RAIB investigations: the risks that we see

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Introduction

- An overview of the Rail Accident Investigation Branch
- Risk on the railways in the UK – the RAIB's perspective
- Case studies – learning

The Rail Accident Investigation Branch

- Recommendation from Pubic Inquiry into the Ladbroke Grove accident
- Became operational in October 2005
- Independent of all parts of the rail industry
  - *Part of Department for Transport but functionally independent*
  - *Chief Inspector reports to Secretary of State*
- Sole purpose to improve safety
  - *does not apportion blame or liability*

Passenger and freight trains, metros, trams, heritage rail.

RAIB's geographical area and operation

On-call staff at both operational centres 24/7, with an expectation that they will deploy within 30 minutes of an accident being notified

Railways covered by the RAIB

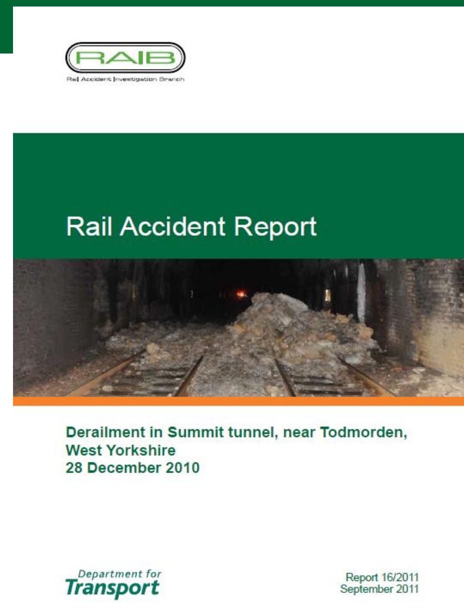
Channel Tunnel –
The UK part and the French part in conjunction with our counterparts in France

Who and what comprises the RAIB?

- RAIB staffing:
  - 26 rail professionals
    - Chief Inspector
    - Deputy Chief Inspector
    - 5 Principal Inspectors
    - 19 Inspectors
  - 17 support staff
- RAIB facilities include:
  - Two operational bases
  - Modest Workshops
  - Response vehicles

The story so far, 9 years on………

Deployed to <u>454*</u> incidents



RAIB
Rail Accident Investigation Branch

Rail Accident Report

Derailment in Summit tunnel, near Todmorden, West Yorkshire
28 December 2010

Department for Transport

Report 16/2011
September 2011

Published <u>252*</u> investigation reports and <u>40*</u> bulletins

Average 4-5 recommendations per report

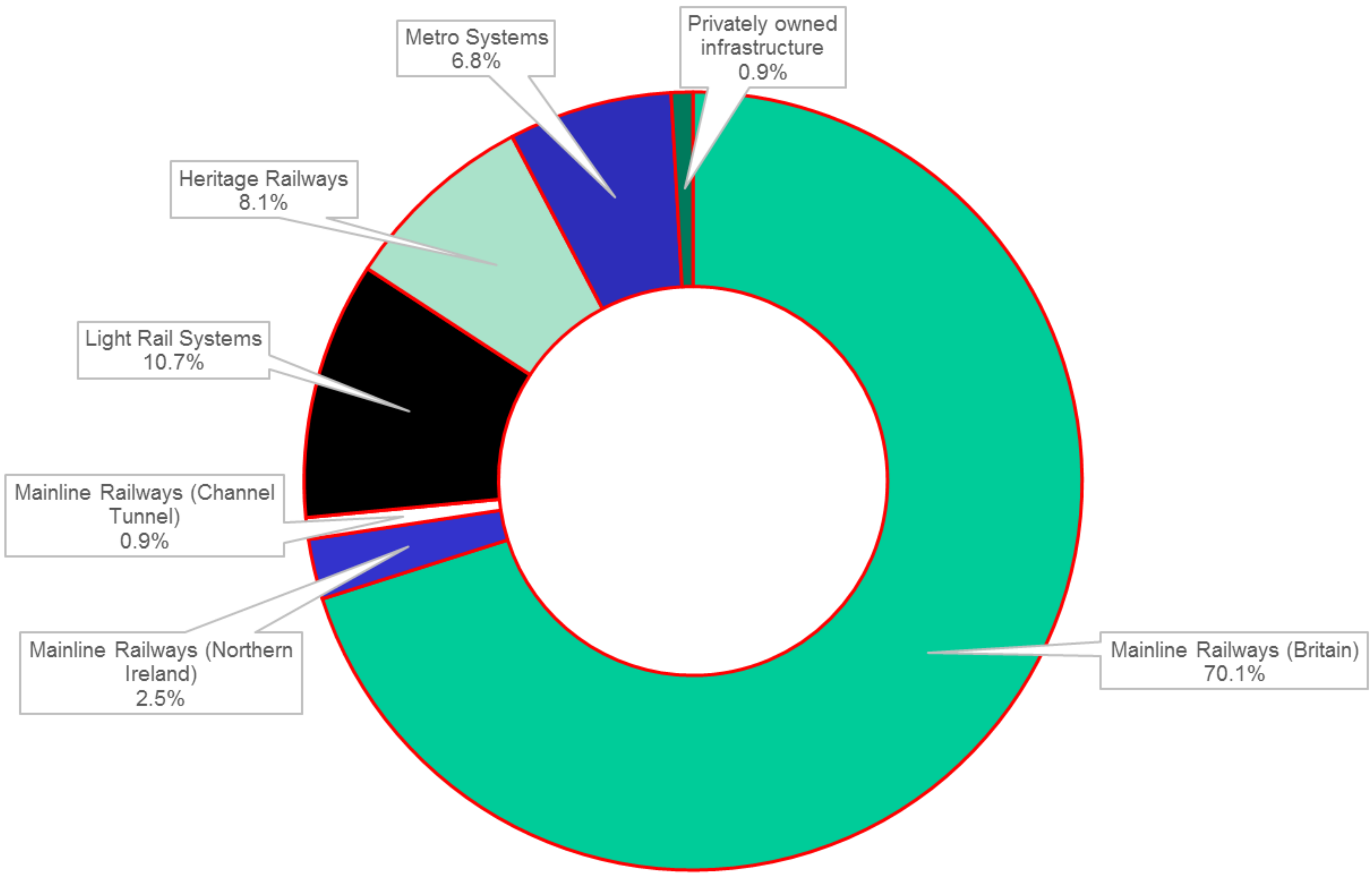
Over <u>90%*</u> have accepted or been implemented

