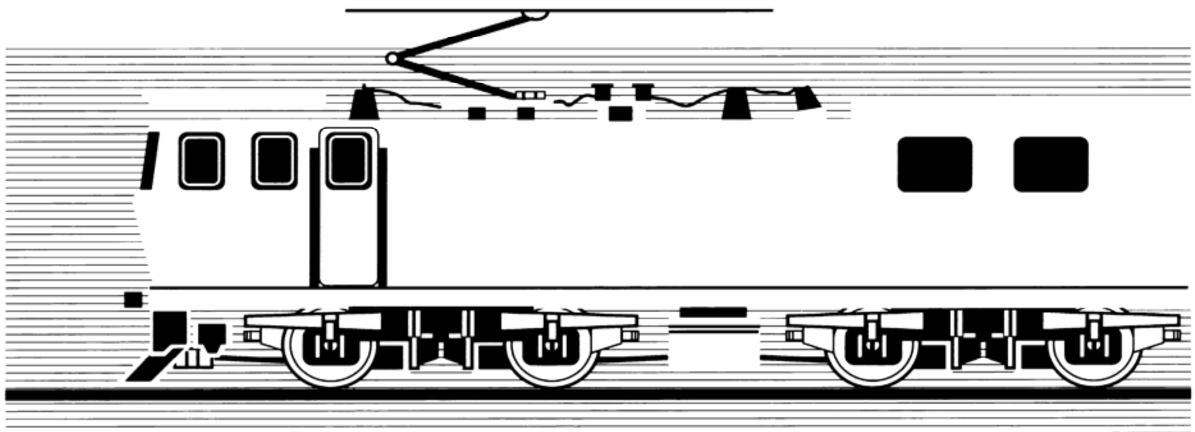
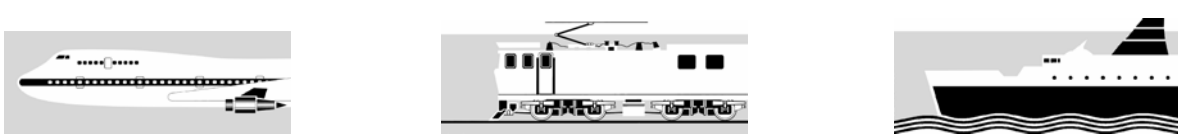


RAILWAY OCCURRENCE REPORT

05-124 express freight Trains 834 and 841, collision, Cora Lynn 20 October 2005



TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

Report 05-124

express freight Trains 834 and 841

collision

Cora Lynn

20 October 2005

Abstract

On Thursday 20 October 2005 at about 1900, eastbound express freight Train 834 was scheduled to cross with westbound express freight Train 841 at Cora Lynn on the Midland Line. Train 841 was berthed on the loop when Train 834 also entered the loop and collided head-on with Train 841.

The locomotives on each train were extensively damaged, but there was no damage to the wagons on either train or to the track infrastructure.

The locomotive engineers suffered minor injuries.

The safety issues identified included:

- the appropriateness of the signalling and interlocking arrangements and operating procedures on the Midland Line
- the use of non-compliant work practices on the Midland Line.

Two safety recommendations covering these issues were made to the Chief Executive of ONTRACK.

Contents

Figures

Abbreviations

CTC	centralised traffic control
km	kilometre(s)
km/h	kilometre(s) per hour
kW	kilowatt(s)
m	metre(s)
t	tonne(s)
Toll Rail	Toll NZ Consolidated Limited
Tranz Scenic	Tranz Scenic 2001 Limited
TWC	track warrant control
POI	point of impact
SLAS	single line automatic signalling
UTC	coordinated universal time

Data Summary

Train type and number:	express freight Trains 834 and 841
Date and time:	20 October 2005, at about 1900[1]
Location:	Cora Lynn
Persons on board:	crew: 2, one locomotive engineer on each train
Injuries:	2 minor
Damage:	4 locomotives extensively damaged
Operator:	Toll NZ Consolidated Limited (Toll Rail)
Investigator-in-charge:	D L Bevin

[1] Times in this report are New Zealand Daylight time (UTC+13 hours) and are expressed in the 24 hour mode.

1. Factual Information

1.1 Narrative

1.1.1 On Thursday 20 October 2005, Train 841 was a westbound Lyttelton to Ngakawau express freight train and consisted of 2 DXH[2] class locomotives in multiple and 30 empty coal wagons for a gross weight of 514 tonnes (t) and a total length of 472 metres (m).

1.1.2 On the same day, Train 834 was an eastbound Stillwater to Lyttelton express freight train and consisted of 2 DXH class locomotives in multiple and 20 loaded coal wagons for a gross weight of 1288 t and a total length of 324 m.

1.1.3 The locomotive engineers of Trains 841 and 834 had each received operating instructions from train control, which included their planned crossing at Cora Lynn. Train 841 was to berth on the loop and Train 834 was to berth on the main line.

1.1.4 At about 1859, Train 841 arrived at Cora Lynn and the locomotive engineer berthed his train on the loop. Shortly afterwards, Train 834 approached and passed the western end arrival signal at stop, entered the loop and collided head-on with Train 841.

1.1.5 The locomotive engineer of Train 834 jumped from his cab shortly before impact but the locomotive engineer of Train 841 remained in his cab, sheltering on the floor. Both received minor injuries.

1.1.6 Neither train derailed, but all 4 locomotives were extensively damaged. There was no damage to the infrastructure or wagons and no coal was lost as a result of the impact.

1.2 Route and site information

1.2.1 The West Coast coal route was used to transport coal from Ngakawau (near Westport) and Greymouth, both on the west coast of the South Island, to the coal export facility at the port of Lyttelton on the east coast.

1.2.2 The coal route utilised the Midland Line from Rolleston to Stillwater, a distance of 197 kilometres (km), and the Stillwater to Westport Line from Stillwater to the loading facility at Ngakawau, a distance of 164 km. The route traversed the Southern Alps with an eastbound ruling gradient[3] of 1 in 33 on the 12 km section between Otira and Arthurs Pass (including the Otira Tunnel) to reach a height of 745 m above sea level at Arthurs Pass.

1.2.3 As well as the Otira Tunnel, there were another 5 significant eastbound grades on the route:

Grade	Average gradient	Approximate length of grade
Tawhai Bank (between Reefton and Stillwater)	1 in 45	2.0 km
Approach to Jackson	1 in 80	1.0 km
Approach to Aickens	1 in 60	4.0 km
Cass Bank (between Cass and Craigieburn)	1 in 70	7.0 km
Otarama Bank (between Staircase and Springfield)	1 in 60	1.5 km

[2] DX class locomotive with modified draw gear for hauling coal wagons on the Midland Line.
[3] The maximum gradient on the route.

1.2.4 Coal trains of up to 30 loaded wagons (about 2100 t gross) travelled eastbound and the empty wagons returned westbound. The loaded trains were scheduled to take the main line at most stations when crossing opposing trains.

1.2.5 There were 18 daily train movements between Rolleston and Stillwater, made up as follows:

Eastbound:

- 6 loaded coal trains
- 3 general express freight trains
- one passenger express service.

Westbound:

- 6 empty coal trains
- one general express freight train
- one express passenger service.

1.2.6 Stillwater was the junction of the Midland and Stillwater to Ngakawau Lines. Services destined for Greymouth diverted here so traffic on the Stillwater to Ngakawau Line was not so dense, with 4 return services from Stillwater to Ngakawau on any day.

1.2.7 At the time of the collision there were 18 scheduled train crossings on the Midland in a 24-hour period, which compared with 22 scheduled crossings on the busiest track warrant controlled line, the Main North Line between Picton and Christchurch.

Otira Tunnel

1.2.8 A banker consist[4] of 3 DX class locomotives was based in Otira, where it was attached to eastbound coal trains for the climb through the Tunnel to Arthurs Pass. Figure 1 shows the western approach to Otira Tunnel.

Figure 1
A loaded eastbound coal train approaching the western portal of the Otira Tunnel

[4] Additional locomotive power.

1.2.9 Until 1997, all eastbound freight trains and most passenger trains had been hauled through the Tunnel by electric locomotives operating in multiple, using a 1600-volt overhead direct current electric system. In 1997, following the installation of 2 extraction fans and a sliding door at the western portal of the Tunnel, electric operations were replaced by full diesel locomotive operations. The extraction fans worked in conjunction with the sliding door to provide engine combustion and cooling air for the diesel locomotives hauling trains up the gradient from Otira to Arthurs Pass, as well as purging the Tunnel of diesel fumes.

1.2.10 Once an eastbound train was inside the Tunnel, the sliding door closed and the first extraction fan started, which provided airflow through the Tunnel. When the train arrived at Arthurs Pass, the second fan started and both fans ran for 20 minutes to purge the Tunnel of exhaust fumes before the door reopened.

1.2.11 After a westbound train had cleared the Tunnel, the door closed and both extractor fans started and ran for 11 minutes to purge the Tunnel of exhaust fumes. When the fans stopped, the door reopened. Figure 2 shows the extractor fan outlets.

1.2.12 Purging the Tunnel of fumes following a train movement often contributed to train delays, resulting in the Tunnel becoming an operational bottleneck at times.

Figure 2
The extractor fan exhaust outlets at the western portal of the Otira Tunnel

Cora Lynn

1.2.13 Cora Lynn was a crossing station between Cass and Arthurs Pass on the Midland Line (see Figure 3).

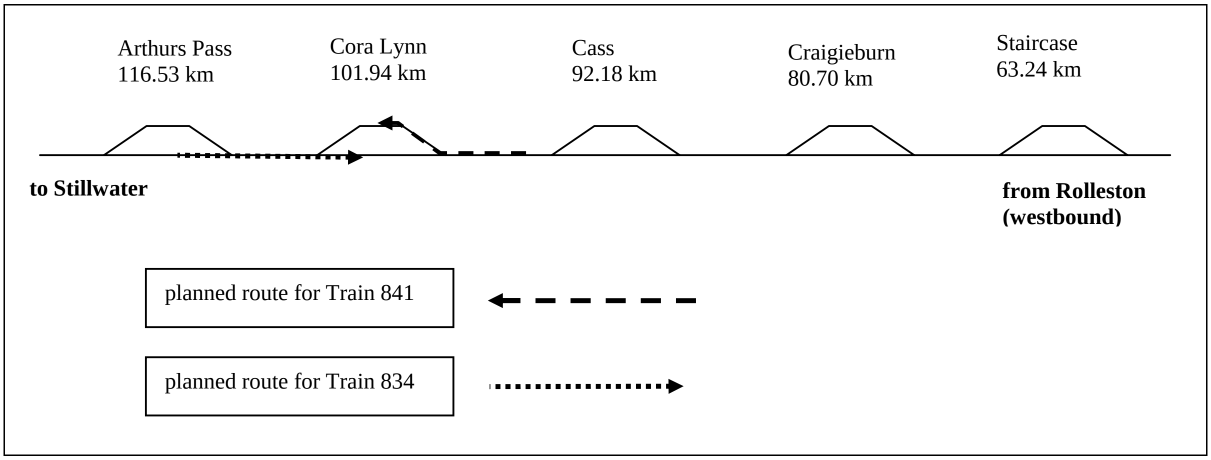


Figure 3
Route map (not to scale)

1.2.14 The maximum authorised line speed for express freight trains between Arthurs Pass and Cora Lynn was 80 kilometres per hour (km/h).

1.2.15 Following a 14 km descending grade from Arthurs Pass, the majority of which was 1 in 85, the eastbound approach to Cora Lynn was a level section for about 250 m after rising a gentle gradient of 1 in 210 for about 750 m.

1.2.16 Cora Lynn consisted of a main line and a 572 m long crossing loop, connected to the main line at each end by hand-operated points.

1.2.17 The first evidence of sand application[5] was about 38 m before Arrival Signal 10244 at Cora Lynn. Sand had continued to be from there to the point of impact (POI), a further 75 m beyond the signal.

1.2.18 The impact of the collision pushed Train 841 back 18 m while Train 834 continued about 12 m past the POI before stopping (see Figure 4).

[5] When an emergency brake application was made, sand was automatically applied to the head of the rail by the locomotive's sanding system.

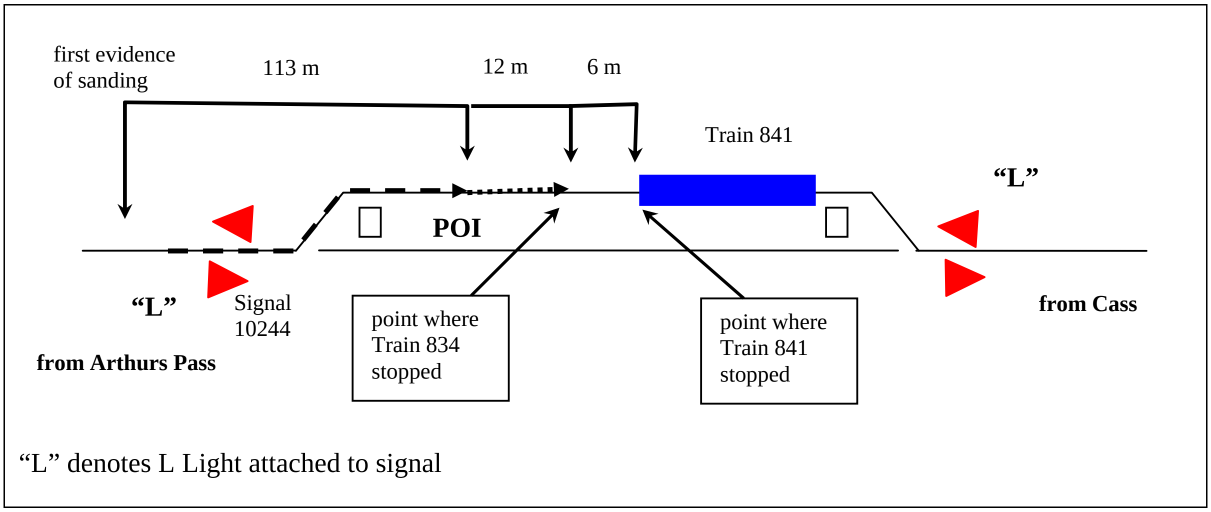


Figure 4
Positions of Trains 841 and 834 after impact (not to scale)

1.3 Signalling information

Single line automatic signalling

General

1.3.1 Train movements on the Midland Line were controlled from the national train control centre in Wellington, and operated under single line automatic signalling (SLAS) rules and operating procedures. SLAS was introduced on the Midland Line when the Otira Tunnel was opened in 1923.

