



Office of the Chief Investigator  
Transport Safety

**Rail Safety Investigation  
Report No 2010/06**

**Train-to-Train Collision**  
**Metro Trains Melbourne Train 5863**  
**Pacific National Train 9319**  
**Between Roxburgh Park and Craigieburn**  
**4 May 2010**





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## **THE CHIEF INVESTIGATOR**

The Chief Investigator, Transport Safety is a statutory position under Part 7 of the *Transport Integration Act 2010*. The objective of the position is to seek to improve transport safety by providing for an independent no-blame investigation of transport safety matters consistent with the vision statement and the transport system objective.

The primary focus of an investigation is to determine what factors caused the incident, rather than apportion blame for the incident, and to identify issues that may require review, monitoring or further consideration. In conducting investigations, the Chief Investigator will apply the principles of 'just culture' and use a methodology based on systemic investigation models.

The Chief Investigator is required to report the results of investigations to the Minister for Public Transport and/or the Minister for Roads and Ports. However, before submitting the results of an investigation to the Minister, the Chief Investigator must consult in accordance with section 85A of the *Transport (Compliance and Miscellaneous) Act 1983*.

The Chief Investigator is not subject to the direction or control of the Minister(s) in performing or exercising his or her functions or powers, but the Minister may direct the Chief Investigator to investigate a transport safety matter.



## **EXECUTIVE SUMMARY**

At about 20:35 on 4 May 2010, a Flinders Street to Craigieburn Metro Trains Melbourne suburban train, travelling on the Down broad gauge line, ran into the rear wagon of a stationary Pacific National freight train midway between Roxburgh Park and Craigieburn stations. At the time, the freight train was stopped at a signal waiting for the departure of an Up suburban train occupying the Down line platform at Craigieburn.

The driver and 14 passengers on the suburban train were treated by paramedics on site with the driver and four passengers subsequently being taken to hospital. The two crew members of the freight train were uninjured. Both trains were extensively damaged with the freight train being propelled about 30 metres forward from the point of impact.

The investigation determined that the driver of the suburban train had passed two automatic signals after departing Roxburgh Park that presented a stop aspect. When passing the signals the driver did not comply with the network Rules and operating procedures. The train was then operated at speeds up to 69 km/h, also in contravention of the Book of Rules and Operating Procedures 1994. The reason for the driver's actions could not be determined.

No faults were found with any rolling stock, track or signal infrastructure.

The investigation makes recommendations with respect to the network's ability to monitor the application of and compliance to Section 3 Rule 1 of the Book of Rules and Operating Procedures 1994, the number of automatic signals currently on the system, the acceptance and application of industry standards for train tail signals, train speed limiting devices after passing signals at stop and train crashworthiness.





## 1. CIRCUMSTANCES

On Tuesday 4 May 2010, the 19:49 Flinders Street to Craigieburn suburban passenger train number 5863, a six-car Comeng set, collided with the rear wagon of the empty Pacific National freight train number 9319. The collision occurred on the Metro Trains Melbourne (MTM) broad gauge track between Roxburgh Park and Craigieburn Stations near the 24 kilometre marker at Patullos Lane, about two kilometres south of Craigieburn Station.

The freight train consisted of one G class locomotive and 21 wagons and was travelling between Brooklyn and Kilmore East. It was stopped at signal CGB539 on the Melbourne side of Craigieburn Railway Station awaiting the departure of a Melbourne bound suburban service from number two platform, the Down platform at Craigieburn.

The freight train was protected from following trains by two Automatic (Permissive) signals, E785 and E809, both of which were displaying 'Stop' aspects. Suburban train 5863 was identified as having rolled past both of these signals without stopping; a Signal Passed at Danger (SPAD). On both occasions the train was brought to a stand by the safety intervention system before proceeding.

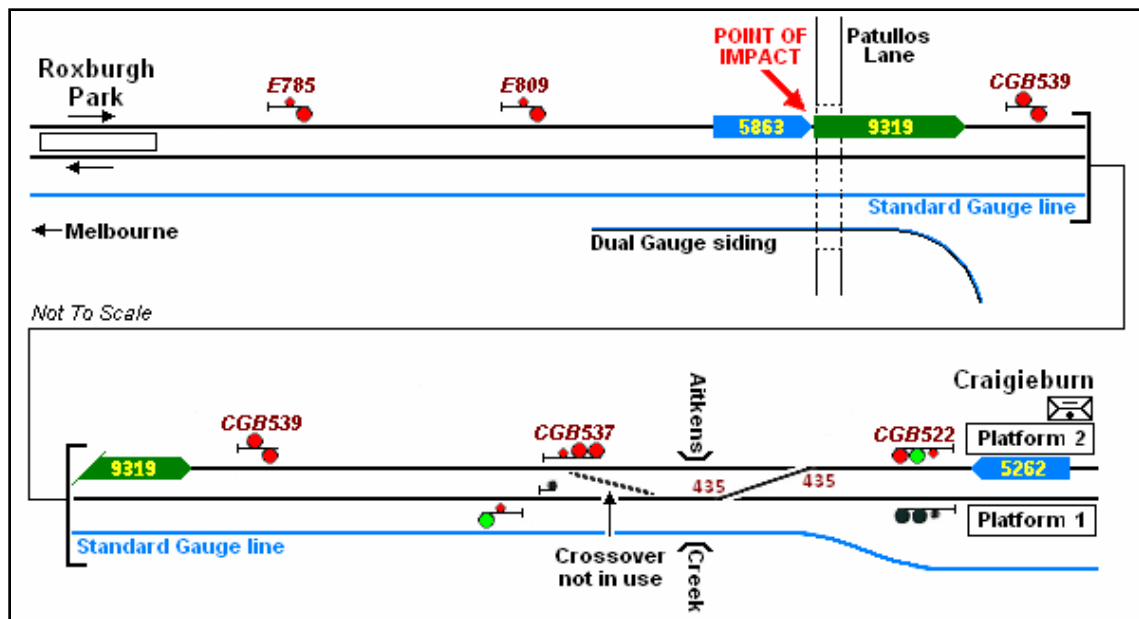


Figure 1 – Schematic Roxburgh Park – Craigieburn.

The collision was reported to Centrol<sup>1</sup> and then to the signaller at Craigieburn by the freight train driver. The signaller then reported the incident to Metrol<sup>2</sup> who advised the various emergency services. Members of the public also reported the incident to the emergency services.

<sup>1</sup> Centrol is the train control authority for the Victorian non-metropolitan broad gauge network.

<sup>2</sup> Metrol is the train control authority for the Melbourne metropolitan broad gauge network.



## **2. FACTUAL INFORMATION**

### **2.1 Train Operator details**

The suburban passenger train was operated by MTM. MTM was accredited by the Victorian rail safety regulator as a Rail Infrastructure Manager as well as an Operator of Rolling Stock on 30 November 2009.

The freight train was operated by Pacific National Pty Ltd (PN) which was accredited as an Operator of Rolling Stock as well as a Manager of Infrastructure on 1 July 2008.

### **2.2 Personnel**

#### **2.2.1 Suburban train driver**

The driver qualified as a suburban train driver in 1995 and had been assigned to either Broadmeadows or Craigieburn depots since 2002. Prior to qualifying as a driver he was employed as a suburban guard for about two years.

The driver completed a Category 1 medical on 23 March 2010 when he was passed fit for duty with no restrictions. His medical record did not record any pre-existing condition, a requirement to wear vision correcting spectacles or that he was taking any medications.

The driver successfully completed Suburban Train Driver continuation training on 3 April 2002. This addressed 'Detention at Automatic signal' which includes Section 3 Rule 1. An in-field safety audit (to monitor driver performance), conducted on 25 January 2010, recorded that he demonstrated a satisfactory application of the rule. His last in-field safety audit conducted on 28 April 2010 did not assess the requirements of Section 3 Rule1.

During the seven-day period prior to the incident the driver worked five consecutive shifts, then had a day off and then worked the day prior to the day of the incident. His rostered shift on 4 May 2010 commenced at 15:38 with a sign-off time of 21:33 for a total of 5 hours 55 minutes. This shift did not incorporate a meal break.

On 23 December 2009, the driver was involved in a Signal Passed At Danger (SPAD) incident at Laverton. The investigation conducted by the operator identified the cause of this SPAD as a misjudgement of braking distance on the approach to the signal. Signal LAV6 had been previously identified as a multiple SPAD signal requiring the installation of a co-acting signal. As a result of this incident, the driver was placed on the company's post incident performance monitoring program which was completed by the administering of a Train Driver Safety audit on 25 January 2010.

On the night of the incident alcohol breath testing was carried out by the police at the site and no level of alcohol was recorded. The driver was transported to hospital for observation. Testing for drugs was not conducted.

The driver was interviewed by investigators about three months after the incident, following his recovery from the injuries he had sustained. He advised that he had suffered a deep cut to the top of his head and bruising to the left side of his body. He commented that he had little recall of the events leading up to the incident, of the

events of the day or the preceding couple of days. He said he was suffering nightmares about the incident and was seeking counselling.

The driver believes that he was knocked unconscious as a result of the impact and recalls 'coming-to' on the floor of the driver's cabin then attempting to contact Craigieburn to advise them of the incident and to stop trains on the parallel tracks. He said that he remembered that another suburban train approached on the adjacent track and stopped.

The driver said that he walked around in an attempt to identify a street near the incident site that emergency services could be directed to. When asked, the driver said that he did not think that it was raining at the time of the incident but said that it was muddy at the site.

The driver advised that he had worked permanent afternoon shifts for several years up until six months' prior to the incident when he commenced working rotating shifts. He commented that he preferred to work the afternoon shift. He said that he had returned from a months leave a week before the incident. On leave he had been camping for the first two weeks and said that he was well rested before returning to work.

The driver commented that he was not taking any medication at the time of the incident and did not wear prescription lenses.

### **2.2.2 Freight train crew**

Both crew members of 9319 were appropriately qualified to operate the train on the scheduled journey. Their medical assessments were current and without restrictions or notations. Post-incident alcohol breath tests conducted on both crew did not detect the presence of alcohol.

The crew reported that after departing Brooklyn at 19:20 they were advised by Control that their train was to follow a Patrick Port Link Tocumwal service.

As train 9319 departed Sunshine the signaller conducted a roll-by inspection and advised the train crew that the train's ETM (End-of-Train Marker)<sup>3</sup> was in place and operating. The crew reported that the journey was uneventful until passing Roxburgh Park Station where a yellow aspect<sup>4</sup> was displayed on automatic signal E809 ahead. The driver reduced train speed and stopped at the automatic signal CGB539. The crew said that after waiting a couple of minutes, during which time several attempts were made to contact the signaller at Craigieburn, a following train was observed in the side mirrors approaching from Roxburgh Park. The crew said that as they were about to move their train past signal CGB539, they were struck from behind with a force that dislodged them from their seats and caused locomotive G524 to shut down.

Almost immediately after the impact the Craigieburn signaller contacted train 9319 by the local radio to advise that he would now allow their train to proceed. The crew said that they then informed the signaller that they had been struck by a following train. The crew contacted Control using the emergency call feature of the train-to-base radio to arrange protection for the adjacent running lines. They also contacted Junee control to stop rail traffic on the DIRN<sup>5</sup>.

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<sup>3</sup> Refer to section 2.11.4.

<sup>4</sup> A yellow aspect displayed by a signal indicates to a train driver that they should proceed with caution as the next signal may be displaying a Stop aspect.

<sup>5</sup> The Defined Interstate Rail Network is the standard gauge rail line that runs parallel to the MTM broad gauge rail line at this location.

The crew advised that they stopped a Melbourne bound suburban train by using the locomotive headlight and red maker lights. They then travelled with the driver of this train to the incident site where one crew member rendered assistance and the other went to the rear of the suburban train to provide protection from any following traffic.

The freight train driver reported that after securing the suburban train, he returned to his locomotive where an inspection identified a minor leak of bilge oil from a broken pipe. The spilt oil was contained by the fire authority.

### **2.2.3 Craigieburn signaller**

The signaller was qualified on the Craigieburn signal panel and held a current medical assessment.

