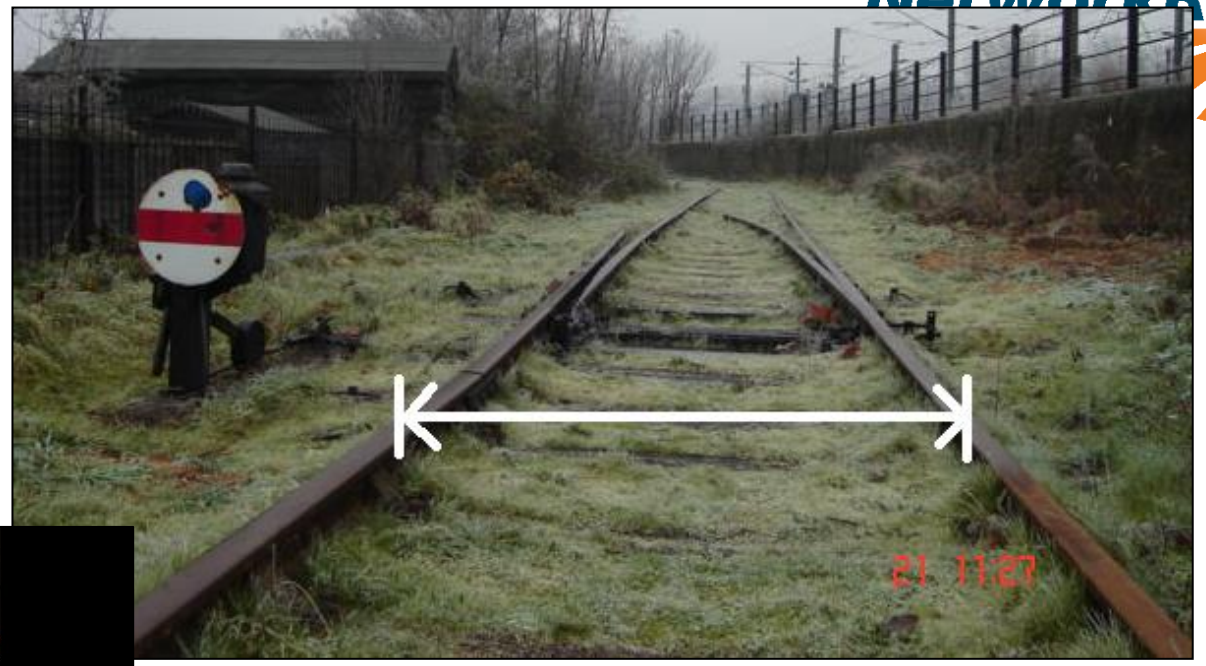
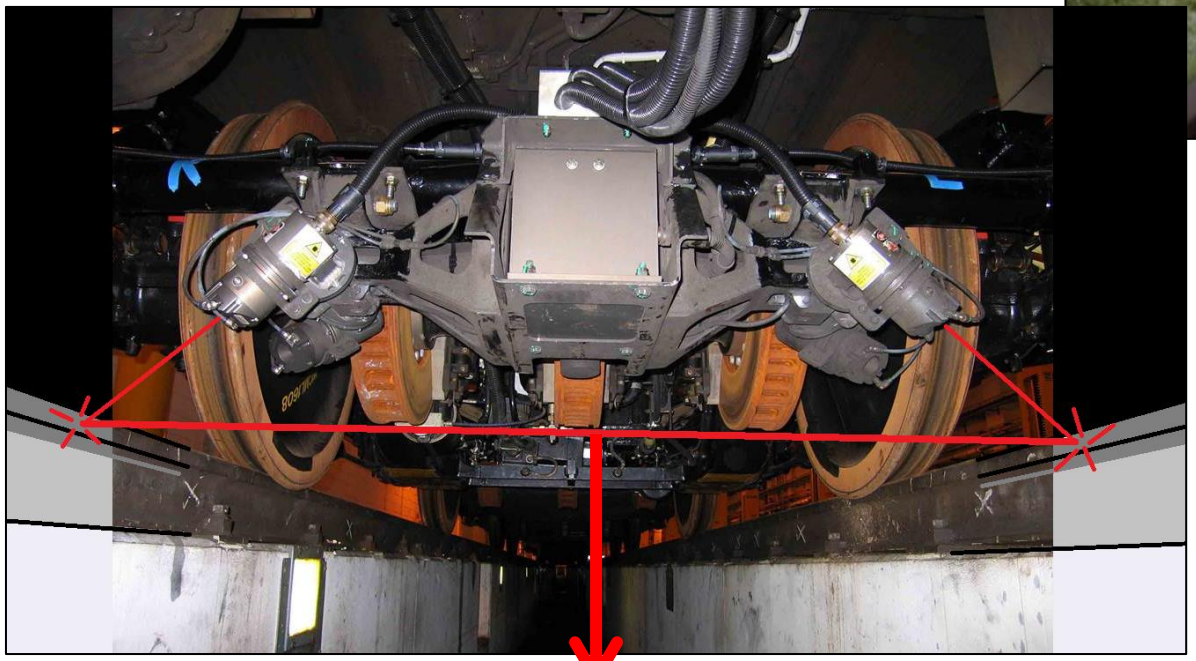
Wide Gauge Derailment Risk

