Report 07-114: Derailment caused by a wheel-bearing failure, Huntly, 19 October 2007, and 11 subsequent wheel-bearing failures at various locations during the following 12 month period

Final Report

Rail Inquiry 07-114

Derailment caused by a wheel-bearing failure, Huntly, 19 October 2007, and, 11 subsequent wheel-bearing failures at various locations during the following 12 month period

Approved for publication: November 2010

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission and this Report

The Transport Accident Investigation Commission (Commission) is 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 accident and incidents with a view to avoiding similar occurrences in the future. Its purpose is not 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. The Commission carries out its purpose by informing members of the transport sector, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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Important notes

Nature of the Final Report

This final report may not be used to pursue criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

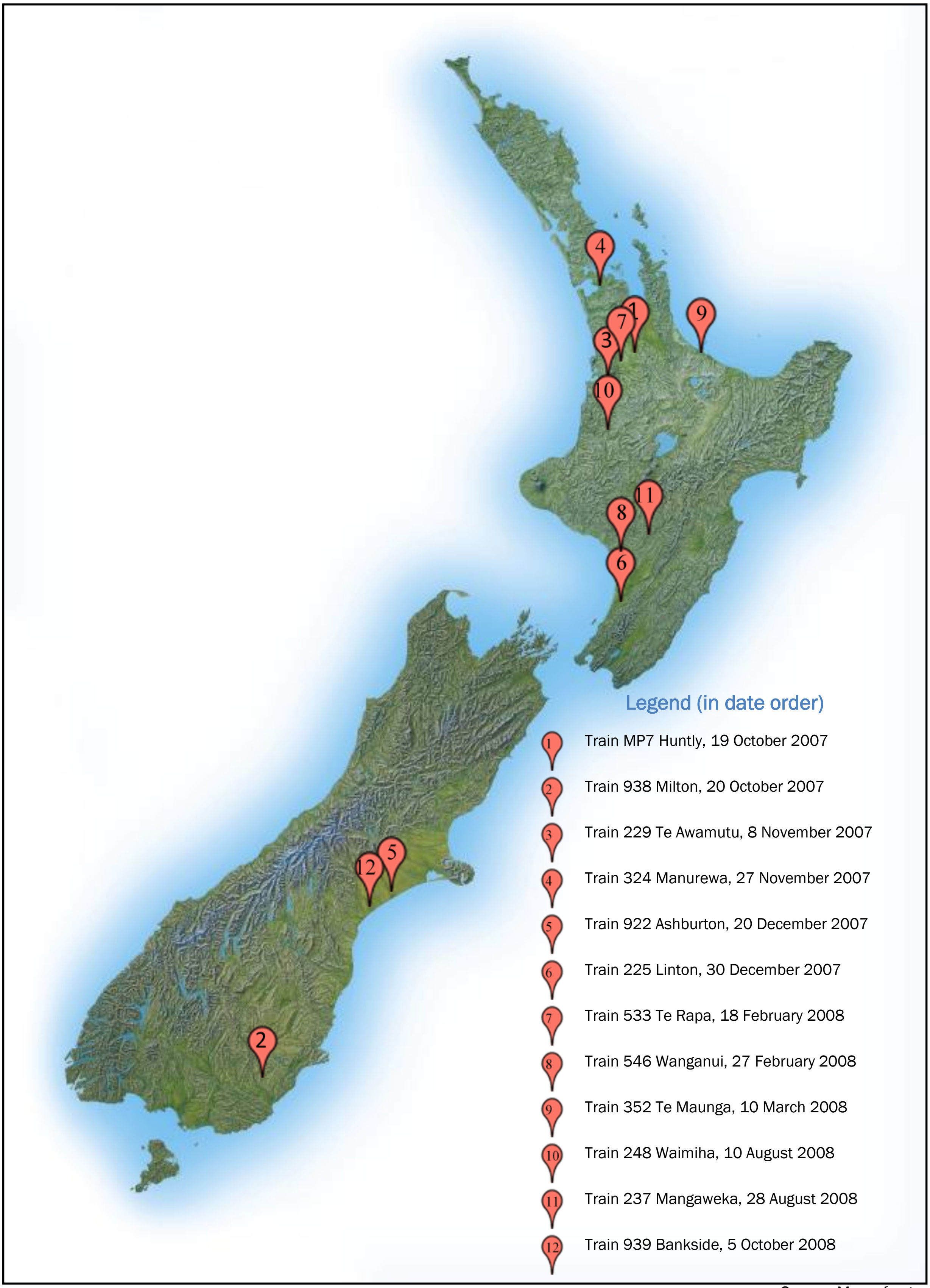
Ownership of report

Citations and referencing

Information derived from interviews during the Commission's inquiry into occurrences is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1980 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publically available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.



Source: Mapsof.net

Figure 1
Occurrence locations

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Abbreviations

Alstom	Alstom Transport New Zealand Limited
mm	millimetre(s)
Toll Rail	Toll New Zealand Consolidated Limited
UGL Rail	United Group Rail Limited
USA	United States of America
UTC	universal coordinated time

Data summary

Initial occurrence:

Train type and number:	express freight Train MP7
Date and time:	19 October 2007 at about 0010[1]
Location:	577.39 km, Huntly, North Island Main Trunk
Persons on board:	crew: one
Injuries:	nil
Damage:	extensive to rolling stock, freight, rail infrastructure and road infrastructure on adjacent State Highway 1
Operator:	Toll New Zealand Consolidated Limited (Toll Rail)

Subsequent occurrences:

Date	Location and line	Express freight Train	Derailment resulted yes/no
20 October 2007	Milton, Main South Line	938	no
8 November 2007	Te Awamutu, North Island Main Trunk	229	yes
27 November 2007	Manurewa, North Island Main Trunk	324	no
20 December 2007	Ashburton, Main South Line	922	yes
30 December 2007	Linton, North Island Main Trunk	225	yes
18 February 2008	Te Rapa, North Island Main Trunk	533	yes
27 February 2008	Wanganui, Marton-New Plymouth Line	546	yes
10 March 2008	Te Maunga, East Coast Main Trunk	352	yes
10 August 2008	Waimiha, North Island Main Trunk	248	no
28 August 2008	Mangaweka, North Island Main Trunk	237	no
5 October 2008	Bankside, Main South Line	939	no

[1] Times in this report, applicable to the derailment of Train MP7 at Huntly on 19 October 2007, are New Zealand Daylight Time (UTC + 13) and are quoted in the 24 hour mode.

1. Executive summary

1.1. Between Friday 19 October 2007 and Sunday 5 October 2008, there were 12 occurrences when wheel-bearings failed on wagons travelling on express freight trains at various locations in the North and South Island.

1.2. Seven of the 12 wheel-bearing failures resulted in the affected wagon derailing, and causing a number of following wagons to also derail. The derailments caused extensive damage to the rolling stock, freight it was conveying and the rail network. On 2 occasions, molten metal from the failed wheel-bearings resulted in fires in trackside foliage and across adjacent land.

1.3. No-one was injured in any of the derailments.

1.4. The Commission determined that wheel-bearings were critical items, the failure of which had the potential to result in a derailment. The derailments usually resulted in substantial damage to track and infrastructure, and have the potential to cause injury to third parties if the derailment occurs adjacent to populated areas or other infrastructure.

1.5. The reason for the failures of the wheel-bearings could not be conclusively determined because the bearings had usually catastrophically failed, destroying the evidence and historically inadequate record-keeping for maintenance and service life of the bearings that could not support probable cause investigation.

1.6. Because the impending failure of wheel-bearings can be difficult to detect through traditional inspection procedures, the Commission recommended to the Chief Executive of the Land Transport NZ (predecessor to NZ Transport Agency) on 8 March 2008 that he address the safety issue where the New Zealand rail network had not been protected with a track-side acoustic wheel-bearing monitoring system in line with current international best practice.

1.7. In the latter half of 2010, KiwiRail was completing the installation of an integrated acoustic wheel-bearing monitoring, coupled in motion weighbridge, wheel impact and automatic vehicle identification system at strategic sites on its network. The Safety Action section of the report shows a number of other initiatives that have been taken by KiwiRail since 2008, which together with the acoustic wheel-bearing monitoring system appears to have reduced the number of reported bearing related occurrences.