1.3.2 When SLAS was introduced, freight train crews comprised 3 persons: the locomotive engineer, the locomotive assistant whose duties included opening the points for the train, and the guard, who was also responsible for closing the points after the passage of the train.

1.3.3 The removal of the guard from the rear of the train, and the later introduction of single-person locomotive crewing in 1992, meant that the closing of points by train crews after a train entered or departed the loop was no longer practical. To overcome this, operating procedures were amended to allow for main line points to be left in reverse following a departure from the loop. When points were left in the reverse position, train control was to be advised and the train control diagram endorsed accordingly.

1.3.4 It was not mandatory for train controllers to advise locomotive engineers of any reversed points affecting the running of their train. There were 3 main reasons for this:

- the points were protected by the signalling system design, and any pre-advice could cause a locomotive engineer to pre-empt a signal aspect or requirement to stop
- the resetting of reversed points to the normal position by other than train crews was a common practice when they were in a position to do so, and as a result the train controller could never guarantee that the latest information regarding the setting of the points was still current
- the operating system had a high level of radio traffic during the day, which generated a high task load on train control, and the addition of non-critical tasks could impact on a train controller's ability to undertake critical tasks related to the safe running of the trains.

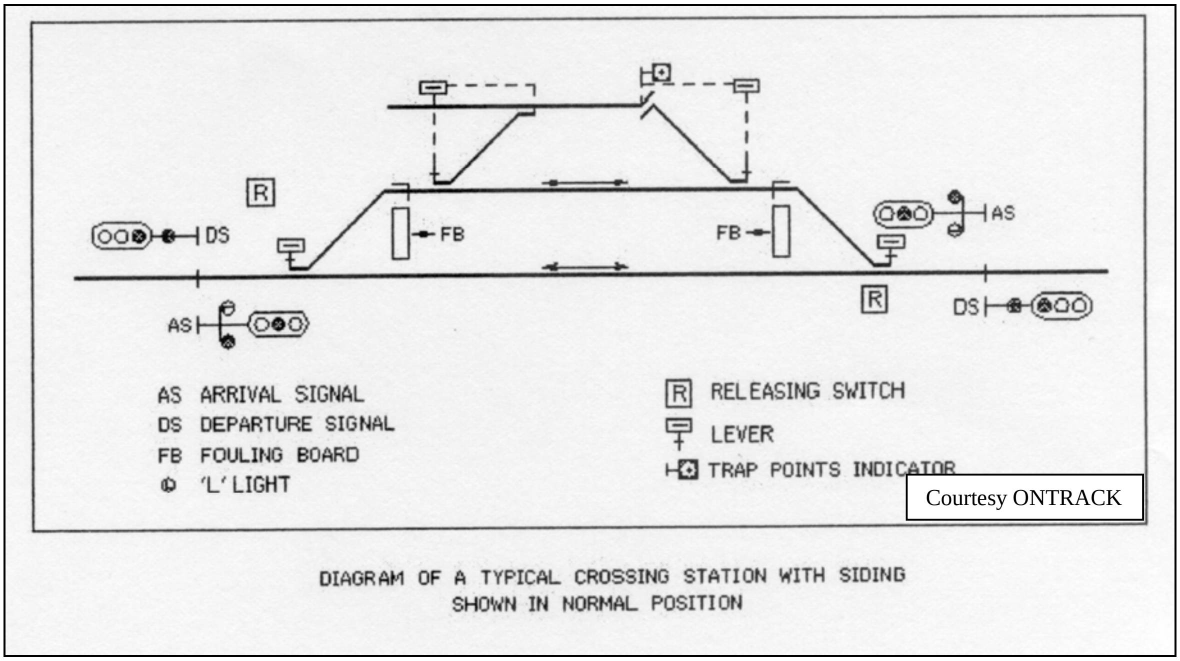


Figure 5
Typical layout of a crossing station in SLAS territory (not to scale)

1.3.5 The arrival signal and the departure signal in SLAS were positioned adjacent to each other, either on opposite sides of the main line (see Figure 5) or back to back. The design of the signalling did not provide for an overrun of either signal.

1.3.6 In SLAS territory, Arrival signals were stop and proceed signals and were sited at the entrances to crossing stations. When such signals were displaying a stop indication, the locomotive engineer was required to stop the train, ensure that the route was properly set and safe for the passage of the train, and wait 10 seconds before proceeding.

1.3.7 Arrival signals displayed a stop indication if:

- opposing trains were approaching the station at the same time
- the trailing points at the opposite end of the station were reversed
- the facing points immediately beyond the Arrival signal were reversed (in which case the "L" light would also be illuminated).

When both sets of points were set for the main line, the arrival signal would normally display a caution proceed or clear proceed indication for an approaching train, provided there was no train in the section ahead.

1.3.8 Arrival signals were fitted with a short-range light, which showed an illuminated white letter "L" when the points were set for the loop (see Figure 6), with the points for any diverging lines off the loop in the normal position. With the points set for the loop, the arrival signal controlling the entrance of a train into the station was at "Stop". The illuminated "L" light confirmed that the route was set for the loop, but not that the loop was unobstructed. If the "L" light was illuminated, locomotive engineers on trains entering the loop were not required to stop at the arrival signal but were required to satisfy themselves that the route was clear before proceeding.

1.3.9 The points were electrically connected to the signals so that when the points at either end of a station were reversed, both arrival signals went to "Stop" and the "L" light was illuminated at the end at which the points were reversed.

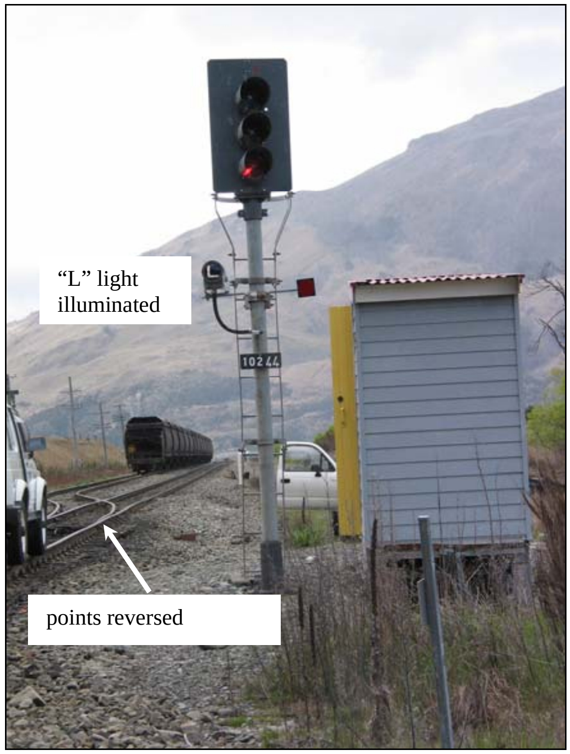


Figure 6
Arrival Signal 10244 at Cora Lynn with the “L” light illuminated

1.3.10 The departure signal controlled the exit from the station and the entrance to the next single line block section. In SLAS territory, there was only one departure signal at each end of the station and this controlled the departures of trains from either the loop or the main line (see Figure 5).

1.3.11 Intermediate signals were provided where necessary in SLAS areas to divide the line between stations into shorter sections and to control the entry of trains into such sections. These signals were also provided near a station to advise the locomotive engineer of the indications he should expect on the next signal in advance, in this case the arrival signal.

1.3.12 Intermediate Signal 10530 was positioned 2875 m in advance of Arrival Signal 10244 at Cora Lynn.

1.3.13 Under SLAS operating procedures there was no requirement for locomotive engineers of opposing trains to make radio contact when approaching crossing stations[6], but locomotive engineers operating on the Midland Line generally did so as a courtesy to their colleagues.

Cora Lynn

1.3.14 About 2 hours before the collision, 2 other trains had crossed at Cora Lynn. After the crossing, the east end points had been left set for the main line and the west end points set for the loop. When Train 841 arrived, the locomotive engineer had stopped his train at Signal 10170, reversed the east end points, and berthed his train on the loop, in accordance with his operating instruction (see Figure 7).

[6] There was such a requirement under track warrant control operating procedures.

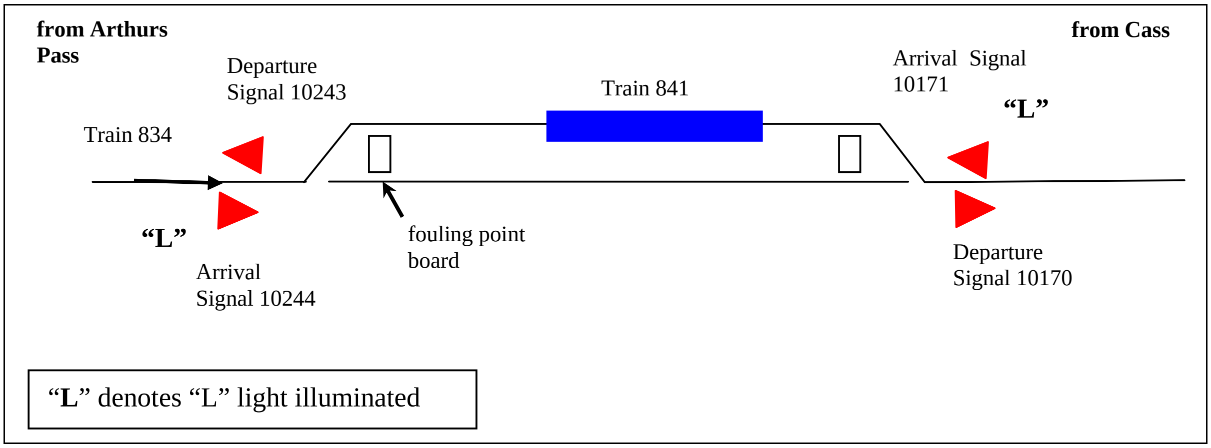


Figure 7
Points settings and signal indications after Train 841 berthed
(not to scale)

1.3.15 A fouling point board was positioned on the ground between the main line and loop, 42 m from the western end points. This provided a 60 m overlap inside Arrival Signal 10244 (see Figure 7). Trains berthing on either the main line or loop could proceed as far as the fouling point board, which indicated the position inside which trains crossing on the loop and main line were safely separated.

Centralised traffic control signalling

1.3.16 Areas of line worked under centralised traffic control (CTC) were arranged and equipped so that interlocked stations could be unattended. The signals and motor-driven points at such stations were operated from a CTC machine located either in train control or in a remote signal box.

1.3.17 For new crossing loops in CTC signalling territory, the nominal distance between a home signal[7] and an opposing departure signal (back to back) was normally150 m. This distance was to provide for opposing trains approaching CTC crossing stations at normal speed at the same time, but could be varied (normally increased) depending on other factors, including signal sighting. One of the purposes of the 150 m overlap was that should an overrun occur, an additional minimum buffer zone was provided before a collision could occur. The overlap was designed to minimise the risk of collision after a signal overrun as a result of minor braking misjudgements.

Comparison of signal distances in SLAS and CTC

1.3.18 A comparison of signal overrun buffers provided between the home signal and the opposing departure signal in CTC territory on the North Island Main Trunk showed that, in the northbound direction the distances were 150 m at Maewa, 154 m at Rangitawa and 300 m at Greatford. In the southbound direction the distances were 158 m at Greatford, 150 m at Rangitawa and 346 m at Maewa.

1.3.19 A sample of distances between intermediate signals and home signals in the same CTC area showed that in the northbound direction, the distances were 950 m at Maewa, 1250 m at Rangitawa and 950 m at Greatford. In the southbound direction, the distances were 1702 m at Greatford, 950 m at Rangitawa and 1260 m at Maewa.

[7] A home signal authorised entry to a station.

1.3.20 A sample of distances between intermediate signals and arrival signals in the vicinity of Cora Lynn showed that, in the westbound direction, the distances were 2090 m at Craigieburn, 2832 m at Cass and 2559 m at Cora Lynn. In the eastbound direction, the distances were 2875 m at Cora Lynn, 2913 m at Cass and 3339 m at Craigieburn.

1.4 Points operation in track warrant control areas

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

1.4.2 TWC areas contained locations known as warrant stations for the purpose of crossing trains. The majority of warrant stations were equipped with motor points, which allowed opposing trains to cross, with the locomotive engineers manually operating the signalling system and points to enter the loop. Additionally, track circuiting linked to the arrival signals and points indicators provided a degree of interlocking at each end of the warrant station. Figure 8 shows a typical interlocked crossing station in TWC with the track circuit limits identified.

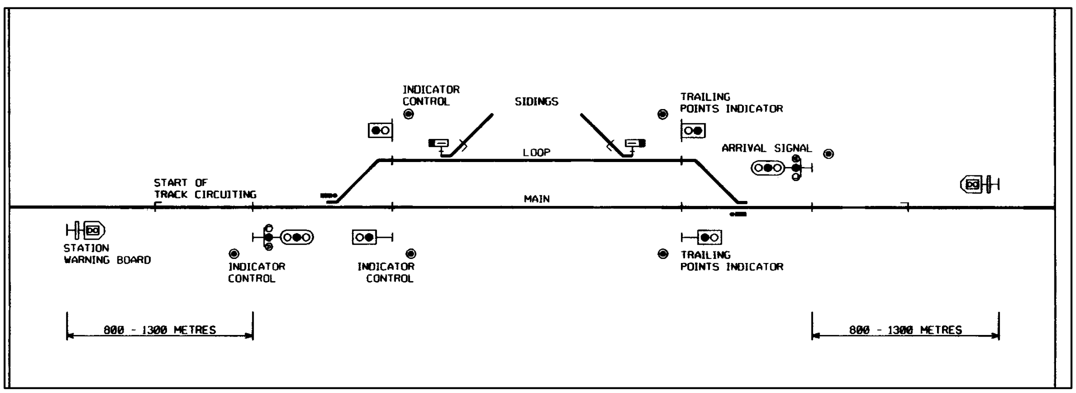


Figure 8
TWC crossing station (courtesy ONTRACK)

1.4.3 The automatic operation of the system was controlled by track circuiting that could identify the direction in which a movement was being made. The system worked automatically for non-stop movements on the main line.

