Axle Bearing NIR Investigation
Final Report
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C Cork
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RSSB

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Executive Summary

Between January and June 2014 there have been eleven NIRs raised relating to axle bearings. The RISAS Board has been in discussions with ATOC, FTC and the BSI RAE/3/-/2 UK Bearing Group and commissioned RSSB to carry out an investigation into the high number of NIRs with the aim of identifying the underlying causes, reducing the likelihood of recurrence and the consequences of any local actions. Seven of the eleven NIRs were related to RISAS approved suppliers.

Meetings were held with the originators of the NIRs, the suppliers of the wheelsets in question and the RISABs involved where applicable. The immediate and underlying causes were determined along with any contributory factors. The actions taken to reduce the likelihood of reoccurrence were also identified.

The eleven NIRs were classified against ten Incident Factors and six Human Error causes with the aid of a Human Factors specialist. The majority of the causes were identified as being due to ‘Practices and Processes’ with eight of the eleven given this Incident Factor. Six of the eleven NIRs were further classified as being directly due to Human Error. Two NIRs are still under investigation and appear to be design and operational related.

Recommendations have been made covering design and workshop practice on secondary locking of axle end cap bolts, human factors development on definitions associated with workshop practice, as well as reducing errors during axlebox assembly and review of risks from intermediate attention to axleboxes. In addition, the guidance note on training of staff associated with axlebox work should be updated with human factors issues becoming part of the training and assessment requirements. A review of the NIR On-Line standard GE/RT8250 has also been recommended concerning the competence requirements for those carrying out incident investigations.

Recommendations have also been made about potential amendments to the RISAS Scheme, which should be expanded to include a section on Organisational Culture and Human Factors, improved data availability for wheelset incidents and improvements to the NIR on-line process. A review of the RISAS Assessment report content and structure has also been recommended.

Whilst none of these recommendations can guarantee to significantly reduce the possibility of further wheelset incidents, each will bring about an incremental improvement in the processes involved and, together, reduce the overall likelihood of further incidents occurring.
Revision Record

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<th>Author</th>
<th>Key updates</th>
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<td>M Osman</td>
<td>Initial report</td>
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<td>- Human Factors Checklist Definitions added</td>
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<td>Aug 2014</td>
<td>M Osman, C Bryan</td>
<td>- First draft of Final report</td>
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1 Introduction

This report details the findings of the investigation into eleven bearing related NIR’s raised between January and June 2014. The investigation was started in May when nine axle bearing related NIRs had been raised. During the investigation, two further axle bearing related NIRs were raised, one in May and one in June. The investigation was carried out to a remit agreed between RSSB, ATOC Engineering Council, FTC and the RISAS Board. It was led by Martin Osman, supported by Colin Bryan, with additional support from John Barber, Ken Timmis, Mick James, Huw Gibson and Cliff Cork from RSSB.

The base details of the eleven NIRs investigated in this report are shown in table 1. A more detailed table is included as Appendix A.

Table 1: List of the eleven NIRs investigated in this report

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Vehicle</th>
<th>Raised by</th>
<th>Title</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>2986</td>
<td>16-Jan</td>
<td>377</td>
<td>Southern</td>
<td>Dave Hickson</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Axle bearing contamination</td>
<td>Bombardier Siegen</td>
</tr>
<tr>
<td>2995</td>
<td>31-Jan</td>
<td>377</td>
<td>Southern</td>
<td>Dave Hickson</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Incorrect assembly of axle end equipment</td>
<td>Bombardier Siegen</td>
</tr>
<tr>
<td>2996</td>
<td>06-Feb</td>
<td>JNA</td>
<td>GE Capital Rail Services</td>
<td>Les Bryant</td>
<td>Loose bearing end cap bolt</td>
</tr>
<tr>
<td>2998</td>
<td>04-Feb</td>
<td>180</td>
<td>First Hull Trains</td>
<td>Jon Plowright</td>
<td>Axle bearing failures</td>
</tr>
<tr>
<td>2999</td>
<td>11-Feb</td>
<td>43</td>
<td>East Midlands Trains</td>
<td>Nigel Yule</td>
<td>Axle bearing end cap defective retaining bolts</td>
</tr>
<tr>
<td>3000</td>
<td>19-Feb</td>
<td>JNA</td>
<td>GE Capital Rail Services</td>
<td>Les Bryant</td>
<td>Multiple bearing failure</td>
</tr>
<tr>
<td>3001</td>
<td>21-Feb</td>
<td>377</td>
<td>Southern</td>
<td>Dave Hickson</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Catastrophic failure of axle end earth assembly leading to axle bearing disintegration</td>
<td>Bombardier Crewe</td>
</tr>
<tr>
<td>3011</td>
<td>14-Mar</td>
<td>TEA</td>
<td>GE Capital Rail Services</td>
<td>Les Bryant</td>
<td>TF25 axle journal incorrect finish</td>
</tr>
<tr>
<td>3021</td>
<td>05-Apr</td>
<td>Mk3</td>
<td>ECML</td>
<td>Keith Mack</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Detached BT10 bogie WSP axle end distance piece</td>
<td>Unipart Rail</td>
</tr>
<tr>
<td>3041</td>
<td>16-May</td>
<td>185</td>
<td>First / Keolis</td>
<td>Eddie Knorn</td>
<td>Axle end earth disc fitted back to front</td>
</tr>
<tr>
<td>3054</td>
<td>19-Jun</td>
<td>Mk3</td>
<td>Cross country</td>
<td>Stuart Rawlings</td>
<td>BT10 Bogie WSP axle end distance piece and cover detached</td>
</tr>
</tbody>
</table>

Note: The titles given to the NIRs can sometimes prove to be misleading once the underlying cause has been determined. For example, the term ‘bearing failure’ is the consequence rather than the cause.
2 Background

At their February 2014 meeting the BSI RAE/3/-/2 UK Bearing Group expressed concern over the high number of bearing related problems being experienced by industry and reported by NIRs in a short period of time. These concerns were brought to the attention of ATOC, FTC and RSSB in a letter by the Chair of BSI RAE/3/-/2 panel (see Appendix B). Between January and June 2014 eleven axle bearing related NIRs have been raised, seven of which involve RISAS approved suppliers. In accordance with RISAS Scheme rules, each incident has been reviewed by the certifying RISAB.

RSSB brought the concerns expressed in the letter to the attention of the RISAS Board (Chair). As a result of the discussions and to inform debate at the RISAS Board meeting, some high level analysis of axle bearing related NIRs issued over the previous two years was carried out by RSSB. The purpose of the analysis was to determine what could be established from a review of the NIRs, including whether RISAS approved suppliers were involved and whether any learning points could be identified.

To establish whether there was a rising trend in axle bearing related issues and to some extent check the outcome of the NIR analysis, a separate analysis of SMIS, European and International data was carried out by RSSB. The combined results of the analysis was summarised in a paper submitted to and discussed by the RISAS Board during its meeting of the 18th March 2014 (see Appendix C).

The outcome of the discussion at the RISAS board meeting was to develop a remit in conjunction with ATOC and FTC, to carry out a special topic exercise, to understand more fully the bearing related NIRs with a view to making recommendations for change.

The remit agreed for the investigation was to:

"Investigate axle bearing related NIRs issued since January 2014 to establish immediate, underlying and any contributory causes and make recommendations for improvements to address the likelihood of recurrence and the consequences of any local actions".

3 Approach

The approach taken was to meet with each of the NIR originators to understand why each NIR was raised and what the initial immediate and underlying causes were. The purpose of the meetings was to understand the progress of the incident, from initiation and investigation through to resolution and prevention in the future, as well as understanding what mitigation had been put in place. There was no intention to attempt to repeat the investigations that had been carried out, not least because some of the NIRs were several months old.

Meetings were then held with the wheelset suppliers / overhaulers involved to understand the incident from their point of view and to determine the immediate cause, the underlying cause, any contributory factors and the actions being put in place to reduce the likelihood of it occurring again. Finally, discussions were held with three RISABs which had certificated suppliers who had had NIRs raised against them, to ascertain what monitoring they had done and whether they considered that there should be any changes to the approach taken under RISAS.

During the meetings the opportunity was also taken to obtain views and feedback on the NIR On-line process and on the RISAS scheme.
All of the parties were supportive of the investigation and were very open in their discussions. The contact details of all the meeting participants are included in Appendix D.

Discussions were also held with Huw Gibson, from RSSB to confirm the Human Factors classifications and with John Reddyhof from Eversholt Rail for his expert knowledge of wheelset related issues. John raised a series of questions regarding the scope of RISAS and these are set out in section 8 of this report.

## 4 Findings

The detailed findings on each NIR have been included in Appendix E, with a separate section for each NIR, describing the immediate cause, underlying causes (where determined) any contributory factors and a Human Factors classification if applicable. The actions taken to reduce the likelihood of reoccurrence were also identified along with a timeline of the events.

In this section the findings have been aggregated to establish what trends could be identified across more than one NIR and what aspects of the activities associated with bearings and axleboxes needed to be improved to reduce the risk of failure. In all cases there was evidence of a detailed investigation by the supplier into the incident. In two cases, 2998 and 3001, the investigations had not been completed so concluding reports had not been raised. The findings to date have been shared with the investigation team.

The main overall finding was that in every case the bearing had failed or was at risk of failure as a result of some external influence. There was no evidence of any problem with the bearing units themselves, but found to be related to installation and assembly of associated equipment. For 2998, the failure was due to high impact loading, as the wheels were out of round, but no cause for this has yet been established.

Table 2 summarises the various causes of the failures. Section 6 covers the Human Factors issues and classifications in more detail.
Table 2: Summary of NIR Causes

<table>
<thead>
<tr>
<th>NIR</th>
<th>Title</th>
<th>Immediate Cause</th>
<th>Underlying Cause</th>
<th>Contributory Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>2986</td>
<td>Axle bearing contamination</td>
<td>O ring seal damaged allowing water ingress</td>
<td>Incorrect fitting on assembly</td>
<td>Possible bogie storage issues increasing risk of water ingress</td>
</tr>
<tr>
<td>2995</td>
<td>Incorrect assembly of axle end equipment</td>
<td>Tab washers not tabbed up</td>
<td>Learning curve for operator, procedure missed</td>
<td>First ever assembly of this type of axle end equipment</td>
</tr>
<tr>
<td>2996</td>
<td>Loose bearing end cap bolt</td>
<td>Tab washers not tabbed up</td>
<td>Operator forgot to complete the procedure</td>
<td>Documentation supplied not complete</td>
</tr>
<tr>
<td>2998</td>
<td>Axle bearing failures</td>
<td>Excessive vertical load due to wheel wearing out-of-round</td>
<td>Uneven wheel tread wear on same axle - investigations still proceeding</td>
<td></td>
</tr>
<tr>
<td>2999</td>
<td>Axle bearing end cap defective retaining bolts</td>
<td>End cap bolts being over-tightened</td>
<td>Design parameters and process control</td>
<td>Bolts at lower end of strength requirements</td>
</tr>
<tr>
<td>3000</td>
<td>Multiple bearing failures</td>
<td>End caps missing</td>
<td>Documentation signed off to say complete and inspected when task had not been done</td>
<td>Shop floor supervision and cultural issues</td>
</tr>
<tr>
<td>3001</td>
<td>Axle end earth assembly failure</td>
<td>Interference between rotating components within axle end assembly</td>
<td>Assembly process not well understood. Distortion of components during torque tightening,</td>
<td></td>
</tr>
<tr>
<td>3011</td>
<td>TF25 Axle journal incorrect finish</td>
<td>Grinding machine malfunctioned during machining</td>
<td>Specification incorrect - Operator checked surface measurements but did not identify a failure</td>
<td>Operator observed defect but did not react in correct manner</td>
</tr>
<tr>
<td>3021</td>
<td>Detached BT10 Bogie WSP axle end distance piece</td>
<td>Retaining bolts came loose</td>
<td>Design - Relaxation of neoprene gasket led to loss of pre-load.</td>
<td>Incorrect specification</td>
</tr>
<tr>
<td>3041</td>
<td>Axle end earthing disc fitted back to front</td>
<td>Earthing disc fitted wrong way round</td>
<td>Assembly instructions not sufficiently clear</td>
<td>Design enables earthing disc to be fitted in incorrect orientation</td>
</tr>
<tr>
<td>3054</td>
<td>BT10 bogie WSP axle end distance piece and cover detached</td>
<td>Retaining bolts came loose</td>
<td>Design - Relaxation of neoprene gasket led to loss of pre-load.</td>
<td>Incorrect specification</td>
</tr>
</tbody>
</table>

Nine of the eleven NIR’s had causes associated with the assembly of equipment fitted to the axle or axlebox once the bearing had been located, including two cases each of:

- tab washers not applied correctly (2995, 2996)
- axle end caps not fitted / bolt issues (2999, 3000)
- axle end earth equipment not fitted correctly (3001, 3041)
- axlebox bolted assembly coming loose (3021, 3054)

The others were:

- one case of damaging an O-ring (2986)
- one due to vertical loading on bearings (2998)
- one due to axle journal manufacture (3011)

The investigations have shown that bolts which have come loose on 3021 and 3054 showed evidence of being torque tightened, although it was not possible to determine if the correct value was reached on each bolt.
5 Assembly Processes Review

The majority of the issues relate to the assembly process for the axle end equipment and axlebox itself, including distance pieces, end caps and earth return equipment. The processes involved relate to correct seating of O-rings, torque tightening of bolts and locking of these bolts, by tab washers.