2. Conduct of the inquiry

2.1. Inquiry opened

2.1.1. Following the incident on 19 October 2007, Land Transport NZ notified the Commission under section 13(4) of the Railways Act 2005. Upon reviewing this notification and making initial inquiries, the Commission formed a belief that either the circumstances of the incident had, or would be likely to have, significant implications for transport safety or that the incident had given rise to, or would be likely to give rise to, findings or recommendations that may increase transport safety. Upon forming this belief, the Commission opened an inquiry under section 13(1) of the Transport Accident Investigation Commission Act 1990 to determine the circumstances and causes of the incident. A Commission rail investigator was then assigned as the investigator-in-charge.

2.1.2. The terms of reference for the Commission's inquiry into the incident were set out in sections 4 and 8 of the Transport Accident Investigation Commission Act 1990. Section 4 required the Commission to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future rather than to ascribe blame. To assist it with this purpose, section 8 required the Commission to investigate the incident, including to make such inquiries as it considered appropriate in order to ascertain the cause or causes of the occurrence; and to prepare and publish findings and recommendations (if any) in respect of its investigation.

2.2. Investigation process

2.2.1. On the day of the incident on 19 October 2007, the investigator-in-charge visited the site and examined the rail infrastructure and damaged rolling stock from the derailed train. The focus of the investigation turned to the history of a failed wheel-bearing after it was seen to have caused the derailment. Information relating to the history of the bearing was sourced. The event recorder information from the lead locomotive, the locomotive engineers report, the train consist report and printouts from the track database were examined and analysed.

2.2.2. During the 12 month period following the incident, the Commission was notified of 11 further incidents involving wheel-bearing failures on freight trains, six of which resulted in derailments. Rather than commencing 11 new inquiries, these incidents were included in the inquiry for the first incident. Information pertinent to the history of the 11 wheel-bearings was sourced from the rail operator after each incident. Financial costs that the rail participants had to expend to recover from the seven derailments and other related derailments throughout previous years, were obtained and analysed.

2.2.3. The Commission researched policy, procedures and practices in use at the time of these incidents covering the rail operator's mechanical management of the wheel-bearing asset. The Commission visited Hutt workshops near Wellington to examine the maintenance practices of fitting and removing bearings to wheel sets. Discussions were also held with maintenance engineers at Hutt workshops and this led to contact being made with the overseas contracted company responsible for the overhaul of bearings.

2.2.4. Previous Commission reports relating to failed wheel-bearings and industry reports written by contracted mechanical maintenance providers were sourced and researched. A review of international rail accident reports covering derailments caused by failed wheel-bearings, and research of the technology options available to monitor the in-service condition of wheel-bearings was conducted. This led to the Commission issuing an urgent recommendation in early March 2008 to Land Transport NZ to address the situation that the rail network was not equipped with an acoustic wheel-bearing monitoring system compatible to current international practices.

2.3. Consultation on the draft final report

2.3.1. As a result of its inquiries, the Commission prepared a draft final report of the incidents containing factual information relevant to the incidents, an analysis of those facts, and initial findings and recommendation. The draft final report was provided to interested persons for comment as part of the Commission's consultation process.

2.3.2. Two written submissions were received; one from the regulator and the other from the rail operator. The rail operator's submission, in particular, contained a number of detailed comments regarding the factual information and analysis contained in the draft final report. These comments, and those of the regulator's, were fully considered and, in some cases, caused the Commission to make further inquiries. Appropriate amendments were then made to the report to reflect the comments received and the results of the Commission's further inquiries.

2.3.3. After a final review of the report and all the facts relevant to the incidents, including all submissions received, this final report was prepared.

3. Factual information

3.1. Huntly derailment narrative

3.1.1. On Thursday 18 October 2007, Train MP7 was a scheduled Toll New Zealand Consolidated Limited (Toll Rail) express freight service travelling from Auckland on the North Island Main Trunk to Tauranga on the East Coast Main Trunk. The train consisted of locomotives DFT7282 and DC4104 (operating in multiple) hauling 31 loaded intermodal[2] wagons. The trailing weight behind the second locomotive was 1102 tonnes and it was 638 metres long overall. Train MP7 was crewed by a Toll Rail locomotive engineer.

3.1.2. At about 0010 on Friday 19 October 2007, a wheel-bearing on the lead wheel set (see Figure 2) on the lead bogie on wagon IB53 (the 3rd wagon behind DC4104) failed while Train MP7 was travelling between Te Kauwhata and Huntly, about 87 kilometres and about 90 minutes after leaving Auckland.

Figure 2
Lead wheel set from IB53

3.1.3. When the wheel-bearing failed completely, the wheel set derailed and was dragged to No.17 points (a diverging turnout from the main line) approaching Huntly station where IB53 completely derailed. Nine other wagons subsequently derailed at the now-damaged points (see Figure 3). Damaged and melted components from the failed wheel-bearing were found scattered over 4 kilometres of track.

Figure 3
Huntly derailment site

[2] A term describing the carriage of containers by sea, rail and road transport.

3.1.4. The locomotive engineer had felt a slight "tug" followed shortly afterwards by a complete loss of air pressure in the automatic brake system when the train was approaching Huntly. At the same time the train controller radioed the locomotive engineer to report a loss of detection on his signalling mimic screen after the train had passed over several motorised turnouts, including No.17 points.

3.1.5. The locomotive engineer left his cab on stopping and saw the derailed wagons. Emergency services were informed of the derailment because some hazardous freight was being conveyed within some of the containers and also some of the containers had spilled onto the adjacent State Highway 1, blocking the lanes for road transport. There were no injuries.

Locomotive event recorder

3.1.6. A download of the event recorder data from DC4104 showed the train had been driven within the authorised speed limits between Auckland and Huntly.

Eleven subsequent wheel-bearing failure incidents

3.1.7. The Commission was notified of a further 11 incidents of wheel-bearing failures on various classes of freight wagons running on express freight services throughout the network during the 12-month period following the derailment of Train MP7 at Huntly on 19 October 2007. Six of those 11 incidents resulted in the derailment of the wagon with the failed wheel-bearing and other wagons. The Commission did not attend these subsequent incidents but received pertinent information from Toll Rail/KiwiRail on the history of each wagon and the failed bearing.

3.1.8. The following table summarises the information from the 12 incidents, including that from IB53 at Huntly:

Wagon id, location and date	Age of wheel-bearing and when fitted	Most recent C check	Most recent B check	Date of wheel-bearing survey	Comment
IB53 Huntly 19 October 2007	could not be determined	12 September 2007	26 June 2007	not surveyed	no history of defects indicating pending bearing failure
UK19462 Milton 20 October 2007	wheel set marked January 1997	17 October 2007	17 September 2007	not surveyed	nine fused brake blocks replaced up to October 2007
USQ8076 Te Awamutu 8 November 2007	could not be determined	30 October 2007	none recorded in previous 2 years	December 2006	no history of defects indicating pending bearing failure
UK8066 Manurewa 27 November 2007	could not be determined	9 October 2007	21 November 2007	May 2006	seven fused brake blocks replaced up to November 2007
UK6523 Ashburton 20 December 2007	could not be determined	30 March 2007	12 December 2007	July 2006	five fused brake blocks replaced during 2006 and 2007
UK3889 Linton 30 January 2008	could not be determined	28 November 2005	15 November 2006	not surveyed	three fused brake blocks replaced during 2006 and 2007
USL4500 Te Rapa 18 February 2008	could not be determined	6 July 2007	24 August 2006	April 2006	no history of defects indicating pending bearing failure
OM70 Wanganui 27 February 2008	fitted July 2005	10 April 2007	23 October 2007	not surveyed	wagon had been involved in a yard derailment 3 days previously
ULA1461 Te Maunga 10 March 2008	fitted August 1999	30 November 2006	7 September 2007	not surveyed	wagon had 2 previous instances of brake block issues
Mechanical Code M2000 amended on 23 May 2008 to include instruction that wagons with repeat brake faults must be removed from service until the cause has been investigated and rectified					
UK8135 Waimiha 10 August 2008	could not be determined	8 January 2007	16 July 2008	not surveyed	nineteen fused brake blocks replaced during 2006/2007 and up to August 2008
ZH1207 Mangaweka 28 August 2008	three wheel sets marked November 2004 and one December 2004	23 August 2007	27 August 2008	not surveyed	six fused brake blocks replaced during 2007 and 2008
UK1534 Bankside 5 October 2008	three wheel sets marked July 2001, November and December 2005. one not recorded	15 February 2007	23 September 2008	December 2006	thirteen fused brake blocks replaced during 2007 and 2008

The term "fused blocks" describes the situation when brakes fail to release, and the brake blocks overheat to the point of melting onto the brake beam shoe.

