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Australian Transport Safety Bureau

Derailment of train 7MP7

Coonana, Western Australia on 19 August 2018

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Addendum

Page	Change	Date

Safety summary

What happened

At about 1040 on 19 August 2018, the train crew of Pacific National train 7MP7, travelling from Cook, South Australia to Parkeston near Kalgoorlie in Western Australia approached the points located at the eastern end of the Coonana train order location. Around 4 hours earlier, the trackside interlocking at Coonana detected that the point machine at the eastern end had not set correctly for the main line following the passage of a previous train. The colour light indicator (enhancer) situated adjacent to the point machine displayed a red light (stop indication) to approaching train crew of 7MP7.

During the approach to Coonana, the train crew of 7MP7 maintained track speed while looking for the light displayed by the enhancer ahead. When they realised that they could not see the enhancer, they braked but were unable to stop train 7MP7 before it traversed the eastern point machine travelling at 44 km/h and derailed. The two lead locomotives, unoccupied crew car and first two platforms of the lead wagon derailed, destroying around 200 m of the main and crossing loop tracks. The train crew were uninjured.

What the ATSB found

Point machines at each end of Coonana crossing loop would normally be set to allow travel along the main line. An incorrectly stored locking pin from a point clamp dislodged and caught in a mechanical pivot mechanism attached to the eastern point machine, preventing the correct movement of the points to reset for the main line after the departure of the previous train.

The ATSB found that during the approach to Coonana the train crew sought to identify and confirm the light displayed on the enhancer. While doing so, the speed of 7MP7 was not sufficiently reduced at the Location Ahead sign to ensure the train could be stopped before the facing points should the light indicator not display a green aspect. Additionally, a breakdown in verbal communication between the supervising and trainee driver resulted in a misunderstanding of the significance of not sighting the enhancer indication when predicted, and the urgency of the intended action to brake the train. Consequently, train 7MP7 approached the eastern end of Coonana at a speed where it was unable to stop before the open points.

The subsequent manipulation of locomotive control inputs in response to the situation highlighted how the on-the-job component of the Pacific National driver competency program did not adequately prepare the trainee driver to control the train in response to an emergency.

What's been done as a result

Post the derailment of 7MP7, the Australian Rail Track Corporation (ATRC) removed all point clamps from the point indicator stands and relocated them to the adjacent equipment huts at each location between Malbooma (South Australia) and Parkeston (Western Australia). Additionally ARTC have replaced all K3 searchlight units with long-range LED luminaire type units between Malbooma and Parkeston.

Pacific National (PN) introduced a SPAD reduction program and reinforced that train crews reduce speed in preparation for stopping short of facing points, until both drivers confirm recognition and understanding of indicator aspects. Additionally PN discussed with ARTC the implementation of improvements to point indicators between Kalgoorlie (Western Australia) and Cook (South Australia).

Safety message

The practice of maintaining momentum approaching a train order location, before confirming the enhancer indication, is an issue that probably affects multiple operators. The variability in the distance for the effective sighting of enhancers and targets at these safety critical locations means the available distance when an indication is sighted may be less than the effective braking distance of the train, which represents a physical gap or limitation in the system. This gap/limitation places the onus on train crews to implement a rule-based procedure to reduce speed at defined locations repeatedly, in preparation for an anomalous event where the enhancer might display a red light (stop indication).

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The occurrence

At about 0320[1] on 19 August 2018, a train crew comprising a supervising and trainee driver signed on to duty at Cook in South Australia. They were rostered to work a westbound Pacific National freight train (7MP7) to Parkeston, located near Kalgoorlie in Western Australia (Figure 1). The journey to Parkeston was the return leg of their first round trip[2] together as a crew.

Figure 1: Referenced locations between Cook and Parkeston (Kalgoorlie)

Source: Geoscience Australia, annotated by ATSB

The crew took control of 7MP7 following its late arrival into Cook. After refuelling train 7MP7, the crew received a Train Authority[3] (TA) from the Australian Rail Track Corporation Network Control Officer (NCO). With the trainee driver driving, train 7MP7 departed Cook at about 0347, approximately one hour later than the scheduled departure time. Shortly after, as 7MP7 approached the Koonalda Block Point,[4] the driver performed a routine running brake test,[5] which indicated no abnormality in the train's braking performance. The lead locomotive intermittently lost traction en-route, activating the wheel slip alarm, causing the train crew to apply various driving techniques in an attempt to rectify the issue and restore tractive effort.

At about 0545, the crew travelled through the main line at Reid, crossing the first in a series of eastbound trains that would be stopped on the adjacent loop track at the respective crossing locations. Around the same time, the crew of an eastbound train (7PM5) were preparing to depart the Coonana loop track, about 500 km ahead. The crew of 7PM5 had completed a similar cross with the preceding westbound train to 7MP7.

1 The 24-hour clock used in this report is referenced to Western Standard Time (WST): Coordinated Universal Time (UTC) + 8 hours.
2 Pacific National roster train crews to work trains from Kalgoorlie to Cook then return. Pacific National billet crews at Cook to rest between shifts.
3 An instruction in the prescribed format issued by the train controller in connection with the movement of a train.
4 A place where trains are not able to cross or pass but is available for the purpose of reporting or obtaining an authority.
5 Pacific National policy to carry out a brake test as soon as possible after departing the originating location or following a train crew changeover for train crew to get a feel of the braking ability of the train.

To depart the loop track, a crewmember from 7PM5 operated a trackside pushbutton to motor the point machine at the eastern end of the yard to the reverse position. Once reversed, the point indicator displayed a yellow dumb-bell,[6] signalling the points had set correctly for the crew's departure. Shortly after, the rear of train 7PM5 cleared the points at the eastern end of Coonana and the trackside interlocking automatically controlled the point machine to return to the normal position, set for the main line.

At about 0550, the trackside interlocking detected that the point machine had not motored to the normal position within the required time. As the points were not correctly set, the light indicator (enhancer) at the eastern end of Coonana displayed a red light (stop indication) to westbound train crews.

At about 0640, the crew of 7MP7, the next westbound train, passed through the main line at Mundrabilla after crossing another eastbound train stopped on the adjacent loop track. At Mundrabilla, the trainee and supervising driver changed over, with the supervising driver moving into the driver's position. The supervising driver continued driving through to Wilban, where the trainee driver again changed over into the driver's position at about 0820. Shortly after, the NCO issued the next TA to the crew, authorising travel from Rawlinna through Coonana to Golden Ridge. The NCO had no information to indicate that the eastern end-point machine at Coonana had not returned to normal for the passage of 7MP7 or that the point indicator was displaying a stop light.

The trainee continued driving, crossing train 7PM5 which stopped in the loop track at Rawlinna. The trainee and supervising driver planned another driver change at Zanthus (about 39 km before Coonana), but the trainee wanted to continue toward Parkeston to gain additional driving experience and route knowledge for the track section in that direction. At about 1020, the crew passed through Zanthus, and the supervising and trainee driver continued to discuss train-handling practices for maintaining momentum on the undulating grades through the sand hills ahead.

Approaching Coonana, the In-Cab Activated Points System (ICAPS) sounded an alert that the crew were approaching a crossing location ahead. The train crew did not need to take any action to the ICAPS alert, as their TA allowed travel on the main line through that location. The train crew cross-called[7] the TA and again discussed the typical train-handling practices for the approach. The trainee driver was also aware of an unposted temporary 80 km/h speed restriction at the eastern end of Coonana, and the need to manage train speed for that restriction. About 2,500 m from Coonana and travelling at about 115 km/h, the train passed the Location Ahead sign.

The trainee and supervising driver were both looking for the indication displayed on the eastern end enhancer, located to the left of the track ahead. From the driving position, the trainee could not discern any indication among the trackside vegetation and was waiting for the supervising driver's call that he had sighted an indication from the observer's position. Shortly after, the supervising driver, unable to sight any indication, calmly said to the trainee 'brakes'. The supervising driver continued to look ahead, searching for the indication.

About 1,700 m from Coonana and travelling at 115 km/h the trainee understood the instruction from the supervisor was in relation to slowing the train in preparation for the 80 km/h speed restriction ahead. The trainee subsequently applied a minimum service airbrake application before incrementally reducing the throttle setting from notch T8 towards idle. Shortly after the supervising driver, still unable to sight an indication, realised the brake application was minimal and that the throttle setting was in power. The supervising driver told the trainee to make a full service application then, shortly after, to put the automatic brake into the emergency position.

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6 See *Point indicator* and Table 2 under *Context* section.

7 If the train crew consists of more than one crew member, each shall confirm and verbally call its meaning to the other crew members, and each shall obey its meaning.

About 1,200 m from Coonana and travelling at 110 km/h, the trainee moved the throttle control rapidly through idle to notch D8, the full dynamic braking position. Shortly after, the trainee moved the automatic brake handle toward the emergency position. About 750 m from Coonana, the supervising driver told the trainee to apply the independent brake also. Initially the trainee manipulated the independent brake handle position in order to maintain a light application before the supervising driver said to apply the independent brake fully. About 550 m from Coonana, the supervising driver left his seat and operated the End-of-Train emergency switch located on the driver's console, in an attempt to exhaust air in the brake pipe from the rear of the train in addition to the automatic brake control setting.

The indication on the enhancer was still unsighted, but the trainee recalled the point indicator appeared to display a green arrow as they approached. Around 500 m from the points, the supervising driver saw a red light displayed on the enhancer. Shortly after, the supervising driver saw that the points were not fully set for the main line and warned the trainee to brace for a derailment (Figure 2).

Figure 2: 7MP7 approaching Coonana eastern end indicators and points.

