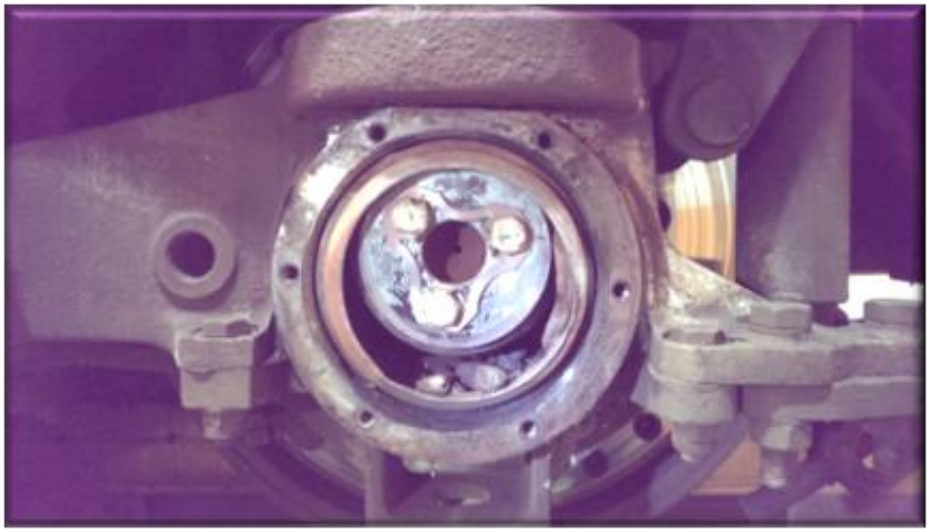
Axle Bearing NIR Investigation 2016 Report v1

Sponsor:
Hugh O'Neill
Professional Head of Rolling Stock Standards

Investigation conducted by:
Colin Bryan, RISAS Assurance Engineer
Supported by:
John Barber, Principal Assurance Engineer and Martin Osman, Vehicle Dynamics Engineer



Published by RSSB

CONTENTS

1 Introduction

This report documents the investigation into a further series of NIRs relating to wheelsets and axle bearings. It follows on from the investigation carried out in 2014 and was aimed at two specific elements. These were whether any new issues had been identified which had led to the NIRs being issued, and what implementation had taken place following the issue of RSSB research reports T774, relating to ultrasonic axle testing. The remit for the investigation is given in Appendix A.

2 Population of NIRs

The base details of the NIRs raised between July 2014 and March 2016 are in Table 1. Further details of each of the NIRs are given in Appendix B.

Table 1 Wheelset and axle bearing NIRs

Number	Date	Vehicle	Raised by	Cause	Supplier
3113	30 Jan 15	375	LSE Railway Ltd	Incorrect gasket supplied	Bombardier
3121	20 Feb 15	458	South West Trains	Electrical damage due to earth bond issues	Not advised
3143	22 May 15	158	First Great Western	Bearings not assembled correctly	SKF Italy
3163	20 Jul 15	332	Heathrow Express	Bearing not fitted correctly	LUR
3171	4 Sep 15	N/A	EMT on behalf of LH	Poor overhaul practices identified during assessment	LH Group
3172	9 Sep 15	PCA	Freightliner	Axle end cap not fitted	Wabtec Scotland
3178	14 Sep 15	JGA	NACCO	Not clear – bearing overhauled 5/11	LH group
3179	22 Sep 15	JNA	GECapRS	Bearings incorrectly greased at supplier	SKF
3188	27 Oct 15	221	West Coast Trains	Bearings potentially used beyond design life	Bombardier
3192	17 Nov 15	N/A	LUL	Counterfeit bearings identified prior to fitting	Not advised
3210	28 Dec 15	158	Arriva Train Wales	Tab washer not tabbed up	Wabtec Doncaster
3225	1 Mar 16	OBA	Network Rail	Bearing ages not in accordance with maintenance plan	Wabtec Doncaster

Following a review of the detail, it was decided to take no further action in relation to NIRs 3121, 3171 and 3178 for the following reasons:

- 3121 and 3178 both describe a catastrophic bearing failure. Investigations have taken place but no underlying causes can be established beyond doubt, although similar bearings to the failed one in NIR 3121 showed signs of electrical damage. This is already known as a significant cause of bearings being scrapped.
- NIR 3171 was issued as a result of a surveillance visit by a RISAB to the wheelshop. The problems had been found and were being dealt with. Further details are given in section 4 concerning RISAS approved suppliers.

In the previous axle bearing NIR report there had been 11 NIRs in six months, between January and June 2014. This investigation looked at 12 further NIRs, but over a twenty-month period, between July 2014 and March 2016. No new NIRs relating to axle bearings were raised in the first six months (July – December 2014).

3 Definition of causes

RSSB's publication from 2014 'Investigation Guidance Part 3' defines only two types of causes, **immediate** and **underlying**. It also acknowledges that the RAIB uses causal and contributory factors.

