Transport Accident Investigation Commission

Final report

Rail inquiry RO-2019-105
Express freight Train 268
Derailment
Wellington
2 July 2019

December 2020

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is a standing commission of inquiry and an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas.

The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoid similar occurrences in the future. It is not the Commission's purpose to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. However, the Commission will not refrain from fully reporting on the circumstances and factors contributing to an accident because fault or liability may be inferred from the findings.

Figure 1: Express freight Train 268
(Credit: KiwiRail)

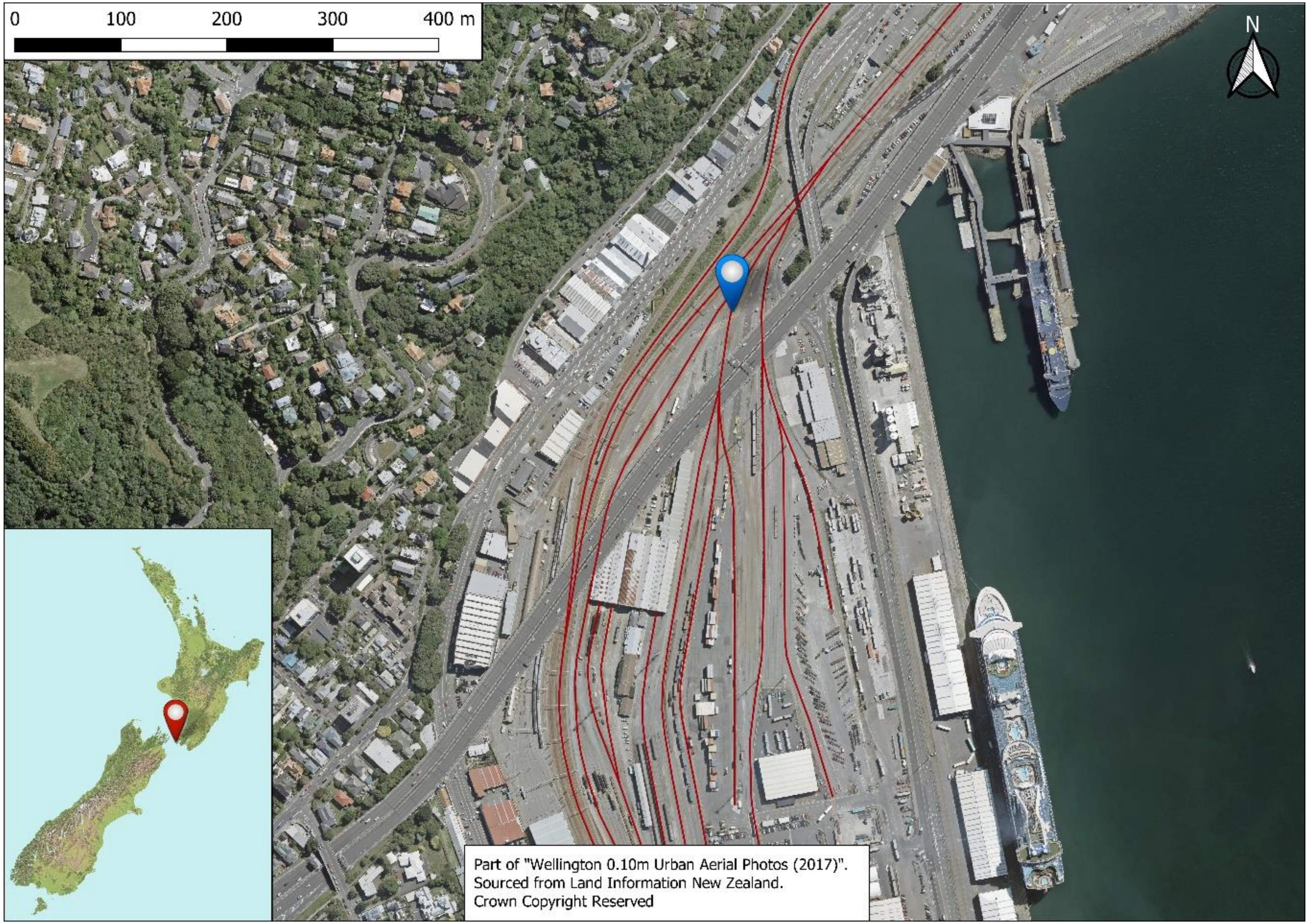

Figure 2: Location of accident

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What happened

1.1 On Tuesday 2 July 2019, express freight Train 268, consisting of two locomotives and 15 loaded wagons, was travelling from the Wellington Freight Terminal to Palmerston North.

1.2 The train was travelling at 25 kilometres per hour, within Wellington Station limits, when the leading bogie of the ninth wagon derailed while passing over a set of points. The derailed wagon was dragged through six sets of points before the train parted between the ninth and tenth wagons.

1.3 The train's vigilance system detected a sudden drop in train pipe pressure and the train brakes were applied automatically, stopping the train 256 metres past the point of derailment.

1.4 The train driver was not injured. However, there was substantial damage to the rail infrastructure that led to a 21-hour suspension of passenger services into and out of Wellington Station.

Why it happened

1.5 The Transport Accident Investigation Commission (Commission) **found** there was an insufficient vertical load on the leading bogie of lightly loaded wagon UKK9599 to prevent it climbing the outer right-hand curved rail on the 21A set of points.

1.6 The Commission also **found** that no single factor led to this derailment. Instead, it is very likely that a combination of factors, contributed to the wheel climb that resulted in the derailment:

- the track alignment was at the limit of the wagon's ability to negotiate the track safely
- track faults identified during routine inspections had been closed out without repair
- the long-wheelbase track twist was close to the wagon's maximum design limit
- the wheel flange surface roughness exceeded limits by a factor of nearly four.

What we can learn

1.7 Standards and procedures are put in place to ensure consistent and safe outcomes.

1.8 Preventive rail-maintenance activities require careful planning and timely execution to maintain a safe operation.

Who may benefit

1.9 Rail operators may benefit from the key lessons of this inquiry.

2 Factual information

Narrative

2.1 On Tuesday 2 July 2019, Train 268 (the train), an express freight train, was travelling from Wellington to Palmerston North. The 289-metre (m) long train consisted of a DFB-class locomotive hauling an unpowered locomotive and 15 loaded wagons[1] with a total weight of 475 tonnes (t), including the unpowered locomotive.

2.2 The rake[2] of 15 wagons had been placed on the J4 departure road at the Wellington Container Terminal by 1915, in readiness for the locomotives to be driven from the locomotive storage road and piloted[3] onto the head of the rake.

2.3 The pre-departure train examination and terminal brake test[4] had been completed and the train examiner[5] walked to the head of the train and handed over the signed train inspection form to the driver. Once the driver had confirmed that the train was "ready to go", the train examiner radioed the signaller in A-Box[6] and requested that the route be set for the train's departure from J4 road (see Figure 3).

[1] 'Wagon' is the generic term for freight-carrying vehicles.

[2] Two or more wagons coupled together.

[3] A pilot is a person qualified to ensure the safety of rail vehicle movement by guiding the driver.

[4] A terminal brake test must be carried out when any locomotive-hauled train is made up or any wagon is added to a train. The test involves checking both sides of each wagon on the train to ensure the braking system is connected correctly and functioning in both application and release.

[5] A person qualified to carry out a full terminal brake test, a pre-departure inspection above and below a wagon's decks while a train is stationary – before issuing a certificate to the driver as confirmation that the train is safe to run to its destination.

[6] The signaller in A-Box, who is remote from the centralised national train control centre, is responsible for managing all track occupations and train movements within Wellington Station limits.