1.4.4 The distance between arrival signals and trailing indicators in TWC territory was nominally 70 m. However, this varied in some places due to sighting requirements and other features such as level crossings. The expectation was that trains approaching an arrival signal would be preparing to stop until the locomotive engineer had determined that the signal was clear.

1.4.5 When the first train to arrive for a crossing was to berth on the loop, the locomotive engineer operated the designated "loop" button in the control box at the arrival signal. After the points had reversed, the "L" light on the arrival signal illuminated and the train entered the loop. Once the rear of the train cleared the points, track circuiting at that end automatically restored the points to the normal position (see Figure 8).

1.4.6 After the train entering the main line had cleared the points, the points for the departure of the train in the loop would automatically set the route for the departure of the train. When both trains had departed and cleared the track circuited area, the main line points automatically returned to their normal setting.

1.4.7 TWC was referred to as “dark territory” and the route was not track circuited as in SLAS. As a result, track circuiting and interlocking applied only in the immediate vicinity of the crossing stations and track detection did not extend beyond 1300 m into the single line section at either end (see Figure 8). In SLAS, track circuiting extended through the single line section to the next crossing station in advance.

Analysis 1

Route and site information

1. The number of trains operating on the Midland Line made it one of the busiest lines on the rail freight network. When single-person train crewing was introduced, the provision to leave main line points reversed was included in the SLAS procedures.

Signalling and interlocking

2. As well as being influenced by the proximity of opposing trains, the indications displayed by arrival signals in SLAS were controlled by the setting of either the facing main line points immediately beyond the signal or the trailing mainline points at the opposite end of the crossing station, or both. This was because SLAS provided for only one departure signal at the opposite end of the station to the arrival signal and, as the departure signal was positioned outside the points, there were no fixed signals protecting the trailing points for through trains. Thus the arrival signal protected 2 sets of points, which could create uncertainty as to the reason for the stop indication on the signal. However, when a stop indication was displayed for whatever reason, the locomotive engineer of an approaching train was required to comply with the indication. The reasons for any stop indication could then be established before moving on.

3. Changes were made to the SLAS operating rules and procedures to provide for leaving main line points in the reverse position after train crossings following the introduction of single-person locomotive crewing. Although this change to operating procedures was probably appropriate at that time, its suitability under present train operations was questionable given the increased frequency and size of the trains using the route. The SLAS was 80 years old and newer operating standards and procedures had evolved that offered improved operational safety.

4. Although the train controller was aware that the west end points at Cora Lynn were in the reverse position, there was no requirement under SLAS operating procedures for him to advise the locomotive engineer of Train 834. Had there been such a requirement, this collision might not have happened. Making this a mandatory requirement would add to the existing workload of the train controller, and while it would add an extra defence by forewarning locomotive engineers of the position of facing points set against the passage of their trains, it would create another opportunity for missed communication and human error. The stop indication and the illuminated “L” light on the arrival signal could be reasonably considered to have already provided adequate defence, had the signal indications been adhered to.

5. The possibility of a train colliding with another train berthed on the loop after having overrun an arrival signal in a TWC area was unlikely because both the facing and trailing points were motorised and automatically returned to normal after trains had departed following a crossing. The points were never left in the reverse position for the approach and passage of the next train. The number of scheduled train crossings in a 24-hour period on the Midland Line was exceeded by such crossings scheduled on only one of the TWC routes on the network so, based on traffic density alone, the installation of motorised points on the Midland Line would have not only improved operational efficiency but improved operational safety as well.

6. The provision of motorised points at crossing stations in SLAS, regardless of how they were operated, would not completely remove the risk of a head-on collision following

a signal overrun, but would significantly reduce the potential. However, had the points at Cora Lynn been motorised, this collision probably would not have happened. Except in the case of a points failure, the western end points would have been set for the main line when Train 834 arrived, having returned to that position following the previous crossing 2 hours earlier. The eastern end points would also have returned to the normal position after Train 841 had entered the loop.

7. Motorised points and appropriate signalling or points indication systems at stations on the Midland Line could potentially remove the need for locomotive engineers to stop when they knew the opposing train was berthed in the loop and clear of the main line.

Buffer zone

8. The existing policy of providing a 150 m minimum buffer zone between the home signal and the opposing departure signal where possible in new CTC crossing station installations was realistic for typical train consist and weights. If such a policy had been applied on the Midland Line, the Cora Lynn collision could have been avoided, or at least the force of the impact reduced. At Cora Lynn the "minimum buffer zone" available between the arrival signal and the fouling point board was 60 m, which was not sufficient to prevent collisions from overruns in any situation other than minor braking misjudgements. Given the higher-than-average train weights travelling over the Midland Line, the 150 m minimum buffer zone may need reviewing.

9. The issues raised regarding the signalling, interlocking and operational procedures in effect on the Midland Line are incorporated in a safety recommendation that has been made to the Chief Executive of ONTRACK.

1.5 Personnel

The locomotive engineer of Train 841

1.5.1 The locomotive engineer had been driving for about 30 years, and for most of this he had been based in Christchurch. He started work on Thursday 20 October at 1500 for his rostered shift, which involved driving Train 841 from Christchurch to meet eastbound Train 826, which he was to return to Christchurch.

1.5.2 At Rolleston, he received an operating instruction by radio from train control, which authorised his train to travel to Arthurs Pass, crossing Train 804, the eastbound *Tranz Alpine* passenger express at Springfield and Train 834 at Cora Lynn en route.

1.5.3 As he approached Cora Lynn on Train 841, there was a "yellow" indication on the intermediate signal[8]. This indicated that the next signal in advance, the arrival signal at Cora Lynn, was at either "red" or "yellow". He said he stopped at the arrival signal at the eastern end of Cora Lynn to reverse the points so that he could berth his train on the loop. After he stopped his train at the arrival signal, he radioed the locomotive engineer of Train 834, who advised that he was "just around the corner", so the locomotive engineer of Train 841 advised that he was going to continue on to the loop, which he did after he had reversed the main line points.

1.5.4 The locomotive engineer knew Train 834 was not far away because he had earlier heard on his radio the locomotive engineer receive his operating instruction at Arthurs Pass, the next station in advance of Cora Lynn. He said he had just stopped his train short of the fouling point board at the western end of the loop at Cora Lynn when he saw Train 834 approaching the arrival signal. When he saw Train 834 enter the loop, he took shelter on the cab floor.

1.5.5 The locomotive engineer said that once his train had berthed on the loop at Cora Lynn, the arrival signal at the western end would have displayed a "red" indication for Train 834 because the points at the eastern end were reversed following the passage of his train. He said that if

[8] The Intermediate signal was positioned 2559 m in advance of Arrival Signal 10171.

there was sufficient time after a train had berthed on a loop for a crossing, the locomotive engineer usually went back and restored the points to the main line for the convenience of the opposing train, but this was not mandatory. He did not know when he berthed on the loop that the points at the western end, the facing points for approaching Train 834, were set for the loop.

1.5.6 He said that train controllers sometimes advised locomotive engineers when the points at a particular station were reversed for the loop, but there was no requirement under normal operating circumstances for them to do so. However, train controllers would know which points were reversed because locomotive engineers were required to advise train control of any points left in reverse after they had departed a crossing station. He said that, in this instance, the points had been left in the reverse position following an earlier crossing at Cora Lynn.

1.5.7 Although he considered that it would be helpful if train controllers advised locomotive engineers when points were set in reverse against their train, he accepted that ultimate responsibility rested with the locomotive engineer to ensure the route was correctly set for his train.

The locomotive engineer of Train 834

1.5.8 The locomotive engineer had been driving for about 31 years, all of that time in Christchurch. He started work on Thursday 20 October at 1400 for his rostered shift, which was on the depot shunt. However, on arrival at work, he was asked instead to travel by car to relieve the locomotive engineer on late-running Train 844, and return to Middleton. As he travelled by car, his duties were again changed and he was instructed to change instead to express freight Train 834 at Otira.

1.5.9 He said that many of the company cars used for crew changes were equipped with train control radios, but the car he was driving was a rental car so it did not have a radio. He had a handheld radio with him, but coverage was restricted and it was only useful for talking to the locomotive engineer of the train onto which he was to change once he could see it. He thought that not having a train control radio in the vehicle had placed him at a disadvantage as he had not been able to monitor what was happening on the train control radio channel regarding other train movements. It also did not enable him to hear the setting of points en route as locomotive engineers radioed in that a particular set had been left at reverse following their departures.

1.5.10 At Arthurs Pass, he received an operating instruction from train control by radio for his return journey to Middleton on Train 834, crossing Train 841 at Cora Lynn en route. He departed Arthurs Pass and shortly afterwards activated dynamic braking[9] on his train and later made an air brake reduction to slow the train to 55 km/h for some curves.

1.5.11 After negotiating the curves, he said he thought that he had disengaged the dynamic brake and let the train speed increase to about 70 km/h. He then reactivated dynamic braking and made a further air brake reduction as he approached the intermediate signal about 2 km from Cora Lynn, which had displayed a "yellow" indication. He said that at this time he spoke by radio with the locomotive engineer of Train 841, who confirmed that he was entering the crossing loop.

1.5.12 Once the locomotive engineer knew that Train 841 was in the loop, he said that he planned not to stop his train at the arrival signal at Cora Lynn, but rather continue on down the main line and stop at the fouling point board immediately before the points at the eastern end, which he knew were set for the loop, following the arrival of Train 841. He said this saved stopping his loaded train twice and reduced the risk of stalling. He said this was a common practice amongst locomotive engineers at potential trouble spots at some stations on the route if they knew that the opposing train was already berthed on the loop.

[9] The locomotive traction motors are used as generators to create a braking force.

1.5.13 The locomotive engineer had his train under control as he rounded the curve on the approach to Cora Lynn and made a brake application to reduce the speed of the train. When he saw the "L" light illuminated, he then realised the facing points also were set for the loop. He made an emergency brake application but realised his train was not going to stop before it entered the loop. He realised a collision was inevitable and leapt from the locomotive cab, injuring his ankle as he landed on the ground.

1.5.14 He said the "L" light on the arrival signal was illuminated when he approached but it was dusk and he had not had a good view of the signal until he was very close. He said he had not been distracted, was not fatigued and his hours on duty were not excessive. Even though his duties had been altered on his arrival at work, he would still have been able to book off at his rostered shift completion time of 2300.

1.5.15 He expressed concerns about the permitted practice of leaving points in the reverse position in SLAS territory after crossings, and felt that points should be motorised in the same way that they were in TWC areas where the points automatically reverted to the normal position after the trains had cleared the crossing loop. He said that he felt the 60 m overrun distance between the arrival signal and the fouling point board was probably not enough, especially as the locomotive engineer would not have to make much of an error with 2000 t behind the locomotives to require more overrun than that provided.

1.5.16 He said he did not consider the practice of not stopping at the arrival signal to be unsafe when crossing another train if the opposing train was safely berthed on the loop. If he had thought it was unsafe, he would not have done it.

1.5.17 The locomotive engineer estimated it took 10 minutes for a loaded train to negotiate the main line when crossing an opposing train berthed in the loop. This allowed time to reduce speed and stop at the arrival signal, wait the mandatory 10 seconds before proceeding forward over the facing points and continuing on to stop at the fouling point board, set the trailing points to normal, then get the train back to maximum authorised line speed for the section. He was aware that this time was not allowed for in the train schedules, nor was time allocated for personal needs breaks, crew changes or stopping to reset points.

1.5.18 The locomotive engineer expressed concern about the continual late running of the coal trains. He said that the constant late running led to regular long hours and extended shifts and resulted in relief crew changes in the field because trains could not reach their destinations before the locomotive engineers' maximum shift hours expired. He said one of the major causes of delays was the congestion caused by the banker programme at the Otira Tunnel. He said that Train 834, which he had taken over at Otira, was running 5 hours late when he did so.

1.5.19 The locomotive engineer said that the turnaround time for the coal trains was tight, so he felt there was pressure on the locomotive engineers to try to keep the trains running to time. He said he also felt there was an expectation on the part of the company for that to happen. He said that the 25 km/h speed restriction at Tunnel 1, between Staircase and Springfield, was because of the tightness of the curve approaching the Tunnel, but that if loaded eastbound trains maintained 25 km/h on wet rail they would stall every time. He said that he thought the company management was probably aware that trains were exceeding the 25 km/h restriction because the trains were not stalling.

1.5.20 In the fortnight leading up to the accident, the locomotive engineer had been rostered on duty for 88 hours 50 minutes and had actually worked 90 hours. He had 3 days rostered off-duty during that period. The collision occurred about 5 hours into his shift, which had started at 1400 on Thursday 20 October. He was on his fifth consecutive shift after 2 days off-duty.

1.6 Locomotive event recorder

1.6.1 The locomotive event recorder from DXH5229, the lead locomotive on Train 834, was downloaded. Analysis of the data revealed:

- at about 18.48:00, 2 minutes after leaving Arthurs Pass and while travelling at about 40 km/h in throttle notch 5, the locomotive engineer reduced power and selected notch 1 in dynamic braking
- at 18.49:00 the speed of the train had increased to about 78 km/h and the locomotive engineer made the first of several incrementally increasing air brake applications to reduce the speed to about 62 km/h, at which point the brakes were released
- at 18.51:00 the speed had increased to about 67 km/h and the locomotive engineer again made an incrementally increasing air brake application and brought the speed back to 50 km/h before he released the brakes
- at about 18.55:25 the speed had increased to about 80 km/h and a further incrementally increasing air brake application was made, which brought the speed back to about 72 km/h and the brakes were released
- at about 18.57:00 the speed had increased to about 78 km/h and a further incrementally increasing air brake application was made, which reduced the speed to about 50 km/h by 18.58:00, at which point the brakes were again released
- at about 18.59:18 a further air brake application was made and the train speed reduced to about 45 km/h before the brakes were released at 18.59:30 (see Figure 9)
- at 19.00:08 the train speed had increased to about 49 km/h and an incrementally increasing air brake application was made, which reduced the train speed to about 35 km/h at 19:00:38 when an emergency air brake application was made (see Figure 9)
- at 19.00:51 the speed reduced from 22 km/h to 15 km/h at 19.00:52
- at 19.01:00 the speed ceased to register.