Immediate cause is defined as:

> *The error/unsafe act or condition just before the accident. Usually there would be only one such immediate cause,*

Underlying cause refers to:

> *What are also known elsewhere as **root causes** and all the causes that may have preceded the **immediate** cause and the associated unsafe act and/or conditions.*

Table 2 gives details of the immediate cause and underlying cause for each of the NIRs where it was possible for them to be identified.

Table 2: Causes of NIRs raised between July 2014 and March 2016

NIR	Title	Immediate Cause	Underlying Cause
3113	Axle end earth equipment sheared off	Supply of incorrect thickness gasket	lack of control of supply chain
3121	Bearing collapsed	Not known	Possible defective earth braids
3143	Incorrect bearing assembly	Incorrect assembly of bearings	
3163	Incorrect bearing assembly	Incorrect location of bearing on axle	New type of wheelset to be overhauled. Transport stillage awkward to use, Bearing pressure advised was wrong
3171	Assessment concerns	Failure of staff to comply with policies and procedures	Poor management and culture
3172	Missing axle end cap bolts	Axle end caps not fitted	Method of working for this type of activity Human error
3178	Bearing failure	Not known	Not known
3179	Bearing overhauled incorrectly	Bearing failed rotation test	
3188	Bearings overhauled too many times	Bearing overhaul policy not defined	Failure of customer to specify bearing overhaul policy Failure of customer to track its bearings
3192	Counterfeit bearings supplied	Failure to order bearings in time	OEM not able to supply
3210	Axle end cap bolts not tabbed up	Failure to tab up washer	Method of working for this type of activity Route card not identifying task as critical ATW not advising Wabtec of criticality of task Assessments not challenged control of task
3225	Overdate bearing fitted	Fitting of overdate bearing	Route card not clear on bearing life

Summary of **Immediate causes** is as follows:

Incorrect assembly during overhaul	3
Defective material	3
Bearing age	1
Not known	2
Production issues	1
Bearing policy not defined	1
Defect not proven	1

Table 3 shows the comparison of the immediate causes from the 2014 NIRs with those from this report.

Table 3: Comparison of Immediate causes from 2014 report

Cause	2014	2016
Incorrect assembly	8	3
Defective material	1	3
Material damage	1	
Suspension loading	1	
Bearing age		1
Not known		2
Production issues		1
Bearing overhaul policy not defined		1
Defect not proven		1

In the recent examples there have been three cases of incorrect assembly in 20 months, compared with eight cases in 6 months in the previous report. This suggests, on the basis of the NIRs examined, a significant reduction in the frequency of assembly defects has been achieved, for which suppliers should be congratulated. However, no statistical significance may be drawn from this, as the NIR On-line process is not designed to collect all incidents of this nature. It should be noted though that there has been an increase in defective material entering the supply chain and increased reporting of catastrophic bearing failures.

4 RISAS Approved Suppliers

Four different companies are involved as suppliers in the incidents, with a number of different sites involved. These are listed in table 4. It should be borne in mind that Wabtec operates a significant number of wheelshops in this country, so has the largest throughput of wheelsets.

Table 4: RISAS Certification

Company	Location	RISAS Approved	NIRs
Wabtec	Scotland	Yes: - SGS Correl	3172
	Doncaster	Yes: - SGS Correl	3210, 3225
	LH	Yes: - SGS Correl	3171, 3178
Bombardier	Ramsgate	No	3113
	Central Rivers	No	3188
	Crewe	Yes: - SGS Correl	3188
Lucchini Unipart Rail	Manchester	Yes: - SGS Correl	3163
SKF	Italy	No *	3143
	Luton	No	3179
Not advised			3121, 3192

* SKF Italy is an IRIS approved supplier

In each case, where relevant, the RISAB concerned, SGS Correl, had followed up the NIR with the supplier and had assessed whether the incident had an effect on the certificate. In one case, NIR 3171, the company voluntarily suspended production whilst immediate improvements, including changes in supervision, were carried out. The new protocol within RISAS has helped support this action and gives the RISAB the chance to revise its approach for any future assessment.

SGS Correl also applied the requirements of clause 3.5.5 of RISAS/003 during its surveillance of L H Group when it found unsafe practices, resulting in NIR 3171 being issued.

When considering the causes of these NIRs, there is little that could be changed in the scheme to prevent the incidents happening. However, the knowledge of the causes and the ability to tune following assessments to review areas of interest, will improve the effectiveness of the wheelset and bearing overhaul process.

It should be noted that one of the NIRs was raised against an IRIS approved supplier.

5 Human Factors

Table 5 below give details of the human factors involved in the incidents. These have been reviewed with Huw Gibson a specialist from the RSSB Human Factors' team, who was also involved in the earlier 2014 investigation.

Where no further investigation of the cause of the incident has taken place, no human factors categories have been assigned.

The definitions of the incident factors have evolved over the intervening period, with one, in particular, having a significant change. Management and Supervision has now been amended to Leadership and Risk Management. This provides a much clearer focus if it is considered that the culture of the company is an underlying cause of any issue.

