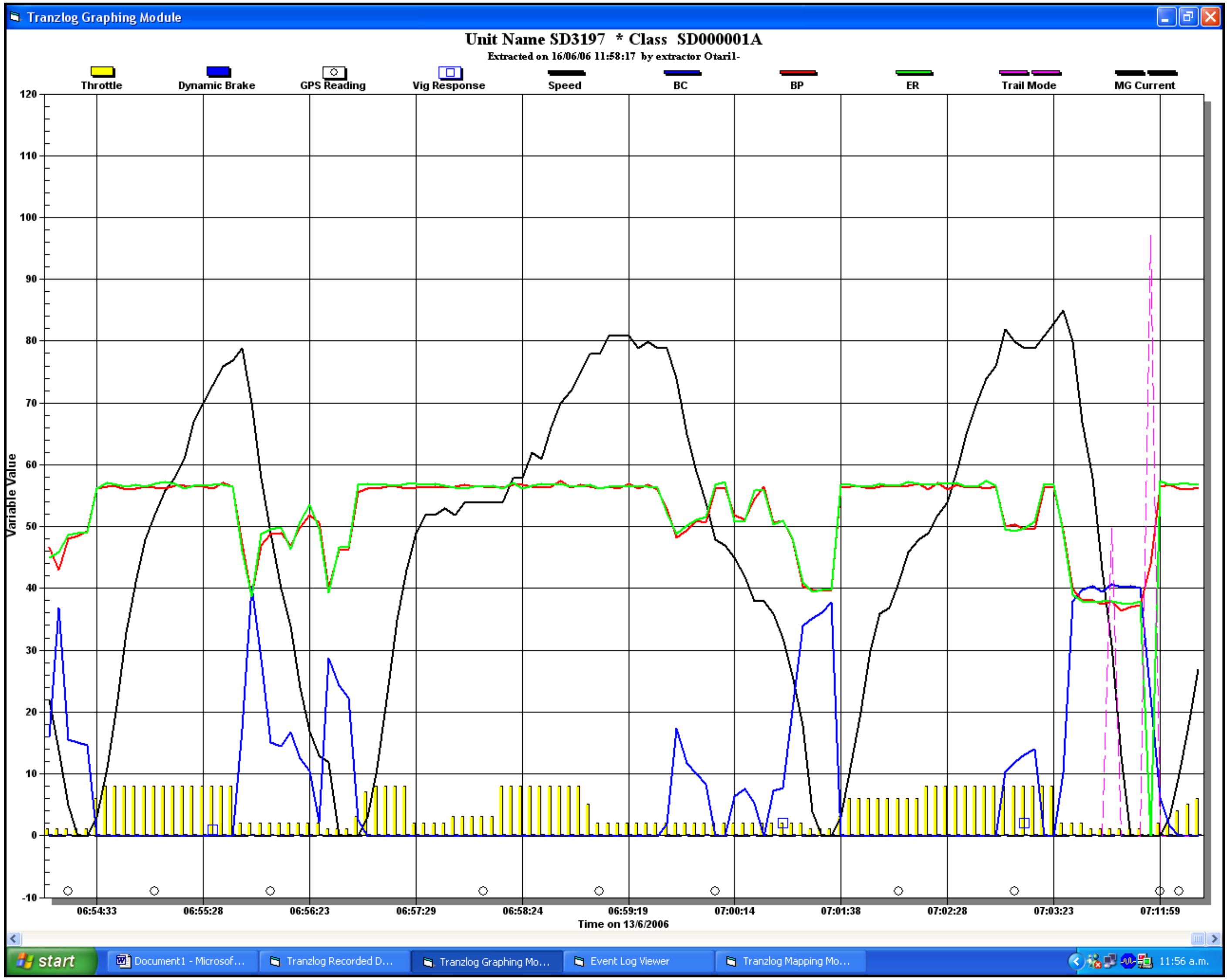
9114	Britomart	Waitakere	58	66	8	Infrastructure activity and heavy passenger loading
9119	Waitakere	Britomart	58	59	1	Infrastructure activity
3155	Britomart	Pukekohe	66	70	4	Heavy passenger loadings
3264	Pukekohe	Britomart	58	63	5	Infrastructure activity and heavy passenger loading
3171	Britomart	Pukekohe	66	66	-	
3164	Pukekohe	Britomart	69	71	2	Delayed Papakura-not apparent
1077	Britomart	Papakura	50	50	-	
1072	Papakura	Britomart	53	53	-	
1081	Britomart	Papakura	50	50	-	
DC4605/SD5648						
9130	Britomart	Waitakere	58	63	5	Infrastructure activity and heavy passenger loading
9137	Waitakere	Britomart	58	58	-	
9140	Britomart	Swanson	52	56	4	Not apparent
9147	Waitakere	Britomart	58	61	3	Not apparent
DC4951/SD3199						
8103	Swanson	Britomart	53	54	1	Not apparent
9110	Britomart	Waitakere	58	58	-	
9115	Waitakere	Britomart	58	58	-	
9118	Britomart	Waitakere	58	58	-	
9123	Waitakere	Britomart	58	61	2	Not apparent
8118	Britomart	Swanson	52	56	4	Not apparent
8127	Swanson	Britomart	53	58	5	Crossing opposing late-running services
8128	Britomart	Swanson	52	54	2	Infrastructure activity and heavy passenger loading