7%* awaiting response

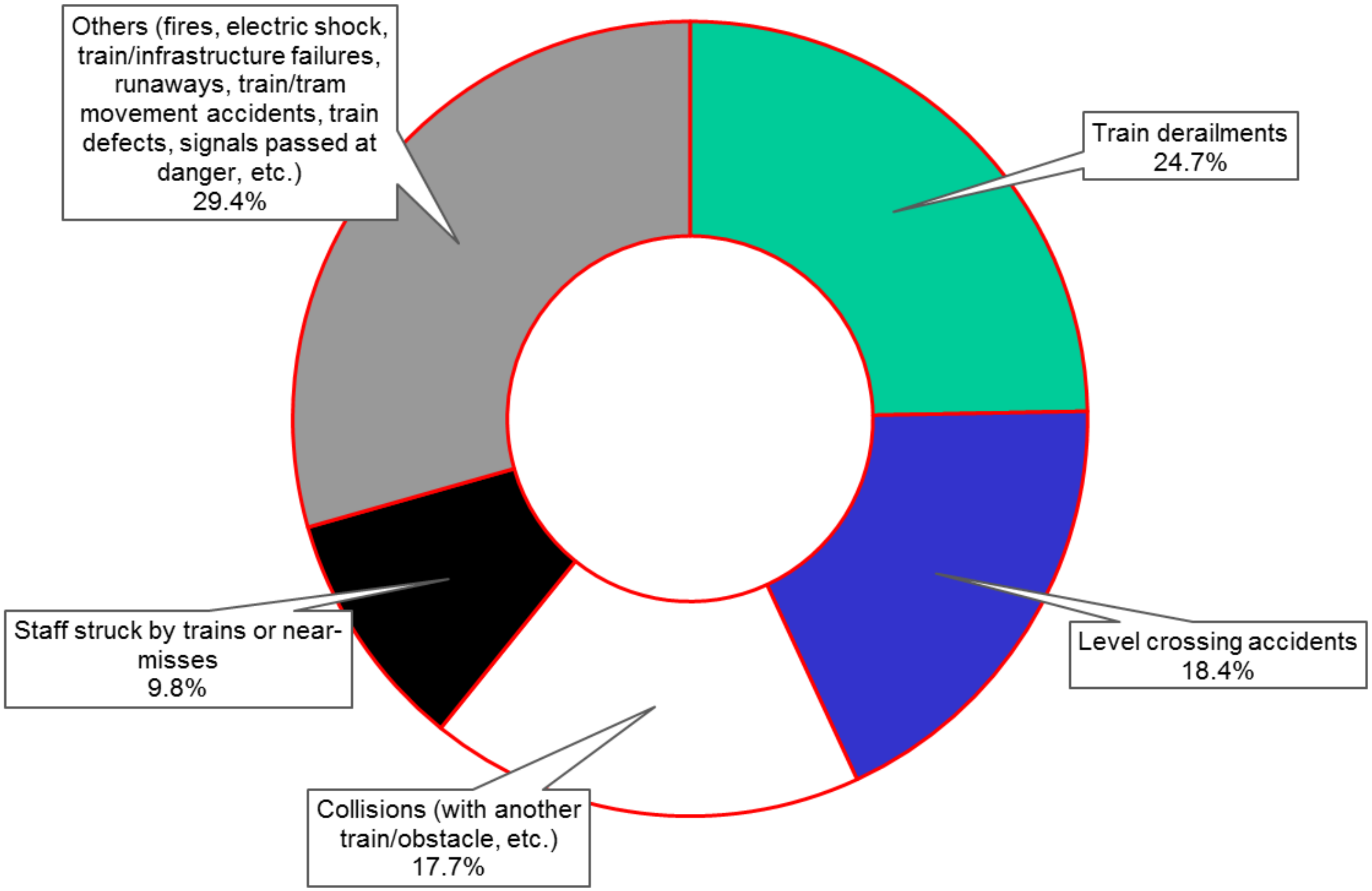
3%* not implemented

* As at August 2014

RAIB investigations by railway sector (to August 2014)



RAIB investigations by principal causes (to August 2014)



RAIB’s approach to selection of investigations

- Not lead by industry’s perception of risk
- Investigations selected for significant safety learning
- Conducts detailed investigations into near-miss incidents

Level crossings

Level crossings – recurrent issues	Areas of action by railway industry

The RAIB has identified the need:
 	
- for improved risk management processes
  - taking account of local factors
  - history of previous accidents and near-misses
  - competence of risk assessors
  - translating findings of inspections and risk assessments into actions for improvement
	
	Network Rail national initiatives

- to better understand the behaviour of level crossing users and how this is influenced by factors such as signage and layout	**RSSB research**

Safety of track workers

Track worker safety – recurrent issues	Areas of action by railway industry

The RAIB has identified the need:
 	
▪ to address safety culture
  ▪ unsafe behaviours
  ▪ inadequate safety leadership
  ▪ unwillingness to challenge those in authority
	Network Rail national initiative (Safe Work Leader)

▪ to minimise the need to work on tracks that are open to traffic ▪ automated inspection	**Network Rail national initiative**
▪ Planning and how information is presented to the COSS re the SSoW	

Platform/train interface (PTI) safety

- RAIB have investigated seven mainline PTI accidents, but this not all of those that have occurred, it has depended upon whether we thought there were lessons to learn
- An area where, even normalising for increasing passenger number, the risk was rising
- Recent high profile accidents: James Street and Charing Cross

James Street and Charing X

James Street

Issues

- Maximising observation time of PTI by dispatcher as train leaves
- Ability of dispatcher to stop train in an emergency after it has started
- Size of platform/train gap

RSSB research project

Case studies

- East Langton – fractured axle
- Camden Rd - derailment
- (Gloucester- derailment)

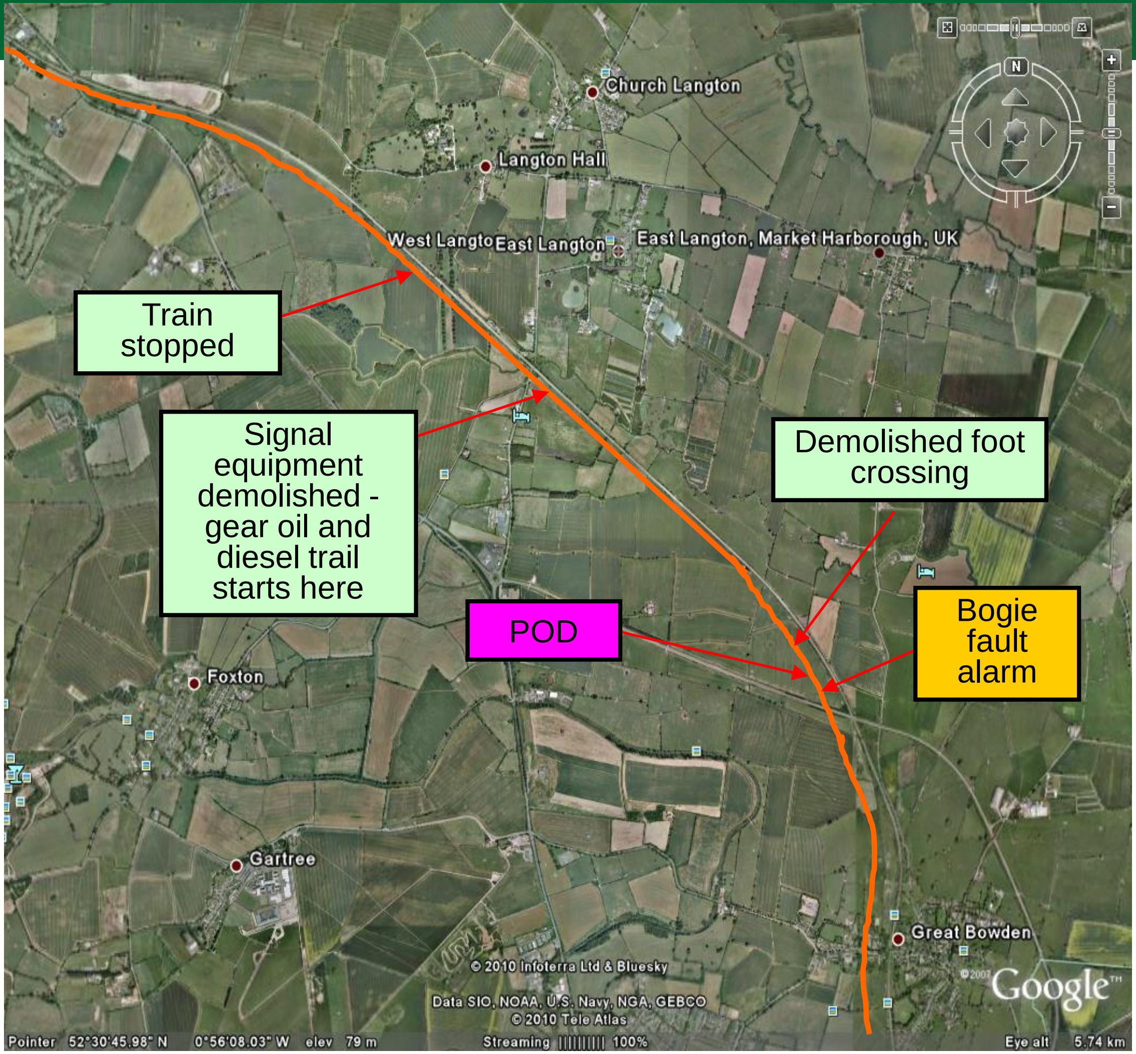
Common themes?