Correct seating of O-rings and gaskets is under the control of the artisan doing the work. This is covered by competence assessments and also by tool box briefings on the risks associated with water or other material ingress into bearings.

As a result of the suppliers' investigations there have been a number of changes to torque tightening methodology. The practice at some sites whereby the bolts are torqued to a specific value and then tightened further to accommodate the tab washer has been shown to introduce risk including necking of the bolt. Other sites remove a bolt if it doesn’t line up and try a second, which, anecdotally, has been found to be effective. The original bolt has been put back into the stock bins for re-use. It is recommended that this process, rather than over tightening the bolts to achieve the correct head alignment, be considered by all suppliers. **Note:** It is imperative that all returned bolts are not damaged and are put back in the correct stock bins.

The practice of using tab washers in these cases has been shown to create some difficulty in the assembly process, both with the alignment of bolts and with the artisan’s ability to gain access to tab up. Chisel damage on end caps was evident.

At one of the meetings, it was stated that some German manufacturers do not use tab washers but a separate serrated locking washer. Such a change, if introduced at overhaul, could eliminate the need to over-torque bolts, remove the need to use a chisel within the confines of an axlebox and would also remove the risk of forgetting to tab over the tabs, all three considered to be beneficial changes. However, the issue of secondary locking of bolts is a design issue and the appropriate method needs to be determined at the design stage and be accompanied with detailed procedures of how to implement it effectively. Issues with certain end cap designs, requiring relatively low torque values to prevent deformation, may prevent certain alternative solutions being adopted.

It is recommended that a feasibility study be undertaken to establish what other alternative approaches to secondary locking could be used, which could reduce the risk of human error.

6 Human Factors

Once the investigation team had concluded its interviews with the suppliers it discussed its findings with Huw Gibson, from RSSB’s Human Factors team. The discussion centred on the 10 Incident Factors and 6 Human Error and Violations factors described in the draft Human Factors Investigation Checklist, produced by RSSB (consistent with the classifications used by Network Rail). The Incident Factors and Human Error definitions are given in two tables in Appendix F. The definitions for these Incident Factors in the draft document have been based on operational considerations and it was felt that for at least two elements, Information and Equipment, the existing definitions did not transfer effectively into a workshop environment, particularly as all the activity was being carried out on equipment.
It is recommended that some additional work be undertaken to support the use of these Incident factors within workshops and depots by developing definitions which are relevant to the processes undertaken in these environments.

Tables 3 and 4 give details for each NIR of the Human Factors involved. The reasoning behind each classification is given in the detailed report of each individual NIR which are included in Appendix E.

Table 3 covers the Incident Factors. The category ‘Information’ has not been used, and any issue with specifications has been classified as ‘Practices and Processes’. The category ‘Supervision and Management’ also covers cultural issues within the organisation. In addition ‘Equipment’ has only been identified where equipment used in the processes has been shown to be a contributory cause.

Analysis of the findings arising from the investigations established that 4 of the 10 Incident Factor categories covered all of the NIRs, with the other 6 Factors not being identified as the cause for any of the NIRs. The ‘Practices and Processes’ category was clearly the main contributor with 8 of the 11 NIRs having this as the cause, although 3 of the 8 had more than 1 factor assigned to the cause. As can be seen from table 3 only one of the eleven NIRs (2998) has not been classified with a Human Factors Incident Factor and this is due to the cause of the out-of-round wheel wear still being under investigation.
The frequency of the Incident Factors are displayed visually in Fig 1.

![Incident Factors](image)

**Fig 1:** Incident Factor classifications for 10 of the 11 NIRs

<table>
<thead>
<tr>
<th>NIR</th>
<th>Brief Description</th>
<th>Practices and Processes</th>
<th>Knowledge Skills and Experience</th>
<th>Supervision and Management</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2986</td>
<td>Axle bearing contamination</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2995</td>
<td>Incorrect assembly axle end equipment</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2996</td>
<td>Loose bearing end cap bolt</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2998</td>
<td>Axle bearing failure</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2999</td>
<td>Axle bearing end cap defective retaining bolts</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td>Multiple bearing failures</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3001</td>
<td>Axle end earth assembly failure</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3011</td>
<td>Axle journal incorrect finish</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3021</td>
<td>Detached distance piece</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3041</td>
<td>Incorrect fitting axle end earthing disc</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3054</td>
<td>Detached distance piece</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
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<td></td>
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<td></td>
<td><strong>8</strong></td>
<td><strong>2</strong></td>
<td><strong>2</strong></td>
<td><strong>1</strong></td>
<td></td>
</tr>
</tbody>
</table>
The frequency of the Human Factors classifications are displayed visually in Fig 2.

![Human Error Classifications](image)

**Fig 2:** Human Error classifications for 6 of the 11 NIRs

**Table 4:** Frequency of Human Errors and Violations

<table>
<thead>
<tr>
<th>NIR</th>
<th>Brief Description</th>
<th>Memory Lapse</th>
<th>Action Slip</th>
<th>RoutineViolation</th>
<th>Decision Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>2986</td>
<td>Axle bearing contamination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2995</td>
<td>Incorrect assembly axle end equipment</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>2996</td>
<td>Loose bearing end cap bolt</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2998</td>
<td>Axle bearing failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2999</td>
<td>Axle bearing end cap defective retaining bolts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td>Missing end caps</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3001</td>
<td>Axle end earth assembly failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3011</td>
<td>Axle journal incorrect finish</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3021</td>
<td>Detached distance piece</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3041</td>
<td>Incorrect fitting axle end earthing disc</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3054</td>
<td>Detached distance piece</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Totals**

|                | 2 | 1 | 1 | 3 |

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Table 4 highlights that 6 of the 11 NIRs have been classified as being due to Human Error, with half of them being due to Decision Errors of the operatives such as fitting components the wrong way around or accepting components that should have been rejected. Memory Lapse was put down to 2 incidents and some classifications were hard to make a decision on as they could have been classified as a Decision Error or a Memory Lapse but there was not enough information on the individual’s state of mind (at the time of the action taking place) to know which classification was more suitable. The Routine Violation relates to an Inspector signing to confirm that he had inspected the end caps being fitted even though he later admitted he had not.

The investigation team has reviewed the likely events leading to the failure causing NIR 3000. The default classification is that the fitter had a Memory Lapse and forgot to fit all the end caps on the 3 wheelsets and then signed the paperwork. One credible possibility, rather than the fitter just forgetting to fit the end caps on all the wheelsets he was working on, was for the wheelsets to be moved out of the production line to be completed at a later date, but once the dust covers had been fitted it was not possible to determine that the end caps had not been fitted, even though the paperwork had been signed. If in reality this scenario occurred then it would not be classified as a Memory Lapse and it would be a Practices and Processes issue.

In addition to the review of these NIR’s, report T774, *Research investigating the value, reliability and effectiveness of axle inspection techniques Human factors - detailed guidance*, which had recently been published, was also discussed. Chapter 14 of this report identifies the human factors issues associated with axle end equipment and concludes, following a discussion with operatives and a HAZOP of the operation;

“Based on the HAZOP assessment, there is not a single solution to managing human error in the axle end re-assembly task.”

Appendix D.2 of the same report identifies a task analysis for this work and details the complexity of the operations.

Additional research work as part of T774 is currently being considered, to determine if there is less risk to the industry from NOT carrying out intermediate NDT. As the axle end equipment and end caps often have to be completely removed, this introduces an additional risk of incorrect assembly when being put back together.
7. NIR On-Line

During the course of the investigation, each party was asked their opinion of the NIR On-Line process set out in the Railway Group Standard, GE/RT8250 Reporting High Risk Defects. All felt that it was a necessary and useful system, although there were a number of differing views about whether all the NIRs being investigated should have been raised as NIRs.

Two instances where participants expressed concerns were NIR 3011, ‘TF25 axle journal incorrect finish’, which was identified during the wheelset assembly process, so was perceived by some as not presenting a risk to the industry, and NIR 3054, ‘BT10 bogie WSP axle end distance piece and cover detached’ where the retaining bolts loosened, identified exactly the same risk as 3021. However, in this case, it was suggested that industry would not have been aware of the second problem, if it had not been raised as an NIR. This lack of visible data is discussed further below.

During the investigation, it became apparent that information supplied in one NIR, relating to debris in bolt holes, was incorrect, but this had never been corrected in any of the interim or concluding update reports.

There was a general acceptance that NIRs should not be concluded until the underlying cause of the NIR had been resolved and then published. This was not the interpretation of one originator, who interpreted the closure option as appropriate if he had informed industry of the risk, rather than the underlying cause of the risk.

A number of participants, not just suppliers, used the term “name and shame” or “used to beat the supplier” with regard to NIRs they had seen, where suppliers were mentioned, and felt this was not an appropriate use for the process. If suppliers were mentioned by name, and this was not always the case, their reputation was damaged. This was inevitable, but it was felt that suppliers were blamed too quickly. Of the eleven NIRs reviewed, it was claimed that five had contributory causes from the customer’s specification and one where it was concluded that there was no supplier error.

One supplier advised that they would like there to be a requirement for a joint conclusion to relevant NIRs, where both parties agree on the wording for the concluding report before it is published on NIR On-line. One or two suppliers also said that the first they heard of a particular NIR was when customers rang up asking about the incident. It was claimed that this put them ‘on the back foot’ when, with a little forewarning, they could have prepared information and assessed the risks, to enable them to answer relevant questions. In general, the suppliers claimed that they were not asking for a right of veto, just to have been able to do some initial research on the incident.

There was a general feeling amongst participants other than operators that the supply chain was not given sufficient consideration when NIRs were raised and as a result, suppliers certainly felt vulnerable. They felt that there were very few occasions when a duty holder raised an NIR for an in-house fault, even if it was a new risk, so it was felt there was some under-reporting.

There needs to be clarity whether the NIR process is the mechanism for industry to be alerted to progress with the investigation, including correction of inaccurate information, or whether this should follow other industry channels.

One further comment was that the search facilities on the database could be improved. One particular request was for there to be a search facility for the latest NIRs only. At present from a search every new report could include closure of a two year old NIR, rather than only each new NIR.
There was also a request that, for NIRs involving components supplied, the serial numbers (if relevant) and the catalogue numbers be included in the details of the NIR. This would enable suppliers to investigate the incident more quickly and identify any other components at risk.

One of the more serious concerns was that in some cases there was no clear identification of the underlying cause of the problem but the NIR had been ‘concluded’ on NIR On-Line. The identification of the underlying causes does not appear to have been ‘brought out’ during some of the originator / supplier investigations which was concerning. It is felt that there should be a review of the competence requirements of the individuals assigned to carry out the incident investigations and also further explanations on what information is required to be added to NIR On-Line to close out the NIR effectively so that ‘lessons can be learnt’.

Overall, there was agreement that the process was effective but there was a need to deal with the issues of updating and closure of NIRs and a desire for the supply chain to be consulted prior to the issuing of the NIR.

It is recommended that the NIR On-Line Management Group review the findings of this study to establish whether there is a need to clarify process controls and data requirements within the NIR process and propose any changes required to the Railway Group Standard, GE/RT8250 Reporting High Risk Defects.
8 RISAS

Seven of the eleven NIRs have been identified as being related to RISAS approved suppliers as shown in table 5.

Table 5: NIRs with RISAS Approved Suppliers

<table>
<thead>
<tr>
<th>NIR</th>
<th>Originator</th>
<th>RISAS Approved Supplier</th>
<th>RISAB</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2998</td>
<td>Hull Trains</td>
<td>Railcare /Lucchini</td>
<td>Lloyds / RAL</td>
<td>Bearing failed due to dynamic vertical loading</td>
</tr>
<tr>
<td>2999</td>
<td>East Midlands</td>
<td>Wabtec Doncaster</td>
<td>SGS Correl</td>
<td>Bolts necked due to over tightening</td>
</tr>
<tr>
<td>3000</td>
<td>GE Capital</td>
<td>Pullman Rail</td>
<td>Atkins</td>
<td>Axle end caps not fitted</td>
</tr>
<tr>
<td>3001</td>
<td>Southern</td>
<td>Bombardier Crewe</td>
<td>SGS Correl</td>
<td>Axle end earth assembly failure</td>
</tr>
<tr>
<td>3011</td>
<td>GE Capital</td>
<td>Lucchini</td>
<td>RAL</td>
<td>Manufacturing defect</td>
</tr>
<tr>
<td>3021</td>
<td>East Coast</td>
<td>Unipart</td>
<td>SGS Correl</td>
<td>WSP Distance piece detached</td>
</tr>
<tr>
<td>3054</td>
<td>Cross Country</td>
<td>Unipart</td>
<td>SGS Correl</td>
<td>WSP Distance piece detached</td>
</tr>
</tbody>
</table>

Of the other four, two related to Bombardier Siegen, 2986 and 2995, were associated with assembly of axleboxes on a new build project. Bombardier Siegen is certificated for overhaul of trailer and power wheelsets, but the scope does not include assembly of axleboxes. Neither LNWR, for 2996, nor Siemens, for 3041, are RISAS certificated. The RISAS suppliers involved in supplying the wheelsets for First Hull Trains (NIR 2998) were only clarified towards the end of the investigation so neither the suppliers nor the RISABs have been contacted to date. Further meetings may be required once the underlying cause has been determined.