3.1.9. KiwiRail's maintenance system detected wagons with abnormal brake block consumption. The suspect wheel sets were inspected and in most cases there was either a problem found in the braking system (often the VTA valve which detected whether a wagon was loaded or empty and increased/decreased braking power accordingly) which caused wheel flats, or surface defects which "chewed out" the brake blocks. In both of these situations the damaged wheel sets were replaced. Repeated vibrations from wheel-flats were considered to be a possible factor in the premature failure of wheel-bearings.

3.1.10. For the 12 wagons that suffered the wheel-bearing failures, KiwiRail was not able to tell the exact age of the wheel-bearings, or the dates they had been fitted to the axles and nor could it find the date the axles had been fitted to the wagons. This was mainly due to the bearings and axles not always being individually identifiable. However, KiwiRail said that the wear or "Z" readings (refer paragraphs 3.2.4 and 3.2.5) of the wheels gave a reasonable indication of the age of the bearings.

3.1.11. Because reference is made to several ownerships of the rail industry between 2000 and period of the occurrences, the following table shows the ownership periods including the outsourced mechanical services providers within the same period:

<table>
<tr><th>Date</th><th>Industry name</th><th>Mechanical services provider</th></tr>
<tr><td>Prior to 2000</td><td rowspan="2">Tranz Rail Limited</td><td>Tranz Rail Limited</td></tr>
<tr><td>May 2002</td><td rowspan="2">Alstom Transport New Zealand Limited</td></tr>
<tr><td>May 2004</td><td rowspan="2">Toll Rail</td></tr>
<tr><td>September 2005</td><td rowspan="2">United Group Rail Limited</td></tr>
<tr><td>July 2008</td><td rowspan="2">KiwiRail Limited</td></tr>
<tr><td>March 2009</td><td>KiwiRail Limited</td></tr>
</table>

3.2. Wheel-bearings

Description

3.2.1. Tapered roller-bearings (wheel-bearings) were the principle type of wheel-bearing in use on freight wagons in New Zealand. The advantages of tapered roller-bearings included:

- a rolling motion with load bearing contact and positive roller alignment
- low friction from start and at all running speeds
- an ability to sustain large radial and thrust loads
- a high level of reliability
- long intervals between re-lubrication
- ease of installation and removal.

3.2.2. The wheel-bearing was fitted to the axle journal ends on the outside of each wheel. Two wheel-bearings and associated bearing elements were combined into self-contained assemblies (see Figure 4) and were fitted to each axle journal. The wheel-bearing was fitted over the axle journal (the cylindrical portion of the wheel set) and was retained by an end cap.

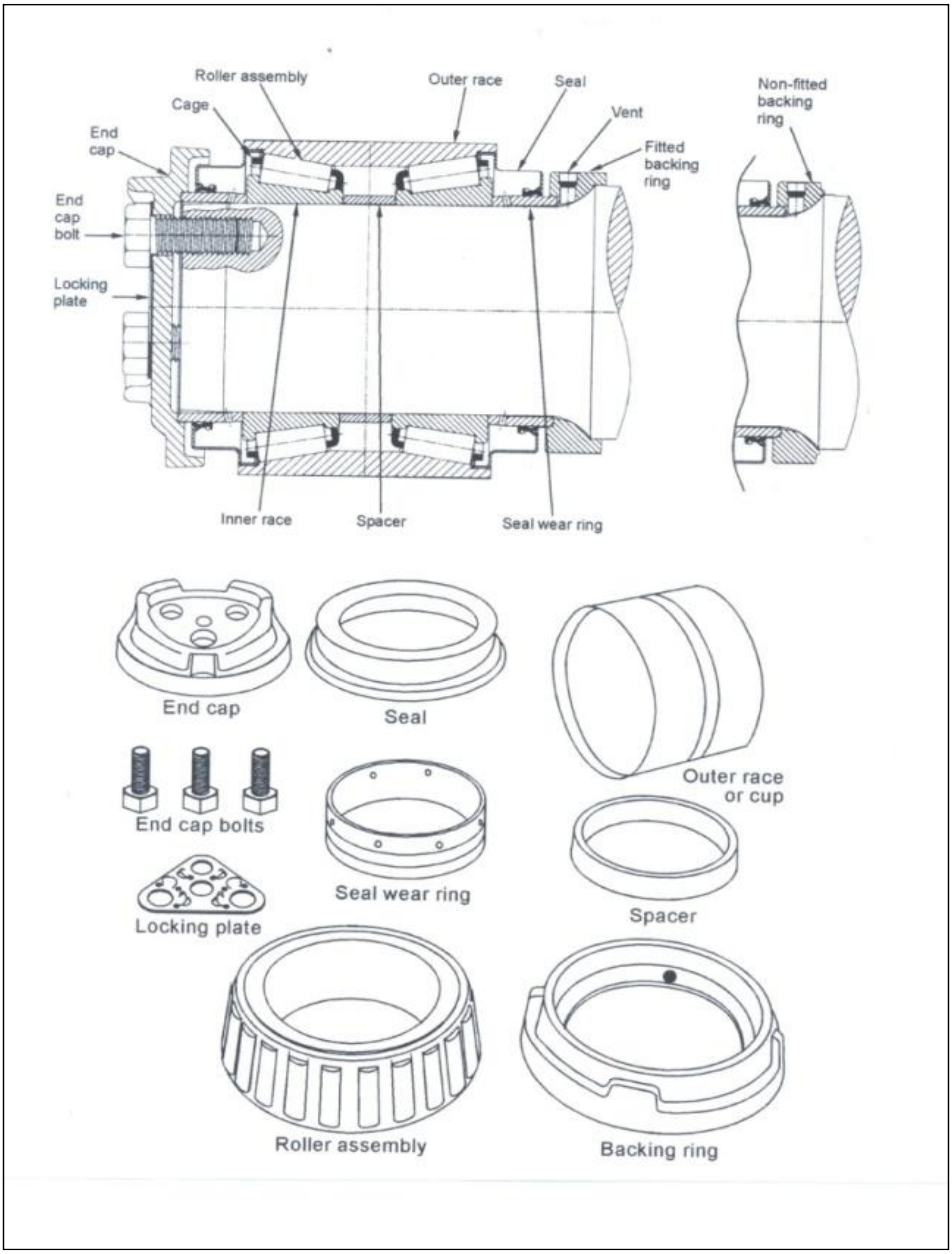

Figure 4
Packaged wheel-bearing components
(courtesy of KiwiRail)

3.2.3. The "interference fit" of the inner race on the journal and the lateral clamp provided by the end cap bolts prevented rotational creep between the inner race and the axle. The wheel-bearing was located and retained in the wagon bogie side-frame pedestal by a bearing adaptor casting (see Figure 5).

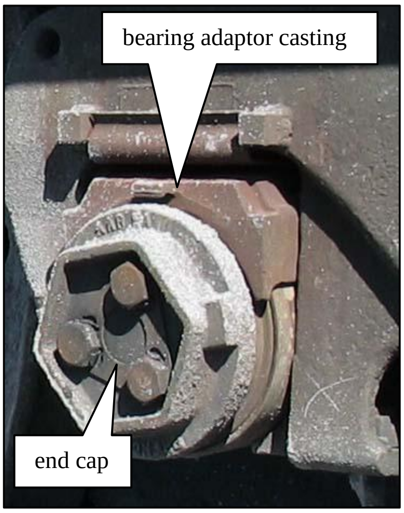

Figure 5
A wheel-bearing located in a freight wagon bogie side-frame pedestal

3.2.4. Throughout the report there is reference to wheel sets. A wheel set consists of an axle, 2 wheels and 2 wheel-bearings. The lifespan of the wheel-bearing was determined by the wear limitations of the tyre portion of the wheels, which were generally reached after about 10 years in normal service. At that time, and if tyre/rim thickness (refer Z measurement references in Figure 6) condemning limits of 16 millimetres (mm) had been reached, the wheel set was changed out from the bogie. Tyre/Rim thickness on a new wheel was 57 mm.

3.2.5. For example, "Z" readings of 24 mm and 20 mm were recorded on the 2 wheel sets from the lead bogie on IB53 during a programmed C-check, one month prior to the derailment at Huntly. The wheel sets were retained on the wagon at that time.