- ‘Overlooking’ first principles
- System design

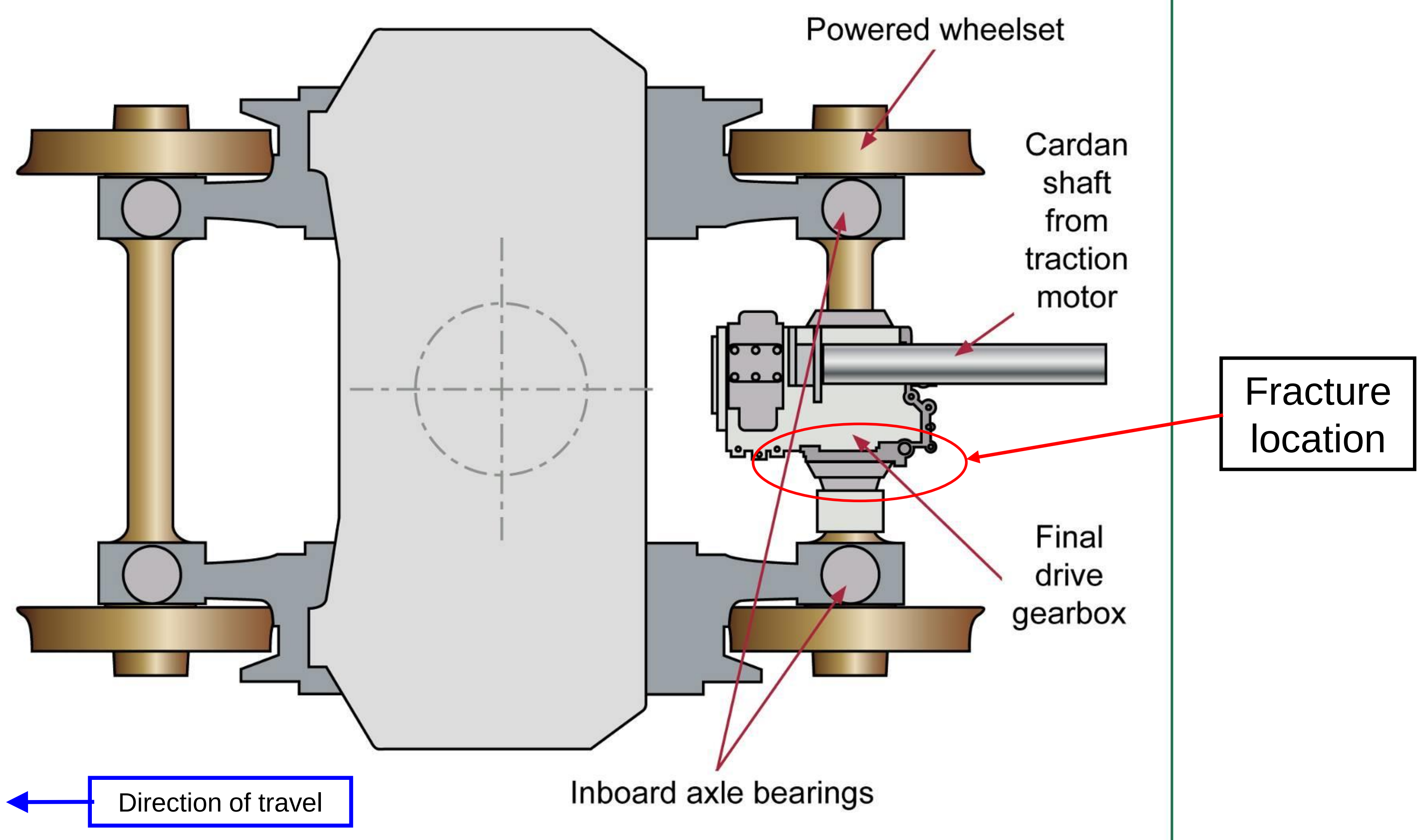
Passenger train derailment at East Langton
20 February 2010