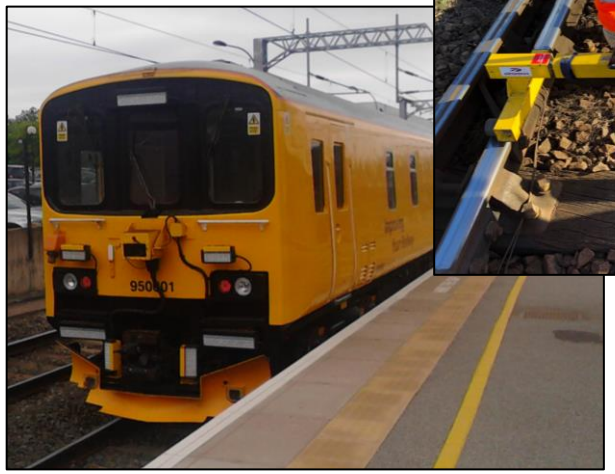
TME Conference

Chris Fuller / Rich Gibson / Andrew Turner

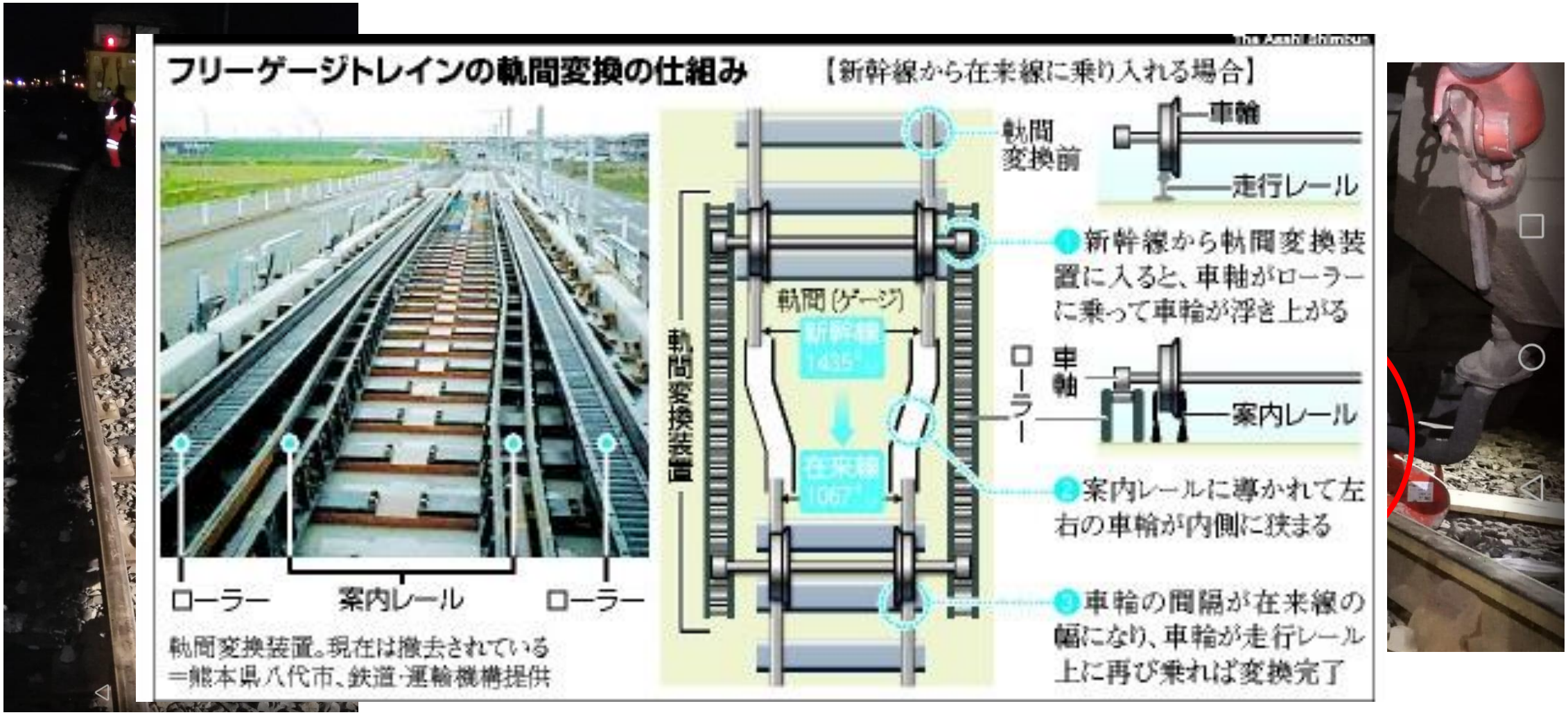
What is Track Gauge



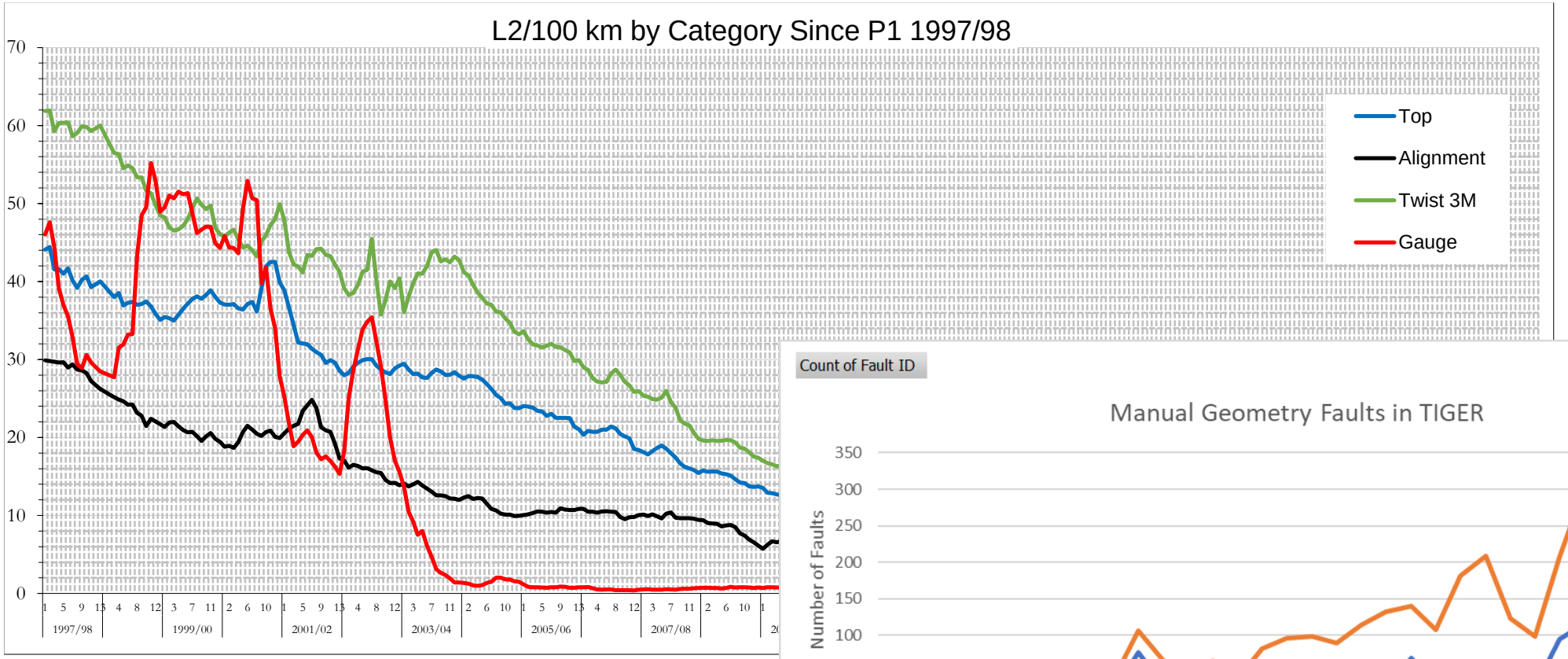




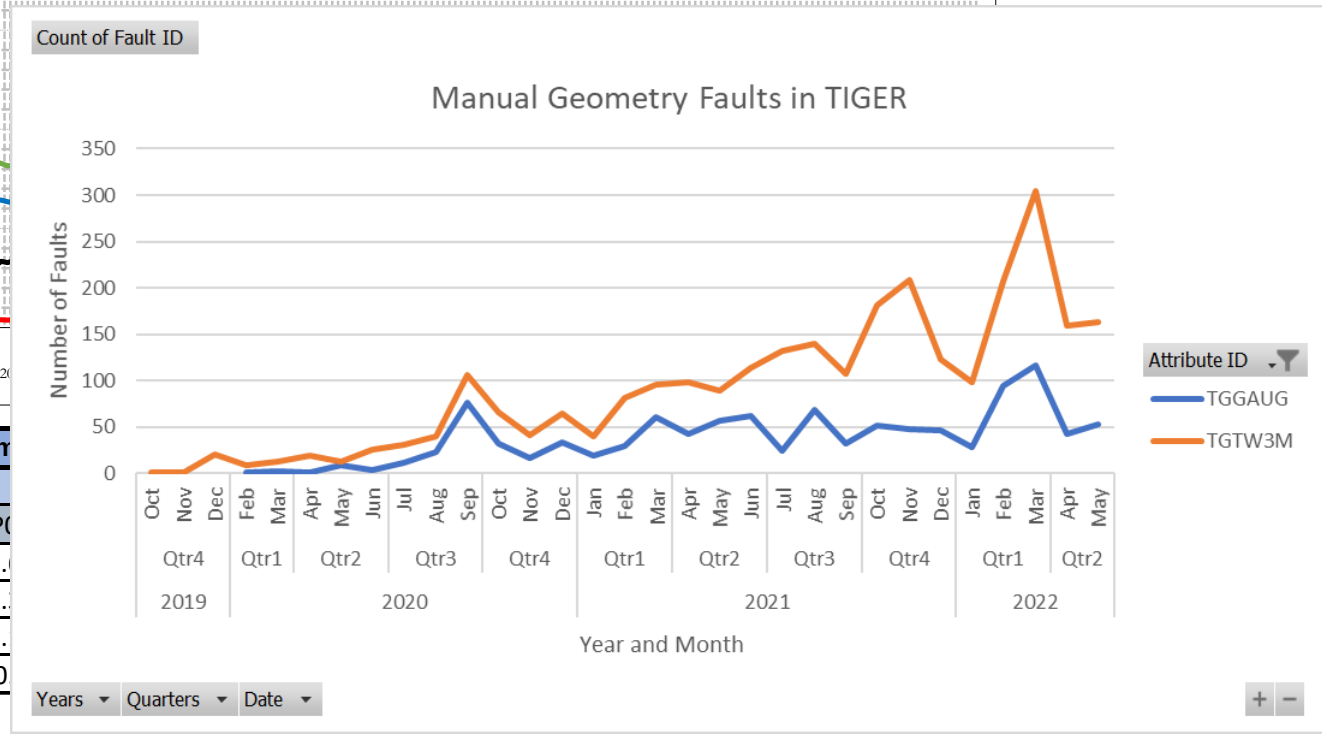
Why is Track Gauge Important?



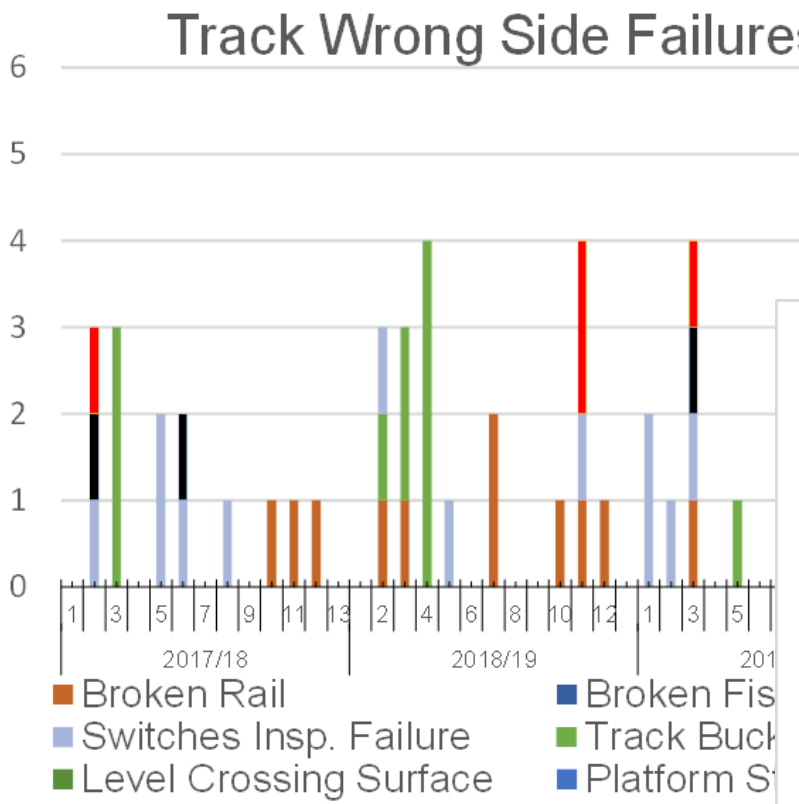
Track Geometry Trends with Gauge

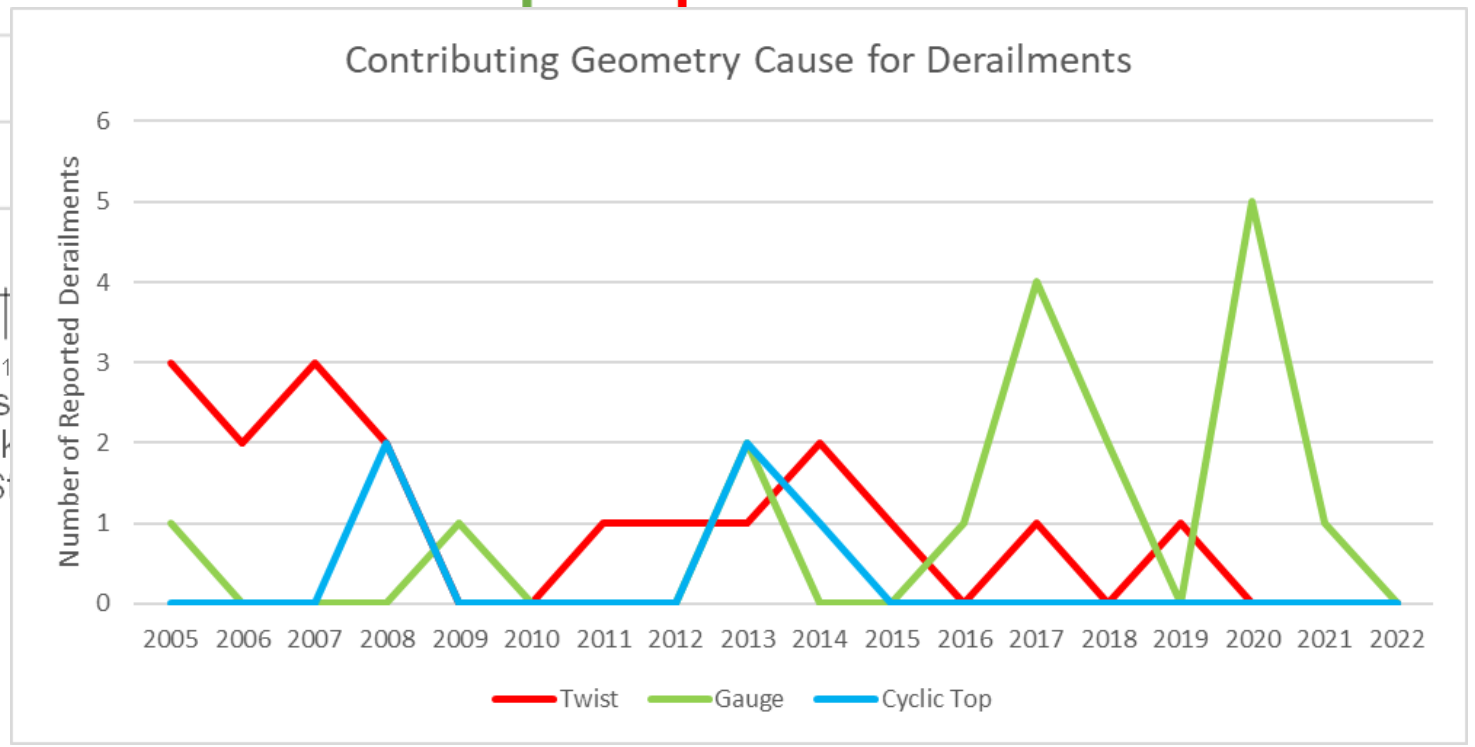


	Track Geom						
	2020/21						
	P13	P01	P02	P03	P04	P05	P(
Top	2.92	2.59	2.45	2.65	2.58	2.70	2.
Line	7.99	8.12	7.98	7.94	8.05	7.94	8.
Twist	5.67	5.30	5.51	5.59	6.08	6.06	6.
Gauge	5.34	8.73	8.81	9.68	9.82	9.60	10



Risk and Derailment Trends with Gauge Spread





What we have learnt from these events?