Table 5 shows the human factors classification associated with each NIR.

Table 5: Human Factors classification

NIR	Brief Description	Practices and Processes	Knowledge Skills and Experience	Leadership and Risk Management	Equipment
3113	Axle end earth equipment sheared off	X			X
3121	Bearing collapsed				
3143	Incorrect bearing assembly				
3163	Incorrect bearing assembly	X		X	X
3171	Assessment concerns	X	X	X	
3172	Missing axle end cap bolts	X			
3178	Bearing failure				
3179	Bearing overhauled incorrectly				
3188	Bearings overhauled too many times	X		X	
3192	Counterfeit bearings supplied	X			X
3210	Axle end cap bolts not tabbed up	X			
3225	Overdate bearing fitted	X		X	
Totals		**8**	**1**	**4**	**3**

Four of the incidents have no classification, as there was no information on causes. Most of the others showed symptoms of lack of effective practices and processes. Many also had issues with leadership and risk management.

Table 6 compares the number of each human factor in the 2014 investigation with the ones in this investigation.

Table 6: Comparison of Human Factors

Report	Practices and Processes	Knowledge Skills and Experience	Leadership and Risk Management	Equipment
2014	8	2	2 *	1
2016	8	1	4	3

*One of the 2014 NIRs classified as Management and Supervision would not be classified as Leadership and Risk Management under the new definition, so there has been a significant increase in this category in the 2016 investigation.

The chart in Fig 1, compares the percentages of the 2014 findings with those in this report. There has been a slight change in the distribution, with a small reduction in the frequency of knowledge and skills. However, this is offset by an increase in leadership and risk management and also equipment. The equipment issue is all associated with procurement and effective control of suppliers, so there needs to be greater emphasis on these issues. The drafting of RIS-2750-RST should help to address the issues identified in this report.

Fig 1: Comparison of Human Factors

There are also human error issues. Table 7 lists the 2016 NIRs and identifies which ones involved human errors and what the classification was.

Table 7: Human Error classification

NIR	Brief Description	Memory Lapse	Action Slip	Routine Violation	Decision Error
3113	Axle end earth equipment sheared off				
3121	Bearing collapsed				
3143	Incorrect bearing assembly				
3163	Incorrect bearing assembly				
3171	Assessment concerns			X	
3172	Missing axle end cap bolts	X			
3178	Bearing failure				
3179	Bearing overhauled incorrectly				
3188	Bearings overhauled too many times				
3192	Counterfeit bearings supplied				
3210	Axle end cap bolts not tabbed up	X			
3225	Overdate bearing fitted				X
Totals		**2**		**1**	**1**

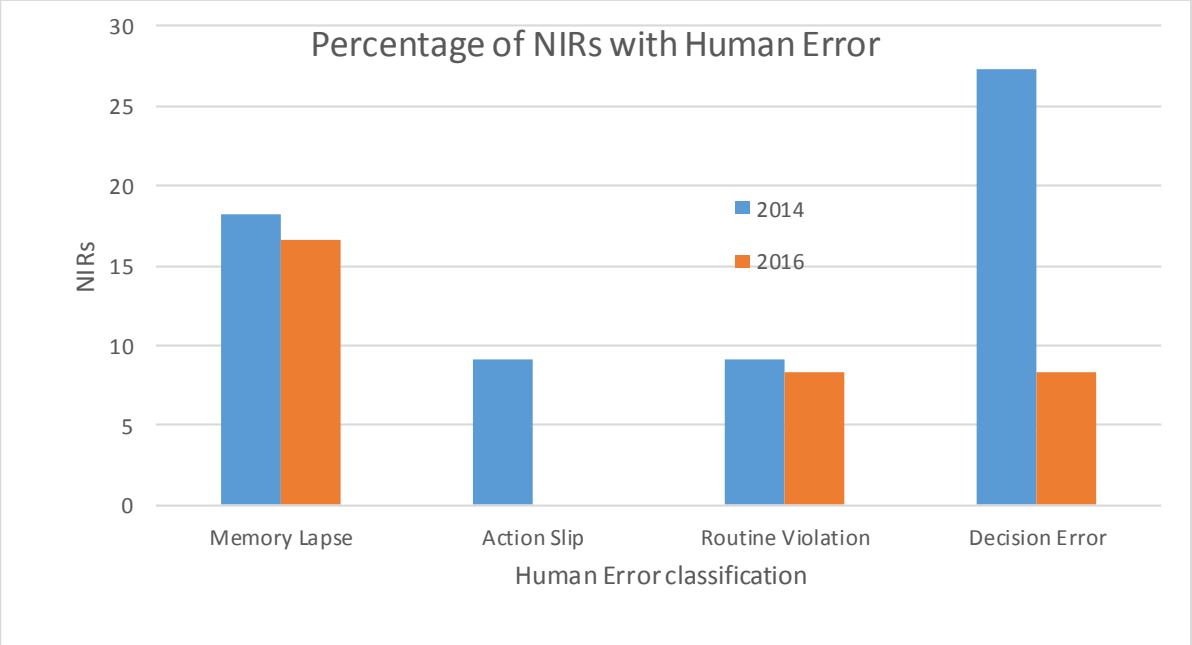
Only four NIRs have been identified as having human error involved. This compares with five in the previous investigation. The comparison is given in table 8 below.