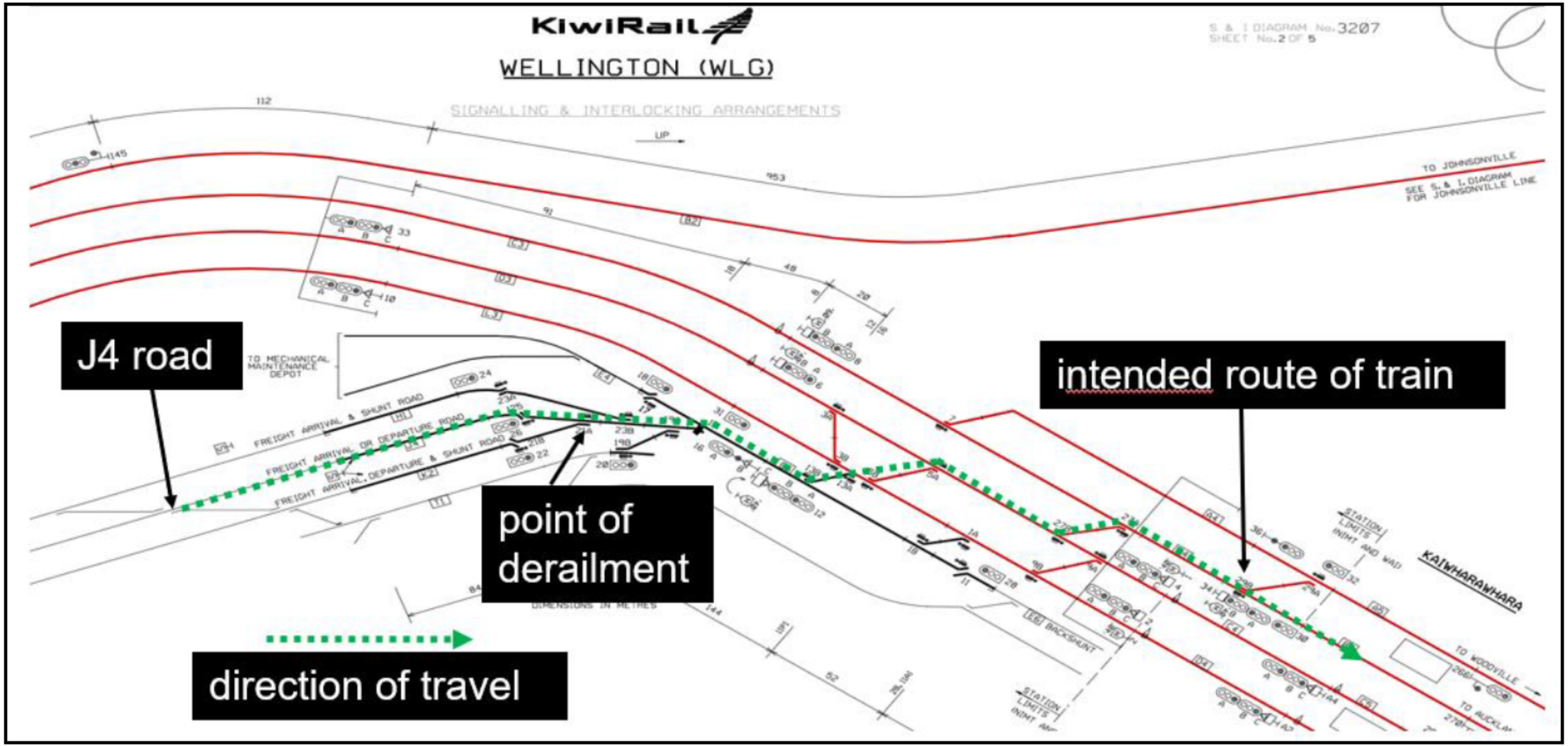

Figure 3: Location of derailment

2.4 The train data recorder[7] showed that the driver selected power-setting notch two of the eight power-setting notches available when the train movement started at 1931:47[8].

2.5 At 1933:14 the train was travelling at 15 kilometres per hour (km/h) when the train examiner radioed the driver to confirm that the train-end monitor was illuminated and flashing, the terminal roll-by inspection[9] was complete, and there were no issues with the train.

2.6 The train speed was kept to 15 km/h when the lead locomotive passed over the 21A set of points[10] at 1933:26. At about the same time the driver applied additional locomotive power by moving the throttle control handle from power setting notch two to notch four over the next four seconds.

2.7 The train data recorder output showed that at 1933:55 the train was travelling at 25 km/h when wagon UKK9599, the ninth wagon on the train, passed over the 21A set of points. At that time the driver reduced power by moving the throttle control from notch four to notch three.

2.8 At 1934:25 the train speed had slowed to 21 km/h when there was a sudden drop in the train brake pipe[11] pressure and the train surged, indicative of a train parting[12]. The driver looked back along the train and saw that some wagons had derailed, so moved the power control handle back to idle. The train's vigilance system[13] had detected the sudden loss of train brake pipe pressure, applied the brakes automatically and sent an alert to train control. The train stopped at 1934:40.

2.9 Once stopped, the driver radioed the train examiner to inform them of the derailment, then made a radio call to inform the controller of all rail vehicle movements within Wellington Station limits. The driver then secured the train, removed the portable radio and walked the length of the train to determine the extent of the damage.

2.10 The derailed train blocked three of the four electrified main lines that provided access to and from the Wellington Station platforms. As a consequence, commuter train services were suspended until about 1640 on 3 July 2019.

Site information

2.11 The point of derailment[14] (POD) was on the right-hand closure rail (in the direction of travel) of the 21A set of points.

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[7] A device that continuously captures and stores train systems' data. The data stored typically includes location, speed, locomotive power setting, brake pressure, dynamic brake, whistle activation, time and duration of radio communications, and vigilance activation and cancellation. The data is downloaded and used in the evaluation of incidents and accidents.

[8] Times in this report are New Zealand Standard Times (universal co-ordinated time + 12 hours) and are expressed in the 24-hour mode.

[9] An inspection intended to detect rail vehicle irregularities that are not so apparent when the vehicle is stationary. Potential irregularities include; wheels derailed during the loading process, loose backing rings or hot axle bearings, skids or flat spots on wheels, and dragging equipment.

[10] An assembly of switches and crossings designed to divert a train from one line to another.

[11] A pipe that runs the length of a train connecting all the wagons. The pipe is kept permanently under pressure. Brake control is achieved by varying the pressure in the train brake pipe.

[12] A loss of connection between adjacent wagons, leaving the brake hose no longer connected.

[13] A system fitted to locomotives for the protection of the crew. The system can carry out a number of functions, including applying the brakes automatically when wagons become disconnected.

[14] The exact location where the first wheel flange lost guidance from the rail.

2.12 The track measure-up after the derailment showed a 360-millimetre (mm)-long witness mark[15] on the inside face of the right-hand rail (in the direction of travel) that then ran along the head of the rail for a further 3.10 m before dropping on the outside of the rail. The derailed wagon had been dragged through six more sets of points before coming to a stop 256 m past the POD. During the derailment sequence three other wagons had derailed: the 10th, the 11th and the 15th, all UKK-class wagons.

2.13 The 21A set of points had been renewed in 2012, with 50-kilograms-per-metre rail fixed to new composite sleepers[16] with standard fastenings. There was no sign of sleeper deterioration and no wear was evident on either the top or the side of the rail at the POD.

2.14 The curved track through the vehicle access roadway leading up to the 21A set of points had been renewed in February 2018 with 50-kilograms-per-metre rail fixed to concrete sleepers with standard fastenings. The rail sections had subsequently been welded to form continuous welded rail before an asphalt coating was applied across the access-road level crossing (see Figure 4).