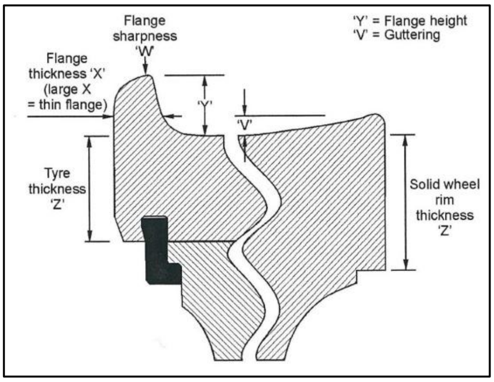

Figure 6
Profile of rail wheel tyre
(courtesy of KiwiRail)

3.2.6. The 2 wheel-bearings were removed and the 2 wheels were discarded after the wheel set was removed from the bogie. The axle was checked and, if in good condition, it could be overhauled for reuse.

3.2.7. Packaged wheel-bearings were supplied by 8 different manufacturers. Reliable in-service running required the continuous presence of a very thin lubricant film (measured in micro mm) between the roller bearings sandwiched between the inner and outer races (refer Figure 4).

3.2.8. The normal running temperature of wheel-bearings was between 30° and 55° Celsius. The continual running of the wheel-bearing at about 40° Celsius above normal running temperature started to degrade lubricant properties and, if undetected, would eventually lead to a "hot box" condition. A hot box is a colloquial industry term describing the overheating of a wheel-bearing. If a developing hot box is not discovered and the wagon continues running, it normally leads to a seizure, then potentially a "screwed" journal situation where the axle becomes separated, leading to a derailment.

3.2.9. The overheating of a wheel-bearing is generally a symptom of an internal defect such as excessive loading, brinelling, contamination, lubricant failure, corrosion, misalignment or loose or tight fits onto the wheel set.

Inspection

3.2.10. After a worn wheel set was removed from a bogie, maintenance staff in outlying depots or in Hutt workshops applied the following inspection criteria to determine whether the wheel-bearings could be reconditioned or should be discarded:

Part	Standard
External parts	No cracks, breaks or bends No evidence of fire or submersion
Outer race wear bands	Two full-width bands of no depth No visible impression of adaptor caused by the race's failure to move
End cap bolts	None visibly loose or missing
Locking plate	Present and intact with tabs bent over correctly
Backing ring	Not loose, i.e. cannot be moved by hand
Seals	Not loose, dented, damaged or out of position A seal that can be moved by hand with a probe is loose
Grease leakage	No newly leaked (wet) lumps of grease from bearings with blue painted end caps
Internal parts	No roughness or catches when the bearing is checked as follows: Push the cup in and rotate for at least 2 turns Pull cap out and rotate for at least 2 turns in the same direction as before Roll the wheel around one third of a turn if possible and repeat the 2 aforementioned procedures Roll wheel another third of a turn if possible in same direction and repeat aforementioned procedures
Lateral movement	In service standard: No more than 1/16th of an inch (1.6 mm) lateral movement when the cup is first pushed towards the wheel then pulled away from it Overhaul standard: Less than 0.025 inches lateral movement and bearing rotates freely when turned by hand
Vertical movement	No visible movement when the bearing is pushed up and down, one end at a time. Movement that can be felt but not seen is allowed

Overhaul

3.2.11. KiwiRail said that all inspection, gauging, repair, assembly and testing procedures used for the overhaul of wheel-bearings were in accordance with the Roller Bearing Manual, section H – part 2 issued by the Association of American Railroads on 1 February 2000.

3.2.12. Historically, the overhauling of wheel-bearings had been performed at Hutt workshops but from July 2006 the task was outsourced to Bearing Engineering Services Proprietary Limited, a specialised approved company in Sydney, Australia. From that date, reconditioned wheel-bearings returned to New Zealand could have previously been used in railway systems throughout South East Asia and Australia.

3.2.13. KiwiRail did not distinguish between a brand-new and an overhauled wheel-bearing, and both began 10-year lifespans (approximately) when fitted to a reconditioned axle to form a wheel set. Hutt workshops had retained the capability to fit reconditioned wheel-bearings to axles.

3.2.14. The following table shows the number of wheel-bearings that were inspected after withdrawal during a recent 3½ year period, and after inspection, the number of bearings that were either discarded or sent for overhaul:

Year	Number inspected	Number discarded	Number sent for overhaul	Percentage discarded
2007	3396	976	2420	29%
2008	3467	855	2612	25%
2009	2641	956	1685	36%
2010*	2532	1000	1532	39%

*up to 20 June 2010 only.

3.2.15. KiwiRail said it did not perform quality assurance sampling when the refurbished wheel-bearings were returned to New Zealand, because the overhaul of the bearings was conducted by a specialised approved company. There was, however, an ongoing trial to verify the performance of the overhauled bearings.

Inventory recording

3.2.16. In April 2008, United Group Rail Limited (UGL Rail) estimated that its automated maintenance database would hold records for about 50% of the wheel sets in service by about 2014. That percentage would increase to 95% by about 2017.

3.2.17. In April 2008, KiwiRail advised that it had about 4200 bogie (4-axle) freight wagons on its asset register, which meant that there were about 33 600 wheel-bearings in service plus a number cycling through overhaul and those held in inventory.

3.2.18. On 14 June 2010, KiwiRail advised that the quality of data recorded at Hutt workshops had been improved so that individual wheel-bearings were now recorded against individual axles to ensure component data for all wheel sets was recorded. This information was recorded in a database, supported by the retention of hard-copy check sheets completed by machine operators. The Maximo[3] system in which wagon maintenance records were held could not associate an axle with a wagon or inventory group. At that time KiwiRail was developing a replacement software-based maintenance system (referred to as SAP) that was planned to include:

- the recording of a unique identifier for each axle
- associating the axle to a wagon (including the positions of the 4 axles on each wagon) or inventory group
- changing the location of the axle in the event of wheel set change-outs, expired life etc.

3.2.19. It was not intended to enter individual bearing details in SAP, but this information was to be available at Hutt workshops and would include the same unique axle identifiers. This would enable more detailed analysis.

3.2.20. On 23 November 2010, KiwiRail advised that record keeping improvements had been introduced in 2005 to record specific bearing serial numbers to the “A” and “B” end of the axle. The axle also carries a serial number at each end so that in the event of a bearing failure, all information can be traced from the surviving end.

3.2.21. On 1 December 2010, KiwiRail advised that SAP was implemented into its business on 1 November 2010 allowing the tracking of wheel sets on wagons. It is planned to transfer the accumulated data held in Maximo to SAP early in 2011.

Historical data

3.2.22. During 2006, UGL Rail conducted a survey that examined the wheel-bearings on about 60% of Toll Rail’s wagon fleet covering a wide range of wagon classes. The survey found defects on 0.96% of the wheel sets examined. Seventy one percent of the defects were leaking grease and 25% loose backing rings.

3.2.23. Toll Rail’s internal Huntly derailment report dated November 2007 stated that of the 19 wheel-bearings that had suffered failures since the UGL Rail survey began, 8 had been subjected to the survey with no fault being detected. It added that in a review of 45 bearing failure incidents that had occurred between 1 July 2002 and 31 October 2007, twenty four of the failed bearings had successfully completed scheduled maintenance checks during the previous 2 month periods.

3.2.24. A further wheel-bearing survey, similar to that done in 2006, was undertaken in 2008. About 1000 bearings were surveyed, with 1.05% being faulted. Fifty-five percent of the defects were grease related and 40% backing ring related. The other 5% encompassed a number of other fault factors.

[3] An automated system with information databases detailing mechanical engineering assets and maintenance done.

3.2.25. The following table shows the number of wheel-bearing failures on running trains reported between 1 July 2002 and 11 March 2010. Each 12-month period spans 1 July to 30 June the following year, except for 2010, which covers to 11 March 2010 only. The inside column in the right-hand side of the table shows the total number of all running train derailments during the same 12-month periods.

12 month period	Wheel-bearing failures on running trains			All running train derailments	
	Yearly figure	Derailed no	Derailed yes	Yearly figure	% of wheel-bearing derailments against all derailments
2002/03	10	6	4	60	7
2003/04	6	3	3	63	5
2004/05	8	2	6	50	12
2005/06	5	2	3	41	7
2006/07	11	8	3	45	7
Wheel-bearing reconditioning responsibility outsourced to Australia in July 2006					
2007/08	11	4	7	32	22
2008/09	3	3	0	37	0
2009/10	1	0	1	30	3
Total	**55**	**28**	**27**	**358**	**7.5%**

Note: Two of the 4 wheel-bearing failures highlighted in red, and, all 10 of the wheel-bearing failures highlighted in yellow make up the 12 wheel-bearing failures covered in this report.