He reported that due to a defect with Signal CGB522, the Up home departure signal from number 2 platform, the 20:28 Melbourne bound train number 5262 was delayed while he issued a Caution Order<sup>6</sup> for train 5262 to proceed past signal CGB522. On returning to the office he called train 9319 and was advised by the driver that his train had been struck by a following train. He said that he advised Metrol and responded to a call from Centrol notifying him of the report received by them from 9319. He did not receive any communication from the suburban train involved in the collision.

### **2.2.4 Sunshine signaller**

The signaller reported that on the evening of 4 May 2010 he conducted a roll-by inspection of train 9319 as it passed his signal box and said that the ETM was operating satisfactorily. He communicated this to the train's driver. The signaller commented that there was nothing unusual or different about the ETM and added that if an ETM is not flashing or is ineffective he would inform the train crew.

### **2.2.5 Suburban train passengers**

The suburban train was carrying 14 passengers at the time of the collision. Paramedics assessed all passengers on site and transported four to hospital for further treatment. The injuries suffered by the passengers were reported by Ambulance Victoria to be suspected spinal injuries, a broken chest bone, various neck injuries and cuts and abrasions.

## **2.3 The suburban train**

### **2.3.1 Comeng Electric Multiple Unit - (EMU)**

Comeng type EMUs are single deck stainless steel car body trains built by Commonwealth Engineering (Comeng) Dandenong, Victoria between 1982 and 1989.

They were produced in two brake variants - tread and disc. There is a slight weight variation between tread and disc braked vehicles. Comeng trains are made up in a Motor (M) - Trailer (T) - Motor (M) three-car configuration and can be coupled to form six-car sets.

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<sup>6</sup> A paper instrument conveying authority from a signaller to a train driver to pass a Home signal displaying a Stop indication.

The Comeng fleet is fitted with a Vigilance Control Event Recorder System (VICERS) which consists of a Faiveley Transport VM-40 device that interfaces with existing on-train systems. The VICERS has two sub-systems:

- A vigilance control system, which verifies that the driver is not incapacitated by monitoring task linked activities and in the absence of any such activities provides intervention by applying the train's brakes. At the time of the incident the vigilance control system was not operational as the fleet requires further modification.
- An event recorder system, which provides monitoring of a number of on board systems including the operation of a number of driver control functions. This sub-system was functioning at the time of the incident.

The operating station is located to the left of the cabin with a wrap-around style instrument console. Brake and traction controls are separate with the brake controller on the left.

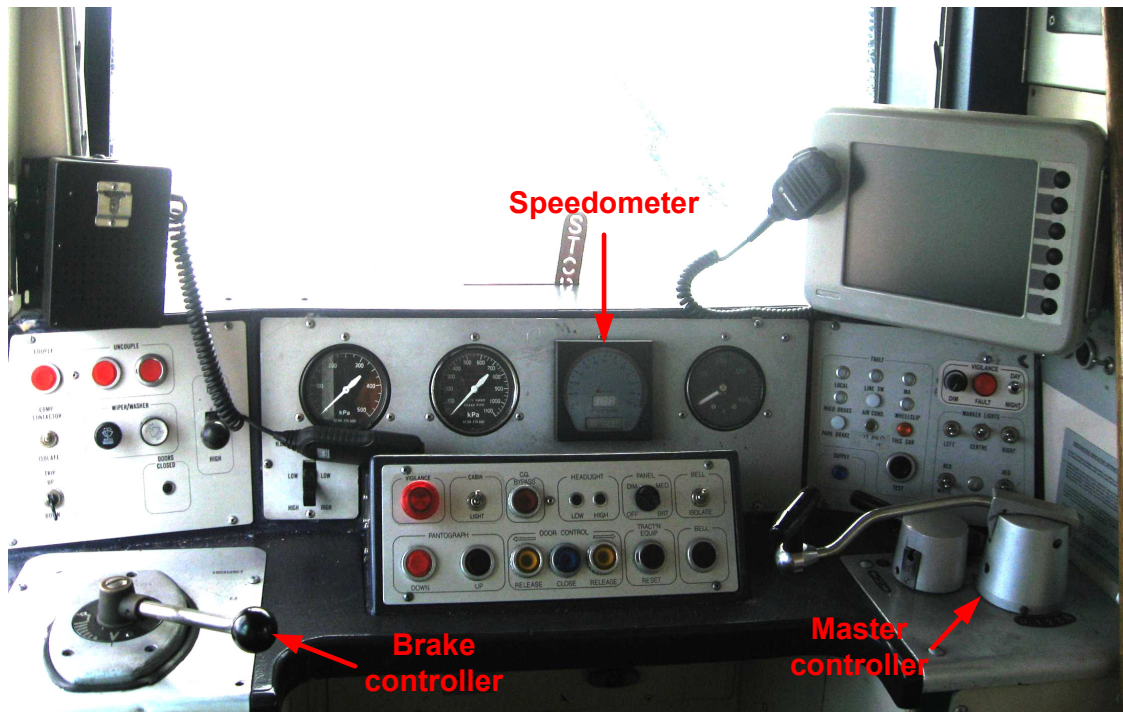


Figure 2 – Driver's control console of 570M.

The master controller is used by the driver to control traction power. It has four power positions; shunt, series, parallel and weak fields, and is located on the right hand side of the driver's console.

The brake controller is used to control the amount and type of braking. It has eight positions, seven of which are for service braking, the eighth position is used for emergency air brake applications. All suburban electric trains are fitted with an *automatic train stop*, known as a 'Trip'<sup>7</sup>. The purpose of the trip is to bring a train to a stop when, for any reason, the train passes a signal at the Stop position.

<sup>7</sup> The device fitted to suburban M (motor) cars that engages with a raised train stop arm to cause the air brake to be applied in emergency.

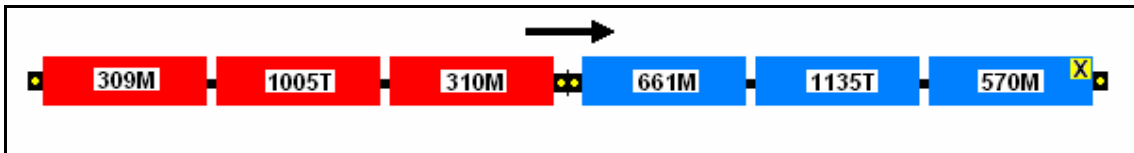


**Figure 3 – Trip arm on 570M**

When a signal is at Stop the arm of the automatic train stop is raised so that the trip valve lever on a train will strike it and cause the emergency air brake to be applied and the power circuit to be opened causing the train to come to a stand. Before a train can proceed after being ‘tripped’ the brake application has to be released by the driver. This process in a Comeng train takes about 30 seconds.

### **2.3.2 Train 5863**

Train 5863 consisted of two three-car sets. It was 142.4 metres in length, weighed about 260 tonnes and had a maximum allowable speed of 115 km/h. Cars 570M and 1135T in the leading set had been involved in a mainline collision at Holmesglen on 26 July 2000, they were extensively damaged and repaired before being returned to service.



**Figure 4 – Consist of train 5863**



### 2.3.3 VICERS operational data

The VICERS system records a comprehensive range of operational parameters including control equipment status, train speed and location over time. The investigation examined the record to gain a clear understanding of the operation of the train, particularly following its departure from Roxburgh Park. The following provides a summary of this review. All times quoted are based on the VICERS time clock which was confirmed as being synchronised throughout the train.

Train 5863 departed Flinders Street Station on time at 19:49 and its operation was without incident until Roxburgh Park. After departing Roxburgh Park (about a minute behind schedule), the master controller was stepped through to position 4 (maximum traction power). About 19 seconds after departure, the train reached a peak speed of 34 km/h and traction power was shut off. A few seconds later braking was commenced.

On the approach to signal E785, the brake controller was moved between positions 1 and 5 to provide various levels of braking, and the train reduced to a speed of about 9 km/h at which point the brake was fully released. It then coasted before rolling past signal E785 at a speed of about 3 km/h. The train was brought to a stand by the operation of the trip valve and automatic application of the emergency brake. After being stopped while the brake system recharged, the master controller was activated and traction power engaged. The train had been stopped for a total of about 38 seconds before recommencing its journey.

From its stopped position a short distance past signal E785, the train was accelerated under full power before the traction power was shut off. The train reached a peak speed of 63 km/h and was then allowed to coast for about five seconds before braking was commenced.

On the approach to signal E809, the brake controller was moved through various settings until the speed was reduced to about 11km/h. About four seconds later with the brake controller in position 1 or 2, the train rolled past signal E809 at a speed of about 4 km/h. The train came to a stand after the activation of the trip valve and the automatic application of the emergency brake. At 20:33:42 the train was stationary a short distance past signal E809. The brake was subsequently released.

About 32 seconds after stopping, and following the recharge of the brake system, traction power was energised and a few seconds later at 20:34:17 the train moved away under full traction power. At 20:34:58, traction power was shut off and the train had reached a peak speed of 69 km/h. At this point the train had progressed about 450 metres beyond signal E809. The train then coasted for about 13 seconds and travelled a further 250 metres at which point braking was initiated.

From 20:35:11, with the train travelling at 66 km/h and about 116 metres away from impact with the freight train, the brake controller was rapidly moved through all positions until reaching the emergency brake position 0.9 seconds later. At 20:35:18 and about six seconds after the emergency brake application, the train impacted the freight train at a speed of about 47 km/h. The train came to a stop at 20:35:23, approximately 16 metres after the point of impact.



Car ID: 0000570 - Short Term Data - Tue 4 May 2010, 8:30 pm (Local Time)

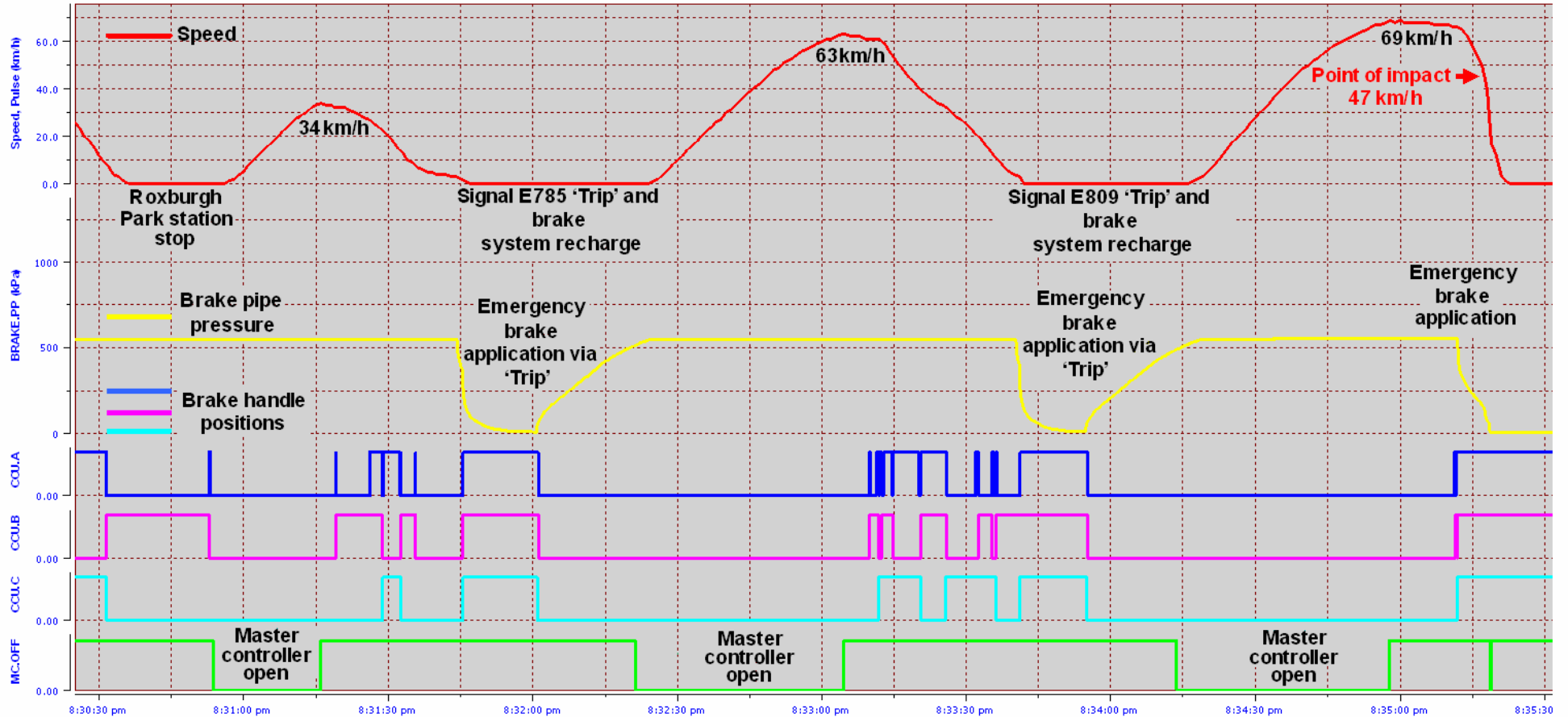


Figure 5 – Operation of train 5863 from Roxburgh Park to the point of impact.