Class 222 Meridian DMU

The derailment



Location of axle failure

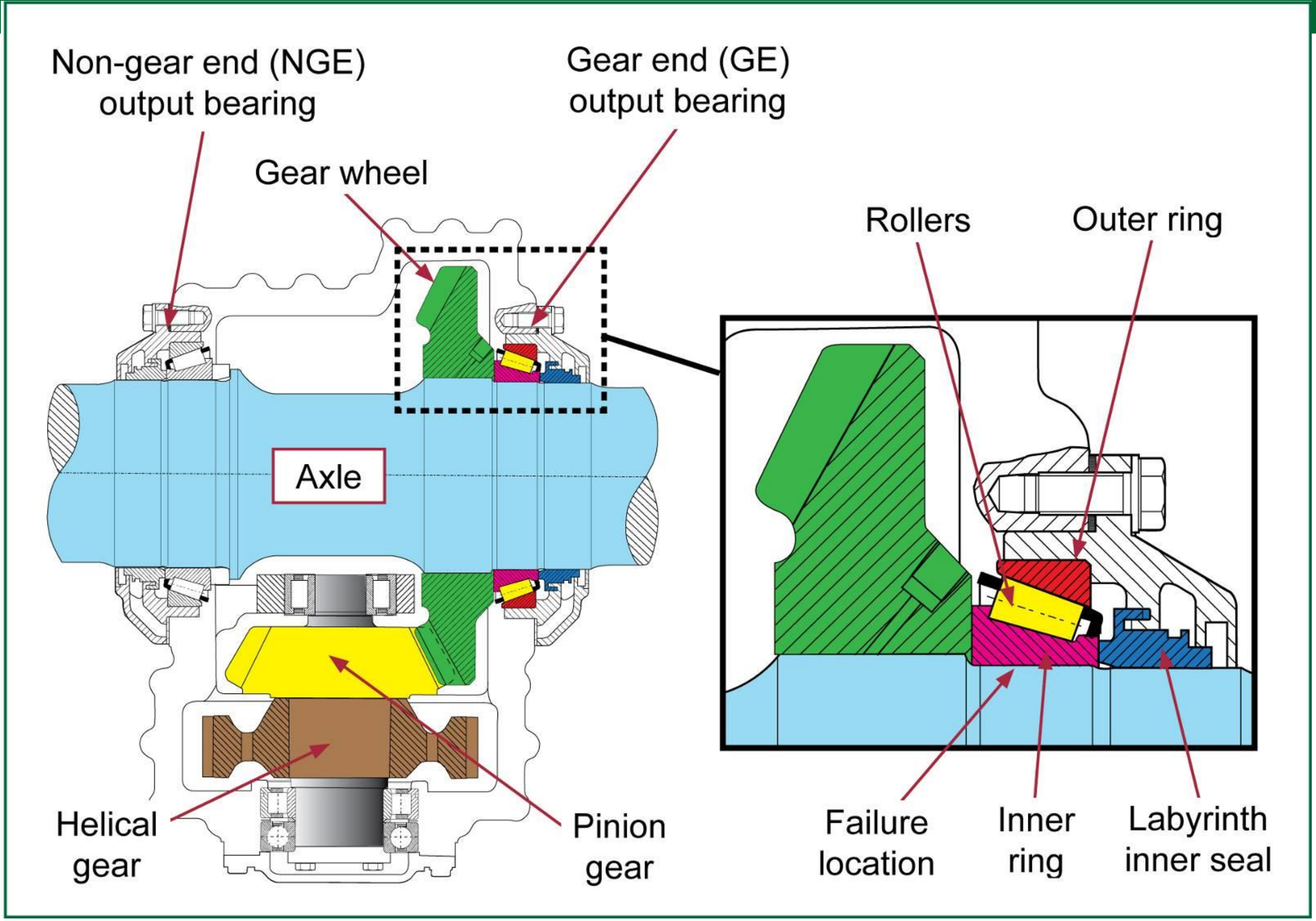


Fractured wheelset

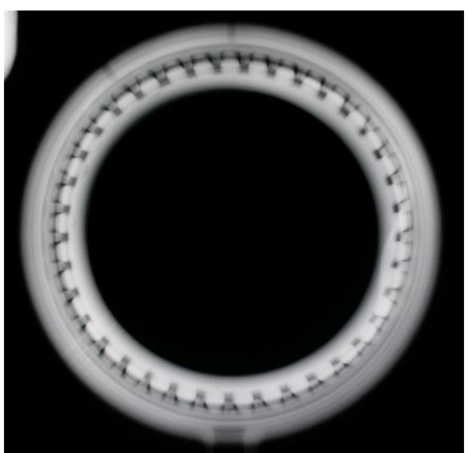
LHS half

RHS half

Fractured wheelset

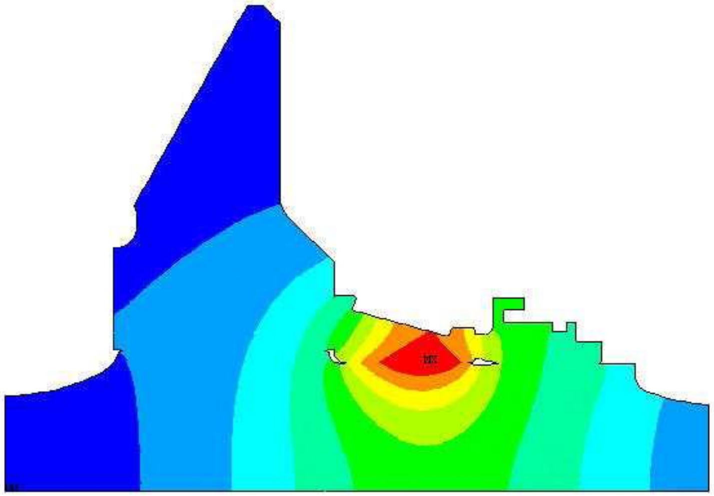


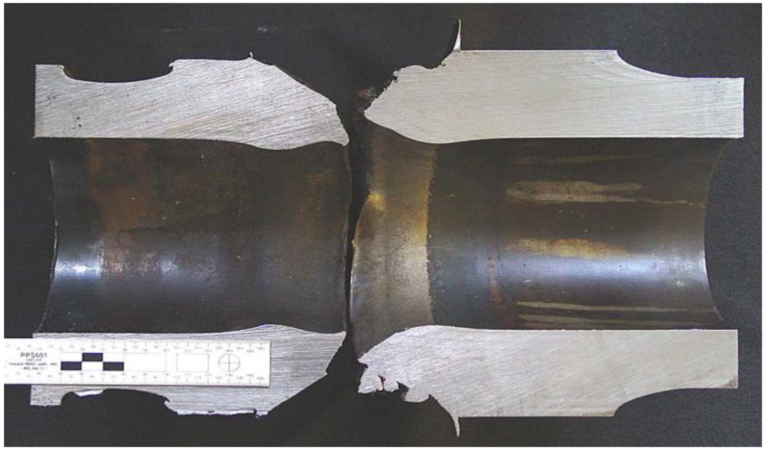
Failed GE output bearing



Key Findings

- **Axle fracture caused by rapid overheating**
- **Overheating caused by spinning of the axle within the inner ring of the GE bearing, which had become stiff.**
- **Bearing probably became stiff due to a clearance which had developed between the inner ring and axle.**
- **Likely causes of clearance:**
  - **Design fault resulted in a low initial interference fit.**
  - **Progressive loss of bearing interference fit in service due to bore growth and fretting wear.**
  - **Bearing seat on axle may also have been manufactured undersize.**
- **Also train operation issues – train took 2 miles to slow down after bogie warning light**





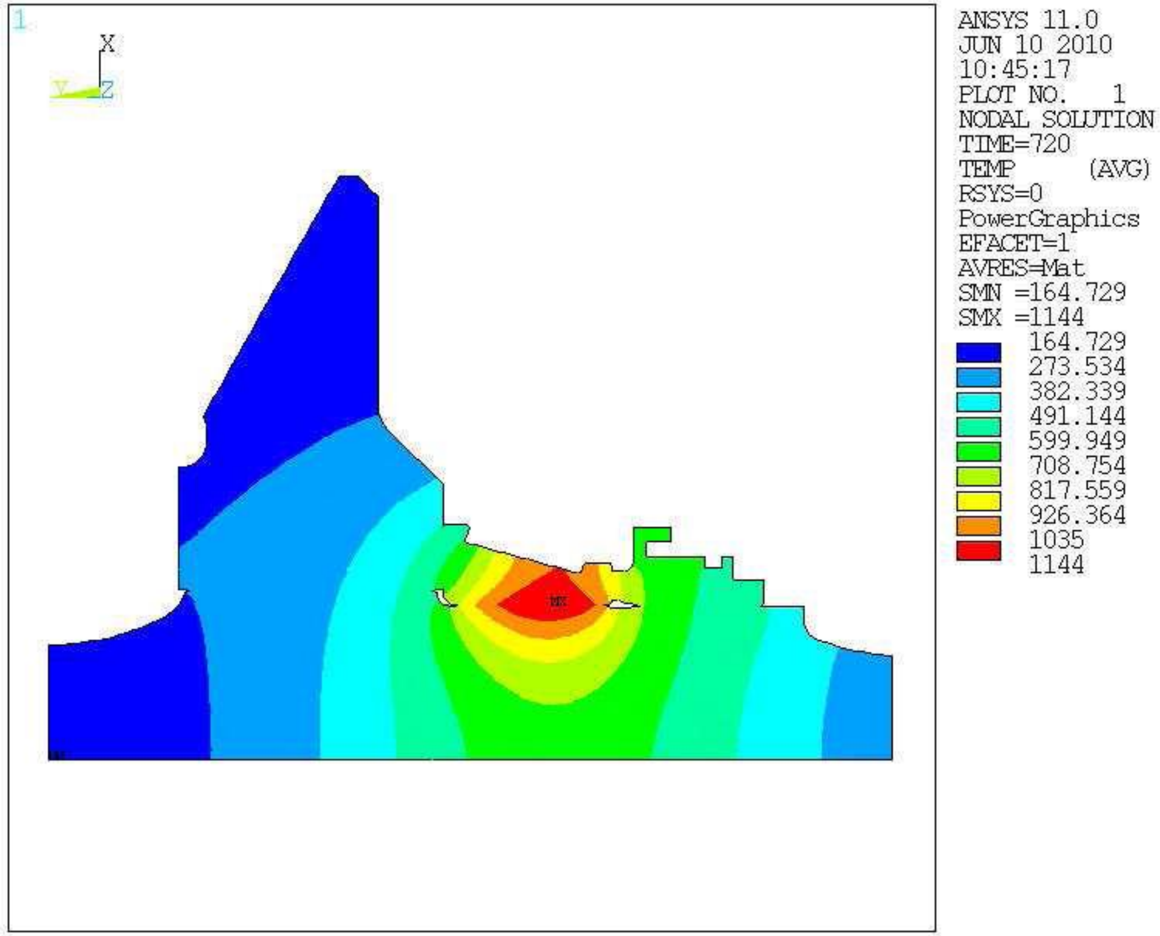
Technical lessons

Calculations show around 30 kW of heat input can be generated at the axle/inner ring interface.

