



Australian Government
Australian Transport Safety Bureau

Derailment of ore train 4413

Bonnie Vale, Western Australia | 14 May 2014



Investigation

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Addendum

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Safety summary

What happened

On 14 May 2014, train 4413 – a bulk iron ore service operated by Aurizon, derailed on the Defined Interstate Rail Network (DIRN) between Stewart and Bonnie Vale, about 54 km west of Kalgoorlie in Western Australia. As a result of the derailment there was significant damage to track and rolling stock. There were no injuries.

What the ATSB found

The ATSB determined that the derailment of train 4413 was most likely initiated by lateral harmonic vehicle oscillation induced by a combination of minor cyclic cross-level and lateral track irregularities just in advance of the point of derailment. As a result of these irregularities, it was likely that the roll of wagon WOE33548K caused the left hand wheels to unload at a time when the leading left wheel came into contact with the left rail face – resulting in flange climb and derailment.

While the wagon type that derailed (WOE class) had passed prescribed dynamic performance testing, and the wagons and track complied with mandated engineering requirements, post-derailment computer modelling showed the onset of lateral harmonic wagon oscillation of sufficient magnitude to increase the likelihood of derailment at this location. Simulations showed that iron ore wagons, with their short length, react more severely to 22 m wavelength cyclic irregularities (as evident at this site) than do the typically longer intermodal wagons. The ATSB concluded that undertaking computer modelling when changing rolling stock and/or track working conditions offers rail transport operators an opportunity to identify potential areas of risk exposure before implementing new service arrangements.

Track maintenance and inspection was found to be in compliance with engineering requirements, however the track leading into the derailment site was known (to train drivers) as an area of rough ride. It was found that the systems in place between the train operator and track maintainer for the reporting of track irregularities (in particular the rough riding of trains) was ineffective, and hence the opportunity was lost to check for uncharacteristic track qualities through the derailment site – before such qualities contributed to a derailment.

While not influencing the derailment, it was noted that the loss of the train's brake pipe integrity (loss of air), including activation of the end-of-train monitor, had *not* resulted in the immediate and full automatic activation of the train brake.

What's been done as a result

Brookfield Rail and Aurizon have developed enhanced procedures for reporting track irregularities and have jointly committed, through the Rail Industry Safety and Standards Board, to ongoing industry support and research into the cause of this type of derailment. Aurizon is examining, with the intent of rectifying, the train braking irregularity (brakes not activating) that occurred following the loss of brake pipe integrity.

Safety message

To reduce the potential for unforeseen dynamic stability issues affecting the safety of rolling stock operations, it is essential that train operators and track maintainers:

- Appropriately test and model rolling stock dynamic characteristics and the effects of changed track conditions before implementing new service arrangements.
- Develop proactive interface management strategies that promote the prompt reporting, capture and feedback of uncharacteristic track qualities.

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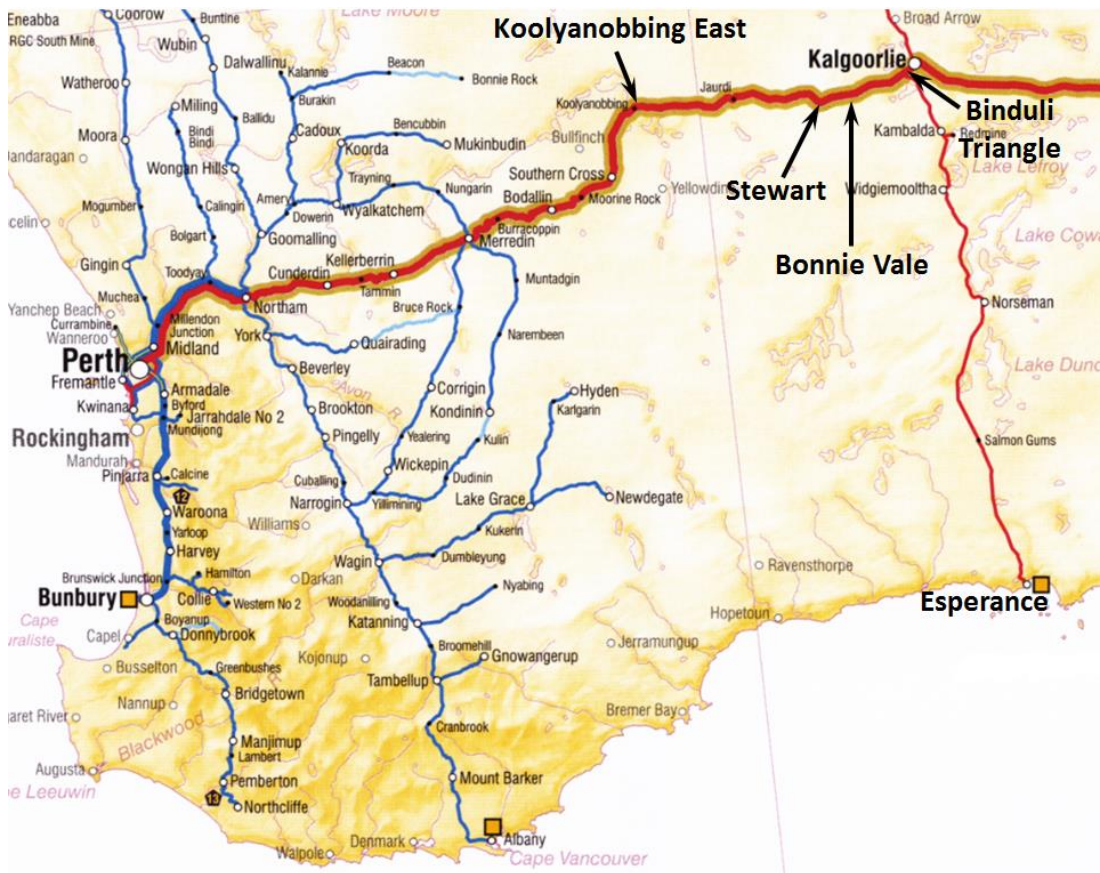
The occurrence

At 0100¹ on 14 May 2014, train 3416, a scheduled bulk iron ore service operated by Aurizon, departed from the Binduli Triangle, Western Australia (650 km),² for Koolyanobbing East (458 km). The train, crewed by two drivers,³ travelled empty to Koolyanobbing East.