NetworkRail

Technical Authority

Providing technical leadership

Review of Gauge Spread Derailments

Report number: V1.3

Produced: Chris Fuller
Senior Engineer [Track, Switches and Crossings]

Signed: _____

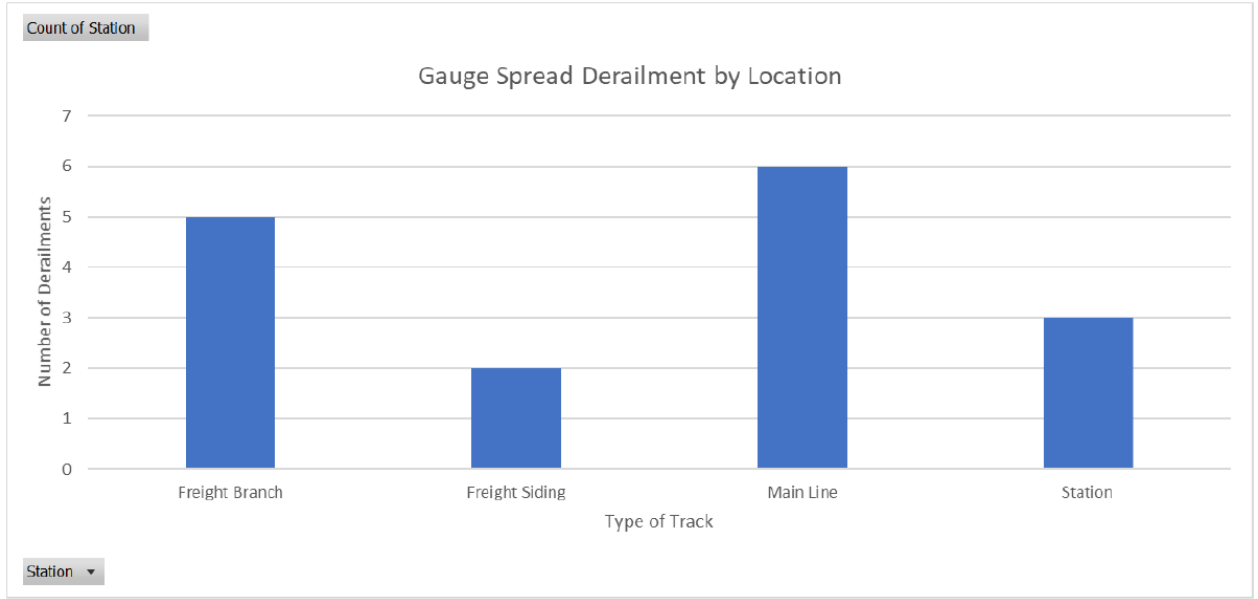
Checked: Ian Barber
Principle Engineer [Track, Switches and Crossings]