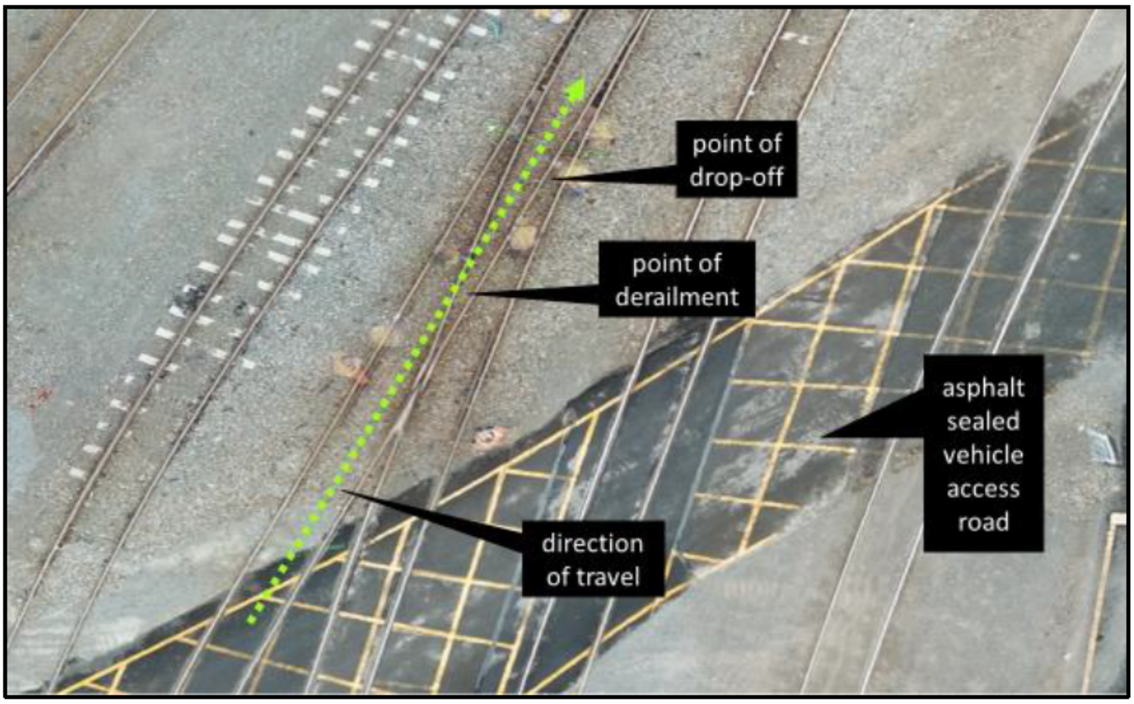

Figure 4: Point of derailment

Personnel information

2.15 The Palmerston North-based driver had been qualified to drive freight and diesel-hauled passenger trains since January 2006.

2.16 The driver's roster was not out of the ordinary: they had had the previous weekend off duty and worked from 0515 to 1530 on Monday 1 July 2019. The driver reported having had a seven-hour sleep before waking at 0700 on Tuesday 2 July.

[15] A physical mark made when a wheel flange climbs up and across a railhead (the bulbous upper part of a rail section).

[16] Beams placed at regular spaces at right angles to and under rails. Their purpose is to support the rails and ensure the correct gauge is maintained between the rails.

2.17 The driver reported "feeling good" when booking on for duty at 1615 on Tuesday 2 July 2019, before departing from Palmerston North with a Wellington-bound freight train at 1638.

2.18 The driver's mandatory post-accident drug and alcohol test, carried out at the Wellington Operations depot about two hours after the derailment, returned a negative (clear) result.

Track inspections

2.19 Track inspections are carried out to ensure that sections of track are safe for the passage of rail vehicles at the authorised line speeds until the next scheduled inspections. The multi-tiered inspection regime for the J4 road is carried out at the following intervals:

- a visual and detailed inspection by foot every 13 weeks
- a track evaluation car[17] run annually to measure, record and analyse track geometry parameters such as cant[18], line[19], gauge[20], top[21] and twist[22]
- an annual detailed engineering inspection of the track asset condition.

2.20 The track evaluation car had last recorded J4 road on 3 December 2018. The run had identified a Class 1**[23] line fault through the vehicle-access level crossing on the approach to the 21A set of points, and a 21 mm (Class 2[24]) twist fault within the set of points.

2.21 The most recent scheduled visual/detailed track inspection had been carried out on 27 June 2019. There was no entry reporting any deterioration in the track condition near the POD.

Vehicle information – wagon UKK9599

2.22 The UKK-class container-carrying wagons had been converted from UK-class wagons by fitting automatic couplers[25] and heavy-duty draw-gear to increase the maximum allowable train weight hauled on the Auckland to Christchurch corridor. The original UK-class wagons had been assembled in New Zealand between 1971 and 1981.

2.23 The UKK-class wagon fleet was fitted with standard three-piece Type 14 bogies[26] designed for 14 t per axle and restricted to a maximum load weight of 43 t or a gross laden weight of 57.3 t. The distance between bogie centres was 12.192 m.

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17 A track evaluation car uses a system with sensors to measure the track geometry, and computer software to continually analyse the measurements. The system produces a real-time graphical output and a separate exception report that identifies location, type and priority wherever follow-up maintenance is required.

18 The height of one rail above another rail. Also known as 'cross level'.

19 The horizontal or lateral position of a track measured on both rails.

20 The distance between the inside faces of railheads, measured 16 mm below the running surface.

21 The longitudinal level of the running surfaces on both rails.

22 A variation in cant over a base length of 4 m.

23 At or above the maximum allowable limit; must be planned for repair within defined limits.

24 At or above an acceptable maintenance tolerance; should be planned as a normal maintenance activity to bring within tolerance.

25 Devices used to connect wagons for haulage purposes.

26 Metal frames, each equipped with two wheelsets and able to rotate freely in plan, used in pairs under a wagon body to improve ride quality and better distribute forces to the track.

2.24 Following a scheduled maintenance check, wagon UKK9599 had been hauled empty from Auckland to Wellington, arriving on the morning of 30 June 2019. There had been no alerts generated when the wagon passed over the wagon condition monitoring unit located near Palmerston North. The wagon had been loaded the next day and hauled to Palmerston North. It had returned to Wellington as an empty wagon at about 0350 on 2 July 2019. The wagon had then been placed in the container terminal where, at about 0815, 40-foot (12-metre) container TLLU4655018 was secured on it.

2.25 The declared load weight for the container and product was 8.24 t. Following the derailment, the container was check-weighed at 8.12 t and opened to examine the load distribution (see Figure 5). The load was shown to be evenly distributed.

Figure 5: Loaded container from wagon UKK9599

2.26 The KiwiRail Holdings Limited (KiwiRail) M2000 Mechanical Code required all freight wagons to be inspected at the following intervals:

- a pre-departure check
- a visual examination whenever two or more brake blocks were changed (B-Check)
- a detailed examination every two years (C-Check)
- a detailed inspection of the body-mounted brake cylinder, every 10 years.

2.27 The pre-departure check was conducted as described in paragraph 2.3.

2.28 B-Checks had been carried out on wagon UKK9599 on 30 November 2018 and 14 January 2019.

2.29 The two-yearly C-Checks were to ensure that all maintenance had been carried out to specification so that wagons could be released in a reliable, fit-for-service condition. The checks included structural inspections of the wagons and detailed examinations of the couplers, braking system, wheelsets[27] and bogies.

[27] Two rail wheels mounted on a joining axle.

2.30 The most recent C-Check on wagon UKK9599 had been carried out at KiwiRail's Westfield maintenance facility, Auckland, from 13 May 2019. The following work was carried out during the scheduled inspection:

- structural repairs to the wagon underframe and hand-grab
- the brake valve was replaced and tested
- the coupler at the handbrake end of the wagon was replaced
- the bogie at the non-handbrake end of the wagon (the leading bogie in the direction of travel at the time of the derailment) was replaced with an overhauled bogie
- the wheelsets at the non-handbrake end were re-profiled on a wheel lathe
- a wheelset on the bogie at the handbrake end (trailing bogie) was re-profiled.