Source: Pacific National, annotated by ATSB

At about 1045, train 7MP7 traversed the eastern points travelling at 44 km/h and derailed, destroying around 200 m of the main and crossing loop tracks. The two lead locomotives, an unoccupied crew car and wagons RQFY 58G and RRQY 733K-platforms 4 and 5 derailed all wheels (Figure 3). The train crew were uninjured.

Figure 3: Derailed locomotives NR 54 (lead) and NR 120 (trailing).

Source: Pacific National, annotated by ATSB

Post-derailment

Investigators from Pacific National and the Australian Rail Track Corporation (ARTC) attended the site after the derailment to gather evidence. ARTC undertook the onsite inspection and testing of the point machine, point control system and indicators.

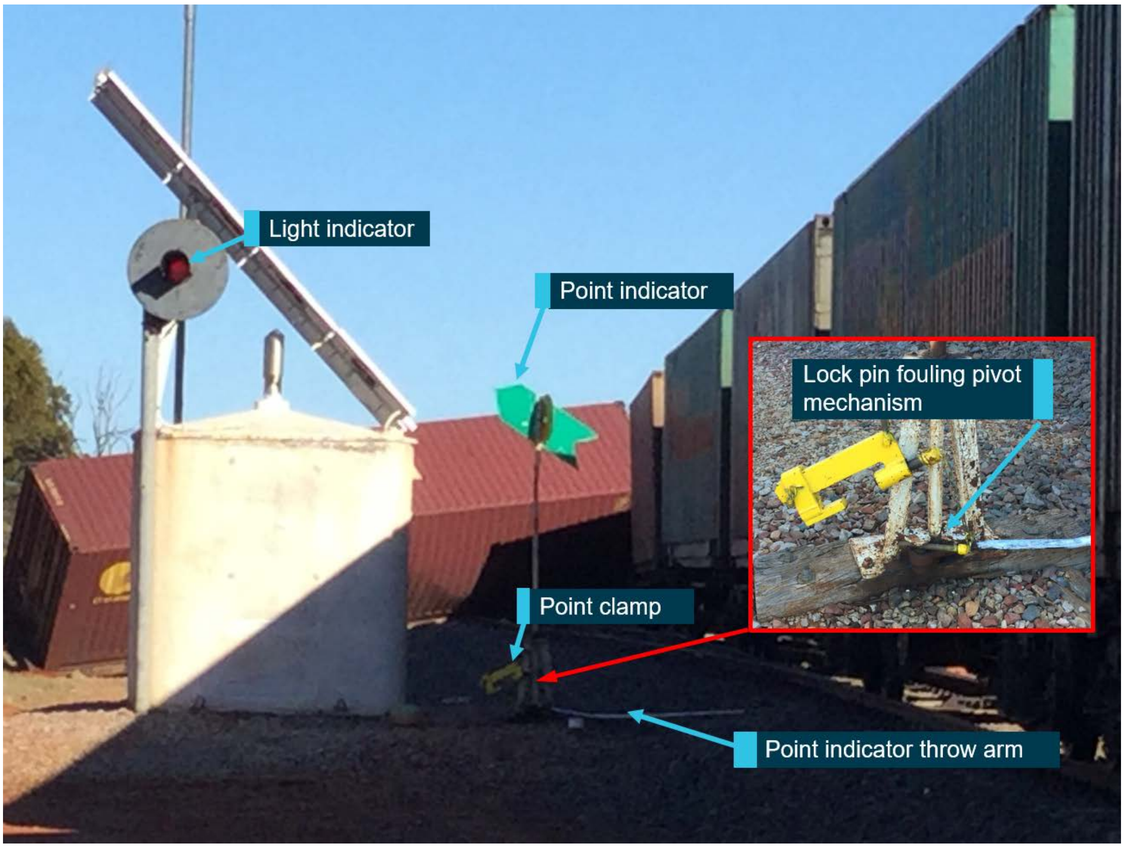
Investigators identified that an unsecured locking pin from a point clamp stored on the eastern Point Indicator stand had fouled the pivot mechanism of the Point Indicator, preventing the complete travel of the throw arm and the attached point blade (Figure 4). The left point blade in the direction of travel had not closed against the stock rail, meaning the gauge face[8] of the left running rail was not continuous through the main line. The wheel flanges of the leading locomotive split the points, resulting in the derailment.

Investigators also verified that following the departure of 7MP5 from the eastern end of Coonana, the trackside interlocking restored the enhancer to display a red light. The points commenced motoring from the reverse position toward normal, but were not detected as being locked in the normal position (set for the main line). Additionally, the point indicator attached mechanically to the points had not rotated fully 90º to display a complete green arrow target. The trackside interlocking functioned as designed, with the light indication on the enhancer remaining at red and the point indicator not rotating fully.

On the morning of 23 August 2018, train services resumed via a temporary deviation track. The main line at Coonana remained closed until the completion of the track infrastructure replacement works.

8 The inner side of the running rail head, i.e. the side of the rail head where the track gauge is measured and could be contacted by the wheel flange

Figure 4: Light and point indicators at eastern end of Coonana post-derailment.



Source: Pacific National, annotated by ATSB

Context

Location

Coonana is located about 170 km east of Kalgoorlie in Western Australia at the 1610.942 km point[9] on the Australian Rail Track Corporation (ARTC) interstate rail network. A Network Control Officer (NCO) manages train movements through Coonana from the ARTC Network Control Centre located at Mile End, Adelaide, South Australia,

Approaching Coonana from the east, the last 10 km of track is tangent, with falling grades of around 1:100 transitioning about 4 km from the points through level to primarily rising grades of around 1:200.

The environment along the train line between Cook and Kalgoorlie is comprised of predominately gently undulating terrain, with low-lying saltbush and scattered over-story of western Myall or Mulga vegetation. At Coonana, there were numerous tall trees bordering the rail corridor on the eastern approach to the enhancer (Figure 6).

Train and crew information

Train 7MP7

Train 7MP7 was an intermodal freight service operated by Pacific National between Melbourne and Perth via Adelaide. The train consisted of locomotives NR 54 (leading) and NR 120 (trailing) hauling 27 wagons for a total length of 1,639 m and gross mass of 3,702 t.

Based on an analysis of the available information, the condition and serviceability of train 7MP7 did not affect its handling in the lead-up to the occurrence, and were therefore not factors in the derailment.

Train crew

The supervising driver was a senior driver, holding a Certificate III in Transport and Logistics (Rail Operations) with around five years' driving experience. The supervising driver had arranged a shift swap with the mentor driver, who normally worked with and tutored the trainee driver. Prior to the shift, the supervising driver and mentor driver had discussed the proficiency of the trainee.

The trainee driver commenced work with Pacific National in mid-December 2017. Following completion of the classroom component of the training in mid-February 2018, the trainee commenced the practical training (on the-job) component, operating various train services from Kalgoorlie on track sections toward Merredin to the west and Cook to the east. The trainee had driven sections of the track between Kalgoorlie and Cook for about six months, but mainly in the direction toward Cook.

The duration of the Pacific National practical training component was typically 12 months, but a planned train crewing change at the Kalgoorlie depot brought forward the trainee groups' assessment to October 2018. The rescheduling of the assessment increased the trainee driver's awareness of the need for additional experience in operating trains on the undulating grades toward Kalgoorlie. This provided impetus for the trainee driver continuing to drive from Zanthus, rather than changing roles with the supervising driver as originally planned.

Toxicology, medical and physiological factors

On returning to the Pacific National offices at Kalgoorlie at about 1800, the crew of 7MP7 submitted to a post-incident screening test for the presence of alcohol or drugs. Each crewmember tested negative to the presence of alcohol or prescribed drugs.

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

An examination of the trainee and supervising driver's health assessment records confirmed that their health assessments were current and that the individuals met 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 either crewmember's 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 (Battelle Memorial Institute, 1998). Due to these negative effects on cognitive performance, fatigue is a factor that increases the risk of transport accidents.

The crew of 7MP7 had worked train 6PS7 from Kalgoorlie to Cook the previous day (18 August 2018), signing off at about 1720. After signing off, they went to their designated accommodation in Cook and retired for the evening.

The following day, the crew were rostered to commence their shift at 0240 but, as train 7MP7 was running late, Pacific National delayed the crew's wakeup call until about 0220. The crew commenced their shift at about 0320 on the morning of the 19 August 2018. The crew were about 7 hours and 25 minutes into their shift when the derailment occurred.

The off-duty period provided an opportunity for the crew to attain restorative sleep prior to commencing work. Each driver advised that they had a good sleep and felt rested when they commenced duty. It is unlikely that fatigue adversely affected the crew's performance during this shift.

Environmental Conditions

The train crew reported that, on departure from Cook, the weather was cold and foggy. The fog cleared shortly after sunrise and approaching Coonana, the weather was clear. The crew advised that the position of the sun (rising directly behind them) could at times adversely affect their ability to sight an enhancer ahead. The signals at Coonana, like many signals from Cook to Parkeston, were oriented approximately due east.

Safeworking system

ARTC managed the safe movement of trains between Cook and Parkeston via a verbal communications based Train Order Working system (TOW). Before issuing a Train Authority (TA), the NCO would verify, through manual procedures, that the proposed route was clear. The NCO could then issue an authority to the train crew, who then recorded the authority on a paper based Train Authority form. The train crew reading the TA back to the NCO validated its content. The TA, once validated, then authorised the train crew to proceed between specified locations and in accordance with any additional instructions, if included.

The train crew were responsible for the setting and verification of points at the locations between Cook and Parkeston. The NCO does not have any visibility of the position of points or the status of trackside light indicators (enhancers) at the locations.