Six of the seven NIRs above relate to the equipment fitted onto the axle causing the problem, with only 2998 identifying purely premature bearing failure, although even this has been found to be as a result of excessive dynamic vertical loading. Discussions regarding torque tightening, use of tab washers and correct fitment of the various components have taken place during the investigation.

There is clear evidence that there has been good co-operation between suppliers and the originators of these NIRs. There is also clear evidence that human factors issues have been a contributory factor in a number of cases (given the repetitive nature of the tasks) and hence the reason a recommendation to carry out research into human factors guidance tools has been made.

Meetings have also been held with SGS Correl, RAL and Atkins, to establish their role and their views on whether a change in the approach undertaken within RISAS would have prevented the failure mode.

The results of the investigation show that there is no simple change to the RISAS scheme which would prevent similar NIRs occurring, as there is no clear evidence that the assessment process has fallen short. The results also show that there is a differing approach within RISABs to monitoring and follow up of NIRs affecting their certificated suppliers, with some keeping documented trails while others prefer a telephone
conversation to determine if the issue is worthy of further investigation. In all cases the response was
deemed appropriate by the investigation team.

However, some areas have been identified which could potentially lead to improvements in the assessment
approach. These are identified below, noting that some are already taking place.

Firstly, the RISAS briefing note (BN-004) on assessment of suppliers of wheelsets (M1A) and wheelset
components (M1B) will be reviewed, following the experiences of recent assessments and this investigation.
Scheme documentation is regularly reviewed, to incorporate best practice. In respect of the principal
assessment standard (RISAS/003), updates are based on experience in the field, so is likely to reflect
current assessment practice.

Secondly, the likelihood that human factors issues played a significant part in many of the NIRs has
emphasised the need to increase the priority for a section 10 in the Supplier Assessment Module, to cover
Organisational Culture and Human Factors. This would closely follow the ORR’s publication RM3 (Railway
Management Maturity Model), so that if a supplier were certificated under RISAS, it would also comply with
the requirements of RM3.

In addition the RISAS guidance document ‘Engineering Excellence into Competence’ will be reviewed to
determine whether it should become a requirement under RISAS, particularly within the organisational
structure of RISAS approved suppliers, not purely on the shop floor.

The RISAB’s are agreeing an intervention methodology for suppliers who have had NIRs raised against
them and will use the executive summary mechanism within the RISAS web site to report on findings. This
should ideally include the following steps:

- Identification of NIR
- Request from supplier for results of investigation
- Review of this to ascertain efficacy of certification
- Decision by signatory based on recommendations from technical expert and lead assessor on action
  needed (if any)

Finally, a review of the scheme delivery model is to be undertaken to establish if a collective assurance
scheme for critical suppliers continues to be supported by industry and if so to identify possible models for
optimisation of service delivery including the sustainability of industry assurance resources

Whilst none of these, apart from the human factors section, can be said to address any of the underlying
causes of the NIRs, each will bring about an improvement in the way suppliers are assessed and this
incremental improvement should help to improve industry performance.

During each of the meetings with the RISAS approved suppliers, they were asked to provide feedback on the
RISAS scheme. Each of the suppliers commented that the number of times that they are now audited has
greatly reduced since they were approved. The majority of suppliers expressed the view that they had found
the assessments helpful and that the RISAB had passed on best practice advice from across the industry.
Some suppliers had requested additional assessments outside of the normal RISAS approval and monitoring
regime and used the feedback to improve processes and control within other sectors of their business.
Regarding the full RISAB reports, all suppliers felt that they were very informative and comprehensive, but due to the amount of detail within them some were concerned that not everyone would read them fully. One supplier commented that they liked the structure of the IRIS reports and that they would like to see the RISAB reports merge to use the best bits of the two formats. This issue is discussed further in the Observations section.

There was also some discussion over what the term 'wheelset overhaul' includes and whether this covers the removal of the axlebox and bearing and also whether the abutment ring should be removed as this can lead to scoring of the axle journal and potential scrapping of the axle. It is recommended that this should be reviewed against the current issue of WOSS612/10.

John Reddyhoff from Eversholt Rail, also interviewed for his expert knowledge of wheelset related issues, raised a series of questions regarding the scope of RISAS, including:

- **Does RISAS provide a sufficient quality stretch target for our wheelset suppliers?** I have an involvement with wheelset overhaulers in the heritage market and, whilst their RISAS scope is usually narrow, they have a heavy reliance on the good bloke rather than systems. This raises some concerns as I would expect the audit standards to be consistent across the supply base and may be indicative of inconsistency elsewhere.
- **How does RISAS assess wheelset engineering capability and design authority?** There are multiple stakeholders and shared materials in the wheelset supply chain with a lack of industry consensus on the management of the design risk except where the OEM is both the designer and the contracting entity.
- **Does RISAS consider the ability of the supplier to reconcile these requirements to ensure that each customer receives the specified product or does it look at their response to a single order?**
- **Does RISAS assess the risks associated with the configuration control of components that are visually identical but may have minor dimensional variations that make them non-interchangeable?**
- **Whether RISAS is calibrated against the Safety Risk Model to check that the assurance provided by the scheme is an effective control of the T&RS risks in the model.**

These questions will be reviewed by the RISAS Board as part of the review of the recommendations from this report.

### 9 Data Availability

The investigation has focussed on eleven wheelset NIRs raised between January and June 2014. During the investigations, a number of parties explained how they were managing other bearing related issues within their fleets. This has identified that using data compiled from the NIR database cannot give a complete picture of wheelset and bearing incidents within the industry. The database is designed for ‘urgent safety alerts’, particularly when a significant new risk has been identified. This outcome mirrors findings from a separate study into performance measures for RISAS approved suppliers carried out for the RISAS Board by one of the investigation team. No evidence of the existence of a comprehensive list of wheelset and bearing incidents has been found. Mention has been made of DRACAS by RSSB personnel, but none of the originators raised it.
It is likely that to obtain such a comprehensive list would require a review of each duty holder’s safety monitoring system as well as that of train owners and wheelset suppliers. Creating such a list would require considerable effort on behalf of the industry, which may or may not be justified. It could perhaps be beneficial to compile a snapshot, say for the first six months period, to make a first attempt at identifying the relationship between NIRs and the totality of wheelset defects, to establish if this data should be reported regularly. It is recommended that this proposal be discussed by the RISAS Board.

10. Observations

In this section comments that have been raised during the investigation but are not directly relevant to the individual NIRs have been included. The discussion on each observation also identifies the appropriate body to decide if any action should be undertaken to review the issue raised.

10.1 European Considerations

Two comparisons were made with European freight activities, one favourable, one less so. European sites for wheelset overhaul were considered to be better than sites used in the UK for freight wheel overhaul, where additional capacity and competition would be welcomed. However, maintenance of the axleboxes was considered to be poorer in Europe, with more incidents occurring, similar to the ones investigated in this report. RISAB’s involved in assessing wheelset activity on the continent should use the opportunity to identify best practice and encourage other suppliers to improve, where appropriate.

Secondly, concern was raised about the apparent de-skilling in the freight maintenance activity, with a discussion on incidents where significant defects on wagons were missed. This may be addressed as the requirements for the Maintenance Delivery Function within the ECM regulations are followed through, as these include competence requirements for staff.

10.2 RISAS Report

During discussions on RISAS, one supplier, who was also IRIS approved, felt that the RISAS report was too long. “The supplier knows his processes and procedures, so doesn’t need the detail in the report. The interest is in the corrective actions and observations”. However, it should be noted that as well as providing a ‘base-line’ of the supplier’s arrangements to manage risk and industry demonstration of ‘due-diligence’, it is also used by the Accreditation Agency to monitor compliance with RISAS requirements and could potentially be used by RAIB for investigative purposes. The thought was that a report, which was laid out in a similar framework to an IRIS report, but with the necessary additional information, could be easier to read and understand, as well as simpler to produce. It is recommended that the RISAS Board review the requirements for the assessment report, taking these comments into account.

10.3 Customer Responses

One supplier expressed concern that they received no feedback from a particular customer regarding risks identified after an NIR had been raised, so were unable to be satisfied that the issue had been closed out. This is not considered satisfactory and should be covered as part of the assessment of Entities in Charge of Maintenance, which covers monitoring of safety incidents.

10.4 Customer Specifications
One supplier, which carries out varied work for a number of different companies, commented that the quality of the specifications it receives for the work was very variable, with many needing considerable clarification. The investigations into the NIRs have already shown that there are concerns over the specifications provided to suppliers. The competence of engineering staff producing and signing off these specifications should be reviewed. The document “Engineering Excellence into Competence” should be reviewed within Customer organisations and be part of the assessment approach of competence under ECM regulations.

11. Additional Investigations

The investigation has identified a number of areas where further investigation is recommended.

11.1 Secondary Locking of Bolts

Eight of the NIRs have been raised as a result of bolts associated with axle end or axlebox equipment either being missing, coming loose or being over tightened. In most cases, a tab washer is the secondary locking mechanism. Experiments by suppliers during their investigations into the NIRs have shown that over tightening a bolt to line up with a tab washer can increase the torque value considerably. In addition, some axle end caps, when examined, have shown significant damage from chisels when trying to tab up the washers.

One of the contributory factors to NIR 2995 was said to be that the supplier had never assembled an axlebox of this design before, due to the fitter being used to using the serrated washers rather than tab washers. It is recommended that a review of current international design practices should be undertaken as an RSSB research project to establish if there are alternatives for secondary locking of bolts associated with axlebox equipment, that are both cost effective and feasible to transfer to GB’s railway. Possible alternatives would also need to reduce the likelihood of occurrence of the types of human error identified during this investigation.

11.2 Competence

All of the staff carrying out work on the axleboxes have been assessed as competent by their employers. Competence is a key area within a RISAS Assessment. However, there is still a significant number of NIRs associated with human error. This investigation did not review employee records against GM/GN2646, the guidance note on axle bearing maintenance, but this is seen as very much an input specification for the training, without mentioning human factors issues. It is recommended that a review of this guidance note should be undertaken to establish whether it should become a Railway Industry Standard (RIS) that duty holders can adopt and include in contracts with suppliers and also to to ensure human factors issues are given sufficient weighting in both the training and competence assessments. This review could also determine whether the competence assessment approach is sufficient or whether a form of licensing or certification for staff who carry out work to axleboxes should be re-introduced.

11.3 Human Factors

Research project T774 has looked at the human factors issues associated with axle inspection techniques. A further step has been discussed regarding the risks of carrying out this inspection against the risks of
disturbing axlebox equipment. It is recommended that this study is carried out, so that a clear recommendation may be given to industry on the relative risks of both operations.

The draft Human Factors checklist used for this investigation has used examples from the operational railway to illustrate the definition. These examples do not always transfer easily into a workshop environment. It is recommended that illustrations which reflect workshop practice are developed, to assist with implementing effective incident investigation and mitigation of human factors.

11.4 Data Availability

The investigation has not identified an industry wide source of data on wheelset incidents. The NIR database only highlights issues raised as NIRs. Not all of these have caused problems on the operational railway, with the incidents identified in 2998 and 2999 both being found on routine examinations. Incidents are recorded in both duty holders and suppliers own records, but not collated. It is recommended that a study of these records, for the same period as this investigation, is carried out to identify, as a snapshot, the total population of wheelset defects. The results of this review could inform discussions on data capture requirements for DRACAS, if this is to be the preferred system for the future. However, for wheelsets, it needs to look further than just operational incidents.

12. Conclusions

No one single action has been identified that, if implemented, will bring about a significant reduction in risk of bearing failures. However, a number of areas for improvement or further investigation have been identified, which, if followed through, will lead to a minor reduction in overall risk across a wide range of activities.

Ten of the eleven NIRs were classified with one or more of the Human Factors 10 Incident Factors. The other one is still under investigation to determine the underlying cause. The main Incident Factor was identified as being ‘Practices and Processes’ which covered eight of the ten classified NIRs.

Six of the eleven NIRs were further classified as being due to Human Error with three of them being classed as ‘Decision Errors’.

The guidance note GM/GN2646 does not include human factors issues in its content.

A number of improvements to the NIR database were identified during the investigation, which if implemented would lead to easier use by stakeholders and better information available to all.