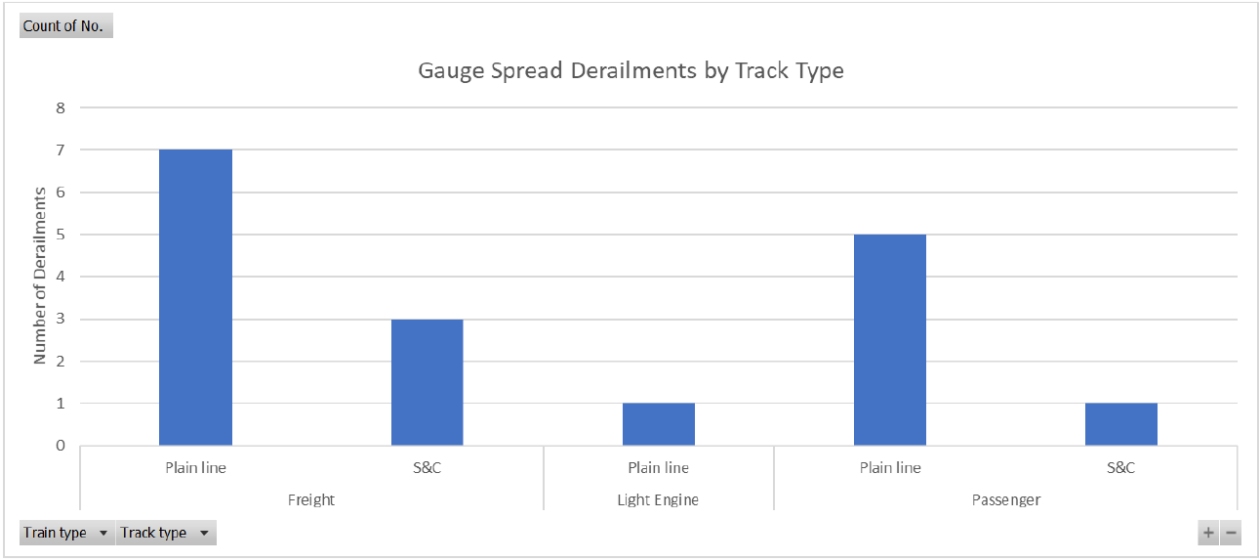
Signed: _____

Approved: Gareth Evans
Professional Head of Track

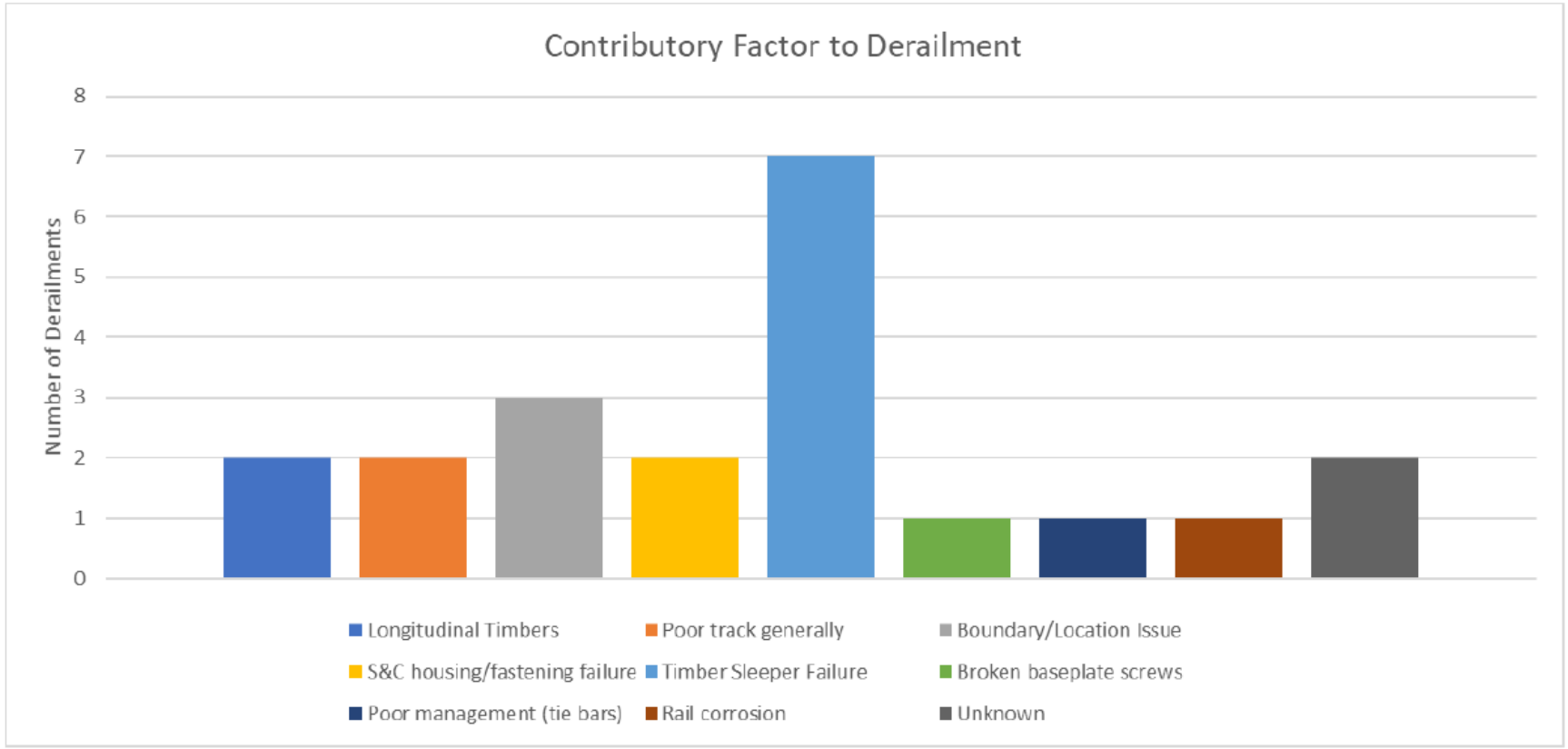
Signed: _____

Page 1 of 17





Causes/Contributing Factors



Significant Instances of Gauge Spread Derailments

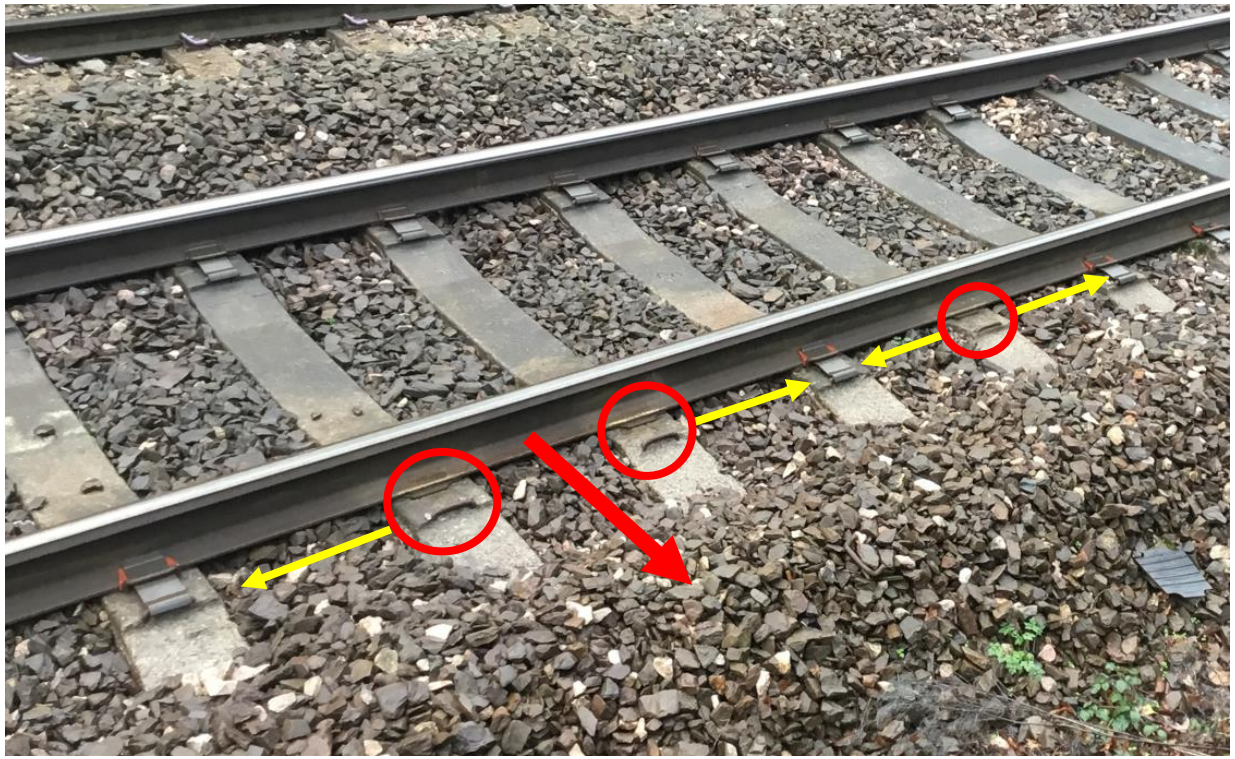
Gauge Spread Risks

- Ineffective wood sleepers
- Pan 8 Lockspike fastenings
- F19 sleeper SHC broken hoops
- Longitudinal bearers failure
- Timber S&C broken screws
- Concrete S&C broken screws
- Concrete S&C broken housings

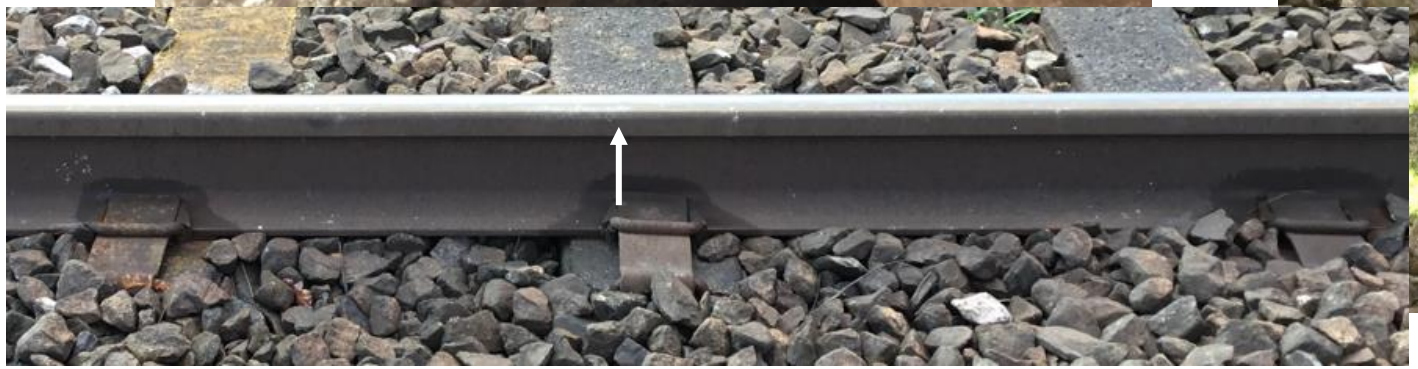
F19 SHC Sleepers – Gauge Spread Failure Mechanism

- Hoop fails and detaches from sleeper
- Increases forces on adjacent sleeper hoops
- Adjacent sleeper hoops subsequently fail
- Increases forces on their adjacent sleeper hoops
- Rail ‘unzips’ causing gauge spread
- Wide gauge derailment risk

Nothing to prevent rail movement

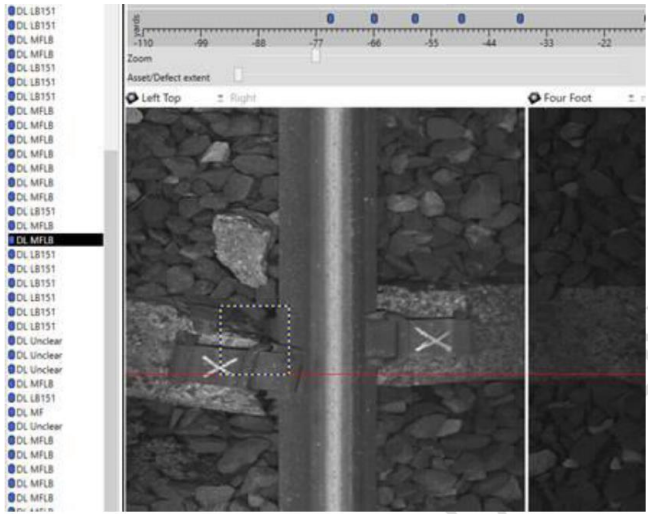


F19 SHC Hoop Failure Identification



F19 SHC Tactile Inspection

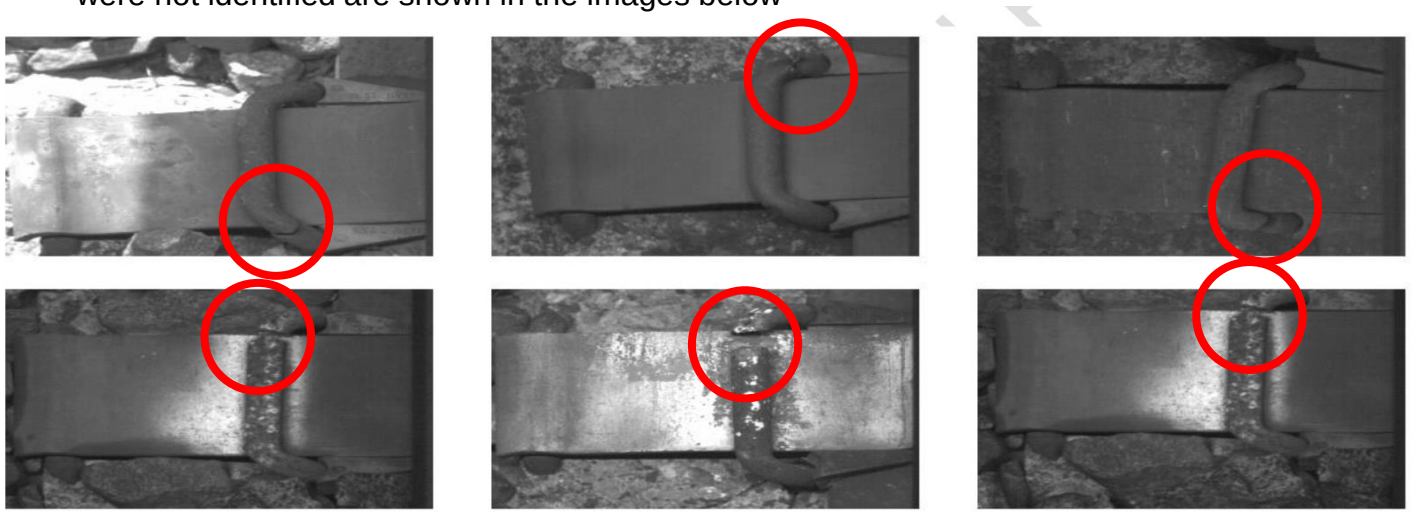
F19 SHC - PLPR



Can identify missing clips / broken hoops with missing clips

Can't identify broken hoops with clips and hoops still in place / broken off sleeper ends or defects with heavy ballast / broken or cracked sleepers with clips in-situ

- Some examples of SHCs with a 'Defective Housing' defect class from the trial that were not identified are shown in the images below

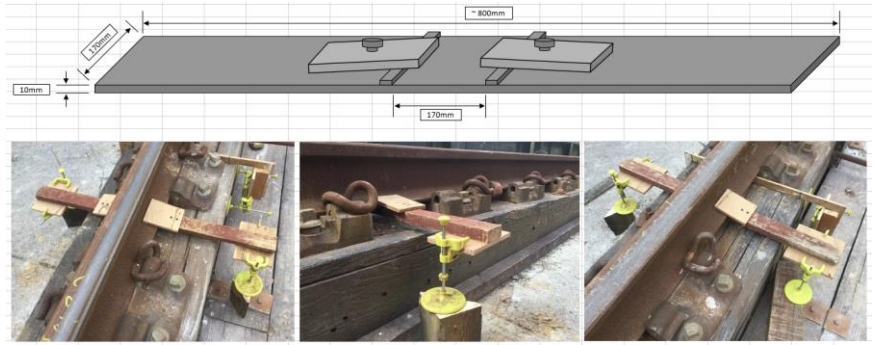


LBS Gauge Spread Derailment Risk

Pontsmill Derailment Picture 4 Copyright Stephen Heginbotham Railcoach

Pontsmill Derailment Picture 3 Copyright Stephen Heginbotham Railcoach

Issues With LBS



- Unusual / bespoke designs / components
- Difficult to observe under traffic
- Difficult to measure dynamic movement
- Hidden elements
- Limited experience / knowledge
- Low familiarity with the asset

Hidden Elements

Progress With LBS

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Ref:	**NR/SIN/196**
Issue:	1
Date:	29th July 2020
Compliance date:	5th August 2020