30 kW can generate temperatures of around 1200C at the axle/inner ring interface in as little as 12 minutes.

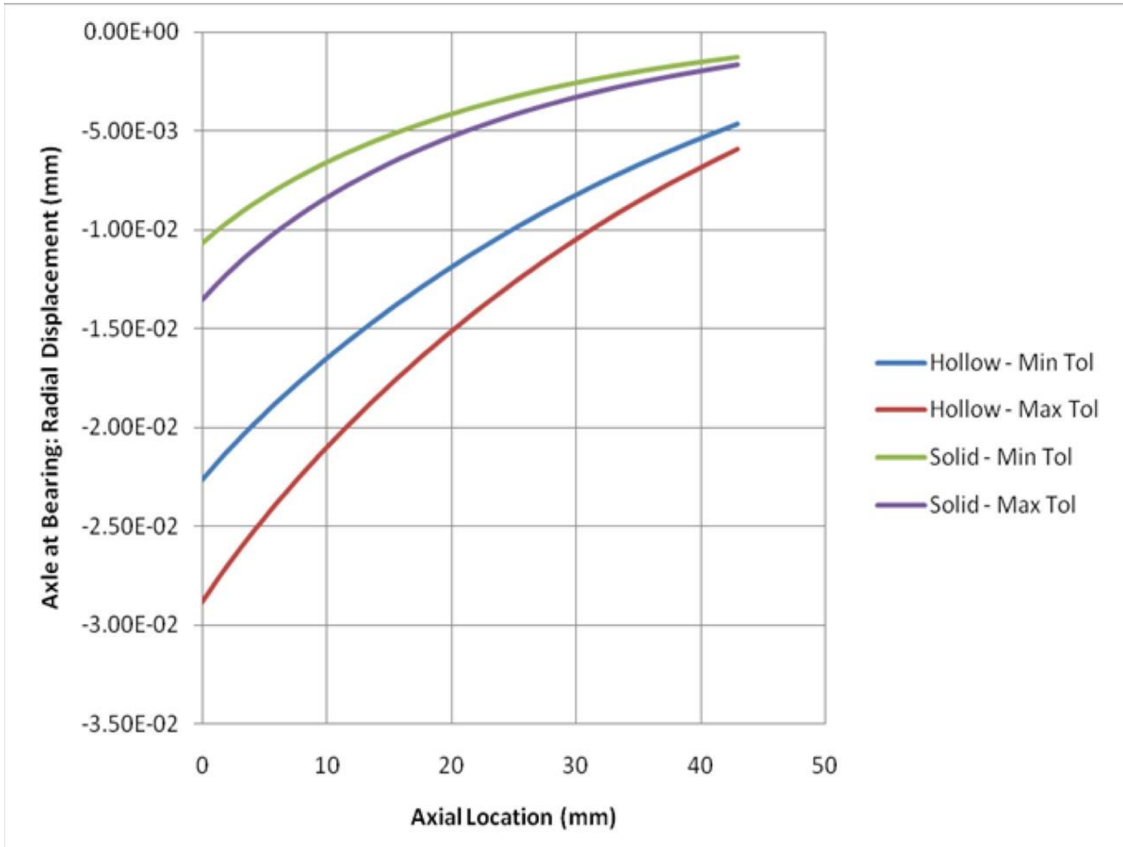
Axle strength reduced to <10%.

Pre-condition is that GE bearing must stiffen up significantly (but not locked)



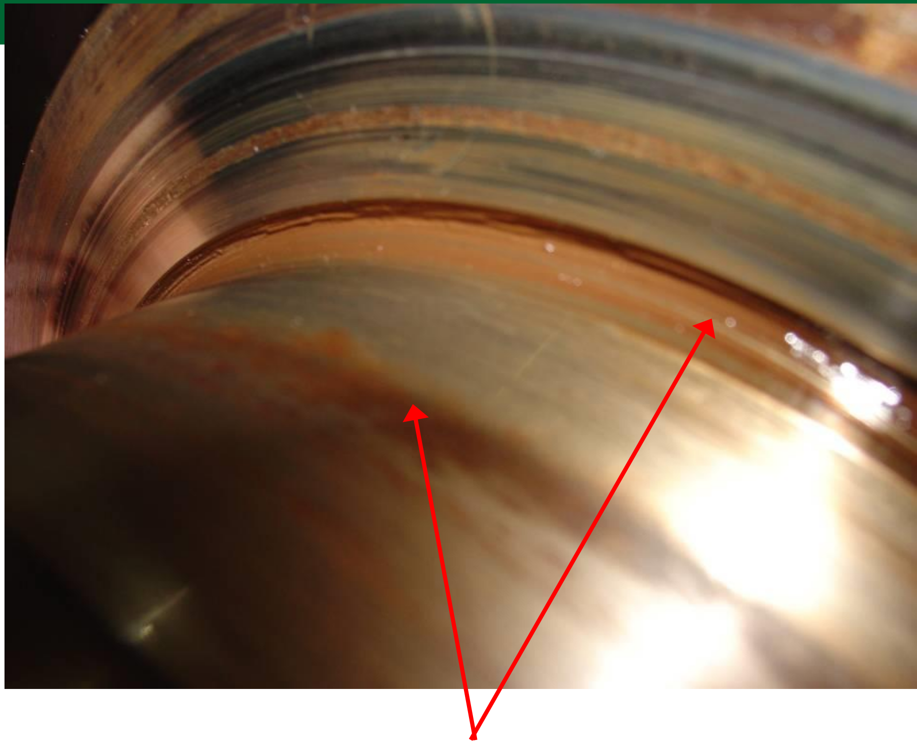
Technical lessons

- A heavy gear interference fit can cause significant shrinkage of a nearby bearing seat.
- Hollow axles are more vulnerable than solid axles
- Nearby interference fit needs to be allowed for at the design stage.



Technical lessons

- **Inadequate bearing fits can lead to complete loss of interference and even clearance.**
- **3 mechanisms:**
  - **inner ring growth**
  - **fretting**
  - **inner ring creep**
- **Once inner ring creep starts, fretting wear is accelerated, potentially leading to clearance.**
- **3 wheelsets found with clearance (and severe fretting (see photo).**
- **2 wheelsets found with low interference**



Reddish brown fretting residue found on axles with axle/inner ring clearances

Technical lessons

- East Langton FD:
  - oil samples did not indicate signs of impending failure, such as elevated iron, throughout its history.
- FD’s tested at Voith with axle/inner ring clearances;
  - low levels of iron and other elements (even though iron debris on magnetic dipstick was significant).
- However, cumulative trending of iron over the life of the East Langton FD, indicated it had produced more than any of the other FDs found to have a clearance between inner ring and axle and significantly more than other ‘normal’ FDs.