A train crew executing a TA were therefore required to comply with the instructions of the TA together with any additional trackside signs or indications. The train crew were required to implement the applicable operational 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).

For this occurrence, the NCO issued a sequence of four TA's to the crew of 7MP7 for the trip from Cook. Each TA authorised the crew to travel along the main line to the next location where a cross with an opposing train would occur (Reid, Mundrabilla and Rawlinna). The Addendum required each train crew undertaking a cross at a train order location to implement specified crossing and passing procedures. The train crew were also required to comply with various Pacific National operational procedures to mitigate the potential for passing a signal at stop.

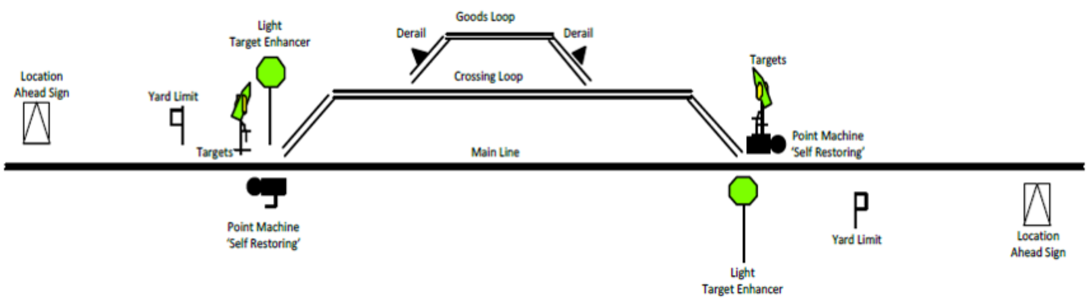
Train order locations

Between Cook and Parkeston, 22 locations were available to cross or pass trains to a maximum length of 1,800 m. Each location had the facility to operate the points via local controls (push buttons installed on the wall of the equipment tank) or remotely from locomotives equipped with an 'In-Cab Activated Points System' (ICAPS). Both the local and remote controls interfaced through trackside interlocking equipment to operate the facing points and the aspect displayed on the respective light indicator. The trackside interlocking also provided the auto-normalisation feature of the point machines.

Remote operation was available provided the locomotive's ICAPS GPS detected that it was located within a set limit (window), typically a two-kilometre long strike point located five to eight kilometres from the train order location. Within this limit, the train crew could enter a selection to control the facing points ahead. The points were normally set and locked for travel through the main line, therefore a selection by the train crew was only required if the TA instructed the crew to take the crossing loop track.

Each location was similar in track configuration, equipped with trackside signage, targets and light indicators adjacent to the track. The features provided additional information to train crew approaching the self-restoring point machines[10] located at either end (Figure 5).

Figure 5: Typical Train Order Location with Light Indicators and self-restoring points.



Source: Australian Rail Track Corporation

Trains crossing at train order locations

The Addendum contained various procedures for sequencing the crossing or passing of trains at train order locations. In the majority of cases, train crews would undertake a cross, where the authority of the first train crew train to arrive at the location required them to occupy the crossing loop track.

This required the train crew to operate the points to reverse via ICAPS, and reduce train speed toward the target speed of 35 km/h for the turnout at the points. After confirming the correct indications, they were to enter the crossing track and clear the main line.

[10] 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.

After stopping prior to the clearance point at the opposite end of the loop, the train crew were to confirm the points ahead were correctly set for the approaching train to travel along the main line. After confirming the points, the train crew were also required to report their arrival at the location to the NCO. The train crew also communicated via UHF radio with the train crew of the approaching train to provide admittance into the location. The train crew of the approaching train were not to proceed beyond the Yard Limit Sign until they received the admittance from the train crew of the opposing train.

Predicted braking distance based on particular train type

The selected trackside location for signals, indicators and signage considered a range of factors in providing train crews with sufficient opportunity to sight and react to the trackside indications. The Train Braking Application Design Standard[11] detailed the typical stopping distances for the particular train-type travelling at various speeds, on an applicable track gradient.

The configuration of train 7MP7 was consistent with the specified train type of a '1800 m long Super-freighter braking 115 km/h max'. The ARTC GW-50 brake table illustrated the calculated braking performance for this train type travelling at varying speeds and gradients (Table 1).

The table indicated that the designated stopping distance (with full service brake application to point of stop) for a train travelling at the maximum permitted track speed of 115 km/h and on the track grade approaching the eastern end of the Coonana location would be about 2,124 m.

Table 1: GW-50 Super-freighter stopping distance

STOPPING DISTANCE TABLE (distances in metres) (Includes 15 % allowance in distances only)
Full service brake application applied to locomotives and train until point of stop

	GRADE (1 in X)														
	Rising											Falling			
	33	40	60	100	200	300	600	Level	600	300	200	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
10 km/h	14	16	23	31	41	47	52	59	64	72	82	117	192	358	529
20	52	61	78	100	123	133	144	155	168	182	199	258	373	605	835
30	112	128	161	198	236	251	267	285	305	327	350	435	593	903	1193
35	148	168	209	256	302	320	339	361	384	409	437	536	719	1064	1383
40	190	214	264	320	375	396	419	444	471	500	532	646	853	1232	1587
45	236	264	325	391	454	478	506	534	565	599	635	764	992	1406	1802
50	285	320	391	467	539	567	598	630	665	703	743	887	1137	1593	2033
55	339	381	461	547	630	661	696	731	770	813	858	1015	1289	1789	2282
60	398	444	536	634	726	761	798	839	882	928	979	1151	1449	2000	2547
65	461	513	616	726	828	866	907	951	999	1050	1104	1293	1617	2222	2832
70	527	585	702	821	934	976	1021	1071	1122	1178	1236	1440	1792	2458	3139
75	598	662	790	923	1046	1092	1142	1194	1250	1310	1374	1595	1977	2709	3470
80	672	744	884	1029	1163	1213	1266	1324	1385	1449	1518	1756	2171	2976	3826
85	750	829	982	1140	1285	1339	1397	1458	1524	1594	1669	1924	2376	3261	4214
90	833	918	1084	1256	1411	1470	1533	1598	1670	1745	1824	2101	2591	3565	4626
95	918	1011	1191	1375	1543	1607	1673	1745	1820	1900	1986	2285	2818	3889	5023
100	1007	1107	1303	1501	1681	1749	1820	1896	1977	2063	2155	2477	3056	4223	5421
105	1099	1209	1419	1631	1824	1895	1972	2054	2140	2232	2332	2678	3307	4547	5826
110	1197	1313	1539	1765	1971	2048	2130	2217	2309	2408	2515	2890	3565	4875	6241
115	1297	1423	1663	1904	2124	2207	2293	2386	2486	2592	2707	3107	3820	5210	6667

Source: Australian Rail Track Corporation. Annotation by ATSB

Trackside signs

Trackside signs provided train crew with either operational or advisory information defined by the shape and colour of the particular sign. The Location Ahead sign provided operational information and was a caution sign, warning train crew of the approach and distance to a location and recognition of its designated name (Figure 6). For the ARTC TOW safeworking system, the typical approach warning distance from the Location Ahead sign to the location's yard limit advisory sign was 2,500 m. The Addendum described requirements for train crews:

[11] Australian Rail Track Corporation, *Standard Train Braking Application design*, ESD-05-03, version 1.1, 21 August 2018

At the location sign in advance of a location equipped with light indicators and/or with point indicators.

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.

Figure 6: Coonana eastern approach Location Ahead sign.

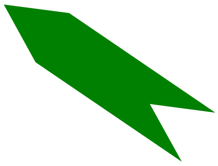
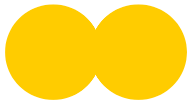
Source: Australian Rail Track Corporation

Indicators

Point indicator

The points installed at each end of the train order locations between Cook and Parkeston were equipped with a Point Indicator, positioned adjacent to the main line and mechanically connected via rodding to the self-restoring motorised point assembly. The Point Indicator displayed a standard day/night reflectorised target, indicating to the train crew the direction the points were set (Table 2). Movement of the points operated the mechanical rodding and an attached vertical spindle that rotated the Points Indicator targets through 90º so that only one target faced the oncoming train crew and the other obscured from the drivers view by being side-on. The position of the points normal or reverse determined which target displayed. The positioning of the target next to the track should afford train crew adequate sighting and convey a clear and unambiguous message about the state (direction of lie) of the attached points.

Table 2: Point 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.

To depart a crossing loop track, a member of the train crew would detrain and operate a local push button control to motor the points to the reverse position. Prior to moving off, there was ample time for the train crew to sight the target indication and confirm the correct lie of the points ahead. Similarly, a crew departing from the main line after stopping for a cross or pass would also have ample time to confirm the lie of the points ahead before moving off. In both scenarios, once the rear of the train cleared the points the trackside interlocking auto-normalisation feature would control the points to return to the normal position (set for the main line) and a corresponding green arrow target displayed on the Point indicator.

A train crew approaching a train order location should also have reasonable opportunity to sight the target indication to determine the correct lie of the points. The engineering standard *Signal Sighting and Position*[12] defined the primary minimum sighting distances applicable to the Point Indicator target, relative to the approach speed of the train (Table 3). The standard indicated that the positioning of the Point Indicator target should allow the train crew a minimum approach view of 8 seconds.

For locations fitted with point indicators only, the Addendum limited the maximum permissible speed over the points to 70 km/h. The minimum sighting distance for a train travelling at 70 km/h, was 156 m in order to ensure the required 8 seconds of viewing distance. To ensure sufficient distance remained available to stop the train upon sighting the indicator, the driver needed to commence braking approaching the location, prepared for a stop at each location.