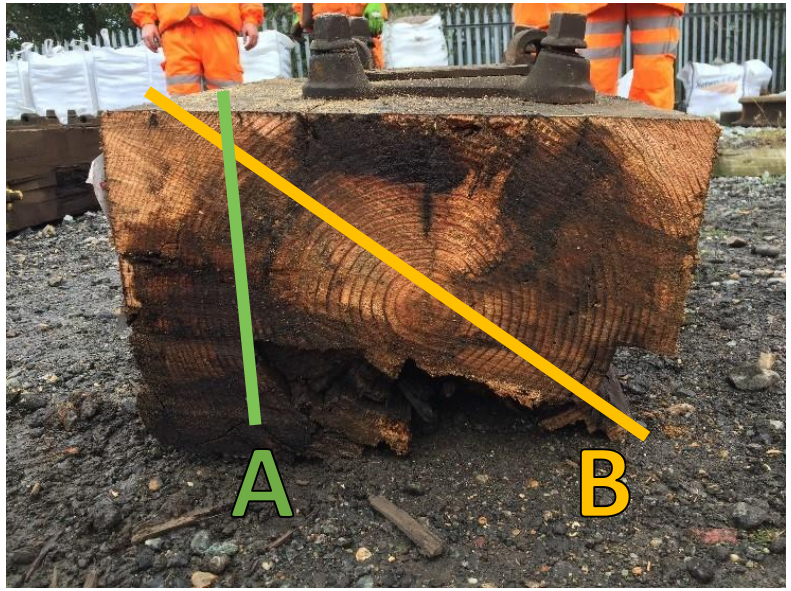
6 Actions required and timescales

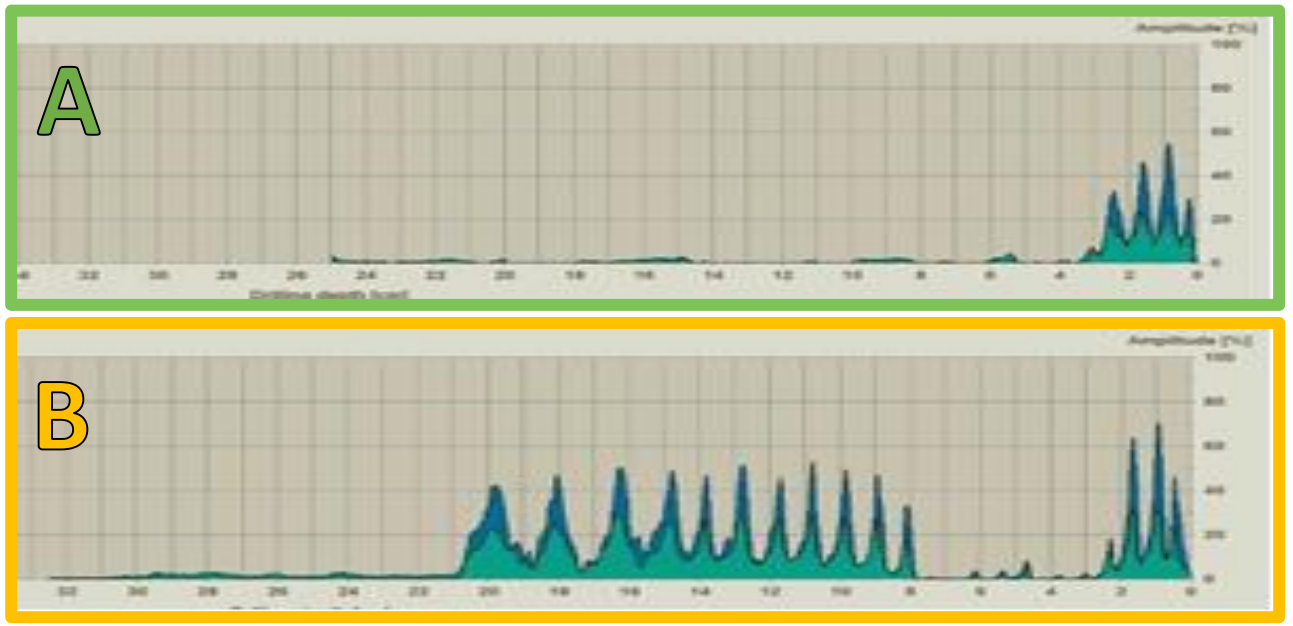
6.1 All phases

The SIN is split into 4 phases as described in Table 4 as a summary. The requirements of each phase are detailed in 6.2 to 6.5. The phases can be undertaken in parallel where this can be managed appropriately.

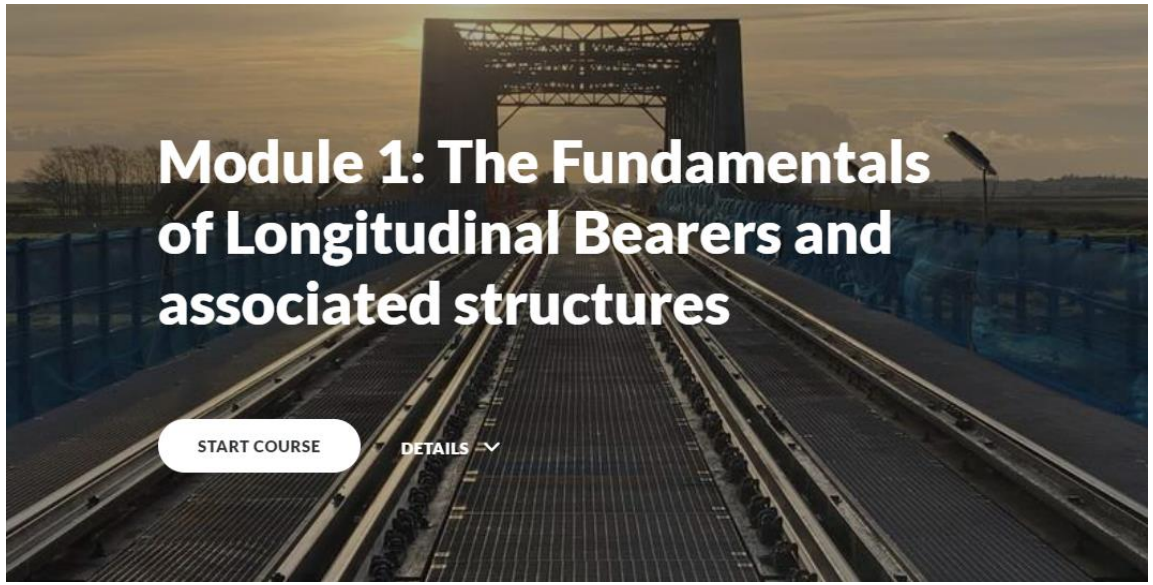
Phase 5 does not form part of this SIN but is provided for clarity and good practice.

	SIN Actions				Follow Up Work
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 5**
What does the phase include	**Briefing** of: ○ key elements of this SIN to all key accountable and responsible roles and; ○ the importance and effectiveness of BVI and SVI to key responsible roles.	**Risk assessment** of all LBS. A desktop study of key asset information to prioritise all longtimbers based on known key risk criteria. The risk score agreed by TME & RAM determines the classification of a high-risk asset.	**Tactile Inspection –** undertake inspections by trained and competent people on all high-risk assets(from score agreed by RAM & TME as defined in phase 2) and identify all work required to reduce the likelihood or consequence of failure.	**Planning of work**- Plan all items of work at an appropriate timescale *in prioritised order.* Load work into an approved work management system/renewals workbank.	**Delivery of work** and **ongoing assurance** arrangements including **Ellipse arrangements** - All assets in ellipse, all MSTs for supervisor and detailed examinations, and review of TEF3279 set up.

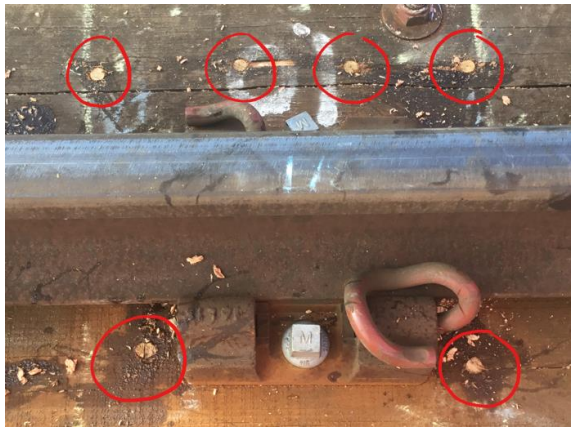




Progress With LBS



- Boron gel timber life extension trial



- DELB
- Mod 1 – Fundamentals of LBS
- Mod 2 – Understanding Detailed Examination
- Mod 3 – Microdrill and application

- LBS TWI Suite - TRK/3038 - Community of Practice

	TWI	Title and Contents
1	Components	Applies to All – components, nomenclature, basics, how to identify type
	Ellipse	Management – How to set up Longitudinal Timbers in Ellipse?
2	BVI	Inspection – BVI
	SVI	Inspection – SVI
	Reactive inspection	Inspection following defect or fault?
	Drainage	Inspect/Maintenance – Drainage (Mtce comes under 5 & 6)
	Defects	Inspect/Maintenance – defects - common defects (Mtce comes under 5 & 6)
3	DELB	Inspection – Detailed examination
4	NDT	Inspection – Non-destructive testing
5	Rail support	Maintenance - Support of rails (vertical / horizontal / rotational restraint at baseplate / chair)
6	Gauge (bearer support)	Maintenance – Gauge management of bearers - packings and wedges (lateral)
	Top / Line (bearer support)	Management of Top and alignment – 2. transitions and interface, 3. Support arrangements for bearers, 4. transom replacement, 5. packings & wedges (vertical & lateral)(duplicated above?)
7	Preservatives	Maintenance – preservatives
8	Composite bearers	Maintenance/Replace – Composite bearers - specific risks and challenges – should be read in conjunction with others.
	FFU bearers	FFU Bearers
9	Walkways	Maintenance/Replace – Walking routes & surfaces. 1. How to maintain, 2. Taking up & replacing etc.
10	Material / component selection	Replace – Material selection and components
	Scoping	Replace – Planning replacement (scoping).
	Measuring	Replace – Measuring – survey –
	Design	Replace - design (2500) – 1. Single longtimber or system, 2. Conversion possibly, 3. Guardrails, 4. Conductor rails, 5. checkrails
	Replacing /delivery of work	Replace – delivery of work – 1. Site adjustments (tools) single or system, 2. Approved standard techniquesfor timber replacement such as use of cheese plates, 3. Use of pitch/bitumen hot works regs for trough timbers
	Resin treatments	Maintenance – Resin treatments

Item	Description	Date
1 – 24 are completed by the Technical Lead at the start of a project and do not get changed.		
1	Baseline - approval of remit.	01/02/2022
2	Baseline - working group resolve outstanding emergency changes.	
3	Baseline - working group resolve outstanding standard challenges.	31/03/2022
4	Baseline - working group resolve outstanding variations pending standards change.	
5	Baseline - working group resolve outstanding Standards Update Suggestion Log content. Click here	31/03/2022
6	Baseline - working group resolve any issues relating to connected documents	31/03/2022
7	Baseline - working group agree draft content (includes identifying applicable legislation and confirming requirements of remit have been met).	30/04/2022
8	Baseline - edit by Standards team.	30/04/2022

Broken Screws In Timber S&C Layouts

- Sheffield
- East Somerset Jcn.

