



Australian Government

Australian Transport Safety Bureau

Derailment of train 3MP5

Rawlinna, Western Australia, on 21 April 2016

ATSB Transport Safety Report

Rail Occurrence Investigation

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Addendum

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Safety summary

What happened

On 21 April 2016, at about 1115¹, train 3MP5 (travelling from Melbourne to Perth) derailed while traversing the eastern points at Rawlinna. The points failed to restore to the normal position after the last train departed the loop line, leaving the points in an unsafe open position. The colour light point indicator system worked as designed by displaying a red indication when the points were unable to be detected and locked in a safe position.

There were minor injuries sustained by the crew. About 200 m of track infrastructure was damaged, and the main line between Adelaide and Perth was blocked until 1351 on 25 April 2016.

Derailed locomotives



Source: Driver 3MP5

What the ATSB found

The ATSB found the driver's expectation that the system was likely set for the main line contributed to train 3MP5 travelling at a speed where it could not be stopped before the open points. Additionally, it was likely a common practice for drivers to approach crossing locations without slowing when authorised for the main line. Compounding this was the points enhancer sighting distance being less than the effective braking distance of trains travelling at line speed, thereby increasing the risk of overrun if not displaying a green aspect.

The ATSB also found that the crew van did not meet the requirements of AS 7522-2012 - *Railway Rolling Stock Access and Egress*, since the occupant could not access any escape paths without external assistance and additional equipment.

What's been done as a result

Pacific National have reviewed operational instructions, audited enhancer sighting distances between Cook and Kalgoorlie, and reviewed emergency egress arrangements. The Office of the National Rail Safety Regulator will look further into the possibility of prescription glasses with progressive lenses altering the perception of signal colours.

Safety message

The common practice of approaching safety critical zones at higher speed probably affects multiple operators. The effective sighting distance of safety critical locations (enhancers, targets, etc) being less than the effective braking distance of trains represents a physical gap or limitation of the system. This limitation places more reliance on procedures to cover the gap. Although the Australian Rail Track Corporation and Pacific National have procedures in place, not all operators have the same requirements. Other operators may instead rely on one layer of procedural protection provided by the track manager, increasing the likelihood of an occurrence.

¹ The 24-hour clock is used in this report. Local time was Western Standard Time (WST)

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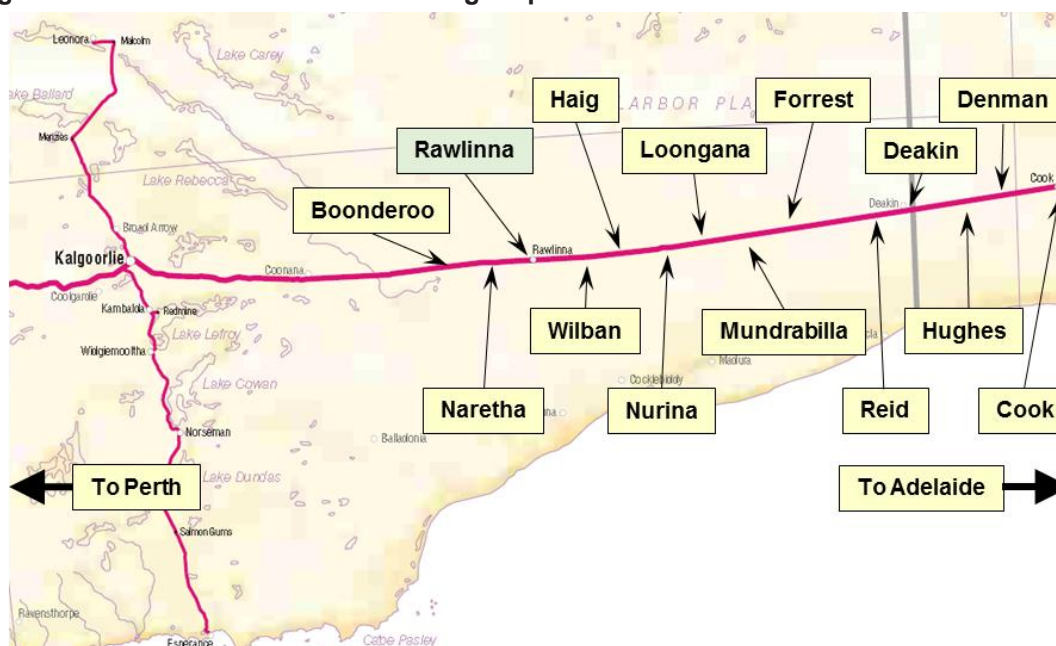
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The occurrence

At 0540² on 21 April 2016, the crew of Pacific National (PN) train 3MP5 signed on duty at Cook for departure to Kalgoorlie. At about 0602, after attending to locomotive fuelling and paperwork, the train departed Cook under train authority W16 to Deakin. The train was crewed by three drivers, a driver operating, a co-driver observing, and a driver resting in the crew van.

Train 3MP5 continued its journey towards Perth on its scheduled timetable. At about 0632, just west of Denman, the driver performed a running-brake-test, testing the effectiveness of the train brakes.

Figure 1: Location of Rawlinna crossing loop and other referenced locations



Source: Geoscience Australia, annotated by ATSB.

Over the next 2 hours, train 3MP5 continued towards Loongana, having received further authorities at Deakin and Forrest.

At Rawlinna, an east bound freight train (4PS6) had entered the crossing loop at about 0900. About eight minutes later, another freight train heading west (3MP9), passed through Rawlinna on the main line.

Shortly after at 0910, authority W37 was granted to 3MP5 for the section between Loongana and Nurina. Near Loongana, the observing driver took control of train 3MP5 and the outgoing driver was now observing in the co-driver position. The resting driver remained in the crew van.

As train 3MP9 cleared Rawlinna on the main line heading west, train 4PS6 departed from the Rawlinna crossing loop heading east for a planned crossing with 3MP5 at Haig. At 0915, after train 4PS6 cleared the eastern points, the points activated a 'self-restoring' mode whereby the points would return to the normal position for main line movements. After 2 minutes, the points control system had not restored the points to the main line, and as a result the enhancer³ indicator light remained at red.

Meanwhile, train 3MP5 continued west towards Rawlinna. At 1015, authority W45 was granted to 3MP5 for the section between Haig and Boonderoo (81 km beyond Rawlinna). About 20 minutes

² The 24-hour clock is used in this report. Local time was Western Standard Time (WST)

³ The enhancer is a light indicator that relays information provided by the points and provides some additional (or enhanced) information of the condition of the trailing main line points.

later, train 3MP5 passed through Haig on the main line with train 4PS6 standing in the crossing loop⁴. The train continued, passing through Wilban on the main line at 1056.

At about 1110, approximately 8 km from Rawlinna, the crew acknowledged a message from the In Cab Activated Points System (ICAPS). As 3MP5 held a train authority to pass through Rawlinna on the main line, there was no requirement for any points control action to be sent via the ICAPS.

At about 1113, train 3MP5 passed the Rawlinna location board, positioned about 2600 m from the eastern end of the crossing loop points, travelling at 104 km/h.

A little further on, the driver called a green light on the enhancer at Rawlinna then double-checked the authority with the co-driver. The co-driver confirmed the authority was to proceed to Boonderoo via the main line. The driver checked the train for any irregular operation through the rear vision mirrors. A short time later, both drivers noticed the enhancer at the same time. The co-driver commented that the enhancer was showing red. The driver, who was wearing prescription tinted sunglasses, thought to himself that the enhancer was showing a steady yellow. Because the co-driver had called a red indication, the driver started to apply the train brakes. Both drivers commented that they thought the points were set for the mainline, as they could see the green arrow on the mechanical indicator.

The driver removed his glasses and immediately realised that the enhancer was displaying a red light. The driver continued to apply the brakes as the train approached the points, by which time the co-driver commented that he could now see 'some yellow of the dumb bell', indicating that the points may not be correctly set (Table 1).

