Australian Government
Australian Transport Safety Bureau

Derailment of freight train 6MP4

near Glenalta, South Australia on 21 April 2018

ATSB Transport Safety Report
Rail Occurrence Investigation (Defined)
RO-2018-009
Final – 23 December 2020

Cover photo: Pacific National

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
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Addendum

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Safety summary

What happened

On 20–21 April 2018, Pacific National intermodal freight train 6MP4 was travelling from Melbourne, Victoria via Adelaide, South Australia to Perth, Western Australia. A short time after commencing the downhill grade from Mount Lofty to Belair, South Australia, there was a structural failure in the underframe of platform 2 of wagon RRYY01X. Soon after, the shared bogie between platform 2 and 3 of the wagon derailed. The train continued down the grade until it separated (between platform 2 and platform 3), with both portions of the train coming to a stop near Glenalta.

What the ATSB found

The investigation found that a pre-existing structural crack in the underframe of platform 2 of wagon RRYY01X likely expanded due to in-train forces (compression and tension), causing the platform's deck to bend and change the deck angle at the coupling to platform 3 (supported over a common bogie). As train 6MP4 negotiated a series of tight curves on the descending grade, the combination of wheel unloading (due to compressive forces and coupling angle on a light wagon) combined with increased lateral forces (due to compressive forces and a tight curve), resulted in flange climb (possibly complete wheel lift) and subsequent derailment.

The ATSB found that multiple train examinations and maintenance inspections did not identify the crack in platform 2 of wagon RRYY01X. In addition, Pacific National's inspection processes did not identify key structural points for inspection on RRYY class wagons, including the susceptibility to cracking in the junction between container loading outriggers, pull rod boxed opening, and the bottom centre sill sections. This reduced the likelihood of the cracks being detected.

Additionally, the ATSB found that the train separation at Glenalta did not activate the locomotives' emergency braking systems, although this did not increase the risk associated with this accident.

What has been done as a result

Immediately following this accident, Pacific National issued a Rolling Stock Notice requiring immediate inspections of all RRYY class wagons for underframe cracking, with wagons exhibiting cracking around the underframe removed from service for repairs. Magnetic particle inspection or dye penetrant inspection of welded connections were also added to the scheduled preventative maintenance requirements.

Following the initial response, Pacific National undertook a fleet assessment of RRYY class wagons to ensure that they were safe to return to revenue service and developed a long-term repair methodology for RRYY wagons with identified cracks.

Safety message

Rolling stock managers should consider the key structural risk areas of their rolling stock and establish guidance methods for ensuring that these risk areas are given an appropriate level of priority when undertaking inspections.

Contents

The occurrence

Overview

On 20–21 April, Pacific National intermodal freight train 6MP4 was travelling from Melbourne, Victoria via Adelaide, South Australia to Perth, Western Australia. At about 0003[1] on 21 April 2018, a short time after commencing the downhill grade from Mount Lofty to Belair, South Australia, there was a structural failure in the underframe of platform 2 of wagon RRYY01X. Soon after, the shared bogie between platform 2 and 3 of the wagon derailed. The train continued down the grade until the train separated (between platform 2 and platform 3 of wagon RRYY01X) and came to a stop near Glenalta.

Wagon RRYY01X was a multi-platform 5-pack[2] wagon. The wagon's position behind the locomotives placed it about the centre in the train consist, and platform 2 was the only one not loaded with a container.

Prior to derailment

The train crew of 6MP4 involved in this accident commenced their shift at Dimboola (Victoria), departing at about 1854 on 20 April 2018. They did not pass or cross any trains between Dimboola and Glenalta. The train crew reported that, apart from a level crossing near miss with a road vehicle forcing an emergency stop near Lillimur (Victoria), the journey towards Mount Lofty was uneventful.

A third locomotive (8223) was added to train 6MP4 at Tailem Bend (88 km before Mount Lofty). At about 2342, the train began an 11 km steep climb up to Mount Lofty (Figure 1). The three locomotives were operating almost continuously in throttle notch 8 (maximum tractive effort), only easing off slightly at a couple of short sections of level track. At about 2358, 6MP4 passed Mount Lofty and commenced travel on the downhill grade[3] towards Belair (Figure 1).

Mount Lofty is located at the top of a cresting grade.[4] As the train passed over the cresting grade, the weight and resistance of the train's rear portion still on the ascending grade (1,485 t trailing behind wagon RRYY01X) was opposed by the combined tractive effort and weight of the front portion of train now on the descending grade (1,368 t ahead of wagon RRYY01X).

As more weight moved onto the descending grade, the driver gradually decreased tractive effort and began applying braking effort using the locomotives' dynamic brakes. The driver progressively increased braking effort until the locomotives were applying full dynamic brake, with the train transitioned to a compressed state.

1 All time reference in this report are in local time (Central Standard Time).
2 5-pack wagon: an articulated wagon comprising five platforms, with the adjacent ends of individual units being supported on a common bogie and permanently connected by a device, which permits free rotation in all planes.
3 The downhill grade between Mount Lofty and Belair varies between 1:45 and 1:48.
4 Cresting grade: a long ascending grade that changes to a long descending grade, both grades being of sufficient magnitude to require a change in train handling procedures as the grade is topped.

Figure 1: ARTC track from Mount Lofty station to Glenalta station, including derailment information

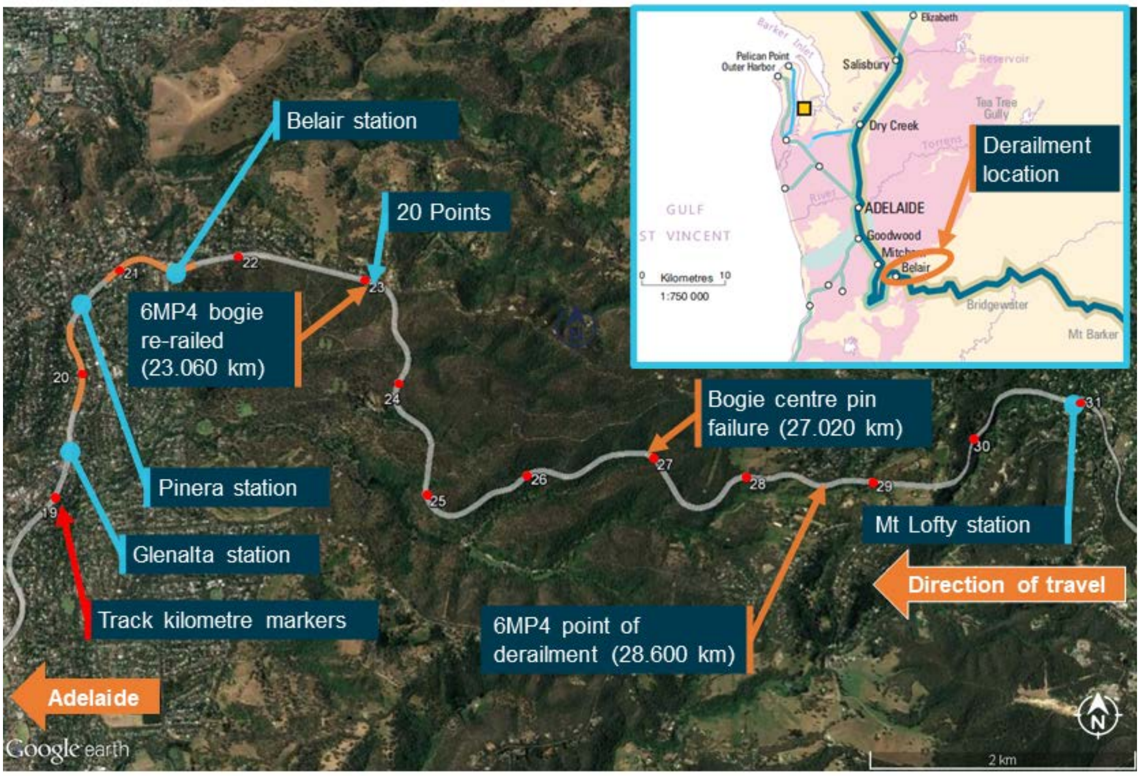

Image shows ARTC track from Mount Lofty station to Glenalta station in grey, with red indicators showing kilometre markers. Location of key events indicated with orange markers.
Source: Google Earth annotated by the ATSB, and inset ARA Railways of Australia Map 2014 annotated by the ATSB

At some point during the train's descent, the underframe of wagon RRYY01X's platform 2 experienced a structural failure, which led to the deck of platform 2 dropping or sagging (Figure 2). This resulted in the deck angle of platform 2 rising towards the coupling to platform 3. The compressive forces acting on the angled deck of the empty platform 2 reduced the weight acting on the trailing axle from the bogie/wheels shared between platform 2 and 3.

Figure 2: Structural failure in underframe of platform 2 of RRYY01X

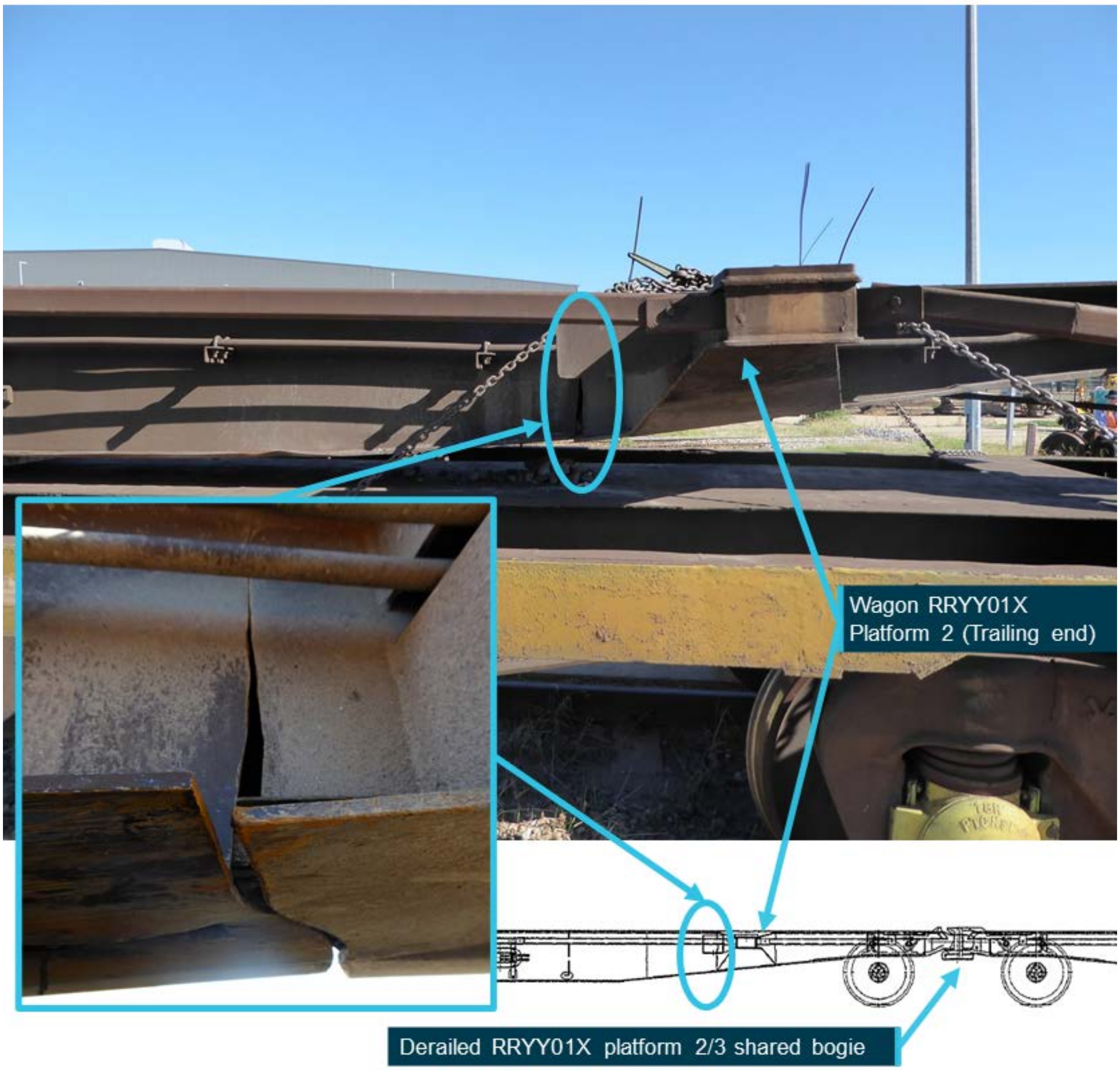

Image shows the structural failure in the underframe of wagon RRYY01X (platform 2) and its respective location to the derailed shared bogie between platforms 2 and 3.
Source: Pacific National and ATSB, annotated by the ATSB

Derailment

At about 0003 on 21 April, as the wagon negotiated a series of tight curves, the lightened axle between platform 2 and platform 3 climbed or lifted over the rail and subsequently derailed.