Table 8: Human Error comparison

Report Date	Memory Lapse	Action Slip	Routine Violation	Decision Error
2014	**2**	**1**	**1**	**3**
2016	**2**		**1**	**1**

The chart Fig 2, shows the percentage of each type of human error.

Fig 2: Comparison of Human Error Classifications



The figures show a small reduction in human error, from seven in the 2014 report to four in this report. However, where it has not been possible to identify the error specifically, no category has been assigned. The only significant change is a reduction in decision errors.

6 Data availability

As with the previous 2014 report, the analysis has focused on the NIRs raised. There is no indication whether these represent a significant proportion of wheelset and axle bearing incidents as there is no coherent data capture requirements within the industry.

It is disappointing that no advice has been received that recommendation 5 of the previous 2014 report has been effectively actioned in a coordinated manner, enabling analysis and safety performance monitoring. However, at a recent Wheelset Management Group meeting, at which the findings of this report were presented, one representative believed that ATOC had carried out such an exercise.

7 T774 Research Reports - Dissemination

In 2012, RSSB carried out a human factors scoping study into ultrasonic axle testing, particularly concentrating on the UAT inspectors' activities. The output from this was a remit for further work. This is given in Appendix C. This was followed up by field work resulting in a large report in 2014. The recommendations from that report are given in Appendix D.

This field work involved visits to three depots and two overhaulers, but for the sake of confidentiality, these are not identified in the main T774 report.

During this investigation into wheelset NIRs, visits were made to three wheelshops, at Kilmarnock, Manchester and Doncaster, and discussions held with a fourth, at Crewe.

7.1 Wabtec Scotland, Kilmarnock

Wabtec Scotland had not been involved in the fieldwork for T774 and the wheelshop manager was not aware of the report. An electronic copy was passed to him, for review and to see if any changes should be made. This again highlights the issue of how wheelset overhaulers receive copies of this report specifically, but, more generally, how useful research is made available to anyone in the industry that would benefit from it. An improved supply chain would, of course, benefit all RSSB members.

7.2 Lucchini - Unipart Rail, Manchester

The Lucchini site at Trafford Park volunteered that it had been one of the sites visited and had received a copy of the draft report prior to publication. It had taken no deliberate action as a result of the work. It was, however, carrying out a culture change programme at the site, but this was focussed more on health & safety behaviour, although it expected that there would be benefits throughout the business.

7.3 Wabtec, Doncaster

Wabtec, Doncaster had not been involved in the T774 study, but had been briefed on it by one of their major customers, DB Schenker, in particular Paul Antcliff. As Wabtec was not a member of the RIA, so not a member of RSSB, there does not appear to be a mechanism (apart from via a customer) for non RIA members to be informed of RSSB research reports.

Wabtec had looked at how to vary the work of the inspectors, to keep them fresh, but had not reviewed any other element of axlebox work at that stage. They are currently looking at ways of reducing the likelihood of incorrect axlebox equipment installation.

7.4 Bombardier, Crewe

Like Lucchini, Bombardier had been involved in the fieldwork but had not made any changes as a result of the study. A number of changes had been made, however, as a result of company initiatives. The clear difference was drawn during discussions between UAT inspectors at a depot, who may have to inspect a four or five car unit in a short amount of time, and UAT inspectors in a

wheelshop, who may be doing one or two wheelsets at a time and which are all stripped down. Crewe had not picked up on any initiative on automatic assessment of signals or on deliberate introduction of rogue signals. It had however, moved all its UAT work to days and had improved lighting.

Discussion in relation to original report recommendations

T774 relates to the work carried out by NDT inspectors on wheelsets, particularly in relation to the small number of defects identified. It touches on the issues of repetitive work on testing, but not, in detail, for axlebox building.

The clear differences between depot UAT work, on complete units, often at night or to a tight timescale, with the need to dismantle and rebuild axleboxes, and wheelshop UAT work, on individual wheelsets already stripped down, was highlighted during discussions at wheelshops.

The recommendations from the original 2014 NIR study were as follows:

- **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.

- **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.

T774 had produced a 126-point set of HF guidance points, many (but not all) of which are common between axle NDT and bearing inspection & overhaul. However, the issue is not bearing overhaul, but axlebox equipment rebuild. This is covered in one line of T774:

Task step	EEM	PEM	PSF	Recovery
Reassemble axle end	Reassembled but inadequately	Selection error Poor decision Forget action Mis-see	Axle end and tools eg torque wrench and extent to which they provide clear feedback that reassembly adequate	Various recovery actions may be possible. Are there any secondary checks?