Train 3MP5 was unable to stop and, at 1114:56, it travelled over the points (Figure 2) at 90 km/h and derailed. The train continued to travel derailed for a further 160 m, coming to rest between the main and loop lines. Both locomotives and the crew van tipped onto their sides. The following six wagons, totalling 389 tonnes and 450 m in length, all derailed. Most of the wagons jack-knifed into an area about 140 m in length (Figure 3).

Figure 2: Open points at Rawlinna – as seen from 3MP5.



Graphic derived from the General Electric LocoCAM showing the Rawlinna eastern points in an open condition. That is, the points are not closed for either the main line (straight through) or the loop line (diverging to the right). Source: Pacific National

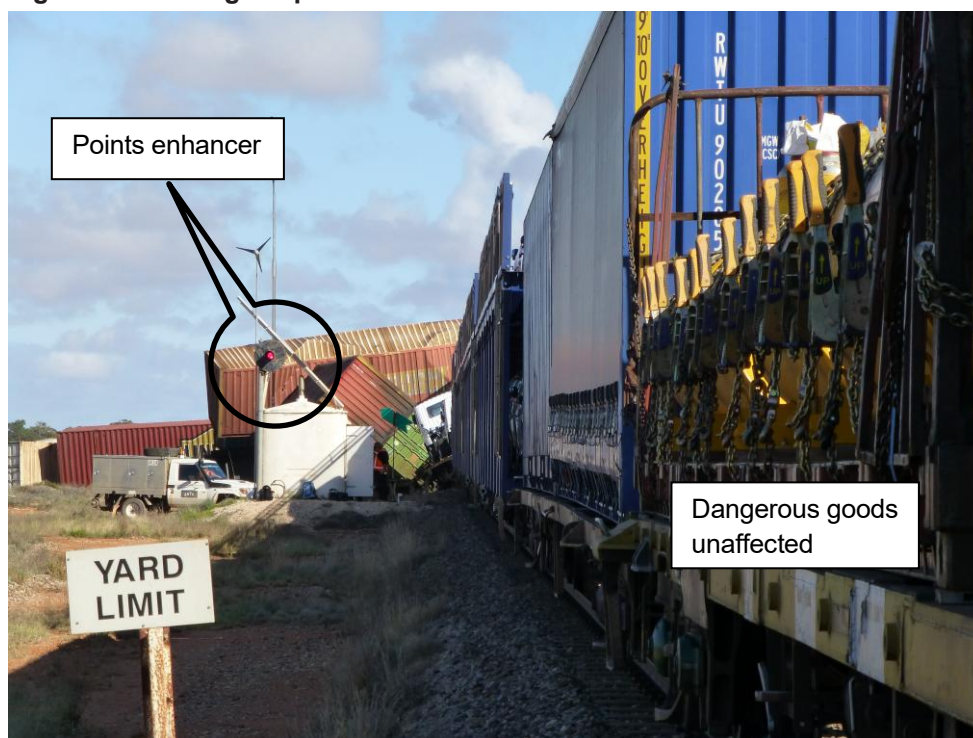
⁴ A length of track connected to the mainline by switches at both ends to provide a facility that permits trains to both cross and pass each other

At 1117, the crew, after checking themselves, notified train control. After initially having difficulty, they evacuated by climbing up inside cabin, through the side window, then down over the front of the locomotive. After exiting the cab, they started back to check on the condition of the resting driver in the crew van. The *Network Control Officer* (NCO) in train control notified a local Australian Rail Track Corporation (ARTC) track patroller in the vicinity to attend and help. Dangerous goods were on the train but were not involved in the derailment.

The position of the crew van made it difficult to reach the resting driver. The co-driver climbed onto the side of the crew van and smashed a side window to try to gain access to the resting driver, who was conscious, but had received moderate head and body injuries and, initially, was unable to be extricated from the wreckage. By this time the ARTC track patroller was on site and assisted with the extrication of the resting driver from the wreckage.

A registered nurse from a local property attended and rendered first aid to the resting driver. All three drivers were transferred back to their home depot at Kalgoorlie, signing off duty at 0030 on 22 April 2016.

Figure 3: Wreckage at points



Source: ATSB.

Figure 4: Front of train



Source: Pacific National co-driver,

Post derailment

About 200 m of track was damaged, including the points. The ARTC built a track deviation to the south around the wreckage in order to allow rail traffic pass while recovery works were undertaken. The deviation was completed and the track, main line only, was reopened to allow rail traffic to pass at 1351 on 25 April 2016.

Context

Location

Rawlinna is a crossing loop located at the 1403.000 km⁵ point on the interstate rail network in Western Australia. Train movements are managed by the ARTC from Network Control Centre West located at Mile End, Adelaide, South Australia.

Environmental conditions

At the time of the occurrence the weather was dry, with temperature about 21 °C and 55 percent humidity. The sky was slightly overcast with about 1/8 cloud cover. The sun was at about 45 degrees in the north.

Considering the conditions, sighting and conspicuity of the colour light enhancer or points indicator had not been adversely affected at the time of the occurrence.

Train and crew information

Train 3MP5 was an intermodal freight service operated by Pacific National between Melbourne and Perth via Adelaide. The train departed Melbourne on 19 April 2016 and arrived in Adelaide the following day.

On departure from Adelaide, the train consisted of locomotives NR 34 (leading) and NR 50 (trailing) hauling 32 wagons for a total length of 1693 m and gross mass of 4343 t.

Based on an analysis of the available evidence, the condition and serviceability of train 3MP5 did not affect its handling at the time of the occurrence and was not considered a factor in the derailment.

Train crew

At the time of the occurrence, the driver and co-driver of train 3MP5 had extensive railway experience working on the interstate rail network between Cook and Kalgoorlie.

The driver and co-driver were qualified in the operation of the locomotives, the ARTC Code of Practice (CoP) and in route knowledge for the portion of the network between Cook and Parkeston.

Toxicology, medical and physiological factors

Upon returning to the Pacific National offices at Kalgoorlie at about 2140, the crew submitted to a screening test for the presence of alcohol and drugs. Each crew member tested negative to the presence of alcohol and drugs.

An examination of the driver's and co-driver's health assessment records confirmed that their health assessments were current and that the individuals had been assessed as meeting the required standard, prescribed by the National Standard for Health Assessment of Rail Safety Workers. There was no evidence to suggest that any medical or physiological factors affected their performance leading up to or during the incident.

Fatigue

Fatigue can have a range of influences on performance, such as decreased short-term memory, slowed reaction time, decreased work efficiency, reduced motivational drive, increased variability in work performance, and increased errors of omission. Fatigue impairment has been identified as a contributing factor in accidents such as this.

⁵ Distance in track kilometres from a reference point located at Coonamia near Port Pirie, South Australia.

The crew had worked train 3PS6 from Kalgoorlie (sign-on 0250) to Cook (sign-off 1605) in the previous day (20 April 2016). They went to their designated accommodation in Cook, had dinner, and then went to bed. On the following day, the crew signed on for duty at 0540 (WST) for a 0602 departure as the ‘working out’ crew. Because the anticipated travel time was less than 12 hours, the crew worked ‘two-up’, with the third driver remaining in the crew van.

The duration of the off duty period meant that there was sufficient opportunity available for the crew to attain restorative sleep prior to commencing work. The drivers each advised that they had a good night’s sleep and felt well rested when they commenced duty. Therefore, it is unlikely that fatigue adversely affected the crew’s performance during this shift.

Safeworking system

The ARTC managed the safe movement of trains on the section of the network between Cook and Parkeston via a verbal communications based *Train Order Working* system (TOW). The system required the NCO to issue an authority to the train crew, who then recorded the authority on a paper based *Train Authority* (TA) form. The content is validated by reading the TA back to the NCO. The TA, once validated, authorised the train to proceed between the specified locations and in accordance with any additional instructions.

The train crew of 3MP5 executing the TA were required to comply with instructions contained in the TA together with the applicable rules and procedures contained in the ARTC *Code of Practice for the Interstate Rail Network* (CoP) and ARTC *Addendum to the Code of Practice for the Defined Interstate Rail Network* (Addendum) version 4.3 dated 4 October 2015.