### **2.3.4 Measured accelerations at impact**

The VICERS unit is mounted in the obsolete periscope cavity on the right of the rear wall of the driver's cabin. Within the unit are accelerometers measuring acceleration in the longitudinal and lateral directions. The point of impact with the freight train is identified by sharp changes in accelerometer readings in both directions. Measured accelerations peak at 6g in the longitudinal direction and 5g in the lateral direction. There is also a small although identifiable lag in longitudinal deceleration along the train.

### **2.3.5 Brake equipment functionality**

Detailed inspections and testing of the train's braking systems were carried out at Newport Workshops. The trailing three-car set was intact, permitting system testing as a complete car-set. The lead set had sustained significant damage limiting the testing to individual cars.

The two car-sets had different braking arrangements; the lead set being a disc brake unit and the trailing set having tread brakes. Inspection of both car-sets revealed braking equipment in a condition that would support the correct operation of the train's brakes. All wheels, callipers and pads in the case of the leading set and wheels, rigging, cylinder pistons and brake shoes in the case of the trailing set, were found to be in good order, correctly adjusted and not significantly worn.

The trailing car-set was subject to a series of instrumented tests including brake handle operation and the response of brake system control equipment, brake cylinders, brake rigging and brake shoes. In all instances of emergency and pneumatic full service brake application, brake cylinder pressures met or exceeded the minimum specified requirements for the system.

For the leading car-set, inspection of brake control wiring identified a loose connection, which was most probably as a result of the collision. Subsequent testing found all the control wiring to be working correctly.

The most recent braking system maintenance checks for the leading car-set were undertaken as part of the 'C' exam for this set (570M - 1135T - 661M) on 29 April 2010.

### **2.3.6 Braking performance prior to collision**

Examination of VICERS data indicates that the train stopped under braking at a number of locations prior to the collision. Braking utilising the electro-pneumatic system was evident at Broadmeadows Station, a signal 260 metres south of Somerton Road, Roxburgh Park Station, on the approach to signal E785 and on the approach to signal E809. At the stop prior to collision, brake cylinder pressures were consistent with expectations for the system.

The VICERS data for the train deceleration just prior to the collision was analysed by the investigation. After the brake handle was put in the emergency position, the speed changed at an average rate of approximately  $-0.84 \text{ m/s}^2$ . This is consistent with the average deceleration of  $0.83 \pm 0.05 \text{ m/s}^2$  quoted on the emergency braking curve for the Comeng train on flat track.

The average deceleration values incorporate lag in the system which is a feature of pneumatic braking systems as it takes time for pressure to build in the brake cylinders. The deceleration after brake cylinder pressure was achieved and after braking became fully effective, was also calculated and found to be approximately 1.1 m/s<sup>2</sup>. This exceeds the published Comeng deceleration performance figure of 1.0± 0.05 m/s<sup>2</sup>.

### **2.3.7 Estimated required stopping distances**

The investigation examined what stopping distance would have been required from the actual peak approach speed of 69 km/h and also the distance to stop if the train had been travelling at a speed of 25 km/h.

Based on the Comeng Emergency Braking Curve, the distance required to stop from the peak train speed of 69 km/h with an emergency brake application is approximately 220 metres. The distance required to stop from a train speed of 25 km/h is less than 40 metres in either Full Service or Emergency braking. In neither case does the distance include the time and distance for the driver to react to observing an obstruction.

### **2.3.8 Headlights**

Comeng M-cars are fitted with separate low and high beam headlights. The low beam is automatically illuminated when the reverser in the controlling cab is placed in the forward direction. High-beam is selected by the driver.

Both low beam and the driver's side high beam headlights of 570M were destroyed in the collision and the remaining high beam headlight was significantly dislodged from its normal location. Consequently, it was not possible to measure the alignment of the headlights of 570M at the time of the collision. A headlight alignment check is a task undertaken as part of the Comeng 'D' exam which is performed at intervals of 40,000 km; about five months of normal running. The last 'D' exam on 570M was on 22 February 2010 and the investigation was advised that there were no headlight faults reported from this examination.

The headlight system was subject to testing, inspection and review of maintenance records. The headlight circuitry within the driver's cab of 570M was tested for continuity and no evidence was found of any fault in the headlight switch on the driver's console, the headlight transformers or the interconnecting wiring to the headlight globes. The headlamps on 570M were examined and three of the four found to be broken. The filament of the intact right-hand high beam headlamp was found to be shaped consistent with the lamp being in operation at the time of impact. For the two car-sets involved in the collision, no headlight related faults were reported between 1 November 2009 and the date of collision.

Examination of the VICERS data for the journey from Broadmeadows Station to the collision confirmed that for the full duration, systems and circuits supporting the automated low beam headlight operation were energised. The VICERS system also records the On/Off status of low and high beam headlights. The records indicated that the high beam lights were on for a period between Broadmeadows and Roxburgh Park stations then, about 250 metres after departing Roxburgh Park, the high beam lights were again switched on and remained in an 'On' condition until the collision.

The last station stop prior to the collision was at Roxburgh Park. CCTV from the Down platform (Platform 2) shows the train arriving at about 2030, about five minutes before the collision and with the low beam headlights illuminated.

With respect to headlight performance, MTM advised that the focal range of the forward lights on high beam seem to provide a sphere of intense light at around 40 metres, with diffraction and diffusion allowing perception of colour on a degrading scale outside of 100 metres. There is general agreement between the operator's technical and operational staff that large dark objects may become just noticeable at around 140 to 150 metres. Smaller dark objects such as a person in dark clothing may not become noticeable until as close as 30 to 40 metres.

### **2.3.9 Speedometer**

The speedometer fitted to Comeng motor(M) cars is a combination analogue and digital unit manufactured by Innovonics. The speedometer uses a pulse signal generated by an axle encoder mounted on the driver's side leading axlebox with the encoder providing 40 pulses per revolution of the wheel. The train's speed is derived based on a stored value of wheel diameter. The VICERS unit uses the same pulse signal to generate a train speed measurement.

Following the collision, tests were performed by MTM on the speedometer fitted to 570M to verify its correct function. The tests concluded that the speedometer was functional and that the speed indications would have accurately reflected the pulse signal provided by the wheel encoder with the wheel diameter accurately set.

Accurate indication of train speed for both the speedometer and VICERS unit requires an accurate measure of wheel diameter to be stored in both systems. Both systems had a stored value for wheel diameter of 920 mm which can be compared to the actual diameter of the leading wheel, measured at 919.1 mm. This difference between stored and measured values of wheel diameter would lead to a minimal over-reading error of 0.1 per cent.

The VICERS system also generates an estimation of train speed utilising the change in GPS location over time. In stable speed conditions with low rate of speed change, the GPS generated speed was found to closely align with the pulse generated speed, providing an additional level of confidence that the speedometer was indicating an accurate measure of train speed. When the train is accelerating or decelerating, the GPS generated speed is known to lag the actual speed and for this reason, the pulse speed is considered the more accurate.

Records for the journey from Flinders Street Station indicate consistent peak speeds between stations generally in the range of 60 to 70 km/h, again suggesting consistency in the speed information conveyed to the driver.

## 2.4 Freight train

Train 9319 consisted of a G class locomotive weighing 128 tonnes and 21 empty VHQF hopper wagons. It had a total length of 298 metres and a trailing load of 420 tonnes. This train was a regularly scheduled service from Brooklyn to Kilmore East, Monday to Thursday, and was due to pass through Craigieburn at 20:40. An examination of the Tachograph<sup>8</sup> fitted to locomotive G524 verified that train 9319 was stationary at the time of impact.

In addition to the Sunshine signaller's observation of the train's ETM, it was also observed on CCTV footage that the ETM was operating when the train passed through Roxburgh Park Station, although it was noted that it appeared to be of a lesser brightness than the ETM on the previous freight train.

## 2.5 Site data

The damaged condition and location of both trains was consistent with the suburban train having impacted the rear of the freight train and shunted the freight train forward. The front of the suburban train had come to a stand about 20 metres past the 24 kilometre marker post with the rear wagon of the freight train about 15 metres ahead. The freight train's ETM had been destroyed and was located between the rails of the Down track about 5 metres ahead of the suburban train.

The leading bogie of 570M and trailing bogie of 1135T had derailed to the left. Wheel flange marks on the railhead indicated the leading bogie of 570M had climbed the rail about 11 metres before the suburban train had come to a stand.

Locomotive G524 was about 29 metres on the Roxburgh Park side of signal CGB539, which was displaying a Stop aspect.

Automatic signal E809 was observed displaying a stop aspect with the automatic train stop in the raised position.

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<sup>8</sup> A wax type chart which records speed and other functions on locomotives.

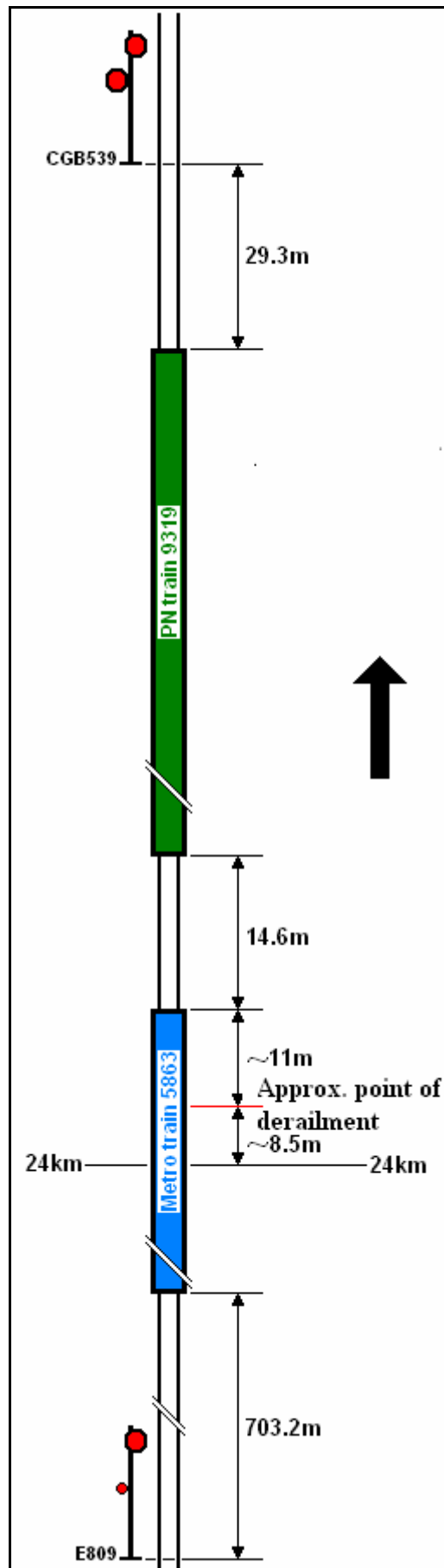


Figure 6 – Schematic of site (not to scale).

## 2.6 Environment

Bureau of Meteorology observations from the nearest observation point, Melbourne Airport, at 20:30 on 4 May 2010 recorded a northerly wind of six knots, with no precipitation. Rain was recorded at 0.4 mm between 18:30 and 19:00 with the radar image indicating there would have been similar rainfall at Craigieburn between 19:00 and 19:30. The temperature was 12 degrees with overcast skies.