Regarding the RISAS scheme, due to the wide variety of issues identified there was no simple change identified which would prevent similar NIRs occurring. There was also no clear evidence that the assessment process had fallen short. However, there are a number of actions which are being followed, to bring about changes and these have been put forward as recommendations.
13. Recommendations

The following recommendations have been made:

**Industry recommendations:**

1. Over tightening of bolts to enable tab washers to line up should be stopped immediately. The procedures need to clearly explain how this should be achieved. This should be communicated to Industry immediately.

2. A review of secondary locking of axle end cap bolts within the international rail industry, and similar applications in other industries, should be undertaken to establish if there are feasible, cost effective mechanisms, which will reduce the likelihood of human factors errors. Subject to industry discussion, development and approval of a remit.

3. A review by BSI RAE/3/-/2 UK Bearing Group of GM/GN2646 should be undertaken, particularly with reference to research project T774 and the option of making the document a Railway Industry Standard. This should also look at the competence requirements and whether some form of licensing or certification be introduced. Subject to industry discussion, development, approval and submission of a proposal for standards change.

4. A review of by the NIR ONLINE Management group of the NIR On-line process should be undertaken with reference to the requirements for the information required to effectively close out an NIR (determination of the underlying cause and contributory factors) and also of the competence requirements of the individuals assigned to carry out the incident investigations. Subject to industry discussion, development and approval of a proposal for a standards change to GE/RT8250.

5. An investigation to establish the totality of wheelset incidents occurring within the timescale covered by this investigation should be carried out, to understand the type and frequency of incidents and identify whether this type of data should be captured continually, on an industry wide basis. Subject to industry discussion, development and approval of a remit.

**Human Factors Recommendations:**

6. Human Factors research should be undertaken which will aim to deliver guidance tools to be used to support human performance reliability for bearing and axle end equipment fitting tasks. This work should build on work undertaken for RSSB project T774 (Research into the effects of human factors in axle inspection) to produce a tool kit for use by industry. The scope of the work should consider how job, individual and organisation factors be optimised to support task reliability. Subject to industry discussion, development and approval of a remit.

7. The Human Factors Incident Checklist definitions should have examples drawn from workshop practice added, to enable these to be used consistently when investigating incidents such as wheelset NIRs. Subject to industry discussion, development and approval of a remit.
RISAS Recommendations:

8. The RISAS briefing note (BN-004) on assessment of suppliers of wheelsets (M1A) and wheelset components (M1B) is reviewed for potential improvement, following the experiences of recent assessments and this investigation. Review of Revision of BN-04 is already underway and subject to RISAS Board approval should be completed by the end of September 2014.

9. The likelihood that Human Factors issues played a significant part in at least one NIR for a RISAS approved supplier, and in several other NIRs, has emphasised the need for the RISAS Board to: Increase the priority for a ‘Section 10’ in the Supplier Assessment Module, to include Organisational Culture and Human factors. (This would closely follow the ORR’s publication RM³ (Railway Management Maturity Model), such that a supplier certificated under RISAS would also comply with the requirements of RM³). Subject to RISAS Board approval.

10. The RISAS guidance document ‘Engineering Excellence into Competence’ should be reviewed to see if it should become a mandatory requirement under RISAS, particularly within the organisational structure of RISAS suppliers, not purely on the shop floor. Subject to RISAS Board approval.

11. The RISAB’s are developing an intervention methodology for ‘Out-of-Course’ supplier issues (for example NIRs, CIRAS reports, website feedback, customer complaints etc) and will use the executive summary mechanism within the RISAS Online website to report on findings. Subject to RISAS Board approval this could be completed within 6 months.

12. The RISAS Board should commission a review of the current format of the Assessment Report, taking into account feedback from RISAB’s and suppliers and the style of the IRIS report, such that a simplified, more cost effective format be created. Subject to RISAS Board approval

13. The RISAS Board should review the observations and issues raised by John Reddyhoff in order to improve and clarify the scope of the RISAS scheme. Subject to RISAS Board approval

Comment: Whilst none of the recommendations, apart from the Human Factors study and not over tightening bolts, can be said to directly address any of the underlying causes of the current NIRs, each would bring about an improvement in the overall process, including the way suppliers are assessed and this incremental improvement across all operations would help the industry to become safer.
### Appendix A: Details of Bearing related NIRs Investigated between January and June 2014

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Vehicle</th>
<th>Raised by</th>
<th>Title</th>
<th>Supplier</th>
<th>RISAB</th>
<th>Bearing Affecting Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>2986</td>
<td>16-Jan</td>
<td>377</td>
<td>Southern</td>
<td>Axle bearing contamination</td>
<td>Bombardier Siegen</td>
<td>N/A (New Build)</td>
<td>High</td>
</tr>
<tr>
<td>2995</td>
<td>31-Jan</td>
<td>377</td>
<td>Southern</td>
<td>Incorrect assembly of axle end equipment</td>
<td>Bombardier Siegen</td>
<td>N/A (New Build)</td>
<td>High</td>
</tr>
<tr>
<td>2996</td>
<td>06-Feb</td>
<td>JNA</td>
<td>GE Capital Rail Services</td>
<td>Loose bearing end cap bolt</td>
<td>LNWR</td>
<td>N/A</td>
<td>High</td>
</tr>
<tr>
<td>2998</td>
<td>04-Feb</td>
<td>180</td>
<td>First Hull Trains</td>
<td>Jon Plowright</td>
<td>Axle bearing failures</td>
<td>Railcare / Lucchini</td>
<td>High (Failure)</td>
</tr>
<tr>
<td>2999</td>
<td>11-Feb</td>
<td>43</td>
<td>East Midlands Trains</td>
<td>Nigel Yule</td>
<td>Axle bearing end cap defective retaining bolts</td>
<td>Wabtec Doncaster</td>
<td>SGS Correl</td>
</tr>
<tr>
<td>3000</td>
<td>19-Feb</td>
<td>JNA</td>
<td>GE Capital Rail Services</td>
<td>Multiple bearing failure</td>
<td>Pullman</td>
<td>Atkins</td>
<td>High (Failure)</td>
</tr>
<tr>
<td>3001</td>
<td>21-Feb</td>
<td>377</td>
<td>Southern</td>
<td>Catastrophic failure of axle end earth assembly leading to axle bearing disintegration</td>
<td>Bombardier Crewe</td>
<td>SGS Correl</td>
<td>High (Failure)</td>
</tr>
<tr>
<td>3011</td>
<td>14-Mar</td>
<td>TEA</td>
<td>GE Capital Rail Services</td>
<td>TF25 axle journal incorrect finish</td>
<td>Lucchini</td>
<td>RAL</td>
<td>Low</td>
</tr>
<tr>
<td>3021</td>
<td>05-Apr</td>
<td>Mk3</td>
<td>ECML</td>
<td>Keith Mack</td>
<td>Detached BT10 bogie WSP axle end distance piece</td>
<td>Unipart Rail</td>
<td>SGS Correl</td>
</tr>
<tr>
<td>3041</td>
<td>16-May</td>
<td>185</td>
<td>First / Keolis</td>
<td>Eddie Knorn</td>
<td>Axle end earth disc fitted back to front</td>
<td>Siemens</td>
<td>N/A</td>
</tr>
<tr>
<td>3054</td>
<td>19-Jun</td>
<td>Mk3</td>
<td>Cross country</td>
<td>Stuart Rawlings</td>
<td>BT10 Bogie WSP axle end distance piece and cover detached</td>
<td>Unipart Rail</td>
<td>SGS Correl</td>
</tr>
</tbody>
</table>
Appendix B

Letter from BSi Bearing Group

Mr, Mark Molyneux,  
Head of Engineering,  
ATOC.

Mr, Mick James,  
Senior Plant Engineer,  
RSSB,  
Chairman,  
Freight Technical Committee.

Copy to;  
Cliff Cork.

February 25th 2014

Axle Bearing Problems

Dear Mark / Mick,

At the BSI bearing panel meeting, RAE/3/-/2, held on 20 February 2014, it was identified that there have been a high number of bearing related NIR’s this year. A total of 8 bearing related NIR’s have been raised, representing approximately 45% of the total NIR’s this year. This compares with a background of about 12% (370 bearing related NIR’s in a total population of 3000). A significant number of these recent NIR’s appeared to be associated with bearing end cap installation.

Our discussions did not identify any specific issues, rather a general concern with the level of bearing awareness and effectiveness of maintenance at locations dealing with wheelsets. The group identified several areas where it considered that industry awareness should be raised, in an attempt to address the problems and risk being experienced, as indicated below;

a) Training and Competence  
There is concern that staff dealing with bearings, are not aware of the importance of bearings or the significance and consequence of their actions. The group expressed apprehension with regards to the capabilities of staff and their abilities to reliably undertake the tasks related to bearing assembly, to ensure safety and reliability in service.

b) Documentation
The group has concerns that in many cases, the base document was not easily identified. Historically, the drawing was the defining document which may not always be the case today, with the ROSCO’s using their wheelset data sheets to define the technical requirements for their wheelsets. However, the definition of the axle end interfaces may be specified elsewhere, possibly in other maintenance documentation. Some doubts were also expressed over the clarity of the information that is used by staff undertaking tasks associated with bearings.

c) Materials
The availability of spares, when undertaking inspections, or maintenance of bearings has been raised as a problem, when ensuring that certain parts are replaced. Also, there is a need for clarity over what components can be reused and the level of inspection to be applied to those components.

The wheelset, including the journal bearings, represents a significant risk in the operation of the railway which is being challenged by the number of bearing related incidents being reported by the NIR system. There have been no major incidents related to journal bearings for some time, and the industry has been fortunate in finding defects before a catastrophic situation has arisen.

It is in the context of raising awareness of the increasing number of bearing problems that have been reported, and the importance of correct bearing maintenance, that the bearing group has requested that such issues are raised across the industry with the Supply Chain, Train Operating and Freight Operating communities.

The bearing group has summarised its concerns here, however, in order to address these concerns, what actions can industry take to tackle these challenges? Please forward this letter to the appropriate organisations in order that the above concerns can be raised and communicated effectively to all those involved in the maintenance of axle bearings.

Yours Sincerely

Keith Mack
Appendix C

Axle bearing problems

Greg Morse, Operational Feedback Specialist, RSSB

Introduction

It is difficult to say with any degree of certainty if there is a rising trend in axle bearing-related issues, for though Colin Bryan’s analysis (Appendix A) does show a rise in related NIR activity, as he clarifies in his conclusion, ‘five of the eight so far in 2014 are for only two fleets’.

The problem is that this has not traditionally been a focus of full analysis, in part because a train has to derail – or at least be taken out of service – for the event to appear in SMIS, and thence the Safety Intelligence Database (SIDB) and the Annual Safety Performance Report (ASPR).

However, if an axle problem is taken as a precursor to a derailment, the figures from the 2012-13 ASPR suggests that the risk is small and that most derailments in 2012-13 resulted from track or environmental conditions.

Furthermore, ERA statistics for 2010-11 show SPADs to be the most common precursor for the EU-25, while broken axles and wheels have shown a 40% reduction year-on-year when taken together.

The four incidents taken from SMIS and the Safety Intelligence Centre cover a collapsed axle bearing on a Mark III coach, a defective axle bearing bracket on a TEA, a collapsed bearing on a JNA and a hot box on a 377.

The Canadian incident involved a sudden wheel bearing failure on a wagon which led to a derailment and bridge collapse, reminding us that incidents like these do have the potential to lead to more serious consequences. The same cause may also be a factor in the North Dakota incident. Both have highlighted the risks from an increase in oil traffic in North America, which in turn has placed greater emphasis on wagon maintenance.

Most of these shipments have resulted from a rise in shale oil/fracking, which is considered highly flammable and poses questions for us, the UK considering a number of options to increase similar operations.

Throughout this paper, I have highlighted certain points in red for clarity.

For context purposes long-term historical rail usage statistics are included at Appendix B.
Statistics

Trends in potentially higher-risk train accidents

The SRMv7.5 modelled risk from PHRTAs on the running line equates to 7.6 FWI per year. While PHRTAs comprise the types of train accident that have the greatest potential to result in higher numbers of casualties, the majority result in few or no injuries.

![Chart 1. Trends in the numbers of PHRTAs](image)

- The number of PHRTAs in 2012/13 stayed at a similar level to the previous year, and was low compared with the ten-year average of 42.8. **There were 16 derailments**; none resulted from collisions with road vehicles at level crossings.

Derailments

The modelled risk from derailments is 2.8 FWI per year. The last train accident with a train occupant fatality was the derailment at Grayrigg in 2007, which was caused by points failure.

---

1 Some events involve more than one train accident (for example a collision leading to a derailment). In the key safety fact sheets these are shown against the initiating incident to avoid duplicating the counting. In this section the number of derailments includes derailments following collisions with road vehicles at level crossings or trains being struck by large falling objects (which are shown in separate categories in the key safety fact sheet), but does not include derailments following train collisions or buffer stop collisions.
• There were 16 derailments in 2012/13, which is the same as the previous year, and low by historical standards.