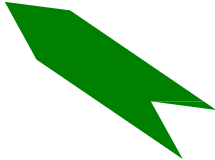
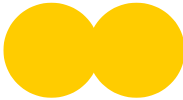
Train Authority rules and procedures

The NCO could issue a TA that authorised the crew to travel over a series of consecutive track sections that included a number of crossing loops or other locations. To enable the coordination of other train movements, the NCO may also request that the train crew report the times of their arrival or departure from specified locations en route.

Points indicator and remote control systems

Rawlinna was equipped with two systems to indicate the position of the self-restoring motorised points to approaching trains. Each set of points had a *points stand indicator* (Table 1) that was mechanically connected to the points mimicking the position of the points. It displayed whether the points were in the reverse (crossing loop line) or normal (main line) position and was reliant on approaching trains having a line-of-sight to the target.

Table 1: Points stand indicator target aspects

 Green arrow	 Yellow dumb bell
Points are set for the main line. The arrow points up and away from the line.	Points are set for the crossing loop.

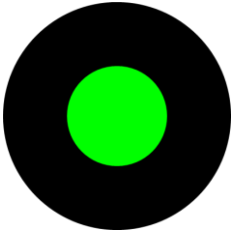
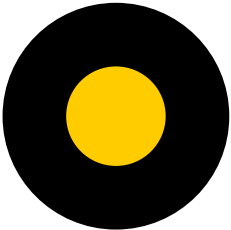
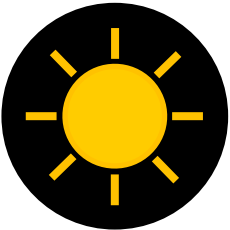
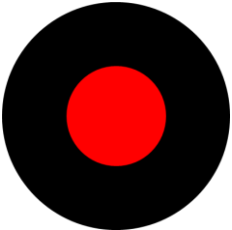
Points enhancer

In addition to the points stand indicator, a colour light indicator called the *points enhancer* was installed next to the points stand indicator. The enhancer indicates the position of the points and provides some additional (or enhanced) information. Due to sighting limitations caused by

obstructions at some locations, repeaters can be located (about 2500 m before the enhancer) that 'repeat' the indicator aspect (colour) of the enhancer in order to give advance warning of its condition. Rawlinna did not have repeaters installed.

The indications displayed by the enhancer⁶ are shown in Table 2.

Table 2: Colour light points enhancer aspects

			
Steady green	Steady yellow	Flashing yellow	Steady red
• Facing points are correctly set and locked for the main line. • Trailing points are correctly set and locked for the main line. • Proceed at authorised speed in accordance with the train authority.	• Facing points are correctly set and locked for the main line. • Trailing points are NOT correctly set and locked for the main line. • Proceed in accordance with Train Authority only to the clearance point at the other end of the location. • Stop and inspect or set trailing points.	• Facing points are correctly set and locked for the crossing loop. • Proceed onto the crossing loop only to the clearance point at the other end of the location. • Stop and inspect or set trailing points.	• The run down timer is in operation; or, • The points locking track circuit is occupied; or, • The points are not correctly set and locked for either route; or, • The points may be out of adjustment. • Stop and inspect the points.

The colour incandescent light of the enhancer is more conspicuous than the mechanical points stand indicator target. It also provides additional information on the lay of points at the other end of the crossing loop.

If the points at both ends of the loop are correctly set for the main line (as was intended in this case), the points enhancer would display a steady green indication. However, if the points do not fully transition for access onto the main line, the enhancer will display a red indication (as occurred in this case). The required action at a red indication is to stop and inspect the points.

The ARTC Addendum to the CoP (date 4 October 2015) states:

Where possible, following departure observe that the points have restored for the main line and a steady green aspect is displayed by the light indicator.

The intent of this requirement is to identify any failures before the passage of the next train. In this case, train 4PS6 was the last train to depart the eastern end of Rawlinna loop. However, given the length of the train (1552 m), train exit speed and the distanced travelled it may not have been possible for the crew to observe the points or light indicator via the locomotive driver's mirrors once the train had completely cleared the loop and the points have completed the intended function and returned to the normal position.

Radio remote control points operation

The crossing loop at Rawlinna was installed with radio remote control, self-restoring points. The system allowed drivers to select the loop line when approaching Rawlinna. The points would automatically return (self-restore) to the normal (main line) position after the train has fully entered or departed the loop line.

⁶ Code of Practice (Volume 3) for the Australian Rail Network, 3 December 2007.

Drivers are required to transmit (by an in-cab activated points system [ICAPS]) a designated command to initiate the points control sequence. The points enhancer would display red and, after a 120 s time delay, the points would move for access into the crossing loop. When the points were detected in the correct position and locked for the loop line, the indicators would display a flashing yellow light and the train could pass into the loop line. If the points are not detected fully home and locked, the indicator would remain red and trains would be required to stop short (clear) of the points.

The ARTC addendum to the CoP (dated 4 October 2015) section 6.9.2 states:

There is no requirement to enter a command to set the points for the main line.

The operation of the ICAPS equipment does not remove the responsibility of the train crew to ensure that the points are correctly set by observation of the Light Indicator and Point Indicator.

Section 6.9.2.1 further reiterates:

Train crews should not assume that the entry of the loop command will set the points for the crossing loop and shall control the movement prepared to stop at the facing points unless the point indicator is displaying that the points are correctly set for the movement.

Section 6.9.2.2 confirms:

If the movement is not required to select the loop, the driver is not required to take any action and shall proceed in accordance with the instructions on the train authority.

In this case, there was no requirement for the crew (train 3MP5) to operate the ICAPS equipment as their authority was to take the main line. The ARTC addendum to the CoP (dated 4 October 2015) section 19 *Maximum Train Speed for Particular Locations and Circumstances* states:

- b. At the location sign in advance of a location equipped with light indications and/or with points indications.

The train shall reduce speed, and be prepared to stop before the facing points. The maximum speed may be maintained or resumed when the Train Crew has confirmed that the correct indication is displayed.

Regardless whether the ICAPS is used or not, section 19 places a restriction on the approach speed of trains.

Post incident testing

Following the derailment, mechanical and electrical inspection and testing was conducted on the points. An initial assessment was conducted on the day of the incident and found that the equipment worked as designed. Examination of the electrical equipment data logs confirmed the enhancer indicator restoring to a red display, the run-down timer, movement and eventual timing-out of the action after the points had not reached the normal position, and the ICAPS transmission to train 3MP5.

A number of follow up tests confirmed that the points were mechanically correct and within specified operational tolerances. The ARTC could not identify a cause for the points failing to operate to normal. However, the system worked as designed and failed to a safe condition by maintaining the indicator at red after the points had not moved fully to the normal position.

The equipment at Rawlinna had been regularly maintained in accordance with the ARTC standards. The next scheduled inspection of the equipment was due on the day of the derailment.

Pacific National systems

In-cab activated points and GPS location alerter systems

The Pacific National NR Class locomotives were fitted with In-Cab Activated Points System (ICAPS), and the Pacific National AWARE⁷ and GPS location alerter systems. The systems were interconnected to provide the required functionality.

The ICAPS enables the remote operation of the self-restoring point machines⁸ at crossing loops by the crew from the locomotive cab, allowing train crews to set the required route without having to stop the train. ICAPS activation occurs at a strike-in point (generally 5 to 8 km from the facing point at each crossing location) and remains active for a distance of about 2 km, providing a window within which the crew can remotely operate the points. The functionality to operate the points is deactivated once the train is outside this window. Pushbutton controls located adjacent the point machine are available if a train is required to stop for the crew to manually operate the points.

When ICAPS is activated, a screen in the locomotive cab displays a message showing the location name and two touch-screen buttons. An audible tone accompanies the message to alert the driver that the system is active. If a loop movement is authorised, the crew can command the points to set for the crossing loop. If a main line movement is authorised, the crew can dismiss the message and leave the points in their current position (usually set for the main line). Similarly, if the crew take no action, the points will remain in their current position.