To the east of the railway reserve there is an industrial complex which operates throughout the night and to the west there is a housing estate. There are substantial embankments providing sound and light barriers on both boundaries. As a result of this there was minimal lighting spillage onto the railway reserve.

## 2.7 Damage to trains

### 2.7.1 The impact

Damage to the suburban train had occurred predominantly to the leading car-set. The front face of 570M was damaged as a result of direct impact with the trailing wagon of the freight train, including extensive damage to the coupler, headstock and underframe indicating significant load transfer occurred through these structures.

The trailing wagon of the freight train also suffered significant direct impact damage including damage to the brake equipment canopy and brake equipment located beneath it.



Figure 7 – The suburban train in its final position following the collision.





Figure 8 – Trailing freight wagon damage.

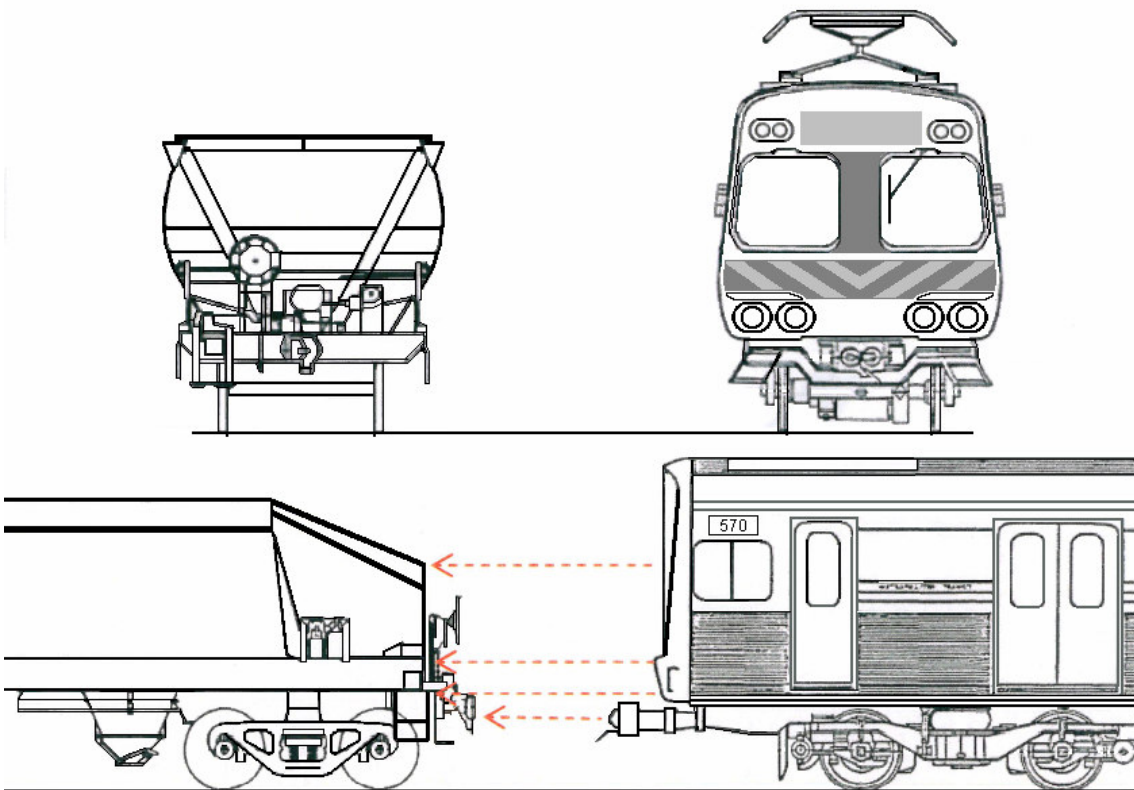


Figure 9 – Alignment of impact points.



The damage marks on the front of 570M and the rear of the freight wagon, suggested that there was not significant relative override during the impact. Loads would have been predominantly transferred through couplers and stiff in-line underframe structures. A small amount of lifting of the leading end of the suburban train is likely to have occurred during the collision and would account for the derailment of the leading bogie.

### 2.7.2 Other significant damage to the suburban train

The semi-permanent couplings between the cars of the leading set had collapsed and the car ends were together. The multi-function coupler between the two car-sets had also collapsed. Other than minor damage to the leading face of 310M, there was no observable damage to the trailing car-set structures.

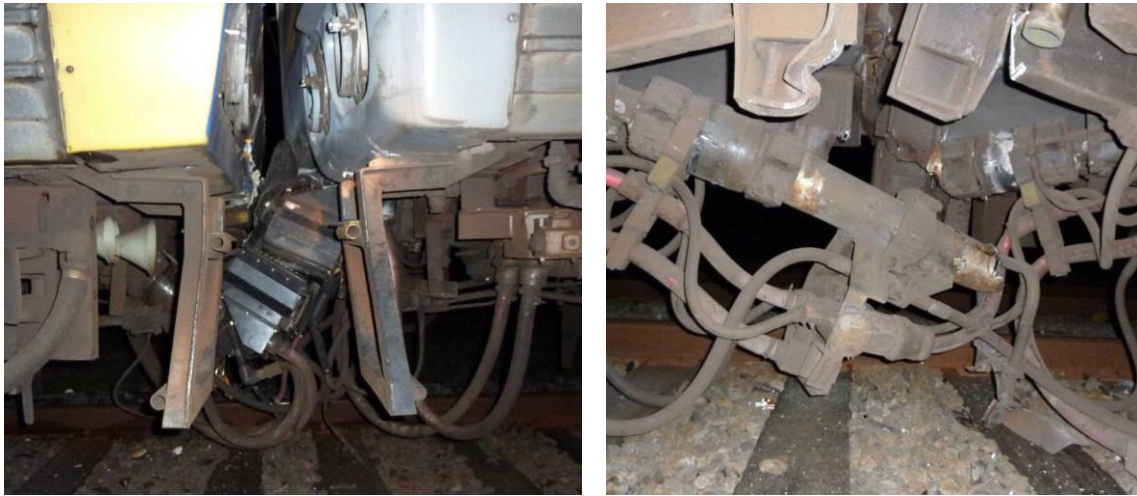


Figure 10 – Multi-Function coupler between 661M and 310M (left) and Semi-Permanent between 570M and 1135T (right).

Whereas the relative climb between the lead car, 570M, and the second car, 1135T, was not significant, 1135T was found to have climbed around 400 mm above the third car, 661M. The consequence of the override by car 1135T was significant structural damage to the leading end of car 661M. The collision posts had been rotated backwards with the top connections detached. The rear-facing seats adjacent to the leading bulkhead had also been pushed backward, ceiling panels had cracked and were dislodged and the Passenger Information Display System (PIDS) Internal Display Unit (IDU) was detached and hanging by electrical cables.



Figure 11 – Car 1135T impact on 661M and evidence of override crease in 661M (right).



Figure 12 – Leading end of 661M showing structural distortion and dislodged PIDS Unit.

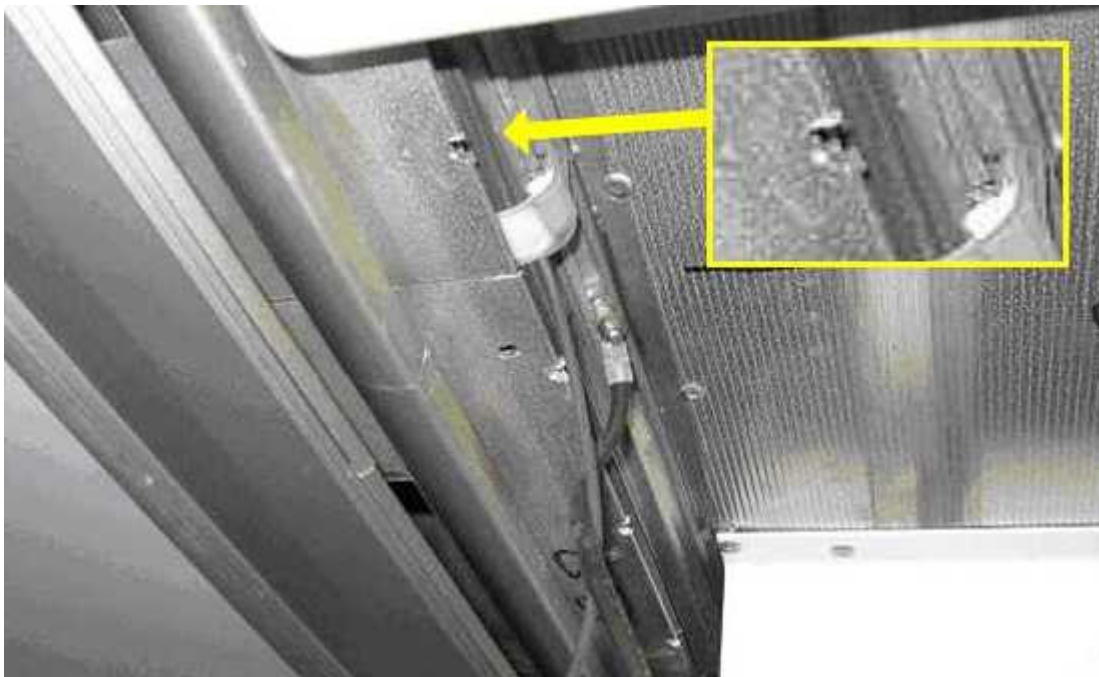
In addition to the override damage to 661M, all three cars in the leading car-set sustained various forms of damage to the occupied spaces.

The Driver's cab sustained relatively minor damage given its direct impact with the freight wagon. Inspection identified some deflection of the body shell structure back into the driver's cab area, movement of a ceiling panel and the dislodgement of the CCTV box on the right-hand-side of the cab. The shattered windscreen remained in place and there was no loose glass.

The remainder of 570M was not significantly damaged. The trailing end had suffered some structural deformation as a result of impact with 1135T and a number of windows were shattered but with glass remaining in place. Of note was the dislodgement of two light fittings. One was fully detached with the connecting rivets having pulled through the mating material. The other was partially detached with evidence of poor fastening arrangement.

Car 1135T had suffered structural deformation in its ends and a number of windows had shattered, although again glass had remained in place. There was a detached light fitting, with rivets having been pulled through or in some cases having failed in tension. Particular to this car, a number of seat back covers had 'popped' from the fibreglass seat installations.

Car 661M received some of the more severe internal damage, particularly its leading end which suffered significant structural deformation, with the collision posts being pushed back as a result of the override by car 1135T. The glass of shattered windows had remained in place. In addition to the detachment of the PIDS unit from the overhead, a light fitting had detached with evidence of poorly located rivet holes on the mating surface.



**Figure 13 – Poorly located rivet holes on mating surface associated with some detached light fittings.**

### **2.7.3 Assessment of crashworthiness of suburban train**

The Comeng train was designed over 30 years ago, and is unlikely to meet current international crashworthiness standards which incorporate collision energy criteria. For the Comeng train, the requirements for the car design included draft and buff loads, shunting loads associated with impact with a similar train at a speed of 15 km/h and requirements and loading scenario for end-of-car 'anti-collision' members to protect against the override of another vehicle.

The investigation found that the collision with the freight train resulted in collision energy which exceeded the design capacity of couplers and would be expected to cause plastic deformation of structures. Measured 'g' loadings were of similar order to the ROA Manual<sup>9</sup> with recorded peaks of 6g in the longitudinal direction and 5g in the lateral direction.

An engineering assessment of crashworthiness performance concluded that the structures, couplers and draw gear generally performed in accordance with the relevant crashworthiness design requirements for the Comeng train but that some components did not perform favourably; specifically, the collision posts on the leading end of 661M and the fastening of some overhead equipment.

### **2.7.4 Other damage to the freight train**

Seventeen of the 21 freight wagons sustained damaged to their bogie bolster Trunion bolts. The number two bogie of VHQF421 - midway along the train - moved and was hard up against the end step of the wagon. As a result of the transmission of impact loads along the consist, the locomotive at the head of the freight train suffered severe damage with the diesel electric power plant being dislodged from its mounting position by about 75 mm.

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<sup>9</sup> The Railways of Australia (ROA) Manual of Engineering Standards and Practices was published in 1992 and specifies loadings for internal and external fixtures as 3g laterally, 5g longitudinally and 3g vertically.