2.31 Figure 6 is a schematic showing the wagon and bogie layout.

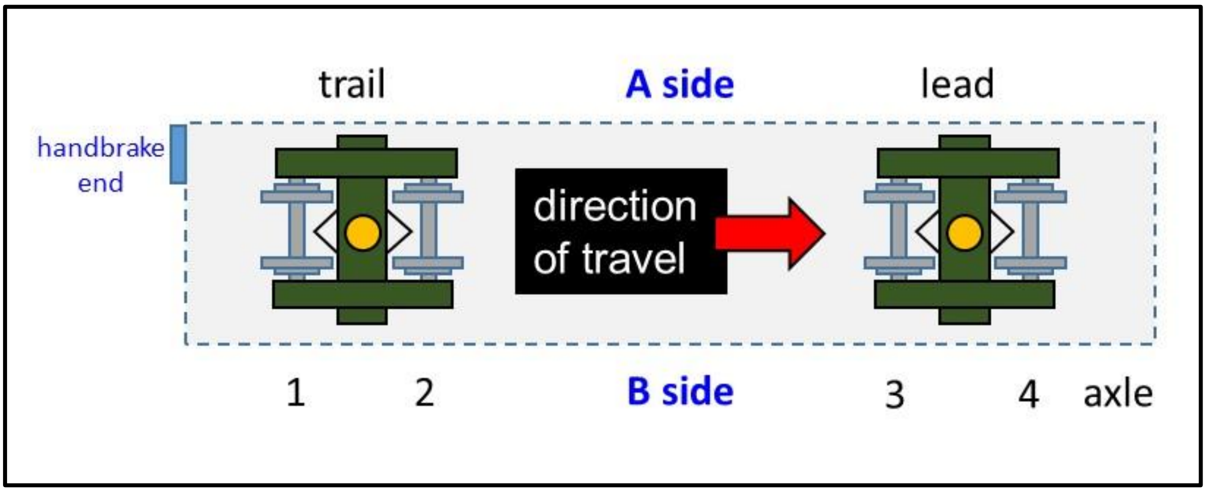

Figure 6: Schematic of wagon and bogie layout

Previous similar occurrences investigated by the Transport Accident Investigation Commission

Inquiry RO-2003-114

2.32 On Friday 21 November 2003, express freight Train 220 derailed near Shannon on the North Island Main Trunk line.

2.33 Post-derailment track measurements identified opposing cyclic track twists[28], within acceptable maintenance tolerance limits, before the POD.

2.34 An examination of the derailed wagon identified worn friction wedges[29], but they were within the KiwiRail Mechanical Code limits.

Inquiry RO-2005-103

2.35 On Thursday 20 January 2005, express freight Train 237 derailed near Hunterville on the North Island Main Trunk line.

[28] A series of track twists alternating between a negative cant difference and a positive cant difference.

[29] Friction wedges perform a similar function to shock absorbers in a car by controlling the bounce when a wagon passes over undulating track. They also hold the bogie bolster perpendicular to the side-frames to provide better steering and a longer wheel life.

2.36 Post-derailment track measurements identified two contributory track conditions, previously identified by the track evaluation car but not repaired. Individually, the track exceedances would not have caused the derailment.

2.37 An examination of the derailed wagon found two inner wedge springs and one outer spring shorter than the minimum length required for reuse.

2.38 The Transport Accident Investigation Commission (Commission) made recommendations to the Chief Executives of Ontrack and Toll Rail (predecessors of KiwiRail) to critically review current track and the KiwiRail Mechanical Code standards and maintenance tolerances to ensure they were compatible and minimised the potential for derailments caused by dynamic interaction[30] (009/05 and 010/05). Codes and standards for the track and wagons have since been changed and the status of the recommendations changed to 'closed acceptable'.

Inquiry RO-2007-115

2.39 On Wednesday 7 November 2007, express freight Train 533 derailed on the Stratford-Ōkahukura line.

2.40 The Commission was unable to determine conclusively the cause of the derailment. However, both the track condition and the condition of the derailed wagon were at or near the KiwiRail Mechanical Code tolerance limits and were considered to be contributory factors.

2.41 The Commission made a recommendation to the Chief Executive of the NZ Transport Agency to address the issue of the current track and mechanical standards and maintenance tolerances not being compatible, and stated that there remained a high risk of derailments caused by dynamic interaction (029/09). In view of the actions taken in 2.38, the status of this recommendation has been changed to 'closed acceptable'.

Inquiry RO-2019-103

2.42 On Thursday 4 April 2019, express freight Train 626 derailed within Palmerston North station limits.

2.43 The Commission found that no single factor led to the derailment. However, it was very likely that a combination of factors contributed to the derailment, including:

- the track alignment and condition
- the train travelling above the authorised line speed
- the condition of the wagon's suspension system and its sensitivity to the track condition
- the multiple cyclic track twists before the POD.

2.44 The Commission identified that KiwiRail had no procedure for identifying, evaluating and rectifying cyclic track twists of a repetitive nature. The Commission recommended that KiwiRail address this issue in order to reduce the likelihood of a wheel climb[31] derailment. (Recommendation 003/20).

[30] A situation when the track geometry, wagon condition, wagon loading and train speed are individually within tolerance limits, or marginally in excess, but not to an extent that each variation on its own is sufficient to be a prime cause of a derailment. However, when in combination these conditions can result in a derailment.

[31] The action of a rail wheel being driven up the running face of a rail, resulting in a derailment.

3 Analysis

Introduction

3.1 While the likelihood of a freight train derailment on the network is low, a derailment has the potential to cause injury and significant property damage that result in disruptions to scheduled passenger and freight services. In this accident, the derailed wagons caused major damage to three main lines that caused the suspension of passenger trains into and out of the Wellington Station platforms for nearly 21 hours.

3.2 Closed-circuit television security recordings showed the first sign of sparks came from the leading bogie under wagon UKK9599 as it passed over the 21A set of points. The sparks confirmed that the wagon had derailed.

3.3 Wagons fitted with Type 14 bogies have been prominent in KiwiRail derailment statistics. In the year ending 30 June 2019, wagons fitted with Type 14 bogies accounted for 40% of the total track kilometres run yet featured in eight of the 10 derailments (80%) on the rail network. The Commission found no evidence to suggest that, on its own, the Type 14 bogie design contributed to the derailment.

3.4 With respect to this derailment, the Commission found that there was insufficient vertical load[32] on the leading bogie to prevent it climbing the right-hand rail (in the direction of travel). See Figure 7.

Figure 7: Rail climb at the point of derailment

3.5 The Commission found that it was very likely that a combination of factors contributed to the wheel climb that led to the derailment.

[32] The downward force on an individual wheel can vary as a wagon travels along a track. When the vertical load is low compared to the lateral force, the wheel can climb the rail, potentially leading to a derailment.

3.6 The following section analyses the circumstances surrounding the event to identify those factors, which increased the likelihood of the event occurring or increased the severity of its outcome. It also examines any safety issues, which have the potential to adversely affect future operations. It examines the three safety issues that increased the likelihood of a derailment:

- there was no track standard that specified the minimum permitted track radius
- the track faults identified during routine inspections were not closed out in accordance with company standards
- the wagon was authorised to return to service following a routine maintenance inspection with wheel flange surface roughness outside specified limits.

Track geometry of the approach curve

Safety issue: There was no track standard that specified the minimum permitted track radius.

3.7 The approach track curve leading up to the POD had been constructed in February 2018. A detailed measure-up of the track geometry after the derailment recorded the maximum versine[33] at 175 mm within the sealed vehicle access road and 15 m before the POD (see Figure 8).