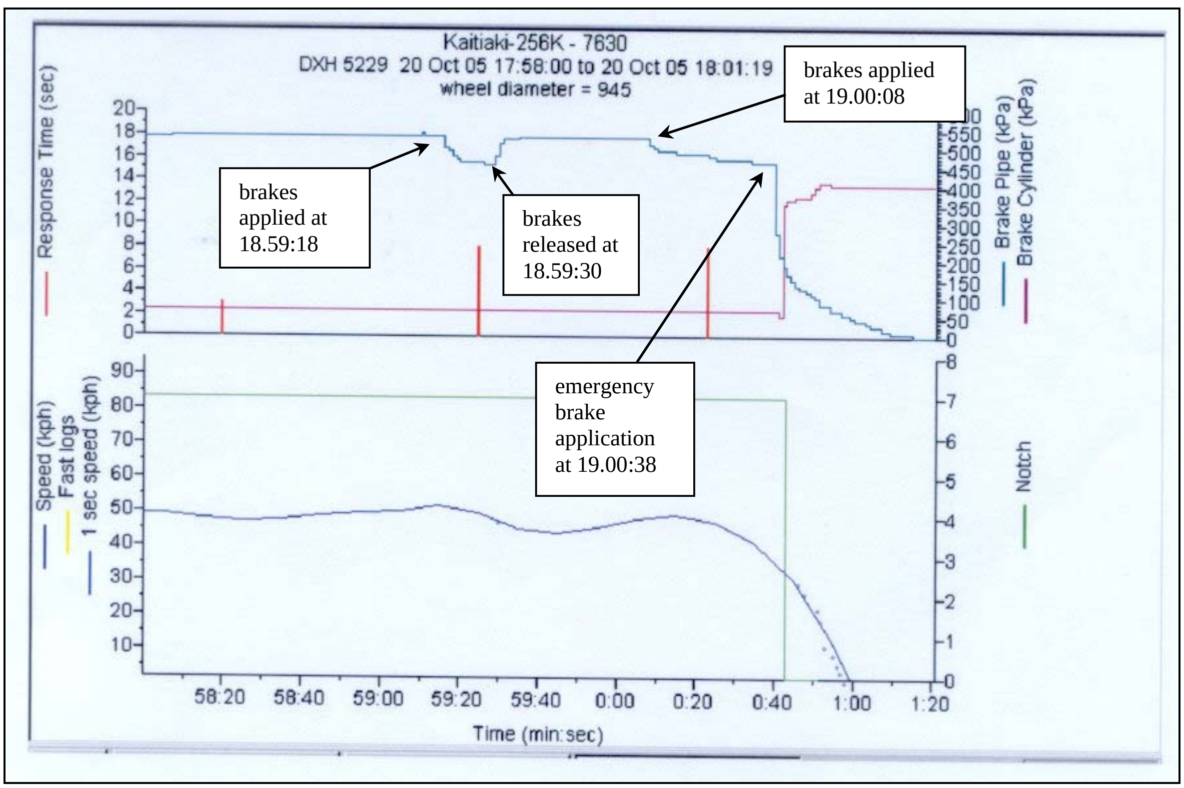


Figure 9
Locomotive event recorder data from DXH5229
(courtesy Toll Rail)

Analysis 2

1. The locomotive engineers of Trains 841 and 834 had operated in SLAS territory for many years and were experienced in interpreting the signal indications when approaching crossing stations, and the operating procedures to be followed for working such stations when crossing trains there.

2. When the locomotive engineer of Train 841 berthed his train on the loop at Cora Lynn, he would not have known that the points at the western end were set for the loop. From where he had stopped his train, he would have had difficulty determining the setting of the points. Even if he had been aware, there was no requirement for him to restore the points to normal for the passage of Train 834, and in this instance he would not have had time to do so anyway as he had just stopped his train when Train 834 approached the arrival signal.

3. The locomotive engineer of Train 834 knew before he sighted the arrival signal at Cora Lynn that Train 841 was berthing from the eastern end of the loop. The "yellow" aspect on the intermediate signal as he approached Cora Lynn would have confirmed for him a "red" aspect on the arrival signal. The arrival signal being at red could have been for one or a combination of the following reasons:

   - Train 841 was still berthing in the loop
   - the eastern end points were reversed
   - the western end points were reversed.

4. The locomotive engineer of Train 834 clearly did not expect the western end facing points to be reversed, otherwise he would have been preparing to stop at the arrival signal, leave the cab and reset the points for the main line for the passage of his train. Any other course of action would have been likely to result in a collision.

5. The locomotive engineer of Train 834 did not intend to stop at the arrival signal as he was required to. This was evident because:

   - he said he didn't intend to
   - the approach of Train 834 to Cora Lynn was fully controlled with a fully serviceable braking system
   - at a speed of 35 km/h when the emergency brake application was made, the train was never going to stop before the arrival signal.

6. The intermediate signal for eastbound trains was sited nearly 3 km in advance of the arrival signal at Cora Lynn. Travelling at 50 km/h, the locomotive engineer therefore had about 3.5 minutes' warning of the stop indication on the arrival signal. This was ample time for him to prepare to respond to the arrival signal.

7. All incremental air brake applications made by the locomotive engineer were minimal and when the brakes were released the air pressure in the brake pipe recharged to 550 kilopascals instantly. At no stage would there have been a shortage of air pressure in the auxiliary reservoir that would have prevented further brake applications to slow and stop the train as it approached the arrival signal.

8. The locomotive event recorder on Train 834 confirmed that the locomotive engineer had his train under control and had been slowing as he approached Cora Lynn. The incremental brake application at 18.59.18 was made at about the distance from Cora Lynn when a brake application could have reasonably been expected for slowing in preparation for stopping at the arrival signal. Had he continued with that brake application, rather than release the brakes 12 seconds later, he would probably have been able to stop at the arrival signal once he saw that the "L" light was illuminated. Instead, he released the brakes and left them off for another 38 seconds, losing any opportunity to stop his train short of the arrival signal.

9. Shortly after departing Arthurs Pass, the locomotive engineer had reduced power and activated the dynamic brake to hold the train on the downhill run to Cora Lynn. This, together with a series of incremental air brake applications, ensured that the train had not exceeded the maximum authorised line speed for the area. The event recorder data confirmed the locomotive engineer's comments regarding his use of the dynamic brake and the air brake as he travelled from Arthurs Pass to Cora Lynn, and also that he was responding to speed increases and decreases with the train handling skills of an experienced locomotive engineer.

10. The locomotive engineer's roster for the period leading up to the incident did not indicate any rostering practices or excessive work periods that could have led to fatigue being a contributing factor, and supported the locomotive engineer's comment that he had not felt fatigued prior to the collision.

11. The presence of sand alongside the track from about 38 m before the arrival signal at Cora Lynn confirmed that an emergency brake application had been made, and also probably identified the point at which the locomotive engineer had first seen and responded to the illuminated "L" light. It was not possible to determine the distance that the illuminated "L" light was visible on the day, but it was not relevant, as the locomotive engineer should have been preparing to stop his train at the arrival signal anyway.

12. While the responsibility for controlling his train and responding appropriately to signal indications and operating instructions rested solely with the locomotive engineer, the practice of allowing points off the main line to be left in the reverse position meant that if he did lose control of his train and overrun an arrival signal, a collision with a train already berthed on the loop was a possible outcome. The arrival signal and the "L" light indicated to an approaching locomotive engineer the setting of the points, but not the occupation status of the loop.

13. That there was no requirement for the locomotive engineers of trains berthing on the loop or departing from the loop to restore points to normal behind their trains was understandable. This would have incurred delays and also created a risk of injury while walking beside the track for several hundred metres on their own and in remote countryside.

14. The locomotive engineers operating on the Midland Line were also qualified for TWC operations, where the practice of communicating with each other by radio when approaching crossing stations was mandatory. For this reason the practice had probably become common on the Midland Line. For the same reasons as in TWC operations, the practice was useful in providing accurate information on the location of the opposing train and assisted locomotive engineers when interpreting signal indications. However, voice communication was not a substitute for signals nor was it an early warning of the position of the facing points for approaching trains. In this case, it provided confirmation for the locomotive engineer of Train 834 that, with Train 841 berthing on the loop, the eastern end points at Cora Lynn would be set in the reverse position. The formalising of this process in SLAS operating procedures is included in the safety recommendation that has been made to the Chief Executive of ONTRACK.

1.7 The train control diagram

1.7.1 The train control diagram showed the timetables of all scheduled trains printed in green. The train controller drew plot lines on the diagram using a black pencil to show the anticipated progress of the trains. Lines in red representing each train were drawn across the diagram in the form of a graph of the actual movement of trains from one station to the next against time. If a train was on time, the appropriate red line would be directly over the green line showing the train's schedule.

1.7.2 ONTRACK's Rail Operating Procedures stated that the objective was to ensure that the completed diagram provided a complete record of performance and was adequate for analysis purposes even after a considerable time had elapsed. The completed diagram became a visual record of a day's working.

1.7.3 The train control diagram showed that the previous crossing at Cora Lynn had occurred at about 1655 when Train 804 *Tranz Alpine* passenger express had crossed westbound Train 835. This was about 2 hours before the collision between Trains 841 and 834. The train controller had endorsed on the train control diagram that the west end points at Cora Lynn had been left in the reverse position following the departure of Train 835 from the loop.

1.7.4 A review of the schedule lines printed on the train control diagram showed that, in most instances, no time allowance had been included in the schedule lines for loaded eastbound coal trains to stop at the Arrival signal, then move down the main line and stop again short of the east end points when crossing an opposing train berthed on the loop.

1.7.5 On 11 August 2006 Toll Rail advised:

> Train control diagrams do not show time for scheduled crossings for a train stopping twice when an opposing train has berthed in a crossing loop. This detail has never been specifically included in schedules or on train control diagrams since this method of operation was introduced in excess of ten years ago.
>
> The scheduled time forms part of the contingency outlined above.

1.8 Train scheduling

Toll Rail scheduling principles

1.8.1 Train scheduling was carried out by Toll Rail.

1.8.2 In response to questions relating to scheduling on the coal route, Toll Rail advised on 11 August 2006 in part:

> Toll Rail considers it is appropriate to firstly outline the scheduling principles adopted to meet the commercial objectives of this route, particularly as they differ from the principles adopted for our other routes, which have differing scheduling demands.
>
> Because train performance on this route is based on continual turnaround of train consists on a 24 hour x 7 basis it is exposed when outages such as mechanical failures at the loading and discharge facilities or on the trains, peaks in speed restrictions etc, or accumulated lesser delays occur. Because of the unpredictable nature of these events the method of mitigating them is to schedule sufficient trains over a monthly/yearly period which allow a cancellation factor of about 11%. It is important to note these cancellations are in addition to pre-programmed cancellations for ONTRACK's planned maintenance program.
>
> When major outages occur or the time-keeping of trains accumulates a succession of delay events, trains are cancelled to "normalise" the timetable.
>
> This method is preferred to building excessive robustness into each train path to cater for unexpected outages or other network issues, as this would unnecessarily reduce route capacity over an extended period

Basic running times

1.8.3 The basic running time referred to a specific section of track, locomotive, train weight and train type. For any given set of conditions, the basic running time could be defined as the least time the specified weight of train could run through the particular section of track, the speed at all times being as close as possible to the authorised speeds, up to the performance of the locomotive.

1.8.4 Basic running times were based on:

- normal operating conditions
- the normal condition of locomotives and rolling stock
- authorised speeds as defined in the Rail Operating Rules and Procedures for the locomotive and train concerned, including permanent speed restrictions
- curve speeds as authorised by ONTRACK.

The basic running times did not include allowances for such things as:

- starting and stopping at the beginnings and ends of the specified sections
- temporary speed restrictions or deceleration and acceleration in connection therewith
- standing time at intermediate stops for crossings, crew changes
- contingencies or make-up time.

1.8.5 Train schedules on the route were calculated on the basis of 2 DX class locomotives (or derivatives) in multiple with a 2160 t gross train and included an additional time allocation of about 13% of the base running time to cover reduced speeds as a result of temporary speed restrictions. This allocation was periodically reviewed as conditions warranted.

1.8.6 The train scheduling computer software also allowed additional time to be added to the base running time to provide for stops and restarts en route. An additional 2 minutes deceleration time was added when a train was scheduled to stop and an additional minute was added to the running time for the train to accelerate from a standing start to the authorised maximum line speed.

1.8.7 As part of its response about scheduling principles on 11 August 2006, Toll Rail advised in part:

> The weekly schedule, expressed in hours and minutes, for the 30 wagon programme now consists of:
>
> | | | |
> |---|---|---|
> | Base point to point running time | = 509:36 | = 69% |
> | Scheduled crossings/meal breaks | = 73:23 | = 10% |
> | Contingency | = 180:39 | = 21% |
>
> The contingency, which remains significant, primarily takes into account speed restrictions and general day to day operational variations. More significant outages eventually lead to cancellations as outlined above.

1.8.8 The basic running times for trains on the coal route had been reviewed during the implementation of the 30-wagon coal trains.

1.9 Time-keeping survey

1.9.1 Train time-keeping performance data for loaded eastbound coal Trains 842, 844, 846 and 848 for the period 1 October 2005 to 20 October 2005 was reviewed. The findings are tabled below:

Train number	842	844	846	848
Number of trains surveyed	12	12	13	14
Number of late departures (>10 min)	12	10	10	10
Average late departure	97 min	64 min	64 min	45 min

Number of late arrivals (>10 min)	12	12	13	12
Average late arrival	3 hr 32 min	1 hr 50 min	2 hr 10 min	2 hr 43 min
Scheduled running time over route	9 hr 21 min	10 hr 4 min	10 hr 33 min	10 hr 54 min
Average running time taken over route	11 hr 15 min	10 hr 53 min	12 hr 45 min	11 hr 52 min
Average running time lost en route	1 hr 54 min	49 min	2 hr 12 min	1 hr 58 min

1.9.2 The review showed that of the 51 services reviewed:

- 9 services (18%) departed on time
- 2 services (4%) arrived on time
- 6 services (12%) made up time en route
- 44 services (86%) lost additional time en route
- one service arrived late at destination by the same time difference as it departed late from origin
- of the 9 services that departed on time, none arrived at destination on time.