Train and wagon examination procedures

3.2.26. KiwiRail's mechanical code M2000, Issue 7, effective 1 April 2007, required all freight wagons to undergo at least a pre-departure check before leaving on a main line train, a B-check and a C-check. These checks were performed while a train/wagon was stationary and while the wheel-bearings were (mostly) cold.

3.2.27. On 5 June 2009, KiwiRail introduced new procedures detailing roll-by inspections that were to be conducted on moving trains. These new procedures are detailed in the "Safety actions" section.

3.2.28. The B-check covered safety-critical items and was performed when 2 or more brake blocks were changed or after an incident. The B-check was carried out by qualified maintenance personnel to set criteria.

3.2.29. The more detailed C-check was performed generally every 24 months, with an upper limit of 27 months. The C-check could be brought forward if a wagon had been involved in a derailment or collision or had a fault with braking. The C-check was carried out by qualified maintenance personnel to set criteria.

3.2.30. KiwiRail's Wagon and Container Inspection Manual M9209 required the following wheel-bearing components to be inspected during both the B- and C-checks:

Wheel-bearings	no sign of overheating
	cap bolts in place and secure
	backing rings secure
	no excessive grease leakage

Wheel-bearing quality assurance

3.2.31. The issue of wheel-bearing failures is one that the industry has been trying to address for a number of years. In 2001, the Commission received the following response from Tranz Rail in relation to an inquiry (report 01-102) involving a derailment and subsequent collision caused by a failed bearing:

> The vast majority of Tranz Rail's fleet of wagons run with "packaged type" tapered wheel-bearings on their axles. These bearings are overhauled at Tranz Rail's Hutt workshops during their lives, at intervals of four to ten years.
>
> In late 1997, two separate audits were carried out concerning overhaul processes at Hutt, which revealed that not all work was being performed to the required standard. The second audit was aimed at the overhaul of axle boxes rather than packaged bearings, although there are relevant aspects to both types. Specific problems found at the time included:
>
> - lack of formalised training of staff involved in the overhaul of bearings
> - failure to carry out checks to bolt hole threads, bearing components, and fitted bearings
> - inadequate procedures covering the overhaul of axle boxes and bearings
> - lack of measuring of axle journals
> - measurement of lubricant
> - general lack of in-depth knowledge amongst staff at that time.
>
> Training and technical input was immediately sought from Rolling Bearing Consultants for staff involved in the inspection and overhaul of wheel-bearings. Soon after, Tranz Rail's bearing supplier, FAG Australia Pty Ltd, conducted a two day in-house training course for the same staff. Supplier provided training has occurred every February at Hutt workshops and the standard has improved noticeably. Tranz Rail's present supplier, SKF New Zealand Ltd, have recently stated that work performed is to a good level of quality.
>
> In 1998 other work was then carried out to ensure field and depot staff were aware of correct inspection procedures and criteria for the removal from service of bearings. This was done with on-site training courses, with staff from every mechanical work centre attending. Follow up was made by issuing FAG training videos outlining proper field inspection.
>
> Hillside workshops fit bearings and qualify axle journals and staff have also had purpose designed, supplier provided training.
>
> A new procedure was implemented in M2000 whereby bearings which are suspected of leaking lubricant are cleaned and the cap marked with blue paint. This indicates to other mechanical staff the bearing has been examined and if leakage is found, the bearing should be removed from service.
>
> Documentation such as the Wheel set Manual and site procedures have been updated in accordance with updated AAR manuals.

3.2.32. In 2001 as part of its internal investigation into the same derailment, Tranz Rail commissioned SKF New Zealand Limited to evaluate the damaged bearing components. Tranz Rail said that the report contained the following comment:

> The failed bearing has suffered severe overheating due to spinning on its journal. The heat generated by the relative movement between the bearing cones (inner ring) and the journal has resulted in the lubricant failure followed by bearing seizure. This in turn has led to accelerated overheating of the journal, softening of the axle material, and eventual fracture of the axle.
>
> The wear and damage to the cone face indicates that the cone was loose on the journal. In this case inadequate fits and tolerances were the primary cause of failure.

3.2.33. Tranz Rail then commissioned SKF New Zealand Limited to carry out a specific audit of its wheel-bearing overhaul practices at Hutt workshops to determine if the practices and procedures then used by Tranz Rail when refurbishing axle boxes and packaged wheel-bearings resulted in a reliable product being returned to service.

3.2.34. The audit was carried out on 24 April 2001, and found all key processes were carried out competently. Tranz Rail said that the report included the following comments:

> The fitters involved with bearing refurbishment showed a high level of motivation and desire to achieve excellent results. They were familiar with the dimensional requirements of each assembly and showed the necessary skills to be able to accept or reject components based on the references provided

3.2.35. In August 2002, Tranz Rail contracted an Australian-based consultant to complete an external review of bearing failure issues. This review identified a range of corrective actions in relation to:

Bearing Overhaul:

- Facility improvement
- Tools and equipment
- Backing rings
- Seals and Seal Rings
- Lubricant

Bearing Mounting:

- Facility Improvement
- Tools and Equipment
- Components

Bogie Overhaul:

- Bogie and Side Frames
- Adaptors

Field Maintenance:

- Inventory
- Component Replacement
- Code Checks

Maintenance Manuals

Maintenance Records

Training

3.2.36. The Commission conducted inquiries into a series of 4 derailments caused by the failure of wheel-bearings during late 2004 and early 2005. During that inquiry Toll Rail confirmed that Alstom Transport New Zealand Limited (Alstom) and Toll Rail had "closed out" most of the corrective actions arising from the 2002 external review and that those remaining were nearing completion.

3.2.37. A subsequent internal review prepared by Alstom for Toll Rail was completed in June 2004. This review looked at derailment risk reduction options for wheel-bearings. It concluded that loose bearing components were likely a dominant cause of bearing failures. A number of options were identified:

- Retaining the existing maintenance regime for checking quality of clamp forces
- Introduce an "end cap bolt re-torque" procedure
- Accelerate bearing overhaul rates
- Wayside detection.

3.2.38. Toll Rail said that as a result of the Alstom review, the 66 OM class (which convey bulk milk) and 4 UCG class (which convey highly flammable bulk liquefied petroleum gas) wagons were presently undergoing "end cap bolt re-torque" tests. The decision to reduce the derailment risk on those classes of wagon was primarily influenced by the potential environmental and personal safety risks should they be involved in derailments.

3.2.39. Toll Rail said that it was reviewing remaining options. Toll Rail also said that its initial evaluation showed that those options all involved cost increases that outweighed the present costs/risks of wheel-bearing related failures. Toll Rail added that its review would consider if there were lower - cost intermediate steps that could be taken to reduce progressively the likelihood of these derailments and at the same time allow funding for higher priority safety initiatives.

3.2.40. On 7 December 2005, the Commission made 2 recommendations to the Chief Executive of Toll Rail. The first recommendation (110/05) was for Toll Rail to withdraw from service and investigate the braking systems of all wagons that exhibited an abnormally high incidence of brake-block burn-out. Toll Rail replied that this fitted in with its overall strategy to reduce wheel-bearing related derailments.

3.2.41. The second recommendation (111/05) was for Toll Rail to develop a system for recording and tracking both new and reconditioned key components used on bogies. Toll Rail agreed, but said it would take 10 years for the implementation to be complete, as bogies can have up to 10 years' life between overhauls.

3.2.42. In 2006, the overhaul and supply of wheel-bearings was outsourced to the Australian company referred to earlier in this report.

3.2.43. In June 2008, a mechanical engineer employed by UGL Rail at Hutt workshops produced a report titled "Wagon Axle Bearing Failure". The report looked at 12 wheel-bearing failures, of which 7 had resulted in bearings screwing off the journal.

3.2.44. The report said that there was an almost complete lack of traceability of the failed wheel-bearings and axles. Most of the axles did not have an identification number that related to code and only one axle record could be found. The report added that record-keeping had improved from around 2002 and all axle records from that date were being filed.