In the outcomes and comments column of the report it states:

“Critical error leading to damage to axle and failure. Task could be looked at in more detail to look at most likely paths for it to be left in the wrong position. Also, there may be a wider systematic issue if a number of axles are inadequately reassembled by the same inspector or inspectors working with faulty equipment, eg torque wrench.”

(Taken from Appendix B UAT Inspection Error analysis of T774 Scoping Study Report, p55).

Discussions were held with Huw Gibson, of RSSB's Human factors team, regarding the human factors issues associated with the NIRs reviewed in this report. Huw wrote the two reports mentioned above, for T774. During these discussions, two further reports were identified. One of these, the Short Report for Depots, Overhaulers and Technical Experts, includes as Appendix B, a section dealing with Axle end reassembly error management. This provides details to support the task step identified above and gives some answers to the question raised in the first recommendation above.

During a presentation of the findings of this report to Wheelset Management Group, this report was mentioned and participants were asked if they were aware of it. Only two were, including one who had acted as project champion for T774.

In addition, no one mentioned this work during drafting, checking and presenting the earlier 2014 Axle Bearing NIR Investigation report to a number of different audiences.

This suggests that there may be an issue with the way results of RSSB research are made available to those who can benefit from it. In this specific case, information which would have been useful to a number of different organisations does not appear to have reached them. The communication route for these reports should be reviewed, to see if improvements can be made to dissemination of information.

8 Procurement

The biggest change in underlying causes has been an increase in issues with material bought in, although there are different specifics within this. One was supply from an OEM, another with counterfeit bearings bought through an intermediary and the third through not managing supplier queries and provision of drawings, resulting in defective material. These highlight the risks from procurement activities and the need for continued vigilance during this process.

9 Conclusions

On the basis of the limited information analysed, there are fewer instances of incorrect assembly on axlebox equipment, although these are still the most significant causes of the NIRs. The frequency has fallen from 1.3 per month to 0.15 per month, a very significant reduction, however statistical significance/certainty cannot be placed on this figure as the NIR database does not provide a full picture.

Human factors analysis shows a reducing frequency of issues with knowledge skills and experience, but an increase in leadership and risk management and equipment. The reasons for this are unclear and may require further investigation. There needs to be continued emphasis on control of the activities on the shop floor, covering leadership and risk management, procedures, and staff competence.

So far as T774 is concerned, one of the wheelshops visited had no knowledge of it and none had specifically incorporated the recommendations. All the shops were, however, making improvements to their activities, including UAT. It was identified that one of the four T774 repots did address the

issue of axlebox equipment rebuild, but it is not clear how this information was made available to interested parties.

One significant new underlying cause is problems with new material. There needs to be continued awareness of the risks of this activity. RIS-2750-RST when published, should provide some assistance with this.

10 Recommendations

1) There needs to be continuing emphasis on axlebox assembly processes as this is still a significant area for concern.
2) The process for disseminating the information in the T774 reports to interested parties should be reviewed to see if it could have been improved and to see if there are wider lessons that can be learnt.
3) Appendix B of the T774 Short report should be circulated to all sites involved in axle end assembly.
4) An exercise needs to be carried out to understand the totality of wheelset issues within the industry.
5) Suppliers need to review on a continual basis the leadership, processes and staff competence within wheelshops.
6) RISABs need to ensure that their assessments review areas identified as causing problems with wheelset integrity.
7) RIS-2750-RST drafting should take into account the findings in this report on procurement risks.

Appendix A - Remit

Further Work

1. Determine level of implementation of the T774 Recommendations:
   a. Feedback via Wheelset Management Group and Bearing Group
   b. Discussions with wheelset inspection / maintenance companies including specifiers of such services e.g. ROSCOs, ECMs, RUs etc. and RSSB
   c. Where applicable visit specific companies involved with the new NIRs and determine if they are aware of T774

2. Identify axle bearing related NIRs raised since the NIR Investigation report was issued and investigate where applicable:
   a. Make an initial categorisation into the root cause to compare with those in the 2014 NIR investigation report
   b. Determine any New type of root causes and categorise them
   c. Identify New NIRs of interest and visit the suppliers / overhaulers concerned
   d. Check with the RISABs (where applicable) what actions they have taken
   e. Confirm the categorisation of the New NIRs in a short report

3. From outcome of 1. and 2. above, put together an action plan to decide if there is a gap in the knowledge / guidance:
   a. Has the guidance in T774 been used by the axle bearing supply chain?
      i. Used: Yes, No, In Part
      ii. Reason: Already implemented, not aware of it etc.
   b. Does the supply chain feel that T774 is sufficient or do they feel a need for specific guidance on axle bearing assembly - Task Design?
   c. Could the New NIRs have been avoided if the T774 guidance had been implemented?
   d. Are there New NIRs where there has been a failure in the axle bearing assembly - Task Design?

4. Review the findings to 3. above and consider if any further research into axle bearing assembly – Task Design is required.