• There were seven derailments of passenger trains in 2012/13. Four were due to landslips, one involved a collision with cows, and one a collision with objects placed on the line by vandals. In the remaining case, the train derailed on points before re-railing further down the track.

• There were six freight train derailments (plus one derailment of a light locomotive operated by a freight company). Freight train derailments have reduced from a typical rate of around 40-50 per year in the late 1990s. Various factors – including improvements in the quality of both track and rolling stock – have contributed to this success.

• Over the last five years, irregular working has been the main cause of derailment, followed by environment and track problems.

**Causes of derailments**

Chart 4 shows the primary causes assigned to train derailments. On investigation, train accidents are generally found to have numerous causal factors. Nevertheless, this basic approach can be useful for identifying general trends.
• Most derailments in 2012/13 resulted from track or environmental causes; there were fewer caused by irregular working than in the previous year.

• The most common cause of derailments related to the environment was landslips, in which debris from cuttings fouls the line, or subsidence affects the track (see section Error! Reference source not found. for more information). There were six such derailments in 2012/13, four affecting passenger trains and two affecting freight trains.

The situation in Europe is even harder to divine, as the following from the ERA’s Intermediate report on the development of railway safety in the European Union 2013 suggests.

Intermediate report on the development of railway safety in the European Union 2013

Precursors to accidents

As accidents on railways are rare, the monitoring of less serious events occurring on railways is an essential tool of a proactive SMS. ‘Precursors to accidents’ are indicators of incidents that under other circumstances could have led to an accident. The indicators reported to the Agency are: broken rails, track buckles, signals passed at danger, wrong-side signalling failures, broken wheels and broken axles (Chart 5).
Over the period 2010–11, EU countries reported as many as 20 650 precursors to accidents; this is a ratio of more than four precursors to one significant accident. However, if we discard accidents to persons caused by rolling stock in motion, the ratio between the precursors and accidents rises to 11:1. This unveils the great potential benefit in analysing precursors in the proactive monitoring of railway safety.

Signal passed at danger is the most common type of accident precursors; it is also a precursor for which the highest absolute reduction has been registered in 2011. The most important reduction has been however achieved for the category of broken wheels and broken axles (a 40 % year-to-year reduction when taken together).

**Chart 5. Precursors to accidents (EU-27) per ERA**

<table>
<thead>
<tr>
<th>Precursors to accidents (EU-27)</th>
<th>2010</th>
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</thead>
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<tr>
<td>Signals passed at danger</td>
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<td>4186</td>
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<tr>
<td>Broken rails</td>
<td>1776</td>
<td>2713</td>
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<tr>
<td>Track buckles</td>
<td>525</td>
<td>433</td>
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<tr>
<td>Wrong-side signalling failure</td>
<td>2740</td>
<td>2700</td>
</tr>
<tr>
<td>Broken wheels</td>
<td>56</td>
<td>33</td>
</tr>
<tr>
<td>Broken axles</td>
<td>41</td>
<td>28</td>
</tr>
</tbody>
</table>

**SMIS/SIC events**

- **15/09/13:** At 15:22, the Shift Signaller Manager at Thames Valley SC reported that an Oxford–Paddington HST service had activated Basildon HABD on the Up Relief line. The train was brought to a stand on the Up Relief at Tilehurst where, at 15:33, the driver reported that they had extinguished a small brake block fire on coach 42071 and isolated the brakes. It was found that at, 15:07, that station staff at Didcot Parkway had advised the Train Manager on 1P51 of a small amount of smoke and burning smell coming from the rear of the train. The Train Manager failed to check the coach concerned or advise the driver. Technical staff had arrived by 15:45. At 15:51, it was reported that the technical staff had examined the coach and, on removing the axlebox cover, discovered that the **axle bearing had collapsed** and the train was unable to move until a wheelskate had been fitted. **Delay minutes: 1246**

- **17/10/13:** At 12:11, the driver of an Edinburgh Waverley–Plymouth, reported to the signaller at Gloucester SB, that as they passed a Robeston Sidings–Westerleigh Murco freight, which
was on the Up Charfield line approaching Gloucester Yard Junction, smoke was observed to emanating from the centre of the train. The signaller brought the train to a stand at G237 signal and instructed the driver to carry out an examination. The train was formed of 60092 & 66194 marshalled at either end of a rake of 23 loaded wagons, conveying dangerous goods. The Fire Service were also summoned. At 12:35, the driver reported the discovery of defective axle bearing bracket, which was causing smoke and heat. The affected bogie was under TEA GERS 89006, loaded with oil. A MOM was on site at 13:12 and assumed the duties of RIO. After the liaising with the Fire Service, the bi-directionally signalled Down Charfield line re-opened without restriction at 13:15. Authority was given for the train to proceed at extreme caution into Gloucester Yard, where it could be attended to by technical staff. Delay minutes: 1823

- **18/02/14:** At 23:00, the driver of a Leeds–Sheffield service reported passing a freight service on the Down Main between Sheffield and Attercliffe with the second wagon from rear appearing to have glowing wheels. The train was identified as a Peak Forest–Attercliffe Sidings, hauled by 66142 with a mixed rake of 20 loaded JNA/JRA wagons and was stopped at Mill Race Junction to advise the driver to examine the train. At 23:50, the freight driver reported that were no axle covers on the affected wagon, (JNA GERS4408) and that the train was not fit to proceed. A fitter arrived at 00:35 and at 01:30 reported that the wagon had substantial defects, both bearings of the leading bogie had collapsed and the bearings on the trailing bogie of the wagon had partially collapsed. Three wheelskates were required and an additional locomotive was required to attach to the rear of the train for braking purposes. The BRUFF was mobilised from Knottingley and Network Rail Operations staff were sent to site. Investigations revealed that wagon JNA GERS4408 had been released from pre-planned maintenance at Peak Forest on 17 February 2014, having been taken out of traffic on 30 December 2013. Delay minutes: 91

- **20/02/14:** At 18:31, a Reigate–London Victoria service (377139+377119+377160) arrived at platform 17 at destination with a fire beneath the train. This was believed to have been paper which had collected beneath the train and caught fire. Platforms 17-19 were initially subject to an associated emergency switch off of the traction current, extended to Platforms 14-19 at 18:50. The MOM arrived on site at 19:05 and carried out switching to reduce the emergency switch off to Platforms 16 and 17 only. At 19:23, Southern Fleet control advised that the RSI on site had concerns that an axle bearing on 377139 was the heat source. A wheel rotational test was carried out which proved the wheel was moving freely. The unit was eventually worked ECS to Stewarts Lane. Delay minutes: 540

**Overseas incidents**

*Canada: Rail bridge collapses, 5 wagons fall into river, 2 June 2013*

On 2 June 2013, five wagons of a freight train derailed and fell into Wahnapiate River, Northern Ontario, after a bridge collapsed. There were no reported injuries.

A preliminary investigation by Canadian Pacific identified that one of the wagons experienced a sudden and unexpected wheel bearing failure, which caused it to derail just before the bridge. The wagon then struck the bridge, causing the collapse.
US: Collision leads to dangerous goods explosion in North Dakota, 30 December 2013

At 14:00 (local time) on 30 December 2013, a wagon amid a westbound freight derailed at a set of points near Casselton, North Dakota, and fouled the adjacent line. Shortly after, an oil train ran into the wagons, causing a series of explosions that sent a fireball into the sky and a thick pall of smoke across the local area. There were no reported injuries, but residents within a five-mile radius were urged to evacuate.

The operator – Burlington Northern Santa Fe – and the National Transportation Safety Board are investigating. Members of the latter discovered a broken axle at the scene, but are yet to determine if it caused the westbound freight to derail or happened as a consequence of it.

Annex A - Analysis of bearing failure NIRs, Colin Bryan

Introduction

Concern has been raised about the number of NIR's being raised relating to bearing issues and what can be established from a review of their findings, including whether RISAS has a part to play.

NIRs reviewed

A search has been carried out of the NIR database, using the keywords “bearing” and “axle”. No axle bearing NIR’s were found to have been initiated in 2012, 7 in 2013 and 8 so far in 2014, indicating a significant increase.

Conventional statistical process control analysis indicates that this is not yet a trend but must be investigated as it is out of the ordinary. In addition two fleets, 377 and JNA, account for five of the eight NIR’s in 2014, which the heightened awareness may have contributed to the volume of NIR’s.

Fleets involved were as follows:

<table>
<thead>
<tr>
<th>Wagon</th>
<th>DMU</th>
<th>EMU</th>
<th>HST</th>
</tr>
</thead>
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<td>JGA</td>
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<table>
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<th>Wagon</th>
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</tr>
<tr>
<td>TEA</td>
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<td>508</td>
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</tbody>
</table>

Suppliers of the equipment that caused the problems were:

<table>
<thead>
<tr>
<th>Supplier</th>
<th>RISAS NIR</th>
<th>Supplier</th>
<th>RISAS NIR</th>
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<tbody>
<tr>
<td>Wabtec Doncaster</td>
<td>R 2885</td>
<td>Bombardier Siegen</td>
<td>2986, 2995</td>
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<tr>
<td>Wabtec Scotland</td>
<td>R 2918</td>
<td>LNWR</td>
<td>2996</td>
</tr>
</tbody>
</table>
R indicates RISAS certification for wheelsets, at the time of the NIR. Over half the NIR’s are as a result of non RISAS certificated suppliers and four, 2901, 2986, 2995 and 2998, assuming the detail of the NIR has been understood correctly, are associated with new build vehicles, which have not yet received an overhaul.

Causes of failure may be grouped into the following areas:

- Assembly of bearings: 2885, 2891, 2892, 2918
- Axlebox sealing: 2986
- Axlebox end cap fitting: 2889, 2996, 2999, 3000
- Axle end equipment fitting: 2907, 2995, 3001
- Axlebox manufacture: 2901
- Axle condition: 3011
- Not finalised: 2998

There is a wide range of differing causes of the NIRs, so it is difficult to identify any single cause of failure, either of suppliers or of the RISAS scheme in particular.

Concerns needing to be raised

The majority of the NIR’s are concerned not with the overhaul of the basic wheelset, ie axle, wheels and bearings, but with the ancillary aspects, end caps, axle end equipment and sealing. These are disturbed when wheelsets, particularly for EMU and DMU vehicles, are fitted and at UAT and tyre turning. In addition, control of equipment used for pressing bearings on needs to be more rigorous. A review of existing documentation and practices should be instigated by the relevant suppliers and the output checked, for RISAS certificated suppliers, by the relevant RISAB.

Conclusion

There has been a significant increase in axle bearing NIR’s recently. However, five of the eight so far in 2014 are for only two fleets.

Continued vigilance and a review of practices throughout the industry regarding use of tools for pressing on bearings and fitting of axle end caps and other equipment is recommended.
These areas should form part of any future assessments under RISAS for work on wheelsets, whether at wheelset overhaulers or depots undertaking wheelset changes.

**Annex B - Rail Usage - Long-term historical trends**

<table>
<thead>
<tr>
<th>Chart 6. Trends in rail usage over the past 50 years</th>
</tr>
</thead>
</table>

- Between the early 1960s and the early 1980s, passenger journeys and passenger kilometres showed decreasing or flat trends, largely as a result of the increasing ownership of road vehicles.
- Since privatisation began in 1994/95, there has been a general growth in passenger kilometres and journeys, reflecting changes in society, transport policy and the economic climate.
- In 2009/10, the economic recession led to a slowing down in the growth in rail usage; passenger journeys briefly showed a small decrease. However, figures since then indicate that this was a temporary effect, with rail passenger usage again showing rising trends.
- Up until around 2006/07, freight usage showed a similar trend to passenger usage, although it has never regained the volumes seen in the early 1960s and earlier. Following 2006/07, there was a short period of decreasing trend, which now appears to be reversing.
- Over the past decade (2003/04 to 2012/13):
  - Passenger kilometres have increased by 43%
• Passenger journeys have increased by 49%
• Freight tonne kilometres have increased by 15%
• Train kilometres have increased by 10%
Appendix D: Contact details of personnel involved in the investigation meetings