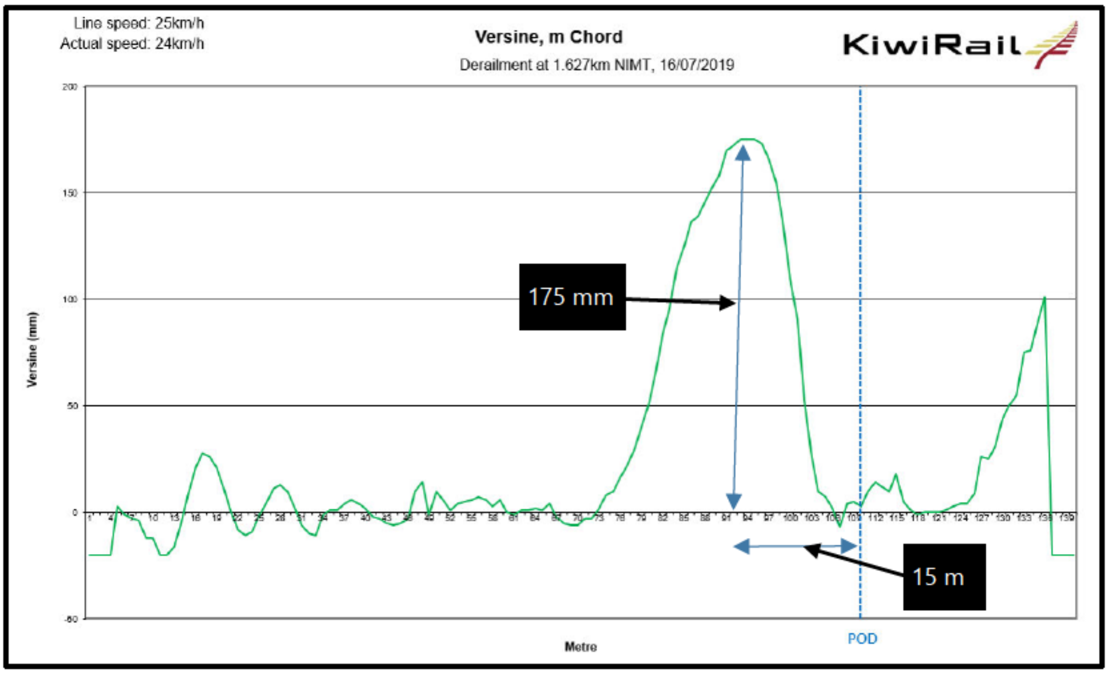

Figure 8: Versine measurements from the curve leading up to the point of derailment (Credit: KiwiRail)

3.8 The standard formula of $R=C^2/8V$ was used to calculate the curve radius, where C was the chord length (in metres) and V was the versine (in metres). In this case the chord length was 10 m and the maximum recorded versine was 0.175 m. The minimum or tightest curve radius was therefore determined as 71.4 m.

3.9 The KiwiRail Track Code Supplement CSP 33 was the guiding document for track design standards at the time the approach track was relayed. CSP 33 made no

[33] The distance from the circumference of a circle to the mid-point of a chord of that circle.

reference to the absolute minimum and/or desirable minimum curve radius standards for track within yards or sidings.

3.10 The National Rail System Standard[34], Section 6, Engineering Interoperability Standards, required all rail vehicles to be capable of safely negotiating track with a curve radius of 70 m.

3.11 KiwiRail Track Code Supplement CSP 33 was replaced by the KiwiRail Track Design Standard T-ST-DE-5200, effective from 30 June 2019. The standard for main lines and loops required a desirable minimum curve radius of 150 m and an absolute minimum curve radius of 90 m. Where the coupling/uncoupling of rolling stock was to be carried out in yards and sidings, the minimum curve radius was to be 140 m.

3.12 The 71.4 m-radius curve leading up to the POD was therefore significantly tighter than the absolute minimum prescribed in the current standard. When combined with other track defects described in the next section, and the absence of lubrication on the rail, it was likely that the tight-radius curve contributed to the derailment.

3.13 KiwiRail has since introduced a revised track design standard and undertaken a national project to identify and programme remedial work to achieve a minimum curve radius of 90 m on all curves within freight yards and sidings. Had this not happened, the Commission would have likely made a recommendation.

Safety issue: The track faults identified by the track evaluation car were not closed out in accordance with company standards

3.14 The KiwiRail Track Geometry Standard T-ST-AM-5120 required the Class 1** line fault to be inspected and verified within three days, a 40 km/h temporary speed restriction to apply during the inspection and repairs to be completed within 14 days. If it were not possible to achieve the repair within the required timescale, mitigations were required to be in place until the repair were completed.

3.15 KiwiRail could not provide evidence to confirm that the Class 1** line fault had been inspected and repaired by 17 December 2018. The fault had been recorded as closed out by the asset engineer on 31 May 2019 without inspection or repair. The post-derailment track measure-up confirmed that the line fault remained (see Figure 7). The asset engineer had stated, "design geometry at turnouts, mitigation per 20 km/h" [maximum authorised line speed on the arrival/departure road]. On its own, the line fault was not likely to have caused the derailment.

3.16 The Track Geometry Standard T-ST-AM-5120 specified that a 21 mm twist fault was to be inspected and verified within three months and repaired within six months.

3.17 KiwiRail could not provide evidence that the 21 mm twist had been repaired by the target date of 3 June 2019. An analysis of the post-derailment manual track geometry measure-up provided confirmation that the 21 mm twist had not been attended to (see Figure 9).

[34] The National Rail System Standards have been adopted by KiwiRail and other operators using the controlled rail network.

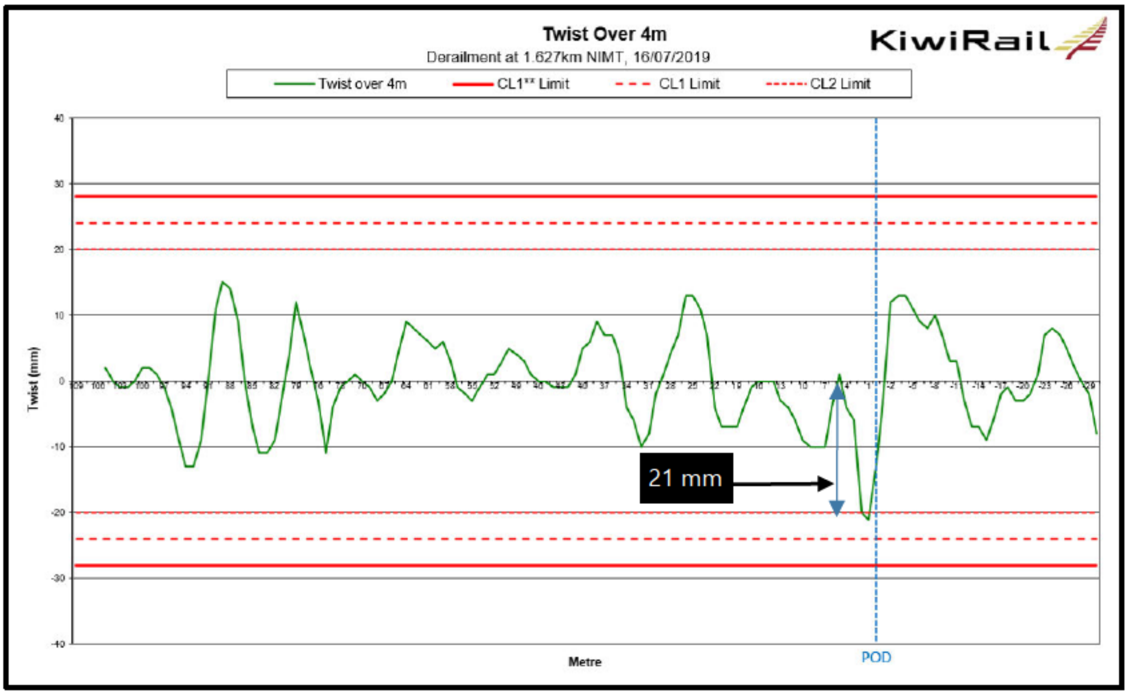

Figure 9: Post-derailment output graph of track twists (Credit: KiwiRail)

3.18 The distance between the bogie centres of the first wagon to derail was 12.19 m. One of the output graphs from the post-derailment track measure-up showed a long-wheelbase reverse twist (over 12 m) of 57 mm (see Figure 10). Wagons are designed to negotiate a long wheelbase twist of up to 62 mm. The 57 mm twist was therefore near the wagon's design limit and likely contributed to the derailment.