## 2.8 Infrastructure

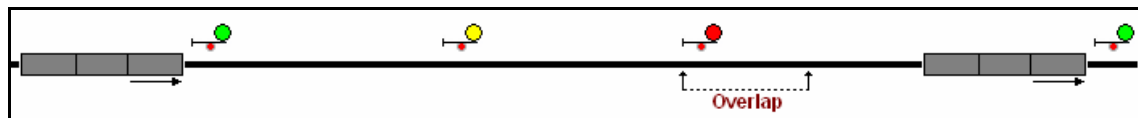
### 2.8.1 Track

The track configuration between Broadmeadows and Craigieburn consists of two class 2 uni-directional lines with 47kg CWR (Continuous Welded Rail) mounted on timber sleepers. The maximum allowable line speed was 130km/h. A temporary speed restriction of 80km/h was in place on the down line between 22.596km and 25.480km due to the installation of a new crossover and signal sighting requirements at Craigieburn. At the collision site the track was tangent and on an uphill gradient of 1:73. The approach from signal E809 is slightly downhill. Paralleling the MTM Up broad gauge line is the standard gauge interstate line (the DIRN).

### 2.8.2 Signalling system

#### Introduction

The purpose of a signalling system is to provide separation between following trains and to provide protection from conflicting movements. With a three-position ABS (Automatic Block Signalling) system, such as employed in Victoria, control of trains is accomplished by controlling the entering block signal<sup>10</sup> via track circuits in advance of that signal. With automatic signals, when the controlling track circuit is unoccupied, the signal will by design display a proceed aspect.



**Figure 14 – Three-position, three aspect signal block sections and overlap.**

Signals are spaced to provide the headway (distance between trains) required for that line section. The minimum spacing between signals in a section is based on:

- The service braking characteristics of the type of train operating in the section,
- The line speed on the approach to the signal,
- The average gradient between signals,
- The permitted speeds authorised by the aspects of the block entry signal.

A train driver is assumed to be:

- In control of the train,
- Trained on the route,
- Aware of the environmental conditions (rain, slippery rails),
- Aware of the braking ability of the train (including compensating for any reduced or enhanced braking performance) and the known grade;
- Driving at or below the authorised speed.

In the event of driver error or misjudgement, a safety margin is provided by a track circuit overlap, see Figure 14.

<sup>10</sup> A block is a section of track between two signals.

The signalling system has various types and kinds of signals. Those involved in this incident are described below.

Three-position Signals

For three-position three aspect signalling where the block entry signal can display a 'normal speed warning aspect', the minimum distance between signals shall not be less than the longest service braking distance calculated from line speed at the signal displaying a normal warning aspect to rest at the signal at stop. Three aspect signals convey normal speed information.

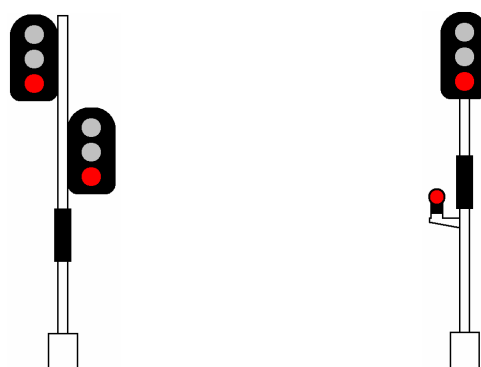
A (top) light	B light	Aspect	Indication	Meaning
Green	Red	Green/Red	Clear Normal speed	Train may proceed at the maximum speed for the section. The next signal is displaying a normal speed proceed aspect.
Yellow	Red	Yellow/Red	Normal speed warning	Train may proceed at normal speed but must be prepared to stop at the next signal.
Red	Red	Red/Red	Stop	Train must not proceed past the signal unless authorised.

**Figure 15 – Description of three-position aspects and meanings.**

Mainline three-position signals on the MTM network are fitted with an *automatic train stop* which is raised to provide intervention for suburban trains should they pass the signal at the 'Stop' position.

Metrol have the ability to monitor and/or directly control about 50 percent of the network with localised signalling locations accounting for another 20 percent. This leaves 30 percent of the network 'unseen' by Metrol, or local controlling signal facilities. This unseen part of the network is commonly referred to as 'Dark Territory' and the status of the signalling system and the location of trains is not known to train controllers in real time.

Automatic/Permissive signals



**Figure 16 – Two typical three-position automatic signal configurations.**

Automatic signals are mainline signals which provide authority for trains to proceed to the next signal. They are not directly controlled by a signaller or train controller but by the passage of trains (track circuits) and their function is to provide separation between trains travelling in the same direction on the same track in accordance with the line speed and headway requirements of that section of track. On a uni-directional running line, Automatic signals usually display a Proceed aspect.

The conditions required to allow an automatic signal to display a proceed aspect are:

- The block and the overlap are continuously detected clear of trains. This requires that all track circuits in the block and overlap of the signal are detected as energised in the signal control.
- The train stop is driven down. This occurs when conditions are safe for the signal to clear and only applies to the Melbourne metropolitan area as train stops are not provided outside of this area.
- The aspect displayed on an automatic signal is dependent on the aspect of the signal ahead. The aspect displayed will be modified, by a change in the aspect of the signal ahead.

Automatic signals, which have staggered lights, see Figure16, are permissive signals that allow a train to pass them at Stop (in compliance with Section 3, Rule 1 of the Book of Rules and Operating Procedures 1994). On the Melbourne metropolitan network there are about 1,150 three-position automatic signals.

Generally in Victoria, an automatic signal is immediately replaced to Stop after the first axle of a train is detected as having passed it. The train stop, where fitted, is also raised to the tripping position after the first axle of a train is detected as having passed the signal.

#### Controlled Automatic signals

Controlled Automatic signals are mainline signals that provide authority to proceed to the next signal. They are usually directly controlled by a signaller as well as by track circuits. Controlled Automatic signals are represented in the field as automatic signals (staggered lights) and when displaying stop are treated as an automatic signal.

#### Home/Absolute-signals

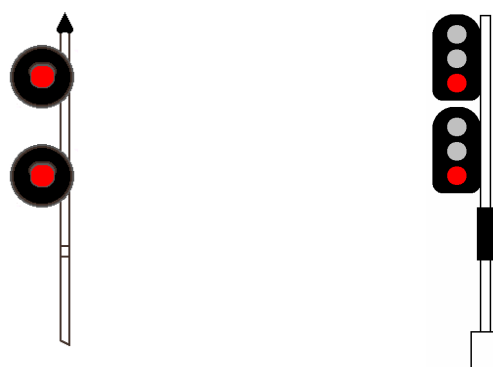


Figure 17 – Two typical three-position Home signal configurations.

Home signals are mainline signals that provide a train with the authority to proceed to the next signal. They are usually directly controlled by a signaller or train controller as well as by track circuits. Home signals are provided to protect movements over points and crossings or to prevent trains entering bi-directional running lines when it is not safe to do so. They are placed at stations, junctions, sidings, signalboxes and some level crossings. Home signals are absolute signals and are not to be passed when displaying a Stop aspect unless written or verbal authority is provided as specified in the Book of Rules and Operating Procedures 1994.

### **2.8.3 Flinders Street - Craigieburn signalling system**

The signalling system in use between Flinders Street and Craigieburn stations is standard Victorian three-position Automatic Block Signalling (ABS)<sup>11</sup> using three aspect signals with four aspect signals on the approach to and through junctions and locations such as Craigieburn.

When suburban services were extended to Craigieburn in 2007 three-position signalling was also provided which was designed and commissioned in accordance with accepted industry standards at the time. In early 2010 an upgrade between Broadmeadows and Craigieburn was undertaken to reduce the headway times of trains to three minutes.

The upgraded system utilises Computer Based Interlockings controlling Broadmeadows, Somerton and Craigieburn. It is controlled by signallers using a VDU system located at Craigieburn.

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<sup>11</sup> ABS – A signalling system whereby two or more trains travelling in the same direction are spaced a track section apart. Each track section is governed by signal indications that operate automatically for the passage of the train. It may also include locations where certain types of signals may be controlled remotely or locally.



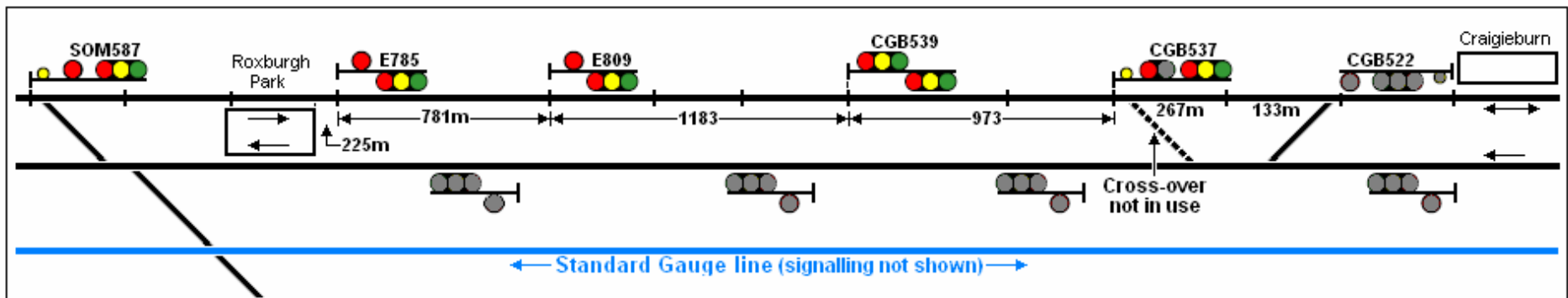


Figure 18 – Schematic of signalling system Roxburgh Park to Craigieburn - down line.

Signal E809, a three-position Down automatic signal (see Figure 19), is situated about 1,183 metres on the Up side of signal CGB539 (see Figure 18) and was commissioned during November 2009 as part of the upgrade. It is fitted with LEDs which have a medium spread and a nominal sight distance of 600 metres. A signal sighting inspection involving engineering and operational personnel from MTM and V/Line conducted during March 2010 identified that previous issues with this signal had been addressed and that the focussing and performance of this signal was satisfactory.



Figure 19 – Automatic signal E809 courtesy of C. Gordon.

Signal CGB539 (the signal at which the freight train was stopped) is a three-position Down controlled automatic signal<sup>12</sup> situated 937metres on the Up side of Home signal CGB537. When a route is set for a train to depart Craigieburn platform 2 in the Up direction, home signal CGB537 is held at Stop (to protect the Up move) and signal CGB539 cannot be placed to proceed. In this situation drivers of Down trains arriving at CGB539 are required to apply Section 3 Rule 1 to progress towards home signal CGB537.

## **2.9 Craigieburn**

### **2.9.1 Background**

Craigieburn is one of two locations on the Melbourne metropolitan network which interface directly with V/Line's network and also indirectly with the parallel DIRN. Network interface communication protocols for emergency situations are in place between all three track managers.

The broad gauge between Broadmeadows and Craigieburn is controlled from the Craigieburn signal panel where the operation and status of the signalling system is displayed to the signaller on visual display units. The Craigieburn signaller makes decisions related to the movement of trains through the territory.

The track configuration at Craigieburn at the time of the incident required suburban trains that were terminating to occupy the Down (Number 2) platform, during their turnaround. In turn this required regional services (passenger and freight) to wait until the platform track was clear before proceeding beyond Craigieburn. Infrastructure works to improve the operational flexibility of Craigieburn were underway and scheduled to be completed the weekend following the collision.

### **2.9.2 Communications**

The Craigieburn communications system combines radio and telephone (landline and mobile) which provides the signaller with the ability to receive or initiate communication with Metrol, Centrol and all trains. However, when signallers are required to perform safeworking duties outside the office, they are out of contact for incoming calls unless the incoming call is directed to their mobile phone.

### **2.9.3 Operations on evening of 4 May**

At 18:53 home signal CGB522 became defective, alternating from proceed to stop when placed at Proceed by the signaller. This condition required the signaller to issue Caution Orders to several Up suburban trains to facilitate their departure and required the affected trains to proceed cautiously to the next fixed signal, consequently delaying the flow of traffic through Craigieburn. Due to signal faults in another area of the network, signal maintenance personnel were unable to attend at Craigieburn until after the incident. The fault with signal CGB522 was caused by an act of vandalism that interfered with the correct operation of the trip arm.