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Company</th>
<th>Job Title</th>
<th>NIR</th>
<th>Originator / Supplier / RISAB</th>
<th>Contact Details</th>
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<tbody>
<tr>
<td>1</td>
<td>Les Bryant</td>
<td>GE Capital Rail Services</td>
<td>Professional Head of Engineering</td>
<td>2996, 3000, 3011</td>
<td>Originator</td>
<td><a href="mailto:leslie.bryant@gecapital.com">leslie.bryant@gecapital.com</a></td>
</tr>
<tr>
<td>2</td>
<td>Dave Hickson</td>
<td>Southern</td>
<td>Fleet Engineer</td>
<td>2986, 2995, 3001</td>
<td>Originator</td>
<td><a href="mailto:david.hickson@southernrailway.com">david.hickson@southernrailway.com</a></td>
</tr>
<tr>
<td></td>
<td>Iain Nairne</td>
<td></td>
<td>Fleet Manager</td>
<td></td>
<td></td>
<td><a href="mailto:iain.nairne@southernrailway.com">iain.nairne@southernrailway.com</a></td>
</tr>
<tr>
<td>3</td>
<td>Nigel Yule</td>
<td>East Midlands Trains</td>
<td>Fleet Engineer</td>
<td>2999</td>
<td>Originator</td>
<td><a href="mailto:nigel.yule@eastmidlandstrains.co.uk">nigel.yule@eastmidlandstrains.co.uk</a></td>
</tr>
<tr>
<td>4</td>
<td>Keith Mack</td>
<td>East Coast Main Line</td>
<td>Engineering Standards Manager</td>
<td>3021</td>
<td>Originator</td>
<td><a href="mailto:keith.mack@eastcoast.co.uk">keith.mack@eastcoast.co.uk</a></td>
</tr>
<tr>
<td>5</td>
<td>Jon Plowright</td>
<td>First Hull Trains</td>
<td>Head of Engineering</td>
<td>2998</td>
<td>Originator</td>
<td><a href="mailto:jon.plowright@firstgroup.com">jon.plowright@firstgroup.com</a></td>
</tr>
<tr>
<td>6</td>
<td>Eddie Knorn</td>
<td>First / Keolis</td>
<td>Standards Engineer</td>
<td>3041</td>
<td>Originator</td>
<td><a href="mailto:eddie.knorn@firstgroup.com">eddie.knorn@firstgroup.com</a></td>
</tr>
<tr>
<td>7</td>
<td>John Williams</td>
<td>Alstom</td>
<td>Product Safety Manager</td>
<td>2998</td>
<td>Technical Support</td>
<td><a href="mailto:john.williams@transport.alstom.com">john.williams@transport.alstom.com</a></td>
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<tr>
<td>8</td>
<td>Kevin Bayliss</td>
<td>Bombardier Bogies Derby Engineers</td>
<td>2986, 2995</td>
<td>Supplier</td>
<td><a href="mailto:kevin.bayliss@uk.transport.bombardier.com">kevin.bayliss@uk.transport.bombardier.com</a></td>
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<tr>
<td></td>
<td>Richard McCune</td>
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<td>9</td>
<td>Brian Harrop</td>
<td>Bombardier Crewe</td>
<td>Technical Support Engineer</td>
<td>3001</td>
<td>Supplier</td>
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<td>Bob Williams</td>
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<td>Quality Manager</td>
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<td>Ian Moverley</td>
<td>Wabtec</td>
<td>Quality Assurance Manager</td>
<td>2999</td>
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<td><a href="mailto:imoverley@wabtec.com">imoverley@wabtec.com</a></td>
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<td>Roy Green</td>
<td>Unipart Rail</td>
<td>Technical Support Manager</td>
<td>3021, 3054</td>
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<td><a href="mailto:roy.green@unipartrail.com">roy.green@unipartrail.com</a></td>
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<td>14</td>
<td>Barry Cullinane</td>
<td>SGS Correl</td>
<td>RISAB Signatory Manager</td>
<td>2999, 3001, 3021, 3054</td>
<td>RISAB</td>
<td><a href="mailto:barry.cullinane@sgs.com">barry.cullinane@sgs.com</a></td>
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<td></td>
<td>Chris Llewellyn</td>
<td></td>
<td>RISAB Manager</td>
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<td></td>
<td><a href="mailto:chris.llewellyn@sgs.com">chris.llewellyn@sgs.com</a></td>
</tr>
<tr>
<td>15</td>
<td>Richard Bagworth</td>
<td>RAL</td>
<td>RISAB Manager</td>
<td>2998, 3011</td>
<td>RISAB</td>
<td><a href="mailto:richard.bagworth@railwayapprovals.com">richard.bagworth@railwayapprovals.com</a></td>
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<tr>
<td>16</td>
<td>Neil Clarke</td>
<td>Atkins</td>
<td>RISAB Manager</td>
<td>3000</td>
<td>RISAB</td>
<td><a href="mailto:neil.clarke@atkinsglobal.com">neil.clarke@atkinsglobal.com</a></td>
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</tbody>
</table>
Appendix E

Individual NIR Reviews.

1. NIR 2986 – Class 377 Axle Bearing Contamination

2. NIR 2995 – Incorrect Assembly of Axle End Equipment

3. NIR 2996 – Loose Bearing End Cap Bolt

4. NIR 2998 – Axle Bearing Failures

5. NIR 2999 – HST Power Car, Axle Bearing End Cap, Defective Retaining Bolts

6. NIR 3000 – Multiple Bearing Failures

7. NIR 3001 – Catastrophic Failure of Axle End Earth Assembly leading to Axle Bearing Disintegration

8. NIR 3011 – TF25 Axle Journal Incorrect Finish

9. NIR 3021 – Detached BT10 Bogie WSP Axle End Distance Piece

10. NIR 3041 – Class 185 Axle End Earthing Disc fitted back to front

11. NIR 3054 – BT10 Bogie WSP Axle End Distance Piece and Cover Detached
NIR 2986 – Class 377 Axle Bearing Contamination

Background

Originator Meeting - Southern – Thursday 12th June - Selhurst Depot

A meeting was held with Dave Hickson and Iain Nairne from Southern Railways. Dave is the Fleet Engineer for ‘New trains’ and Iain is the Fleet Manager. Southern have had a lot of long running issues with axle bearings for their Class 377 Electrostar fleets and they have been trying to improve reliability.

Supplier Meeting - Bombardier – Wednesday 9th July - Crewe

A meeting was held with Brian Harrop the Technical Support Engineer from Bombardier Crewe and with Kevin Bayliss and Richard McClune who are Engineers from Bombardier Bogies in Derby.

Findings

NIR 2986 was raised when the axle end cover was removed and the grease was found to be contaminated with water and carbon and the earth return assembly had seized and was not in contact with the axle end slip ring.

After the fleet check had been completed, 16 further wheelset ends were found to be not tabbed (NIR 2995) but no further water ingress was found. The fleet check involved around 1360 ends being inspected. The problems were found to have occurred randomly and could not be traced to a particular individual.

The immediate cause of the incident was found to be a pinched O-ring seal which had allowed water ingress through the front cover.

The underlying cause of the incident has been classified as a ‘Knowledge, skills and experience’ Incident Factor due to inadequate care / skill during assembly, with the fitter’s human error classified as an ‘Action Slip’.

The contributory factors were considered to be the unusually high rainfall experienced over the winter of 2013/14 which increased the risk of water ingress if bogie storage became compromised.

The actions taken to help reduce this type of incident were:

1. The fitters have been briefed on the issue at Bombardier Siegen and Derby, where the bogies were originally assembled.

2. NIR On-Line Timeline

The NIR was raised on 16th January 2014 and immediately input as ‘Complete’ due to the simple nature of the issue. The fleet check for vehicles in service was completed by the end of February 2014. Remaining vehicles still being assembled were completed by the 21st May 2014.
NIR 2986 – Earth return damage due to water ingress
NIR 2995 – Incorrect Assembly of Axle End Equipment

Background

Originator Meeting - Southern – Thursday 12th June - Selhurst Depot

A meeting was held with Dave Hickson and Iain Nairne from Southern Railways. Dave is the Fleet Engineer for ‘New trains’ and Iain is the Fleet Manager. Southern have had a lot of long running issues with axle bearings for their Class 377 Electrostar fleets and they have been trying to improve reliability.

Supplier Meeting - Bombardier – Wednesday 9th July - Crewe

A meeting was held with Brian Harrop the Technical Support Engineer from Bombardier Crewe and with Kevin Bayliss and Richard McClune who are Engineers from Bombardier Bogies in Derby.

Findings

NIR 2995 was raised when an un-tabbed tab washer was found when replacing a damaged WSP cable. A fleet check was carried out and 12 other un-tabbed axle ends were found along with missing locating screws (linked to NIR 2986). The torque tightness of all the bolts were checked and reported to be OK.

The bogies had been delivered directly from first assembly at Bombardier Siegen and the axle end covers had not been disturbed since delivery. During discussions, the Bombardier Engineers advised that these were the first of this type of wheelset ever assembled at Siegen. During recent visits by Southern Engineers to the Siegen factory, it was noted that additional checking and sign-off procedures had been put in place for all axle end assembly.

The Immediate cause of the incident was human error and was classified as a ‘Decision Error’ with the tab washers not being tabbed over and locating screws being missed.

The Underlying cause was classified as both ‘Practices and Processes’ and ‘Knowledge, Skills and Experience’ Incident Factors due to poor build process control and a lack of secondary inspection and sign-off. These classifications reflect the ‘learning curve’ that the staff were going through.

The Contributory factors to this issue were considered to be that these axleboxes were amongst the first to be assembled and delivered. The issue was not found on later builds.

The Actions taken to help reduce this type of incident were:

1. Additional checking of tabbing over and sign-off have been added to the build process procedure

NIR On-Line Timeline

The NIR was raised on 24th January 2014 and as with 2986 was immediately input as ‘Complete’ due to the simple nature of the issue. The first un-tabbed end was found on 10th November 2013. The fleet check for vehicles in service was completed by the end of February 2014. Remaining vehicles still being assembled were completed by the 21st May 2014.
NIR 2995 – Locking plate not tabbed over
NIR 2996 – Loose Bearing End Cap Bolt

Background

**Originator Meeting – GE Capital Rail Services – Friday 30th May – RSSB London**

A meeting was held with Les Bryant the Professional Head of Engineering. GERS owns 2100 vehicles which are leased to a number of RU’s which operate across Europe with 1200 having authority to operate in the UK. GERS customers include Freightliner, Colas, DB Schenker UK.

GERS currently buy new wheelsets from Lucchini in Manchester, the overhauls are carried out by Pullman Rail and wheel re-profiling and ultra-sonic axle testing by LNWR, among others.

Specifications were stated to have been developed by Interfleet to assist in the better management of GERS wheelsets.

**Supplier Meeting – LNWR – Tuesday 15th July – Crewe**

A meeting was held with Brian O’Hanlon the Quality Manager for LNWR who also provided a guided tour of the assembly areas and wheel lathe. LNWR are currently busy undertaking work for around 12 different customers. They maintain and overhaul a large amount of different stock, such as heritage DMUs, EMUs, and a wide range of wagons.

Findings

NIR 2996 was raised following identification of a damaged axle end cover at the Peak Forest depot. A fleet check was implemented to check all wheelsets recently tyre-turned and ultra-sonically tested (UAT) by LNWR and no further occurrences have been reported. Axiom and Direct Rail Services also checked their affected fleet and no further issues were reported. The fitter could not recall how he could have missed the tabbing procedure as he had been doing the UAT for many years without incident.

The **Immediate** cause of the incident was human error with a classification of ‘Memory Lapse’ by the fitter in not correctly fitting the tab washers and the end cap bolts were also not correctly torque tightened following tyre turning.

The **Underlying** cause was identified as being down to human factors. The Incident Factors were classed as ‘Practices and Processes’ and also ‘Supervision and Management’, due to incorrect specifications and incomplete paperwork.

The **Contributory** factors were considered to be the paperwork not being signed off (to confirm the tabbing was complete) as this should have acted as a secondary check before the vehicle was returned to the customer. It was also noted that GERS had not supplied the latest version of the job specification.

The **Actions** taken to help reduce this type of incident were:

1. Restricted release protocol for team leader to check tabbing and then sign-off
2. Review of all previous 3 months sign-off paperwork to check for missing signatures and follow up with customers if required
3. Review of wheel lathe management process and key elements to accept / reject work
4. Review of competence and training for lathe operative concerned
5. Change of process form to separate out tabbing over as an individual action for sign-off
The following reports were received after the meeting from GERS:

1. Report: LNWR INC 035 Incident Report – B O’Hanlon – Sequence of events and proposed improvements

**NIR On-Line Timeline**

The NIR was raised on the 6th February 2014 and was input as 'Initial'. On the 14th February the ‘Concluding’ report was added.

![Image of NIR 2996 Loose bolt damaged axlebox cover]
NIR 2998 – Axle Bearing Failures

Background

Originator / Supplier Meeting – First Hull Trains / Alstom– Thursday 3rd July – RSSB London

A meeting was held with Jon Plowright the Head of Engineering at First Hull Trains and John Williams the Product Safety Manager at Alstom. FHT have four Class 180 trains consisting of 5 cars each. Angel are the owners of the trains but FHT have a maintenance contract with Alstom to supply parts and technical expertise to Old Oak Common, which is operated by First Great Western. FHT are an ‘Open access’ operator and are not subject to franchise restrictions. A further nine Class 180 units are operated by First Great Western and Grand Central.

The four units were overhauled in the summer of 2012. The bogies were overhauled by Railcare Wolverton and the new wheelsets were supplied by Lucchini. New bearings were also fitted at Railcare and these were supplied by SNR from France. The units typically run fourteen services a day and cover 270,000 miles per year.