Broken Screws In Timber Layouts

Wales and Western	Document Reference Numbers	Date	Version
	WW/EAM/IN/TRK/0001	April 2021	1

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Engineering and Asset management

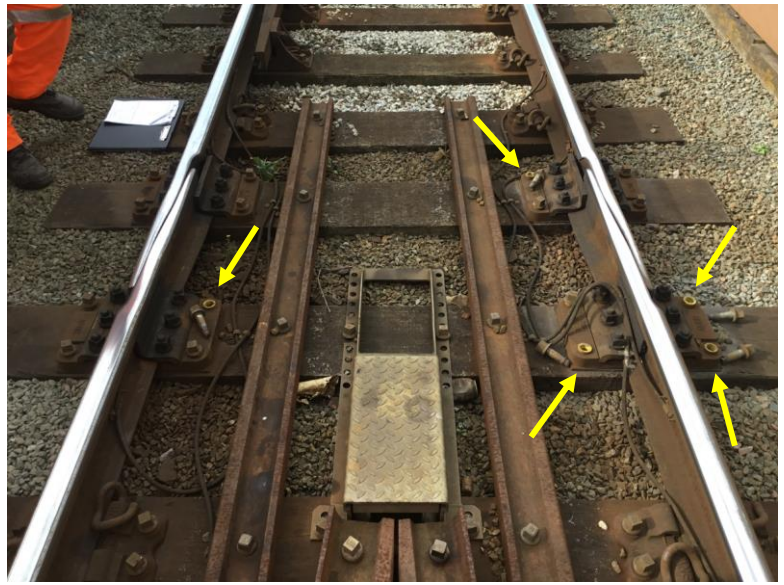
Wales and Western

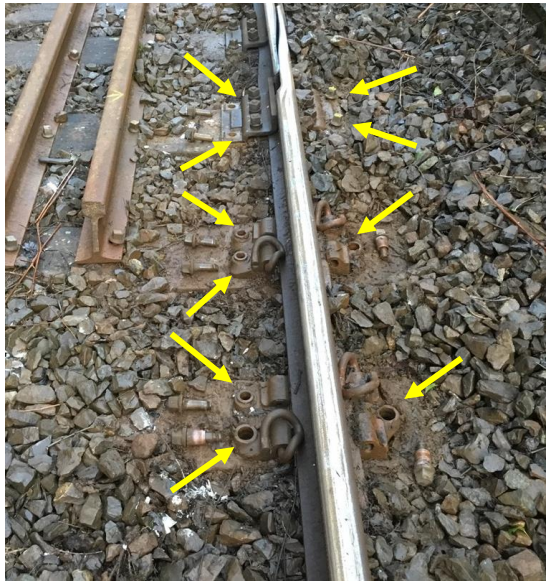
Inspection Notice

Checking screws in tight radius timber S&C

Broken Screws In Timber Layouts

- RAB adjustment switch
- Pontsmill adjustment switch

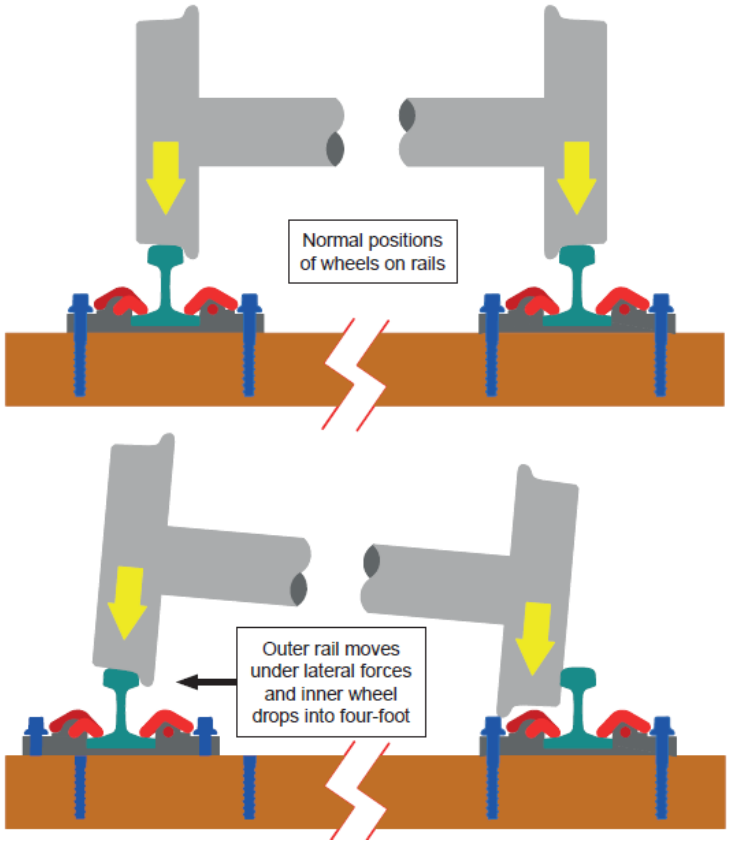


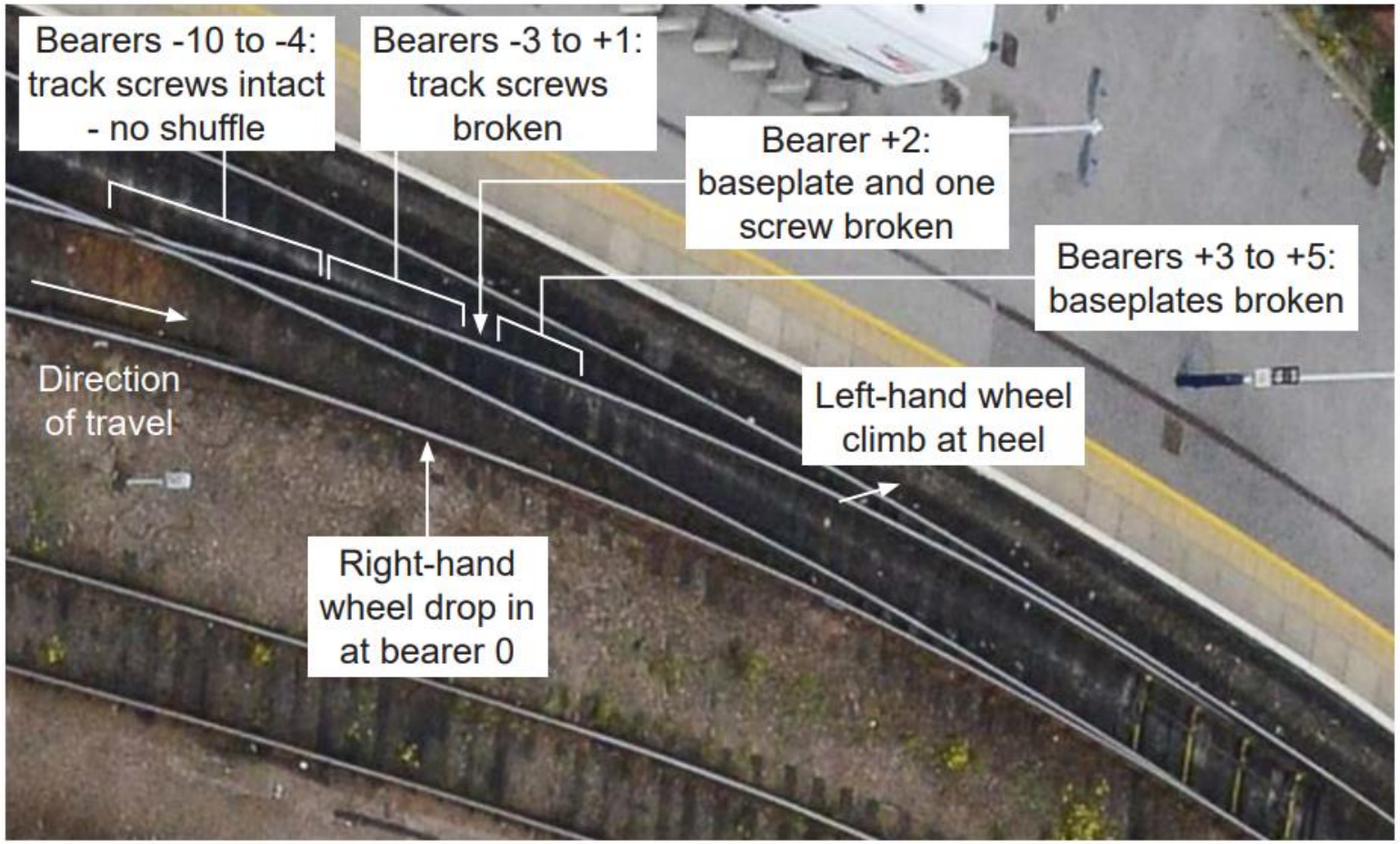


Sheffield Derailment

Above: Wagon BCC10756 toppled on its side

Sheffield Derailment





The track gauge had widened because a number of screws in the timber bearers had broken, allowing the rails to spread apart under load.

Sheffield Derailment

The repeated lateral loading of the outer rail under the passage of loaded freight trains led to fatigue cracking of the screws and subsequent failure over an extended period, despite the track screws being compliant with standards.

Reverse Engineering

Reverse engineered components include:

- PANV Baseplate
- Pandrol Clips
- AS Screw
- CEN56 Rail

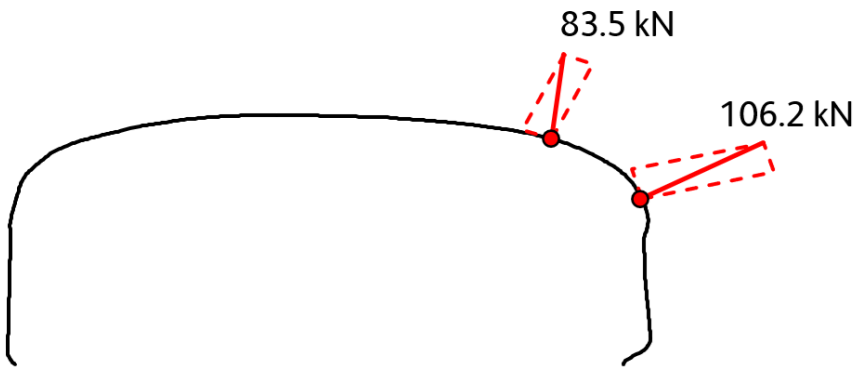
Sheffield Derailment

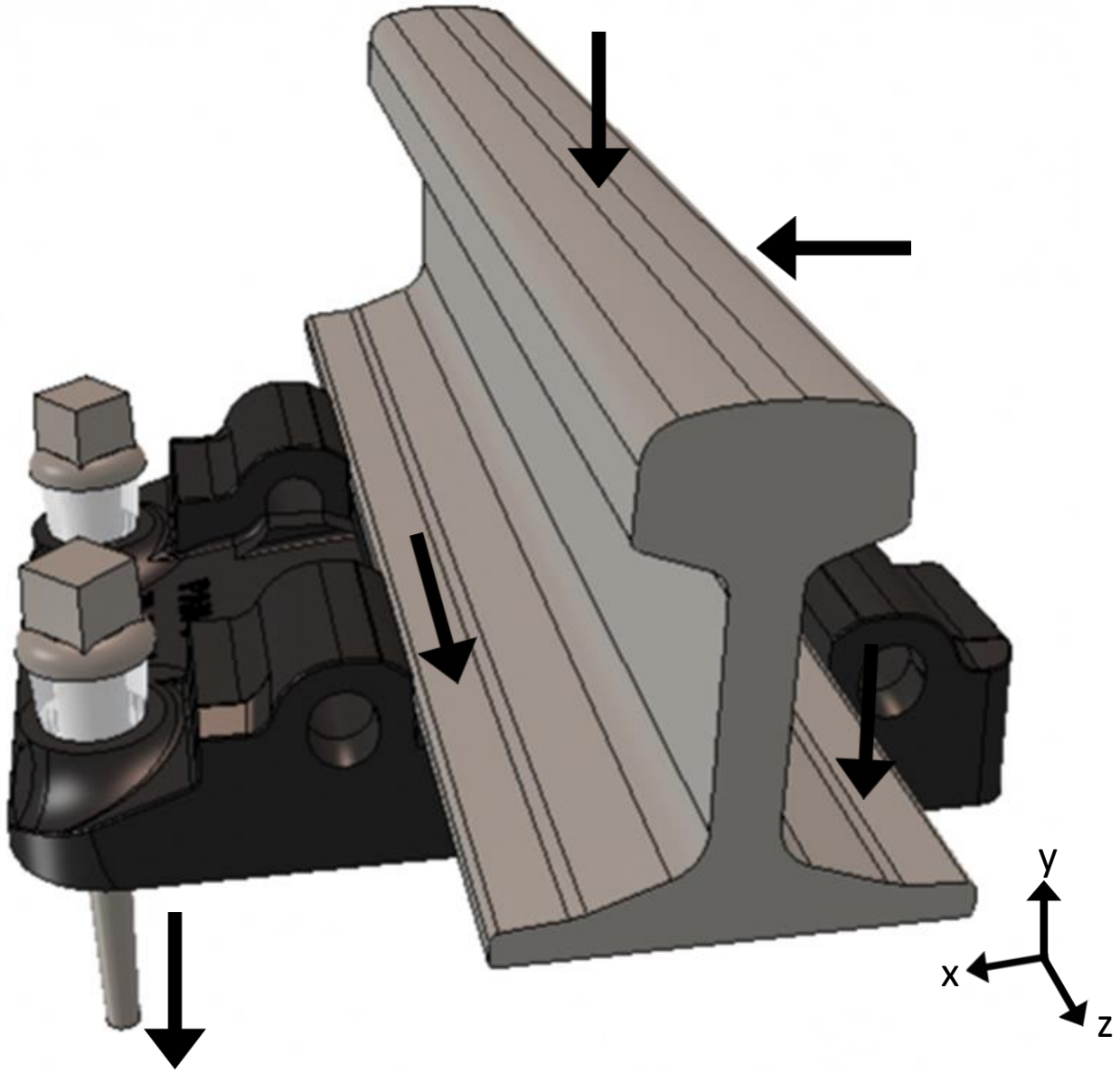
Assumptions

- No torsion stored in screws
- Constrained in z
- Contact Patch of Wheel 10mm

Forces

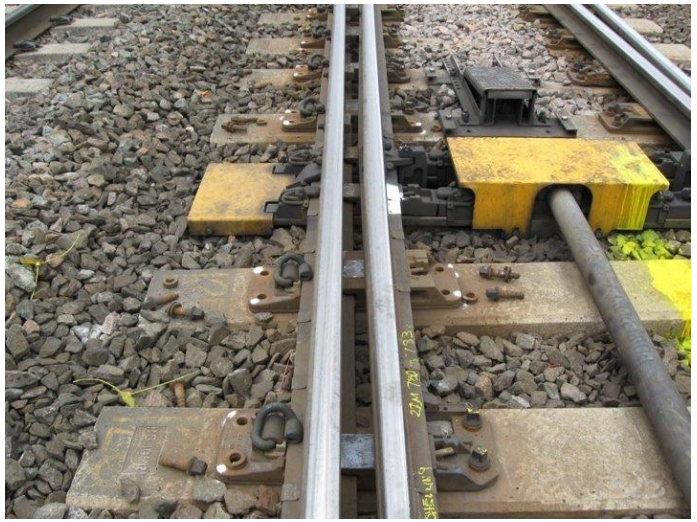
- Tensile force on Screws
- Toe load 6.5KN
- Friction coefficient between baseplate and sleeper 0.485
- Forces on Rail (see below)

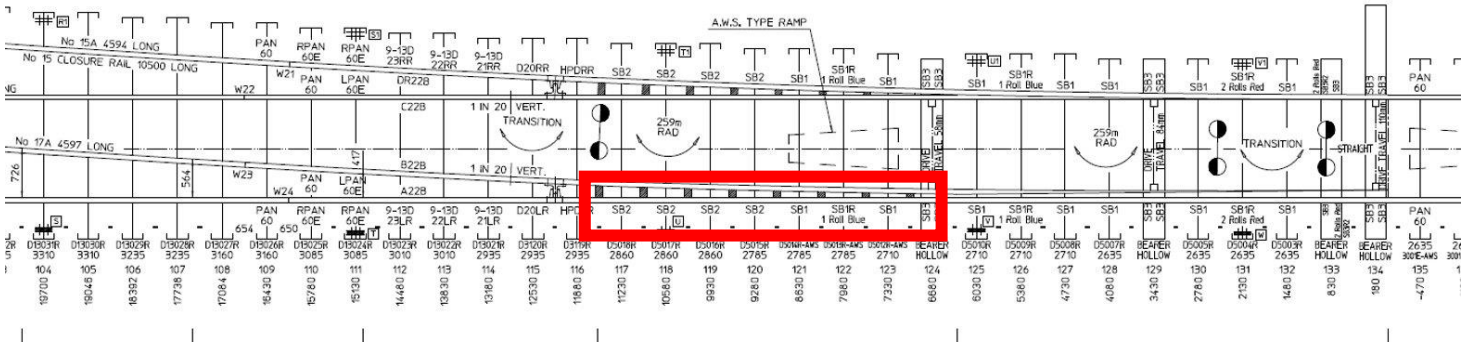




Broken Screws In Concrete Layouts - Kingsbury Junction

2009





2022

Similar failures

Oxford Road - Reading

Pts 8806A

Pts 8808

BBRT60 Elevated Housings

Andrew Turner

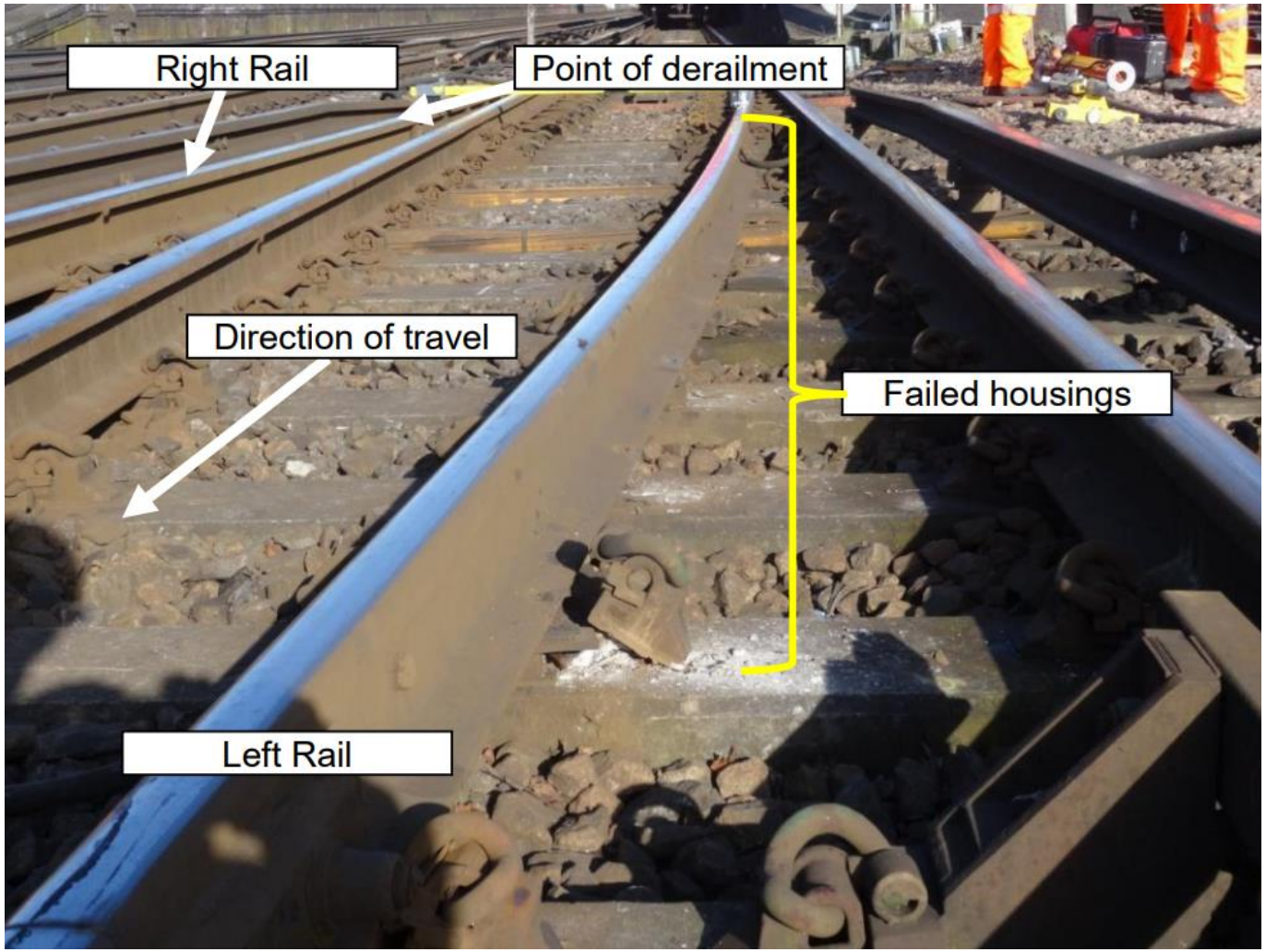
Content

- Background to Eastleigh
- Failure mechanism
- Immediate response (SIN/191 + results)
- Short-term actions (TRK/001 update + EV programme)
- Medium/Long-term actions (RAIB recs, new housing, UT, NR60 Mark 1 bearers)