8133	Swanson	Britomart	53	57	4	Crossing opposing late-running services
9138	Britomart	Waitakere	58	64	6	Infrastructure activity and heavy passenger loading
9145	Waitakere	Britomart	58	64	6	Crossing opposing late-running services
9150	Britomart	Waitakere	58	59	1	Not apparent
9157	Waitakere	Britomart	58	66	6	Crossing opposing late-running services
DC4381/SD6166						
8104	Britomart	Swanson	52	53	1	Not apparent
8109	Swanson	Britomart	53	53	-	
3113	Britomart	Pukekohe	66	67	1	Not apparent
3124	Pukekohe	Britomart	69	69	-	
3227	Britomart	Pukekohe	66	67	1	Not apparent
3134	Pukekohe	Britomart	69	71	2	Infrastructure activity and heavy passenger loading
1043	Britomart	Papakura	50	52	2	Not apparent
1042	Papakura	Britomart	53	54	1	Not apparent
8136	Britomart	Swanson	52	54	2	Crossing opposing late-running services
9141	Swanson	Britomart	53	55	2	Infrastructure activity and heavy passenger loading
9146	Britomart	Waitakere	58	58	-	
9151	Waitakere	Britomart	58	62	4	Delayed by Overlander at Papakura
9154	Britomart	Waitakere	58	65	7	Delayed by Police incident
9161	Waitakere	Britomart	58	58	-	