Recommendations

1. Design review of Meridian/Voyager gearboxes to reduce the risk of recurrence. (Train and gearbox manufacturer)
2. Review and improvement of design, manufacture and overhaul procedures for final drives on other fleets, to ensure lessons from EL are built into industry practice (ROSCOs and other CEs, maintainers).
3. Review and optimisation of final drive oil sampling regimes for Meridian and similar fleets to improve failure detection capability (Train maintainer)
4. Practical rolling stock specific refresher training, including simulation, for drivers and train crew on handling emergencies. (Train operator)

Camden Road Oct 2013

The accident

- Train from Birmingham to Felixstowe, containers for export
- 5th wagon derailed on 183 m radius curve
- Empty container toppled off wagon and brought down OLE
- Damage to track, OLE, viaduct wall, wagon and containers
- Section of North London Line (London orbital – busy throughout day) closed for 6 days

Camden Road

Derailed bogie

Container fallen from wagon

Collapsed overhead line equipment

Derailed wagon

- FEA type loaded with 2 containers:
  - Laden 20' container with scrap electrical machines - weighing 28.8t at the front of wagon
  - Empty 40' container weighing 3.9t at the rear of wagon

- Rear bogie substantially damaged, remaining parts of wagon no relevant faults

The investigation – sources of evidence

- Site survey
- Reconstruction of the how the container was packed
- Data: NR's 'Wheelchex' & track recording vehicles
- Historic train loading data
- Specs & vehicle acceptance records
- Sensitivity analysis of the derailment – computer modelling

Principal findings from the investigation

- Causal factors:
  - track geometry and general condition
  - Wagon asymmetrically loaded laterally and
  - asymmetrically loaded longitudinally

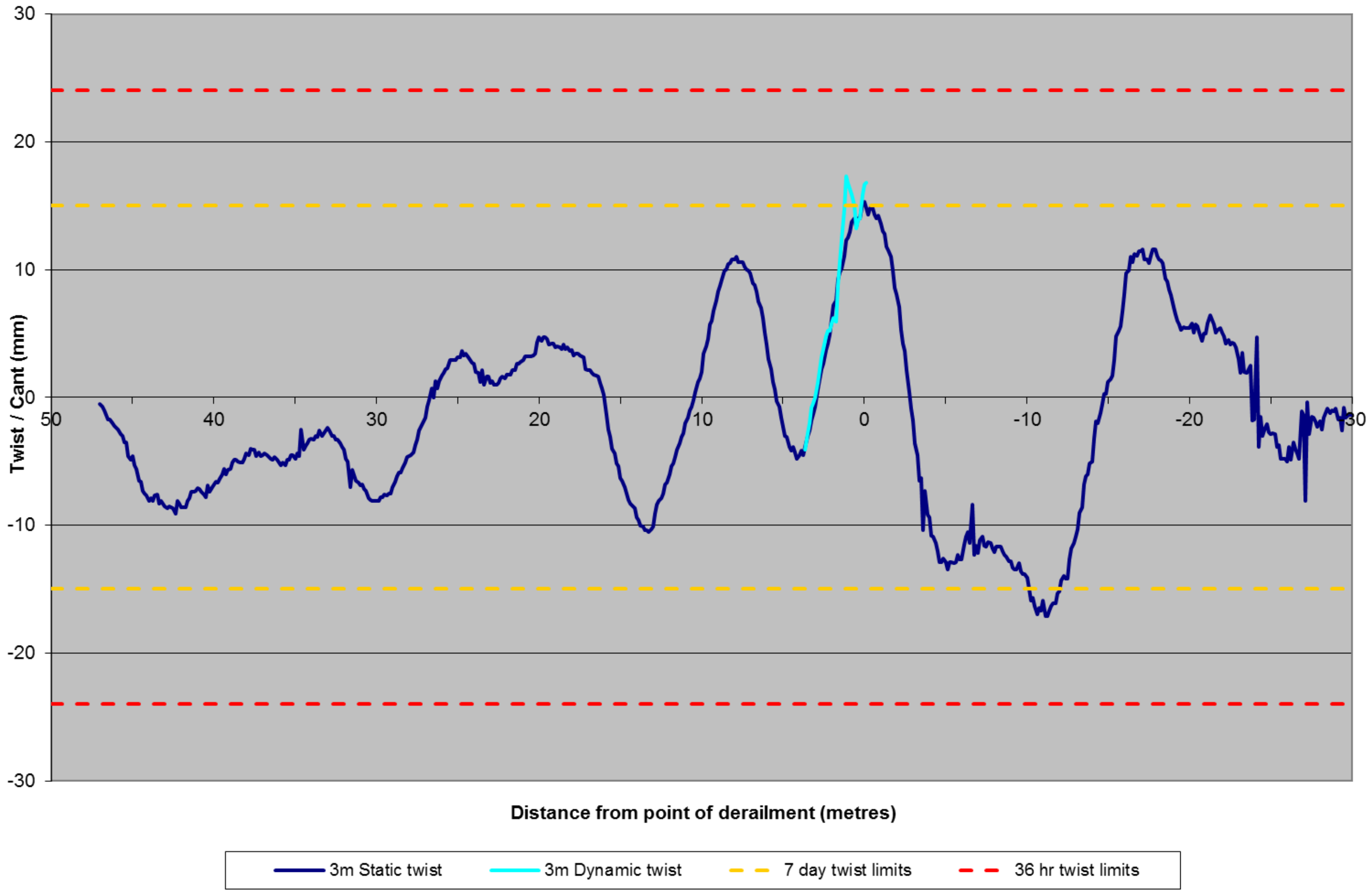
- Modelling: a<u>l</u>l of the above conditions required for derailment