The GPS location alerter system is an enhancement to the AWARE system that provides track position information to the train crew when approaching a crossing loop or block point location.⁹ The purpose of the system is to 'prompt the train crew to check their current limit of authority'.¹⁰ If the crew has already made an ICAPS selection for the loop, the alerter will not activate since the crew has taken action relevant to the train authority.

The GPS location alerter system displays a message on the AWARE screen when the locomotive is about 5 km from the crossing location. A single audible beep is also sounded, but under the ARTC CoP there is no requirement to acknowledge the message.

When a locomotive is within 3 km of the crossing location, the system sounds three audible beeps and a message on the AWARE screen. For this alert, the system requires acknowledgement within 10 seconds using the AWARE system touchscreen located adjacent the co-driver's position. If not acknowledged, the audible beeps continued with increasing volume until actioned or if the train has travelled 3 km past that particular crossing location.

When the locomotive is about 3 km past the crossing location, the AWARE screen displays a message identifying the name and track kilometre point for the next crossing loop. This message is not accompanied by an audible tone and there is no requirement to acknowledge it.

Together, this combination of systems provides a sequence of messages and audible alerts to the train crew at each location traversed. The systems do not have (nor are they required to have) the functionality of providing real time train location information to network control. Similarly, the systems do not provide information relating to the condition of the points.

⁷ Australia Wide Augmented Radio Environment System, a touch screen communications system. An AWARE screen is provided for both the driver and observer (co-driver) positions in the locomotive cab.

⁸ A qualified employee sets the self-restoring point machine to the required lie prior to the passage of a rail vehicle. The self-restoring point machine automatically returns to the default position following the passage of the rail vehicle.

⁹ A place where trains are not able to cross or pass but is available for the purpose of reporting or obtaining an authority.

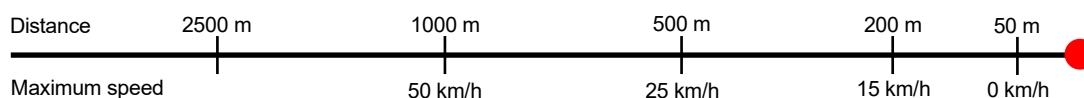
¹⁰ Pacific National Information Bulletin No. 54A, AWARE Train Radio System, GPS Location Alerter – Driver Information System.

Safety critical zones

A strategy used by some Australian rail operators to enhance train crews' threat and error management is the identification of 'safety critical zones'.¹¹ A safety critical zone is generally identified as a set time or distance on approach to a known higher risk phase of the trip, such as a stopping location, or limit of authority. While in the safety critical zone, the crew restricts all attention, actions, and communications to safety critical functions to the exclusion of other non-critical tasks or communications. Ideally, on entering the safety critical zone, the crew would also conduct a briefing to confirm each crew member's responsibilities during this period, thus verifying assumptions and expectations before proceeding.¹²

The Pacific National document *Defensive Train Handling Techniques and Strategies* provided general advice for the safe working and operation of Pacific National intermodal services throughout Australia. The document defined a safety critical zone (Figure 5) and specified the need for train crew to restrict all their actions and attention to safety critical communication, and appropriate defensive driving and train handling techniques within this zone, to ensure that they stop the train prior to the designated stopping point.

Figure 5: Pacific National Safety Critical Zone



Source: Pacific National, enhanced by ATSB.

Sun glasses

The driver stated that on this occasion, he was wearing prescribed sunglasses supplied by an ophthalmic retailer through Pacific National. The lenses were tinted grey and not polarised, Figure 6.

Figure 6: Prescribed tinted sunglasses



Source: ATSB.

¹¹ See for example, Australian Transport Safety Bureau (2014) *RO 2013-019 Overrun of authority involving train 6MP5, Blamey, Western Australia 14 July 2013*. p6. Available from

¹² Rail Safety Regulators' Panel (2007b). *Rail Resource Management Training Toolkit, Facilitator Guide, Module 6, Situational Awareness*.

An ophthalmic retailer website¹³ states that grey tinted lenses:

Grey - reduces brightness and glare, a neutral tint that transmits colours so they retain their true beauty. Best for bright outdoor sunlight to help reduce squinting and eyestrain

The driver had last undergone a medical assessment on 25 May 2015. This assessment included vision and colour blindness testing, requiring 'normal colour vision' for identifying point sources such as signals. The driver was declared fit for duty without restriction.

Given the driver's fitness for duty and no evidence of colour interference from a grey tint, it is likely that the prescription sunglasses worn by the driver did not affect the colour transmission of the red indicator. It is plausible that other factors such as distance, heat haze, and expectation may affect the interpretation of a red indicator.

As a result of the ATSB investigation, the Office of the National Rail Safety Regulator (ONRSR) reviewed literature regarding misperception of signal colours. Studies conducted by Hovis (2011)¹⁴ concluded that the North American and European standards did not meet the requirements for the railroad in the Canadian environment. The Australian/New Zealand standard also did not meet all the requirements for the railroad environment.

Further studies had been conducted which showed that in addition to tint, other properties of lenses could cause red railway signals to be perceived as yellow. When conducting a study in this field, Wood et al, (2005)¹⁵ reported concerns by a Queensland Rail train driver that yellow signals appeared to be red when viewed through graduated lenses. A subsequent study found that the colour misperception occurred with both progressive-addition lenses and lenses with small amounts of positive defocus.

¹³ <http://www.opsm.com.au/sunglasses/prescription-sun-lenses>

¹⁴ Hovis, J. K. (2011). *When yellow lights look red: tinted sunglasses on the railroads*. *Optom Vis Sci*. 2001 Feb;88(2):327-33. doi:10.1097/OPX.0b013e31820847f1.

¹⁵ Wood JM, Atchison DA, Chaparro (2005) A When Red Lights Look Yellow. *Investigative Ophthalmology & Visual Science* 46(11): 4348-4352

Safety analysis

Sighting distance versus braking distance

Train crew vigilance and effective indicator sighting distance are critical. The enhancer lights at Rawlinna consisted of an incandescent long distance (K3) search light. Depending on lens system, lamp, and ambient conditions, the K3 signal can attain a range of up to 2500 m in clean air. Any form of beam spread applied to a signal reduces its range. Based on the recollections of train crews (including 3MP5), the effective sighting distance of the eastern enhancer light is about 1000 m. ATSB investigators onsite measured about 1200 m sighting of the eastern enhancer light from ground level. This is dependent on time of day, weather, heat haze, direction of sun, and other environmental conditions.

Figure 7: Sighting from Rawlinna location board

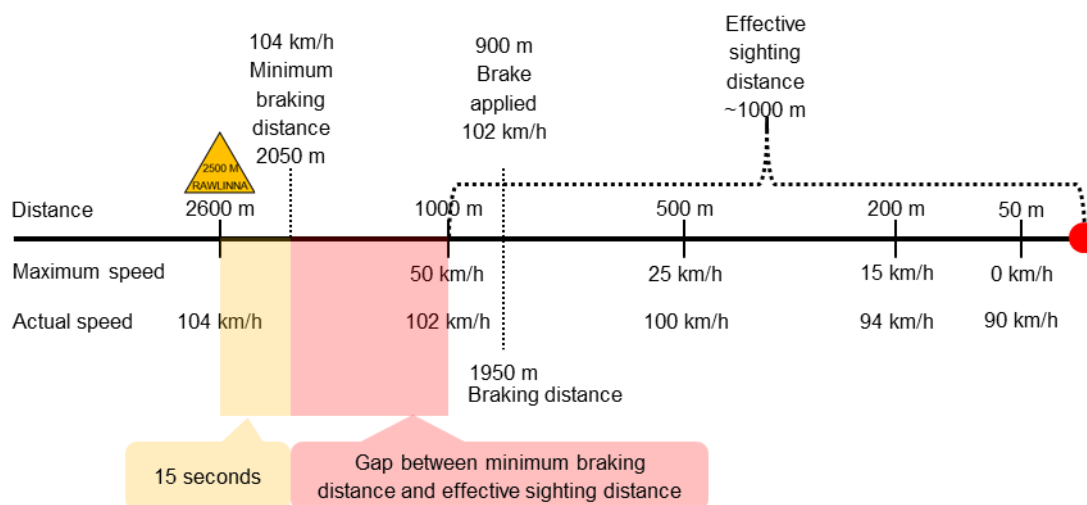


Source: ATSB.