6.6 Event recorder detail

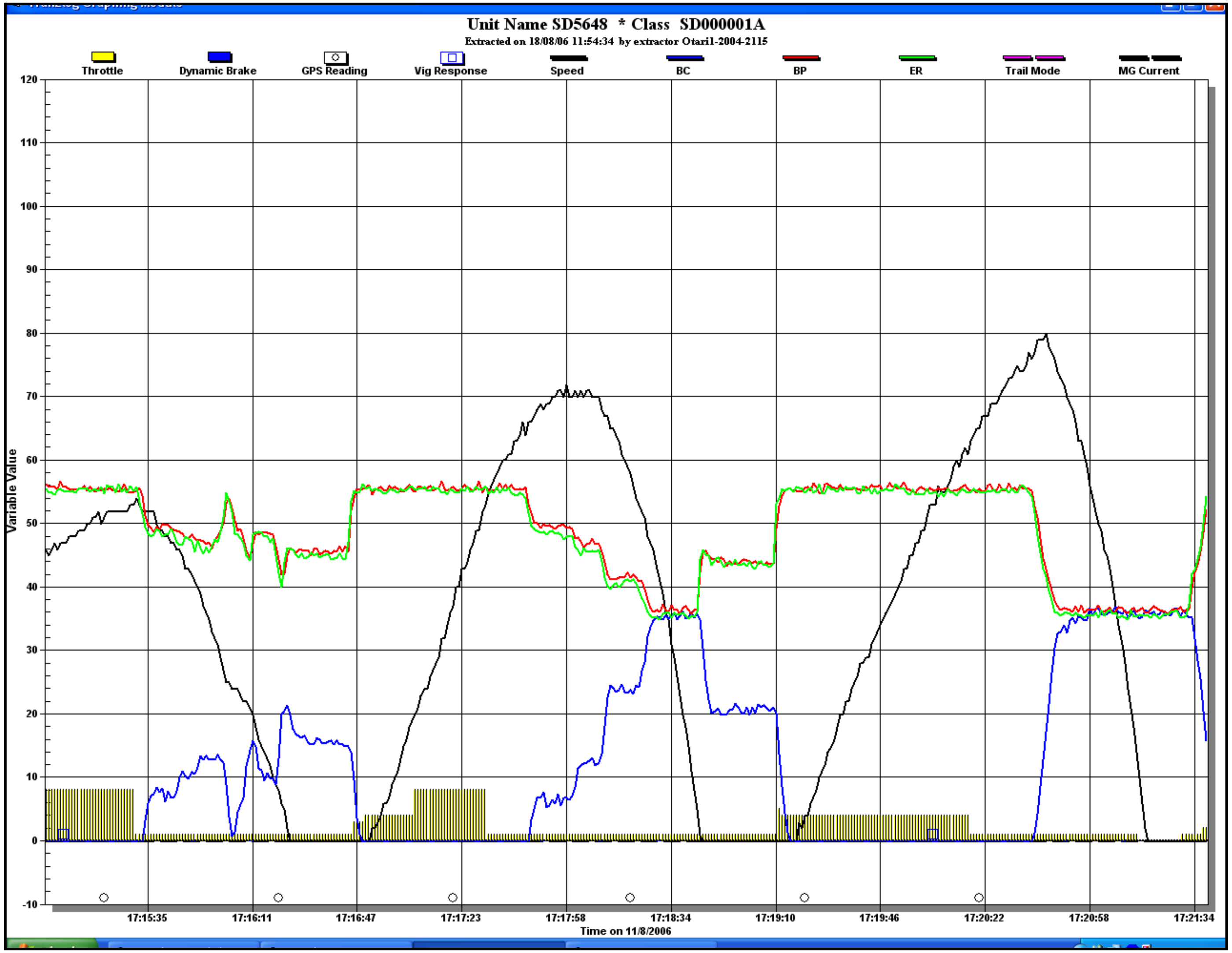
6.6.1 The following 5 pages repeat the event recorder data in larger scale from sections 1.2 to 1.5 inclusive.