The first evidence of derailment was subsequently observed at the 28.6 km mark (about 2.4 km past Mount Lofty station). Wheel witness marks were identified on the exposed upper surface of the resilient track fastenings through a right curve (Figure 3).

Figure 3: Initial evidence of derailment between Mount Lofty and Belair

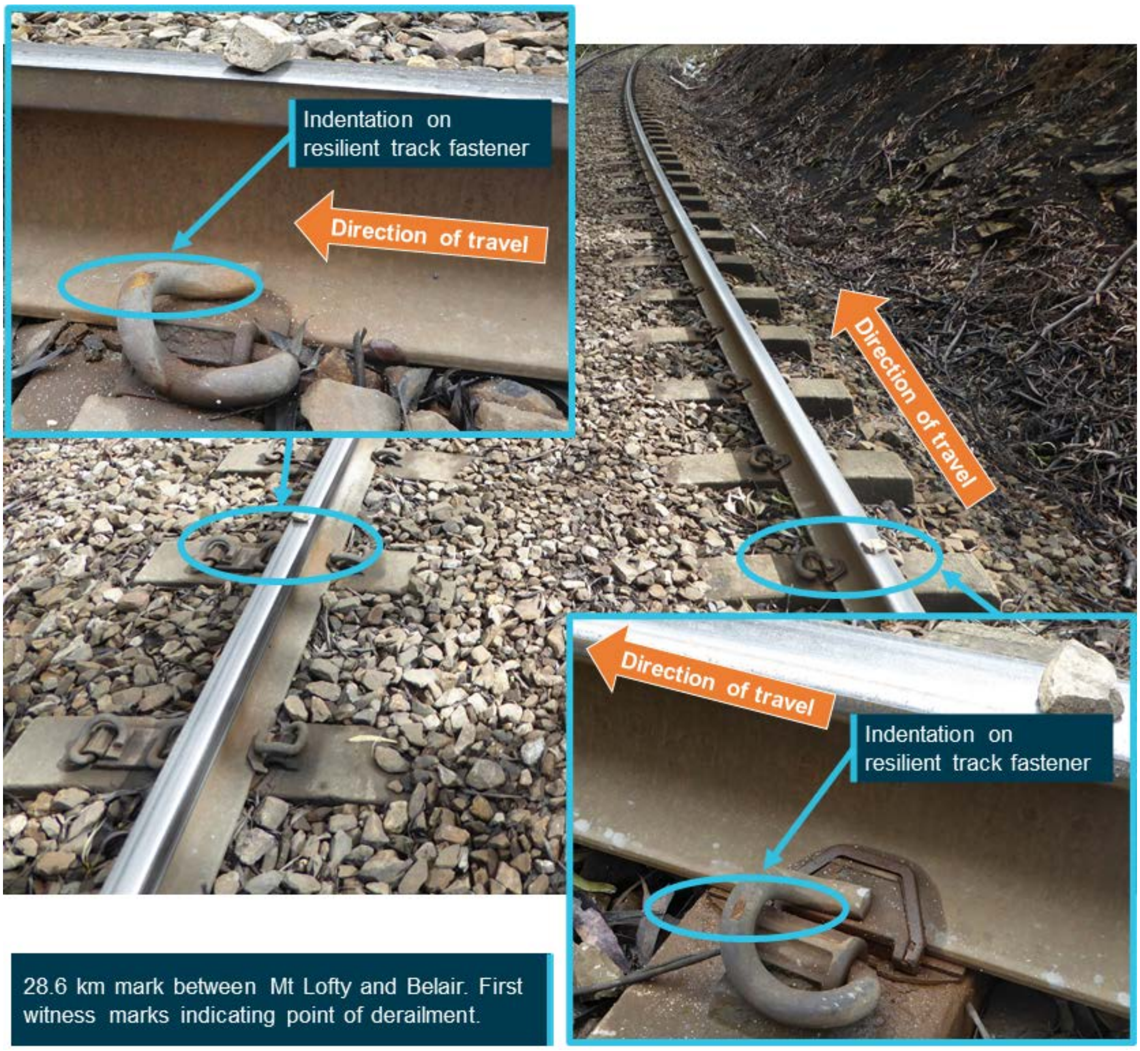

Image shows the location of the initial wheel witness marks on the upper surface of the resilient track fastenings at the 28.6 km mark.
Source: ATSB

The combination of a sagging deck and derailed wheels allowed the underframe to start rubbing on the leading axle of the bogie shared between platform 2 and 3 (Figure 4).

Figure 4: Contact abrasion damage to wheelset axle and platform 2 of 5-pack wagon RRYY01X

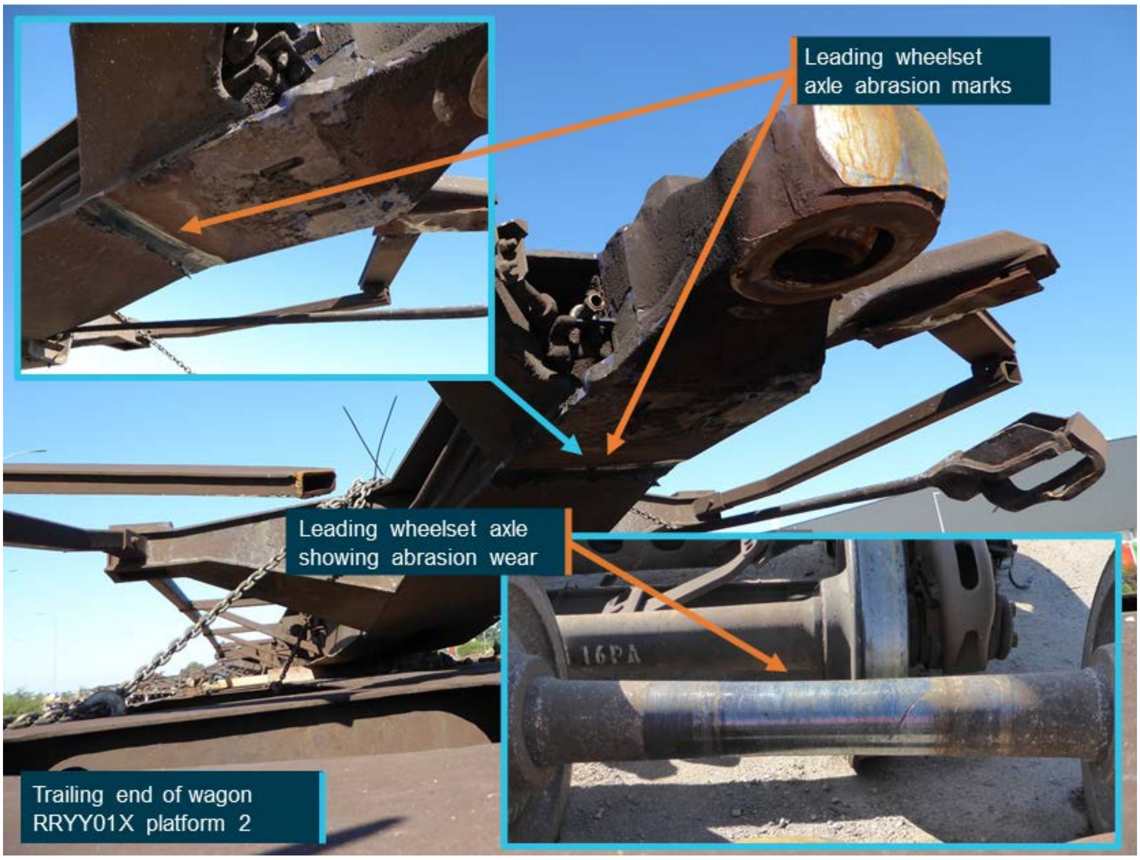

Image shows leading wheelset axle abrasion marks from the shared bogie between platform 2 and 3 of 5-pack wagon RRYY01X.
Source: ATSB

The trailing axle continued in a derailed state for a further 1.58 km, making intermittent contact with the ground, track fastenings and sleepers. At about 0005, when passing the 27.02 km point, bogie components collided heavily with a concrete sleeper, dislodging the constant-contact side-bearer pads at this location and breaking the bogie centre-pin (Figure 5).[5]

The failed centre-pin allowed the bogie to dislodge from its centre-bowl and move back towards the rear of the train, fouling with the leading end structure of platform 3. Over the next 3.9 km, the derailed rear axle made more frequent contact with the ground, track fastenings and sleepers.

[5] Bogie centre-pin: in the case of a RRYY class 5-pack wagon, the pin used to locate the bogie within the centre-bowl and secure the bogie to the wagon structure. Note: the bogie centre-pin and platform coupler-pin are joined to each other in a RRYY class wagon.

Figure 5: Wagon coupler-pin and bogie centre-pin from RRYY class wagon

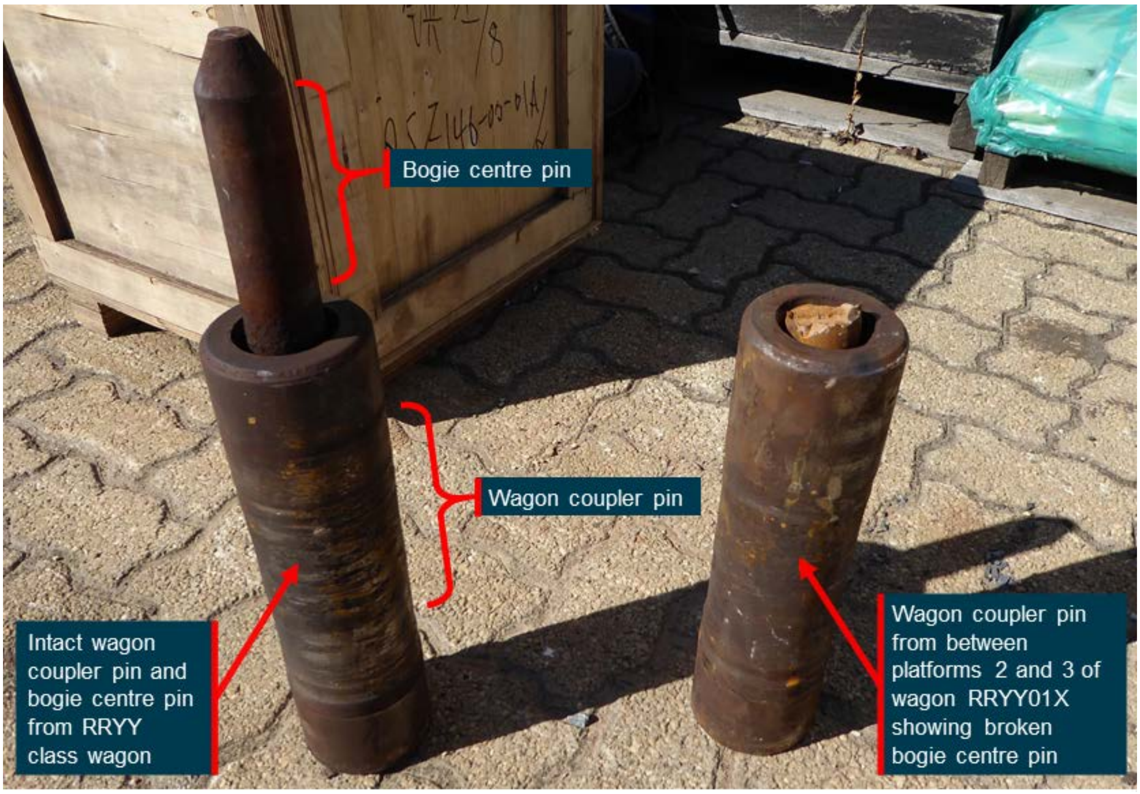

Image shows an intact combined wagon coupler-pin and bogie centre-pin from a RRYY class wagon, alongside the wagon coupler-pin from wagon RRYY01X with missing bogie centre-pin.
Source: ATSB

At about 0011, as the derailed bogie of wagon RRYY01X passed through 20 Points at the entrance to the Belair crossing loop (23.081 km point, Figure 1), bogie components collided with the point components. About 25 m later, the derailed axle re-railed at the V-crossing[6] for the crossing loop. The train continued, with the bogie between platforms 2 and 3 running on the rails, but dislodged from its centre-bowl and fouling with platform 3.