The ARTC use a train braking calculator¹⁶ when determining braking distances of trains. The calculator specifies a full service braking application stopping distance of 2220 m for an 1800 m freight train, three quarter loaded and travelling at track speed of 110 km/h.

Train 3MP5 was approaching the location board at 104 km/h. Using the same parameters, the calculator specifies a full service braking distance of about 2050 m on level track. This equates to about 15 seconds for the train crew to make a full service brake application after passing the Rawlinna location board, Figure 7.

¹⁶ ARTC STOPDIST version 2.1, GW-50

Figure 8: Sighting and braking distances

Source: ATSB.

Figure 8 illustrates a gap of about 1050 m between the minimum full service braking distance and effective sighting distance. In order for trains to approach at a speed at which they can stop, a brake application is required near the location board. Following this, it is inevitable that a train travelling at about 100 km/h at a sighting distance of 1000 m would not stop in time. Train 3MP5 was travelling at 102 km/h when the co driver called a red enhancer and the brakes were applied. This equates to a full service braking distance of about 1950 m on level track, considerably more than the 900 m available in this case.

When considering Pacific National's train handling guidelines and safety critical zones, Pacific National trains should be braking at the location board in order to reduce speed to 50 km/h at the 1000 m point. This would allow trains greater time to slow or stop as required or until the condition of the points could be positively confirmed.

However, other train operators over this section of track may not have the same guidelines as Pacific National. The absence of advanced warning (such as a repeater enhancer) or other measures to manage train speed (such as permanent speed restrictions), places further reliance of drivers' interpretation of what an appropriate approach speed is (in line with ARTC procedures) before sighting of the enhancer is possible.

Following the incident, Pacific National conducted an audit of enhancer sighting distances between Cook and Kalgoorlie, both east and west bound. The results of the audit found that about 50 percent of locations exhibited effective sighting distances of less than 2000m in daylight hours. Although sighting distances may not be ideal depending on local conditions, current rules and procedures, when followed, should address and increased risk.

Rules and routine violations

The ARTC use a master train plan (timetable) to manage/plan train movements on their network. The master train plan is a complete listing of all contracted path schedules and associated information for the entire ARTC network.

The master train plan relies on section running times between locations. The ARTC publishes indicative section running times to assist stakeholders.

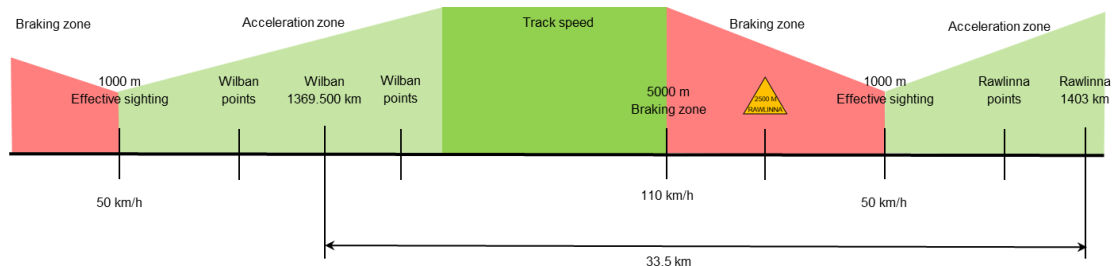
The ATSB examined the ARTC section running times to ascertain if enough time was allowed for trains to safely traverse a section while complying with the ARTC rules and PN's train handling guidelines.

The master train plan allows 23 minutes for trains to travel the 33.5 km long section between Wilban and Rawlinna. This equates to an average speed of 87 km/h throughout the section, well below the track speed of 110 km/h.

The section between Wilban and Rawlinna was then divided into operational zones (Figure 9) to determine the appropriateness of the section running time. Given the difference between braking distance and effective sighting distance of the enhancer, the braking zone is compressed into a full service application at the location board. In reality, this is not consistent with best practice driving principles. Best practice driving involves predictive driving, anticipating braking requirements well in advance.

The section running time of 23 minutes for train 3MP5 was analysed as shown in Figure 9.

Figure 9: Section time analysis



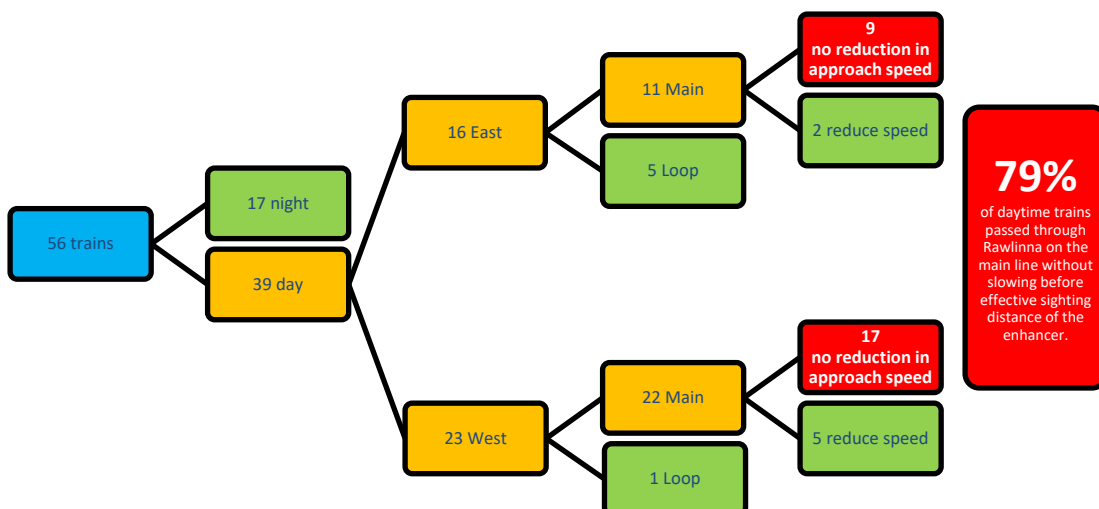
Source: ATSB. Not to scale.

The analysis concluded that the section running time allowed for train 3MP5 between Wilban and Rawlinna was likely adequate for normal running. The section running time did not include extra time for adverse weather or other conditions that might affect train-running speeds.

The ATSB also examined recorded data so as to understand the common behaviour of trains approaching crossing locations. The data was derived from the Rawlinna ICAPS GPS data for the period between 14 April 2016 and 21 April 2016 (seven days leading up to the incident).

Train speeds were examined over the section beginning 6 km prior to the enhancer/points. Movements outside of daylight hours were excluded due to enhancer conspicuity and increased sighting distance. The results are shown in Figure 10.

Figure 10: Approach speed analysis results



Source: ATSB.

The results indicate that 79 percent of daytime trains (passing through Rawlinna) do not slow down before the effective sighting of the enhancer, both east and west. This meant that trains

were approaching Rawlinna at a speed where the train crew cannot ensure stopping at the points if the enhancer is not indicating the road is correctly set for the main line, or it was incorrectly read.

Although this analysis focused on data from Rawlinna, it is likely that this is common practice for most trains traversing other crossing locations where self-restoring points and enhancers/point indicators are installed. This common practice is not consistent with the ARTC addendum to the CoP (dated 4 October 2015) section 19 *Maximum Train Speed for Particular Locations and Circumstances*.

Furthermore, this common practice may involve multiple operators, other locations, and varying operational circumstances increasing the likelihood of an occurrence.

Train handling

The crew approached Rawlinna with authority to pass through on the main line. There was no requirement to interact with the ICAPS system. Therefore, the crew had the expectation that the points were correctly set and they could continue as per their authority. Unbeknown to the train crew, the points had failed to self-restore to the normal position after the last train 4PS6. This meant that the protection of the points relied solely on the vigilance of the train crew, defensive train handling techniques, ARTC procedures; and the sighting distance of the enhancer light, the last lines of defence.