3.2.45. The report also said that the exact cause of a failed wheel-bearing leading to a screwed journal was complicated by the fact that such events normally resulted in a catastrophic mechanical failure of the bearing. Often the bearing disintegrated and the combined effects of heat and pressure could mask or obliterate signs that would otherwise have indicated the actual failure mode. The 12 failed bearings were assembled between 1987 and 2004. From available information, the ages of the bearings were determined as follows:

Year of manufacture	Number of bearings
2004	3
1999*	2
1997*	1
1987*	1
could not be determined	5

*The bearings dated 1999, 1997 and 1987 were nearing or had exceeded their nominal 10 year lifespans.

3.2.46. The report made 12 recommendations. In 2010, and in connection with this inquiry, KiwiRail said that all of the recommendations from the report had been implemented with the exception of the last 3. The 12 recommendations are listed as follows and, by exception, the reasons KiwiRail gave for not implementing the last 3 are included:

- A test to enable the evaluation of wheel-bearing rotating freely by hand when being assembled should be established
- Records of wheel-bearings fitted to axles should be recorded on the wheel set check sheet so a complete history of the wheel set axles and bearings can be maintained
- Wheel sets with tread defects should be tested as per mechanical code M2000
- Depots reporting wheel-bearing failures should record the wagon number and also the axle number
- Wheel sets that have derailed should be checked as per the wagon packaged wheel-bearing maintenance manual. Wheel sets that have been put back into service should also be marked in some way or orders created in Maximo so that they can be checked again at set periods to ensure they do not develop any faults
- Random measurement sampling of supplied axles should be undertaken to ensure suppliers' conformity to specification

- Ensure that wheel sets are stored, handled and transported correctly. It is recommended that wheel-bearings on wheel sets in storage be rotated several revolutions every 30 to 60 days to prevent corrosion. Wheel sets should be stored flange to flange, contact between wheel flange and bearing is to be avoided. Appropriate slings are to be used which don't damage the bearing, wheel seats or axle barrels. Forklift tines are not to come into contact with bearings, wheel seats or bearing assemblies
- Ensure the welding operators do not earth their welders through wheel-bearings
- An investigation into the grease leakage from wheel-bearings and how effective the present system is in controlling what condition the bearing is in.

  Not implemented; the acoustic bearing monitoring system project is the principal strategy to improve the monitoring of wheel-bearing condition.

- Wheel-bearings need to be checked for their age during normal checks and any found to exceed 10 years should be marked for overhaul

  Not implemented; it was not considered necessary because the average wheel set life is less than 10 years, and all wheel sets that are put back into service have either new or newly refurbished wheel-bearings fitted.

- Maximo has been used for tracking axles on wagons for about 18 months. The feasibility of using it to track wheel set components fitted to the axles should be investigated

  Not implemented; the new SAP system will be configured to track axles/wheel sets. It is not proposed to track wheel-bearings via SAP. Wheel set assembly records will be retained at the workshops.

Cost of damage

3.2.47. Ontrack[4] advised that the financial cost to restore the track to normal running order following derailments induced by wheel-bearing failure in 19 of the 28 incidents mentioned in the table in paragraph 3.2.26 was $870 380. However, Ontrack advised that the financial costs of 5 of the 19 incidents had yet to be finalised. Extrapolating the known costs, the average cost of each derailment was $45 809, which meant that across the 27 derailments the overall infrastructure costs would have been in the order of $1.28 million.

3.2.48. KiwiRail advised that individual financial costs for each derailment induced by wheel-bearing failure were not available, but its analysis showed that for the period between November 2004 and February 2008, the average financial cost was about $69 000 per derailment. Based on KiwiRail's analysis, the overall costs of the 27 derailments would have been in the order of $1.93 million.

2.2.45 Factoring in all the financial costs provided by both entities meant that for the 27 derailments induced by wheel-bearing failure, the total cost was in the order of $3.21 million. The period measured was when the rail industry was under Toll Rail ownership.

Development of automated systems to monitor wheel-bearings in service

3.2.49. During the 1960s, advancements in technology allowed railway systems in the United States of America (USA) to install a network of installations to detect wheel-bearings that were running hot. These installations recorded the temperatures of the wheel-bearings as they passed by. An alarm was generated to warn that a hot bearing had been detected and arrangements were made to stop the train.

3.2.50. While the detection system was adequate for the detection of hot wheel-bearings, it proved inadequate for the detection of bearings that were in the early stages of failure before they had begun to heat up. The time span from when a bearing had begun to heat up to its catastrophic failure was short and the network of detectors could miss the failure mechanics of a bearing because the failure could occur in the distance between the detectors.

3.2.51. From the time that the first wheel-bearings were installed, railway systems in the USA began looking for automated solutions to monitor the operational health of the bearings.

[4] Brand name of rail infrastructure owner, maintainer and access provider at the time.

3.2.52. The solution came in the form of detectors that listened to the audible acoustic emissions produced by wheel-bearings as trains passed. Using this method, the embryonic system was able to detect the more common flaws in bearings before they began to overheat and fail catastrophically. A prototype acoustic monitoring system was installed in the USA in the late 1980s and commercial installations became available from 1989. Evaluation work undertaken afterwards showed that about 85% of the flawed bearings detected by the acoustic monitoring systems had defects that would have had them condemned under the Association of American Railroad Standards.

3.2.53. Accident investigation organisations in Australia and Canada published accident reports throughout the 2000s that focused on wheel-bearing failures.

3.2.54. In one part of the Australian rail system, a recent network installation of 4 acoustic monitoring systems (with 3 more subsequently installed) had realised a 50% increase in the health of wheel-bearings in a 12-month period with a consequential 70% reduction in derailments related to failed bearings. In another part of Australia, 2 acoustic monitoring installations had seen a "significant" reduction of failed wheel-bearing incidents because of their ability to identify flawed bearings before they entered their final failure phase.

3.2.55. The Australian Transportation Safety Bureau said in a report dated March 2009, following a derailment of a freight train in Western Australia, that a number of detection and monitoring installations were used at key locations throughout the rail network with the intention of detecting failing wheel-bearings before they led to derailments. Acoustic bearing-monitoring systems provide a predictive method of monitoring by recording sound signatures emitted from each bearing travelling on a moving train. The collected data is collated and is used to determine wheel-bearing condition and to trend monitor every individual bearing that regularly passes the monitoring stations. It was found that catastrophic bearing failures had been "significantly" reduced since the introduction of acoustic monitoring systems (Australian Transport Safety Bureau, 2009).

3.2.56. The Transportation Safety Board of Canada said in a 2005 rail report that there had been 55 incidents of failed wheel-bearings, most resulting in derailments, in the 5-year period between 2000 and 2004. The report said that the continued growth in the installation and use of wayside technology such as acoustic bearing detectors had reduced the overall risk of derailment owing to bearing failures (Transportation Safety Board of Canada, 2005).

4. Analysis

4.1. In the absence of maintenance records, it was not possible to determine accurately the age of the failed wheel-bearing that caused the Huntly derailment, nor the other failed bearings in the subsequent 11 incidents, some of which also led to derailments as listed in this report. KiwiRail said that a general indication of the age of the bearings themselves could be obtained by measuring the wear or "Z" readings of the wheels. By the time a wheel-bearing had failed to the point where the bogie side-frame collapsed, or worst case, a derailment occurred, the destruction of the bearing made it almost impossible to determine why it had failed.

4.2. Wheel-bearings on bogies are a critical component because the failure of a single bearing can, and often does, result in a derailment of a train that could at the time be running at mainline speeds of up to 80 kilometres per hour.

4.3. Once a bearing begins to disintegrate, the wheel set begins to lose its symmetry with the bogie and track, and is at risk of derailing. If a failing bearing reaches the point of screwing off its journal, the derailment of that bogie is almost a certainty while the train remains in motion. In recent history there have been a number of wagon derailments, not all caused by failed wheel-bearings, that have gone unnoticed by the locomotive engineers, with the derailed wheel sets, bogies or wagons being dragged some distance until meeting with track geometry features such as facing turnouts. In this case the severity of the derailments is determined by the number and weight of the wagons coupled behind the already-derailed equipment.

4.4. Derailments represent a high risk to the rail industry, certainly with respect to damage to rolling stock and freight, and damage to the rail infrastructure. The other risk to consider is that to people and the environment.