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<sup>12</sup> In Victoria, controlled automatic signals are commonly incorporated into signalling designs when there are no points in the block section but there are points in the overlap of the automatic signal. These signals have the same design properties as a home signal however in the field they appear as automatic signals allowing the application of Section 3 Rule 1.

## 2.10 Recorded information

### 2.10.1 Signalling system logger data review.

Investigators replayed the recorded signal data, immediately after the incident, which identified the faulty operation of signal CGB522 and the sequence of signal aspects presented to trains 9319 and 5863. Train 9319 was presented with Proceed aspects from Somerton signal SOM587 up to signal CGB539, which was at Stop. Train 5863 was presented with stop aspects at E785 and E809. Further analysis of the signal system logger data by independent signals engineers verified that the changes and inputs and outputs were consistent with normal operation of the signalling system and compliant with design.

## 2.11 Book of Rules and Operating Procedures 1994 (PTC)

### 2.11.1 Section 3 Rule 1 - Detention at Automatic Signal

The 'Detention at Automatic signal' rule was incorporated into the Victorian system with the introduction of three-position signalling in the early 1900's. The content of the rule has undergone several minor amendments, mostly as the result of investigation recommendations, until July 2000 when a collision between two suburban trains at Holmesglen resulted in significant changes to the rule from 21 April 2002. The rule as amended is quoted below:

#### 1. **AUTOMATIC SIGNAL AT STOP**

##### **(a) Automatic Signal at stop**

*The Driver must bring the train to a stand for 30 seconds if an automatic signal displays 'Stop'. If the automatic signal is still at 'Stop' after 30 seconds, the Driver may proceed, but must control the speed of the train at extreme caution, being prepared to find the section ahead occupied or obstructed, or the track damaged.*

***Extreme caution is defined as being able to stop the train in half the distance that can be seen ahead; not exceeding 25 km/h or the posted track speed if that is the lesser, and always being prepared to find the section ahead occupied or obstructed, or the track damaged***

*For example, if the Driver can only see 50 metres ahead, the speed travelled must be suitable for the Driver to stop the train within 25 metres.*

*Except where special instructions are issued to the contrary or where a disabled train requires assistance, a Driver must not pass any signal when it is known there is a train in the section.*

**(2) The Driver must not:**

- (i) pass the signal if the line ahead is known or seen to be occupied, until the train ahead moves out of sight or out of the track section.*
- (ii) assume that the signal being passed is defective, but must always consider the track ahead is occupied, obstructed or damaged.*
- (iii) be distracted whilst the train is in motion. The Driver must bring the train to a stand before performing any other function.*
- (iv) pass the signal unless the Driver can exercise full control of the train.*

**(3) If the Driver considers it unsafe, because of:**

- the braking ability of the train in consideration of the gradient to be travelled*
- defective or isolated equipment*
- extremely bad weather conditions*
- poor or restricted visibility*
- fog;*

*The Driver does not have to pass the signal at the stop position until the signal changes to a proceed aspect, **or until it is safe to do so.***

*The Driver must advise the Train Controller of the circumstances for not proceeding.*

**(4)(a)** *At no time is a Signaller, Train Controller or any other person permitted to indicate to a Driver that an automatic signal is defective when it is at the 'Stop' position.*

**(b) Driver Being Prepared to Stop**

*Should the next signal in advance be at the 'Proceed' position, the Driver must be prepared to stop short of any obstruction. The speed of the train must not be increased until the whole of the train has cleared that signal.*

**(c) Parallel Lines**

*If the Driver sees a train in advance where there are parallel lines, the Driver must stop until it is ascertained that the train is on a parallel line.*

**(d) Two Trains in the Same Section**

*After entering a section, if a Driver sees the preceding train there, the train must be brought to a stand and must wait until the first train has proceeded on its journey unless authorised by the Train Crew of the first train to move cautiously forward.*

*After the front train has proceeded, the Driver of the second train may follow at a distance in order to avoid colliding with the front train in the event of its stopping. The Driver must then bring the train to a stand at the next signal, if at 'Stop'.*

*Radios should be used for communication between Drivers and if unavailable, hand signals must be used.*

**(e) Next Automatic Signal**

*If the next signal is an automatic signal and is at the 'Stop' position, the procedures laid down in this rule apply.*

**CAUTION:**

*It must be clearly understood that the passing of a 'Stop' signal as permitted under this rule applies to an automatic signal only, and not to any other signal.*

**(f) Active Level Crossings**

*Where a level crossing equipped with boom barriers or flashing lights is in the track section and the equipment is not working, the Driver must move cautiously forward until the boom barriers and/or flashing lights are operated by the passage of the train. The train must not proceed over the level crossing until the level crossing equipment is operating and it is safe to do so. The Driver must use the whistle frequently.*

**(g) Train Stopped at Two Position Automatic Signal protecting a Level Crossing**

*Where the signal protects a level crossing equipped with boom barriers or flashing lights in a:*

- (1) Train Order,*
- (2) Section Authority,*
- (3) Staff Section or*
- (4) Double Line Block section*

*and the two position automatic signal is still at the 'Stop' position, the Driver must bring the train to a stand for 30 seconds. The Driver may then move cautiously forward until the boom barriers and/or flashing lights are operated by the passage of the train. The train must not proceed over the level crossing until the level crossing equipment is operating and it is safe to do so.*

*The Driver must use the whistle frequently.*

*The Driver may then resume normal speed after passing over the level crossing.*

The rule, prior to the above amendment and at the time of the incident, had been consistent in the requirement for a train not to pass an automatic signal when it is known that there is a train in the section ahead except where special instructions are issued to the contrary or where a disabled train requires assistance.

### **2.11.2 Compliance monitoring - Section 3 Rule 1.**

On the Melbourne metropolitan network, MTM has the dual role of the network manager and a train operator. MTM train drivers are subjected to regular safety audits but there is no specific network monitoring processes in place to measure compliance with Section 3 Rule 1.

### **2.11.3 ARTC managed track - ARTC Code of Practice for the Victorian Main Line Network TA 20 Section 3 Rule 1.**

The ARTC manage the DIRN, for operations between Dimboola, Melbourne and Albury. ARTC adopted the applicable rules and procedures from the Victorian Book of Rules and Operating Procedures 1994 into their own Safety Management System in the form of document *TA20 ARTC Code of Practice for the Victorian Main Line Network*. However Section 3 Rule 1 in TA20 differs from the current revision of Section 3 Rule 1 in the Book of Rules and Operating Procedures 1994. The differences are:-

- There is no definition of extreme caution.
- There is no requirement regarding a maximum speed of 25 km/h.
- There is no mention that the driver is not to assume that a signal is defective or that other persons are not to intimate that the automatic signal is/maybe defective.
- There is no mention that the driver is not to pass the signal unless they can exercise full control of the train.
- There is no provision for a driver to do a risk assessment considering grade, weather or braking ability of the train before applying the rule.
- There is no mention that the driver is not to be distracted and is to stop the train if required to perform additional functions apart from running the train.

### **2.11.4 Tail signals**

ETMs were introduced as a tail signal to the Victorian rail network with removal of Guard's vans from freight trains from November 1985.

Section 11 Rule 2a '*Train discs and Lights*' of the *Book of Rules and Operating Procedures 1994* states in part that:

*Every train on a running line must display at the rear of the last vehicle:*

- (1) a white disc, or*
- (2) a red light(s) both day and night, or*
- (3) an End of Train Marker both day and night, or*
- (4) an End of Train Monitoring Unit both day and night.*

*An End of Train Marker may consist of a standard ETM, a modified ETM for use when electronic end of train monitoring is provided (TAILS), an ETAS unit, or a unit consisting of a white reflectorised disc by day, or pulsating red lights displayed at nighttime or during inclement weather."*

*Section 11 Rule 3 (e) 'Testing End of Train Marker' states, in part; that the employee fitting the end of train marker to the rear of the train must ensure that the manual switch is on and check both the operation and low battery indicator of the ETM."*

Section 11 Rule 3 (f) 'Tail Signals Not Showing Properly' states that:

*"On lines where there is automatic signalling, Signallers and employees at stations between signalboxes must observe each train when passing and check that it is complete.*

*If a Signaller observes any irregularity with the tail signals, the Stationmaster or Train Controller and Signaller at the next station must be informed. The Stationmaster or Signaller at that station will instruct the Driver to attend to the tail signals.*

*The Signaller, after informing the Train Controller and Signaller at the next station, must record this action in the Train Register Book and must also give a written report.*

*The Signaller or Stationmaster receiving the information from the Signaller in the rear, must also give a written report.*

At no stage during the journey between Brooklyn and Craigieburn was the operation or condition of the ETM on train 9319 questioned or reported as not being to standard or not showing properly.

## **2.12 End-of-Train Marker**

### **2.12.1 Management of ETMs by Pacific National Bulk Division**

The Pacific National Bulk Division adopted specifications for ETMs when operating on the Victorian Network in accordance with the Book of Rules and Operating Procedures 1994 Section 11 Rule 2(a). Their ETMs are maintained in accordance with their maintenance system and train inspection processes.

### **2.12.2 Standards**

The Rail Industry Safety and Standards Board (RISSB) is a fully owned subsidiary company of the Australasian Railways Association (ARA) and was established to produce Rules, Codes of Practice, Standards and Guidelines for the Australian rail industry. ARA and RISSB are non-profit member-based organisations. Membership includes companies in categories of track owners; operators; rolling stock manufacturer and maintenance; signals and communications; research, education and training; consultants; and suppliers.

In 2007 RISSB published a standard for *Railway Rolling Stock Lighting and Rolling Stock Visibility, AS 7531.2.2007*. The RISSB standard is not mandatory and the rail industry in Victoria had not adopted it at the time of this incident.



Part 2: Freight Rolling Stock (of the RISSB standard) states in part:

TAIL AND MARKER LIGHTS
The last vehicle on a freight train shall have a red tail light fitted at the trailing end. (Provides End-of-train and Train-intact indication.)
Portable tail lights may flash.
If portable tail lights are fitted with a flashing feature, the rate of alternate flashing shall be at least 40 flashes per minute and shall be at most 180 flashes per minute.
Tail lights on freight rolling stock shall have a luminous intensity of at least 0.75 candela per light. (Based on AS 1165 <sup>13</sup> (withdrawn standard))
If operating in a network where the Safeworking System allows Permissive Working <sup>14</sup> then each tail light shall have a luminous intensity of at least 100 candela. (Based on US regulation 49 CFR 221.14 and UK standard GM/RT2483.)

## 2.13 ETM testing

### 2.13.1 Background to testing

The investigation sourced an ETM of the same model as that fitted to the rear of the freight train involved in the collision. The ETM unit mounted to the trailing freight wagon had been destroyed in the collision and could not be tested. However, the type of light, the rating of the lamp and the battery power source were clearly evident. The ETM was fitted with an incandescent lamp rated at 6V, 90 mA, powered by two 6V batteries in parallel.



Figure 20 – Tested items, incident model ETM (left) and a second type used on the network (right).

<sup>13</sup> AS1165-1982 Traffic Hazard Warning Lamps

<sup>14</sup> RISSB – Permissive working: a system whereby a train or two or more trains travelling in the same direction are permitted to proceed at low speed to the preceding train or next Stop indication.

The ETM sourced for testing had been in use on the rail network and was therefore regarded as being in typical, if not new, condition. The testing agency described the unit as being “quite weathered” which may have had some impact on performance compared to an as-new unit.

The investigation also sourced for testing a second type of ETM used on the network. The unit uses two small, battery powered LED flashing lamps similar to those used on the rear of bicycles.

The performance of the two ETMs was compared against the requirements of the RISSB standard and the technical requirements of AS1165, the UK rail industry standard GM/RT2483 and the US rail industry regulation 49 CFR 221.14.

### 2.13.2 Test results for incident model ETM

The incident model ETM was tested for luminous intensity, flash frequency, colour and the performance of retroreflective elements on the lamp and background sheeting.