Train separation

Train 6MP4 gradually slowed as it descended the grade. At about 0014, as the lead locomotive passed about the 20.36 km mark, there was a slight increase in train speed. This coincided with wagon RRYY01X uncoupling and separating between platforms 2 and 3.

Separation of the two platforms resulted in the breaking of the train's brake air pipe and exhausting of brake pipe air to the atmosphere. The driver observed a high reading on the locomotive's brake pipe airflow gauge and, expecting an emergency application of the automatic brake (train-line emergency brake), they commenced bailing or holding off the locomotives' brakes.

The reduction in brake pipe air pressure to the rear portion of train 6MP4 resulted in the automatic application of the wagon brakes, bringing the 1,485 t rear portion of train 6MP4 to a stop in about 212 m. The breaking of the train's brake pipe also exhausted air from the front portion of train 6MP4, causing the wagon brakes to apply, though the locomotives' emergency brake systems did not activate.

[6] V-crossing: a track component that enables a wheel travelling along one rail to pass through the rail of a track which crosses its path.

At about 0015, the driver allowed the front portion of train 6MP4 to come to a stop using a combination of wagon braking effort (from the brake pipe rupture and pressure reduction), and an increase in the locomotive dynamic braking effort. The driver applied the locomotives' brakes to stop the front portion of the train in the final 4 seconds of movement. The front portion of train 6MP4 was bought to a stop in about 662 m. After coming to a stop, the front and rear portions of the split train 6MP4 were separated by approximately 450 m (Figure 6).

The drivers recalled that when the front portion of the train came to a stop, there had been no bumping or crashing in the train. As such, neither of the drivers were expecting that the train had separated.

Figure 6: The stopped location of both portions of 6MP4 after the train separated

Image shows ARTC track in grey, with red markers showing kilometre markers, and 6MP4 stopped position of both portions in orange.
Source:
Google Earth annotated by ATSB

The previously derailed bogie was found lodged outside of its normal location under the leading end of RRYY01X platform 3, and the trailing end of platform 2 was found on the ground. There was substantial damage to the bogie and two platforms from the 5-pack wagon RRYY01X (Figure 7), plus minor damage to rail infrastructure (*Location and infrastructure*). There were no injuries.

Figure 7: Platform 2 and 3 from 5-pack wagon RRYY01X in their stopped locations

Image shows the final position of the bogie involved in derailment with platform 2 and 3, after train 6MP4 came to a stop near Glenalta.
Source: Pacific National annotated by the ATSB

Context

Location and infrastructure

The accident occurred over an 8.9 km section of standard gauge track between Mount Lofty and Glenalta, located in the Adelaide Hills approximately 31 to 19 track kilometres from Adelaide respectively (Figure 8). This section of track forms part of the interstate line between Melbourne and Adelaide, and is managed by the Australian Rail Track Corporation (ARTC).

The ARTC standard gauge track from Belair towards Adelaide is adjacent to the broad gauge track, part of the Adelaide Metropolitan Passenger Rail Network, managed by the Government of South Australia, Rail Commissioner.

Figure 8: Location of derailment site, between Mount Lofty and Glenalta

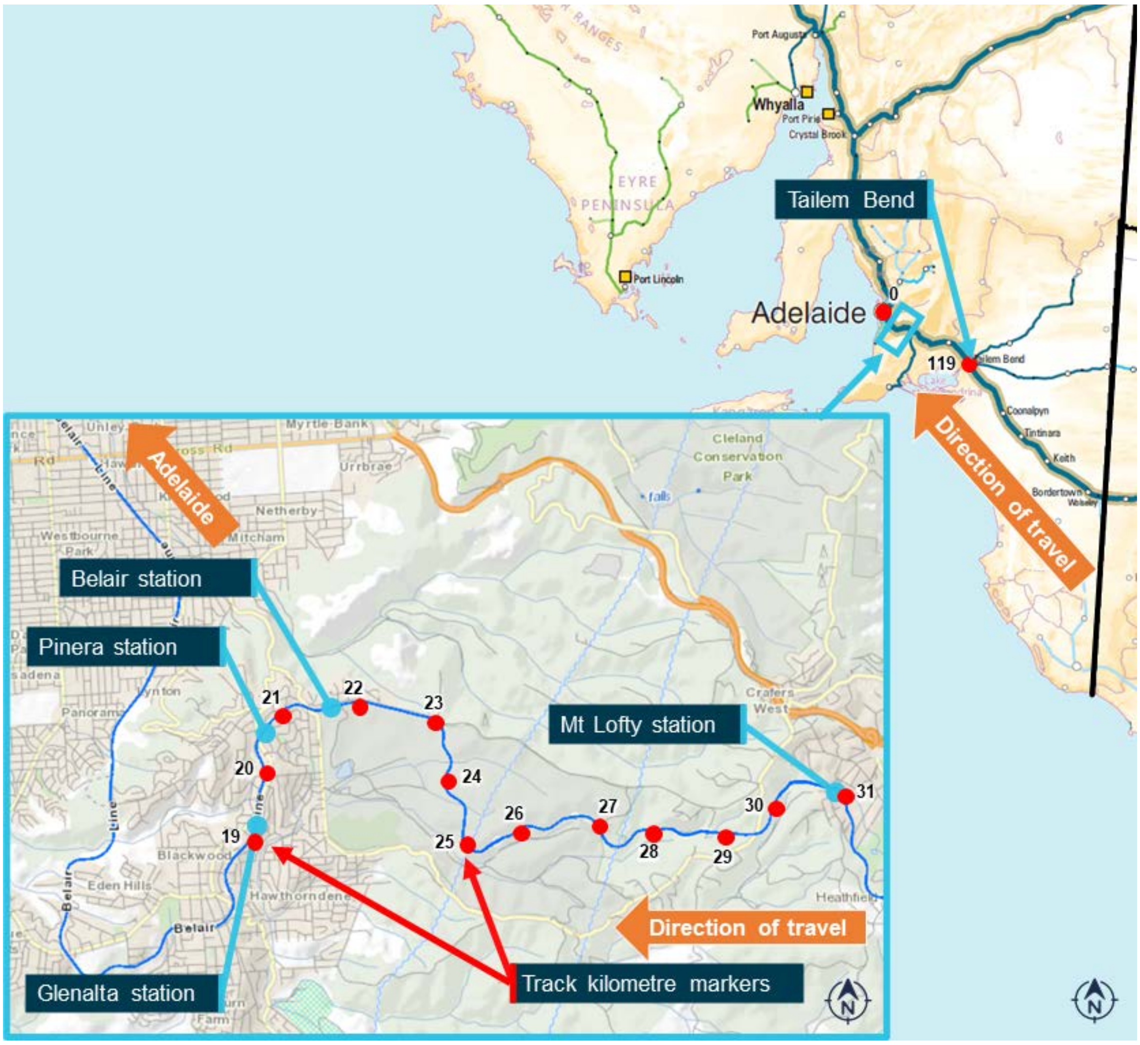

Image shows location of derailment site within South Australia, and inset image shows ARTC track in greater detail from Mount Lofty Railway Station to Glenalta Railway Station.
Source: ARA Railways of Australia Map 2014 and Australian Government National Map, both annotated by the ATSB

The standard gauge track consists of continuously welded rail secured to concrete sleepers by resilient fasteners and supported on ballast. The configuration is typical of the standard used for the interstate line in South Australia.

From Mount Lofty, the track exhibits a 1 in 45 down gradient (Figure 9), with multiple tight curves. This section of track consists of both left and right curves varying in radius between 195 m and

700 m. A standard gauge crossing loop is located at Belair, about 8 km from Mount Lofty. The crossing loop provides 1,543 m of standing room[7] over an almost level straight section of track.

The Belair railway station is located approximately 200 m within the Adelaide end of the Belair crossing loop. The track continues to descend at a 1 in 47 down gradient (Figure 9), through multiple tight curves, towards Glenalta. Although each of the railway stations (from Belair) are active for passenger services, the platforms facing the standard gauge track are unused.

Figure 9: Mount Lofty to Glenalta track layout and gradient information

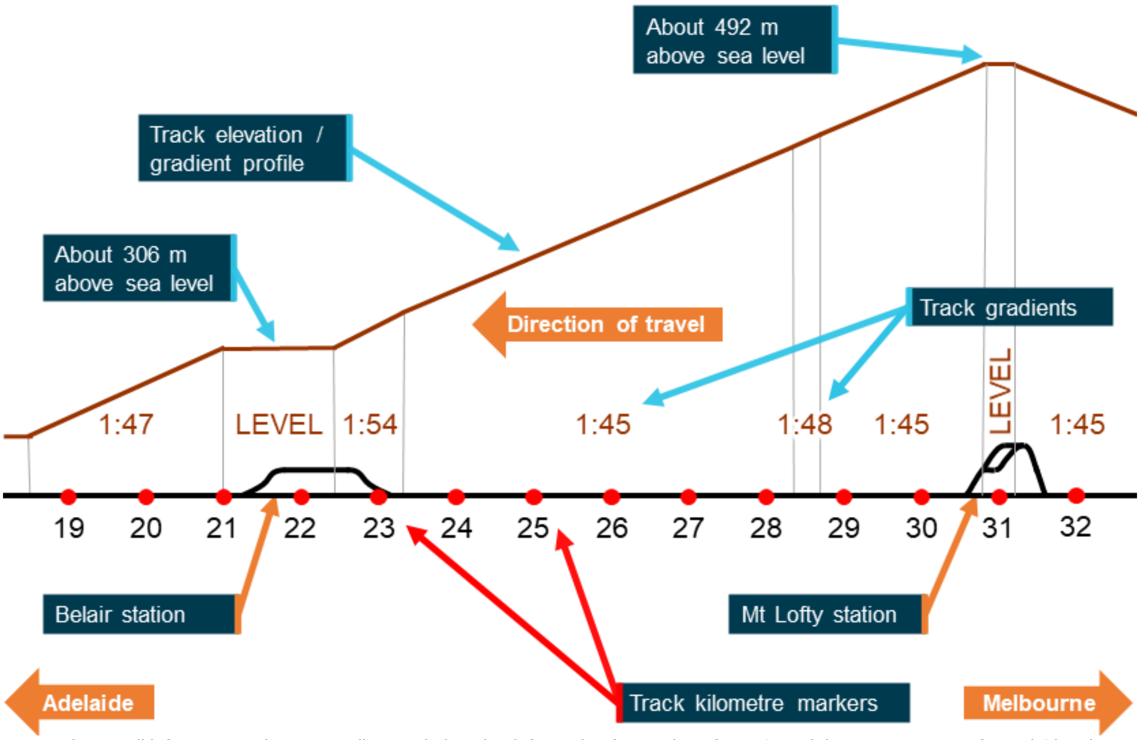

Image shows rail infrastructure layout, gradient and elevation information for section of ARTC track between Mount Lofty and Glenalta.
Source: ATSB

The condition of the rail infrastructure including rail lubrication equipment between Mount Lofty and Belair was observed by the ATSB. The ATSB found no evidence to suggest that the condition of the rail infrastructure contributed to the derailment.