The track: multiple, opposing, twist faults

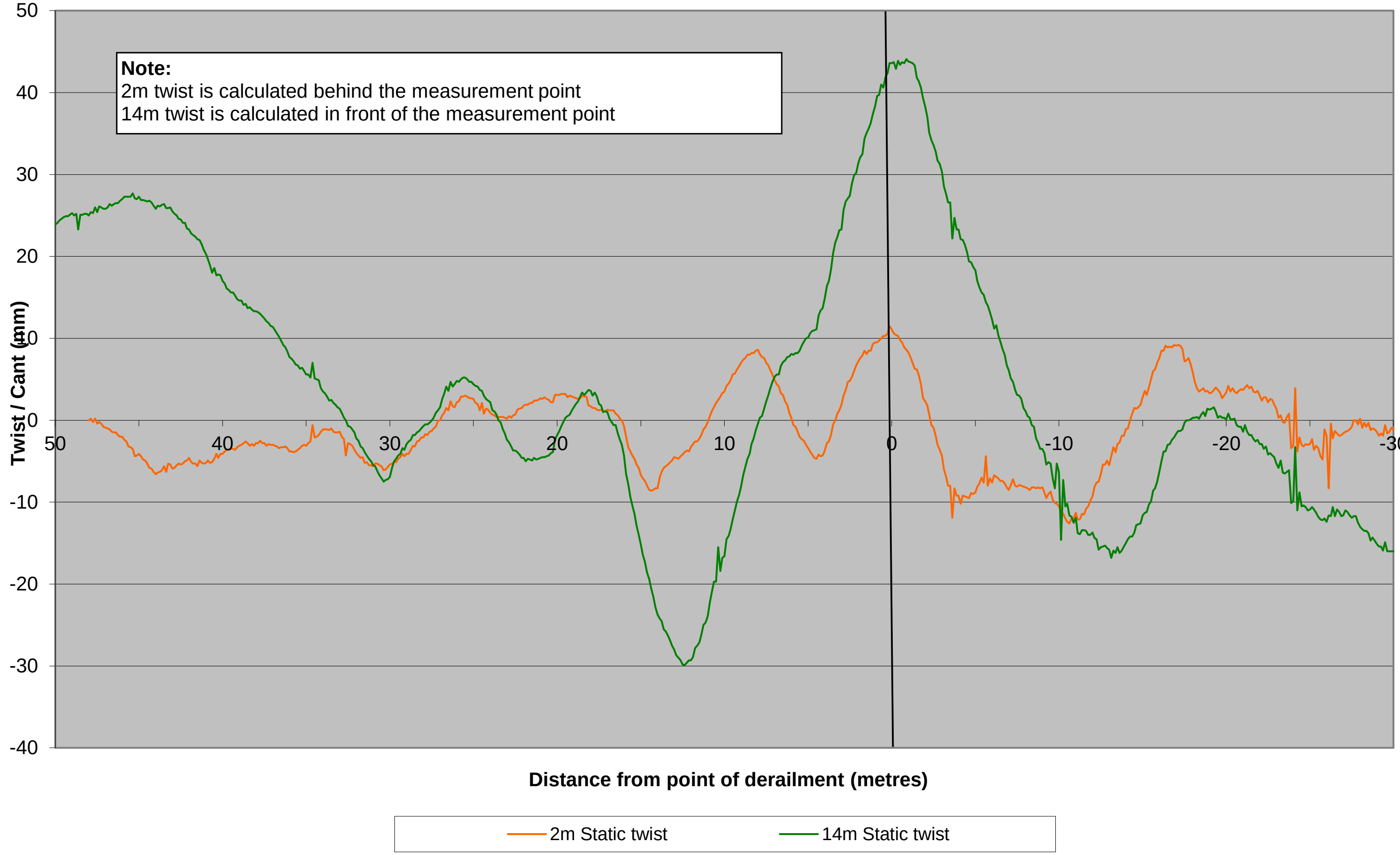
- Track twist measured over 3 metres - intervention regime based on this
- 3 metre-track twist at point of derailment required intervention within 7 days (not block the line)
- Wagon has axle centres at 2 metres (on each bogie) and bogie centres at 14 metres
- Filtering track survey data for 2 and 14 metre wavelengths shows a completely different picture (next slide)

Such measurements not routinely taken

Track survey – three metre wavelength



Actual wagon interaction with track twist



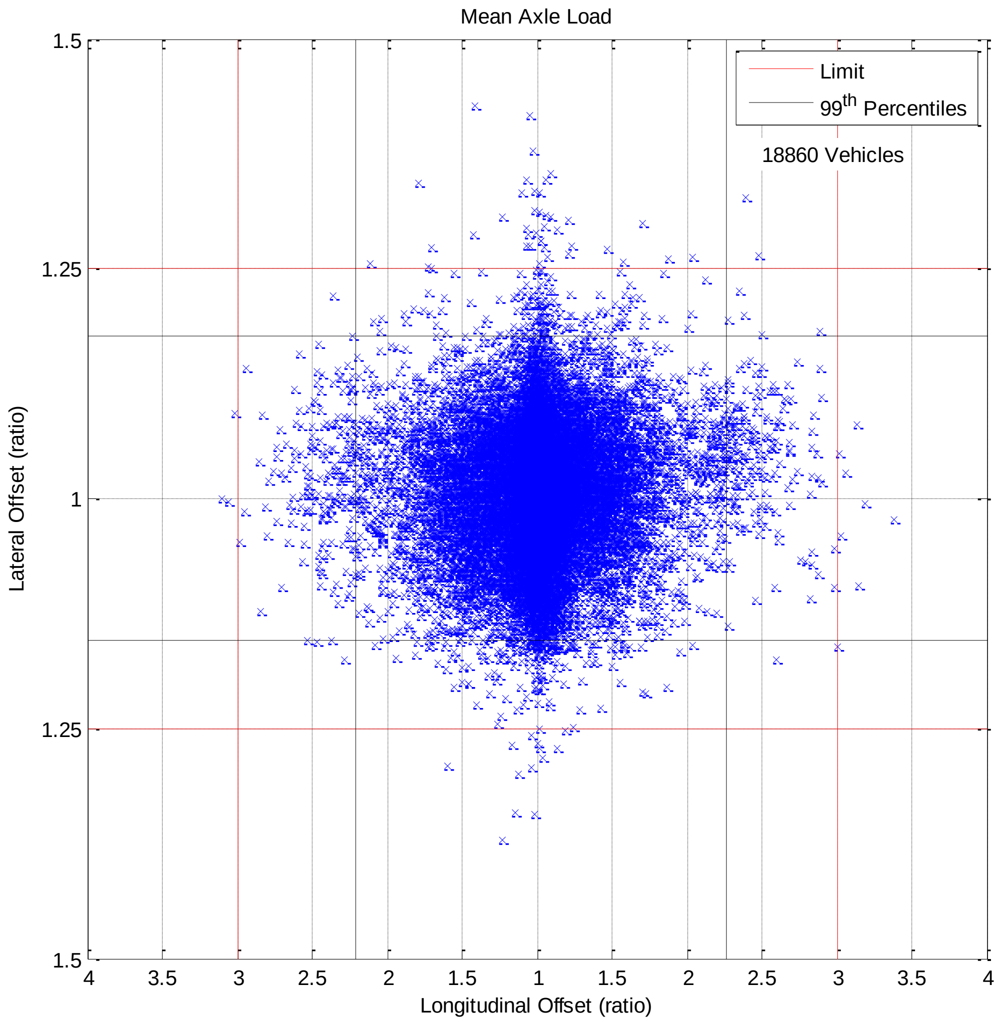
The wagon and its load

- 20 ft container ;leading end wagon
  - gross weight 28.83 t, offset centre of gravity
- Empty 40 ft container ; trailing end of the wagon
  - gross weight 3.88 tonnes
- Wagon centre of gravity offset both longitudinally and laterally