4.5. In each of these derailments the damage to rolling stock, the freight being conveyed and track structures was significant, exacerbated by the fact that wagons behind already derailed wagons also derailed causing further substantial damage. This scenario continues until, at some point, the locomotive engineer detects the derailed wagon or the continuous automatic air brake system becomes separated, finally bringing the train to a stop.

4.6. Of all the derailments caused by bearing failures mentioned in this report, none resulted in injury. This can be attributed in part to the fact that none of the locomotives (in which the locomotive engineers were situated) was affected, and also because a high percentage of the rail corridor that traverses remote areas.

4.7. The consequences, however, could be high. Trains do travel across numerous level crossings and past station platforms throughout their journeys, and lengthy sections of the rail corridor are located adjacent to public highways, such as through the Huntly area. Fire from hot metal being discarded from disintegrating bearings has caused track-side fires in 2 incidents contained in this report.

4.8. The Huntly derailment resulted in loaded shipping containers spilling across the adjacent State Highway 1. Fortunately the derailment occurred late at night when highway traffic was negligible.

4.9. Information obtained from the rail participants indicated direct costs of about $115 000 each time there was a derailment. The Commission considers that these costs are conservative and do not reflect the real losses incurred, such as, the loss of revenue from train cancellations during periods of line closures, but this could not be substantiated owing to the lack of available data.

4.10. There is a high probability of derailments causing damage to rolling stock and track infrastructure, and there is a possibility of a derailment being of high consequence to people. Additionally, some areas alongside the rail corridor are at a greater risk from a fire initiated by a failed wheel-bearing because the land has high economic, environmental and cultural value. Given that wheel-bearing failures caused 7% to 8% (27 in total) of all mainline derailments in an 8-year period between 2002 and 2010, the Commission questions whether enough was done during this period to prevent them occurring.

4.11. The history of corrective actions taken by the industry in response to wheel-bearing-related derailments since 1997 does show recognition of the seriousness of the problem. The series of audits and reviews resulted in improvements to the quality assurance of bearing overhaul and fitment processes, and also the need to track the various components that make up a wheel set. The effect of any corrective action taken is hard to measure over a short period because of the long natural service life of the wheel-bearings. The spike in related derailments around 2007 and 2008 (refer to the table in paragraph 3.2.26), for example, is more likely related to some issue with processes in place a number of years earlier.

4.12. There are a number of reasons for a wheel-bearing failing in service: inadequate lubrication, inadequate overhaul standards, inadequate fitting practices, and possibly a link to wheel flats, to name a few. Not effectively tracking the components of a wheel set and the wagon to which it is fitted can result in bearings being left in service for longer than their normal service lives. Evidence of this was seen in the 2008 UGL Rail report referred to in paragraphs 3.2.44 to 3.2.47,where at least 4 of the failed bearings were nearing or had exceeded their nominal 10-year lifespans, and the ages of a further 5 bearings could not be determined.

4.13. The Commission has previously made a recommendation in report 06-110 to the Chief Executive of the NZ Transport Agency about enforcing within the rail industry the discipline of identifying and appropriately maintaining critical components of rolling stock and the rail infrastructure. This recommendation remained open at the time of publishing this report. In this case the industry has adopted the principle with respect to wheel-bearings, but Toll Rail's response to the 2002 internal review by Alstom, suggested that the real risk had not been fully realised, with the company opting for the easier and less expensive option of a "re-torque" procedure, and only for a relatively small percentage of the fleet.

4.14. In 2004, an acoustic bearing-monitoring system was put forward as an option, and the technology had been well proven in overseas railway systems. With so many possible reasons for the premature failure of wheel-bearings, and the short warning time between a bearing heating up and total failure, early detection of internal defects would seem the logical choice.

4.15. The enclosed arrangement of a packaged wheel-bearing made it impossible to inspect visually its internal moving parts without disassembly, which only generally occurred every 10 years corresponding with the overhaul of the wheel set due to wheel wear.

4.16. The static B- and C- check examinations were unlikely to detect the pending failure of a wheel-bearing. During a 5-year period in the mid-2000s about 50% of the wagons that suffered bearing failures had been checked within the 2 month period before the failures occurred.

4.17. With the advance of technology, modern systems are now readily available to monitor the health of wheel-bearings while they are in normal service. Not only is the technology able to listen for developing problems, it is able to do this in the early stages of possible failure and provide the operating company with advance warnings to enable the wagons concerned to be proactively programmed out of service for detailed examination of the bearings.

4.18. The installation of acoustic bearing-monitoring systems was raised in the Commission's report 04-130 when Toll Rail said in a letter dated 12 September 2005 that it had considered such a system as an option to reduce the derailment risk following wheel-bearing failures. Toll Rail again raised the matter of an acoustic bearing-monitoring system in the internal report (dated November 2007) into the Huntly derailment, when it said that a project reviewing the viability of installing such a system had been initiated.

4.19. Eight further wheel-bearing failures were notified to the Commission during the 5-month period following the Huntly derailment on 19 October 2007. As a result of this, the Commission issued an urgent recommendation to the Chief Executive of Land Transport New Zealand on 4 March 2008 to address the issue of installing an integrated acoustic bearing-monitoring system compatible with current overseas practice. This recommendation remained open at the time of publishing this report, but as commented in section 6, a project to install such a system at 3 key locations, where KiwiRail has identified the potential to record 90% of the wagon fleet every 3 months, is close to going operational.

4.20. The rail industry is likely to benefit from a reduction in the number of wheel-bearing-related derailments, as have other railway operations overseas, following the imminent commissioning of its acoustic bearing-monitoring system.

5. Findings

Findings are listed in order of development and not in order of priority.

5.1. Each of the 12 incidents was caused by the failure of a single wheel-bearing, but the cause of the failures could not be determined because of the catastrophic destruction of the bearings and because the lack of reliable maintenance records of the service life of the bearings preceding the derailments precluded meaningful inspection and analysis.

5.2. The various audits, reviews and incident investigations showed that it was possible for wheel-bearings to remain in service beyond what has been determined as a 10-year service life, based on typical wheel set wear rates.

5.3. The various audits, reviews and incident investigations showed that past inadequate standards in the practice of overhauling wheel-bearings and fitting them to axles, and the inadequate condition of tyre surfaces, could cause premature failure of the bearings.

5.4. The routine wagon inspection process was unlikely to detect developing faults within a wheel-bearing in time to prevent its catastrophic failure in service.

5.5. Trackside acoustic monitoring systems had been available as far back as the early 1990s. Had such a system been installed on the New Zealand rail network, the frequency of failed wheel-bearings while running on main line trains, of which some resulted in derailments, would have been significantly reduced, with a corresponding lower risk and financial cost to the industry.

6. Safety actions

General

6.1. The Commission classifies safety actions by two types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission that would otherwise have resulted in the Commission issuing a recommendation

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally have resulted in the Commission issuing a safety recommendation.

6.2. The following safety actions are not listed in any order of priority.

Roll-by inspections

6.3. On 5 June 2009, KiwiRail introduced new rail operating code procedures explaining the requirement to conduct roll-by train inspections in addition to the static wagon inspection procedures. The procedures, which amended section 5.3, train marshalling, build and inspection procedures, said in part:

> **6.10 Roll-by train inspections** (new instruction)
>
> A roll-by train inspection is intended to detect rail vehicle irregularities that are not so apparent when the vehicles are stationary. Undetected these irregularities could result in a derailment or injury to rail personnel or the public.
>
> Potential irregularities include:
>
> - Wheel-bearings – loose backing rings/hot bearings
>
> **Note**: The roll-by inspection is **additional** to the required stationary train inspection. It cannot be used to replace the stationary inspection.
>
> **6.10.1 Terminal roll-by (procedure)**
>
> Roll-by train inspections <u>must be</u> undertaken for all train departing terminals.
>
> The speed of the train must not exceed 25 km/h during roll-by inspection.
>
> - The person completing the roll-by inspection must undertake the inspection from a position where faults can be detected visually, audibly and by smell.
> - When the roll-by inspection is complete the person undertaking the inspection must confirm this to the locomotive engineer by radio communication.
> - Should a fault/hazard be observed that requires immediate attention, the locomotive engineer is to be requested to stop the train pending remedial action, or further detailed inspection.
>
> **6.10.2 Mainline roll-by (procedure)**
>
> The requirements of Ontrack rail operating rule 6 (a) apply with the following additional requirements:
>
> - In the case of the person undertaking the inspection being the locomotive of a sidetracked train, the inspection may be undertaken from the locomotive cab.