Analysis 3

1. It was evident that the continual late running of the programme, resulting as it did in regular long shifts and crew changes "in the field", was a source of frustration to the locomotive engineers. This supported comments from locomotive engineers and train controllers during the investigation regarding the difficulty in keeping trains operating to their designed schedules.
2. The Toll Rail schedule for the coal trains was not achievable, as evidenced by the continual late running of the services. The time-keeping survey showed that of the 51 loaded services reviewed, only 2 had arrived at destination on time. The number of crew changes that took place in the field because of late running was a consequence of the way the trains were scheduled.
3. Toll Rail accepted the late running of the coal trains as a normal part of its operation to utilise the capacity of the Midland Line. Toll Rail also accepted the consequent need to change crews in the field and work extended shifts. While the philosophy Toll Rail used to achieve this might be logical from a business sense, some degree of caution was needed to ensure that from a human factors' point of view, this did not lead to train crews taking short cuts or ignoring critical procedures due to commercial pressure, perceived or otherwise, to maintain the schedule.
4. Management had a responsibility to make it clear to train crews that they were not responsible for the late running of their trains in a programme where continual late running was accepted, and to make it clear safety standards should not be compromised in an attempt to maintain or improve time-keeping.
5. The time saved by a locomotive engineer deliberately running past a signal at stop, rather than following correct procedures, was inconsequential when compared with the frequency and magnitude of late running trains on the Midland Line.
6. Even making allowances for crossing opposing trains, Train 834 would have arrived at its destination in time for the locomotive engineer to sign off before the end of his rostered shift, albeit some 5 hours behind schedule. The evidence suggests that the late running of Train 834 in this event was not the reason for the locomotive engineer deciding not to stop at the arrival signal.

1.10 Other information

Coal route motive power (Brightstar)

1.10.1 A number of standard DX class locomotives had been reclassified as DXB class and had been upgraded and equipped with the Brightstar microprocessor control system to improve the tractive effort[10] of the locomotives. The Brightstar software included:

- excitation control
- governor control
- wheel slip control
- compressor control
- alarm systems (other than vigilance devices).

1.10.2 The DXB locomotives were rated at either 3000 horsepower (2229 kilowatts (kW)) or 2600 horsepower (1930 kW). There were 14 DXB class locomotives in the fleet, the majority of which were rated at 2229 kW.

1.10.3 There was no difference in the tractive effort between the performances of the 1930 kW and 2229 kW DXB class locomotives as the Brightstar software made it possible to utilise that power with better tractive effort, thereby permitting heavier trains without the need to increase the number of locomotives.

1.10.4 A programme introducing enhanced Brightstar software packages had been underway since 2004, with the latest version being introduced in May 2006. The results of the latest enhancements were still being evaluated.

1.10.5 As part of the upgrade, new traction motors had been fitted to the locomotives. This not only enabled the locomotives to provide increased tractive effort up grades, but also enhanced dynamic braking performance when travelling down grades.

1.10.6 In July 2005, software problems had been identified as a contributing factor to locomotive stallings on up grades. Since then, 3 software enhancements had been installed on the DXB class locomotives prior to the collision. Although these enhancements had improved the locomotive performance, they had not completely eliminated the problems being experienced. As a result, the locomotive manufacturer, General Electric in the United States of America, sent its Brightstar project engineer, who was also the software engineer, to work with Toll Rail staff for 3 weeks identifying and rectifying problems.

1.10.7 Toll Rail had encouraged locomotive engineers to report instances of locomotive performance degradation as a result of the introduced software and any instances reported were considered, with fixes being included in subsequent software enhancements. This, together with the input from General Electric, had ensured that the performance of Brightstar software had progressively improved with each enhancement.

1.10.8 The Project Engineer, Locomotive Performance[11] for Toll Rail (the project engineer) said that he did not think the concerns of the locomotive engineers regarding potential stallings prior to the collision were entirely justified. He said that the potential to stall existed when the locomotive engineer was not intending to stop, but from a standing start the system was quite reliable. Historically, stallings had been at Tawhai Bank and Aickens, not Tunnel 1 or the Otarama Bank.

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[10] The combination of the adhesive weight of the locomotive and the control of the power to the wheels.

[11] The responsibilities of the Project Manager, Locomotive Performance included looking at developing bigger loads on trains, keeping load schedules up to date and following up locomotive performance issues (including stallings).

1.10.9 All eastbound 30-wagon coal trains required a DXB class locomotive to be the leading locomotive in the combination, assisted by either a second DXB class locomotive or DXH class locomotive.

Loaded 30-wagon test train

1.10.10 The project engineer advised that prior to increasing the train size from 24 wagons (1680 t gross) up to 30 wagons (2100 t gross), it had been necessary for some draw gear strengthening to be done, both on the test locomotives and on some of the wagons used in the test.

1.10.11 The test that was undertaken in February 2004 consisted of 30 loaded coal wagons with a DXB class locomotive and a DXH class locomotive in multiple, both locomotives rated at 1930 kW.

1.10.12 The test train was stopped on the Tawhai Bank, between Reefton and Stillwater, and again at the western end of Aickens (between Otira and Jackson) in adverse weather conditions. A Brightstar software problem resulted in some minor problems being experienced after stopping on the Tawhai Bank, but the train eventually cleared the gradient. No software-related problems were experienced at Aickens, although it was found that the sand boxes were clogged and not operating. Both of these were at locations where, from past experience, stallings usually occurred on the route.

1.10.13 There was a 25 km/h speed restriction through Tunnel 1. This was considered by some locomotive engineers to be too slow for a loaded coal train to approach the 1 in 50 grade Otarama Bank, which was encountered shortly after exiting the Tunnel. The test train had been kept at 25 km/h through the Tunnel then stopped on the Otarama Bank to test the lifting capabilities, as potential stalling on the Otarama Bank had been identified during the risk assessment. In light drizzle conditions, no difficulties were experienced as the train lifted away from the stop. The project engineer said the test train had not stopped on the Cass Bank as the grade was not steep enough to challenge the locomotives.

1.10.14 The project engineer said that increasing the coal trains by 6 wagons (a 25% increase in gross tonnage) without needing to increase locomotive numbers had not been difficult. However, the route had 4 gradients where full horsepower was required and trains lost running time. The Brightstar system with its improved use of available horsepower made it possible to negotiate these grades with the increased train size and with minimal lost running time.

The locomotive engineer of the test train

1.10.15 The locomotive engineer who had driven the loaded 30-wagon test coal train from Stillwater to Christchurch said that during the trip he had been accompanied in the locomotive cab by Toll Rail's Operational Risk and Compliance Manager[12] (the compliance manager) and the project engineer.

1.10.16 The locomotive engineer had discussed with the compliance manager locomotive engineers' concerns about the possibility of lifting a train after stopping at the arrival signals at Aickens, Jackson or Cass during inclement weather, or with poor-performing locomotives, or if the train was overloaded. The compliance manager gave him an undertaking to look into this issue as well as the 25 km/h speed restriction in effect in Tunnel 1.

1.10.17 The locomotive engineer said that if a locomotive engineer experienced difficulties climbing the Cass Bank[13] they would have further difficulties if they approached the Otarama Bank at the maximum authorised speed of 25 km/h through Tunnel 1. He said that the Otarama Bank was the last hill on the homeward trip and locomotive engineers were generally not prepared to run

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[12] The Operational Risk and Compliance Manager was the company's senior investigator of rail accidents and incidents who was also responsible for risk assessment and audit.

[13] The Cass Bank was located between Cora Lynn and Craigieburn, about 37 km before the Otarama Bank.

the risk of stalling there, given the amount of time it could take to get assisting locomotives to them.

1.10.18 The locomotive engineer expressed some surprise that the test train had lifted off the Otarama Bank after stopping there. He said he had put this performance down to trial conditions and that other locomotive engineers generally thought that the locomotives had probably been "tweaked" to ensure optimum performance during the trial.

1.10.19 The locomotive engineer said that initially the DXB locomotives had exacerbated the stallings, with most problems being related to the earlier versions of Brightstar software. However, he said he had not heard of any stallings recently and that could be because a lot of the problems had been fixed with the subsequent software enhancements.

Tunnel 1

1.10.20 Tunnel 1 was about 80 m long and was situated between Staircase and Springfield. The track was on a gradient of 1 in 70 (see Figure 10) which continued for a further 350 m after exiting the Tunnel before the gradient steepened to 1 in 55 for a further 450 m.

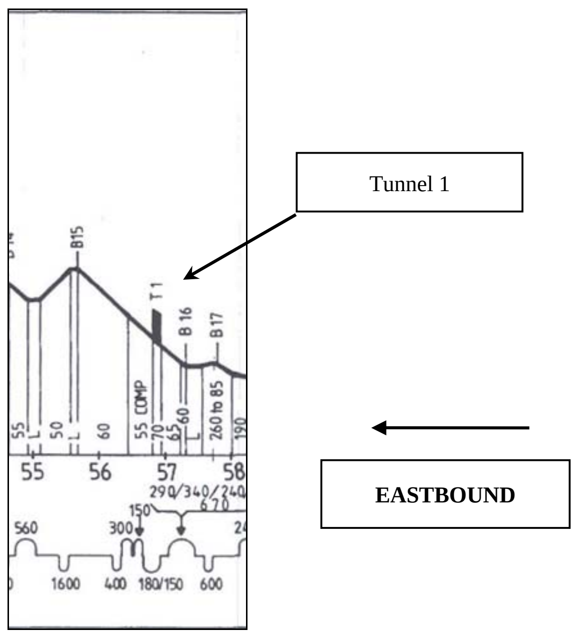

Figure 10
Gradient diagram for Tunnel 1
(courtesy ONTRACK)

1.10.21 Eastbound trains negotiated a 180 m radius right-hand curve as they proceeded through the Tunnel, followed by a 150 m radius reverse curve.

1.10.22 The transition lengths[14] for the curves approaching and leaving the Tunnel were a minimum design length of 35 m. This meant that the cant[15] runoff was at the absolute maximum of 2 mm/m. The standard transition length was 70 m, which gave a design runoff of 1 mm/m.

1.10.23 ONTRACK's Rail Operating Procedures, Local Network Instruction Section L6 specified a permanent speed restriction of 25 km/h through the Tunnel. This was because of substandard tops and bottoms of cab clearances in the Tunnel for DX class locomotives (and derivatives).

[14] Transition lengths were provided between the tangent point and the start of the circular curve.
[15] The difference in elevation between the 2 running rails. On a curve the outside running rail was higher than the inside running rail.

The clearance restriction was also in place for CC class coal wagons. Prior to July 2006 ONTRACK had undertaken a review of the permanent speed restriction in effect in Tunnel 1, which had revalidated the restriction.

Train-stalling survey

1.10.24 A survey of train stallings[16] for the months of September and October in 2004, 2005 and 2006 was undertaken to assess if stallings had decreased with the introduction of Brightstar software to the train locomotives.

1.10.25 The initial survey showed that although train stallings overall had decreased in the 2006 period over the 2005 period, train stallings at both Jackson and Aickens had increased significantly in the 2006 period. In an attempt to identify any trends, the months of November and December 2006 were also included.

1.10.26 Data from the survey is included in the following table:

Location	**Sept/Oct 2004**	**Sept/Oct 2005**	**Sept/Oct 2006**	**Nov/Dec 2006**
Tawhai Bank	3	13	4	4
Jackson	1	3	6	0
Aickens	nil	3	8	1
Otira and Tunnel	2	6	1	1
Cass Bank	6	7	4	0
Otarama Bank	nil	2	3	3
Total	**12**	**34**	**26**	**9**

Analysis 4

1. The original Brightstar microprocessor control system software that had been installed on the reclassified DXB locomotives had caused problems with locomotive performance and frustrated the locomotive engineers. Toll Rail offered them an opportunity to report any problems experienced and had worked on addressing any issues through ongoing software enhancements, together with the involvement of the manufacturer's engineer. The locomotive engineers spoken to during the investigation generally agreed that locomotive performance had improved with these enhancements and that stallings had become less common.
2. The train stalling survey showed that stallings peaked during the September/October period in 2005. This probably reflected the problems being incurred as the initial software was implemented together with the introduction of the 30-wagon coal trains, and the lack of locomotive engineer confidence in the Brightstar software.

[16] Figures include instances where the train came to a complete stop or from its running time it was apparent the train was struggling to maintain momentum.

3. The period of September/October 2006 showed a reduction in stallings of 24% over the same period 12 months earlier. This improvement probably came about following the introduction of the latest version of the software in May 2006, together with increased locomotive engineer experience in the use of, and confidence in, the Brightstar software. The upgrade of the sanding system probably further contributed to the overall improvement.

4. Although the period September/October 2006 showed a decrease in the overall number of stallings, it did highlight an increase in stallings at both Jackson and Aickens over the previous period. This increase could not be accounted for, so the months of November/December 2006 were surveyed to see if numbers of stallings at those sites had continued to increase or had remained at that high level. The figures reflected no stallings at Jackson and only one at Aickens during the period, which was in line with the decrease in the overall total from 34 in September/October 2005 to 26 in September/October 2006.

5. The DXB/DXH class locomotive combination used on the 30-wagon test train was the same combination as that to be rostered for the trains once the program was introduced. Although some locomotive engineers were sceptical and thought that the test train locomotives had probably been enhanced to ensure optimum operation during the test, this was unlikely. It was in Toll Rail's interest to confirm that the planned rostered locomotive combination was capable of handling the larger coal trains under normal operating conditions. To have used any other locomotive combination than the proposed combination on the test train would not have validated that requirement.

6. The potential stalling sites identified by the locomotive engineers had been addressed during the test train run. In inclement weather and even with the locomotives having clogged and non-operating sand boxes, the train successfully lifted off from all identified suspect sites. The test train also successfully negotiated the Otarama Bank, again from a stop, after travelling through Tunnel 1 at the maximum authorised speed of 25 km/h.