12 Australian Rail Track Corporation *Engineering (Signalling) Standard ESC-04-01 Signal Sighting and Position*, Version 1.4, 27 October 2010, pp 5.

Table 3: Minimum sighting distance

Service Speed KPH:	Distance Metres for 6 seconds:	Distance Metres for 8 seconds:	Distance Metres for 10 seconds:
40	67	89	111
50	83	111	139
60	100	133	167
70	117	156	194
80	133	178	222
90	150	200	250
100	167	222	278
110	183	244	306
120	200	267	333
130	217	289	361
140	233	311	389

Source: Australian Rail Track Corporation

The trainee recalled sighting a green arrow target on the Point Indicator when train 7MP7 was further than 550 m from the eastern end of Coonana. The points were not set for the main line and the Point Indicator had not completed a full 90º rotation due to the Point Clamp pin fouling the pivot mechanism. Although the trainee recalled sighting a green arrow on the target ahead, this was not consistent with the information intended from the Point Indicator display.

Point indicators at train order locations do not confirm that the attached point machine is locked in the indicated position (normal or reverse) consequently train crews needed to slow the train to a speed where the correct target display could be confirmed and points checked, while allowing sufficient distance to stop the train if necessary.

Colour light indicators (enhancer and repeater)

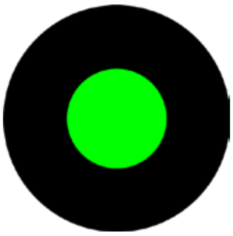
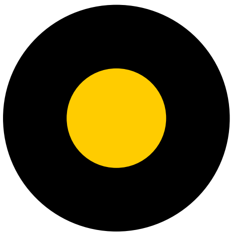
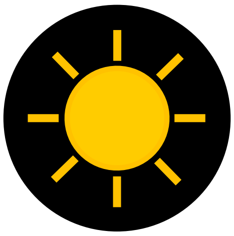
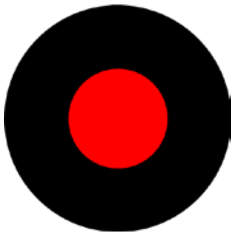
The colour light indicator (enhancer) installed adjacent the Point Indicator provided an enhancement to the standard day/night reflectorised target.[13] The enhancer provided a more conspicuous indicator that the train crew should be able to sight at a greater distance from the facing point[14] enabling them to confirm earlier during the approach that the point machine had set and locked for the correct track. The greater sighting distance meant that if the train crew could confirm a correct indication displayed on the enhancer during the approach to the Location Ahead sign, the train crew could then maintain or resume speed, up to the maximum track speed of 110 km/h, to traverse the facing points.

The colour light indicators were typically equipped with a K3-style Searchlight unit containing an optical system of an incandescent globe, reflector, coloured roundels and lenses intended to provide long-range sighting from a distance of 2,500 m. Following the introduction of the enhancers, ARTC undertook modifications to the K3-style units to rectify significant variations in sighting distance provided between locations. ARTC also substituted the K3-style optical system with a single head colour light unit with a tricolour light-emitting diode (LED) or a multi-head colour light unit with red, yellow and green LEDs at new or upgraded enhancer or repeater installations.

[13] Self-Restoring Point system upgrade initiated by Australian Rail Track Corporation late 1998.
[14] Blades of the point face toward approaching rail traffic.

The enhancer indicated the position of the adjacent points and provided additional information on the status of the points at the opposite end of that location (Table 4). Due to sighting limitations caused by topography or other obstructions at some locations, an additional colour light indicator (repeater) may be installed (about 2,500 m before the enhancer) that 'repeats' the indicator aspect (colour) of the enhancer in order to give train crews advance warning of its condition. Coonana did not have repeaters installed.

Table 4: Colour light 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.

If the points at either end of the location were correctly set for the main line (as was intended in this case), the enhancer should display a steady green light. If the points did not fully transition and set for the main line, the enhancer should display a red light (as occurred in this case). The required action to a red light is to stop and inspect the points.

As the status of the points or enhancers were not known to the NCO, the ARTC Addendum to the Code of Practice required a train crew departing from the crossing loop of a location to:

> 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 aim of this requirement was to identify any failures before the passage of the next train. In this case, train 7PM5 was the last train to depart the eastern end of Coonana loop. However, given the length of the 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 crossing loop, and the points had completed the intended function and returned to the normal position.

The train crew of the next opposing direction train (7MP7) stated that as they approached Coonana, they did not see the indication displayed by the enhancer until the train was about 500 m from the facing points at the eastern end.

ARTC engineering documentation

The optimal visibility of the aspect displayed by railway infrastructure defined as a trackside colour light signal or a colour light indicator (enhancer or repeater), of any luminaire type, is dependent on routine maintenance and the correct alignment of the light beam relative to the railway track.

The engineering standard *Signal Sighting and Position* specified the primary maximum distance to obtain optimal sighting, the maximum sighting distance, was 10 seconds for trackside colour light signals equipped with a standard-type luminaire. The specification of minimum and maximum distances provided drivers with reasonable opportunity to sight and react to the indication, while controlling the risk of read through to a signal in advance. While not specifically referencing being applicable to enhancers or repeaters installed under the TOW safe working system applicable to the Nullarbor Plain, the standard stipulated:

> Where there is an absence of geographic markers for the driver (e.g. Nullarbor Plain) or the signal is not significant against the horizon or the sun may be directly behind the signal then the application of long range luminaries is acceptable.

The intention of providing a long-range type luminaire was therefore to provide a sighting distance greater than the typical 10 seconds at the nominated track speed.

The specification *Signals–Work on Asset* outlined the alignment requirements applicable to trackside colour light signals (including the Searchlight-type) and the routine servicing procedure applicable to both a signal, and enhancer/repeater lamp.[15] The specification required the alignment of Searchlight-type signals (sighting point)[16] to provide a sighting distance[17] of 1,000 m on a main line with straight approach. The specification did not identify whether the signal was fitted with a standard or long-range luminaire nor if the sighting point applied to enhancers/repeaters equipped with Searchlight type units. In contrast, the ARTC documents *Signalling Technical Maintenance Plans* applicable to Colour Light Type signals (multi-head colour light units) fitted with incandescent or LED type luminaires specified a long-range sighting point of 400 m. The documents did not specifically reference if the sighting point applied to the similar multi-head colour light units fitted to some enhancer/repeater installations.

ARTC engineering documents specified varying sighting points (either 400 m or 1,000 m) dependent on luminaire type. Although the documents specifically related to fixed signals, applicable to safe working systems of signalled areas in the ARTC network the light indications provided by enhancer/repeater luminaires that are similar in appearance to fixed signal luminaires (Searchlight and Colour Light type) were not specifically addressed. The ARTC CoP and Addendum purposely did not classify the enhancer as a fixed signal.

Notwithstanding the related ARTC specifications, no ARTC standards or maintenance procedures contained corresponding reference to the sighting point or distance applicable to colour light indicators (enhancers/repeaters). ARTC confirmed the practice in the field was to align enhancers (and repeaters) to a sighting point 1,500 m in the rear of (approaching) the enhancer/repeater.

Pacific National conducted audits of the enhancer sighting on the east and west approaches to each location between Kalgoorlie and Cook. On each occasion, train crew recorded the distance at which they observed the light indication, together with the time of day and environmental conditions. Crews reported significant variations in the sighting distance to enhancers between each location, due to the direction of approach at a particular location, the time of day or ambient light conditions.

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[15] Enhancer lamps addressed separately due to specific requirement to change out enhancer lamps at 12 weekly intervals.

[16] Sighting point is the point in rear of (approaching) a signal at which the driver of a train is first able to view the signal.

[17] Sighting distance is the distance between the sighting point and the signal to which it applies. Sighting distance is not considered as part of the train braking distance when determining the spacing of signals.

Observations for the western approaches identified four locations[18] where a train crew reported difficulty in distinguishing the green light displayed on the enhancer. Observations for the eastern approaches identified four locations[19] where sighting was difficult due to the ambient light conditions at that time of day or other environmental conditions. Each of the locations identified were equipped with K3 style Searchlight units with an optic system containing incandescent lamps. The two records for the eastern approach to Coonana indicated that in the late afternoon, with overcast conditions, the train crew undertaking the audit sighted an indication from a distance of around 2,250 m.

The drivers of 7MP7 stated that approaching Coonana, the trees adjacent to the corridor, and variations in ambient conditions, made it more difficult to sight enhancer indications at a distance, particularly the enhancers fitted with an incandescent globe such as the one at Coonana. The drivers stated that, for that reason, the eastern approach to Coonana was a particularly difficult location for sighting the enhancer from the driving positon. The drivers stated that from previous experiences, the first sighting of the light indication would usually be from the observer's position at around 2,000 m from the points. The first sighting of the indication from the driving position would typically occur at around 1,800 m from the points.

Reported enhancer issues Cook to Parkeston

Train crews encountering issues with the operation of the trackside equipment at train order locations report the occurrence to the ARTC Network Control Officer (NCO). Following receipt, the NCO generates a Train Control Report (TCR), logs the report for attendance by maintenance staff and, depending on the nature of the issue, provides warning to other train crews via the 'Condition Affecting the Network' procedures.

Between April 2016 and August 2018, ARTC recorded 177 TCR reports relating to issues with trackside equipment between Cook and Parkeston. ARTC recorded ten TCRs related to issues with the enhancer at the eastern approach to Coonana where the indication was displaying red, blacked out, or cycling due to a fault. None of the TCRs related to issues associated with poor visibility of the enhancer indication.