The effective luminous intensity was measured ‘on-axis’ (in line with the incandescent lamp and perpendicular to the ETM face) and at various angles to this axis in the up and down and left and right directions. The peak effective intensity measured was about three candela ‘on-axis’. Luminous intensity diminished as the measurement direction moved away from this axis. All readings met the 0.75 candela requirement of AS1165-1982 except in one direction (7.5 degrees to the right on one side). When compared to the other standards, the luminous intensity was reported by the test facility as being “10-25 times” less than the requirements specified in the UK standard and “30-50 times” less than those specified in the US regulation.

The effect of input voltage on ‘on-axis’ effective luminous intensity was also measured. The results are shown in Figure 21 where effective intensity is indicated as a percentage of the intensity at six volts (full battery power). Below a voltage of 3.25 Volts, the lamp did not flash. The flash rate did not vary appreciably with reducing voltage.

Input Voltage (V DC)	Effective intensity (% of maximum)	Flash rate (Hertz)
6.0	100	0.98
5.5	78.2	0.98
5	56.4	0.98
4.5	38.0	0.98
4	24.9	0.98
3.5	12.7	0.96
3.25	0.6	0.84

Figure 21 – Variation in effective intensity with reducing input voltage.

The frequency of flash was measured to be about 0.98 Hertz (just over a second per flash or about 59 flashes per minute) which meets the RISSB standard and is just below the requirement of AS1165 of between 1-1.5 Hertz. The measured flash rate is significantly slower than the UK standard of about 2 Hertz, but does meet the US regulation which specifies a rate of between 0.77 and 1.43 Hertz.

The colour of the ETM met the requirements of AS1165 and the broad requirements of the US regulation. Colour requirements were not identified within the UK standard.

The light has a moulded red retroreflective element as an annulus around the circular lamp. The retroreflectivity of the annulus was measured as being about one third of the requirement specified in AS1165 and about one half of that specified in the UK standard. There were no retroreflectivity requirements identified in the US regulation.

The retroreflectivity of the background (white) sheeting was found to meet the requirements for Class 1 white sheeting as defined and measured in accordance with AS/NZS1906.1:2007.

The light sensor on the ETM was also tested. The ETM has a sensor which turns the lamp off when the ambient light reaches a certain level. With the lamp activated, the illumination of the ETM by an external source was increased until the lamp ceased flashing at an illuminance of about 770 lux. A coarse estimate indicated that the Comeng headlights on high beam would not illuminate the ETM to this level until it had closed to within around 30 metres.

### **2.13.3 Test results for a second type of ETM**

The measured performance of the second ETM was significantly below that of the incident model ETM. When one LED unit was measured (there are two units mounted separately within the ETM), the recorded 'on-axis' effective luminous intensity was 0.72 candela which did not meet the 0.75 candela requirement of AS1165 nor did it meet the significantly more onerous requirements of the UK and US standards. The AS1165 intensity requirement was also not met at off-axis angles except at one point. In addition, the flash rate of about 5.5 Hertz was considerably faster than the requirements of AS1165 and the UK and US standards.

### **2.13.4 Visual range of tail and end-of-train marker lights**

The conversion of the time profile of a flashing light to an 'effective intensity' is to approximately equate the perceptual effect of a flashing light to a steady light. This allows a level of comparison to be made between different types of lamps.

There is a considerable amount of information in the literature concerning the detection of coloured and white lights. One credible source<sup>15</sup> puts the threshold illuminance at the eye for detection from a white point source at night, at approximately 0.2 $\mu$ lux (0.2x10<sup>-6</sup> lux). This reference also suggests that if the light is to be easy to find, then the illuminance values should be increased by a factor of five to ten (to about 2 $\mu$ lux). It goes on to say that these increases in illuminance are applicable only when the observer is looking for the light signal and that much greater increases are needed if the light signal is to attract the attention of an observer who is not searching for it. It describes factors of 100-1000 as not being excessive; a factor of 100 equating to 20 $\mu$ lux. The reference also indicates that for red lights, the threshold for the identification of the colour of the light signal is about the same as for the detection of the light.

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<sup>15</sup> Lighting Handbook of the Illuminating Engineering Society of North America, 8<sup>th</sup> Edition.

Using nominal threshold values of two and 20 $\mu$ lux, it is possible to gain an appreciation of the comparative visual range for lamps of differing luminous intensity. A lamp of 100 candela could be expected to be seen about six times further than a lamp of three candela; the measured intensity for the ‘typical’ in-use ETM.

Lamp (or standard)	Effective luminous intensity (candela)	2 $\mu$ lux threshold Nominal visual range (metres)	20 $\mu$ lux threshold Nominal visual range (metres)
AS1165	0.75	610	195
Tested incident type ETM	3	1200	390
UK standard and US regulation	100	7000	2240

**Figure 22 – Estimation of visibility of lamps of varying luminosity.**

Actual viewing range will depend on many factors including background luminance. Testing by MTM of a typical ETM (of same model as that fitted on the evening of the collision) identified a wide range of results depending on the conditions of the test. The ETM was measured as being visible from over 1000 metres in good dark conditions while only being visible at 186 metres in conditions potentially comparable to those present on the night of the collision. Assuming a six-fold greater range for an ETM of 100 candela luminous intensity, such a lamp could be expected to be seen from at least 1000 metres in similar conditions.

## 2.14 Previous train-to-train collisions

### 2.14.1 Overview

There have been several incidents linked to Automatic signals and the application of the ‘Stop and Proceed’ conditions associated with Section 3 Rule 1. Details of these incidents are outlined below.

#### 2.14.2 Barnawartha - 1982

On 17 June 1982 an Up standard gauge freight train collided with rear of the Up Interstate passenger train Spirit of Progress after passing an automatic signal at Stop as permitted by Regulation 74<sup>16</sup>. At the time of the incident the passenger train was stationary due to a defective locomotive and there was heavy fog in the area. The driver and fireman operating the freight train were fatally injured, 20 passengers on the Spirit of Progress suffered injury with 12 requiring hospital treatment.

As a result of this incident, radio communications between the network control centre and locomotive drivers and the locomotive driver and train guard were introduced on the Intrastate network.

<sup>16</sup> This was the previous regulation which applied to ‘Detention at Automatic Signal’.

### **2.14.3 South Dynon - 1986**

On 8 October 1986 an Up freight train collided with the rear of another freight train which was stationary at a Home signal waiting entry into the South Dynon yards. The previous automatic signal was passed at Stop as permitted by Regulation 74. Visibility was restricted by track curvature.

As a result of this incident, the automatic signal involved was converted to an uncontrolled Home signal.

### **2.14.4 Ringwood - 1989**

On 16 October 1989, a suburban passenger train collided with the rear of another suburban train which was stationary at a Home signal at Ringwood. The driver had passed the previous automatic signal as permitted by Regulation 74. Twenty-one passengers were injured as a consequence of the collision.

As a result of this incident the application of Regulation 74 was reinforced with train drivers.

### **2.14.5 Syndal - 1989**

On 20 November 1989 a suburban passenger train collided with the rear of another suburban passenger train which was stationary at the Syndal Station platform. The driver had passed the previous automatic signal as permitted by Regulation 74. The collision resulted in injury to 75 persons.

As a result of this incident the application of Regulation 74 was reinforced with train drivers.

### **2.14.6 Aircraft - 1998**

On 27 July 1998 a suburban passenger train collided with the rear of a stationary freight train. Weather conditions at the time resulted in a limited viewing distance. Regulation 74 had been superseded by Section 3 Rule 1 in the Victorian Book of Rules and Operating Procedures 1994 (PTC).

As a result of this incident the application of Section 3 Rule 1 was reinforced with train drivers.

The Board of Inquiry into the Aircraft incident recommended that:

- ETMs should denote the rear vehicle of a train to the driver of a following train during darkness and especially during inclement weather.
- That a standard be developed for tail signals that allows viewing by the driver of a following train, as well as by signalling staff and others to ascertain a train is complete.
- That a study be undertaken to assess the viewability of tail lights currently in use on all trains during inclement weather.
- That a defined procedure for checking the viewability of ETMs and (if not already in place) other tail signals be adopted.
- That a survey of train signals be undertaken with a view to determining their effectiveness and what actions are required to enhance their viewability and what maintenance procedures are required to ensure the enhancement is maintained.

### **2.14.7 Holmesglen - 2000**

On 26 July 2000 a suburban express passenger train collided with the rear of another suburban passenger train which was stationary at the Holmesglen Station platform because of a faulty door mechanism. The incident resulted in severe damage to both trains and 12 persons received non-critical injuries.

As a result of this incident Section 3 Rule 1 was amended to include a mandatory maximum speed of 25 km/h after an automatic signal had been passed at Stop.

The train operator also amended their processes for reviewing and assessing the competency of all current drivers and introduced a process to monitor its effectiveness.

The report (dated May 2001) produced by the then Department of Infrastructure's Office of the Director of Public Transport, Safety and Technical Services Branch noted that all new trains on order for Victoria would comply with modern European energy absorption methods and principles. This report recommended that the train operator assess the benefits and practicality of installing speed limiting equipment (after passing signals at danger) and data loggers to suburban trains.

As recommended, suburban train fleets delivered since the Holmesglen incident have incorporated the European energy and absorption methods and principles. However, data loggers are still in the process of being commissioned on the Comeng train fleet and will, at a later date, be introduced to the other suburban fleets.

The operator assessed the benefits and practicality of installing the recommended speed limiting technology for situations such as passing signals at danger. The recommendation was not adopted by the operator which noted it, '...would not support the fitting of equipment to the current rolling stock to limit the speed of trains after passing signals at Stop due to the disbenefits on time performance, the limited effectiveness of the proposal and the complexity and costs involved.'

### **3. ANALYSIS**

#### **3.1 The incident**

Vandalism to signal CGB522 led to an Up suburban train being held at Craigieburn Railway Station, blocking Down traffic. This delay resulted in the freight train being held at signal CGB539, short of the Craigieburn Station. This in turn caused the two automatic signals behind it (E785 and E809) to display a Stop aspect to the following suburban passenger train. Even though these signals displayed a Stop aspect, the suburban train was permitted to pass them if certain conditions were met and procedures followed as described in Section 3 Rule1 of the Book of Rules and Operating procedures 1994.

After the train was 'tripped' at signal E809, it accelerated to almost 70 km/h and was coasting when the driver moved the brake handle to the emergency position, probably as a result of seeing the train in front.

When the emergency brake was applied the distance available was insufficient for the train to stop and the suburban train impacted the stationary freight train at about 47 km/h. The freight train was propelled forward about 30 metres. The suburban train came to a stop about 16 metres after impact; the three leading cars having been pushed together during the collision and the trailing end of the second car (1135T) lifting and overriding the leading end of the third car (661M). Accelerometer data from the train's M-cars shows the sequential nature of the impact along the train.

#### **3.2 Section 3 Rule 1 - Detention at Automatic Signal**

This Rule facilitates the flow of rail traffic on the network by permitting trains to pass an uncontrolled, unmonitored signal, enter a section which may or may not be occupied by another train that is not immediately observable, or enter an unoccupied section where some infrastructure malfunction may be affecting the signal's operation.

The rail system expects train drivers to apply the Rule and indeed requires them to advise the train controller the reasons for not passing an automatic signal at Stop. Conversely, the Rule does not require that a driver report that they are *intending* to pass such a signal. Nor does it monitor compliance with the procedures when a train passes an automatic signal at Stop. It could thus be argued that the rail system is building an expectation within drivers that the track section ahead is clear and safe to travel upon. This appears to have been the case in this incident as it is most unlikely that the driver would have operated the train at speeds significantly in excess of the speed limit had he expected the track section to be occupied or in some way obstructed.



There are about 1,150 automatic signals on the metropolitan rail network. While the investigation accepts the need to keep traffic flowing, hence Section 3 Rule 1, it could be considered unreasonable that a signal that is designed to separate trains can be passed by a driver with no reporting of the event and the driver not being given all available information about the circumstances in the particular track section. Should a driver be required to report their application of Rule 1 to pass an automatic signal at Stop then it is likely that the driver would be more conscious of complying with the Rule. Given this event and other similar events described earlier in the report there is a need not only to review the Rule, its application and monitoring, but also the requirement for the significant number of signals that may require its use.