Factors affecting crew actions

Train driving is a complex task performed in a dynamic environment, requiring the processing of information from outside the cab (eg. signals, speeds, landmarks) combined with a detailed body of experientially acquired route knowledge to effectively control the train. Efficient train handling demands sustained attention over long time periods wherein the driver must respond to current task demands whilst also using higher level cognitive processing to plan ahead with mental time-distance estimations.^{17 18} Furthermore, this demanding role is also often performed in a time constrained organisational context.

Both route knowledge and two driver operations are widely considered to be key defences for human performance limitations as they apply to train driving.

Route knowledge and expectancy

Expectancy can be understood as the extent to which an event or condition is expected to occur or be present at a particular time and place. An individual's expectation can influence their attention to (and preparation for) that event or condition¹⁹. In this case, the train crew said they did not expect to have the colour light points enhancer at red as they were traveling through on the main line. Thus, it can be interpreted that the crew had, through considerable experience, come to trust that the automated points activation system was highly reliable. They had no expectation that they would encounter any issues with the points activation, and anticipated that the enhancer would be displaying steady green as they approached.

This effect is consistent with automation research which has found that systems which have been shown to be reliable can create an effect of over-trust. People will over-depend on the automation, and pay less attention to the true behaviour of the system (in this case, the points and points indicator) which is being controlled by the automation.²⁰

¹⁷ Naweed, A. (2013). Psychological factors for driver distraction and inattention in the Australian and New Zealand rail industry. *Accident Analysis and Prevention*, 60, 193-204.

¹⁸ Naweed, A. (2014). Investigations into the skills of modern and traditional train driving. *Applied Ergonomics*, 45, 462 - 470.

¹⁹ Wickens C.D. & McCarley, J.S. (2008). *Applied Attention Theory*. CRC Press: Boca Raton. pp 55-57.

²⁰ Wickens & McCarley (2008). p59.

Both drivers' previous experience of the area, as well as their trust in a normally reliable automated system created an expectation that the points would be set, detected, and locked for the main line.

The driver's expectation that the signalling system was likely set for the main line, contributed to the overrun of the points.

Train crew emergency evacuation

The Rail Industry Safety and Standards Board (RISSB) of Australia is responsible for the development, maintenance and management of the rail industry's:

- Standards
- Codes of Practice
- Rules, and
- Guidelines.

RISSB develop these products using input from rail experts from across the rail industry to represent good practice for the industry in Australia. The standard relevant to emergency evacuation is *AS 7522-2012 Australian Standard - Railway Rolling Stock Access and Egress*, and is provided in three parts:

- Part 1: Locomotive Rolling Stock
- Part 2: Freight Rolling Stock
- Part 3: Passenger Rolling Stock

Locomotive

For locomotives, Part 1, Section 6.2 *New and Modified Rolling Stock*²¹ states:

Enclosed cabs of new and modified rolling stock shall be fitted with sufficient emergency exits to provide escape paths to the vehicle exterior when the vehicle is upright and when overturned on the side.

A suitable solution is for emergency exit windows on each side and another emergency exit either in the front or rear of the compartment.

The NR class locomotive has an enclosed cab. Access and egress to the cab was via a single door to a central vestibule, and two doors to the outside of the locomotive (Figure 11). This access was also the primary emergency escape path. Although the construction of the NR class locomotive (NR34) occurred prior to the publication of the RISSB Standard AS 7522, Pacific National had included the identification of an alternate escape path through the locomotive cab side windows. The alternate escape path was available after sliding open the side windows.

²¹ Modified rolling stock refers to where changes have been implemented that affect its compliance with the requirements in the standard.

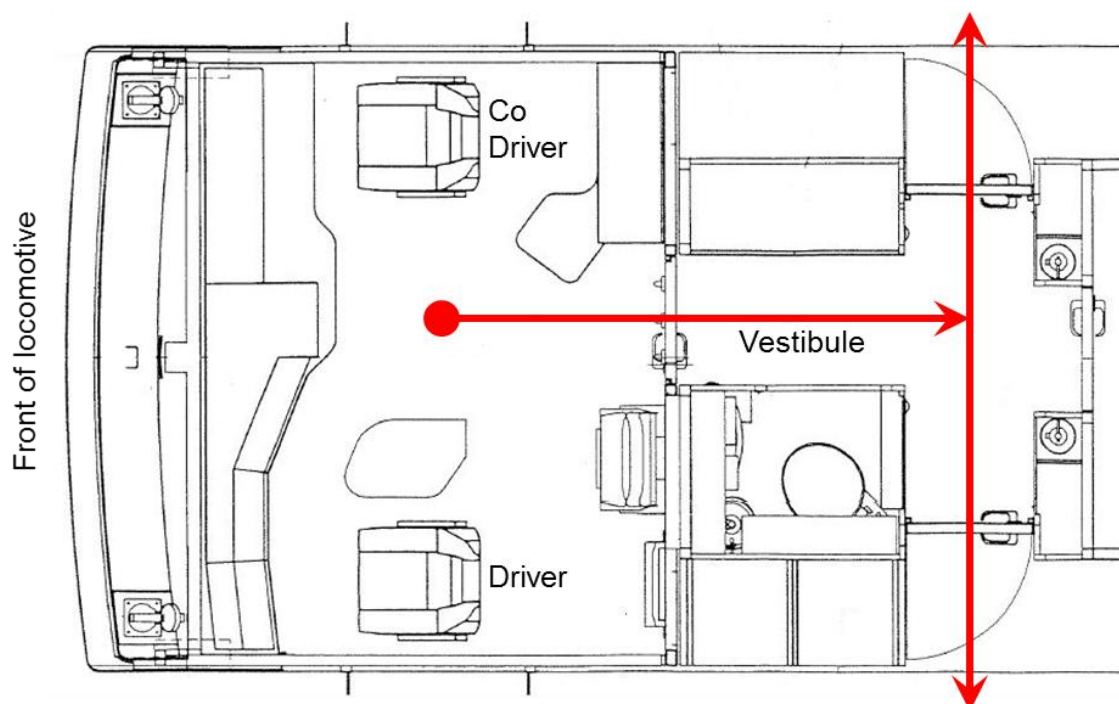
Figure 11: NR class locomotive cab access/egress schematic

Diagram of NR class locomotive primary emergency egress path (in red) through centre vestibule and rear side doors. Source: Pacific National Annotated by ATSB.

Following the derailment on 21 April 2016, locomotive NR34 came to rest on the co-driver's side (right side in direction of travel). Both drivers were thrown into the side of the cab (Figure 12).

Pacific National advised that the emergency escape paths/arrangements to evacuate from a locomotive were part of the training delivered during trainee development. The effectiveness of this training for an escape from a situation where a locomotive had tipped was not evident.

Although the emergency escape paths from an NR class locomotive provided options, these options became less accessible with the locomotive on its side.

In the derailment of train 3MP5, both identified escape paths necessitated the crew climbing on internal structures to facilitate egress. The minor injuries sustained by the drivers did not overly affect their escape in climbing up through the cab and out of the side window (now on top).