7. What those tests demonstrated was that there was no need to routinely pass arrival signals at stop at certain locations for fear of stalling; neither was it necessary to exceed the 25 km/h speed restriction in Tunnel 1. Any instances of these restrictions and procedures being breached were more likely for historical reasons and a mistrust of new technology designed to improve operational efficiency.

1.11 Non-compliant train working practices

1.11.1 During the investigation the Commission became aware of an allegation that prior to the collision, non-compliant train working practices had been used on the coal route. It was established that some locomotive engineers on eastbound trains passed arrival signals at stop at some stations. This was done if the locomotive engineer of the opposing train had confirmed by radio that his train was berthed in the loop clear of the main line, or if the locomotive engineer had concerns about stalling if he did stop. Once past the arrival signal the locomotive engineer would continue down the main line and stop at the fouling point board at the eastern end, where they reset the points for the main line before continuing their journey.

1.11.2 These non-compliant practices also included exceeding the restricted speed of 25 km/h through Tunnel 1 between Staircase and Springfield to maintain train speed for the grade (Otarama Bank) at the eastern exit from the Tunnel.

Survey of locomotive engineers

1.11.3 Several locomotive engineers were interviewed during the investigation. All had considerable experience in driving coal trains on the route and each admitted that they used some or all of these non-compliant operating practices while driving eastbound trains. More detailed comments from some of those interviews are included below.

General comments

1.11.4 The locomotive engineers identified the following sites to be potential eastbound stalling locations:

- the arrival signals when approaching Jackson, Aickens and Cass as these signals were positioned on steep grades
- 3 intermediate signals positioned on steep grades at 139.46 km (between Jackson and Aickens), 89.10 km (between Cass and Craigieburn) and 55.98 km (between Staircase and Springfield)
- the 25 km/h speed restriction in Tunnel 1.

1.11.5 The locomotive engineers said that locomotive performance and weather conditions dictated when and if they used the non-compliant practices at these sites. They said that they considered that if they stopped at the arrival signals at those locations and the locomotives were slipping, or the track was greasy, they would probably not be able to start the train again. The practice was therefore that if they anticipated difficulties in stopping their train at the arrival signal they would instead continue on and stop on the level within station limits and at the eastern end fouling point board.

1.11.6 The intermediate signals were "stop and proceed" signals, as were the arrival signals. Under the operating rules, if these signals displayed a red indication the locomotive engineer was required to stop their train, wait for 10 seconds then move slowly past the signal and continue cautiously on. The locomotive engineers said that generally, with a fully loaded coal train in inclement weather, they would not stop at any of these signals if displaying a red indication as they might not be able to lift the train again. However, they acknowledged that with locomotives performing as designed and under ideal conditions, it was possible to lift a train from a standing start from these signals.

1.11.7 They said that if they had poorly performing locomotives and reduced speed to the maximum allowable 25 km/h for Tunnel 1, or had to contend with greasy track, they would not be able to climb the Otarama Bank at the eastern exit from the Tunnel. One of the locomotive engineers said that he understood there was an acceptance within company management that eastbound trains could travel at 40 km/h through Tunnel 1 to reduce the risk of stalling. Another said that he understood company senior management was aware that maximum authorised line speeds were regularly being exceeded to minimise the potential for stalling, while a third said that he regularly exceeded the 25 km/h speed restriction through Tunnel 1 if he felt weather conditions or poor locomotive performance warranted it. There was agreement that, as the Otarama Bank was the last major gradient on the homeward trip, locomotive engineers were not prepared to risk stalling there because of its remoteness and the length of time it could take to get assisting locomotives to them.

1.11.8 The locomotive engineers said that they were aware of the commercial pressures for getting the coal to the export terminal at Lyttelton without delays and said this was why they took short cuts to minimise the risk of stallings and resulting delays in getting the trains to the port. However, despite their efforts the trains still ran consistently late and relief crew changes for late-running services were regular events. They maintained that these practices were used not so much to reduce delays to already late-running trains, but rather to reduce the risk of stallings, which would have an effect not only on the time-keeping of the affected train, but also on the overall coal programme.

1.11.9 The locomotive engineers expressed concerns that the coal train schedules did not accurately reflect what was required in the field to follow operating procedures for crossing trains. They said it took at least an additional 10 minutes for a loaded eastbound coal train to pass through a station when undertaking a crossing, allowing for:

- deceleration and stopping at the arrival signal
- starting again, moving along the main line and stopping at the eastern end fouling point board
- leaving the locomotive cab and returning the eastern end points to normal for the passage of their train
- returning to the locomotive cab and lifting the train from a standing start back to maximum authorised line speed.

They said that no time had been allowed in the current schedules to reflect these operational requirements.

1.11.10 Concerns were also expressed about the continual long hours being worked by train crews as a result of the late running of the trains. They said it was not uncommon to do crew changes in the field after a locomotive engineer had completed his maximum hours and still not reached his home depot.

1.11.11 The locomotive engineers said there was a "kind of bush telegraph" in place among locomotive engineers on the route that enabled them to advise other drivers when they were accompanied by supervisory staff or if they were aware supervisory staff were in the vicinity.

1.11.12 An informal gathering involving several locomotive engineers and the Regional Manager Southern (the regional manager) had taken place in the amenities room at Middleton locomotive depot. The locomotive engineers said that the use of non-compliant work practices was discussed at that time.

Locomotive engineer #1

1.11.13 Locomotive engineer #1 (the locomotive engineer) had not been present at the informal gathering with the regional manager in the amenities room. He said that he had no evidence of eastbound trains not stopping at arrival signals when crossing opposing trains. He said he did not do it and could only speak from what he personally had done.

1.11.14 The locomotive engineer said he was aware of hearsay evidence that some locomotive engineers were proceeding past the arrival signal at Aickens if it displayed a red indication, after they had satisfied themselves that the route ahead was correctly set and safe for the passage of their trains. He said that he had done this but only when he knew he was not crossing an opposing train there. He considered his colleagues to be a responsible group and maintained that there was no evidence to suggest that locomotive engineers on the coal route were dangerously contravening any signalling rules.

1.11.15 The locomotive engineer said that when eastbound with a loaded coal train, he usually entered Tunnel 1 at 50 km/h, which was double the maximum authorised speed. This was to ensure the train got over the top of the Otarama Bank, immediately after the eastern exit from the Tunnel, without stalling. He estimated that 99% of the locomotive engineers driving the route regularly exceeded the 25 km/h restriction when travelling through Tunnel 1 for this reason. He felt that if the restriction was not exceeded, evidence would point to trains stalling on the Otarama Bank, but there was not a history of stalling.

1.11.16 He said that the DXB locomotives had initially exacerbated the stalling problems and that just about every stalling over recent months had involved that class of locomotive. However, he acknowledged that he had not heard of any stallings lately, which could be the result of ongoing enhancements to the Brightstar software.

1.11.17 The locomotive engineer said that the chances of encountering a team leader on the route were slim. He said there was only one team leader in Christchurch, a part-time team leader who assisted with re-certifications and safety observations, and the Line Haul Operations Manager. He said that the duties of both the team leader and the operations manager kept them mostly in the office and they were seldom seen out on the track. The team leader's driving jobs had also been removed from the roster. He said that with 56 locomotive engineers in the Christchurch depot, it was unlikely you would see them more than once every couple of years.

1.11.18 He said that although he could not confirm it, he was sure that Toll Rail management was aware of the rule breaches, but the company had not openly condoned them. The locomotive engineer said he felt that a review of rules pertaining to operations on the SLAS system on the Midland Line was required to enable locomotive engineers to air their concerns.

Locomotive engineer #2

1.11.19 Locomotive engineer #2 (the locomotive engineer) said that he thought the non-compliant work practices had been common prior to the collision at Cora Lynn but he did not think it had been as common since. He did not know of any locomotive engineers who had been caught following such practices by either supervisory trackside or in-cab observations.

1.11.20 He was adamant that Toll Rail management was aware of the use of non-compliant work practices on the route. He had been present in the amenities room with 4 or 5 other locomotive engineers when the non-compliance issues were discussed with the regional manager. This had not been an organised meeting; the manager had walked in while the locomotive engineers were informally discussing their concerns and he had become involved in the discussion.

1.11.21 The locomotive engineer said he had raised the issue of the 25 km/h speed restriction through Tunnel 1 and the effect it had on the approach to the Otarama Bank. He said he thought the manager had understood what they were talking about as he had taken an active part in the discussion and had responded by telling him not to worry about it.

1.11.22 He said he had once had a senior Toll Rail manager from Wellington travel with him in the locomotive cab of the *Tranz Alpine* passenger express. He said this manager had commented that he was aware locomotive engineers driving loaded coal trains were not slowing for the 25 km/h speed restriction through Tunnel 1. The locomotive engineer had been surprised that the manager had raised the subject and he had wondered how he knew they were having trouble at the Tunnel.

Locomotive engineer #3

1.11.23 Locomotive engineer #3 (the locomotive engineer) had also been present at the informal gathering with the regional manager in the amenities room. He said the manager had talked generally about how the coal programme was going, then asked the gathered locomotive engineers if they had any suggestions to make things work better.

1.11.24 At this point the locomotive engineer had raised the fact that they were going past arrival signals at stop to keep the trains moving. Other members of the group raised the issues of intermediate stop and stay signals at potential stalling spots, and the 25 km/h speed limit through Tunnel 1 as other areas of concern. He said that, in response, the manager asked the locomotive engineer if he "wanted the rule book thrown away". The locomotive engineer responded that local management and locomotive engineers needed to sit down and sort out the problems so that they could get the trains over the route "legally".

1.11.25 The locomotive engineer said he was aware that some locomotive engineers on eastbound trains, when advised that the east end points were in reverse, would arrive at a station and drift in past the arrival signal and down the main line, stopping to reset the points before continuing on. They would approach the facing points at such a speed as to be able to stop if those points were also set for the loop. He said that, although he was aware of the practice, he had not done so himself.

Survey of Toll Rail management

General Manager Operations

1.11.26 The General Manager Operations[17] (the general manager) had been in the role for 4 years. Prior to that he had an extensive rail operations background.

1.11.27 The general manager said that he had not been aware of the practice of trains exceeding the maximum authorised speed through Tunnel 1. He remembered travelling in the cab of the *Tranz Alpine* passenger express on one occasion but could not remember who the locomotive engineer had been. He said that the speed of trains through Tunnel 1 had not been raised with him by anyone at any time.

1.11.28 He said that, following the collision, he had initiated a full review of the health of the locomotive engineer by the company's medical consultant. The general manager said he could not understand why the locomotive engineer had knowingly gone past a red signal in the fashion that he had. Subsequent to the review, he learned that a practice existed where some locomotive engineers proceeded past red signals. He said that this was the first he knew of it. He thought that if locomotive engineers were operating in this manner, he would have expected there to have been a number of serious incidents or near misses given the operating systems and the number of trains, but none had occurred.

1.11.29 The general manager met with locomotive engineers in Christchurch and asked if passing arrival signals at stop was an accepted practice on the coal route or on other routes. He was told that it was not. While in Christchurch he also met with the Regional Manager Southern[18] and the Line Haul Operations Manager, both of whom were adamant that this was not the way people behaved and that there was no information available that suggested such behaviour was a problem on any other route.

1.11.30 The general manager was the Chairman of the Operations Council, a group consisting of management, employee representatives and Rail and Maritime Transport Union representatives. The Council met every 2 months and at the meeting following the collision he again raised the issue with the 3 locomotive engineers on the Council. The representative of the Christchurch locomotive engineers told the meeting that he was aware that some locomotive engineers did not come to a complete stop at signals where there was a risk of stalling. The general manager said the other locomotive engineers on the Council were unable or unwilling to provide confirmation that the practice was occurring on other routes.

1.11.31 As a result of this information, the general manager arranged for the line haul manager in Christchurch to undertake a review to determine if this was the case. No evidence of such occurrences was discovered. He said that, based on trust and the relationship he had with the locomotive engineers, and that ultimately he was responsible, he was satisfied that if it was happening the locomotive engineers would have shared any knowledge with him.

1.11.32 Once he became aware of the allegations, the general manager asked Toll Rail's National Manager, Health Safety Quality and Environment to investigate if the signalling system could be modified, not to reflect the practices, but to recognise that some signals may be in physical conflict with gradients and speed restrictions.

[17] The senior operations role within Toll Rail.
[18] The senior operations role in the South Island, reporting to the General Manager Operations.

Regional Manager Southern

1.11.33 The Regional Manager Southern (the regional manager) had been in the role for 2 years. He had no previous rail experience, having come to the position after 13 years in the shipping industry and 20 years in the military.

1.11.34 He said that his was the senior operations role in the South Island, and that he answered to the General Manager Operations in Wellington. He did not consider it necessary to have an in-depth or working knowledge of operating rules and procedures to operate in the role. At the time, he had 2 Line Haul Operations Managers who reported to him and were responsible for the locomotive engineers at the various depots around the South Island.

1.11.35 The regional manager said he remembered a gathering with some locomotive engineers in the amenities room. He could not remember who was there but he had gone to the room to update them informally on the coal train programme. He could not recall asking for any means to improve the operation but said he may well have done.

1.11.36 The regional manager had been subsequently told that the issue of work practices on the coal route had been raised at that meeting, but he said he could not recall that being part of the discussion. However, he said that because he was new to the rail environment he had difficulty understanding the signalling if it was discussed and often did not understand, unless a picture was drawn for him.

1.11.37 Once allegations of such work practices were made, the regional manager spoke to his management team and team leaders to determine what they had seen and how such practices could be done. He said they were "absolutely horrified" at the suggestion that they were knowingly turning a blind eye to the practices. His staff said that the present train crews had been operating on the route for years and the staff had never seen or heard of any so-called practices. The manager said that he then spoke about the allegations to some locomotive engineers who had extensive experience on the coal route. They were adamant that they had never seen any of these so-called practices.

1.11.38 The regional manager was adamant that there was no commercial pressure on locomotive engineers to break rules. He said that, no matter how many rules were broken, because of the particular type of business, it would never make a lot of difference. He said that despite their efforts, they were never going to make up lost time, and all the company wanted was for the operation to run as efficiently as possible.