On arrival at Koolyanobbing East, the train was loaded with iron ore and made ready for departure as train 4413. At 0755, it departed Koolyanobbing East for the port of Esperance.

En route, train 4413 crossed with the Prospector passenger train at Beckwith (470 km) and then with train 3033 at Mount Walton (534 km). It continued its journey towards Esperance, stopping at the Wallaroo loop (562 km) to cross with empty ore train 4414.

Figure 1: Location map – Western Australia



Source: NatMap Railways of Australia

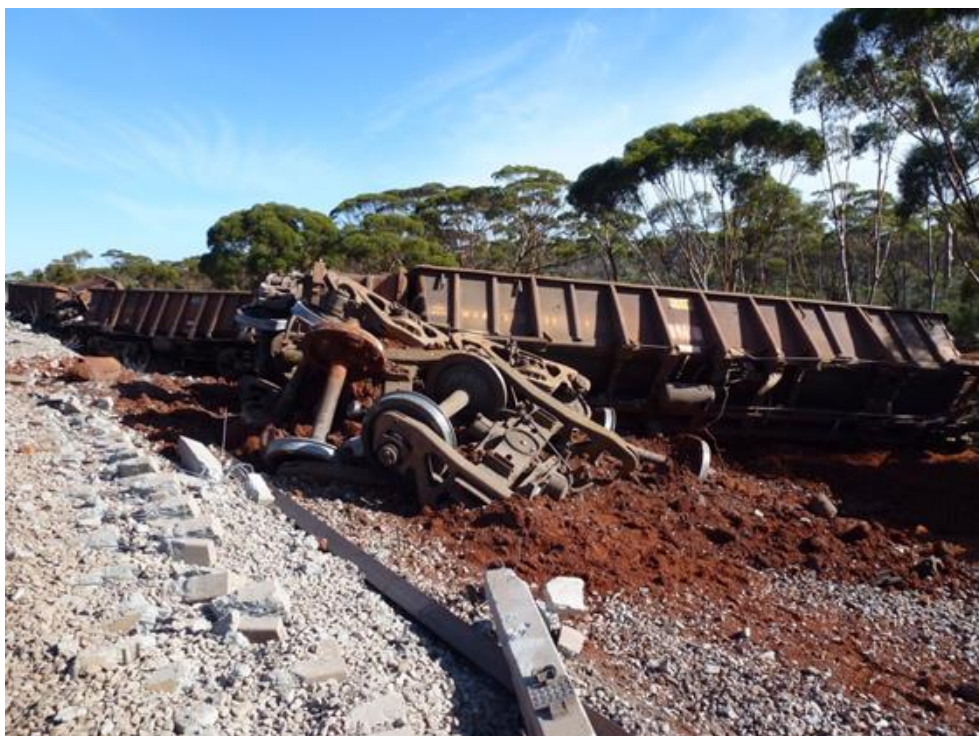
While waiting for the empty ore train, the two drivers operating train 4413 exchanged their respective driver/observer roles. This was the last driver exchange before the occurrence.

At 1010, train 4413 departed the Wallaroo loop. The passage of the train through to Stewart (587 km) was uneventful. As the train entered the Stewart to Bonnie Vale section, the driver gradually accelerated towards 90 km/h, the maximum permitted track speed for loaded ore trains in this section. From the 596 km to 599 km mark the track grade descended slightly. To prevent the train from exceeding 90 km/h, the driver put the train into light dynamic braking.⁴

¹ The 24-hour clock is used in this report and is referenced from Western Standard Time (WST)
² Distances are track kilometres measured from Perth terminus.
³ Two drivers operate alternately as a driver/observer pair.
⁴ The trains' electric traction motors are used for regenerative/electric braking.

Just after traversing a culvert at 600.657 km, the locomotive shuddered. As the train continued, the second driver (observer) commented on the roughness of the ride and the likelihood of a temporary speed restriction (TSR) being required for that area in the future. The train then travelled about 2 km at which time the driver felt a series of jerks of increasing severity from the train. Almost immediately, at about 1048 the driver observed that the end-of-train monitor⁵ (EoT) was showing an alert. He immediately checked the train's brake pipe pressure on the driver's cab controls, but did not observe any decrease which would normally accompany a train parting event.⁶ However, on looking in the rear vision mirror he observed clouds of dust and realised that the rear portion of the train may have derailed. He slowed the train, using the dynamic brakes, bringing it to a stand about 2 km beyond the initial EoT alert. He then advised the train controller that the train was at stop within the Stewart to Bonnie Vale section, had probably derailed, and that the second driver was going back to investigate.

Figure 2: Derailed ore wagons and destroyed track infrastructure



Source: ATSB

Events post-derailment

The second driver walked towards the rear of the train and progressively reported to the driver the extent of the derailment and the damage sustained to the track infrastructure and rolling stock (Figure 2). The driver relayed the information to the train controller.

The Stewart to Bonnie Vale section was subsequently closed and recovery personnel were dispatched from Kalgoorlie. The two drivers were relieved and returned to Kalgoorlie.

On 15 May, track and train maintenance crews commenced recovery and restoration works. The track was re-opened to traffic on 17 May. Following the re-opening of the track a speed restriction of 60 km/h was put in place approaching and through the site until resolution of the underlying issues that caused the derailment were identified.