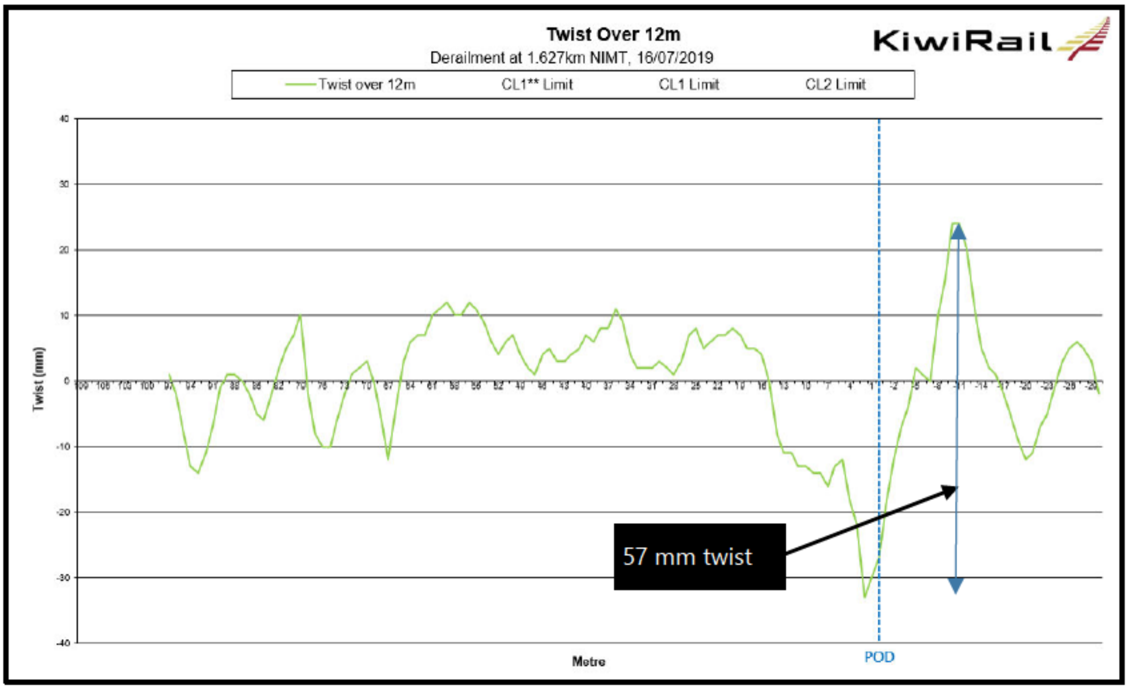

Figure 10: Post-derailment output graph of twists over 12 m (Credit: KiwiRail)

3.19 It was unlikely that the individual twists would have been identified during the three-monthly scheduled visual inspection. The post-derailment track measure-up showed that the value of each twist did not meet the threshold for immediate repair action. However, cyclic track twists are known to contribute to derailments.

Post-derailment condition of wagon UKK9599

Safety issue: The wagon was authorised to return to service following a routine maintenance inspection with wheel flange surface roughness outside specified limits.

3.20 The KiwiRail Mechanical Code required all wagons that derailed, along with the wagons immediately ahead of and behind them, to be examined and critical measurements to be taken.

3.21 Following the derailment, the wagon deck was transported to KiwiRail's Hutt Workshops by the Commission for further examination. The bogies were dismantled on 7 August 2019, components were examined, and critical measurements were taken.

3.22 The maintenance records confirmed that all four wheels on the leading bogie had been re-profiled at the Westfield depot in Auckland on 19 June 2019, as part of the two-yearly scheduled C-Check.

3.23 The KiwiRail Mechanical Code specified that the wheel tread and flange surface roughness finish was to be no more than 12.5 micrometres (μm). The design of the Starrett SR100[35] tool normally used to measure surface roughness was such that it was incapable of measuring the surface roughness on the compound[36], reverse curvature of the wheel flange faces. However, when the machined surface finish on the wheel flanges was compared to a standard 'scratch pad', the surface roughness was estimated to be in the range of 25-50 μm, thereby exceeding the maximum permitted by a factor of two to four (see Figure 11).

[35] A tool that separates into two pieces to measure surface roughness. A diamond stylus from the lower part is drawn across the part being measured. The vertical movement of the stylus as it travels across peaks and valleys is detected by a pizo-electric pickup that converts the mechanical movement of the stylus into an electrical signal. The electrical signal is digitised and sent to a microprocessor where the parameters are calculated using standardised algorithms and displayed on the upper unit.

[36] A compound curve has non-constant radii.

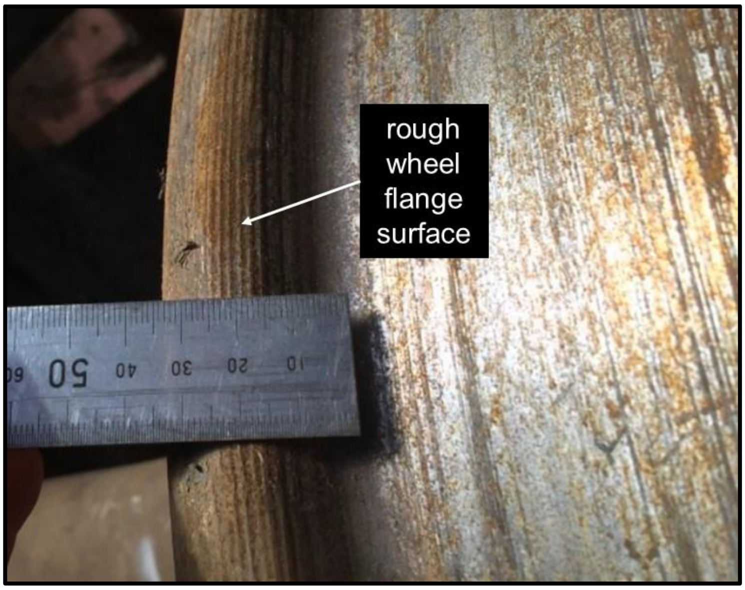

Figure 11: Tread and flange surface roughness

3.24 The out-of-code flange surface roughness increased the friction on the wheel/rail interface. This factor, when combined with the track geometry contributing factors mentioned in the earlier section, increased the likelihood of a wheel climb derailment.

3.25 In October 2019 KiwiRail updated its M6000-500 Wheelset Manual – Wheel Lathes standard to include, in part:

> 3.3 SURFACE FINISH
>
> The surface finish of the tread profiles and tapered face of the flange must not be coarser than 12.5 micrometres Ra. A rough finish on the flange face substantially increases the risk of derailment on curves.
>
> For underfloor lathes, the surface finish on the tread part only, can be [up to] 25 micrometres.