5. Inform Engineering Council of the findings and decision

Appendix B - Review of each NIR

B1 - NIR 3113

Class 375 Axle End Earth Equipment Failure – incorrect gasket - Defect date 28 January 2015

The immediate cause of this incident was the supply and fitting of a gasket which was too thin, causing an interference between the contact disc and the labyrinth seal. However, there has been a change in the axlebox design, unlocking the bearing to reduce stresses within it. This has led to a situation where a previously non critical dimension, which was controlled by a cork gasket, has now become critical. The underlying causes are the design of the axlebox, which utilises a cork gasket to maintain a critical clearance within the axlebox, and failure to control the supply chain for these gaskets, as defectives were supplied from one supplier.

The human factor covering this is **practices and processes**, as the responsibility lies with ineffective procurement processes and equipment.

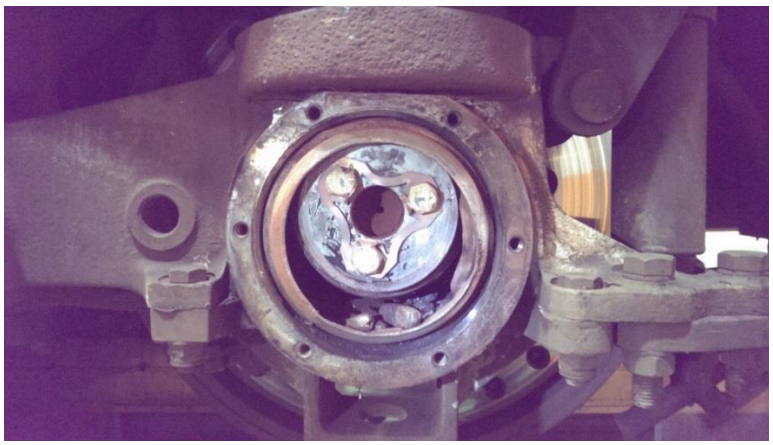
There was **no** human error involved.

B2 - NIR 3121

458026 catastrophic Axle Bearing Failure - Defect date 17 February 2015

The immediate cause of the bearing failure is unknown as the failure has destroyed all evidence of any prior defects. Extrapolation from the condition of the other bearings on the vehicle suggest that the underlying cause is electrical damage, possibly occurring because of defective earthing braids.

No human factor error has been assigned to this, nor human error.



B3 - NIR 3143

Supply of Class 158 Axle Bearings without rear labyrinth seal fitted - Defect date 22 May 2015

The immediate cause of this defect was the failure of SKF Italy to supply bearings which had been assembled correctly. An entire batch of bearings was found to be faulty.

This is a site which manufactures bearings and has provided this type of bearing in significant quantities before. There is no knowledge of the operator involved in this particular case, so it is believed to be **knowledge, skills and experience**. In addition, as all the bearings were found to be faulty, there was a **decision error** on behalf of the operator.

Pullman has approached SKF Italy to obtain information on how this fault occurred and what steps have been put in place to stop it happening again. To date, there has been no response from the company.

SKF Italy does not have RISAS approval, but it does have IRIS certification.

B4 - NIR 3163

Class 332 Wheel Contact with Brake Hanger Bracket Post Overhaul - Defect date 7 July 2015

The immediate cause of this failure was incorrect location of the bearing on the journal. The underlying cause was the response of LUR to the need for new equipment to handle this specific type of wheelset, it being heavier and more cumbersome than other wheelsets manufactured and overhauled. Contributory causes were a misalignment between the transport stillage, used to handle the wheelsets through the overhaul line, which prevented the bearing being pressed on square, and the specification supplied by Siemens not identifying the correct press load, it being too low.

LUR has now introduced an effective means of handling the wheelset, corrected the bearing pressure, and introduced a change management process, to ensure all new contracts are reviewed for all production issues prior to any new wheelset type receiving overhaul.

Human factors appears to include **equipment, knowledge, skills and experience** and **management and supervision**, as well as **practices and processes**. Human error does not seem to have played a part.

B5 - NIR 3171

Substandard wheelset practices identified at LH Wheelsets - Defect date 24 August 2015

LH were receiving a surveillance visit from its RISAB. In accordance with RISAS documentation, as significant issues, which could have serious safety concerns in the industry, were identified, these were advised to industry, along with a risk assessment and mitigation needed.

The immediate cause of the NIR was the failure of staff to comply with their own processes and procedures. Contributory causes included the management and supervision of the shop and the culture that prevailed. It is noteworthy that the NIR identifies that the manager who had been responsible was no longer involved and LH shut down production for a time to enable significant changes to be made.

The staff could also be considered to be short of the necessary **knowledge, skills and experience**, or, if that was not the case, there was a **routine violation** of the required practices.

B6 - NIR 3172

Catastrophic Axle Bearing Failure – PCA 51T Cement Tank Wagon - Defect date 7 September 2015

The immediate cause of this defect was that a wheelset was delivered with no axle end caps fitted to either end. All documentation had been correctly signed off. This is a typical human error failure categorised as memory lapse.