⁵ The end-of train monitor works in conjunction with an end-of-train marker, a device fitted to the trailing end of the last vehicle of a train. The system is used to indicate that the train is intact by monitoring brake pipe pressure.

⁶ A train parting event normally results in a loss of brake pipe integrity and an associated loss of brake pipe pressure.

Context

Location

The derailment occurred between Stewart and Bonnie Vale, about 54 km west of Kalgoorlie, at 600.729 km on the Defined Interstate Rail Network (DIRN) in Western Australia (Figure 1). The DIRN through this area runs in an east-west direction and links Western Australia with the eastern states.

Train crew and train information

Train 4413 was a regular Aurizon iron ore service that operated between Koolyanobbing East and the port of Esperance. The train was configured as a distributed power unit⁷ and comprised two locomotives at the head of the train (AC4301 leading and ACB4404 trailing) followed by 106 wagons, two further locomotives (Q4017 leading and AC4304 trailing) and a final 54 wagons. The train had an overall length of 1,792 m and a gross mass 14,731 t.

Locomotives AC4301 and AC4304 were each equipped with data loggers (loco-log) and CCTV. These systems were used for capturing information such as date/time, speed, brake pipe pressure, throttle position, distance travelled and video imagery.

Rolling stock

Examination of the rolling stock primarily focused on wagon WOE33548K, located towards the rear of the train, at position 146 in a consist of 164 vehicles (count includes locomotives). It was determined that this was the first wagon to have derailed (leading wheel set of the lead bogie derailed to the left in the direction of travel). The wagon had travelled about 2.5 km past the point of derailment (PoD) by the time the train was brought to a stand.

Figure 3: Gauging of centre bowl, wagon WOE33548K



Source: ATSB

⁷ The placing of additional locomotives at intermediate points within a train and remotely controlling these locomotives from the lead locomotive.

The wagon was initially examined on site and later at Aurizon’s West Kalgoorlie maintenance facilities. The wagons were fully inspected including bogie frames, centre bowl centricity (Figure 3) sidebearer assemblies, friction wedges, lead bogie’s wheelsets and wheel profiles. All were found to be operationally fit for purpose and in compliance with maintenance specifications.

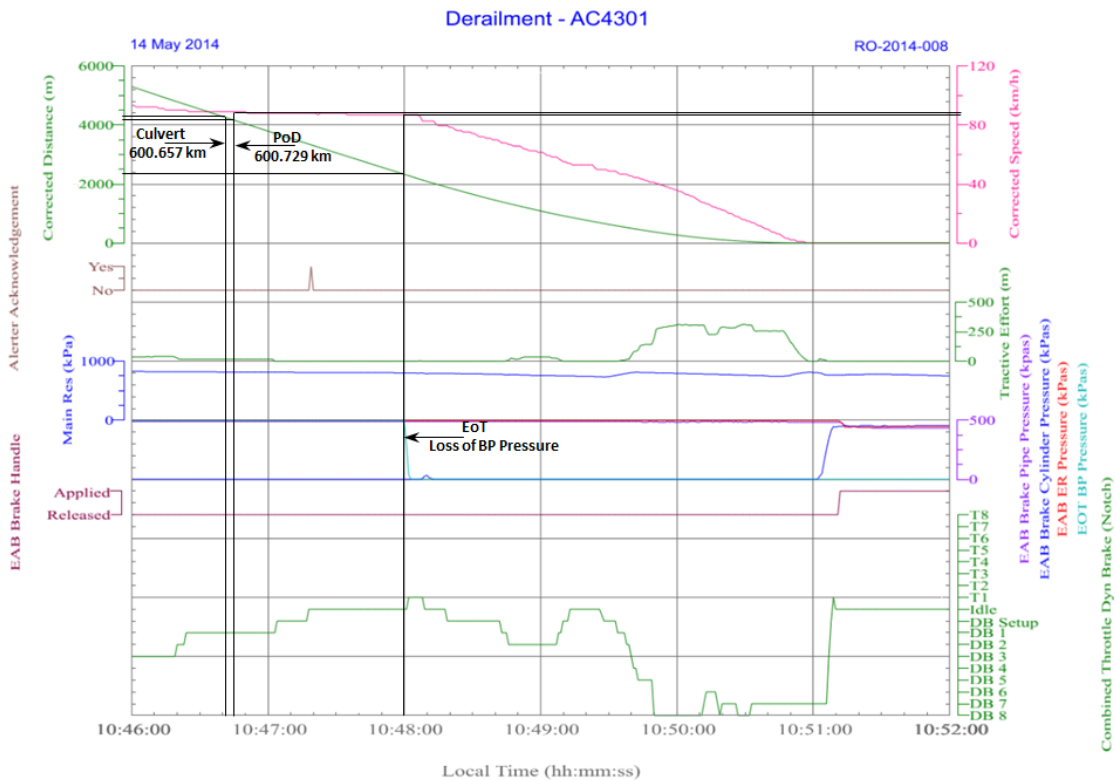
Examination of trackside monitoring data (RailBAM⁸ and WILD⁹) did not uncover any evidence of wagon overloading or wheel defects that may have contributed to the derailment.

Train braking

Analysis of data extracted from the train’s loco-log established:

- The train was travelling at 88 km/h (2 km/h below track speed) as the lead locomotive AC4301 passed over the PoD. The driver was actively controlling and maintaining the train’s speed by applying a range of throttle commands.

Figure 4: Graph derived from extract of loco-log data from AC4301



Source: Data source Aurizon, graphed by ATSB

- The train was travelling at 87 km/h as wagon WOE33548K (first to derail) passed over the PoD. At that time, locomotive AC4301 was in idle/coasting, after coming out from light dynamic braking.
- About 3 seconds after wagon WOE33548K passed over the PoD, the end-of-train monitor (EoT) registered a complete loss of brake pipe pressure. This event probably coincided with wagons breaking away from the main body of the train, and was about the time the driver recalled observing the EoT alert.