Approximately 5 km of standard gauge track sustained intermittent damage from the derailment, with about 50 concrete sleepers requiring replacement. At the Mount Lofty end of the Belair Station crossing loop, timber sleepers and associated points turnout components, rods and bars required replacement. Damage was also sustained to automatic rail lubricators between Belair and Mount Lofty.

There was no damage caused to the adjacent Adelaide Metropolitan Passenger Rail Network, or road bridges within the area.

Environmental conditions

Information obtained from the Bureau of Meteorology (BoM) established that the weather near Mount Lofty was mild, with light rain and relatively light winds in the period leading up to the accident. During the previous day, the BoM weather stations at Mount Lofty recorded a minimum temperature of 17.9 °C and a maximum of 25.6 °C. At the time of the accident, the temperature was about 18 °C.

[7] Standing room: the distance along the track between points of minimum allowable clearance where rolling stock is permitted to stand.

Given these conditions, the ATSB determined that environmental factors were unlikely to have contributed either directly or indirectly to the accident.

Train information

Pacific National was the owner and operator of freight train 6MP4. The train consisted of two locomotives (NR62 and NR58) hauling 26 wagons (both single and multi-platform wagons) from Melbourne, with a third locomotive (8223) added at Tailem Bend (88 km before Mount Lofty). The total train length was about 1,499 m, and weighed about 2,853 t.

Although train 6MP4 was transporting dangerous goods in some containers, these were located on wagons further back in the train consist and were not associated with the derailed wagon. There was no release or spillage of dangerous/toxic goods from containers or wagon loads as a result of the accident.

Train crew information

Two Pacific National locomotive drivers were crewing train 6MP4. The driver operating train 6MP4 and the second driver had about 24 and 12 years' experience (respectively) as locomotive drivers for Pacific National. Both held current driver competencies, route knowledge and rail safety worker health assessments.

The driver of train 6MP4 used dynamic brake alone to control train speed on the steep descending gradient from Mount Lofty. The locomotive event recordings indicate that the driver made gradual changes to dynamic braking effort, maintaining train speed between a minimum of 28 km/h and a maximum of 51 km/h, while also keeping in-train forces as constant as possible.

Although this approach to train handling has a number of benefits, the use of dynamic braking as the sole means of controlling train speed on a descending grade can generate significant in-train longitudinal compressive forces. However, this method of train handling is common practice for freight trains traversing the steep gradients in this location and is consistent with the handling instructions documented in Pacific National standard PN-STD-SAF - *Train Handling*.

In summary, the available evidence indicated that the driver handled train 6MP4 appropriately in the period leading up to the accident.

Consistent with Pacific National procedures, both drivers were requested to undertake drug and alcohol tests following the incident. The tests returned a negative result for each driver. A review of available evidence did not identify any concerns regarding the drivers' fitness for duty in the period leading up to the accident.

Train braking systems

Dynamic brake

The dynamic brake, independent brake, and automatic brake are sub-systems of the train's overall braking system.

Dynamic braking is a locomotive braking function present in diesel-electric and electric drive locomotives. It is not a substitute for the train's air braking, but is a supplementary system that provides an additional means of speed control. A benefit of dynamic braking is to reduce the wear and heat generated by the friction style train braking equipment used by the independent and automatic braking sub-systems.

Dynamic braking uses the locomotive electrical traction motors as generators, converting the kinetic energy of a moving train into electrical energy. The electrical energy generated is dissipated into fan cooled electrical resistor banks. Increasing or decreasing the amount of electrical resistance in the resistor banks varies the load on the traction motor generator, which applies a corresponding resistance/braking effect on the rotating locomotive wheels.

Independent brake

The independent brake solely controls air brakes within the locomotive(s) and works independently of a train's other braking control systems. The locomotive brakes are applied when the locomotive brake cylinder pressure is increased. This pressure can be increased or decreased via the driver's independent brake control handle.

Automatic brake

The automatic brake controls the air brakes in the entire train, including the locomotive(s). An application of the automatic brake applies the locomotive(s) brakes by increasing locomotive brake cylinder pressure (similar to control via the independent brake system). The automatic brake simultaneously triggers the application of the train's wagon brakes by reducing the air pressure within the train's brake pipe. Maximum wagon braking effort is achieved when the brake pipe pressure is reduced to about 350 kPa, and wagon brakes are released when the brake pipe is charged to about 500 kPa.

The driver can vary the train's braking effort, by operating the locomotive's automatic brake control handle. Brake pipe air pressure is reduced at the service rate for normal braking applications, or at the greater emergency rate when an emergency brake application is made. The driver also has a 'bail-off' feature whereby they can suppress the braking action of the locomotive(s) following an automatic brake application, therefore enabling only the wagon brakes to stop the train.

Train-line emergency brake application

In the event that the train's brake pipe is broken or ruptured following a train separation, the train's wagon and locomotive brakes are automatically applied at the emergency rate. This safety feature of the automatic brake is also known as a train-line emergency brake application.

The Australian Standard AS7510.6:2014 (*Braking Systems – Part 6 – Train*), specified the minimum standards for brake performance, features, and compatibility for the braking systems of trains. This standard specified that:

> In the event of train separation, the brake application provided by the stopping brake[8] shall be an emergency application of the stopping brake on every vehicle of the train.

That is, the rapid reduction in a train's brake pipe pressure, caused by a train and brake pipe separation, must apply brakes at the emergency rate within every vehicle within the train, including locomotives. Although the locomotives of 6MP4 had the ability to comply with this requirement, practical application of the requirement can be influenced by the compliance of the connected wagons' braking systems. In this case, the wagons which made up 6MP4 were manufactured before the standard was released, and there was no requirement to retrospectively apply this standard to these wagons.

Operationally, the driver has the option to prevent the automatic emergency application of the locomotive brake by using the bail-off feature. This is usually done in order to prevent a collision between two separated portions of a train, caused by the front portion of the train slowing faster than the rear portion. Despite this, there remains an initial automatic requirement for the braking systems in each vehicle of the train to respond to the train separation.

To detect train separations, locomotives are fitted with braking control systems designed (among other control purposes) to detect the rapid reduction of the train's brake pipe pressure. In the event that a rapid reduction of brake pipe pressure is detected, the braking control systems enable the locomotive(s) emergency braking systems to remove the locomotive drive and provide a faster braking response to bring the train to a stop. These additional emergency braking system actions can include:

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[8] Stopping brake: braking equipment used for stopping a train in running.

- faster exhaustion of brake pipe air pressure via the locomotive's brake control valves
- removal of the brake pipe charging source (compressor output) from attempting to re-charge the train's brake pipe
- application of the locomotive brake
- de-energization of the locomotive traction power via the pneumatic control switch/power knockout switch (PCS)
- application of emergency adhesion sanding.[9]

Automatic braking of train 6MP4

In this case, as the lead locomotive of 6MP4 passed the 20.362 km mark, wagon RRYY01X uncoupled between platforms 2 and 3. This resulted in the separation of the train's brake air pipe, which exhausted the brake pipe air to the atmosphere.

Following the accident, the train's brake pipe connections between platform 2 and 3 of RRYY01X were examined. This examination confirmed that the brake pipe had been cleanly broken in the train separation sequence (Figure 10). The brake pipe was not crimped or partially restricted during the train separation, allowing for unrestricted exhausting of brake pipe air.

Figure 10: Broken train brake pipe in platform 2 of 5-pack wagon RRYY01X

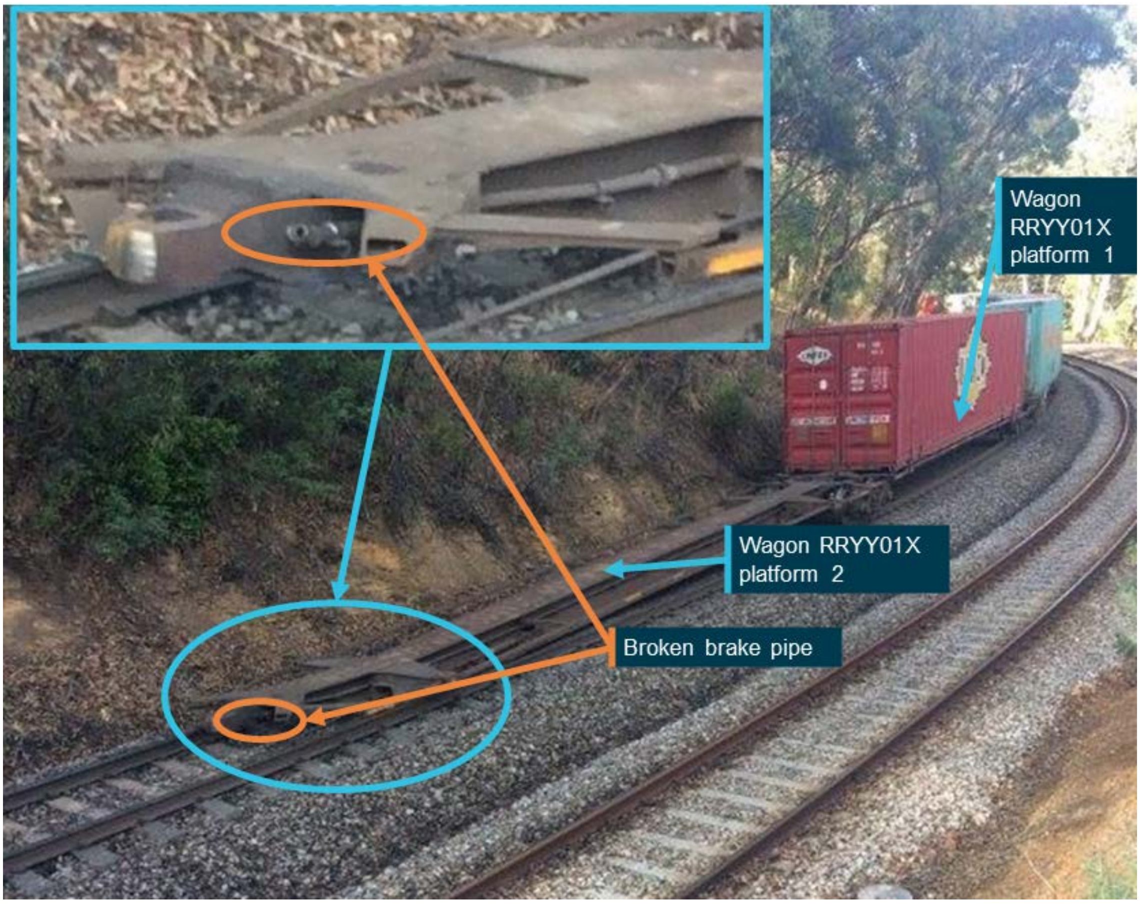

Image shows the broken brake pipe on platform 2 of 5-pack wagon RRYY01X.
Source: Pacific National and ARTC, annotated by the ATSB

The rear portion of train 6MP4 stopped due to the reduction in brake pipe air pressure and automatic application of the wagon brakes. Although the wagon brakes also applied on the front portion of 6MP4, the emergency brake systems on the three locomotives did not activate.