Following the derailment of 3MP5 at Rawlinna in April 2016, Pacific National undertook an audit of sighting distances to enhancers between Cook and Parkeston. The audit identified large variance between the locations in the distance at which the crew sighted the enhancer indication. Notations against the respective enhancer attributed the variations to the type of luminaire (incandescent/LED) and time of day at which the train crew made the observation. Sighting distances recorded against the eastern approach to Coonana varied between 1,500 and 2,300 m. These observations were recorded during the afternoon in overcast to twilight conditions.

Point clamp

ARTC provided a point clamp at selected locations for use by authorised personnel (typically train crew) in the event that a failure of the points prevented them from being correctly set and locked. Once the points are set to the correct position, authorised personnel use the point clamp to secure the points for the desired route, as advised by the NCO. At crossing locations between Cook and Parkeston, point clamps were located on a spigot attached to the point indicator stand.

Post-incident, ARTC provided an image depicting the correct storage method with the point clamp placed on the spigot with the locking pin retained in position (Figure 7). However ARTC could not provide any documentation that instructed authorised personnel on the use of this storage arrangement for the point clamp, or requirements that the point clamp be secured against unauthorised use by installation of a railway 'S' type padlock.

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[18] Denman, Hughes, Reid, Mundrabilla

[19] Curtin, Chifley, Zanthus, Naretha

Figure 7: ARTC example of correct storage arrangement for a point clamp on a point indicator stand.

Source: Australian Rail Track Corporation

At some time prior to the passage of 7MP7, the point clamp at the eastern end of Coonana was placed on the spigot incorrectly: it was not secured by a 'S' type lock and the locking pin was stored in a manner that allowed it to hang loose at the end of its attachment chain. The practice of storing the point clamp on the point indicator stand increased the risk of the point indicator throw arm pivot mechanism becoming fouled.

There was no record of a recent point failure where the NCO authorised the use of point clamp by train crew. ARTC maintenance records indicate the last electrical maintenance inspection of the points occurred on the 22 June 2018. There was, however, no requirement within the electrical maintenance or other inspection procedures for a routine check of point clamp positioning or security.

Pacific National systems

In-cab activated points and GPS location alert systems

The Pacific National NR-Class locomotives were equipped with interconnected ICAPS, and the Pacific National AWARE[20] and GPS location alert systems. The ICAPS equipment facilitated train crews setting the required route at the train order location ahead from within the locomotive cab without having to stop the train at the facing points.

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20 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.

When ICAPS activated, a screen in the locomotive cab displayed a message showing the location name and two touch-screen buttons. An audible tone accompanied the message, alerting the driver that the system was active. If a crossing 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. Similarly, if the crew take no action, the points will remain in their current position (usually set for the main line).

The GPS location alert 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. The purpose of the system is to 'prompt the train crew to check their current limit of authority'.[21] If the crew has already made an ICAPS selection for the loop, the alert will not activate since the crew has taken action relevant to the train authority.

The GPS location alert system displays a message on the AWARE screen when the locomotive is about 5 km from the crossing location. A single audible beep also sounds, but 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 continue 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. No audible tone accompanies this message nor is there a requirement for the train crew to acknowledge it.

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

NR locomotive controls

Master controller - Throttle/Dynamic brake handle

The movement of the throttle/dynamic brake handle enables the control of engine speed (Throttle and Idle) and the application of dynamic braking (Setup and Dynamic brake). Movement of the handle toward the driver, through each of the nine available detent positions (Idle to T8) increases the locomotive traction power applied. By pushing the handle to the right through a spring-loaded gate, the driver sets up a dynamic brake application. After passing through the setup detent, the handle's position can move smoothly through the dynamic operating range from one to eight.

In applying dynamic braking, the NR-class locomotive operations manual recommended drivers apply a 10-second delay when moving the throttle/dynamic brake handle between each of the idle and setup positions before moving into the dynamic braking zone. Pausing the handle operation acts to protect against electrical component failure and prevent excessive train forces.

Automatic brake control

Locomotive NR 54 was equipped with the Wabtec Fast Brake electronic air brake system. The Wabtec system consisted of two major components, the Handle Controller Unit (HCU) and the Pneumatic Operating Unit. The HCU provided the driver with the ability to control separately the application of train or locomotive braking through the operation of the automatic or independent brake handles respectively (Figure 8). The locomotive event logger recorded the brake pipe and brake cylinder pressures resulting from the manipulation of the HCU handles.

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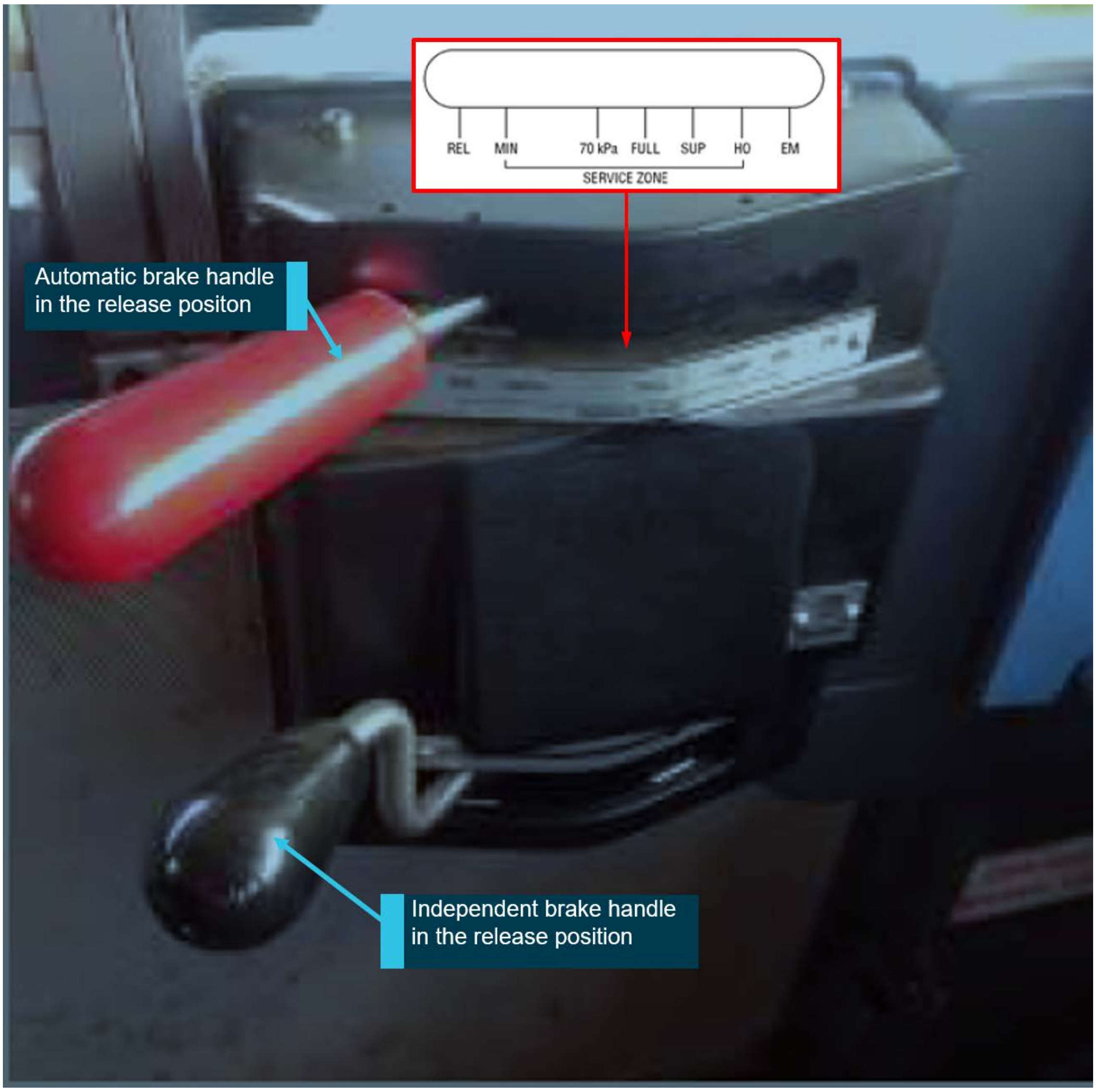
21 Pacific National Information Bulletin No. 54A, *AWARE Train Radio System, GPS Location Alerter – Driver Information System*.

Figure 8: Handle control unit located in the locomotive cab to the left of the drivers position.



Source: Pacific National annotated by ATSB

The automatic brake handle had seven detent positions available through the operating range:

- Release (REL)
- Minimum Reduction (MIN)
- 70 kPa Reduction (70 kPa)
- Full Service (FULL)
- Suppression (SUP)
- Handle Off (HO)
- Emergency (EM).

The operational area between the Minimum Reduction (MIN) and the Full Service (FULL) detent comprised the normal service-braking zone. Positioning the automatic brake handle through this area resulted in typical brake pipe pressure reductions of between 50 and 150 kPa respectively.

Positioning the automatic brake handle further forward engages the detent positons of Handle Off (HO) or Emergency (EM). A driver configures the HCU in the HO position during the setup of the non-driving position whenever a locomotive is a trailing unit in a multi-unit consist or being towed 'dead'. In the HO position, the brake pipe pressure will reduce at the service rate to 0 kPa. The locomotive brake cylinder pressure will rise to approximately 350 kPa.

The automatic brake handle, when placed in Emergency (EM), will immediately initiate evacuation of the brake pipe air, subsequently reducing the brake pipe pressure to 0 kPa. In addition to the reduction in the brake pipe pressure, placing the handle in the EM position on NR class locomotives will cause the sanding system to deliver sand to the railhead in front of the leading wheels of each bogie. Additionally, if the master controller setting was set in the dynamic braking operational range, the selection of EM will cause the automatic release of dynamic braking and the application of the air brake.