3.26 See Figure 12 for surface-finish standards.

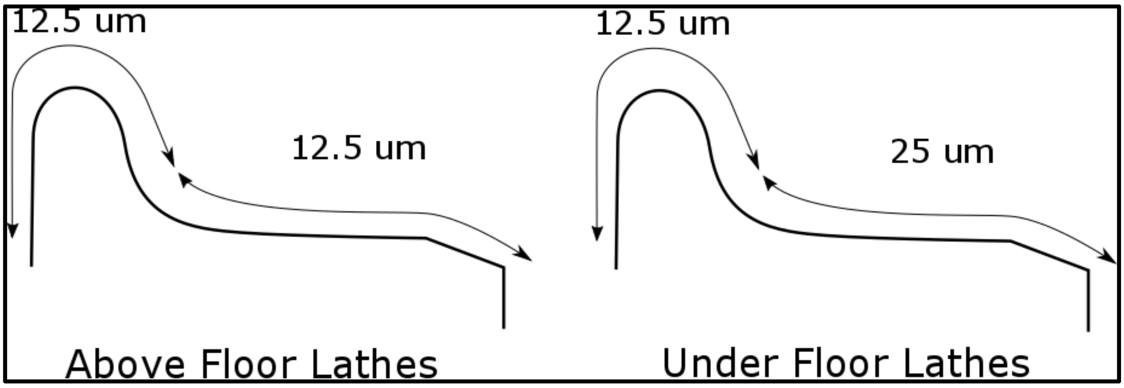

Figure 12: Surface finish on flange and tread

3.27 Had KiwiRail not amended the roughness standard, the Commission would have been likely to make such a recommendation.

Non-contributing factors

Loading

3.28 Wagon UKK9599 was conveying an evenly loaded, 40-foot container with a low-density product. Following the derailment, the container was recovered, and check weighed at 8.12 t before being placed on another wagon and transported to Palmerston North. No load imbalance was identified when the wagon passed over a continuous-in-motion weigh station en route.

3.29 A 40-foot container is relatively stiff when compared to a UKK-class wagon underframe. Therefore, a UKK-class wagon, when conveying a 40-foot container, will reduce slightly the wagon's ability to negotiate long-wheelbase track twists[37].

Train speed

3.30 Express freight trains entering the Wellington Freight Terminal were restricted to a maximum speed of 20 km/h (see Figure 13). However, there was no corresponding board to show the maximum speed for trains departing the Freight Terminal. The driver thought that departing trains were restricted to a maximum speed of 20 km/h. KiwiRail's Joint Yard Operating Plan did not identify the maximum operating speed for trains departing the Wellington Freight Terminal. However, KiwiRail has confirmed that the maximum authorised speed at the time of the derailment was 25 km/h.

Figure 13: Permanent speed board on entry to the Wellington Freight Terminal

3.31 The train was travelling at 25 km/h when the driver reduced power to slow the train to 20 km/h, what they understood was the maximum authorised line speed, at the same time as wagon UKK9599 derailed.

3.32 The Commission determined that the marginal difference between the actual train speed and the posted line speed was unlikely to have contributed to the derailment.

[37] Variations in cant over a base length of 12 m.

4 Findings

4.1 There was insufficient vertical load on the leading bogie of wagon UKK9599 to prevent it climbing onto and over the right-hand rail when viewed in the direction of travel.

4.2 No single factor caused the derailment. It was a combination of:

- track alignment, which was at the limit of the wagon's ability to negotiate the track safely
- track faults identified during a routine inspection being closed out without repair
- the long-wheelbase track twist being close to the wagon's design limit
- the wheel flange surface roughness exceeding specification by a factor of nearly four.

4.3 Train speed was unlikely to have been a contributing factor to the derailment.

4.4 No evidence was found to suggest that the design of the UKK-class wagon contributed to the derailment.

5 Safety issues and remedial action

General

5.1 Safety issues are an output from the Commission's analysis. They typically describe a system problem that has the potential to adversely affect future operations on a wide scale.

5.2 Safety issues may be addressed by safety actions taken by a participant, otherwise the Commission may issue a recommendation to address the issue.

5.3 KiwiRail has taken the following safety action to address issues that would normally result in the Commission issuing a recommendation.

5.4 On 2 September 2020, KiwiRail responded to the Commission. Part of M6000 has been updated.

> [The Standard] allows tread to be relaxed to 25µm and flange finish is retained at 12.5µm Ra. This allows the more critical wheel flange surface toughness to be attained without excessive time required to re-profile the wheel on above floor lathes.
>
> Hutt Wheel Shop Facility Procurement is underway. When completed, this will remove the need to loose turn wheelsets on under floor lathes. The CNC portal lathe associated with the new facility will be able to achieve a much smoother finish.

6 Recommendations

General

6.1 The Commission issues recommendations to address safety issues found in its investigations. Recommendations may be addressed to organisations or people and can relate to safety issues found within an organisation or within the wider transport system that have the potential to contribute to future transport accidents and incidents.

6.2 In the interests of transport safety, it is important that recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

6.3 Mitigating actions taken by KiwiRail and links to an open safety recommendation made to KiwiRail meant that no new safety recommendations were made.

7 Key lessons

7.1 Standards and procedures are put in place to ensure consistent and safe outcomes.

7.2 Preventive rail-maintenance activities require careful planning and timely execution to maintain a safe operation.

8 Data summary

Vehicle particulars

Train type and number:	express freight Train 268, consisting of a DFB-class locomotive hauling an unpowered DL-class locomotive and 15 wagons
Train length:	289 m
Train weight:	475 t (including the trail locomotive)
Operator:	KiwiRail Holdings Limited
Date and time	2 July 2019 1200 at 1933:55
Location	Wellington Freight Terminal, J4 Road to the mainline
Operating crew	one train driver
Injuries	nil
Damage	significant damage to the rail infrastructure and wagons

9 Conduct of the inquiry

9.1 On 2 July 2019 the NZ Transport Agency notified the Commission of the occurrence. The Commission subsequently opened an inquiry under section 13(1) of the *Transport Accident Investigation Commission Act 1990* and appointed an investigator in charge.

9.2 Commission investigators arrived on site early the next day to examine the accident site. An order was issued under section 12 of the *Transport Accident Investigation Commission Act* to protect the site and the derailed wagons. A non-tampering order was placed on all the derailed wagons and the wagons directly in front of and behind the derailed wagons.

9.3 The train driver was interviewed by Commission investigators on 19 July 2019.

9.4 On 23 July 2019 Commission investigators, with assistance from KiwiRail, methodically stripped down the bogies from the first wagon to derail at KiwiRail's Hutt Workshops.

9.5 Operating staff responsible for making up the train and conducting the pre-departure and roll-by inspection were interviewed on 25 July 2019.

9.6 On 5 August 2019 a static re-enactment of the derailment was carried out.

9.7 The Commission obtained the following records and documents for analysis:

- video footage of the departing train
- data downloaded from the train event recorder
- the train driver's timesheets and training records
- track inspection and maintenance records
- wagon inspection and maintenance records.