⁸ RailBAM® is a predictive monitoring system that detects and ranks wheel bearing faults and out-of-shape wheels (wheel flats) by monitoring the noise they make.

⁹ WILD is an acronym for 'Wheel impact and load detection'. The WILD system is primarily used for detecting wheel flats but can be used for calculating the weight of rolling-stock.

- Although the EoT provided an alert, this was not reflected as a loss of brake pipe pressure on the driver's cab controls. The loss of brake pipe pressure that was registered by the EoT did not automatically activate entire train braking. As a consequence, the driver initially assumed a malfunction of the EoT until he observed dust in the train's rear vision mirror.
- The driver slowed the train using dynamic braking, coming to a standstill about 2 km after the initial EoT alert.

While there was no apparent maintenance deficiency that contributed to the derailment, and recorded braking performance was consistent with the operation of the dynamic braking system, the fact that the loss of brake pipe integrity did not automatically activate the train brakes is an operational concern. The loss of brake pipe integrity (loss of air) should always result in the prompt activation of train brakes along the entire length of the consist.

Train crew

The driver in control at the time of the derailment had about 14 years train driving experience. The second driver (observer) had 9 years train driving experience. Both drivers held the required qualifications to operate the train and were route certified.

An examination of the drivers' records confirmed that both had been assessed as meeting the medical standards prescribed by the *National Standard for Health Assessment of Rail Safety Workers*. Following interview and an examination of the drivers' rosters, the ATSB determined that fatigue impairment was unlikely to have affected their performance. Both drivers said they felt well when signing on for duty and subsequently, at the time of the derailment.

After the derailment, both drivers underwent drug and alcohol testing, the results of which were negative.

Available evidence indicates that the drivers' performance was unlikely to have been a factor in the derailment.

Environmental conditions

At the time of the derailment the weather at the Kalgoorlie-Boulder airport was fine. Temperature was about 21°C with the wind blowing from the south at a speed of 4 km/h. The recorded lowest temperature for the day (0600) was fractionally below 7°C. No rain had fallen in the preceding 24 hours.

Environmental conditions leading up to the derailment were not considered extraordinary and were unlikely to have contributed to the derailment.

Track Information

The track from Koolyanobbing East through to West Kalgoorlie substantially comprised a single line (bi-directionally signalled) with crossing loops strategically located throughout its length.

The track through the derailment site was standard gauge (1,435 mm), 60 kg/m continuously welded rail¹⁰ (CWR), fixed by resilient fastenings¹¹ to concrete sleepers at approximately 667 mm spacing. The rails were supported on a bed of ballast with a 300 mm nominal depth under the sleepers. The track leading into the derailment site was straight (tangent track) on a slight downgrade of about 0.2% in the direction of travel. When the track was re-laid with 60 kg/m rail

¹⁰ CWR – Track where the rail is joined by welding (and other non-moveable joints such as glued insulated joints) in lengths greater than 300 metres.

¹¹ A fastening that provides a degree of elasticity between the sleeper and rail with the aim of avoiding the loosening of the fastening due to vibration, as well as enhancing the ability of the fastening system to resist longitudinal creep forces and buckling forces associated with CWR.

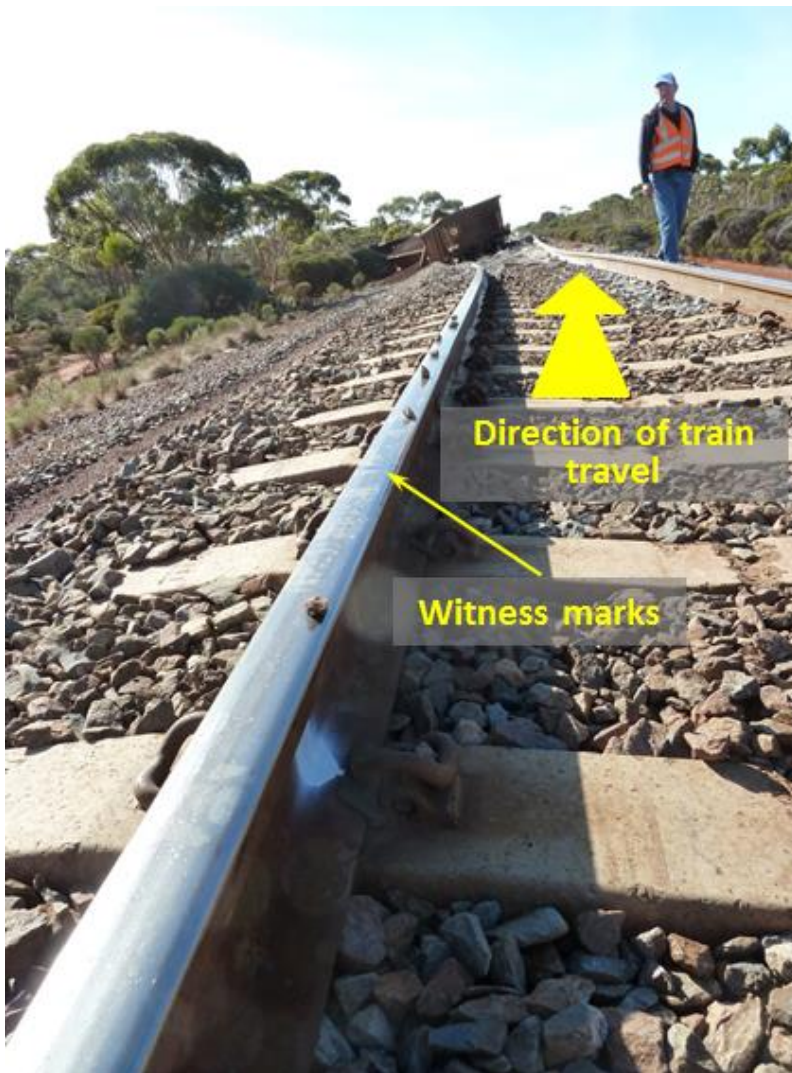
about a year earlier, the infrastructure manager (Brookfield Rail) increased the maximum track speed to 90 km/h for loaded ore trains operating through the area.