Other significant findings - track

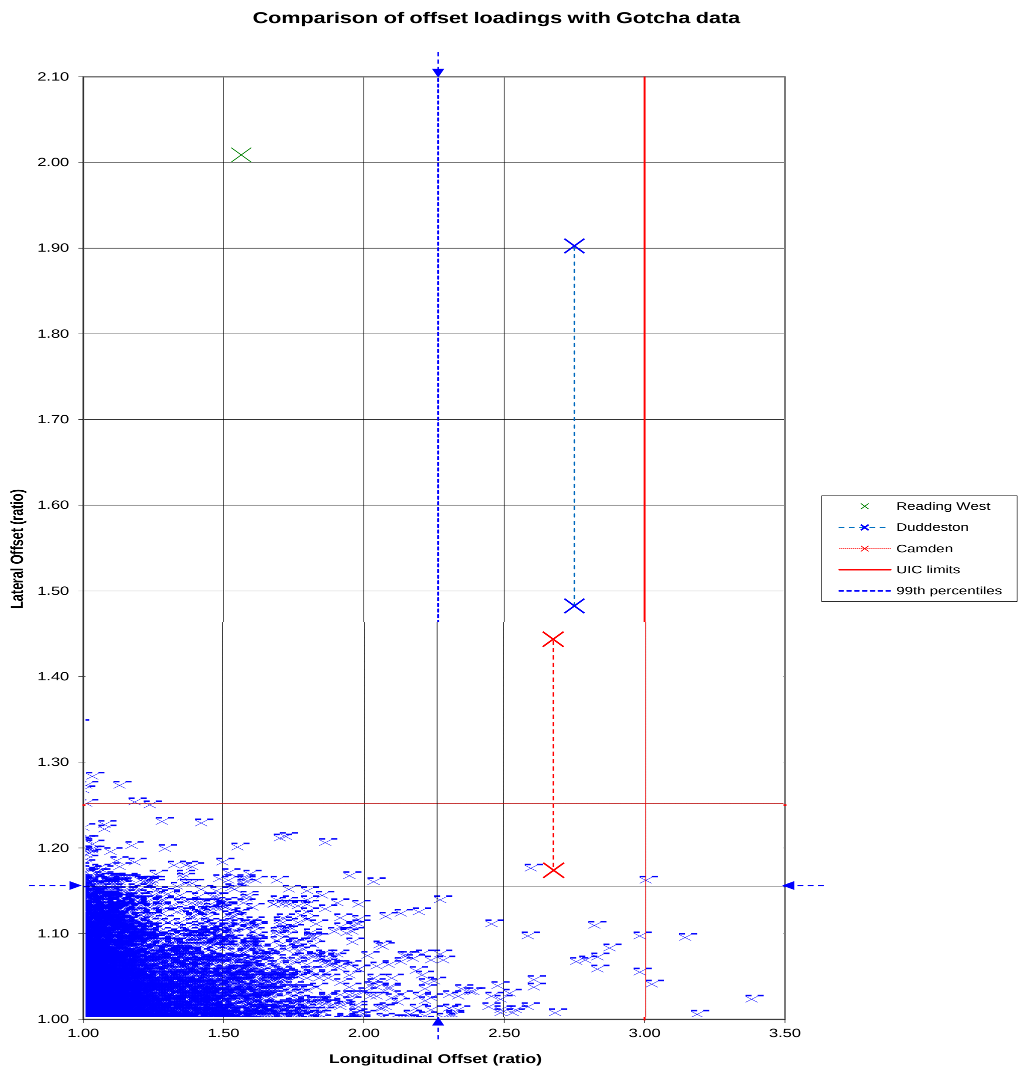
- TRV last scheduled run cancelled
- No check rail to provide lateral restraint
- Flange lubricator not applying grease to gauge corner
- Asset knowledge - affected by high turnover of local management staff

‘Gotcha’ data on asymmetric wagon loading



Vehicle *vs* axle imbalance

Estimated lateral and longitudinal offset in three derailments investigated by RAIB



Vehicle *vs* axle imbalance

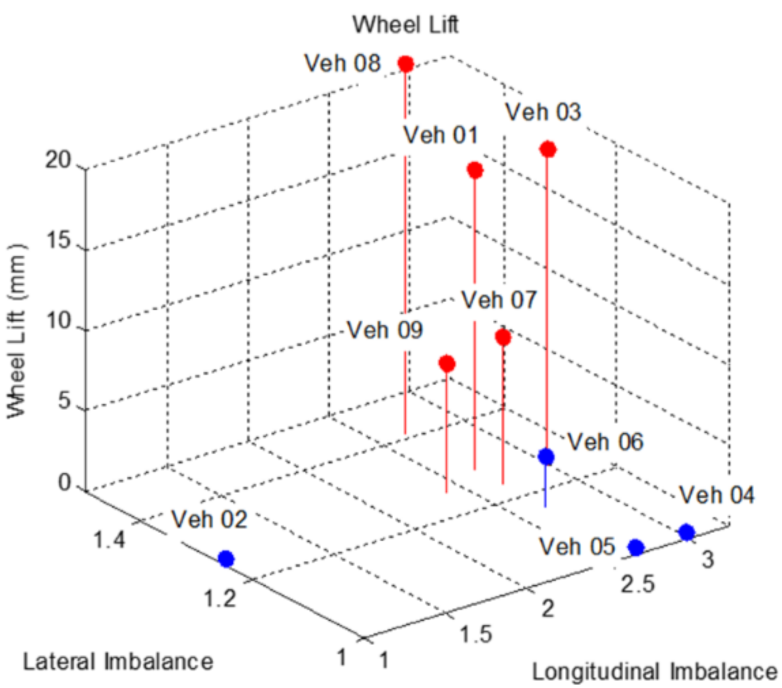
Understanding the causes

- Issues with track and the wagon,

Significance of each contributor?

- Various test cases of different longitudinal and lateral offset:
  - Case 01 (the 'base case') - RAIB's assessment of the most likely weight distribution (actual weights carried and lateral and longitudinal offsets)
  - Case 02 - load balanced longitudinally, offset laterally;
  - Case 04 - load balanced laterally, offset longitudinally;
  - Case 06 - case 01, but lower level of lateral imbalance;
  - Case 08 - case 01, but higher lateral imbalance; and
  - Case 09 - case 01, but lower level of longitudinal imbalance.

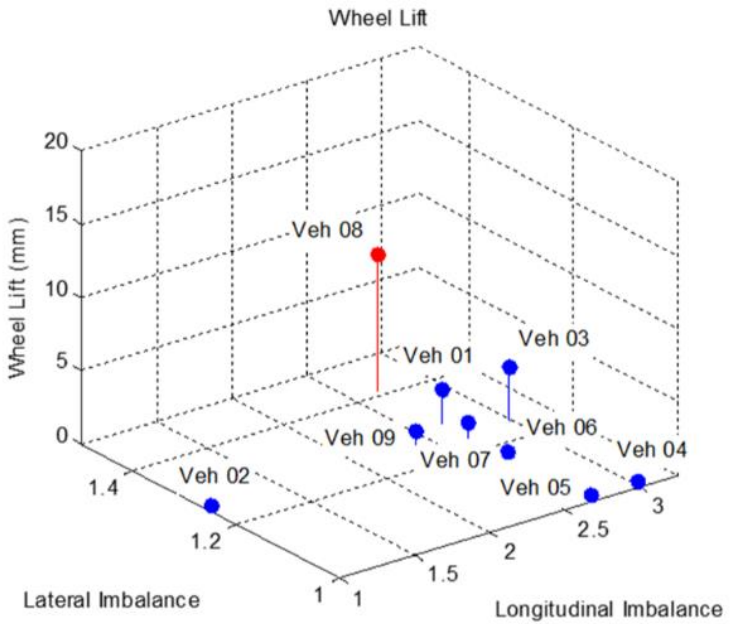
Results: μ = 0.23



Key criterion
Wheel lift in excess of 6mm implies derailment

Case	Characteristics
01	Base case. Most likely load and distribution on day.
02	No longitudinal offset
04	No lateral offset
07	Base case longitudinal offset, lower level of lateral offset
08	Base case longitudinal offset, higher level of lateral offset
09	Lower level of longitudinal offset, base case lateral offset

Reduced track twist



<u>Key criteria</u>

- Track twist reduced to 75% of measured value
- Wheel lift in excess of 6mm implies derailment

Case	Characteristics
01	Base case. Most likely load and distribution on day.
02	No longitudinal offset
04	No lateral offset
07	Base case longitudinal offset, lower level of lateral offset
08	Base case longitudinal offset, higher level of lateral offset
09	Lower level of longitudinal offset, base case lateral offset

Conclusions

- Wagon derailed due to <u>combined</u> high level of longitudinal and lateral load imbalance

- At this location due to a compound track twist, wavelengths corresponding to both bogie wheelbase and bogie spacing

Possible mitigations and key recommendation

Both wagon and track issues caused derailment

- Changes to track inspection and maintenance criteria
- Improvements to lubrication at the wheel/rail interface
- Reducing the permissible longitudinal weight ratio for wagons
- Identifying asymmetrical loading (at terminals or shortly after departure)
- Modifications to wagons : more tolerant of asymmetric loading

Recommendations made to industry to view these matters as a system issue and work together to define the right controls.

‘People need to know that accidents have been thoroughly investigated and that actions have been take so they don’t happen again

That’s what we do…’

Rail Accident investigation Branch UK