9.8 On 23 September the Commission approved a draft report for circulation to two interested persons for their comment.

9.9 The Commission received two submissions, and changes as a result of these have been included in the final report.

9.10 On 9 December 2020 the Commission approved the final report for publication.

10 Report information

Abbreviations

km/h	kilometre(s) per hour
m	metre(s)
mm	millimetre(s)
POD	point of derailment
t	tonne(s)
µm	micrometre(s)

Glossary

bogie	a metal frame equipped with two wheelsets and able to rotate freely in plan, used in pairs under a wagon body to improve ride quality and better distribute forces to the track
brake pipe	a pipe that runs the length of a train connecting all the wagons. The pipe is kept permanently under pressure. Brake control is achieved by varying the pressure in the train brake pipe
cant	the height of one rail above another rail. Also known as 'cross level'
climb	the action of a rail wheel being driven up the running face of a rail, resulting in a derailment
coupler	a device used to connect wagons for haulage purposes
cyclic track twists	a series of track twists alternating between a negative cant difference and a positive cant difference
dynamic interaction	a situation when the track geometry, wagon condition, wagon loading and train speed are individually within tolerance limits, or marginally in excess, but not to an extent that each variation on its own is

	sufficient to be the prime cause of a derailment. However, when in combination these conditions can result in a derailment
gauge	the distance between the inside faces of railheads, measured 16 mm below the running surface
line	the horizontal or lateral position of a track measured on both rails
long-wheelbase track twist	a variation in cant over a wheelbase length of 12 m
point of derailment	the exact location where the first wheel flange lost guidance from the rail
points (or set of points)	an assembly of switches and crossings designed to divert a train from one line to another
rake	two or more wagons coupled together
roll-by inspection	an inspection intended to detect rail vehicle irregularities that are not so apparent when the vehicle is stationary. Potential irregularities include wheels derailed during the loading process, loose backing rings or hot axle bearings, skids or flat spots on wheels, and dragging equipment
sleeper	a beam placed at regular spacing at right angles to and under rails. Its purpose is to support the rails and ensure the correct gauge is maintained between the rails
terminal brake test	a terminal brake test must be carried out when any locomotive-hauled train is made up or any wagon is added to a train. The test involves checking both sides of each wagon on the train to ensure the braking system is connected correctly and functioning in both application and release
track evaluation car	a track evaluation car uses a system with sensors to measure track geometry, and computer software to continually analyse the measurements. The system produces a real-time graphical output and a separate exception report that identifies location, type and priority wherever follow-up maintenance is required

train data recorder	a device that continuously captures and stores train systems' data. The data stored typically includes location, speed, locomotive power setting, brake pressure, dynamic brake, whistle activation, time and duration of radio communications, and vigilance activation and cancellation. The data is downloaded and used in the evaluation of incidents and accidents
train examiner	a person qualified to carry out a full terminal brake test – a pre-departure inspection above and below a wagon's deck while a train is stationary – before issuing a certificate to the driver as confirmation that the train is safe to run to its destination
train parting	a loss of connection between adjacent wagons, leaving the brake hose no longer connected
twist	a variation in cant over a base length of four m
versine	the distance from the circumference of a circle to the mid-point of a chord of that circle
vertical load	the downward force on an individual wheel can vary as a wagon travels along the track. When the vertical load is low compared to the lateral force, the wheel can climb the rail, potentially leading to a derailment
vigilance system	a system fitted to locomotives for the protection of the crew. The system can carry out several functions, including applying the brakes automatically when wagons become disconnected
wagon	the generic term for freight-carrying vehicles
wheelset	two wheels mounted on a joining axle

11 Notes about Commission reports

Commissioners

Chief Commissioner	Jane Meares
Deputy Chief Commissioner	Stephen Davies Howard
Commissioner	Richard Marchant
Commissioner	Paula Rose, QSO

Key Commission personnel

Chief Executive	Lois Hutchinson
Acting Chief Investigator of Accidents	Naveen Mathew Kozhuppakalam
Investigator in Charge	Peter Miskell
General Counsel	Cathryn Bridge

Citations and referencing

This final report does not cite information derived from interviews during the Commission's inquiry into the occurrence. Documents normally accessible to industry participants only and not discoverable under the *Official Information Act 1982* are referenced as footnotes only. Publicly available documents referred to during the Commission's inquiry are cited.

Photographs, diagrams, pictures

The Commission has provided, and owns, the photographs, diagrams and pictures in this report unless otherwise specified.

Verbal probability expressions

This report uses standard terminology to describe the degree of probability (or likelihood) that an event happened, or a condition existed in support of a hypothesis. The expressions are defined in the table below.

Terminology*	Likelihood	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

*Adopted from the Intergovernmental Panel on Climate Change.

TAIC Kōwhaiwhai - Māori scroll designs

TAIC commissioned its kōwhaiwhai, Māori scroll designs, from artist Sandy Rodgers (Ngati Raukawa, Tuwharetoa, MacDougal). Sandy began from thinking of the Commission as a vehicle or vessel for seeking knowledge to understand transport accident tragedies and how to prevent them. A 'waka whai mārama (i te ara haumaru) is 'a vessel/vehicle in pursuit of understanding'. Waka is metaphor for the Commission. Mārama (from 'te ao mārama' – the world of light) is for the separation of Rangitāne (Sky Father) and Papatūānuku (Earth Mother) by their son Tāne Māhuta (god of man, forests and everything dwelling within), which brought light and thus awareness to the world. 'Te ara' is 'the path' and 'haumaru' is 'safe or risk free'.

Corporate: Te Ara Haumaru - The safe and risk free path

The eye motif looks to the future, watching the path for obstructions. The encased double koru is the mother and child, symbolising protection, safety and guidance. The triple koru represents the three kete of knowledge that Tāne Māhuta collected from the highest of the heavens to pass their wisdom to humanity. The continual wave is the perpetual line of influence. The succession of humps represent the individual inquiries.

Sandy acknowledges Tāne Māhuta in the creation of this Kōwhaiwhai.

Aviation: ngā hau e whā - the four winds

To Sandy, 'Ngā hau e whā' (the four winds), commonly used in Te Reo Māori to refer to people coming together from across Aotearoa, was also redolent of the aviation environment. The design represents the sky, cloud, and wind. There is a manu (bird) form representing the aircraft that move through Aotearoa's 'long white cloud'. The letter 'A' is present, standing for aviation.

Sandy acknowledges Ranginui (Sky father) and Tāwhirimātea (God of wind) in the creation of this Kōwhaiwhai.

Marine: ara wai - waterways

The sections of waves flowing across the design represent the many different 'ara wai' (waterways) that ships sail across. The 'V' shape is a ship's prow and its wake. The letter 'M' is present, standing for 'Marine'.

Sandy acknowledges Tangaroa (God of the sea) in the creation of this Kōwhaiwhai.

Rail: rerewhenua - flowing across the land

The design represents the fluid movement of trains across Aotearoa. 'Rere' is to flow or fly. 'Whenua' is the land. The koru forms represent the earth, land and flora that trains pass over and through. The letter 'R' is present, standing for 'Rail'.

Sandy acknowledges Papatūānuku (Earth Mother) and Tāne Mahuta (God of man and forests and everything that dwells within) in the creation of this Kōwhaiwhai.

Transport Accident Investigation Commission

Recent railway occurrence reports published by the Transport Accident Investigation Commission (most recent at top of list)

RO-2019-107	Passenger service SPAD and near collision, Wellington, 6 November 2019
RO-2019-106	Passenger train 804, Irregular disembarkation of passengers, Rolleston, Canterbury, 3 September 2019
RO-2019-104	Unsafe entry into worksite, Taimate, 5 June 2019
RO-2019-103	Derailment of Train 626, Palmerston North, 4 April 2019
RO-2019-101	Safe-working occurrence, Westfield yard, Ōtāhuhu, Auckland, 24 March 2019
RO-2019-102	Clinton derailment, 29 March 2019
RO-2018-102	Freight train SPAD and wrong-routing, Taimate, 1 October 2018
RO-2018-101	Metropolitan passenger train, derailment, Britomart Transport Centre, Auckland, 9 May 2018
RO-2017-106	Mainline locomotives, Wrong-routing and collision with work vehicle, Invercargill, 16 November 2017
RO-2017-105	Collision between freight Train 353 and heavy motor vehicle, Lambert Road, level crossing, near Kawerau, 6 October 2017
RO-2017-104	Unauthorised immobilisation of passenger train, at Baldwin Avenue Station, Avondale, 17 September 2017
RO-2017-101	Signal Passed at Danger 'A' at compulsory stop boards protected worksite, Pongakawa, Bay of Plenty, 7 February 2017
RO-2017-103	Potential collision between passenger trains, Wellington Railway Station, 15 May 2017
RO-2017-102	Signalling irregularity, Wellington Railway Station, 3 April 2017
RO-2016-101	Signal passed at danger leading to near collision, Wellington Railway Station, 28 May 2016

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