An underlying cause of this was the workshop practice, which had this action carried out to a number of wheelsets located on floor level track, normally working along one side and then the other. Wabtec, Scotland has introduced a fixture which locates an individual wheelset at a sensible height and which is just used for all axle end processes. It has also amended the route cards, to improve the clarity and recording of this task. A human factors issue could be **supervision and management**.

B7 - NIR 3178

Catastrophic Axle Bearing Failure – JGA Wagon - Defect date 27 August 2015

The immediate cause of this incident was the failure of a bearing. The bearing had been overhauled in May 2011 and the wheelset turned in 2014.

The bearing was examined by a specialist but no underlying cause of failure could be found.

No human factors issues have been identified.

B8 - NIR 3179

Defective Bearing fitted to overhauled wheelset – Defect date 22nd September 2015

During a hand rotation test on an overhauled bearing fitted by Pullman, excessive vibration, noise and end float were discovered. The bearings, although manufactured by Timken, had been overhauled by SKF.

The wheelsets were examined by Serco, which found that the grease had not been uniformly distributed throughout the bearing.

The bearing was investigated by SKF and Serco. So far as SKF is concerned, there is not a problem. Staff are adamant that it is normal for the grease not to be evenly distributed in the bearing before use. This was confirmed by the Serco rep.

The grease injection process has been audited. The outcome was acceptance that it was a robust process, with the machine calibrated properly, enabling the correct quantity of grease to be injected.

Once the bearing is installed and the wheelset is running, the grease will very quickly spread throughout the bearing.

This is a case where there is an apparent defect, which was not confirmed on investigation. The test which identified the issue will need to be revised.

There was **no** human error involved.

B9 - NIR 3188

Class 221 DEMU – Multiple re-qualifications of Axlebox bearings - defect date 2 October 2015

Bombardier overhauls a number of components on the Cl 221 Voyager vehicles on their own periodicities. Wheelsets are controlled separately from bogies. During an investigation into life extension on wheelsets, a bearing was found which had been overhauled four times. Given that the periodicity for overhaul of wheelsets was 900k miles, and the design life of the bearing 2.1m miles, there was a likelihood that this bearing had exceeded its design mileage.

Overhauled bearings may be fitted to a wheelset which has had a repair. In this context, Bombardier regard changing wheelpans within the wheelset's overhaul periodicity as a repair, even though this is regarded as an overhaul under WOSS612/10 and GM/RT2466.

A review of the maintenance policy identified that there were no explicit instructions regarding overhaul of bearings.

The immediate cause of the problem was the failure of the customer or maintainer to specify the requirement of a maximum of one overhaul in its bearing maintenance policy or order requirements. Bombardier Crewe thus had no instructions to limit these bearings to one overhaul. Investigations have identified a number of underlying causes. These are;

West Coast did not identify bearing treatment explicitly in its maintenance plan,
West Coast did not track bearings individually within its asset management system.

As this NIR relates only to one fleet of vehicles and is related to ineffective communication about the management of the bearings fitted, which are unique to this fleet of vehicles, it is not clear that it actually fits into the requirements for an NIR, as no other fleet of vehicles was involved. However, there is a risk, if other bearings are similarly not limited in relation to numbers of overhaul, that bearings may exceed their design life in service and it was this risk that the originator wished to identify.

No human error classifications have been identified. The incident factor seems to be **practices and processes**, on behalf of the customer, who did not clearly specify the requirements.

B10 - NIR 3192

Counterfeit axle bearings - Defect date 29 October 2015

LUL were undertaking a program of wheelset overhauls. Orders were placed on the OEM, but it was unable to supply sufficient bearings in time for the program, because the order was larger than normal quantities. Following discussion with the OEM, an LU approved bearing distributor was approached who was also approved by the OEM. Further bearings were sourced from this distributor, but still not enough for the full program.

The first distributor offered to search for alternative suppliers and subsequently identified a second distributor who they have been using for over 20 years without problem, who then sourced the outstanding quantity (it is believed that two further suppliers were involved in the chain). The further sources are believed to be Turkish distributors, although the actual supply source of the bearings has not yet been firmly established. Investigations have shown that it is this sourcing that has introduced the counterfeit bearings into the supply chain.

The immediate cause of the defect was the unexpectedly higher need to replace bearings on overhaul (probably due to the age of the stock), coupled with the OEM's inability to supply the larger than normal quantity.

LUL has now changed out all the counterfeit bearings and has determined to source all its bearings from the OEM in future.

Human factors classifications are **equipment**, as it was equipment at fault, and **practices and processes**, which did not identify the higher than normal attrition rate of failed bearings (above normal stock levels) when planning for wheelset overhauls.

There was **no** human error involved.

B11 - NIR 3210

Loose axle end cap - Defect date 22 December 2015

The defect identified was a WSP fault. On examination, it was discovered that the axle end cap bolts had become loose as the tab washer had not been tabbed over.

Investigations could not identify how this had happened and it was identified as a human error.

The immediate cause was the failure to tab up the washer. Underlying causes were the work method, which called for the work to be done to wheels on floor level track and the route card, which had not identified the operation as critical and requiring checking.