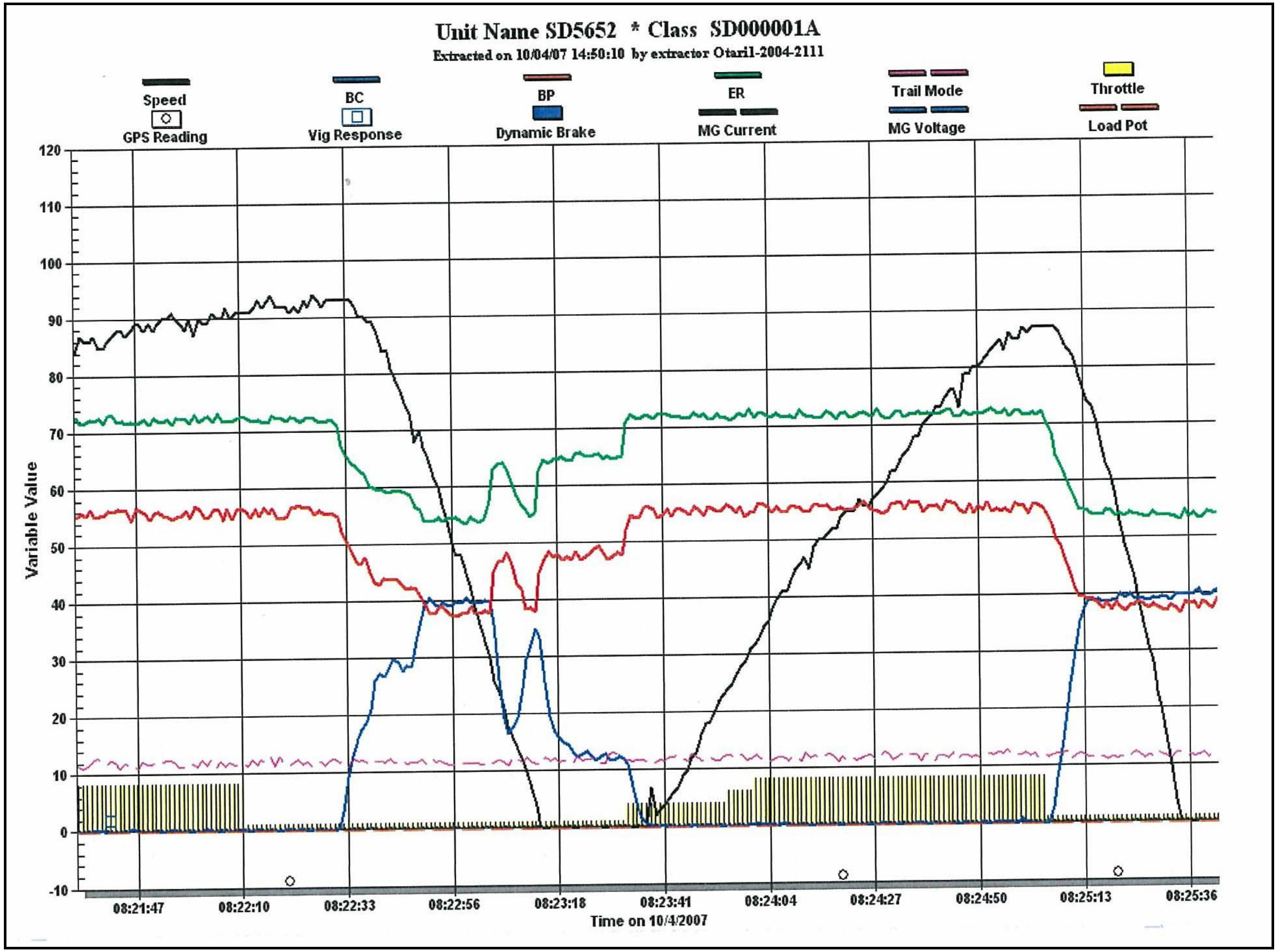
Larger scale of Figure 4 from page 5



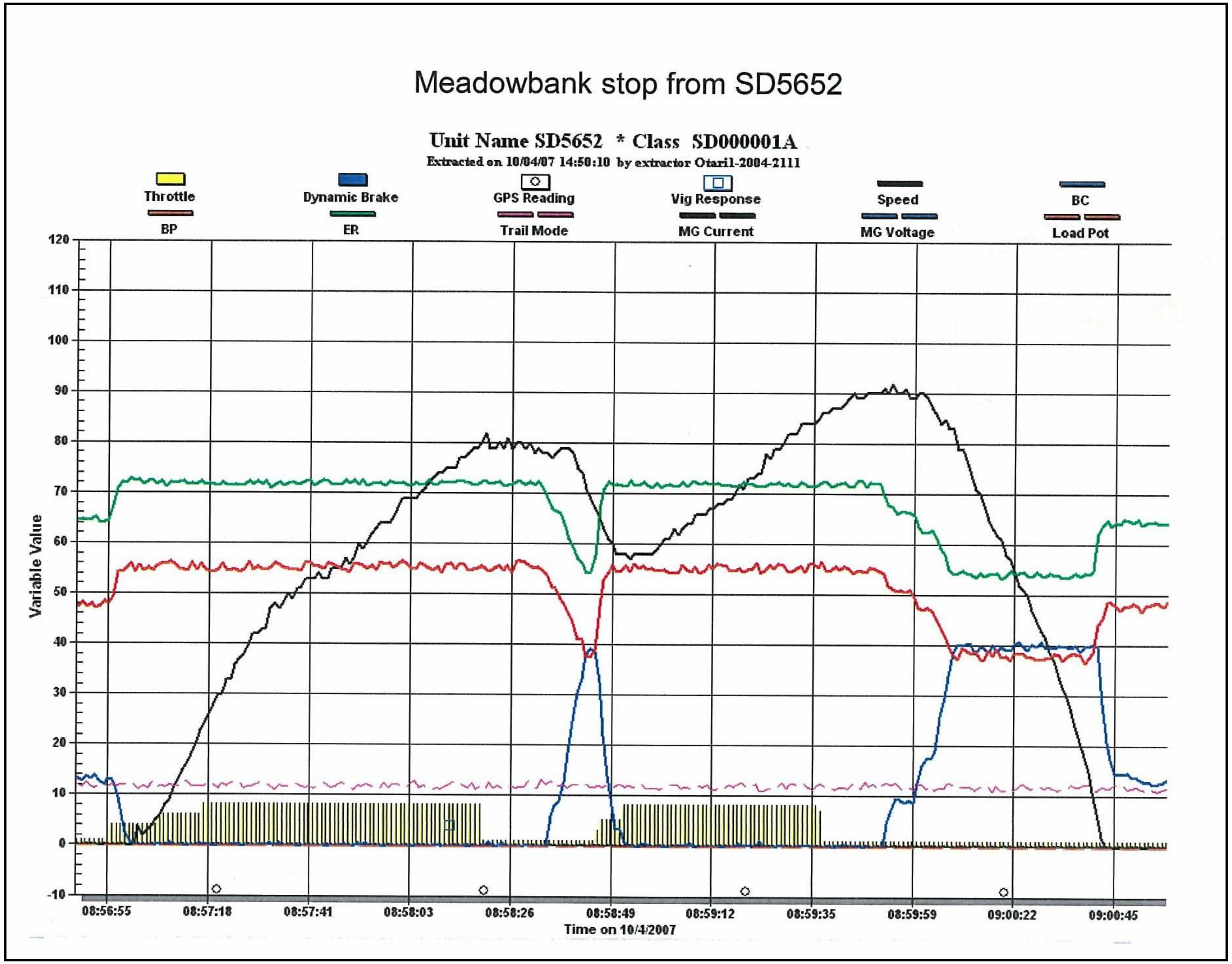
Larger scale of Figure 5 from page 7



Larger scale of Figure 6 from page 8



Larger scale of Figure 7 from page 10



Larger scale of Figure 8 from page 11

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

08-110	train control operating irregularity, leading to potential low-speed, head-on collision, Amokura, 23 September 2008
08-101	express freight train 923, level crossing collision and resultant derailment, Orari, 14 March 2008
08-113	empty push/pull passenger Train 5250, collision with platform-end stop block, Britomart station, Auckland, 19 December 2008
08-103	express freight Train 845, track warrant overrun, Reefton – Cronadun, 13 August 2008
07-103	passenger express Train 200, collision with stationary passenger express Train 201, National Park, 21 March 2007
07-115	express freight Train 533, derailment, 103.848 kilometres, near Tokirima, Stratford – Okahukura Line, 7 November 2007
06-106	express freight Train 826, signalling irregularity, Cora Lynn, 31 July 2006
07-108	express freight Train 720, track warrant overrun at Seddon, Main North Line, 12 May 2007
07-113	express freight Train 239, wagons left in section at 514.9km, between Te Awamutu and Te Kawa, 22 September 2007
07-110	collision, express freight Train MP2 and Work Train 22, Ohinewai, 19 June 2007
06-110	passenger train 4045, uncontrolled movement, between Britomart and Quay Park Junction, 9 October 2006
06-108	EMU Passenger Train 9268, struck slip and derailed, between Wellington and Wadestown, 26 August 2006
07-101	express freight Train 736, derailment, 309.643 km, near Vernon, 5 January 2007
05-123	empty passenger Train 4356, overran conditional stop board without authority following an automatic air brake irregularity, Meadowbank, 6 October 2005
05-116	collapse of Bridge 256 over Nuhaka River, Palmerston North-Gisborne Line, 6 May 2005
05-124	express freight Trains 834 and 841, collision, Cora Lynn, 20 October 2005

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