Operational Risk and Compliance Manager

1.11.39 The compliance manager's role was independent from line management and included risk assessment, audit and internal investigation of rail operating incidents. The manager had an in-depth knowledge of rail operating rules and procedures and extensive operational senior management experience. He had undertaken Toll Rail's internal investigation into the collision.

1.11.40 The compliance manager said he first became aware of the allegations of non-compliant working practices regarding arrival signals during his investigation into the collision. He said that because he could not reconcile the timing of the locomotive engineer's stated emergency braking action with an intention to stop at the arrival signal at Cora Lynn, he had raised the issue of trains not stopping at arrival signals with a locomotive engineer who confirmed that this did happen from time to time.

1.11.41 On his return to his office, he researched incident data to see if any such occurrences had been reported. He found evidence of the reporting of one such incident, which had been dealt with by the team leader in Christchurch in accordance with non-compliance procedures. He was not aware of any other incidents apart from the one he had identified. However, the actions of the locomotive engineer of Train 834, together with the manner of the response from the locomotive engineer with whom he had spoken, led him to conclude that it was likely that non-compliance work practices did exist, although it was difficult to determine to what extent.

1.11.42 He said that when he did the risk assessment for the 30-wagon trains, it had been mentioned to him that the eastbound gradients approaching the arrival signals at Jackson and Aickens were such that they could encourage such practices. For that reason, the test train being used for the risk assessment was stopped at those locations to ensure that the train could lift off again to ensure the locomotive engineers could comply with the signal indications.

1.11.43 He said that, at Tunnel 1, the test train had been slowed to 10 km/h through the Tunnel and had then continued up the gradient. Despite the consequences if the train had not been able to lift off, it was stopped at the intermediate signal near the top of the gradient. From his earlier discussions, it had become apparent that lifting off from here was a greater concern than the Tunnel, so it was important to confirm that this could be achieved, which despite the inclement weather, it was.

1.11.44 Concerns had been expressed to the manager about locomotive engineers' frustrations regarding the speed restriction through Tunnel 1. He undertook to make enquiries with infrastructure staff to see if the speed restriction could be lifted, and when he did so was advised this was not possible because of clearance issues.

Line Haul Operations Manager

1.11.45 The Line Haul Operations Manager (the line haul manager) was a qualified locomotive engineer who held current certification in rules, regulations and operating procedures, including signalling categories, for the area in which he operated. His responsibilities included ensuring that locomotive engineers complied with the necessary rules and regulations and undertaking both formal and casual safety observations[19] and random locomotive event recorder extractions as part of Toll Rail's safety requirements.

1.11.46 The line haul manager said that in the role he was "the keeper of the rules" and was responsible for making sure that everything ran safely. He said it would disappoint him if it were proved that locomotive engineers were following correct procedures during observations by supervisory staff on one day but were reverting to non-compliant practices the next day. That would infer a double standard.

1.11.47 The line haul manager said he was not directly involved in the day-to-day operation of the coal programme but did review locomotive performance and breakdowns, and had daily meetings with the servicing and maintenance agencies.

1.11.48 When the 30-wagon programme was being developed, he was involved in looking at locomotive performance issues and the performance of the Brightstar software against the proposed performance. He said the 30-wagon programme was reliant on the Brightstar modification working well.

1.11.49 The line haul manager said that when Brightstar was introduced, there had been locomotive performance issues, particularly on the Tawhai Bank, but as the issues were identified the software had been enhanced and, together with input from General Motors' engineers, the performance of the locomotives had significantly improved.

1.11.50 Locomotive engineers were initially told that Brightstar would correct wheel slip without any action on their part. However, the line haul manager said that shortly before the collision they had been told that the independent brake was to be used in conjunction with Brightstar recovery actions to minimise some of the wheel slippage that was occurring.

[19] Safety observations were undertaken every 8 months in accordance with Toll Rail's safety system.

1.11.51 When the line haul manager was asked if he had been aware of the alleged practice of not stopping at signals, he said he had not, and found the allegations difficult to believe. He said that in his experience only one locomotive engineer had been observed passing an arrival signal displaying a stop indication and he had been dealt with at the time in accordance with the company's non-compliance procedures.

1.11.52 The line haul manager said that, at the time of the collision, he had 5 locomotive team leaders who answered to him and who were responsible for locomotive engineer safety observations, coaching and counselling as required. Three of these were based in Christchurch and 2 on the West Coast. The Christchurch team leaders each had about 20 locomotive engineers in their teams. He estimated that team leader duties accounted for 70% of their time, with driving duties taking the remaining 30%. He considered the ratio of team leaders to locomotive engineers in Christchurch to be acceptable in terms of meeting the company's safety observation obligations.

1.11.53 He said that both he and the team leaders were out driving trains, often unbeknown to other locomotive engineers. However, none of the team leaders had seen or reported to him any evidence of the existence of non-compliant practices, either while driving themselves or while accompanying other locomotive engineers in an observer's role, with the exception of the single earlier instance mentioned above.

1.11.54 He said that since the allegations had been made, no other locomotive engineers had come forward and confirmed the existence, or provided evidence, of the practices. He said that as well as the team leaders being out in the field, he would have expected the locomotive engineers' health and safety representatives to have reported any non-compliant work practices observed by them. Also, he would have expected any minder driver observing non-compliant work practices amongst locomotive engineers to bring it to the attention of the trainee as unsafe practices then report the incident. He was adamant that had the existence of such practices been brought to his attention before the collision at Cora Lynn, the collision would probably not have happened as he and his staff would have responded quickly and effectively in relation to the correct application of rules and procedures.

1.11.55 The line haul manager said that an earlier allegation had been made to him by one locomotive engineer that some locomotive engineers driving the *Tranz Alpine* passenger express[20] were not stopping at arrival signals when moving forward to cross opposing trains. He had taken this allegation up with the National Training Manager for Tranz Scenic 2001 Limited (Tranz Scenic), which was the operator of the service. The National Training Manager later responded that he had raised the issue with his locomotive engineers, who had maintained that this was not the case and had expressed concerns that such an issue had been raised.

1.11.56 The line haul manager said he had been unaware of the practice of trains travelling at excessive speed through Tunnel 1 until it was raised by the Commission's investigator. He expressed surprise at such a practice because of the tests that had been done, which included stopping a fully loaded 30-wagon coal train on the Otarama Bank and lifting it again. This had been successfully carried out in inclement weather, which he considered to be part of the proving process for the 30-wagon train operation.

1.11.57 As well as in-cab observations, the line haul manager used line-side observations and had access to Tranzlog locomotive event recorder[21] data downloads. These were used frequently to assess locomotive engineer performance. From the data it was possible to identify, in conjunction with the train control diagram, if stops had been made if necessary at arrival signals and points when crossing an opposing train.

[20] At this time the *Tranz Alpine* passenger express was owned and operated by Tranz Scenic 2001 Limited, and crewed by the company's own locomotive engineers.
[21] The latest version of the locomotive event recorder, which provided information on many aspects of train operation.

Locomotive engineer team leader #1

1.11.58 Locomotive engineer team leader #1 (team leader #1) was a qualified locomotive engineer and held current certification in rules, regulations and operating procedures, including signalling categories, for the area in which he operated. He said his responsibilities included the safety processes with locomotive engineers, including in-cab safety observations, and any general day-to-day issues that could come up. He was also rostered to drive trains to maintain his certifications.

1.11.59 He started as a team leader in 2001, and in 2002 transferred to Tranz Scenic as the national training manager. He returned to the team leader role with the freight operation in 2004 and had remained there since. He said that, as a result, he had been heavily involved in staff training and safety observations for many years.

1.11.60 Team leader #1 said that following the collision he had become aware of allegations that locomotive engineers were not stopping at arrival signals when they knew that the opposing train was in the loop. However, until he spoke with the Commission's investigator, he had been unaware of the practices of not stopping at intermediate signals at certain localities because of potential stallings or of travelling through Tunnel 1 at excessive speed for the same reason.

1.11.61 He said that he had never known of any locomotive engineer who had passed an arrival signal without stopping for the required 10 seconds. He had never been on a train that had travelled at excessive speed through Tunnel 1, and if it had happened, he would have brought it to the attention of the locomotive engineer.

1.11.62 Team leader #1 said that driver training for the Brightstar enhancements included a video for viewing and a personal handout that was distributed at the same time. An opportunity was given for locomotive engineers to ask questions on anything they did not understand.

1.11.63 He had been involved in the 30-wagon train trials and had travelled on 35 trains since the size had been increased to 30 wagons. All issues that arose during that time had been discussed with the locomotive engineers and appropriate staff and everyone had been happy with the ultimate outcome. Many of the issues had resulted in changes to the Brightstar software. He said he thought that, from his experience, stallings had decreased since the introduction of the DXB locomotives and the enhancements to the software. He also thought that the locomotive engineers were getting used to the changed driving techniques as a result of Brightstar intervention with wheel slips and this had also contributed to the reduced number of stallings.

1.11.64 During the team leader's time as national training manager with Tranz Scenic, an allegation had been made by a freight train locomotive engineer that Tranz Scenic locomotive engineers were routinely going past arrival signals at stop without waiting the mandatory 10 seconds. The allegation was not supported by any evidence, so the team leader had felt that, because evidence could not, or would not, be provided he was unable to progress the matter any further just on hearsay. However, he did discuss it with about 10 of the Tranz Scenic locomotive engineers who maintained that was not the case and that they were unaware of any situation to which the allegations might refer. He said that the Tranz Scenic locomotive engineers had become very bitter over the allegations.

Locomotive engineer team leader #2

1.11.65 Locomotive engineer team leader #2 (team leader #2) was a qualified locomotive engineer and held current certification in rules, regulations and operating procedures, including signalling categories, for the area in which he operated. He said his responsibilities included conducting safety observations, audit processes and locomotive engineer certifications, and the training of new locomotive staff. He was also rostered to drive trains to maintain his certifications.

1.11.66 During his time as team leader he had only been aware of one occasion prior to the collision where a train had passed an arrival signal at stop. This incident had been dealt with in accordance with the company's non-compliance procedures.

1.11.67 Team leader #2 said that it was possible for trains to climb away from Tunnel 1 without exceeding the speed through the Tunnel by using good driving techniques, including sanding and the use of the appropriate power notches. He also felt that the introduction of the DXB locomotives and the ongoing enhancements to the Brightstar software had further improved the situation.

1.11.68 He said that initially several of the problems were caused by the locomotive engineers not allowing the Brightstar software to work as it was designed to in wheel slip situations. Following stallings, the data from Tranzlog was downloaded for analysis. This showed a clear pattern where drivers were overriding the software, thereby preventing it operating correctly.

1.11.69 Team leader #2 said that the Tranzlog locomotive event recorder allowed the locomotive engineer's performance to be reviewed. From the data and the train control diagram it was possible to see if the correct number of stops had been made for any crossings en route. The speed of the train was also recorded for any given location, so the speed of the train through Tunnel 1 was available. He said that random downloading of Tranzlog data had not identified any instances of non-compliance with rules relating to arrival signals nor any evidence of excessive speed through Tunnel 1.

1.11.70 Locomotive event recorder extractions were completed on a regional basis. Each regional manager was responsible for ensuring that supervisory staff completed a minimum of 6 extractions per quarter and that corrective action was taken to ensure that any deficiencies were corrected.

1.11.71 Safety observations were required to be carried out on locomotive engineers every 8 months.

1.12 Human factors in transport safety

Extracts from "Human Factors in Transport, 2005", a paper by Dr Rob Lee

Transport safety

1.12.1 For almost every transport accident or incident, the subsequent investigation has shown that the main contributing factors were present before it happened and, in some cases, they were common knowledge. In all cases they could have, and should have, been identified and rectified before the accident or incident.

Human factors

1.12.2 The term "human factors" refers to the study of humans as components of complex systems made up of people and technology. Human factors are concerned with understanding the performance capabilities and limitations of the individual human operator, as well as the collective role of all of the people in the system which contribute to its output, including factors such as "organisational culture".

1.12.3 Human factors are about people, and not specific modes of transport. It covers many areas, including:

- perception
- memory
- learning and motivation
- fatigue
- error.

1.12.4 Human factors' analysis in transport safety investigations is not an attempt to minimise individual responsibility. Its objective is to understand human performance in the context of the systems in which the people concerned are components, and to consider all the factors which may have influenced their behaviour.

1.12.5 In a transport accident or incident investigation we need to investigate whether any errors or violations we identify may have involved contributory factors such as:

- poor training
- poorly written procedures
- inadequate documentation
- poor supervision
- the organisation's failure to take action on previous violations
- management or political pressures to take short cuts.

Human error

1.12.6 We know that human error is inevitable, even in the most highly trained and practised people. We understand the nature of human errors and how humans process information, what are our fundamental capabilities and limitations.

1.12.7 Because human error is inevitable:

- we have to accept this fact, and design systems which are error tolerant
- we have to manage errors and violations
- abandon the "blame and train" culture
- create a just organisational culture:
  - where people are encouraged to report errors
  - on which intentional malicious violations are not tolerated
  - but the reasons for routine violations are investigated and rectified.

1.12.8 Human error can be moderated but never eliminated.

Violations – intentionally breaking the rules

1.12.9 As with human error, we know a great deal about violations. We can predict when people in a system are likely not to adhere to standard operating procedures.

1.12.10 The main predictors of violation:

- Expectation – expectation that rules will have to be bent to get the job done
- Powerfulness – the feeling that one has the ability and experience to do the job without slavishly following the procedures
- Opportunities – seeing opportunities that present themselves for short cuts or to do things "better"
- Planning – inadequate work planning and advance preparation, leading to working "on the fly" and solving problems as they arise[22].

[22] Patrick Hudson. Leiden University.

1.12.11 Rather than being acts of recklessness or malice, most violations can be seen as rational although proscribed acts, performed to achieve reasonable goals. For example, some violations are committed by well intentioned staff who are trying to get the job done in the face of challenges such as time shortages or a lack of current equipment[23].