Examination of the track

There was no evidence of track spread before the PoD, so gauge widening was not considered to have been a factor in the derailment. Similarly, there were no signs of any broken/fractured rail immediately at or before the PoD.

There was evidence of flange climb¹² on the left side running rail (direction of travel) at 600.729 km, followed by witness marks over a distance of about 5 m that were consistent with a wheel flange crossing over the rail head (Figure 5). Damage to sleepers was observed only after the point where the wheel(s) dropped off the rail head. Beyond the drop off point, the wheels and bogies of derailed wagons advancing along the sleepers had progressively damaged the track structure both within the four foot¹³ and on the field side of the rail (left side direction of travel). This led to the loss of structural integrity and the subsequent destruction of the track, with rolling stock ploughing into the ballast giving rise to the multi-wagon pile-up shown at Figure 2.

Figure 5: Witness marks at PoD (600.729 km) shown by line of stones on rail head



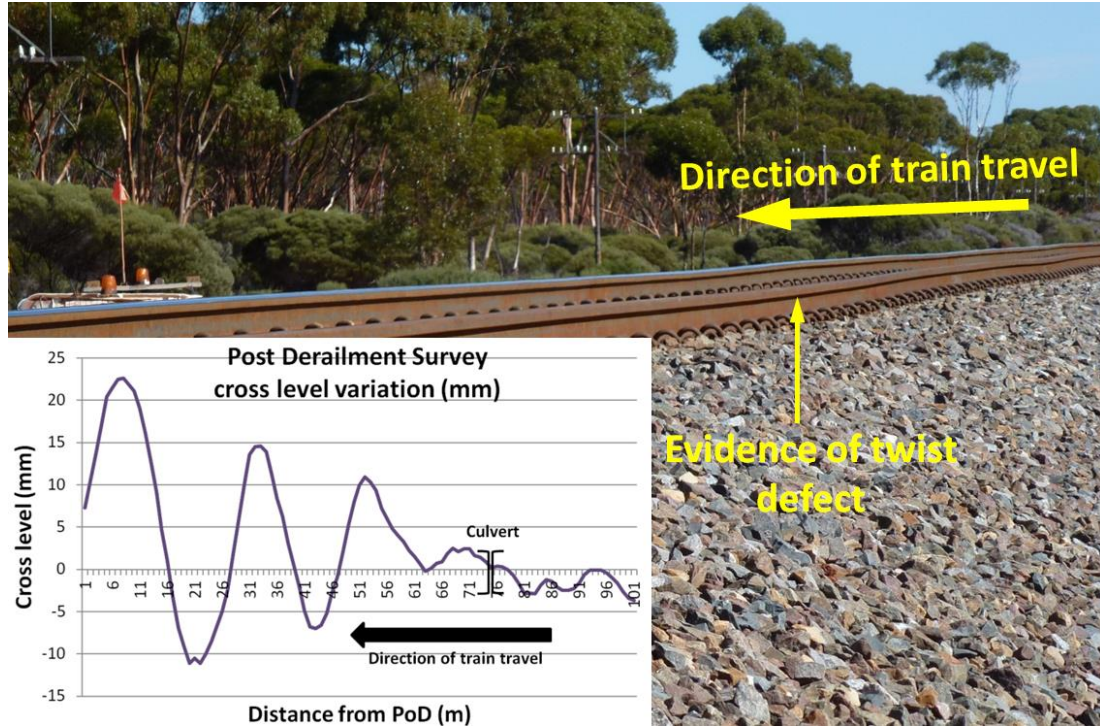
Source: ATSB

¹² A derailment in which a wheel flange will climb to the rail head.

¹³ The area between the rails of a standard gauge railway.

Although the track leading into the derailment site appeared to be in good condition, there were signs of pre-existing lateral vehicle oscillations (characterised by flange contact wear along the gauge face of the rails at regular intervals), and evidence of minor cyclic cross level (Figure 6) and lateral track irregularities before the PoD.

Figure 6: Evidence of minor twist defect in advance of PoD at 600.729 km



Source: ATSB

These observations were supported by:

- Statements from the train drivers, who both indicated that the track was rough (side-to-side oscillations) leading into the derailment site and that the train shuddered at or near the derailment site.
- Forward facing video (Figure 7) from train 4414,¹⁴ which had passed through the site earlier that morning (about 0940), showed very little evidence of any lateral track misalignment at, or near the derailment site.

Figure 7: Video image from train 4414 (left) and photo post derailment (right)



Source: Aurizon (left image) and Brookfield Rail (right image)

¹⁴ Forward facing video evidence was not available from train 4413 (train that derailed) due to a technical failure of the train's forward facing video recorder.

- Rear facing video from train 4413¹⁵ showed wagons directly behind AC4304 oscillating sideways (laterally) when approaching the derailment site, followed by heavy shuddering as wagons passed over (or near) the derailment site.

Post-derailment, the track was surveyed by Brookfield Rail (unloaded) for a distance of 100 m leading into the PoD. The plot at Figure 6 *cross level variation (mm)*¹⁶ was derived from survey measurements and substantiated observations of a minor cyclic twist defect in advance of the PoD. The plot shows a cross level variation of near zero about 100 m before the PoD, which then increases in magnitude to about 22 mm at a location 6 m back from the PoD. Under the *Westrail S.G. Code of Practice Track and Civil Infrastructure (CoP)*, it is unlikely that this specific magnitude of cross level variation would have triggered remedial action by Brookfield Rail. However, the CoP (Table 6.2, Note [7]) also identifies that the onset of a rough ride caused by a combination of laterally induced vehicle oscillations in an area of track with a cyclic twist defect may present a heightened derailment risk and should not be ignored.