Findings

The first failed axle bearing was found on 12th December 2013 after the vehicle was reported for vibration. A further two failed bearings were found on 2nd February during routine inspection as grease was seen to be leaking from the axleboxes. NIR 3021 was raised when a fleet check on the 4th February 2014 revealed a 4th failed axle bearing. All the failed bearings were on trailer bogies and on the same side of the vehicle. The wheels and bearings had covered between 300,000 and 370,000 miles since new which was around a quarter of the desired bearing life.

On investigation each of the wheels being supported by the failed bearings was found to be severely tread worn compared to the other wheel on the same axle with a diameter difference of up to 10 mm. Initial thoughts were that the wheel material may have been soft, so the wheelsets were sent to Lucchini in Italy and also Serco in Derby. The investigations concluded that the material was correct and that the wheels also had a significant three lobe run-out of up to 2 mm.

The wheel lathes were checked and it was confirmed that the profiles had been correctly turned on each occasion. Measurements of the un-worn flange diameters confirmed this. Wheelchex vertical force recordings and Hot Axlebox Detector readings from the time of the incidents were requested from Network Rail. High dynamic forces of up to 300 kN were observed for the wheelsets in question but the HABD did not show particularly high temperatures.

The Immediate cause of the axle bearing failures was due to excessive vertical dynamic loading due to the wheels wearing out of round in a tri lobe pattern.

The Underlying cause was currently still under investigation and vehicle load distribution and dynamics were being looked into.

The Contributory factors cannot be determined at this stage as the investigation is still ongoing. It is considered that the bearings themselves are NOT a contributory factor.
The Actions taken to help reduce this type of incident were:

1. Depot staff are checking for signs of bearing failure on each exam and also measuring the wheel profiles with a MiniProf device to record development of wear patterns
2. Weekly Wheelchex and HABD recordings are being sent to FHT and Alstom for review
3. Wheel tread wear is being closely monitored and wheels are being re-profiled more often
4. Conference call every two weeks between FHT and Alstom to discuss progress

The following reports were received during the meeting with Alstom:

1. Lucchini Report – LTCR185a – S Foulkes – Class 180 Rim hardness vs Rim radial run-out
2. Serco Report - SERCO/AP/10040853 – A Palfreyman – Class 180 Wheelpans
3. Alstom Report – J Williams – Class 180 failed bearing investigation
4. Alstom Spreadsheet – J Williams – Class 180 wheelset data
5. ESR Technology Report - ESR/NCT/UC000499/2114/3930/Issue 1 – I Pleavin – Class 180 Bearing Failure Investigation

NIR On-Line Timeline

The NIR was raised on the 4th February 2014 as an ‘Initial’ report. No further updates have been added to NIR On-Line to date. The first bearing failure was found on 12th December 2013, followed by the 2nd and 3rd on the 2nd February and the 4th on the 4th February 2014.
NIR 2999 – HST Power Car, Axle Bearing End Cap, Defective Retaining Bolts

Background

*Originator Meeting – East Midlands Trains – Wednesday 18th June – Derby*

A meeting was held with Nigel Yule the Fleet Engineer at East Midlands Trains. East Midlands Trains have had an overhaul contract with Unipart Rail in Doncaster for many years. Unipart supplied the power bogies directly, but they subcontracted the individual wheelset overhaul to Wabtec who are located in close proximity. The BP10 bogies have been overhauled at Doncaster since 2007 and East Midlands Trains have been generally very pleased with the quality of the overhaul.

*Supplier Meeting – Wabtec – Wednesday 16th July – Doncaster*

A meeting was held with Ian Moverley the Quality Assurance Manager at Wabtec Doncaster, who also provided a tour of the wheelset assembly areas and wheel lathe.

The design of the axle end caps was changed several years ago to increase the diameter of the central hole to enable UAT to be carried out without the need to remove the end cap. Unfortunately it was later discovered that due to the reduced stiffness of the cap, distortion could occur due to tightening of the end cap bolts and minor damage had been observed on the rotating earth return equipment (similar issue to that found in NIR 3001). During the past 15 months the design of the end cap has been changed back to the previous design.

Findings

NIR 2999 was raised after an end cap retaining bolt failed during removal whilst carrying out UAT. On further investigation at the scene, other bolts were found to have necked under torque tightening and so a full investigation was started.

The initial thoughts were that the bolts were defective. Serco carried out an independent investigation on the failed bolts and the end cap fitting process. Unipart also carried out their own investigation into the bolts. The conclusion from the independent investigation was that the failed bolts (with DFL markings) did actually just meet the minimum hardness values and the metallurgical composition was OK. The cause of the failed / necked bolts was thus put down to over tightening of the bolts on assembly.

The *Immediate* cause of the failed bolt was that the fitters, in accordance with the specification, over-tightened the bolts by continuing to torque tighten each bolt in turn again and again and then rotating the bolt head to align with the tab washer, coupled with the bolts only just meeting the required strength.

The *Underlying* cause Incident Factor was classified as ‘Practices and Processes’ due to the method of torque tightening procedure not being adequately defined and also the design of the tab washer making it difficult to bend the tabs up.

The *Contributory* factors were considered to be due to the fact that the DFL bolts only just met the minimum strength requirements and this highlighted the issues in the tightening procedure where other manufacturer’s bolts had not had a problem. It was also noted that many specifications have a torque range as opposed to a single figure, which allows for some further bolt rotation during the tabbing process.
The **Actions** taken to help reduce this type of incident were:

1. Wabtec have now implemented a two-stage torqueing process, where the bolts are torqued to 85 Nm in turn in a diametrically opposite sequence and then fully torqued to the full 98 Nm in turn with no further checking

2. The tab washers are being slightly bent up at the corners before the bolts are tightened so that it is easier to tab them over once the bolts have been torqued. This reduces the need to align the bolt heads and risk over tightening the bolts

3. The bolt holes are being cleaned thoroughly with a de-greaser

4. The DFL electro-zinc plated (EZP) bolts have been replaced with plain blackened bolts (the original specification called up plain bolts not EZP). (It is noted that some customers have requested that EZP are still used and have raised a concession). Wabtec confirmed that they are no longer using bolts with the DFL markings.

5. 26 affected axles have been identified and it has been recommended that the bolts are replaced

The following report was received after the meeting:


**NIR On-Line Timeline**

The NIR was raised on the 11th February 2014 and input as an ‘Initial’ report. The ‘Concluding’ report was submitted on 24th June 2014 when the Wabtec report (TR-14-023) was added.
NIR 3000 – Multiple Bearing Failures

Background

Originator Meeting – GE Capital Rail Services – Friday 30th May – RSSB London

A meeting was held with Les Bryant the Professional Head of Engineering. GERS owns 2100 vehicles which are leased to a number of RU’s which operate across Europe with 1200 having authority to operate in the UK. GERS customers include Freightliner, Colas, DB Schenker UK.

GERS currently buy new wheelsets from Lucchini in Manchester, the overhauls are carried out by Pullman Rail and wheel reprofiling and ultra-sonic axle testing by LNWR, among others. Specifications were stated to have been developed by Interfleet to assist in the better management of GERS wheelsets.

Supplier Meeting – Pullman Rail – Monday 14th July – Cardiff

A meeting was held with Bob Williams the Quality Manager for Pullman Rail who also provided a guided tour of the assembly areas. Pullman are currently very busy undertaking work for many different customers. The workshop was full of a wide range of different wheelsets and axlebox arrangements.

Findings

NIR 3000 was raised following a JNA wagon on route from Peak Forest to Attercliffe being stopped after it was identified as having severe bearing failure on 3 of the 4 wheelsets.

Three wheelsets were sent to Serco for an independent investigation; two with heavily damaged bearings and the other wheelset with less noticeable damage. The Serco report concluded that the third wheelset would also have failed prematurely due to a large amount of water mixed in with the bearing grease, possibly due to inadequate storage. The fourth undamaged wheelset was not sent for analysis.

Pullman Rail immediately contacted all of their customers to whom they supply this type of wheelset (with the end cap arrangement) to advise them to carry out checks. Many of the operators involved reported that the wheelsets in question had been in service for some time and therefore if the end caps had been missing the bearings would have already been destroyed.

The Immediate cause of the bearing failures was considered to be due to Human Error where the fitter had a ‘Memory Lapse’ and forgot to fit the end caps. It is believed the wheelsets were removed from the production line without having the key process carried out of fitting the end caps. This allowed the inner race of the bearing to be displaced resulting in irregular loading of the bearing leading to overheating and rapid catastrophic failure.

The Underlying cause was considered to be partly due to an organisational and cultural issue within Pullman Cardiff. The classification for the inspector was ‘Routine Violation’ as he admitted not checking every wheelset assembly even though he had signed to say he had done. In addition, the fitter also carried out what was believed to be a ‘Routine Violation’ as he signed off the documentation to say that the work had been carried out.

The Contributory factors were considered to be ‘Supervision and Management’, due to processes and procedures not been strictly followed for some time and this had become the norm.
The **Actions** taken to help reduce this type of incident were:

1. The fitter and inspector were dismissed
2. Review of competence and training for wheelset operatives
3. Review of job process and specification documentation
4. Review of storage and handling of spares

The following reports were received after the meeting from L Bryant:

1. Report: GE AF 14/04 Incident report – Adrian Freely – Initial rescue of vehicle and findings

Atkins, the RISAB responsible for Pullman’s RISAS approval, have also carried out an investigation into this incident and improvements have been requested.

**NIR On-Line Timeline**

The NIR was raised on the 19th February 2014 as an ‘Initial’ report. Two further ‘Interim’ updates were provided on the 20th February and the ‘Concluding’ report was added on the 21st February 2014.

![NIR 3000 – Failed bearing due to no end caps being fitted](image-url)
NIR 3001 – Catastrophic Failure of Axle End Earth Assembly leading to Axle Bearing Disintegration

Background

*Originator Meeting - Southern – Thursday 12th June - Selhurst Depot*

A meeting was held with Dave Hickson and Iain Nairne from Southern Railways. Dave is the Fleet Engineer for ‘New trains’ and Iain is the Fleet Manager. Southern have had a lot of long running issues with axle bearings for their Class 377 Electrostar fleets and they have been trying to improve reliability.

*Supplier Meeting - Bombardier – Wednesday 9th July - Crewe*

A meeting was held with Brian Harrop the Technical Support Engineer from Bombardier Crewe and with Kevin Bayliss and Richard McClune who are Engineers from Bombardier Bogies in Derby.

Findings

NIR 3001 was raised after smoke was noticed around the underframe of the vehicle on arrival into London Victoria station. One end of one wheelset was found to be destroyed due to a failed axle bearing.

Tolerance variations with the axle end components, design of the axle end cap tab washer and differing fastener lengths have resulted in problems achieving reliability of the assembly. The initial cause of debris in the bolt holes and bolts bottoming out was found not to be the case.

The **Immediate** cause of the bearing failure was due to interference within the rotating axle end earth assembly which became worse over time and resulted in arcing and then catastrophic failure of the earth assembly and the shearing of the axle end cap bolts which enabled the inner race of the bearing to become displaced.

The **Underlying** cause is still to be fully confirmed but it is considered that it is due to a combination of the axle end earth assembly components being out of tolerance and distortion of the end cap due to over tightening of the bolts which require the head to align with the tab washer. The assembly process had not made it clear that this could happen or the effect of rotating the head a further 1/12 of a turn, so the Incident Factor has been classified as ‘Practices and Processes’.

The **Contributory** factors were the fit on some of the axle end earth return assembly pieces and the supplier Schunk are looking into the component tolerances.

The **Actions** taken to help reduce this type of incident were:

1. The overall design of the axle end earth assembly and the tab washer is being reviewed
2. Components with rotating clearance requirements have been matched during assembly after torque tightening has been completed.

**NIR On-Line Timeline**

The NIR was raised on the 20th February 2014 and input as the ‘Initial’ report. No further updates have been added since then and the NIR is still ‘Open’.
NIR 3001 – Failed bearing due to axle end earth assembly fouling
NIR 3011 – TF25 Axle Journal Incorrect Finish

Background

**Originator Meeting – GE Capital Rail Services – Friday 30th May – RSSB London**

A meeting was held with Les Bryant the Professional Head of Engineering. GERS owns 2100 vehicles which are leased to a number of RU’s which operate across Europe with 1200 having authority to operate in the UK. GERS customers include Freightliner, Colas, DB Schenker UK.

GERS currently buy new wheelsets from Lucchini in Manchester, the overhauls are carried out by Pullman Rail and wheel reprofiling and ultra-sonic axle testing by LNWR. Specifications were stated to have been developed by Interfleet to assist in the better management of GERS wheelsets.

A meeting was not held with the supplier Lucchini because a full report produced by Lucchini had already been received via GERS explaining the situation.

Findings

GERS raised the NIR following the identification of a substandard surface finish on an axle journal and felt that it was justified because the supplier, Lucchini, also provide axles to the wider industry.