The independent brake handle had two positions available through its operating range:

- Release
- Full Application.

Moving the handle from Release toward the Full Application position increases locomotive brake cylinder pressure, dependent on the position of the handle through the application zone. Alternatively, when in the application zone, moving the handle toward Release would reduce the brake cylinder pressure.

In the Release position, no independent locomotive braking occurs but the driver has the option to release fully (Bail Off) any locomotive brake cylinder pressure increase resulting from the operation of the automatic brake handle. To Bail Off, the driver depressed the independent handle in the Release position. Similarly, depressing the handle while in the application zone could partially Bail Off the locomotive's brake cylinder pressure corresponding to the Independent Brake Handles position.

Sense and Brake Unit

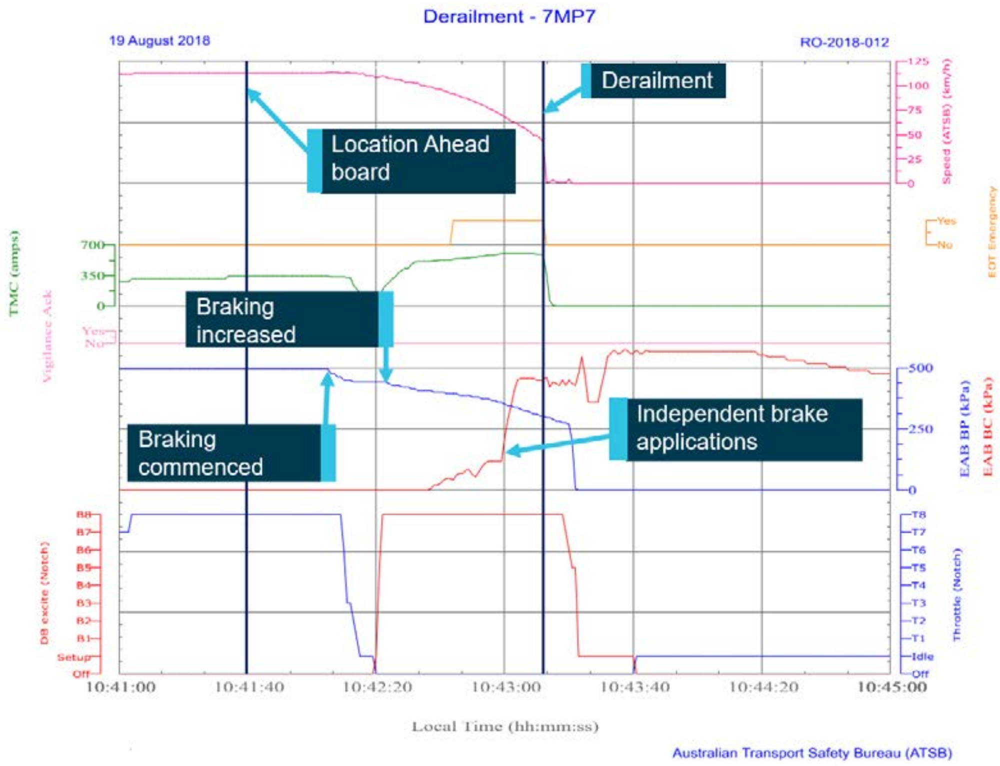
The Sense and Brake Unit (SBU) fitted to the rear vehicle of the train provided End-Of-Train information to the cab display unit in the lead locomotive and End-Of-Train emergency braking in response to a driver-initiated command. The operation of an Emergency EOT Switch located on the left side of the driver's screen console activated an Emergency Dump Valve via the SBU, initiating the release of the brake pipe pressure from the end of the train in an emergency.

End-Of-Train emergency brake application was only available with the SBU 'Armed' and confirmed 'Armed Two Way'. The NR class locomotive event logger did not record the 'Armed' status of the SBU.

Locomotive NR54 event logger

Data extracted from the Wabtec event logger on locomotive NR54 displayed the timing of control inputs and braking application during the approach of train 7MP7 to Coonana (Figure 9).

Figure 9: Event logger locomotive NR54.



Note: DB = dynamic brake, EAB BP = train brake pipe pressure, EAB BC = Locomotive brake cylinder pressure, TMC = Traction motor current Source: Australian Transport Safety Bureau

At about 10:41:40, around 2,500 m from the eastern end points at Coonana and passing the Location Ahead sign, the throttle control of locomotive NR54 remained set to full power (Notch T8) and train 7MP7 was travelling at 115 km/h. Around 25 seconds later, a minimum service brake application (50 kPa reduction in brake pipe pressure) commenced. The brake application was likely in response to the supervising driver's instruction to 'brake'. The absence of an increase in the locomotive's brake cylinder pressure, which would typically occur with an automatic brake application, indicated the trainee likely bailed-off using the independent brake handle control.

Shortly after, the trainee rapidly moved the throttle/dynamic brake handle to maximum dynamic braking, Notch D8. The trainee also moved the automatic brake control from the minimum service position further into the service zone, exhausting additional air from the brake pipe and increasing braking effort along the train. The locomotive did not develop brake cylinder pressure due to the dynamic brake interlock functionality. The trainee's action was likely in response to the supervising driver's instruction to apply full service and then emergency braking. Train 7MP7 was travelling at around 110 km/h and 1,200 m from the points at Coonana.

The train speed reduced to around 70 km/h, when the trainee driver commenced an application of the independent brake causing an increase in the locomotive brake cylinder pressure. The initial independent brake application was light, with the position of the handle likely adjusted to maintain light independent braking. Around this time, the Supervising driver operated the EOT Emergency switch. Train 7MP7 was 400 m from the points at Coonana.

There was no appreciable change recorded in the rate that air exhausted from the brake pipe following the operation of the EOT Emergency switch. Around 140 m from the points, a full application of the independent brake occurred. Train 7MP7 was travelling at 50 km/h.

The event logger indicated that air continued to exhaust from the brake pipe at a relatively constant rate to a pressure of around 300 kPa immediately before locomotive NR54 derailed. At that time, the remaining air vented almost instantaneously to atmosphere level. This was almost certainly due to a break in brake pipe continuity during the derailment.

The venting rate of the brake pipe prior to the derailment is consistent with a controlled release of air at a service rate, rather than the almost instantaneous release that would typically occur with an automatic brake handle placed in the emergency position.

The braking response of the locomotive and the brake pipe pressure falling to below the 150 kPa reduction, typically attained from a full service application, indicated that the automatic brake handle was likely moved through the service zone to the 'handle off' position. The event logger also recorded that the locomotive maintained full dynamic braking from initiation through to the point of derailment, which would not occur following the placement of the automatic brake handle into the emergency position.

Pacific National driver training

Pacific National was an enterprise-based Registered Training Organisation, resourced with facilitators and assessors to conduct training in the workplace at multiple regional sites. The Pacific National worker competency program derived from the applicable Transport and Logistics Training Packages. The Pacific National Certificate IV in Train Driving program instructed train crew in the safe operation of Pacific National train services through a suite of core, specialised elective units of competency, and various supporting Safety Point Lessons delivered through facilitator-led and on-the-job training.

To manage risk associated with multi-site delivery, administrative and regulatory requirements were centralised with the monitoring of the programs by the regional-based line management of the facilitators at the multiple sites. The Pacific National Kalgoorlie Depot managed the delivery of the training syllabus to trainee drivers based at that location.

Competencies in defensive driving

To mitigate the potential for a train crew to pass a signal at stop or exceed their limit of authority, the core and specialist units included training on topics related to the Identification and Response to Signals and Trackside Signs, and Defensive Train Handling Techniques and Strategies. The training associated with defensive train handling encouraged a conservative approach requiring the driver to be aware of the risks and to implement safety actions that suit the environment. Defensive driving relied on the driver knowing the route thoroughly and understanding the capabilities of the tractive effort of the locomotives, and the braking capacity of the train and rolling stock operated.[22]

The associated Single Point lessons provided train crew with a variety of proactive strategies to implement when approaching safety critical situations. Single Point lessons included:

- Active identification of a Stopping Location
- Safety Critical Zone, Approach Speeds & In-Cab Activities – Mainline Operations
- Active Team Work
- Signal Passed at Danger Commandments.

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22 Pacific National TLIIC4019 Drive train to operational requirements, page 8

The safety critical zone related to a set time or distance from a known area of increased risk, such as a stopping location, or limit of authority. While in a safety critical zone, train crew were to direct their attention and actions toward safety critical tasks and the implementation of defensive driving and train-handling techniques, to ensure that they controlled train speed during the approach to stop prior to the designated stopping point. The active teamwork strategies reinforced the importance of shared responsibility to ensure safety would not be compromised by any action, inaction, miscommunication or misunderstanding between crewmembers.

Although Pacific National promulgated these lessons within the organisation, the train crew of 7MP7 maintained track speed at the Location Ahead sign and into the safety critical zone at the eastern end of Coonana.

Competencies in operating a train and responding to abnormal conditions and emergencies

Core and specialist units of competency included respectively, responding to abnormal conditions and emergencies when driving a train and driving a train to operational requirements. The delivery strategy for the training activities included a mixture of facilitator-led activities (eight and 16 hours' duration respectively) and on the job practice/work experience supervised by a mentor driver (30 and 184 hours' duration respectively).[23]

The training delivery comprised three streams:

- Theory and activities in the training room environment.
- Practicals/learning on site and on the equipment to gain familiarisation prior to operating.
- The on-the-job learning component, with trainees performing the task of driving a train supervised by a mentor driver.