Wagon - lateral stability

The conical shape of the railway vehicle wheel/tread tends to cause lateral oscillation of the wheelset along the length of tangent track. At low speed, these oscillations are effectively damped. As speed is increased, the lateral oscillations initiated by a minor track irregularity take longer to damp out, and above a critical speed, oscillations continue indefinitely until a curve or another track irregularity causes them to temporarily cease. This behaviour is commonly referred to as hunting.

If a vertical, lateral, or cross level track irregularity is cyclic and is encountered at a speed corresponding to the natural frequency of vehicles traversing the track, there is a risk of vehicle resonant harmonic oscillation developing. This can be particularly hazardous if the cyclic motion, set up by cross level variations, results in a wheel becoming sufficiently unloaded such that the guidance provided by the wheel flange is no longer adequate – allowing the flange to climb up onto the rail head. Harmonic behaviour is characterised by large amplitude oscillations at specific train speeds, with a significant sideways force that can damage the track and in severe cases result in derailment. Hunting can also exert high lateral forces on the track, but normally only results in derailment when a track irregularity causes the wheel to be unloaded at the same time as it is in contact with the rail.

Examination of the track (post-derailment) found that there was a pattern of wear on the rail gauge face corner at a regular interval of about 6 – 8 m (an indication of lateral vehicle oscillation in a consistent pattern at 12 to 16 m wavelength) and corresponding ballast disturbance along the length of the track leading into the PoD.

Although the ore wagons were determined to be in good condition and had passed mandated dynamic performance tests, it was likely that wagon excitation and associated resonant phenomenon induced by the track in advance of the PoD, was probably of sufficient magnitude for the lead wheel of wagon WOE33548K to unload, mount the rail head at 600.729 km and derail.

Post-derailment computer modelling

To assist in understanding the mechanism of derailment, the dynamic behaviour of the WOE class ore wagon was modelled using two computer simulation packages; Vampire¹⁷ and NUCARS.¹⁸ Track criteria was based on survey work undertaken post-derailment and assumed a continuation

¹⁵ The mid-section trailing locomotive AC4304 on train 4413 had a rear facing video camera.

¹⁶ Cross level variation is a measurement of the difference in level of the two rails at a single point along the track.

¹⁷ Vampire is a computer based rail vehicle dynamics simulation package allowing the modelling of a virtual rail vehicle traversing measured track geometry. Vampire modelling was done by Brookfield Rail.

¹⁸ NUCARS is a computer program that simulates the dynamic response of railroad vehicles to specified track conditions. Both Vampire and NUCARS are recognised as world leading rail vehicle simulation packages. NUCARS modelling was done by Aurizon.

of the track shape beyond the PoD. The WOE class wagon was modelled at a range of simulation speeds, including the derailment speed of 87 km/h.

Inspection and measurements post-derailment showed that both the track and WOE class wagons met the required engineering and maintenance requirements. However, the computer modelling showed the WOE-class wagons were susceptible to the onset of lateral harmonic oscillation (increasing with speed) over track similar in characteristics to that through the derailment site. It was evident from the modelling that the dynamic behaviour of the WOE class wagon when traversing a cyclic track irregularity at about 86 km/h, could give rise to wheel unloading at a time when the wheel came into contact with the rail face, resulting in a flange climb derailment.

Actual on-track physical testing¹⁹ of the WOE class wagon in 2001 had not identified issues with wagon instability; though dynamic wagon behaviour over cyclic track irregularities was not part of the test regime at that time. Post-derailment computer modelling showed that the wagon would also pass the current harmonic roll test specified in section 9.2.5 of AS7509.2. However, when modelled over a continuous cross level variation with a 22 m wavelength (as was measured at the derailment site), severe roll and wheel unloading was evident with conditions close to derailment at speeds of 87 km/h (similar to that of train 4413).

It is apparent that, when changing infrastructure (vehicle/track) working conditions, computer modelling offers rail transport operators a valuable opportunity to identify potential areas of elevated derailment risk before new service arrangements are implemented.

Track inspection

Inspection of track visually, and by use of mechanised track geometry vehicles, are two of the main methods for assessing track geometry and identifying defects. Brookfield Rail applies the CoP as the criteria for assessing and recording the condition of track and determining mandatory remedial maintenance actions. The CoP mandates that inspections are carried out weekly (intervals not exceeding 7 days) by track patrol (road/rail vehicle), and by train cab ride (foot-plate inspection) every 12 months. The interval between track geometry vehicle inspections is 4 monthly.

A review of maintenance records established that the track near the PoD (600.729 km) had been:

- Regularly inspected by track patrol (road/rail vehicle). The last inspection was done on 10 May 2014, four days before the derailment. No defects were identified, and it was unlikely that a track patrol would have identified the minor track irregularity near the PoD because of differing dynamic characteristic of the road/rail vehicle compared to a train.
- Examined by way of train cab ride on 10 May 2013, about 12 months before the derailment. While there were no defects (including rough ride) identified near the derailment site, it was evident from the cab ride inspector's notes, that his observations were effective in detecting some other track irregularities that had been missed by other inspection regimes.
- Regularly examined using a track geometry car. The last inspection was done on 14 February 2014. No defects were identified, and it is possible that an inspection closer to the time of derailment may not have activated a maintenance response, as track measurements after the derailment did not exceed CoP alert criteria.

¹⁹ Testing was done in accordance with the Railways of Australia (ROA) code 'Road Worthiness Acceptance Standards for Rail Freight Vehicles'. The code did not include testing for cyclic track irregularities which has been included in the more recent Australian Standard AS7509.2.