9 Sanding is used in train operations to improve adhesion or traction in both braking and traction.

Examination of the locomotive event recording verified the absence of emergency brake application. More specifically:

- Emergency brake application would normally trigger adhesion sanding in NR class locomotives, but this was not evident after the train separation in this instance (Figure 11).
- Emergency brake application would normally trigger automatic application of a locomotive's brakes. The locomotive brakes did not apply, though in this instance the driver reported bailing or holding off the locomotives' brake after they observed the high brake pipe flow rate.
- Emergency brake application would normally trigger complete evacuation of brake pipe air pressure. In this instance, brake pipe pressure appeared to remain just above 300 kPa (Figure 11).

Figure 11: Graph derived from extract of locomotive NR62 event recorder data

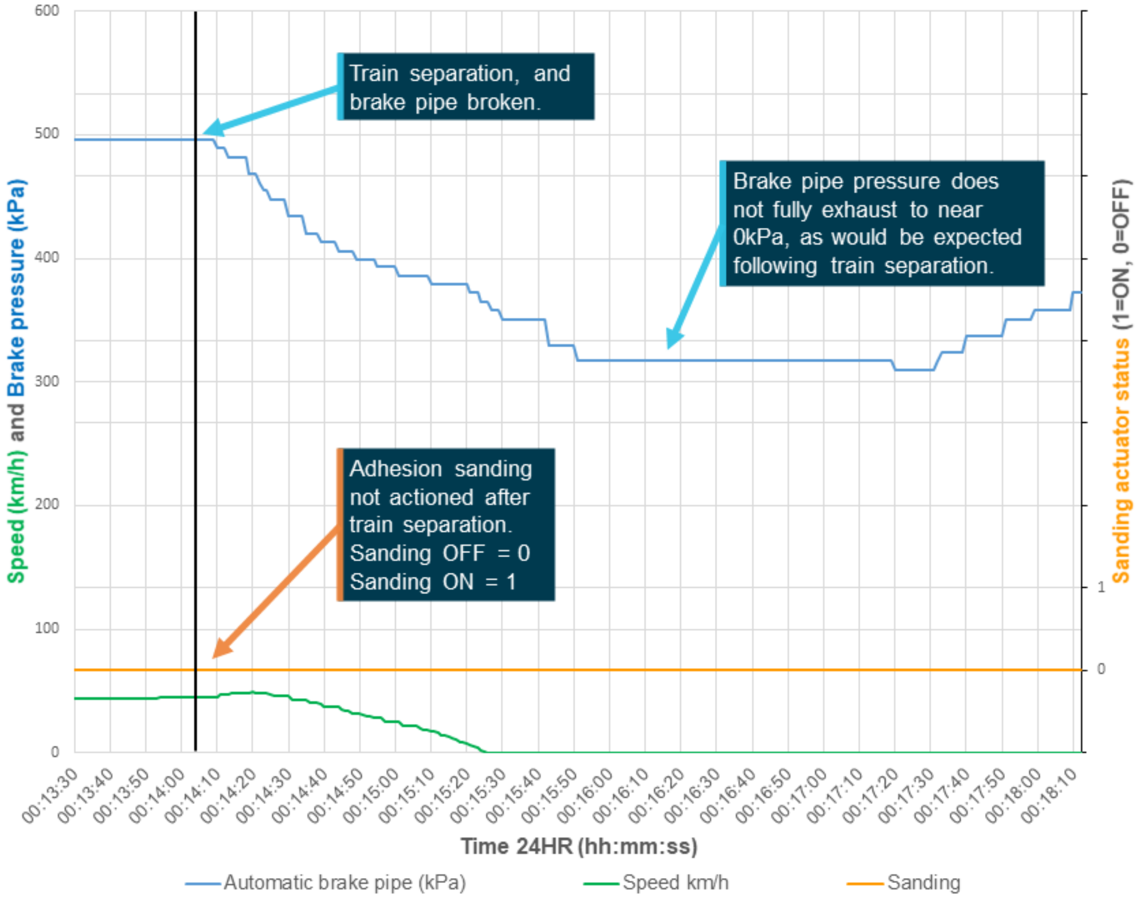

Image shows recorded locomotive NR62 data of the automatic brake pipe pressure, train speed, and sanding status from the front portion of the separated train. The NR62 recordings from the derailment sequence is not displayed in this graph.
Source: Data source Pacific National, graphed by the ATSB

Rolling stock – Wagon RRYY01X

General details

Wagon RRYY01X was one of 52 built in three tranches in 2004–05. The RRYY class wagon is a 5-pack skeletal container wagon (Table 1). This style of wagon consists of five individual wagons referred to as 'platforms 1 to 5', permanently coupled over common bogies (Figure 12).

Table 1: Summary details for Pacific National RRYY class wagons

Element	Value
Tare weight	59.6 t
Length	88.1 m (over couplers)
Max gross weight	200 t
Payload capacity	140 t
Max allowable speed	115 km/h
Number in class	52 (after this accident 50 remained in service)
Date first built	2004

Source: Pacific National Wagon Details Manual WDM-RRYY_04, Issued 28 July 2010

Figure 12: Pacific National RRYY class wagon

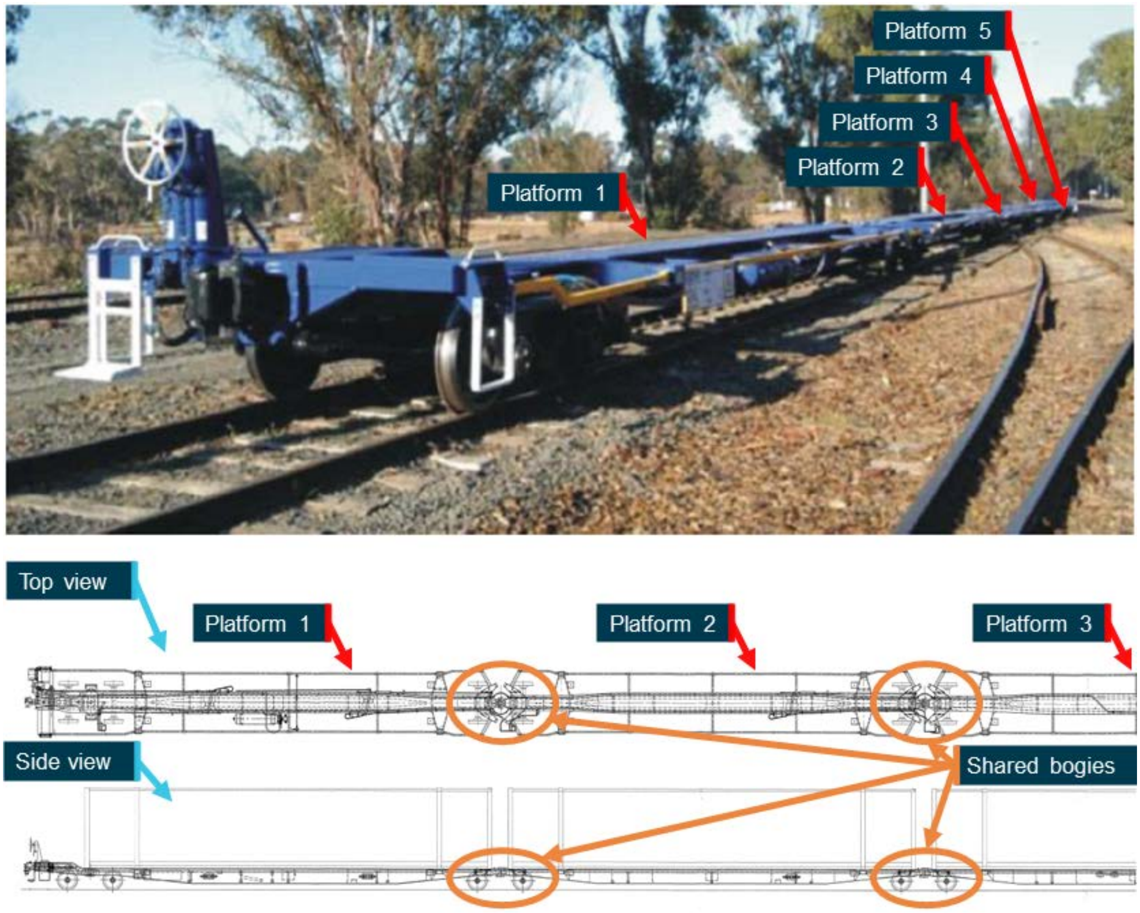

Image shows platform and shared bogie configuration of RRYY class wagon.
Source: Pacific National, annotated by the ATSB

The RRYY class wagons were a non-typical low deck wagon design, incorporating a light underframe that was intended to carry car containers. The low deck level was achieved by a combination of smaller diameter wheels, and large low depth gooseneck sections extending from the platform coupling and bogie centres to the larger platform main centre-sill section (Figure 13). Near the junction of this gooseneck and the main centre-sill section of the platform, an outrigger provided support for the container load via its connection to the main centre-sill and goose neck sections. The outrigger featured a large boxed opening for the wagon's brake pull rod (Figure 13).

Figure 13: RRYY class wagon platform structure

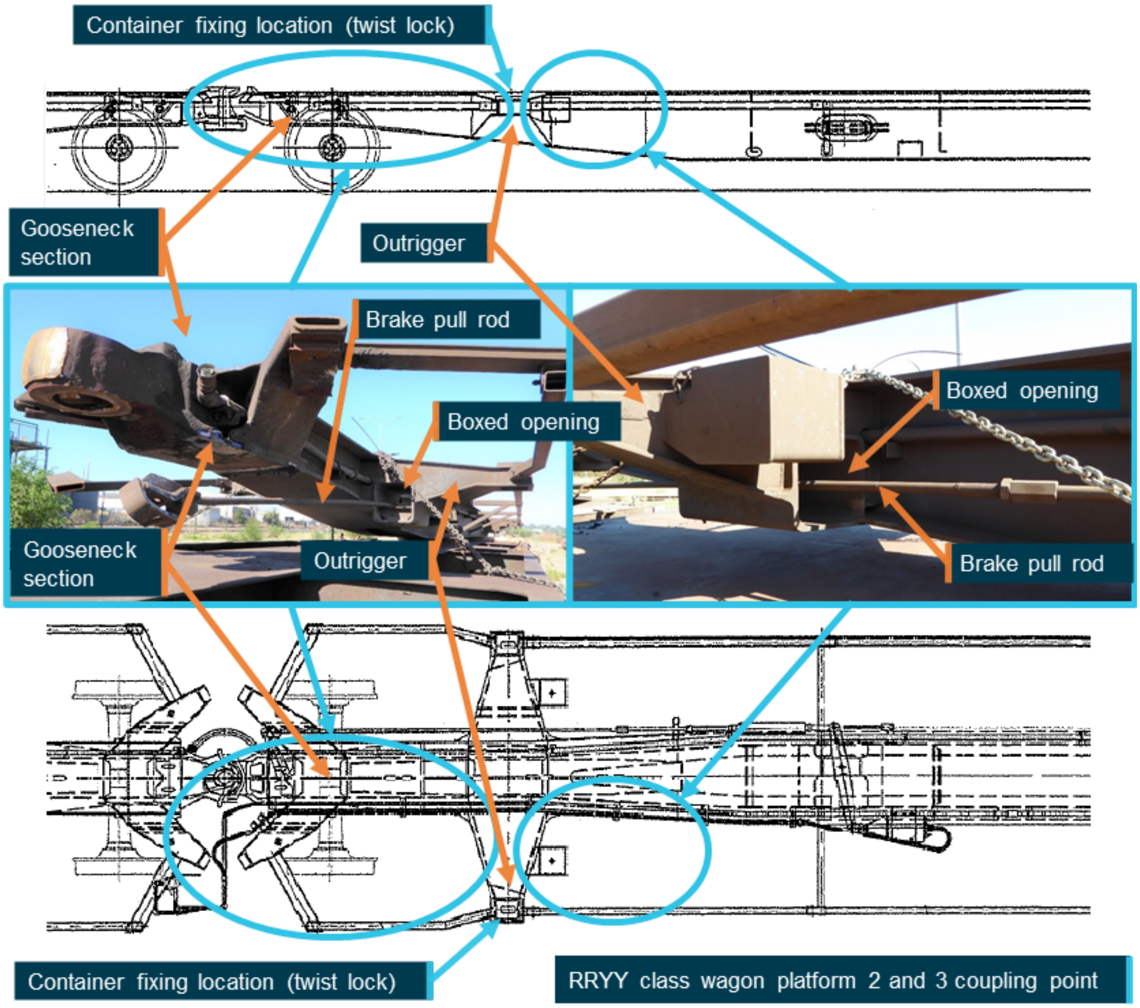

Image shows the low depth platform gooseneck section which extends from the platform coupling and bogie centre to the larger main centre sill section of the platform, as well as the boxed outrigger section.
Source: Pacific National, and ATSB annotated by the ATSB

Post-accident examination

Platform 2 of wagon RRYY01X was recovered to the Adelaide Freight Terminal, allowing for a more detailed examination of the underframe failure. The failure originated from a crack between the join of the bottom centre sill plate and pull rod boxed opening in the wagon's container loading outrigger (Figure 14).