The training room component provided trainees with an understanding of the fundamentals of operating a train and to recognise, report and manage an abnormal situation or emergency. Abnormal situations were identified as incidents or issues during train operations that required an alteration to behaviour, mindset or the performance of an action to correct, but were not life-threatening. Emergencies were incidents that resulted in major impact to the network operations and infrastructure or had the potential for a fatality. The context of the training in responding to emergency and hazardous situations focused on reporting the emergency to the network manager, Pacific National or emergency services. Following completion of the training room component, the trainee transitioned into the on-the-job component.

Trainees were assigned to a mentor driver, working various train services and routes to obtain the necessary competencies in operating rolling stock to Pacific National's operating requirement. The mentor driver guidelines[24] detailed the expectations of the mentor driver and the training plan for the trainee during the on-the-job component. At the completion of the on-the-job component, a Driver Trainer assessed the trainee against a verification of competence checklist (VOC).[25] The mentor driver should have discussed all parts of this checklist with the trainee to determine that they were both satisfied that all aspects were understood before the assessment by the driver trainer commenced.

The VOC section covering train management on the main line included an assessment task on the operation the automatic brake handle. A driver undergoing assessment was to perform a split, cycle, balance, full service and emergency application. The emergency application included a notation 'can simulate'. Pacific National advised it did not carry out practical (on-the-job) training in controlling a train when responding to an emergency event, due to operational practicalities and the potential risk to a train if the training was conducted during normal train operations.

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23 Pacific National Learning and Assessment Strategy TLI42615 Certificate IV Train Driving

24 Mentor driver guideline developed for Perth Drivers Depot.

25 Pacific National Driver Mainline Verification of Competence (VOC) Combined Checklist, Version 2.1 November 2016.

Trainees recorded their experiences gained and the demonstration of practical competencies during the on-the job component in a logbook. A variety of assessment processes determined the trainee's verbal/written knowledge and the practical application of the knowledge/skills for the competency.

Pacific National worker competency programs instructed and assessed the competency of a trainee in responding to abnormal conditions and emergencies through off-the-job training and ad-hoc discussions during on-the-job training between the trainee, mentor driver and finally the assessor. Trainees and assessors recorded the undertaking of these discussions in the trainee's individual logbook and VOC to provide evidence the training provided, and the assessment of the trainee's understanding of the theoretical execution of the competency.

Pacific National provided records of the off-the-job training component for the driver of 7MP7 but were unable to verify the content, or if delivery of the on-the-job discussions related to the automatic brake operation competency, occurred prior to the 19 August 2018 accident.

Previous occurrence

The ATSB investigated a similar derailment of train 3MP5 at Rawlinna, Western Australia on 21 April 2016 (RO-2016-005).

Train 3MP5, travelling from Melbourne to Perth, derailed while traversing the eastern end points at Rawlinna. The points failed to fully restore to the normal position (set for the main line) after the previous train departed the loop track, leaving the points in an unsafe open positon. The colour light point indicator (enhancer) worked as designed by displaying a red light when the points were unable to be detected and locked in a safe position. There were minor injuries sustained by the crew.

The ATSB found that 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.

Safety analysis

Point indications

An incorrectly secured locking pin from a point clamp stored on the point indicator stand fouled the indicator pivot mechanism, preventing the self-restoring point machine from motoring the points fully to the normal position (set for the main line). The practice of storing the point clamp on the point indicator stand increased the risk that the moving point indicator throw arm pivot mechanism could become fouled and prevented from operating as designed.

The points were in an unsafe condition for the passage of rail traffic, causing the enhancer to display a red light (stop indication). The fouled pivot mechanism also prevented the point indicator from rotating fully to display a complete green arrow target. (However, it did rotate enough for the green arrow to be a prominent display to the driver.)

There was no automated system to alert the network control officer (NCO) to the condition of the points or enhancers at the train order locations between Malbooma and Kalgoorlie. Around 2.5 hours after the trackside interlocking at Coonana detected that the points had not correctly set, the NCO issued an authority for the crew of train 7MP7 to travel from Rawlinna to Golden Ridge, passing through the main line at Coonana.

The points at train order locations were normally set for the main line, with corresponding green light displayed on the enhancer and green arrow on the point indicator target. Indications other than green should only display following the initiation of crossing or passing procedures by a train crew or when a failure has occurred, such as the points were not correctly set. The timely identification and response to an abnormal indication relied on the actions of the train crew to either sight the red indication at a distance greater than 2,500 m or applying the organisations' rules and procedures to ensure there was sufficient distance available to stop their train safely should the enhancer indication be at red or blacked out.

The layout of Coonana was typical of all train order locations between Malbooma and Parkeston. ARTC provided a location ahead sign at 2,500 m (nominal braking distance) and an enhancer that theoretically should be visible by crew at a distance of around 2,500 m. The drivers stated that due to the trees adjacent to the corridor combined with variations to ambient conditions and the luminaire type (incandescent globe) used at Coonana, made sighting the enhancer more difficult and first sighting of the indication would usually be from the observer's position at around 2,000 m from the points. The enhancer at Coonana displayed a red light, which the crew stated did not come into view until train 7MP7 was around 500 m from the points, after the trainee driver could see the Points Indicator.

Generally, the conspicuity of a signal is determined by its size and intensity, its contrast with the surrounding environment, and the visual angle at which it is perceived.[26] It is likely a combination of enhancer luminaire type (incandescent globe), beam alignment, trackside vegetation, ambient lighting and other environmental conditions present at the time adversely affected the conspicuity of the enhancer indication at the eastern approach to Coonana during the approach of 7MP7.

[26] O'Brien, K. A., Cole, B. L., Maddocks, J. D., & Forbes, A. B. (2002). Color and defective color vision as factors in the conspicuity of signs and signals. *Human factors, 44*(4), 665-675.

Although sighting the light indicator aspect at 2,500 m or greater is optimal, audits of the sighting points at train order locations found significant variation in distance existed, dependent on the type of luminaire and environmental conditions at the time. Generally, light indicators fitted with LED type luminaires were more conspicuous to the approaching crew providing a greater sighting distance. However, if the train crew could not confirm the light indicator aspect during the approach to the Location Ahead sign, rules and operational procedures required the crew to reduce speed at the sign and be prepared to stop before the facing points until the light indicator aspect could be confirmed. During the approach of 7MP7 this action was delayed until the train was around 1,700 m from the facing points, less than the stopping distance required.

Train-handling factors affecting train crew actions

Given the significant distance required to stop a freight train travelling at main line speeds, the vigilance of the crew is essential to ensure that indications, trackside signs and other cues are perceived and actioned appropriately to enable effective train handling. Having established that the train crew had trouble in sighting the enhancer indication and that a reduction in train speed did not commence until around 1,700 m from the points, the remaining analysis focuses on factors influencing the actions of the trainee and supervising driver in the delayed response to cues.

After departing Cook, train 7MP7 travelled along the main line through each of the 16 train order locations before approaching Coonana. The enhancer indication (green light) displayed the correct route had set at each location traversed. With the correct route set, the train crew were able to maintain track speed through the majority of the locations, reducing speed en-route where required to comply with speed restrictions or when crossing an opposing train.

During crossing or passing procedures, train crews of the first train approaching a train order location would be cognisant that they were nearing the limit of their authority, requiring them to stop. Crews would also be preparing to operate point controls to traverse a turnout if their train was to occupy the loop track. In both situations, train crew were actioning instructions contained in their latest train authority (TA) and were therefore conscious of the requirement to reduce train speed toward achieving target values.

Train crews of the second train approaching a location where a cross/pass was to occur were also actioning instructions on their respective TA. Communications between the train crews provided confirmation to the approaching train that the points were set correctly. In each case, the train crews were responding to specific cues requiring an immediate action to reduce train speed approaching a location.

Where the TA authorised travel through a location where no cross or pass was scheduled, the respective organisation's rules required the train crew to reduce speed at the 'location ahead' sign and be prepared to stop before the points, unless they had sighted and confirmed the enhancer displaying a correct indication for the intended route.

The train crew's experiences in 7MP7 that morning were that the majority of locations did not require a reduction in train speed during the approach. This, coupled with the previous experience that the enhancer at the eastern end of Coonana was difficult to detect and would typically not come into view by both crewmembers until around 1,800 m from the points, probably contributed to the delayed defensive driving actions in response to an unsighted indication and a low expectancy of encountering a restricted signal.

Systems where vigilance tasks (reducing speed at the location ahead sign) are associated with a low likelihood of an outcome (such as there being a restricted indication displayed) tend to produce lower levels of response compliance. High false-alarm rates, where compliance rarely leads to the avoidance of an actual risk, lead to 'cry wolf' phenomena, where individuals start ignoring the warnings.[27, 28] As such, the low incidence of unexpected restricted indications at these locations reduces the likelihood of train crews rigorously complying with the organisations' rules and procedures to reduce speed to target values approaching a location.

This is consistent with other investigations of rail accidents, such as the UK Health and Safety Executive examination of the Ladbroke Grove rail accident, which found:

> The chance of human error can be considered to be enhanced where drivers have a high level of expectation regarding the likely signal aspects which will be displayed.

Focussed attention

Human information processing is limited in that each person has finite mental or attentional resources available to attend to information or perform tasks at any particular time. In general, if a person is focusing on one particular task, then their performance on other tasks will be degraded.[29]

Approaching Coonana, the supervising driver focussed attention on sighting the enhancer, predicting that it would come into view, from his position in the locomotive cab, around 500 m after passing the Location Ahead sign. From previous experience, the supervising driver described the task of identifying the incandescent aspect of the enhancer as very difficult, requiring train crew to scan constantly to identify it amongst the background. Attention to this task likely reduced the supervising driver's awareness of the control inputs and the speed of the train as it passed the Location Ahead sign and approached the points.