Other occurrences involving vehicle/track interaction

The ATSB has investigated several occurrences involving vehicle/track interaction, including the derailment of train 4VM9V near Benalla, Victoria on 23 September 2004 (RO-2004-005), the derailment of train 3MR2 near Roopena, South Australia on 22 May 2007 (RO-2007-003) and the derailment of train 5WX2 near Winton, Victoria on 31 July 2008 (RO-2008-009).

Interaction between rolling stock and track is complex, and mitigating the risk of derailment may not be fully achieved by applying standards and codes of practice in isolation. A common and recurring theme with the occurrences listed above and this latest derailment, relates to envisaging the dynamic performance of compliant, poorer ride quality rolling stock, over conforming track that exhibits low level cyclic track irregularity.

The analysis undertaken following each of these previous occurrences demonstrated that computer modelling/simulation was an effective way of examining and predicting derailment scenarios. Computer modelling/simulation may thus offer rail transport operators an effective tool in predicting and mitigating the risk of derailments when implementing new service arrangements.

Safety analysis

Vehicle dynamic behaviour

Based on the train driver's observations and supported by site evidence and computer modelling, the ATSB concluded that the derailment of train 4413 was initiated by lateral harmonic vehicle oscillations induced in the consist's WOE class wagons, by a cyclic track cross-level defect. It was found that although the WOE class wagons and track complied with engineering and maintenance requirements, the cyclic track twist defect in combination with the wagon oscillations was large enough to promote wheel unloading at a time when the leading left wheel of wagon WOE33548K came into contact with the left running rail, resulting in flange climb and derailment.

A review of evidence established that the WOE class of wagon had passed prescribed dynamic performance testing. While the wagons and track complied with mandated engineering requirements, computer modelling after the derailment showed the potential for an onset of lateral harmonic wagon oscillation of sufficient magnitude to result in derailment at the site of the event. As a result of these findings, it was apparent that undertaking computer modelling *before* changing infrastructure working conditions (vehicle/track), offers rail transport operators a valuable opportunity to identify potential areas of derailment risk exposure.

Track condition reporting

Although the track condition leading into the derailment site was compliant with the CoP, it was known to train drivers as an area of poor ride quality. The drivers of train 4413 stated that they thought the ride approaching and through the derailment site was quite rough. They went on to suggest that other drivers may also have complained about rough ride, but most did not lodge reports because of a perceived lack of response and feedback. The ATSB's examination of driver reports confirmed that there had been no notification to the track owner that would have alerted them to the problem in the area of concern.

Unscheduled inspections by the track owner can be programmed at any time, in response to defined events, such as slips, flooding, irregularity reports and train driver reports. The lack of driver reporting in this instance resulted in missed opportunities for the track owner to undertake such unscheduled inspections (including train cab rides), which may have confirmed the track irregularity through this location and averted the subsequent derailment event.

Train braking

While the ATSB found that there was no maintenance deficiency with train 4413 that contributed to the derailment, a loss of brake pipe integrity (loss of air) should result in the immediate, automatic activation of the train brake. That this did not occur in this event warrants further investigation and resolution.

Findings

From the evidence available, the following findings are made with respect to train 4413 that derailed between Stewart and Bonnie Vale, about 54 km west of Kalgoorlie, Western Australia, on 14 May 2014. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

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

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

Contributing factors

- The derailment of train 4413 was most likely initiated by lateral harmonic vehicle oscillation induced by a combination of minor cyclic cross level and lateral track irregularities, just in advance of the point of derailment.
- **When travelling at speeds near 90 km/h on track having particular track irregularities, the WOE class wagons appear to be susceptible to harmonic oscillations of sufficient magnitude to produce wheel unloading, flange climb and derailment. [Safety issue]**
- **After re-railing the track, permitted train speed was increased without due consideration of the effects of cyclic track irregularities on the dynamic performance of the WOE class wagon. [Safety issue]**
- **The frequency of driver reporting and locomotive cab rides by track inspectors had been insufficient for identifying rough track through the derailment site. [Safety issue]**

Other factors that increased risk

- **The loss of brake pipe integrity during the derailment event did not result in the train brakes automatically activating. [Safety issue]**

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.

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.

WOE class wagon, dynamic performance

Number:	RO-2014-008-SI-01
Issue owner:	Aurizon and Brookfield Rail
Operation affected:	Rail: Rolling stock and Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

When travelling at speeds near 90 km/h on track having particular track irregularities, the WOE class wagons appear to be susceptible to harmonic oscillations of sufficient magnitude to produce wheel unloading, flange climb and derailment.

Proactive safety action taken by: Brookfield Rail and Aurizon

In response to this safety issue, Brookfield Rail and/or Aurizon have advised of the following proactive safety action:

- Brookfield Rail and Aurizon will undertake further investigations into lateral harmonic vehicle oscillations induced by cyclic track irregularities.
- Brookfield Rail and Aurizon will engage independent expertise to assist in the identification of the causes of track misalignment associated with lateral harmonic vehicle oscillation, including analysis of contact band wear, sleeper voiding, rolling contact fatigue and a review of bogie hunting video evidence.
- Brookfield Rail and Aurizon will fit instrumentation to a WOE class wagon for examination of lateral harmonic vehicle oscillation.
- Brookfield Rail and Aurizon will support RISSB in a review of track geometry standards in relationship to combinational and cyclic track defects.
- Brookfield Rail will investigate the acquisition and installation of wayside equipment capable of monitoring the onset of lateral harmonic vehicles oscillation across their network. This will include field testing with the intent of identifying any need for altering current operating parameters of fleets across the network.
- Brookfield Rail and Aurizon on its 'Joint Technical Committee' have added an ongoing item 'Status of follow-up investigations'.
- Brookfield Rail will fully capture rail profile details for all future derailments of this type to assist with computer modelling.
- Brookfield Rail and Aurizon will ensure that mapping of a derailment site is completed prior to the restoration process taking place.