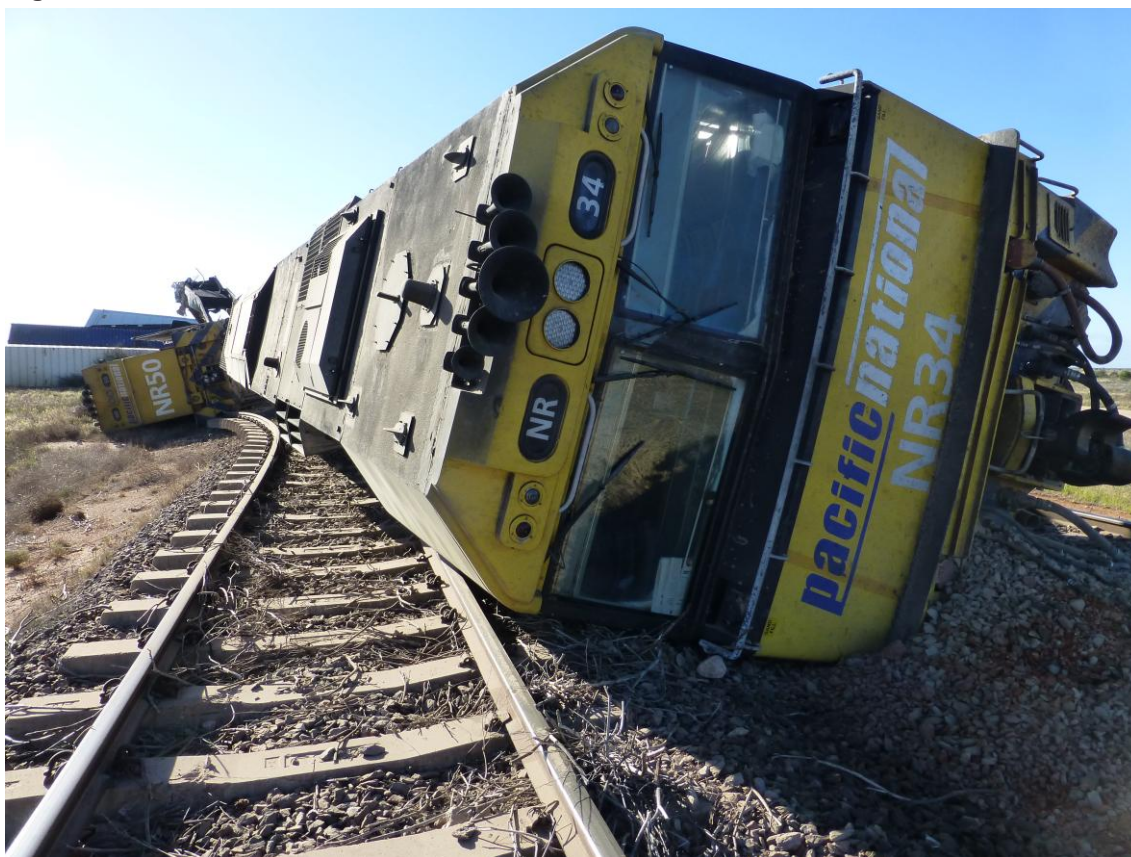
Figure 12: Locomotive NR34 cab

Image showing resting position post derailment. Source: ATSB

Crew van

The RISSB standards for railway rolling stock define passenger rolling stock as vehicles that carry people and facilities for these people²². Consequently, a crew van is generally considered to be a passenger vehicle and the relevant standard for access and egress is AS 7522 Part 3: *Passenger Rolling Stock*. This standard stated:

Enclosed cabs of new and modified rolling stock shall be fitted with sufficient emergency exits to provide escape paths to the vehicle exterior when the vehicle is upright and when overturned on the side.

The crew van consisted of a modified FAM passenger coach. The original FAM configuration contained nine twin sleeper berths. The reconfigured FAM wagon (circa 2012) contained six sleeping berths and a common area containing an entertainment area and kitchen area. The FAM wagon is used by resting train crews.

The crew van is a steel-framed car, has a stainless steel body and rides on all-steel two-axle bogies. Metal-framed rectangular windows are evenly spaced down the sides of the carriage. Vehicle access is via two external side doors into a central vestibule, and a vehicle end door (Figure 13). The external doors were also the primary emergency escape paths. A supplemental escape path through side windows was available after removing the window, and lowering an emergency ladder out of the window.

²² Locomotive and infrastructure maintenance rolling stock are excluded.

Figure 13: FAM crew van layout and exits

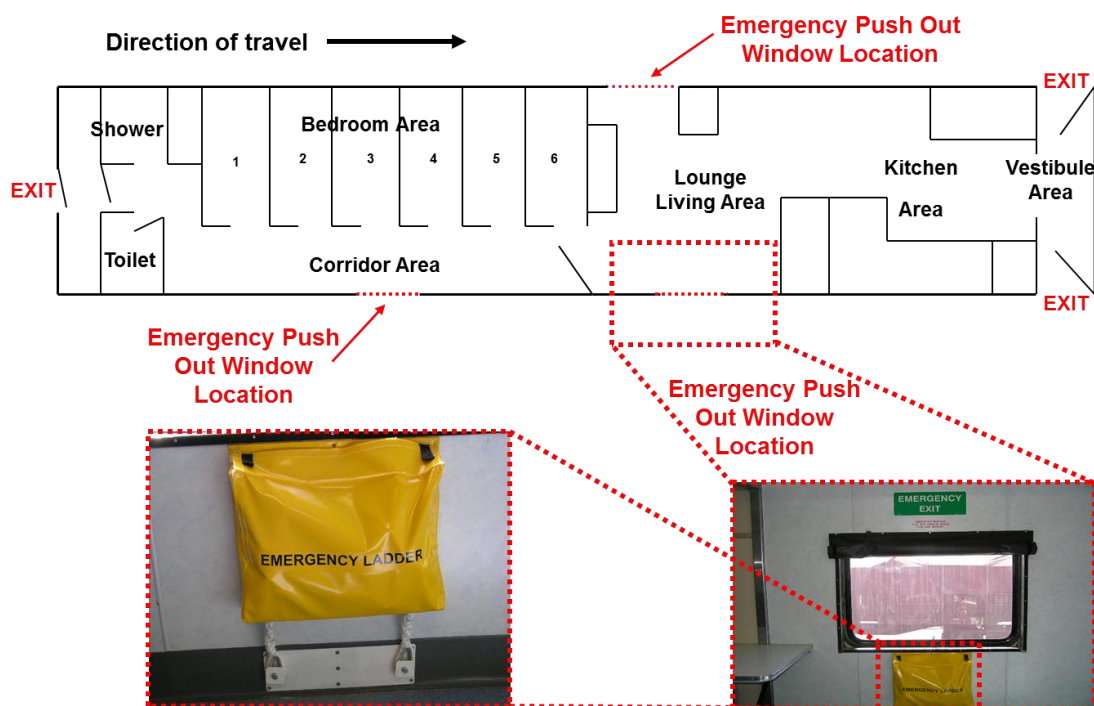


Image showing internal layout of the crew van. Source: Pacific National

Following the derailment, the crew van came to rest on its left side in direction of travel. The resting driver was thrown around inside of the van (Figure 14) and received facial lacerations from a lunch box.

Figure 14: Crew van resting position



Image showing resting place of the crew van. Source: ATSB.

The driver in the crew van could not access the primary escape paths. Similarly, since the vehicle was on its side, the driver could not reach the emergency push-out window, so remained trapped. Both drivers (from the locomotive) tried to assist the driver in the crew van. Initially, the emergency window accessing the dining area was smashed and the emergency ladder deployed (Figure 15).

Figure 15: Crew van emergency ladder



Image showing emergency exit ladder inside the crew van. Source: Driver of 3MP5.

Unfortunately, the ladder was only designed to be deployed to the ground outside the window, providing effective egress from a wagon in an upright position. In this case, the wagon was on its side and the mounting position of the ladder made it ineffective as a method to allow escape. Consequently, the resting driver remained trapped in the crew van until an ARTC worker (who attended the incident site) could provide a standard step ladder (Figure 16).

Figure 16: Crew van evacuation



Image showing step ladder used to extricate the driver from the crew van. Source: Driver of 3MP5.

It is evident that, in this case, the crew van did not meet the requirements of AS 7522 since the driver could not access any escape paths without assistance and additional equipment.

Findings

From the evidence available, the following findings are made with respect to the derailment of train 3MP5 at Rawlinna, Western Australia, on 21 April 2016. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance.

A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

Contributing factors

- The eastern points at Rawlinna failed to fully transition for the main line.
- The driver's expectation that the system was likely set for the main line contributed to train 3MP5 travelling at a speed where it could not be stopped before the open points.

Other factors that increased risk

- It is likely a common practice for drivers to approach crossing locations without slowing when authorised for the main line.
- The points enhancer sighting distance is less than the effective braking distance of trains travelling at line speed, thereby increasing the risk of overrun if not displaying a green aspect.
- The crew van did not meet the requirements of AS 7522-2012 - Railway Rolling Stock Access and Egress, since the occupant could not access any escape paths without external assistance and additional equipment.