The **Immediate** cause of the incident was classified with the Incident Factor of ‘Equipment’ due to chatter on the grinding machine causing the axle journal to have a rippled finish. Lucchini stated that this was a one-off and they have not seen this occur before.

The **Underlying** cause of the incident was part process and part human error. The grinder operator made a ‘Decision Error’ as he noticed the strange finish, but on measuring the surface roughness he thought that it passed the requirement and let it go. There was also a ‘Practices and Processes’ issue as although tested in accordance with the surface sampling criteria the test failed to detect the particular surface condition that should have identified it as unsatisfactory.

The **Contributory** factors were considered to be that the operator went against his better judgement after noticing the strange finish, due to the reasons explained above.

The **Actions** taken to help reduce this type of incident were:

1. Changes to the surface testing requirements have enabled the surface finish to be reliably quantified.

The following reports were received after the meeting from L Bryant:

1. Report: GE AF-039-03/14 Site Visit Report – Adrian Freely – Initial report on axle identified at LH Group  
3. Report: Follow up explanation email – Sean Barson – Explained that axle was re-ground but reached minimum diameter and so was removed from production line.

**NIR On-Line Timeline**

The NIR was raised on the 14th March 2014 and input as the ‘Initial’ report. The ‘Concluding’ report was added on the 28th March 2014 after the conclusions by Lucchini had been reached and submitted.
NIR 3021 – Detached BT10 Bogie WSP Axle End Distance Piece

**Background**

*Originator Meeting – East Coast Main Line – Tuesday 1st July – Derby*

A meeting was held with Keith Mack the Engineering Standards Manager from East Coast Main Line (ECML). Keith is also the Chairman of the BSi Bearing Group. Porterbrook have a contract with Unipart Rail for overhaul of BT10 B bogies who supply them to ECML and also to Cross Country and Chiltern Railways. There are fourteen nine car HST sets in the ECML fleet, so there are 504 wheelsets in total. Each trainset typically covers over 1000 miles each day.

*Originator Meeting – Unipart Rail – Wednesday 16th July – Doncaster*

A meeting was held with Roy Green the Technical Support Manager at Unipart Rail Doncaster. Unipart are also busy with many current contracts and carrying out audits on their sub-suppliers such as Wabtec. They have also recently requested their RISAB (SGS Correl) to carry out audits on their own bogie overhaul operations and found this to be a valuable exercise.

**Findings**

NIR 3021 was raised when a detached axle end distance piece was found on inspection at Neville Hill depot. After a fleet check, 43 other bolts were found to be loose on the same unit, but no others on any of the other thirteen units. The incident was considered to be particularly important to raise as an NIR due to the large fleets of vehicles operating with BT10 bogies.

A new neoprene gasket had started to be used for at least the past three years to solve the water ingress problem that had been occurring. No loose bolts had been reported during this time until the NIR was raised. The unit had the bogies overhauled in January 2014 and had covered approximately 100,000 miles in the three months before the incident was identified. Aluminium distance pieces were being used combined with a 1.5 mm Neoprene gasket.

ECML requested Unipart to carry out an investigation and Doncaster Analytical Services (DAS) were appointed to carry out an independent investigation. The conclusion of the investigation was that the bolts had been torque tightened but that it appeared that some had been tightened higher than others but no torque figures could be estimated. The vehicles involved were checked for wheel or bearing damage that could have led to excessive axlebox vibration, but nothing was identified.

The **Immediate** cause of the incident was that the M10 retaining bolts had come loose and allowed the distance piece to separate from the axlebox and foul the rotating phonic wheel.

The **Underlying** cause could not be definitively determined and investigations are ongoing. Initial investigations have shown that the neoprene gaskets can relax and allow bolts to lose pre-load. This theory does not explain why the issue has not happened before over the previous three years and why so many loose bolts were found on one particular unit. The issue has been classified with the Incident Factor of ‘Practices and Processes’, as no fault by the fitters could be determined and the process has now been updated to reduce the likelihood of the bolts coming loose.
The Contributory factors are thought to be that possible inconsistencies in the thickness of the gasket could allow some bolts to lose most of the pre-load. There were also some minor issues with the assembly procedure in that the spring washers and plain washers were not as specified, but this was how it had been for many years and was not thought to affect the pre-load.

The Actions taken to help reduce this type of incident were:

1. Assembly operatives have been briefed on the issue and signed records obtained
2. Trials have been carried out to check if bolts lose pre-load due to the neoprene gasket relaxing and this was confirmed to be the case; reducing to 70% on average after 1 hour, but no further relaxation after 48 hours
3. M10 Bolts were being torqued to 35 Nm on two occasions due to initial pre-load reducing after 1 hour.
4. Neoprene gaskets are being checked for consistency of thickness
5. The aluminium distance pieces are also being checked for flatness on surface tables with feeler gauges
6. Loctite 243 threadlock (which supercedes 242) is now being used on the threads of the M10 bolts (instead of the torque tightening on two occasions as initially carried out in 3. above.)

The following reports were received during the meeting with ECML:

1. DAS Report – U0178A – S. Lee – Comparative analysis of failed bolts
2. DAS Report – U0178B - S. Lee – Analysis of 4 bolts to determine level of torqueing
3. DAS Report – U0178C – S. Lee – Chemical analysis of bolts, spacers and spring washers

NIR On-Line Timeline

The NIR was raised on the 8\textsuperscript{th} April 2014 and input as the ‘Initial’ report. This was updated to an ‘Interim’ report on 1\textsuperscript{st} July 2014 and then the ‘Concluding’ report was issued on the 7\textsuperscript{th} July 2014.

NIR 3021 – Phonic wheel damage due to loose distance piece
NIR 3041 – Class 185 Axle End Earthing Disc fitted back to front

Background

A telephone conversation was held with Eddie Knorn the Standards Engineer from First / Keolis TransPennine Limited (FTPE). First / Keolis have operated a fleet of fifty-one Siemens Class 185–three car diesel multiple units since 2007. FTPE have a contract with Eversholt Rail Group who have a contract with Siemens for all aspects of maintenance. Siemens subcontract out bogie overhaul to Unipart Rail.

A meeting was not held with the supplier as the issue was clearly just a simple human error and there was nothing further to be gained from another meeting.

Findings

The NIR was raised after minor damage was found on one axle end earth return assembly. The vehicle was undergoing routine maintenance by Unipart Rail in Doncaster and on removal of the axle end cover the damage to the earthing disc was noticed. On investigation it was determined that the earthing disc had been fitted the wrong way around. The axle end earth return assembly had recently been fitted when the wheelset was renewed six weeks earlier. Similar incidents had been found before after direct delivery from Siemens.

The **Immediate** cause of the incident was that the earthing disc was mistakenly fitted back to front so this has been given the human error classification of ‘Decision Error’, due to the fitter inadvertently choosing to fit the component the wrong way around.

The **Underlying** cause was given the Incident Factor classification of ‘Practices and Processes’ as there was considered to be a weakness in the documentation provided to the fitter to carry out the task as the procedures were not sufficiently explicit to describe the correct orientation of the earthing disc.

The **Contributory** factors were considered to be the fact that the design of the earthing disc enabled it to be fitted back to front. Good design practice should make this impossible where practicable.

The **Actions** taken to help reduce this type of incident were:

1. Wheelset renewal procedure re-written by Siemens to provide greater clarity of orientation of the earthing disc.
2. Siemens depot staff briefed on the incident and the new procedure.

**NIR On-Line Timeline**

The NIR was raised on the 4th June 2014 and was input immediately as ‘Complete’ due to the simple nature of the issue. The damaged earthing disc was actually found on the 16th May 2014.
NIR 3054 – BT10 Bogie WSP Axle End Distance Piece and Cover Detached

Findings

This NIR was also discussed with Keith Mack from East Coast Main Line and Roy Green from Unipart Rail the supplier. It concerns the same bogie type and was considered to show exactly the same failure mode as NIR 3021, so all the conclusions and recommendations associated with NIR 3021 also apply to NIR 3054.

NIR On-Line Timeline

The NIR was raised on the 20th June 2014 and was input as the ‘Initial’ report. The issue was discovered on the 19th June 2014. No further updates have been added to date and the NIR is still open.

NIR 3054 – Axle end distance piece missing
Appendix F:

Human Factors Checklist Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition / explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory lapse</td>
<td>Memory lapses are errors concerned with failure of short or long-term memory. So these error types are to do with if the person forgot or mis-recalled information, or forgot to do something.</td>
</tr>
<tr>
<td>Perception slip</td>
<td>Perception slips are errors in visual detection and searching, and listening errors. So these error types are to do with if a person mis-saw or mis-heard, or failed to see or hear something.</td>
</tr>
<tr>
<td>Action slip</td>
<td>Action slips are when actions or speech are not performed as planned (ie unintentionally). Such errors or speech are the execution of correctly formed decisions. So these types of error are to do with a person doing or saying something they did not intend, or being inadvertently incorrect or unclear.</td>
</tr>
<tr>
<td>Decision error</td>
<td>Decision errors are errors in acts of judgement, decisions or strategies. They typically rely on knowledge and information being correctly recalled but wrongly applied. So these types of error are to do with errors in making decisions or deciding on what to do in situations.</td>
</tr>
<tr>
<td>Routine violation</td>
<td>This is when breaking the rule or not following the procedure has become the normal way of working. It is almost invisible until there is an accident (or sometimes as the result of an audit). Usually routine violations occur because the rule is considered unnecessary or is not given any consideration because the act has become a habit (eg a shunter who habitually gets on and off the pilot engine while it is moving.).</td>
</tr>
<tr>
<td>Situational/exceptional violation</td>
<td>A situational/exceptional violation may occur when the work situation or exceptional circumstances make the rules difficult or impossible to follow. This may be because the procedures are impractical, unrealistic or even unsafe, in a particular environment (eg driver who keeps going even though they have lost sight of the shunter during a movement or rules are broken due to an emergency situation where breaking the rule seems necessary as it would be the safer course of action – setting back out of a tunnel with a fire on the train).</td>
</tr>
</tbody>
</table>
## 10 Incident Factor Descriptions

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal</td>
<td>Personal refers to a collection of influences that may affect the individual (in particular that individual’s ability to maintain attention and focus whilst at work), and the way in which an individual approaches a task.</td>
</tr>
<tr>
<td>Communication</td>
<td>Communication is concerned with how we relay information to each other in the context of safety critical information. This typically includes people not communicating information at all or not reaching a clear understanding when they are communicating. It is concerned with the exchange of verbal information only.</td>
</tr>
<tr>
<td>Practices and processes</td>
<td>This refers to <strong>front line</strong> rules, standards, processes and methods of working which guide and structure how certain activities are undertaken on the railway. It includes the operational rules in the Rule Book, technical standards which dictate how activities should be undertaken such as maintenance, fault identification, repairs or reporting, safe systems of work that are set up to protect people in safety critical and other railway environments. Practices and processes may not be available, they may not be adequate for the task or difficult to use.</td>
</tr>
<tr>
<td>Information</td>
<td>Written information is used by staff to support an activity. Railway examples include: train running information, timetable simplifiers, late notices, special train notices, weekly/periodic operating notices, pre-job information, electrification/isolation diagrams and signage. It also includes information about changes to technical and operational standards. Information must be relevant and timely: It is of no use to receive a late change to the weekly operating notice informing signallers and track workers about changes to the possession limits after the date of the possession. This category is concerned primarily with information that is written. Information passed verbally is captured by the ‘Communications’ incident factor.</td>
</tr>
<tr>
<td>Equipment</td>
<td>This refers to any equipment that is used to undertake or support an activity and can be a factor if it is not being used as intended, if it is faulty, if its design is not compatible with its use or if the layout is not in the order in which it is used.</td>
</tr>
<tr>
<td>Knowledge, skills and experience</td>
<td>Knowledge, skills and experience can be a factor in an accident / incident if the individual(s) involved did not have the appropriate knowledge to perform safely or if they were not familiar with the circumstances in which they found themselves.</td>
</tr>
<tr>
<td>Factor</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Work environment</td>
<td>The working environment (both inside and outside of the driving cab) contains environmental stressors such as lighting levels, noise, temperature and vibrations. These can lead to feelings of discomfort or act as distractions, impacting on an individual’s performance.</td>
</tr>
<tr>
<td>Teamwork</td>
<td>This is concerned with how a team is put together, and the interactions at the team-level. There are certain factors that will influence the likelihood of team errors including the number of people in the team, team structure, team stability and team leadership.</td>
</tr>
<tr>
<td>Workload</td>
<td>Workload is about the demand created by particular activities. If the workload is in excess of acceptable limits it will be stressful, fatiguing, de-motivating for the individual and which will make their performance slower and less accurate.</td>
</tr>
<tr>
<td>Supervision and management</td>
<td>Supervisors and managers can be an underlying reason for an accident or incident because of the decisions they make about resources, budgets, risk assessment, work allocation and planning. They can also have a more direct impact through the example they set and the monitoring and assessment processes they have responsibilities for which are aimed at detecting and managing errors or the potential for errors.</td>
</tr>
</tbody>
</table>