- Aurizon will ensure that all locomotive data and video footage is captured (quarantined) following serious incidents/derailments.

Action number: RO-2014-008-NSA-007

ATSB comment in response:

While the ATSB is satisfied that the actions proposed by Aurizon and Brookfield Rail will, when fully implemented, adequately address this safety issue, there remains a broad opportunity for rolling stock providers and rail transport operators to address the future risk associated with the development of resonant dynamic vehicle behaviours. The ATSB is therefore issuing the following Safety Advisory Notice.

ATSB safety advisory notice to: All rail rolling stock providers and rail transport operators

Action number: RO-2014-008-SAN-001

The Australian Transport Safety Bureau encourages all rail rolling stock providers and rail transport operators to note the circumstances of the derailment outlined in this report and to consider the use of computer modelling, along with traditional field testing, in predicting the dynamic behaviour of rolling stock over combinational cyclic cross level/lateral track irregularities.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by Brookfield Rail and Aurizon had not yet been fully implemented.

Increasing train speed

Number:	RO-2014-008-SI-02
Issue owner:	Brookfield Rail
Operation affected:	Rail: Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

After re-railing the track, permitted train speed was increased without due consideration of the effects of cyclic track irregularities on the dynamic performance of the WOE class wagon.

Proactive safety action taken by: Brookfield Rail

In response to this safety issue, Brookfield Rail and/or Aurizon have advised of the following proactive safety action:

- Brookfield Rail has implemented new procedures ‘Operations Change Management’, which will ensure due diligence is given to any changes in operations or new infrastructure (track) configurations.
- Brookfield Rail will undertake a review of all operational track speeds on the Defined Interstate Rail Network (DIRN) between Perth and Kalgoorlie.

Action number: RO-2014-008-NSA-008

ATSB comment in response:

The ATSB is satisfied that the actions proposed by Brookfield Rail, when implemented, will adequately address this safety issue.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by Brookfield Rail and Aurizon had not yet been fully implemented.

Driver reporting and cab ride arrangements

Number:	RO-2014-008-SI-03
Issue owner:	Aurizon and Brookfield Rail
Operation affected:	Rail: Rolling stock and Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

The frequency of driver reporting and locomotive cab rides by track inspectors had been insufficient for identifying rough track through the derailment site.

Proactive safety action taken by: Aurizon and Brookfield Rail

In response to this safety issue, Brookfield Rail and/or Aurizon have advised of the following proactive safety action:

- Brookfield Rail has increased the frequency of in cab train rides/track inspection to monthly.
- Brookfield Rail has issued a safety advice to all above rail operators highlighting the importance of reporting rough ride/track irregularities to Brookfield Rail train control.
- Aurizon has issued instructions (general order) to all of its drivers regarding a requirement to communicate rail/track faults, in particular rough riding track.
- Aurizon is reviewing the feasibility of using acceleration monitors on selected locomotives and/or wagons on the Defined Interstate Rail Network, (DIRN) between Perth and Kalgoorlie.

Action number: RO-2014-008-NSA-009

ATSB comment in response:

The ATSB is satisfied that the actions proposed by Aurizon and Brookfield Rail will, when implemented, adequately address this safety issue.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by Brookfield Rail and Aurizon had not yet been fully implemented.

Train braking performance

Number:	RO-2014-008-SI-04
Issue owner:	Aurizon and Brookfield Rail
Operation affected:	Rail: Rolling stock and Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

The loss of brake pipe integrity during the derailment event did not result in the train brakes automatically activating.

Proactive safety action taken by: Aurizon and Brookfield Rail

In response to this safety issue, Brookfield Rail and/or Aurizon have advised of the following proactive safety action:

- Aurizon will investigate and resolve the braking performance issues that relate to a loss of brake pipe integrity (loss of air) failing to automatically activate train brakes.
- Brookfield Rail has issued a safety advice to all above rail operators highlighting the identified post-derailment braking issues.

Action number: RO-2014-008-NSA-010

ATSB comment in response:

The ATSB is satisfied that the actions proposed by Aurizon and Brookfield Rail will, when implemented, adequately address this safety issue.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by Brookfield Rail and Aurizon had not yet been fully implemented.

General details

Occurrence details

Date and time:	14 May 2014 – 1048 WST	
Occurrence category:	Serious incident	
Primary occurrence type:	Derailment - Running Line	
Location:	Trans Australian Railway near 600.729 km - Kalgoorlie	
	Latitude: 30° 53.158' S	Longitude: 120° 56.172' E

Train details

Train operator:	Aurizon	
Registration:	4413	
Type of operation:	Bulk Freight	
Persons on board:	Crew – 2	Passengers – Nil
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Aurizon
- Data loggers and CCTV from locomotives AC4301 and AC4304
- Brookfield Rail

References

ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology

Bureau of Meteorology - Weather Observations for Kalgoorlie-Boulder (14 May 2014)

RISSB Glossary of Railway Terminology – Guideline

Track Stability and Buckling – Rail Stress Management, Zayne Kristian Ole (Oct 2008)

Submissions

Under Part 4, Division 2 (Investigation Reports), 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. 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 Aurizon, Brookfield Rail, Office of the National Rail Safety Regulator, Office of Rail Safety Western Australia and the train drivers.

Submissions were received from Aurizon, Brookfield Rail, Office of the National Rail Safety Regulator, Office of Rail Safety Western Australia and train crew. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

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

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

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.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report Rail Occurrence Investigation

Derailment of ore train 4413 Bonnie Vale, WA, on 14 May 2014

RO-2014-008

Final – 27 March 2015