6.4. KiwiRail added that the standing procedure was to remove from service the wheel sets that had been detected with irregularities, included suspected wheel-bearings following a roll-by inspection.

Roll-by inspection results

6.5. KiwiRail monitored the introduction of the roll-by inspections and the following results were achieved during 2009 at the following terminals:

- Palmerston North – 33 wheel sets removed
- Other terminals – 7 wheel sets removed

6.6. The faults normally seen on the wheel-bearings during these inspections were either loose backing rings or leaking grease.

Wheel set "turn" procedure improvements

6.7. On 23 November 2010, KiwiRail advised that it has introduced a procedure that requires the mandatory replacement of all wheel-bearings, regardless or present condition, on all wheel sets returned to Hutt workshops as a consequence of any fault or incident such as a derailment, serious wheel flat or overheated bearing.

6.8. All the removed wheel-bearings are sent to the Australian based contractor who holds the responsibility to decide whether to discard or recondition the bearing. The minimal standards that KiwiRail has set for the reconditioning of wheel-bearings was as follows:

Wheel-bearing part	Association of American Railroads (AAR) minimum standard	KiwiRail minimum standard
Cap screw	Used	new
End caps	AAR minimum standard	AAR minimum standard
Cone face wear	maximum allowed .005 inch	no face wear allowed
Outboard cone ID	.0005 inch over OEM spec	OEM specification
Cone raceway spalling	Maximum of 6 per raceway. Not to exceed ⅜ inch	no spalling allowed
Cup raceway spalling	Maximum of 6 per raceway. Not to exceed ⅜ inch	no spalling allowed
Cup & cone raceway brinells	Not to exceed half the length of the raceway with maximum width 5/32 inch	no brinelling allowed
Other cup & cone raceway defects	Peeling, smearing and water etching acceptable after polishing. Frag indentation allowed after subjective inspection.	Peeling, smearing and water etching acceptable after polishing. Frag indentation allowed after removal of high spots
Cup and cone age limit	None	None
Seal type	Standard radial lip	HDL where possible otherwise standard lip
Grease	AAR minimum standard	Timken premium
Inboard wear ring	AAR minimum standard	AAR minimum standard
Mounted lateral	.000 inch to .015 inch	.000 inch to .010 inch
Allowable bearing brands	All	All

Acoustic bearing monitoring system installation

6.9. On 14 June 2010, KiwiRail advised that the acoustic bearing-monitoring system is designed to intercept defective wheel-bearings well in advance of final failure. This will considerably increase the opportunity to examine bearings that have defects as they are less likely to be damaged to the extent that determination of cause is compromised.

6.10. The supporting system will provide for the 3 individual sites to capture and store data on wheel-bearing condition. That data will be transferred to a central system and database. This will enable trend analysis and will also generate alerts where thresholds are exceeded. Alerts where immediate action is required will be sent to train control and in other cases they will be sent to the appropriate engineering teams.

6.11. On 12 November 2010, KiwiRail said that progress towards the installation and commissioning of the 3 combined coupled-in-motion weighbridge and acoustic bearing monitoring system sites was as follows:

Site	Date installed	Comment
Tauranga	December 2010	
Bunnythorpe (near Palmerston North)	December 2010	
Rolleston (near Christchurch)	completed	Site requires recalibration following the Canterbury earthquake in September

The installation cost of the 3 acoustic bearing monitoring sites was $1.8 million.

6.12. The system that supported the 3 sites was tested on the equipment supplier's server in Adelaide, Australia. This arrangement was transferred to KiwiRail's test server in Wellington in July 2010 and was commissioned in August 2010.

6.13. The system relies on every wagon in KiwiRail's fleet being fitted with an identification tag, and a process is underway to fit a tag to each wagon. About 65% of the wagon fleet had been tagged as at November 2010, with the remainder earmarked for tagging as soon as possible.

6.14. KiwiRail said that after the Rolleston site was first activated, the first alert was received on 20 May 2010 and the offending wheel set was taken out or service. Since that date, a further 17 wheel sets have been removed from service and most were opened and inspected to verify the failure mode the acoustic bearing-monitoring system had detected. KiwiRail added that the wheel condition detected by the wheel impact system had shown that in general, the wheel condition was comparatively good and the condition of the captive South Island coal wagon fleet was excellent.

7. Recommendation

General

6.1. The Commission may issue, or give notice of recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, an urgent recommendation was issued to Land Transport New Zealand (now NZ Transport Agency).

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

Recommendation

6.3. On 4 March 2008 the following recommendation was made to the Chief Executive of Land Transport New Zealand that:

> The Commission considers it is a safety issue that the New Zealand rail network is not equipped with an integrated acoustic bearing monitoring system compatible with current international practice. The Commission recommends the Chief Executive of Land Transport NZ urgently addresses this safety issue. (008/08)

6.4. On 19 March 2008, the Chief Executive of Land Transport New Zealand replied as follows:

> Thank you for a copy of the Final Safety Recommendation 008/08 relating to the above incident.
>
> As discussed with TAIC staff, and representatives of Toll NZ and ONTRACK, at a meeting held on 25 February 2008 at TAIC's offices, the implementation is contingent on Toll NZ receiving purchase approval from its Board of Directors.
>
> We are therefore unable to provide a definitive date by which this recommendation will be implemented. However, we will be closely monitoring the situation and will keep TAIC informed of progress.

Further recommendations

6.5. There have been no further recommendations issued.

8. Works cited

UGL Wagon Axle Bearing Failure Report by J Finlayson, June 2008.

KiwiRail's M2000 Mechanical Code, 1 April 2007.

KiwiRail's M6000 Wheel Set Manual, 9 October 2000.

KiwiRail's M9209 Wagon and Container Inspection Manual.

Toll Rail/Ontrack joint investigation report, Mainline Operations Derailment: Toll Freight Train MP7 Derailed at 577.390 km NIMT, Between Te Kauwhata and Kimihia Junction, Friday 19 October 2007.

KiwiRail's draft Packaged Roll Bearing Overhaul Specification, undated but received by the Commission on 16 August 2010.

Transport Accident Investigation Commission report 01-102, express freight Trains 237 and 144, derailment and collision on double-line track, Paerata-Pukekohe, 23 February 2001, published 31 October 2001.

Transport Accident Investigation Commission report 04-130, express freight train derailments due to axle bearing failures, various locations, 5 November 2004 and 21 March 2005, published 16 December 2005.

Australian Transport Safety Bureau report RO-2008-002, derailment of Freight Train 6MP9 near Hines Hill, Western Australia, published March 2009.

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Neural pattern identification of railroad wheel-bearing faults from bearing acoustic signals; Comparison of FFT, CWT and DWT features. Choe, Wan & Chan: CWI Technologies and Department of Electrical Engineering, Texas A&M University, College Station, TX 77845. 1996 approximately.

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

09-103	Passenger Train 1608, collision with slip and derailment, Tunnel 1, Wairarapa Line, Maymorn, 23 July 2009 (incorporating investigation 08-106, collision with slip and derailment on the Johnsonville Line)
09-101	(Incorporating 08-105): express freight train derailments owing to the failure of bogie side frames, various locations on the North Island Main Trunk, between 21 June 2008 and 7 May 2009
07-105	Push/pull passenger train sets overrunning platforms, various stations within the Auckland suburban rail network, between 9 June 2006 and 10 April 2007
08-110	Train control operating irregularity, leading to potential low-speed, head-on collision, Amokura, 23 September 2008
08-101	Express freight train 923, level crossing collision and resultant derailment, Orari, 14 March 2008
06-111	Express freight Train 237, derailment, Utiku, 20 October 2006
08-113	empty push/pull passenger Train 5250, collision with platform-end stop block, Britomart station, Auckland, 19 December 2008
08-103	Passenger Train 6294, electrical fire and collapse of overhead traction line, Mana station, Wellington, 18 April 2008
08-108	Express freight Train 845, track warrant overrun, Reefton - Cronadun, 13 August 2008
07-103	Passenger express Train 200, collision with stationary passenger express Train 201, National Park, 21 March 2007
07-115	Express freight Train 533, derailment, 103.848 kilometres, near Tokirima, Stratford – Okahukura Line, 7 November 2007
06-106	Express freight Train 826, signalling irregularity, Cora Lynn, 31 July 2006
07-108	Express freight Train 720, track warrant overrun at Seddon, Main North Line, 12 May 2007

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