The trainee driver focused attention on identifying the speed restriction ahead and on maintaining the train's momentum in preparation for the rising grades ahead. The trainee had only previously experienced one instance of an abnormal indication displayed on an enhancer. On that occasion, the train was already slowing in preparation to travel along the main line to cross a train in the crossing loop.

Braking actions

Train 7MP7 approached the Location Ahead sign under power at a speed of 115 km/h and no action was taken to reduce power or brake until the call from the supervising driver. The trainee's previous experiences approaching train order locations, limited route knowledge of the track ahead and understanding that the supervising driver would be the first to identify the enhancer indication likely influenced the trainee's actions.

When responding to the supervising driver's instruction to put the automatic brake handle into the emergency position, the trainee's response of rapidly placing the throttle into the full dynamic position and operating the automatic brake handle to the notch corresponding to the 'handle out' position was inconsistent with the action the supervising driver had called for.

Although not placing the automatic brake handle in the emergency position as instructed, the trainee's action in moving the throttle to the full dynamic position with the brake handle in the 'handle out' position resulted in the application of braking effort similar to a service rate of application, while maintaining full dynamic braking on the locomotives. Placing the handle in the emergency position would have resulted in a more rapid reduction in brake pipe pressure but would have also disconnected the additional dynamic braking effort applied by the locomotives.

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[27] Sorkin, R. (1989), Why Are People Turning Off Our Alarms? *Human Factors Bulletin*, *32*, pp. 3-4.

[28] Breznitz, S. (1983), *Cry Wolf: The Psychology of False Alarms*, Lawrence Erlbaum Associates, Mahwah, NJ.

[29] Kahneman, D. (2011). *Thinking Fast and Slow*. Farrar, Straus & Giroux: New York.

In-cab communications

The transfer of concise and explicit information between train crew is essential to identify and respond to abnormal or emergency situations promptly, especially when one of the crew is undergoing on-the-job training. Oral communication is imperfect, and meaning is derived both from what is said and how it is said, as well as the nature of the interpretation of the receiver. As noted by Salas, Sims and Burke (2005), 'very often, individuals will receive very different messages when hearing the same communication because of their own perspectives and biases'.[30] Barriers to effective communication also arise from distraction, stress, incomplete messages and/or ambiguous wording.[31] Lack of common experience, task proficiency and situational awareness additionally impede effective communication of messages between supervisor and trainee.[32]

Due to a roster change with the trainee's assigned mentor driver, the trainee and supervising driver were working together as train crew for the first time. During the trip from Cook, the supervising driver provided instruction to the trainee on driving techniques and addressing issues experienced with locomotive wheel slip without any misunderstanding of the meaning of the communication between the parties.

Approaching Coonana, the supervisor intended to communicate that the he was unable to sight the enhancer, and that the trainee needed to brake urgently, and substantially. The trainee did not understand the call in this way, interpreting the instruction as being related to reducing speed for the 80 km/h restriction ahead. The trainee subsequently applied a minimum 50 kPa brake application and reduced the throttle power setting. The trainee recounted that the supervising driver was very calm when giving the instruction to brake, and did not appear convey any sense of alarm when speaking. The trainee likely perceived the verbal and non-verbal characteristics of the supervising driver's communication as routine, and the inability to sight the enhancer indication as inconsistent with a possible impending emergency.

In this case, a breakdown in verbal communication between the supervising and trainee driver resulted in a misunderstanding of the significance of not sighting the enhancer indication, and the urgency of the intended action to brake the train.

A widely practiced approach for supporting effective communication is the use of standardised calls and terminology. An example of this is air traffic control clearances, which are required to adhere to standardised content and structure.[33] Using standard terminology for known, predictable procedures and scenarios reduces the ambiguity of spoken messages. It also provides operational personnel with a standardised lexicon for communicating urgent messages and instructions when identifying and responding to an abnormal event or emergency.

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30 Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there a "big five" in teamwork?. *Small group research, 36(5)*, 555-599.

31 Kirby, J (1997). *Crew Resource Management (CRM) PowerPoint presentation*. A presentation of the Salt Lake City Flight Standards District Office (FSDO).

32 Civil Aviation Safety Authority (2019). Resource booklet 4: Communication. In Civil Aviation Safety Authority *Safety Behaviours: Human Factors for Pilots* (2nd Edition). Australian Government Publishing.

33 Rantanen, E. M., & Kokayeff, N. K. (2002, September). Pilot error in copying air traffic control clearances. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 46*, No. 1, pp. 145-149. Sage CA: Los Angeles, CA: SAGE Publications.

Task competence

Responding to abnormal conditions and emergencies is a core competency. Trainees are required to undertake a minimum of 8 hours of practicals/learning on the equipment to gain familiarisation and 30 hours of on-the-job operation of a train. Although the training program specifies a practical component to the competency, Pacific National advised that they do not provide any practical training to trainee drivers in the application of emergency braking either in a simulator, on a locomotive (static or moving) or during the operation of a train.

The importance of providing a trainee with opportunity to practice new skills is well-established. However, unstructured practice without objectives, appropriate stimulation, and useful feedback has been shown to be counterproductive.[34] Research in aviation shows that training in abnormal and emergency events improves flight crews' responses to these situations.[35] In a rail context, an abnormal or emergency event might call for heavy brake application.

The absence of equipment-based practicals/learning to gain familiarisation and the on-the-job operation/simulation as part of the Pacific National Certificate IV in Train Driving competency program potentially removes an important learning opportunity in preparing trainee drivers to control a train in response to abnormal situations or in an emergency.

[34] Cannon-Bowers, J.A., Rhodenizer, L., Salas, E., & Bowers, C.A. (1998). A framework for understanding pre-practice conditions and their impact on learning. *Personnel Psychology, 51*, 291-320.

[35] Burian, B. K., Barshi, I., & Dismukes, K. (2005). *The challenge of aviation emergency and abnormal situations*. NASA/TM-2005-213462. NASA.

Findings

From the evidence available, the following findings are made with respect to the derailment of train 7MP7 at Coonana, WA on 19 August 2018. 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

- An incorrectly stored lock pin from a point clamp fouled the indicator’s throw arm pivot mechanism, preventing the points from auto-normalising.
- The practice of storing the point clamp on the point indicator stand increased risk of the point indicator throw arm pivot mechanism becoming fouled.
- The speed of 7MP7 was not reduced sufficiently at the Location Ahead sign to ensure the train could stop before the facing points should the light indicator not display a green aspect.
- A breakdown in verbal communication between the supervising and trainee driver resulted in a misunderstanding of the significance of not sighting the light enhancer, and the urgency of the intended action to brake the train.

Other factors that increased risk

- The combination of enhancer luminaire type, positioning, and trackside vegetation likely reduced the conspicuity of the light indicator to the train crew of 7MP7.
- The driver competency program did not adequately prepare the trainee driver to control the train in response to an emergency.

Other findings

- The east end Light Indicator (enhancer) displayed a red lamp to the train crew.
- It is unlikely a rolling-stock condition contributed to the derailment.
- There was no evidence to suggest that any medical or physiological factor affected the train crew’s performance leading up to or during the incident.
- It is unlikely that fatigue adversely affected the train crew's performance during this shift.

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.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

The initial public version of these safety issues and actions are provided separately on the ATSB website to facilitate monitoring by interested parties. Where relevant the safety issues and actions will be updated on the ATSB website as information comes to hand.

Additional safety actions

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

ARTC

Post the derailment of 7MP7, Australian Rail Track Corporation (ARTC) removed all point clamps from the point indicator stands and relocated them to the adjacent equipment huts at each location between Malbooma (South Australia) and Parkeston (Western Australia). Additionally ARTC have replaced all K3 searchlight units with long-range LED luminaire type units between Malbooma and Parkeston.

Pacific National

Pacific National introduced a SPAD reduction program and reinforced that train crews reduce speed in preparation for stopping short of facing points until both drivers confirm recognition and understanding of indicator aspects. Additionally PN discussed with ARTC the implementation of improvements to point indicators between Kalgoorlie (Western Australia) and Cook (South Australia).

General details

Occurrence details

Date and time:	19 August 2018 – 1045 AWST	
Occurrence category:	Serious incident	
Primary occurrence type:	Derailment	
Location:	About 170 track km east of Kalgoorlie, Western Australia	
	Latitude: 31º 1.353' S	Longitude: 123º 10.328' E

Train details

Train operator:	Pacific National	
Registration:	7MP7	
Type of operation:	Intermodal freight	
Departure:	Melbourne	
Destination:	Perth	
Persons on board:	Crew – 2	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Australian Rail Track Corporation
- Pacific National
- Train crew of 7MP7

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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 the Australian Rail Track Corporation, Pacific National, train crew of 7MP7 and the Office of the National Rail Safety Regulator.

Submissions were received from the Australian Rail Track Corporation, Pacific National, train crew of 7MP7 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.

Australian Transport Safety Bureau

The 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 ATSB's 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.

Terminology used in this report

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing factor: a factor that, had it not occurred or existed at the time of an occurrence, then either:

(a) the occurrence would probably not have occurred; or

(b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or

(c) another contributing factor would probably not have occurred or existed.

Other factors that increased risk: a safety factor identified during an occurrence investigation, which did not meet the definition of contributing factor but was still considered to be important to communicate in an investigation report in the interest of improved transport safety.

Other findings: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.