### **3.3 Suburban train driver**

#### **3.3.1 Driver's actions**

Analysis of information from the train data recorder found that the train had been operated in accordance with the rail network safeworking rules up until the time it was confronted with automatic signals E785 and E809 after departing Roxburgh Park. At both these signals the driver, instead of bringing the train to a stand prior to the signal and waiting 30 seconds before proceeding, allowed the train to roll past the signal, be 'tripped' by the signal trip arm and brought to a stand. Following each of these interventions the train recommenced its journey and reached speeds of 63 and 69 km/h respectively, before it was braked.

At interview the driver said that he had no recollection of the events leading up to the collision. Therefore the investigation is left to review the potential reason/s for him violating Section 3 Rule 1 which he had been trained in and demonstrated his knowledge of at previous safety audits.

#### **3.3.2 Fatigue**

The driver commented, at interview, that he did not like the rotating shift (mixture of early, daytime and late starts) but preferred the afternoon shifts that he had worked up until six months prior to the incident. He had returned to work after a months recreation leave, nine days before the incident. Initially he worked six morning shifts, with two requiring a sign-on time before 04:00 and a further two before 05:00. The last of these shifts ended at noon and was followed by a day off before he worked an afternoon shift. The next day, (the day of the incident) he commenced his shift at 15:38.

The driver said that he was not normally able to get to sleep before 22:00 each night, regardless of the time he went to bed or the time he had to rise to commence work. It is therefore likely that he would have been suffering from a lack of restorative sleep at the end of the six morning shifts. When the driver commenced afternoon shifts he had had three nights where the hours that he could sleep would fit his 'normal' sleep pattern and allow him to recover from the early morning starts. Despite this, it is not possible to determine if he suffered any fatigue at the time of the incident that may have affected his decision-making.

### 3.3.3 Driver's performance

Craigieburn is the terminating station on the route for MTM services and the train driver's home depot, so he would have been familiar with operating trains in that area. This was the last service he was to operate before shunting the train to a siding at Craigieburn and completing his shift.

The train was one minute behind schedule at Roxburgh Park, well within the operator's on-time performance criteria, so the time - a little over a minute - saved by rolling past the two signals would not appear to be motivated by an on-time running desire. In addition, the driver was not due to complete his shift until 21:33, almost an hour after the incident and sufficient existed time for him to complete the service and stable the train before the shift completion time. While the pressure of time is never an excuse for non-compliance with operating rules in this case there was no apparent time pressure.

It is likely that the driver allowed himself to become complacent, shortcut the procedure when faced with an automatic signal at Stop, and then not comply with the speed restriction because he believed the line ahead was clear and the signal was not indicating the correct situation.

### 3.4 End of Train Markers (ETMs)

Section 3 Rule 1 requires that a driver not enter a section when it is known to be occupied; however if they cannot see a train ahead then they must enter the section and be vigilant after passing an automatic signal at Stop. Should another train be sighted in the same track section then the driver is to stop their train short of the other train.

The end of trains are required to be identified by red lights at night (*although the Book of Rules and Operating Procedures 1994 could be interpreted to the contrary*), traditionally so that signallers and train crews of passing trains can check that the train is complete; that is, that no vehicles have become detached. However, in requiring the lighting of the rear of a train the rail network managers are also providing a tail light that is used by following train drivers to identify the rear of a preceding train. Despite this, the operational standards for ETMs have not altered since their introduction in 1985. This is in contrast to trackside signalling which, particularly in the metropolitan area, changed significantly with the introduction of LED lights, which are brighter than older incandescent lights. This increased signal brightness could have an adverse affect on the sighting of ETMs by following train drivers.

The Board of Inquiry investigation into the train-to-train incident at Aircraft in 1998 made several recommendations in respect to tail signals, one of which related to the development of a standard. The rail industry's Standard Development Organisation, RISSB, has promulgated an industry standard for ETMs which has not been implemented by any Victorian network manager.

In this incident the brakes of the suburban train were applied about 116 metres prior to the impact. Given the generally accepted driver reaction time of 2.5 seconds, it is probable that the driver observed the rear of the freight train or its ETM when he was about 160 metres from the point of collision. Had the freight train's ETM met the RISSB standard then it is likely that the suburban train driver would have seen that train earlier and may not have proceeded beyond signal E809 or may have been able to avoid the collision. It should however also be recognised that had the train been travelling at or below the authorised speed of 25 km/h then the estimated sighting distance would have allowed the driver more than sufficient distance to stop the suburban train.

### **3.5 Suburban train crashworthiness**

The investigation concluded that the crashworthiness performance of train 5863 had been reasonable given the age and design of the vehicles, the impact speed and the nature of the collision. The investigation found that the suburban train had been subject to an impact which exceeded the energy absorption capacity of its coupling systems and was sufficient to cause plastic structural deformation of the cars. Measured 'g' loading also indicated the potential for some equipment to be dislodged.

In addition to a train's energy absorption capacity, survivability of train crew and passengers relies to a large extent on avoiding intrusion of occupied spaces. In this incident, the driver's cabin remained largely intact as did most of the passenger spaces. The one exception was the leading end of the third car, 661M. In this car, the collision posts had been forced backward by the overriding of the second car, 1135T, resulting in structural encroachment. This is not dissimilar to the Holmesglen incident in which a trailer car also overrode an adjacent motor car leading to collapse of end collision posts and significant intrusion into the passenger space. Preliminary calculations suggest that the collision posts on trailer cars and the non-cab ends of motor cars may be vulnerable in the case of override by an adjacent car. This vulnerability is heightened by the absence of anti-climber devices on car ends.

Survivability is also enhanced by minimising the possibility of detachment and projection of internal equipment. In this instance there was some dislodgement of overhead fittings and equipment which may have had greater implications for passenger injury had there been more passengers on board. The investigation identified that in some cases the dislodgement of overhead fittings was contributed to by poor fixing methods.

## **4. CONCLUSIONS**

### **4.1 Findings**

1. The suburban train driver was qualified to operate train 5863 on the Flinders Street-to-Craigieburn route.
2. The suburban train driver's medical assessment was current and without restriction.
3. The suburban train driver's physical, psychological and actual fatigue status immediately prior to the incident could not be determined.
4. The suburban train driver passed signals E785 and E809 at the Stop position in a manner contrary to the network operating rules and procedures.
5. The suburban train driver did not comply with Section 3 Rule 1 after passing signals E785 and E809.
6. Both crew members of the freight train were qualified for their assigned duties to operate over the route from Brooklyn to Kilmore East.
7. Freight train 9319 was operated in accordance with the network operating rules and procedures.
8. The freight train was certified as serviceable prior to the impact.
9. The signaller was qualified in the operation of the Craigieburn signal panel.
10. The signaller's medical assessment was current.
11. Prior to this incident the suburban train was in a serviceable condition and had been maintained in accordance with the operator's maintenance regime.
12. The braking performance of the suburban train was in accordance with specifications.
13. The method used to secure some overhead fittings in the passenger saloon(s) failed allowing some to dislodge as a result of the impact.
14. The End-of-Train Marker fitted to the freight train was acceptable to the Victorian Rail Network.
15. The signalling system between Broadmeadows and Craigieburn was operating as designed.
16. The Network manager had no method of monitoring the application by train drivers of Section 3 Rule 1 other than the MTM six-monthly driver audits.
17. The Network manager had not required tail signals on trains to comply with the 2007 RISSB standard for permissive working.
18. The Network manager's emergency response to this incident was timely and appropriate and in accordance with their policies and procedures.

19. The content and application of Section 3 Rule 1 is not consistent on all networks in Victoria.

#### **4.2 Contributing factors**

1. Section 3 Rule 1 of the Operating Rules and Procedures 1994, allows the principles of train separation intended by signalling systems to be overridden by an operating procedure that relies on a train driver providing separation between trains by line-of-sight observation.
2. An act of vandalism affected the correct operation of Home signal CGB522 at Craigieburn.
3. The suburban train was operated at an inappropriate speed after passing automatic signal E809.
4. The conspicuousness of the End-of-Train Marker fitted to freight train 9319.
5. The recommendations arising out of a Board of Inquiry investigation into the collision between a suburban passenger train and a freight train between Werribee and Aircraft, on 27 July 1998 in respect to the standards applied to End of Train Markers were not implemented by the Victorian Rail Network managers.

## **5. SAFETY ACTIONS**

### **5.1 Recommended Safety Actions**

#### **Issue 1**

The train driver did not comply with the speed restriction required by Section 3 Rule 1. The suburban train collided with a train ahead and the resultant damage to both trains was extensive. Although in this case the suburban train was lightly loaded, in other circumstances the injuries could have been more severe and numerous. Had the train speed been limited after passing signal E809 at stop then this incident probably would not have occurred.

#### **RSA 2010010**

That Metro Trains Melbourne review the previous recommendation and train operator's response in respect to the concept of the fitment of a speed limiting system to its trains after passing signals at Stop, or some other defensive mechanism to defend against non compliance to the speed restriction after passing signals at Stop.

#### **Issue 2**

Section 3 Rule 1 sets down procedures with which a train driver must comply in order to ensure the safety of their train. However, other than conducting half yearly Metro Trains Melbourne driver audits, the network manager does not monitor the passing of automatic signals or compliance with the procedures for and after passing them at Stop.

#### **RSA 2010011**

That Metro Trains Melbourne review the content of Section 3 Rule 1 of the Book of Rules and Operating Procedures 1994 and its application.

#### **RSA 2010012**

That Metro Trains Melbourne implement a method of monitoring the application of compliance to the requirements contained in Section 3 Rule 1 on their network.

#### **Issue 3**

On the Melbourne metropolitan network there are about 1,150 three-position automatic signals which are able to be passed at Stop in accordance with Section 3, Rule 1.

#### **RSA 2010013**

That Metro Trains Melbourne review the necessity to retain the number of automatic signals with a view to minimising the need to apply Section 3 Rule 1 on the system.

#### **Issue 4**

The content and application of Section 3 Rule 1 is not consistent on the Intrastate and Interstate networks in Victoria.

## **RSA 2010014**

That the three Victorian network managers Metro Trains Melbourne, V/Line Pty Ltd and Australian Rail Track Corporation review the inconsistencies of Section 3 Rule 1 as published in the Book of Rules and Operating Procedures 1994 and the ARTC Code of Practice for the Victorian Main Line -TA20, with a view to making the rule consistent across all networks in Victoria.

## **Issue 5**

A previous investigation into a train-to-train collision (Aircraft 1998) recognised that End of Train Markers have a dual role in determining that the train is complete and acting as a tail signal that alerts following drivers to the train's presence. However the current standard for ETMs on the Victorian rail networks is not sufficiently robust to prescribe their use as end-of-train warning devices in addition to their accepted use as end-of-train identifying devices.

The rail industry's Standards Development Organisation RISSB, had promulgated an industry standard for ETMs and Tail Signals which has not been implemented by any Victorian network manager.

## **RSA 2010015**

That the three Victorian network managers Metro Trains Melbourne, V/Line Pty Ltd and Australian Rail Track Corporation conduct a survey of available end-of-train signals to determine their effectiveness and what actions are required to enhance their conspicuity giving consideration to the RISSB standard for Railway Rolling Stock Lighting and Rolling Stock Visibility, AS 75312007.

## **RSA 2010016**

That the three Victorian network managers, Metro Trains Melbourne, V/Line Pty Ltd and Australian Rail Track Corporation review the RISSB and applicable international standards for tail signals and adopt a more robust standard than currently used for train operations in Victoria.

## **Issue 6**

In this and the Holmesglen incident, a passenger car overrode an adjacent car leading to intrusion of the passenger space. Comeng cars are not fitted with anti-climb devices and preliminary assessment suggests the end-of-car collision posts are vulnerable to end loading.

## **RSA 2010017**

That Metro Trains Melbourne review the adequacy of collision posts fitted to the Comeng fleet.

## **RSA 2010018**

That Metro Trains Melbourne considers the practicality and potential benefit of fitting anti-climb devices to the Comeng fleet.



## **Issue 7**

Several overhead fittings, including a Passenger Information Display System Internal Display Unit became dislodged in the impact. The investigation found that in some cases this was due to poor fixing methods.

### **RSA 2010019**

That Metro Trains Melbourne inspects the Comeng fleet to the extent considered appropriate to assure the adequacy of the fastening of items in overhead positions in passenger saloons.