Wabtec also identified as contributory that, although ATW had identified this work as high risk because of the human factors issues, this had not been advised to them. In addition, the method had not been challenged during any assessment.

Wabtec has now installed three fixtures which enable all axle end work to be carried out on an individual wheelset at a sensible working height. It has also changed the route card to require a second signature. In addition, the wheelshop manager, once a day, the quality director, once a week, and the managing director once a month, do random checks.

In human error terms, this is regarded as a **memory lapse**. The shop floor surveillance routines failed to pick it up, so there are also **practices and processes** issues and **management and supervision** issues.

B12 - NIR 3225

Provision of overhauled, life expired bearing - Defect date 23 February 2016

The defect creating this NIR was an overhauled bearing being supplied to an overhauled wheelset which contravened the bearing policy of the supplier. On investigation, this was considered to be a human factors issue as the operator concerned, a recent recruit but assessed as competent, had made a genuine mistake. Other customers of Wabtec accept bearings of this age, so it is not clear that this defect warrants an NIR, as there was no significant risk and the concern related to one customer's bearing policy. Perhaps, if 3188 had not been issued, this would not have been issued either.

The immediate cause was fitting a bearing which did not comply with the customer's bearing policy. The underlying cause was route card documentation which did not make it clear to operators contract specific data. These route cards have now been updated and are becoming controlled documents.

This is therefore a **decision error**, but the incident factors again include **practices and processes**, **knowledge skills and experience** and **management and supervision**.

Appendix C - Remit for Further Work T774

One aim of this scoping study is to propose a research plan which could deliver benefits to the industry. Based on this report, the objectives of this research are proposed to be:

1. To work with industry to identify human factors good practices which will improve safety at minimal cost.

2. To develop decision support materials which can be used by industry to quantify the benefits of improving human reliability in the inspection process. Improvements could come from:
   a. UAT task redesign
   b. Changing axle inspection regimes, for example, to take advantage of the potentially more controlled environment at overhaul, or the selection of existing UAT techniques which have better human reliability.

3. The task outline, from which the more detailed study should be developed is proposed to include the following steps:
   a. Identify any quick wins which should be promoted to industry because their costs are small and safety benefits are demonstrable. This may include representing the procedural human factors recommendations in this report in a format which would be more usable in a depot type environment
   b. Development of a fuller model of operator reliability in NDT inspection, which covers the full inspection process and different types of inspection carried out in-situ and at overhaul. This should include the impacts of human reliability in replacing the axle ends during in-situ inspection and take account of signal detection theory.
   c. Determination with industry experts of the cost savings which might be possible if human reliability was improved from that which is used in current industry assumptions.
   d. Based on (b) and (c), identify if significant effort should be expended in the collection of inspection reliability data, based on capturing actual inspection performance. This is proposed as a separate step, as the difficulties in developing and arranging such data collection studies are recognised. Any development of probability of detection (PoD) data should include both engineering and human factors inputs. Human factors input is required because PoD curves express human error probabilities and their development should draw on the established human factors methods for generating human error probability data, whether this be through expert judgement, experimental simulation, or data review.
   e. Use the data from (b) to (d) to deliver decision support materials which allow inspection reliability to be improved through changes to inspection regimes, including which NDT techniques are applied, or significant task redesign.

Appendix D - T774 Recommendations

To support the implementation of the human factors guidance the following should be considered:

- Application of the guidance by technical specialists and by managers and inspectors at sites. The RSSB human factors team would be able to provide phone and e-mail support and collate feedback from different sites. RSSB could periodically monitor via Wheelset Management Group.

- RSSB to develop and deliver Human Factors Awareness training for inspection staff, to support application of the guidance. This is also a potentially cost-effective way of consistently managing human factors through user engagement across sites. This training could be developed at RSSB based on the syllabus for aviation maintenance and RSSB's existing 2-day human factors awareness training course, which has been successfully delivered to a large number of industry participants. This would also fill an immediate gap by providing feedback and opportunity for inspectors from across sites to learn from each other.

- Human factors on-site support for case studies on aspects of the guidance. This support would aim to demonstrate the benefits of implementing the guidance and integrating human factors within wider work processes. This would require funding of human factors support to support the implementation of specific guidance at sites. This funding would be on the basis of providing the industry with practical case studies which could be used as a template for implementation across a number of sites.

- Wheelset Management Group to set up a process for feedback on inspection performance to inspection staff via Wheelset Management Group. This would support the guidance developed on providing feedback to staff. In addition, the following is proposed from a human factors perspective, as the key item of work which was identified during the study but agreed as outside the scope of guidance development (see Section 3.8):

- Carry out experimental validations using meaningful samples of inspectors for MPI and UAT, to provide an assurance of the reliability of the current inspection methods. Human factors support could also be considered for the following potential future developments in the industry:

- Review of NDT technologies and their safety justifications.

- Experimental designs to provide underpinning data for the justification of changes to axle inspection periodicities.