Figure 14: Underframe cracks in platform 2 of 5-pack wagon RRYY01X

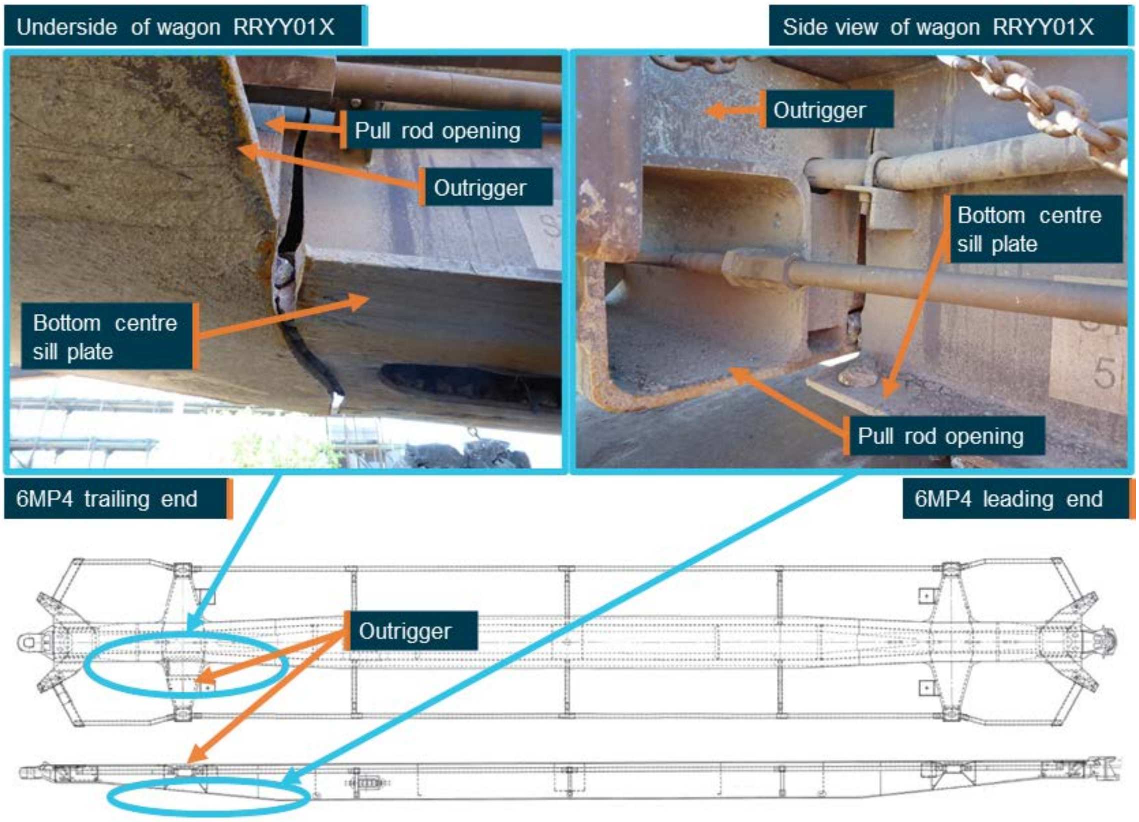

Image shows underframe cracks and their location in platform 2 of 5-pack wagon RRYY01X. The underframe cracks and derailed bogie were located at the trailing end of platform 2 of 5-pack wagon RRYY01X.
Source: Wagon drawing - Pacific National annotated by the ATSB; photos – ATSB

An examination of the crack surface on platform 2 suggested the initial propagation had occurred over a long period of time. This was followed by a rapid propagation shortly prior to and during the derailment. Although the exact period of time the initial crack was evident could not be determined, the crack surface condition suggested it existed weeks to months before, and most certainly was present prior to 6MP4's departure from Melbourne (Figure 15).

Figure 15: Underframe crack fracture surfaces in platform 2 of 5-pack wagon RRYY01X

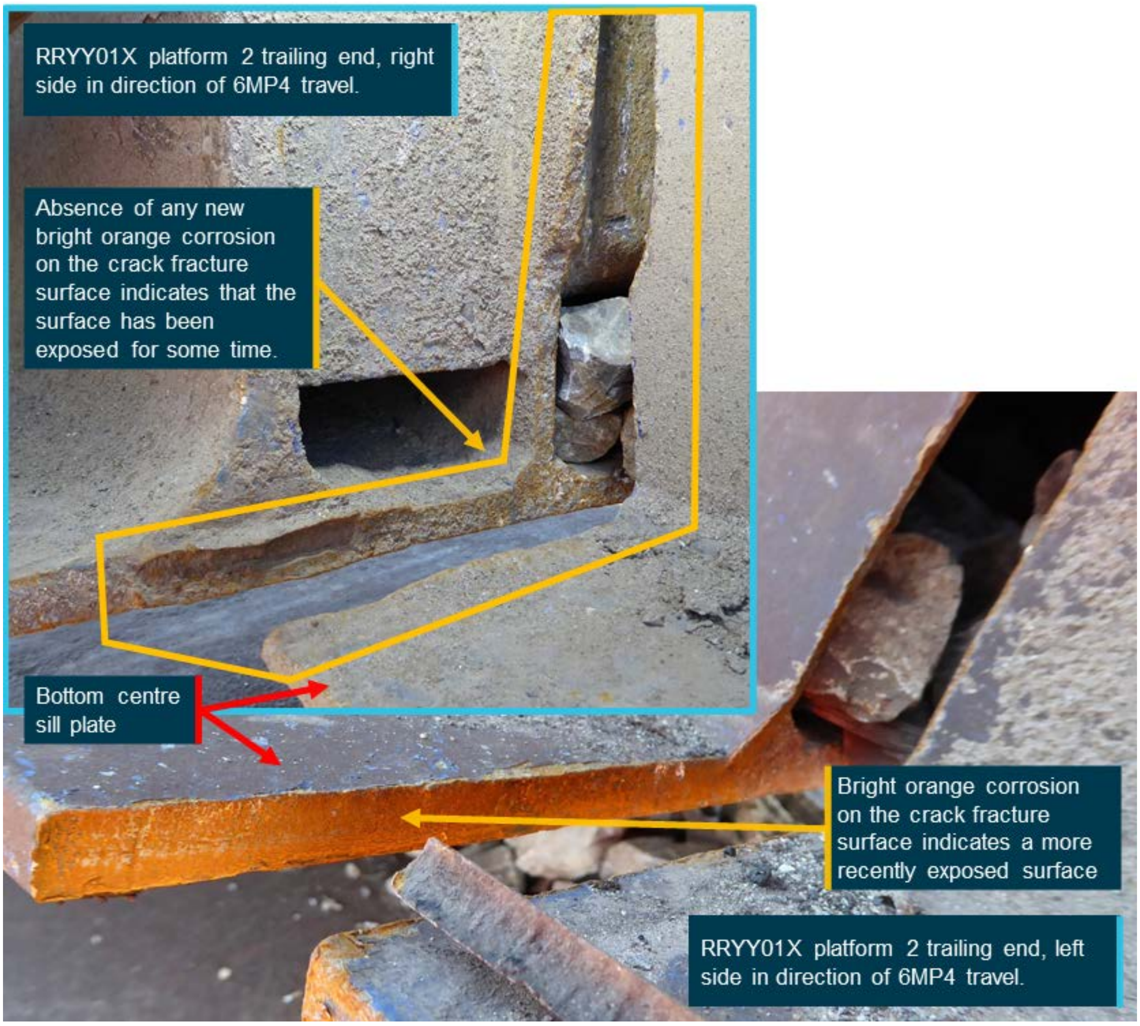

Image recorded on 27 April 2018, 6 days after derailment. Image shows the corrosion differences on the underframe crack fracture surface in platform 2 of 5-pack wagon RRYY01X.
Source: ATSB

Wagon RRYY01X loading

Pacific National documented specific freight loading and marshalling requirements for RRYY class wagons in its train inspection and freight loading manuals. In respect of train 6MP4 on 20–21 April 2018, four platforms of wagon RRYY01X were loaded with one container each. No container was loaded on platform 2 (Table 2).

Table 2: Loading of wagon RRYY01X

Platform number	Load
Platform 1	10 t container
Platform 2	Empty platform
Platform 3	12 t container
Platform 4	18 t container
Platform 5	13 t container

Wagon RRYY01X was positioned about 660 m behind the lead locomotive and about 750 m from the end of the train. There was about 1,405 t trailing[10] wagon RRYY01X.

Train 6MP4 and wagon RRYY01X were loaded in compliance with the Pacific National train inspection and freight loading manuals.

Wagon RRYY01X loading history

The maximum loading for each RRYY class wagon platform was 28 t. A review of the loading records for wagon RRYY01X indicated that platform 2 had exceeded its maximum loading on six occasions between 2005 and 2013. Since 2013, there had been no recorded overloading of this platform.

In summary, although wagon RRYY01X had some history of overloading, there was no recent history to suggest that wagon overloading contributed to its structural failure on 21 April 2018.

Rolling stock maintenance inspections

As per Pacific National *Wagon Maintenance Manual* (WMM), all standard gauge intermodal and steel wagon maintenance was based on time or kilometres travelled. The inspection frequency and assigned maintenance schedule was also dependant on the type of wagon. However, where a defect was detected by a safety inspection, roll-by inspection[11] or other means, the wagon could be scheduled for repairs and maintainer inspections outside of the schedule.

For the RRYY class wagons, the maintenance instruction assigned an IM3[12] maintenance schedule, based on distance travelled (Table 3).

Table 3: IM3 maintenance schedule for RRYY class wagons

Type of inspection	By whom	Schedule
Safety inspection	i) Train examiner ii) Driver or terminal operator	i) FX[13] or GX[14] train examination prior to terminal departure ii) Inward & outward roll-by inspection
Out-of-course repairs	Suitably qualified staff	As required
P Maintainer inspection	Maintainer/contractor	350,000 km (with up to 50,000 km tolerance)
A Maintainer inspection	Maintainer/contractor	700,000 km (with up to 50,000 km tolerance)
B Maintainer inspection	Maintainer/contractor	2,100,000 km (with up to 50,000 km tolerance)

The maintenance controls included a visual inspection to manage the risks associated with structural failure of wagons. Visual inspections were applicable during safety inspections and maintainer inspections, which included both scheduled inspections and anticipated inspections when wagons received out-of-course repairs.

10 Train weight located behind all platforms in wagon RRYY01X.
11 Roll-by inspection: a visual inspection of a train to identify equipment, loading, security or other defects or failure whilst the train is moving.
12 IM3 is a Pacific National maintenance code specifying the distance to be travelled between scheduled maintenance inspections. In the case of IM3, maintenance inspections are scheduled every 350,000 km.
13 Full train examination (FX): performed by examining staff after final marshalling of non-tested loading, prior to commencement of journey consisting of full mechanical examination; complete air brake test; brake pipe leakage test; and issue of train examiners' certificate for interstate freight trains.
14 General train examination (GX): an examination conducted by appropriately qualified employees (normally locomotive drivers) at those times and locations where other staff qualified to conduct an FX inspection are not available.