Other findings

- The failure of the points to operate to normal could not be established. However, the colour light point indicator system worked as designed by displaying a red indication when the points were unable to be detected and locked in a safe position.
- It is unlikely that fatigue adversely affected the crew's performance during this shift.
- There was no evidence to suggest that any medical or physiological factors affected their performance leading up to or during the incident.
- The section running time allowed for train 3MP5 between Wilban and Rawlinna was likely adequate.

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the rail industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report.

Additional safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Office of the National Rail Safety Regulator (ONRSR)

As a result of the ATSB investigation, the ONRSR became aware of research papers and looked further into the possibility of prescription glasses with progressive lenses altering the perception of signal colours.

Pacific National

Pacific National advised the ATSB of the following proactive safety actions in response to the incident the subject of the Draft Report, for inclusion in the Final Report:

- Following the incident, Pacific National issued Safety Share INT-NOT-SAF Share LSN 16-56 – Rawlinna Derailment, to Pacific National Intermodal personnel in WA.
- Pacific National has conducted a Light Indicator (Enhancer) distance sighting analysis for the section of ARTC track between Cook, SA and Parkeston, WA.
- Pacific National will provide ARTC with the Light Indicator (Enhancer) distance sighting analysis conducted for the section of ARTC track between Cook and Parkeston by Pacific National to determine what improvements can be made to improve sighting distances where required.
- Pacific National will approach ARTC to promote improvements to track infrastructure that support driver decision making on the approach to self restoring motorised points, including the potential introduction of a system to issue a warning or alert to operators when the Self-Restoring Switch (SRS) system fails to restore correctly for the main line at all crossing locations between Cook and Parkeston.
- Pacific National has completed the design of an additional emergency egress option for NR class locomotives through the front windows. Pacific National has commenced installation of the emergency egress windows on NR class locomotives and it is anticipated that the installation on all NR class locomotives will be completed by December 2017. In addition, consideration is being given to additional emergency egress options for other classes of Pacific National locomotives.
- Pacific National has conducted a mainline risk assessment which includes assessment for train operations approaching facing points including the hazard of derailment and the associated identified controls.

Australian Rail Track Corporation (ARTC)

- Australian Rail Track Corporation has undertaken the development and roll out of Advanced Train Management System (ATMS) Technology with a view to installing ATMS on the ARTC network between Tarcoola and Kalgoorlie. Australian Rail Track Corporation has invested significant effort and funding into the development of ATMS , a system which has the ability to identify and negate contributing factors to this incident. ATMS creates a safer operational environment by increasing the levels of control, detection and visibility available to Network Control Officers, provides system generated validations and warnings to Train Crews and has the capacity to initiate a brake application to arrest an unsafe condition if the condition is not recognised by or negated by the locomotive crew.
- ARTC have undertaken to review the enhancers at Rawlinna recording the sighting distance, type and any obstructions impacting on sighting.
- ARTC have undertaken discussions with train operators to reiterate the requirements of the ARTC Addendum to the Code of Practice for the Defined Interstate Rail Network Section 19 when approaching a location equipped with light indications and/or with points indications.

General details

Occurrence details

Date and time:	21 April 2016 – 1115 WST	
Occurrence category:	Serious incident	
Primary occurrence type:	Derailment	
Location:	Rawlinna, Western Australia	
	Latitude: 31° 00.315' S	Longitude: 125° 19.537' E

Train details

Train operator:	Pacific National	
Registration:	3MP5	
Type of operation:	Intermodal express	
Persons on board:	Crew – 3	Passengers – Nil
Injuries:	Crew – 2 minor, 1 moderate	Passengers – Nil
Damage:	Substantial track damage, destroyed rolling stock	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Australian Standards
- Australian Rail Track Corporation rules, procedures, and standards
- Pacific National rules, procedures, and standards
- Recorded data

Submissions

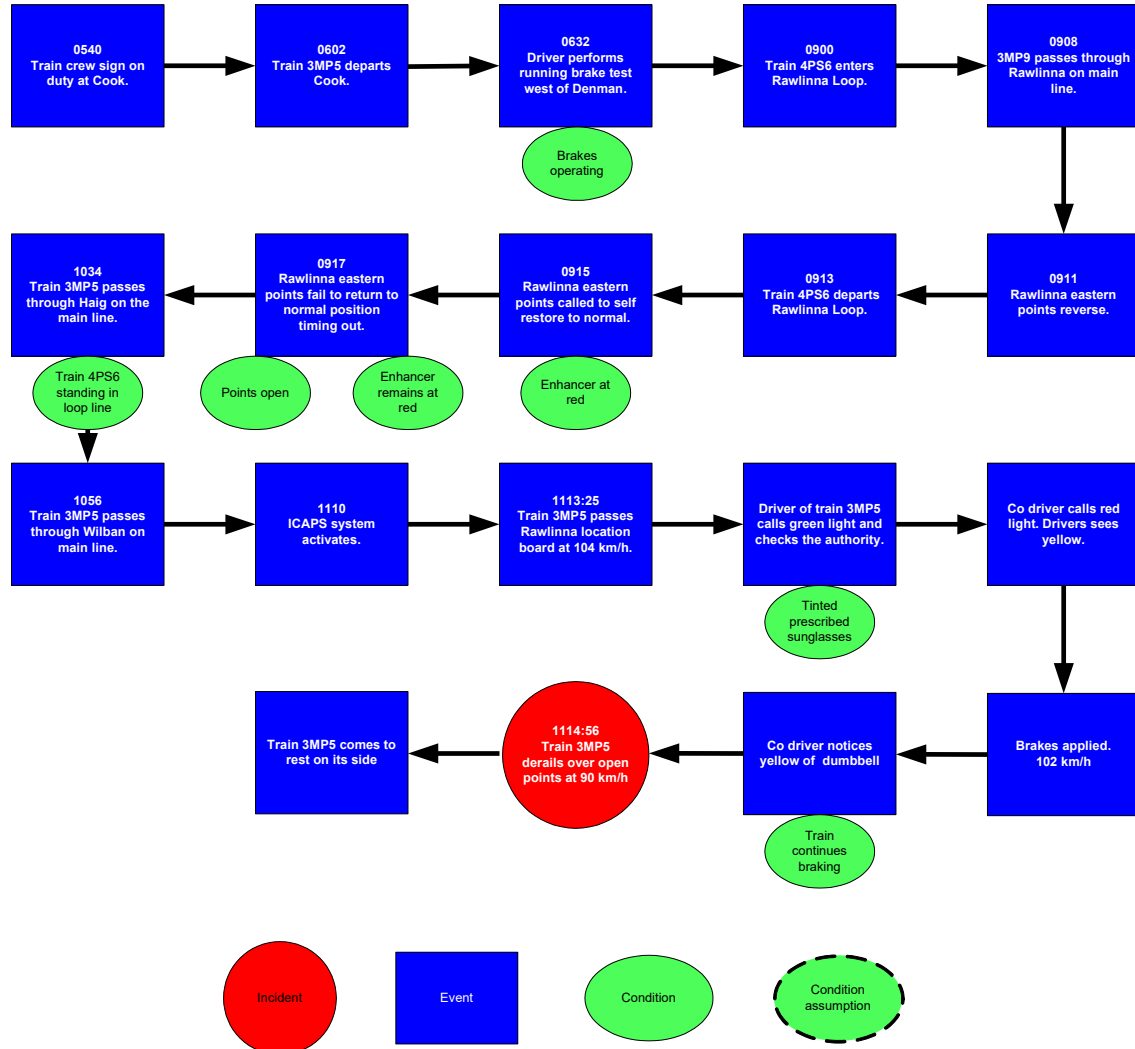
Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to Pacific National, the Australian Rail Track Corporation, and the Office of the National Rail Safety Regulator.

Submissions were received from Pacific National, the Australian Rail Track Corporation, and the Office of the National Rail Safety Regulator. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Appendices

Appendix A – Sequence of events



Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.