Extracts from "Timeliness and task specification in designing for human factors in railway operations", a paper by Andrew Shepherd and Edward Marshall, 31 May 2005

1.12.12 Systems such as railways depend upon the synergy between human beings and engineering assets to ensure that the latter are used appropriately to meet customer requirements, maintain safety of staff and the general public, and meet the organisation's business goals. Thus, human beings must be employed, equipped and managed appropriately for railways to be safe and effective.

1.12.13 It is common for managers to be dogmatic about what operating staff are required to do. Although compliance with the 'rule book' is often the adopted official stance, many people in management and supervisory positions regard some degree of operational flexibility as necessary if business goals are to be met. Such instances are, technically, violations, but may be assumed to be justified if expedited carefully with operating staff fully aware of the risks they are taking in order to ensure that optimal service is maintained. Even so, compliance with the rule book should apply, but the rule book should be written to reflect the realities of operating a complex system according to business as well as safety requirements, because business goals often compromise safety goals.

General

1.12.14 The highest level of management and governance, be it for an airline, a shipping company, a power plant or a railway, is responsible for the design and management of the equipment used in the venture, the policy and financial planning for the business and to provide the defences against potential hazards.

1.12.15 Humans can suffer from hazardous attitudes from which hazardous thoughts develop and affect the standard of their decision-making. These attitudes depend upon an individual's characteristics and the type of environment in which they are operating. Factors that influence decision-making are commercial pressure, peer pressure and the corporate environment in which the decisions are made.

1.12.16 Ideally safety and efficiency should be built on a proactive approach where possible problems are identified and rectified before they can cause any major disturbance in operation[24].

1.12.17 In every enterprise, there is an element of commercial pressure; this is particularly so in transport industries. The export coal traffic on the Midland Line was challenging because of its remote location, the adverse alpine weather patterns experienced, the high tonnages of coal involved and its time sensitivity to meet shipping schedules.

1.12.18 People do not operate in isolation in any system; they interact with each other, equipment and technology, all of which are governed by rules and procedures within an organisational context. In any investigation, each needs to be analysed to determine its level of influence. Although on its own a weakness in any one component may have no effect upon operational safety, when taken altogether they can lead to an unexpected event.

1.12.19 So as well as the individual's cognitive abilities, the environment (thermal, noise, vibration, lighting) in which the operation is carried out also needs to be taken into account. If it is too

[23] Human Factors for Transport Safety, Australian Transport Safety Bureau, May 2006.
[24] "Organisational Factors: Their Definition and Influence on Nuclear Safety". Prof B Wahlstrom 1998.

hot/cold/noisy/dark/bright, the ability of the individual to perform and process information or even physically move may be affected.

1.12.20 Having determined the cognitive and physical capabilities, individual performance can be enhanced, or inhibited, by the structure of the task(s), which in turn is supported by equipment, procedures and the organisational culture.

1.12.21 In summary, the areas that need to be addressed in addition to those previously listed include:

- physical requirements, such as work envelope i.e. reach
- layout of equipment
- noise, vibration, thermal comfort
- visual conspicuity
- tasks and how they are carried out cognitively and physically
- relationships between people and people; people and equipment; people and procedures or rules.

1.12.22 Other factors that may contribute to an individual making an error or deciding to violate existing rules or procedures include:

- poorly designed equipment
- inappropriately positioned equipment
- poorly designed controls
- ill defined roles and responsibilities
- conflicting information
- inadequate presentation of information
- group consensus – repeating actions that other members of a particular group have done without thought of possible adverse outcomes.

1.12.23 Rule violations may arise when individuals undertaking the task believe the rules are inappropriate to the task or conditions in which the task is being carried out. The level of risk they perceive in breaking the rule may be less than the desired outcome.

Analysis 5

1. Failing to stop at a signal displaying a red indication was a violation of signalling rules and regulations and was viewed seriously within the railway industry. Despite their best intentions, locomotive engineers who followed this practice, albeit under alleged "managed" conditions, committed a serious breach of operating procedures.

2. Compliance with the rules and operating procedures was paramount for the safety of the operation and should not have been compromised. Some locomotive engineers were satisfied that company management was aware of the rule breaches and, as no prohibition had subsequently been issued, they took that as tacit approval of the violations. However, they conceded that a "bush telegraph" was in place to warn other locomotive engineers if they were accompanied by a team leader or other supervisory staff. If the locomotive engineers were satisfied that Toll Rail's management knew and approved of the violations, a "bush telegraph" warning system would not have been necessary.

3. It had not been possible to confirm that management did in fact know about the use of the non-compliant work practices. There is no doubt that an informal gathering involving some locomotive engineers and the regional manager took place in the amenities room, but whether or not the subject of work practices was discussed was in

question. The locomotive engineers were adamant that the subject of operating practices had been raised and the manager did not deny it, although he could not recall it. It was therefore likely that it was discussed but, given the manager's admitted lack of operational knowledge, he had not fully understood the implications.

4. The line haul manager was responsible for the overall safety of locomotive engineers in the operational environment, and for their compliance with operating rules and procedures. The safety observations and locomotive event recorder extractions available to him and the team leaders would have assisted in detecting violations of operations procedures, but on average 1 in 6 weeks, while a deterrent, would not in itself have been sufficient to determine whether widespread violations were occurring. It would be highly irregular if those with the responsibility for safety did not follow up on any incidents of which they became aware, from either their observations or reports from other locomotive engineers. Indeed their monitoring procedures had previously identified a case of a locomotive engineer deliberately running past a red signal. This had been dealt with through the company's non-compliance process. Investigations undertaken by the line haul manager following the collision had not found any evidence to support the use of non-compliant work practices.

5. In paragraphs 1.12.5 and 1.12.22 factors are mentioned that could contribute to a violation. These are poor training, poorly written procedures, inadequate documentation, poor supervision, the organisation's failure to take action on previous violations and management pressures to take short cuts. Other potential contributors include poorly designed equipment, inappropriately positioned equipment, poorly designed controls, ill defined roles and responsibilities, conflicting information and inadequately presented information. The investigation found that with respect to this accident:

- locomotive engineer training was appropriate
- although there were some issues raised as to the effectiveness of existing operating procedures within the current train programme, the procedures were clearly written and understood by the locomotive engineers
- operational documentation relating to the safe running of the trains involved in the collision was in accordance with procedures
- the organisation had identified a previous violation and taken action in accordance with disciplinary procedures
- there was no evidence that management was applying pressure to the locomotive engineers to take short cuts
- the equipment (points) was not designed to revert automatically to normal following a train crossing, even though the points in TWC territory did, on routes that were not as busy as the Midland Line.

6. Paragraph 1.12.10 gives 4 predictors of violation: expectation, powerfulness, opportunities and planning. Another possible predictor is group consensus, where individuals repeat the actions of others because they have safely carried them out. The investigation found 3 of these predictors were present among at least some of the locomotive engineers:

- there was an expectation that the rules had to be broken to get the job done
- there was a feeling that they had the ability and experience to do the job without following the procedures
- they saw opportunities for short cuts or to do things "better".

7. The evidence suggests that generally violations of the operating rules and procedures were acts performed to achieve reasonable goals by well intentioned staff trying to get the jobs done in the face of challenges, rather than acts of recklessness or malice.

However, in the interests of safety, compliance with the rules and procedures should have taken precedence. If the locomotive engineers had issues with the operating procedures, which some undoubtedly did, these should have been addressed through the appropriate channel, in this case the Operations Council, rather than violating operating procedures that they considered to be inappropriate.

8. The positioning of arrival signals on steep grades and the performance of the locomotives were not relevant in the circumstances leading up to the collision at Cora Lynn. The arrival signal at the western end of Cora Lynn had not previously been identified as a potential stalling location. The small size of Train 834, about 20% less than the maximum authorised load for 2 DXH class locomotives, meant that locomotive performance was not a concern, especially with the level approach to the signal. The train was already running 5 hours late, and the locomotive engineer was going to complete the trip within his rostered time on duty.

9. The locomotive engineer of Train 834 was one of a number who admitted to passing signals at stop for a number of reasons. Of those who admitted to the breaches, most said they did so under "controlled" or "managed" circumstances. That is, approaching the arrival signal at a speed at which they could stop their train if the facing points were reversed.

10. On this occasion the locomotive engineer of Train 834 approached the arrival signal at a speed where he could not, and did not, stop his train before entering the loop and colliding with Train 841. The investigation did not establish why he chose to pass that signal at speed on this occasion. He is unlikely to have done so routinely, as it is likely his colleagues on opposing trains would have reported so for their own safety.

11. From his evidence it is conceivable that the locomotive engineer of Train 834 had routinely passed arrival signals at stop previously, but at more controlled speeds. Given that more often than not the points would have been set for the main line when heading eastbound, he had probably developed an assumption that subconsciously grew into an expectation that this would be the case.

2. Findings

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

2.1. The collision occurred because Train 834 overran Arrival Signal 10244 at the western end of Cora Lynn showing a stop indication and entered the loop where Train 841 was berthed.

2.2. Once the locomotive engineer of Train 834 saw that the "L" light on Arrival Signal 10244 was illuminated and realised the points at the western end were set for the loop, the speed of his train was too fast for him to bring his train to a stop before overrunning the signal.

2.3. The locomotive engineer of Train 834 had not intended to stop at Arrival Signal 10244 but rather to stop short of the eastern end fouling point board, some 500 m beyond the signal. His intention to stop short of the eastern end fouling point board, rather than at Arrival Signal 10244, was based on his belief that the signal was displaying a stop indication because the points at the eastern end were set for the loop.

2.4. The braking system on Train 834 was fully serviceable and the approach to Cora Lynn fully controlled. The locomotive engineer of Train 834 could have stopped his train short of Arrival Signal 10244 if he had intended to.

2.5. The evidence points to the locomotive engineer of Train 834 habitually passing arrival signals at stop to lessen the likelihood of stalling on grades and to pick up time on a continually late-running operation.

2.6. Other locomotive engineers operating on the Midland Line passed arrival and intermediate signals at stop also. The Commission could not conclude how widespread the practice was, but the evidence points to it being limited to a few locomotive engineers under certain conditions at certain locations.

2.7. The Commission was unable to conclude to what level Toll Rail management was aware of locomotive engineers violating safety-critical procedures. The evidence suggests there was some awareness, but more importantly, there was a belief among locomotive engineers that management was fully aware.

2.8. The knowledge among some locomotive engineers that other locomotive engineers routinely violated safety-critical procedures in the belief they needed to do so to get the job done, and the belief that this practice was condoned by management, would naturally have resulted in the practice growing in frequency and location and potentially enticing other locomotive engineers to do the same.

2.9. Having passed arrival signals at stop on a number of occasions, without incident or recourse, is the most likely reason for the locomotive engineer of Train 834 being prepared to take the risk that the facing points at Cora Lynn were set for the main line.

2.10. The installation of motorised points at crossing stations on the Midland Line would have been a useful defence against collision in the event of intentional or inadvertent passing of arrival signals at stop.

2.11. The increase in the train weight and the increased frequency of trains on the Midland Line warrant a review of operating procedures and the location of signals to ensure minimum buffer zones and train operating speeds are consistent with a safe and efficient train operation.

2.12. The benefits of the Brightstar software on the DXB locomotives were not achieved initially because of the traditional work practices of some locomotive engineers and their mistrust of the new technology, which resulted in some reverting in some instances to violating safety-critical procedures to compensate for what they thought were performance issues with their trains.

2.13. The scheduling of coal trains on the Midland Line where trains frequently ran late with consequent disruptions to crew rosters created the potential to frustrate train crews and encourage them to find short cuts to get the job done.

3. Safety Actions

3.1 On 21 February 2006, Toll Rail advised that the following safety actions had been taken following the collision:

- A Safety Briefing was issued to operating staff on 6 December 2005 summarising incidents where procedural non-compliance had been a significant contributory factor.
- Linehaul Operations Manager has increased compliance monitoring including unannounced casual observations and random locomotive event recorder extractions.
- A review of the existing signalling system, and associated instructions has been initiated to:
    - consider the present variable approach to notification of the position of mainline points, and
    - explore any potential opportunities to provide locomotive engineers with additional visual information about the position of mainline points.

4. Safety Recommendations

4.1 On 9 January 2006 it was recommended to the Chief Executive of ONTRACK that he:

> review existing signalling and interlocking arrangements and operating procedures at Single Line Automatic Signalling crossing stations on the Midland Line with a view to introducing enhanced operating practices or engineering modifications to reduce the risk of a collision resulting from the overrunning of a signal at stop. (109/05)

4.2 On 7 February 2006 the Chief Executive of ONTRACK responded in part:

> ONTRACK accepts this recommendation. This review should be completed in the third quarter of 2006.

4.3 On 31 July 2007 the Chief Executive of ONTRACK advised in part:

> You are advised that ONTRACK has undertaken a review of signalling and interlocking arrangements and operating procedures on the Midland Line and has identified a number of potential alternatives.

4.4 On 5 March 2007 it was recommended to the Chief Executive of ONTRACK that he:

> carry out a review to validate the permanent 25 km/h speed restriction currently in effect for eastbound trains when travelling through Tunnel 1 on the Midland Line. (006/07)

4.5 On 15 March 2006 the Chief Executive of ONTRACK responded in part:

> ONTRACK accepts this recommendation.
>
> We are currently scoping up details for a series of tests, static and dynamic, utilising Toll locomotives at the tunnel.
>
> Results from these tests should be completed by the end of March, and we will advise you of the outcome.

4.6 On 11 June 2007 the Chief Executive of ONTRACK advised:

> A review has been completed and as a result a recommendation has been made to increase the speed to 40 km/h for certain classes of locomotives and wagons.

4.7 On 19 June 2007 it was recommended to the Director of Land Transport New Zealand that he:

> review Toll Rail's compliance monitoring of locomotive engineers to confirm that the increased monitoring as defined in the safety action of 21 February 2006 has been implemented and is effective. (012/07)

4.8 On 24 July 2007 the Director of Land Transport New Zealand responded:

> Land Transport New Zealand accepts this recommendation and will ensure that this is confirmed during the next annual safety assessment that is conducted on Toll Rail. The next assessment is scheduled for March 2008.

Approved on 24 July 2007 for publication

Hon W P Jeffries
Chief Commissioner

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