Safety inspections

Train examination

The Pacific National *Train Inspection Manual* (TIM) required that all trains undergo a train examination prior to departing a yard or terminal location. Although, there were some exceptions to this requirement, these were not relevant to the operations related to this accident and wagon RRYY01X. Train examinations were normally conducted by train examination personnel.

Train examinations included inspections and tests on the train's braking systems and visual inspections of the train's loading and its rolling stock. The rolling stock inspection component included visual inspection of each wagon in the train in respect to the adjustment, condition and/or security of the wagon body. With potential relevance to this accident, this included structural damage and/or failure of components.

In respect to wagon underframes, the Pacific National TIM provided generic guidance on how to handle any identified longitudinal or transverse cracks in wagon underframes, cracks in component supports or mounting brackets, and cracks in body centre plates. However, there was no specific guidance requiring visual inspections of key structural points of RRYY class wagons, which might be susceptible to cracking.

It was reported by Pacific National train examination staff that the ability to visually inspect all areas during a train examination can be limited due to wagons being loaded, ambient lighting, shadows cast from adjacent wagons, cleanliness of wagons, and other obstructions.

The results of train examinations were required to be recorded within the Pacific National *Train Inspection Certificate – Intermodal* (TIM 01-04 Appendix B). The certificate related to train 6MP4 was completed on 20 April 2020 at 1240 and did not include any recorded issues related to wagon body inspections.

In the preceding 3-month period, wagon RRYY01X had been used on about 30 intermodal train services and undergone train examinations at Pacific National freight terminals in Melbourne, Adelaide, Perth, and Brisbane. These inspections, involving a wide group of train examination personnel, did not report any structural cracks in wagon RRYY01X.

Roll-by inspection

The Pacific National TIM required that all trains, excluding coal trains, undergo a roll-by inspection when departing or arriving at a yard or terminal location. They were normally conducted by train examiners, but could also be undertaken by other qualified rail safety workers.

Roll-by inspections included visual inspections, and these visual inspections were aimed at detecting air leaks, wheel flat spots, unreleased handbrakes, correct wheel rotation, axle bearing irregularities and dragging equipment, as well as a catch-all requirement to report any other observable defects. Roll-by inspections were generally concluded with a message to the train crew that the train has been inspected and whether it was complete (all wagons attached) or required action.

Although not directly intended as a method to inspect the wagon's body for cracking, if the structure of the wagon had been compromised, this may be an observable defect during a roll-by inspection. In respect of train 6MP4, there was no evidence available to suggest that a defect had been identified in the roll-by inspection when 6MP4 departed Melbourne Freight Terminal on 20 April 2018.

In addition to arrival and departure from yards and terminals, additional roll-by inspections were also undertaken when a train was en-route. These roll-by inspections were undertaken by train crews of passing trains, incoming/outgoing train crews, and other qualified rail safety workers where applicable. These inspections were intended to observe the general security of loading, overall train integrity, and correct operation of the end of train marker. They were generally concluded with a message to the train crew that the train has been inspected and whether or not it is complete or requires action.

Figure 16: ARTC Adelaide to Melbourne corridor, with 6MP4 roll-by inspection locations

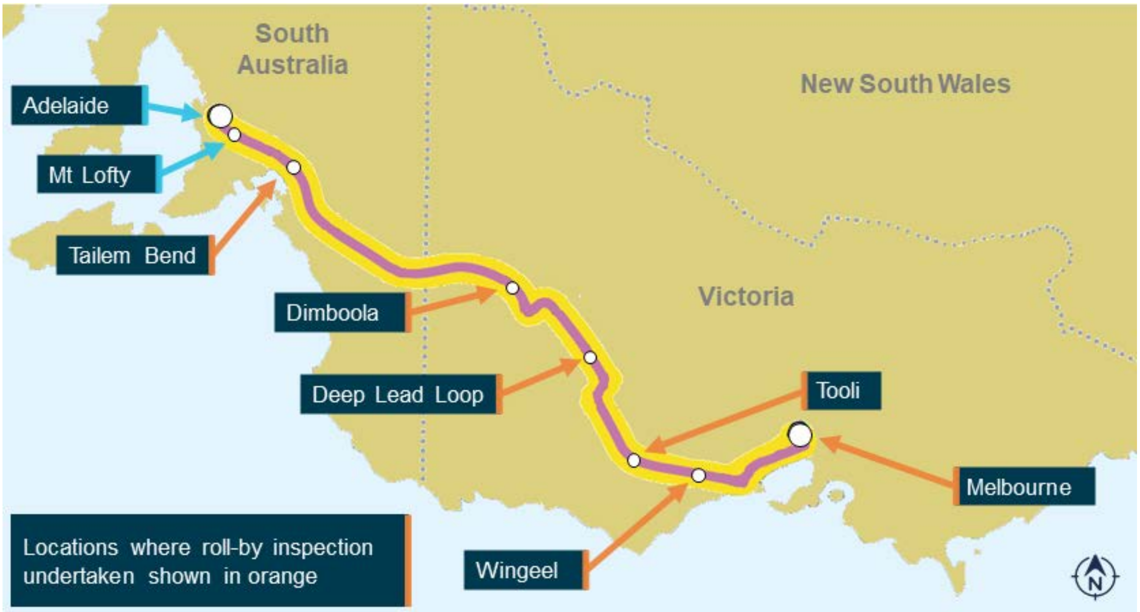

Image shows the location of the roll-by inspections undertaken on 6MP4 on its journey between Melbourne and Mount Lofty, noting roll-by location labels shown in orange.
Source: ARA annotated by the ATSB

Train 6MP4 passed other train services at Tooli Loop, Wingeel, and Deep Lead Loop, Victoria (Figure 16). A roll-by inspection was reported by the departing train crew at Dimboola, and the 6MP4 train crew reported that a roll-by was provided by the station assistant at Tailem Bend, South Australia (Figure 16). There was no evidence to suggest that a defect was identified from these inspections.

Maintainer inspections

Programmed maintenance inspection

The Pacific National *Wagon Maintenance Manual* (WMM) required that all RRYY class wagons undergo a 'P' inspection every 350,000 km with a tolerance of 50,000 km. 'P' inspections were also undertaken in combination with 'A' and 'B' inspections when the wagon had travelled the applicable threshold distances. The inspections were conducted by wagon maintenance personnel.

The wagon 'P' inspections included inspections, servicing, adjustments, and measurement/gauge checks of various wagon body, bogie, brake, and coupler components. With potential relevance to this accident, there was a requirement to check the wagon underframe for structural cracks in compliance with a specific *Underframes, Body Work and Load Supports* procedure.

The Pacific National WMM *Underframes, Body Work and Load Supports* procedure provided broad generic guidance on what to look for, and where to look, with respect to a typical wagon underframe. The procedure did not specifically guide wagon maintenance staff to key structural points on an RRYY class wagon or emphasise the areas susceptible to cracking.

It was reported by Pacific National wagon maintenance staff that wagons were normally delivered to maintenance facilities empty for the scheduled 'P', 'A' and 'B' inspections. As such, the limitations identified previously for train examiners were usually not a factor (for example, wagon loading, ambient lighting, and other obstructions). However, wagon cleanliness (build-up of grease, dirt or similar) could still limit visual inspections.

In relation to the scheduled maintenance inspections on wagon RRYY01X (Table 4), the last maintenance inspection was recorded as being undertaken on 24 October 2016 at the Perth Freight Terminal. There was no evidence available to suggest that this maintenance inspection identified any structural cracks in wagon RRYY01X. At the time of the accident on 21 April 2018, wagon RRYY01X was nearing the scheduled distance for its next ‘A’ Maintainer Inspection.

Table 4: Scheduled inspections of RRYY01X for previous 7 years

Inspection type	Date undertaken	Location
P maintainer inspection	24 October 2016	Perth Freight Terminal
B maintainer inspection	27 January 2015	Melbourne Wagon Maintenance Centre
P maintainer inspection	9 May 2013	Adelaide Freight Terminal
A maintainer inspection	20 July 2011	Adelaide Freight Terminal

The maintenance personnel conducting maintainer inspections were required to report any significant structural cracks or hairline cracks in inaccessible locations to their maintenance manager, with the provision for minor hairline cracks to be gouged and welded on site.

Pacific National maintenance and engineering representatives advised that they had no recollection of reports or observations about any significant structural cracking on RRYY wagons in the area where wagon RRYY01X had failed.

A review of previous ATSB investigation reports and available notifiable occurrence records did not identify any previous structural failures of RRYY class wagons.

Out-of-course maintenance inspection

Out-of-course maintenance inspection relates to ad-hoc maintainer visual inspections outside of the scheduled maintenance cycle. For example, Pacific National maintenance and engineering representatives advised of an expectation that a maintainer visual inspection would occur prior to the release of a repaired wagon. These ad-hoc maintainer visual inspections were also guided by the Pacific National WMM *Underframes, Body Work and Load Supports* procedure.

Wagon RRYY01X had been submitted for repair about 24 times since the last scheduled inspection (24 October 2016), with three of these within 3 months of the accident (Table 5). None of the repairs were specifically related to underframe cracking, and six instances were simply identified as ‘vehicle inspection’ (Table 5). There was no evidence available to suggest that any of these vehicle inspections, or maintainer repair opportunities, had identified any structural cracks in wagon RRYY01X.

Table 5: Out-of-course vehicle inspections of RRYY01X since scheduled inspection including out-of-course repairs undertaken in the 3 months prior to the accident

Reason	Date undertaken
Vehicle inspection	22 April 2017
Vehicle inspection	20 June 2017
Vehicle inspection	8 August 2017
Vehicle inspection	13 September 2017
Vehicle inspection	25 November 2017
Brake repair / wheelset replacements	29 January 2018
Vehicle inspection	29 January 2018
Brake block repair	12 February 2018
Auto-coupler repair	16 April 2018

Personnel information

Pacific National had documented its competence requirements for its rolling stock maintainers, train examination staff and train crew. The Pacific National personnel involved in the operation and pre-departure train examination of 6MP4, as well as the maintainers who had undertaken the last scheduled 'P' Maintainer Inspection, held current competencies for their tasks.

Post-accident RRYY fleet inspections

After the accident, Pacific National published and distributed a Rolling Stock Notice[15] to its terminal managers, maintenance planners, maintainers, train examiners and engineering representatives. The notice identified the location where the structural cracks within wagon RRYY01X had commenced and focussed post-accident inspections onto these specific stress areas of Pacific National's RRYY class wagon fleet.

Staff in Adelaide, Melbourne, Perth, Sydney and Brisbane inspected the RRYY class fleet. Focussing on the structural areas specified within the Rolling Stock Notice, over half of the remaining 50 RRYY class wagon fleet were found to exhibit cracks of varying lengths.

Pacific National train examination, maintenance, and engineering representatives advised the ATSB that the extent of structural cracking on RRYY class wagons had not been observed previously. As a precaution, Pacific National 'red carded'[16] the cracked RRYY class wagons until a long-term solution was formulated.

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[15] Ad-hoc Pacific National instruction to staff relating to rolling stock.

[16] Defect card: a red card is placed in the waybill clip of a wagon to notify all concerned that that particular vehicle is NOT fit for traffic and must be repaired prior to returning to traffic.

Safety analysis

Structural failure

During freight train 6MP4's descent from Mount Lofty, there was a structural failure in platform 2 of wagon RRYY01X. This resulted in one of the axles of the bogey between platform 2 and platform 3 derailing, and ultimately the train parting between these two platforms.

Post-accident observations found a crack in the underframe of platform 2 had propagated over time, most likely in the weeks and months prior to the derailment. The steep climb up to Mount Lofty under maximum tractive effort would have placed significant longitudinal tension through the wagon structure. This would have the effect of opening and encouraging growth of any pre-existing crack in the wagon underframe.

Mount Lofty is located at the top of a cresting grade. As a train passes over a cresting grade, the weight and resistance of the train's rear portion still on the ascending grade is opposed by the combined tractive effort and weight of the front portion of train now on the descending grade. If a train is not handled appropriately, these conditions can cause in-train forces to exceed coupler strength with subsequent failure resulting in a train separation at the crest. In this case, the driver handled train 6MP4 appropriately. However, it is likely that the weakened structure of RRYY01X-platform 2 was unable to accommodate the high in-train forces, causing the underframe to fail and the crack to open significantly.

For the RRYY class wagon, the junction of the wagon's bottom centre sill plate with the container loading outrigger included a pull-rod boxed opening within the outrigger (Figure 13). The loading and unloading of containers on the RRYY class wagons, accompanied by dynamic loading during normal operations, likely exposed this junction to cyclic strain and, as such, it would be susceptible to fatigue.

In support of this, the specific stress areas of the RRYY class wagon fleet that were a feature of this accident were, post-accident, inspected by Pacific National. These inspections identified that over half of the RRYY class wagon fleet were exhibiting cracks of varying lengths in the same areas.

Derailment

Failure of the underframe caused the deck of platform 2 to bend, changing the deck angle at the coupling to platform 3 (supported over a common bogie). Variations to drawbar or coupling angle, combined with large compressive longitudinal forces, are known to cause wheel unloading on empty wagons.[17]

In addition, high compressive longitudinal forces are known to increase lateral forces towards the outside of tight curves. For example, Pacific National's train handling standard (PN-STD-SAF - *Train Handling*) noted the increased potential for derailment when under concentrated compressive force:

> The presence of light wagons in the consist, or long wagons coupled to short wagons, or a coupler misalignment will increase the possibility of derailment.

As train 6MP4 negotiated a series of tight curves, the combination of wheel unloading (due to compressive forces and coupling angle on a light wagon) with increased lateral forces (due to compressive forces and a tight curve) resulted in flange climb (possibly complete wheel lift) and subsequent derailment.

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[17] Refer to ATSB investigation report 2004008, Derailment of Pacific National Train 7MP5, Glenalta, South Australia, 21 November 2004.

Ultimately, the bogie re-railed about 5.5 km after it derailed. However, during this period, the derailed bogie had caused minor damage to rail lubricators, sleepers and points turnout components. In addition, the consequences could have been more serious if more bogies had derailed.

Rolling stock inspections

Pacific National had an established process of visual inspections for its rolling stock, including among other purposes, identifying cracks in wagons. These visual inspections were required to be undertaken within programmed and out-of-course maintenance inspections by maintenance staff, as well as within terminal arrival and departure train safety inspections by train examination staff.

A number of inspections were undertaken during the time that the crack likely existed in the underframe of wagon RRYY01X. More specifically:

- In the 3 months prior to the derailment there had been one out-of-course maintenance inspection recorded on 29 January 2018, as well as two other out-of-course maintenance repairs on 12 February 2018 and 16 April 2018.
- Wagon RRYY01X had performed about 30 train services, including train 6MP4, in the 3 months prior to the derailment. This involved train safety inspections from a wide group of train examination personnel at Pacific National Terminals in Melbourne, Brisbane, Adelaide and Perth.

There was no evidence that these inspections had identified any cracks in wagon RRYY01X. Similarly, it was evident that previous maintenance inspections had not detected cracks of varying lengths in more than half the 50 RRYY class wagon fleet.

Requirements and guidance for rolling stock inspections

As already noted, post-accident examinations found over half the RRYY class wagon fleet exhibited cracks in the junction of the bottom centre sill plate and the container loading outrigger. This junction was likely exposed to cyclic strain and fatigue, due to loading and unloading of containers and dynamic loading during normal operations. Although this was potentially predictable, it had not been considered and identified as a focus point for inspections by Pacific National.

Further to this, the Pacific National WMM *Underframes, Body Work and Load Supports* procedure provided broad generic guidance to wagon maintenance staff about what to look for and where to look, with respect to a typical wagon underframe. However, this procedure was generic and did not guide visual inspections to key structural points of an RRYY class wagon that had a reasonably predictable susceptibility to cracking.

Additionally, the Pacific National *Train Inspection Manual* provided generic guidance to train examination staff on how to handle any identified longitudinal or transverse cracks in wagon underframes, cracks in component supports or mounting brackets, and body centre plates. Similarly, this information also did not provide specific guidance on where to focus visual inspections with respect to key structural points of an RRYY class wagon that had a predictable susceptibility to cracking.

A large number of factors can influence visual inspection performance, such as the nature and salience of the defect, the use of inspection aids, environmental factors, duration of tasks and training and experience (See, 2012). Research across a number of visual search tasks has shown that experts are better than novices because they know from experience the most likely locations that relevant targets (or defects or hazards) are most likely to be located (Wickens and others, 2015). Accordingly, providing inspectors with information about locations most likely to contain defects (of feedforward information) improves defect detection performance.

In this case, Pacific National's inspection processes did not identify key structural points for inspection on RRYY class wagons, including the susceptibility to cracking in the junction between container loading outriggers, pull rod boxed opening, and the bottom centre sill sections. This probably reduced the likelihood of the crack in wagon RRYY01X being detected prior to the accident.

Train separation and subsequent braking

Wagon RRYY01X uncoupled between platforms 2 and 3, resulting in the subsequent separation of the train's brake air pipe, which exhausted the brake pipe air to the atmosphere. It was evident that the brake pipe had broken cleanly, allowing for unrestricted exhausting of brake pipe air.

Although air was exhausting from the front portion of the train via the separated brake pipe (wagon RRYY01X), it is likely the air production from the three locomotive compressors was sufficient to maintain the train's brake pipe at a pressure high enough to inhibit the locomotives' emergency braking system response. This effect meant that, although the wagon brakes on the front portion of the train applied, the locomotives continued to pump air into the broken brake pipe instead of exhausting the remaining brake pipe pressure. Overall, the brakes on the front portion did not slow the train at the emergency rate. The front portion of the train came to a stop about 450 m ahead of the rear portion.

The absence of the locomotives' emergency braking systems was not contributory to the derailment, and did not increase risk associated with this accident. However, the automatic activation of the locomotives' brakes at the emergency rate is a requirement of the Australian Standard and failure to do so may increase risk in different circumstances.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

Safety issues are highlighted in bold to emphasise their importance. A safety issue is a safety factor that (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.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the derailment of train 6MP4 near Glenalta, South Australia, on 21 April 2018.

Contributing factors

- A fatigue crack initiated in the bottom centre sill plate of wagon RRYY01X's platform 2 underframe, which led to structural failure of the wagon and subsequent derailment of train 6MP4.
- Multiple train examinations and maintenance inspections undertaken on wagon RRYY01X did not identify the crack in the wagon's underframe.
- **Pacific National's inspection processes did not identify key structural points for inspection on RRYY class wagons, including the susceptibility to cracking in the junction between container loading outriggers, pull rod boxed opening, and the bottom centre sill sections. This reduced the likelihood of cracks being detected.** (Safety issue)

Other factors that increased risk

- The train's brake pipe between platforms 2 and 3 was broken when wagon RRYY01X separated. Although this allowed air to exhaust from the brake pipe, enabling the train brakes on the wagons to bring the front and rear portions of the train to a stop, this loss of air on the front portion of the train did not activate the emergency braking system response of the locomotives.

Safety issues and actions

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues. The ATSB expects relevant organisations will address all safety issues an investigation identifies.

Depending on the level of risk of a safety issue, the extent of corrective action taken by the relevant organisation(s), or the desirability of directing a broad safety message to the rail industry, the ATSB may issue a formal safety recommendation or safety advisory notice 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 further information about safety action comes to hand.

Inspection processes

Safety issue description

Pacific National's inspection processes did not identify key structural points for inspection on RRYY class wagons, including the susceptibility to cracking in the junction between container loading outriggers, pull rod boxed opening, and the bottom centre sill sections. This reduced the likelihood of cracks being detected.

Issue number:	RO-2018-009-SI-01
Issue owner:	Pacific National
Transport function:	Rail: Freight
Current issue status:	Closed - Adequately addressed
Issue status justification:	The ATSB is satisfied that the action taken by Pacific National will ensure that maintenance inspections and train examinations will be directed to key areas of the RRYY wagon design that are susceptible to cracking.

Proactive safety action by Pacific National

Action number:	RO-2018-009-NSA-044
Action organisation:	Pacific National
Action status:	Closed

Immediately following this accident, Pacific National issued a Rolling Stock Notice in relation to its RRYY class wagon fleet. The notice required that:

- all RRYY class wagons be inspected for underframe cracking
- all RRYY class wagons exhibiting any cracking around the underframe be red carded for repairs
- magnetic particle inspection or dye penetrant inspection of welded connections be conducted during scheduled preventative maintenance
- a fleet assessment of RRYY class wagons be undertaken.

Since this initial response, Pacific National has also completed the following proactive safety actions:

- An independent consultant was engaged to undertake a fleet assessment of RRYY class wagons to ensure that RRYY class wagons are safe to return to revenue service and achieve their initial design life of 30 years. This work included:

  - proposing a long term repair methodology for RRYY wagons with identified cracks
  - determining a maximum allowable crack length, safe operating conditions and an appropriate inspection regime for the wagons that did not require immediate repair.
- Pacific National *Wagon Maintenance Manual* and *Train Inspection Manual* were revised to include key examination points of the RRYY class wagon structure.

Safety action not associated with an identified safety issue

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.

Additional safety action by Pacific National

Pacific National advised that all new wagons and locomotives procured by Pacific National will meet the Australian Standard AS7510.6 for braking systems.

General details

Occurrence details

Date and time:	21 April 2018 – 0015 CST	
Occurrence category:	Accident	
Primary occurrence type:	Derailment – Running line derailment	
Location:	Near Glenalta (between Mount Lofty and Belair) South Australia	
	Latitude: 35º 0.136' S	Longitude: 138º 37.397' E

Train details

Track operator:	Australian Rail Track Corporation Limited (ARTC)	
Train operator:	Pacific National Pty Ltd	
Train number:	6MP4	
Type of operation:	Intermodal freight service	
Departure:	Melbourne, Victoria	
Destination:	Perth, Western Australia	
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:

- Pacific National
- the Australia Rail Track Corporation (ARTC)
- the Office of the National Rail Safety Regulator (ONRSR)
- the train crew of train 6MP4
- Pacific National examination, maintenance and engineering personnel.

References

Pacific National, *Train Inspection Manual*, as current 21 April 2018.

Pacific National, *Wagon Maintenance Manual*, as current 21 April 2018.

Pacific National, *Freight Loading Manual*, as current 21 April 2018.

Pacific National, *Train Handling Standard (PN-STD-SAF)*, version 5.0 issued 22 May 2017.

Rail Industry Safety and Standards Board (RISSB) AS7510.6:2014, *Braking Systems – Part 6 – Train*.

See JE 2012, *Visual inspection: A review of the literature*, Sandia Report SAND2012-8590, Sandia National Laboratories.

Wickens CD, Hollands JG, Banbury S & Parasuraman R 2013, *Engineering psychology and human performance*, 4th edition, Pearson Boston, MA.

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section 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 following directly involved parties:

- Pacific National
- the Australian Rail Track Corporation (ARTC)
- the Office of the National Rail Safety Regulator (ONRSR)
- the train crew of train 6MP4
- selected Pacific National examination, maintenance and engineering personnel.

Submissions were received from:

- Pacific National
- the Office of the National Rail Safety Regulator (ONRSR).

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- 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, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

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

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining 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. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.