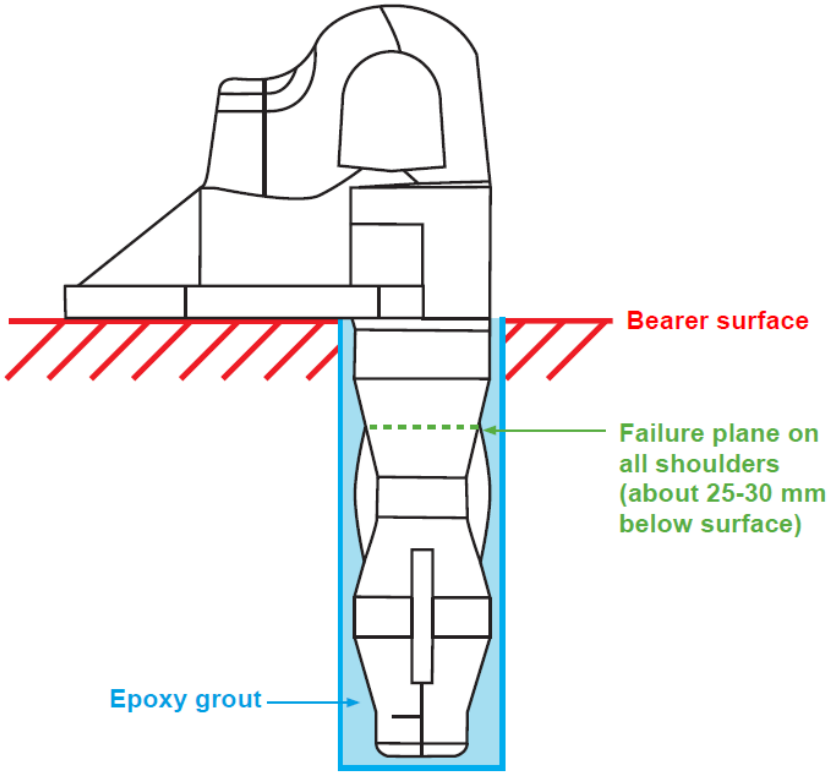
Background

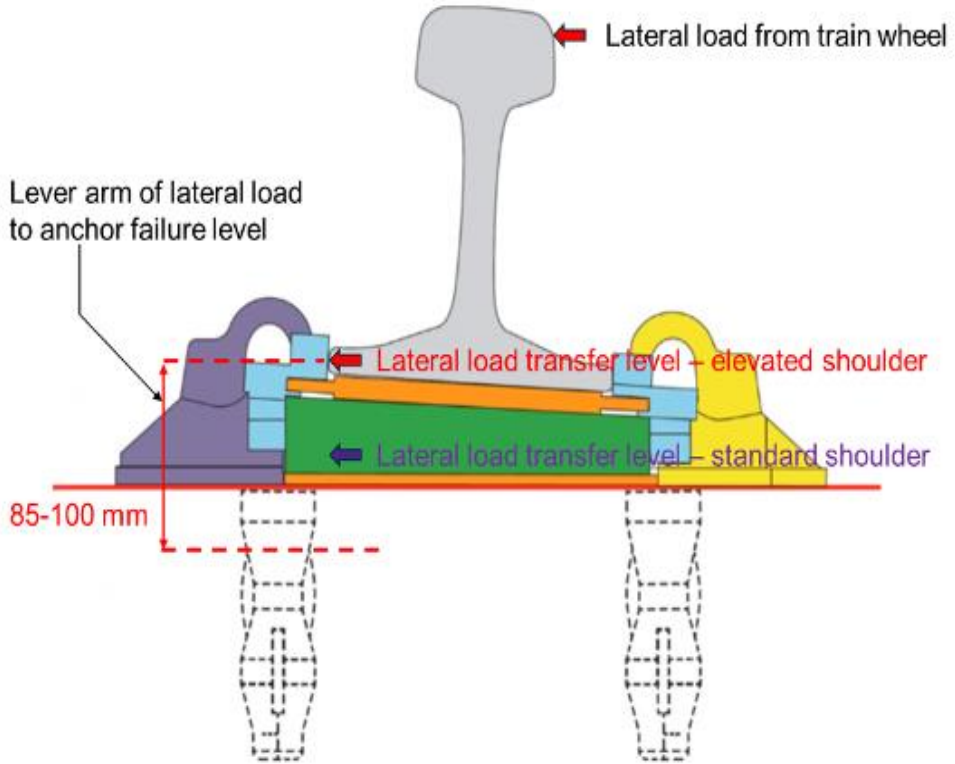
- Eastleigh 450A points
- 28th January 2020
- Balfour Beatty RT60 S&C
- Failure of elevated housings leading to gauge spread

Background


Right Rail
Point of derailment
Direction of travel
Failed housings
Left Rail

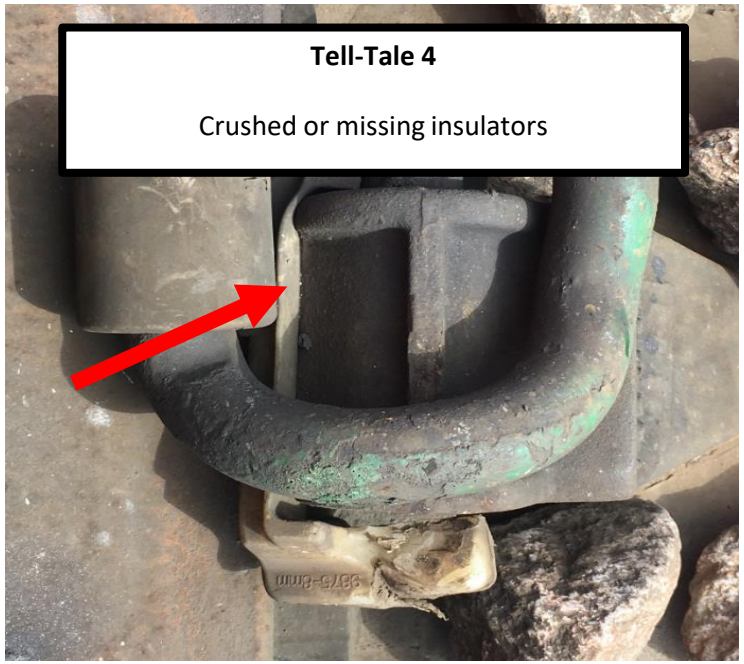
Mechanism of failure





Diagrams adapted from RAIB report 02/2021

Visual Tell-Tale Signs

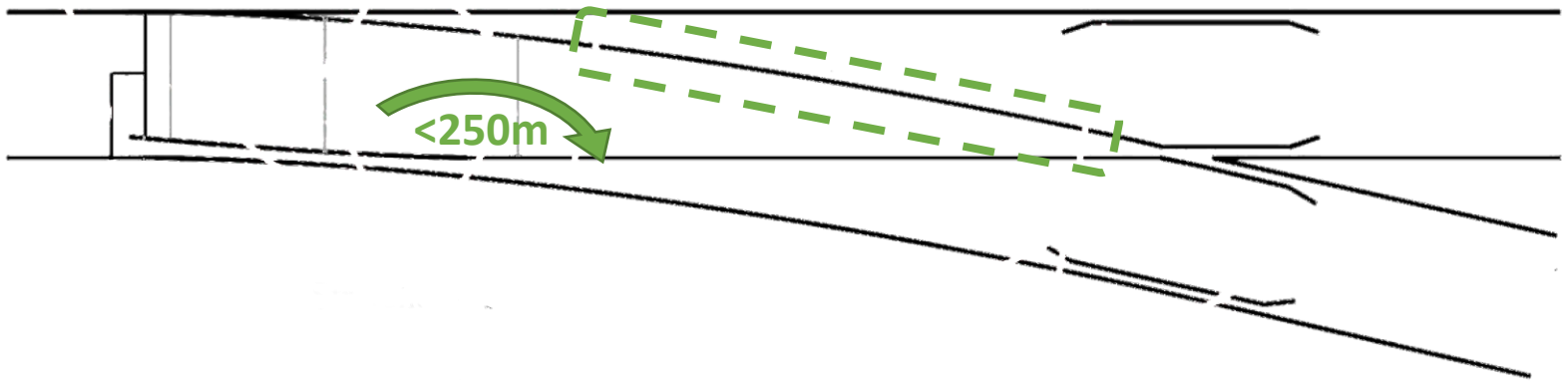


Risk Factors

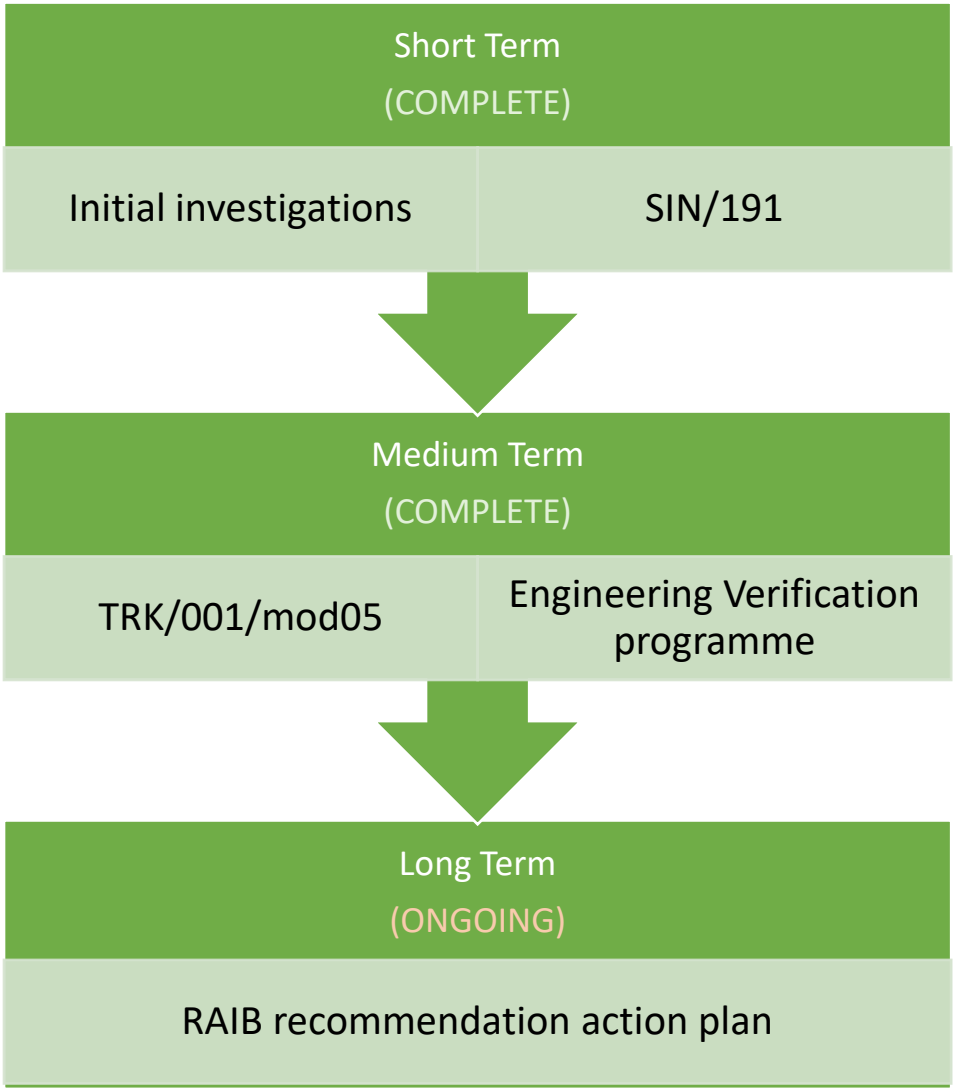
Short switches (such as C or D)

Outer rail between heel and crossing

Heavy freight traffic



Action plan


Short Term
(COMPLETE)
Initial investigations
SIN/191
Medium Term
(COMPLETE)
TRK/001/mod05
Engineering Verification programme
Long Term
(ONGOING)
RAIB recommendation action plan

Action plan

Short Term (COMPLETE)

Initial investigations	SIN/191

Medium Term (COMPLETE)

TRK/001/mod05	Engineering Verification programme

Long Term (ONGOING)

RAIB recommendation action plan

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Ref:	NR/SIN/191
Issue:	1
Date:	07 February 2020
Compliance date:	05 June 2020

Special Inspection Notice

Inspection of Elevated Housings in Balfour Beatty RT60 S&C Units

Approvals

Content approved by:

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Technical Lead

Content approved by:

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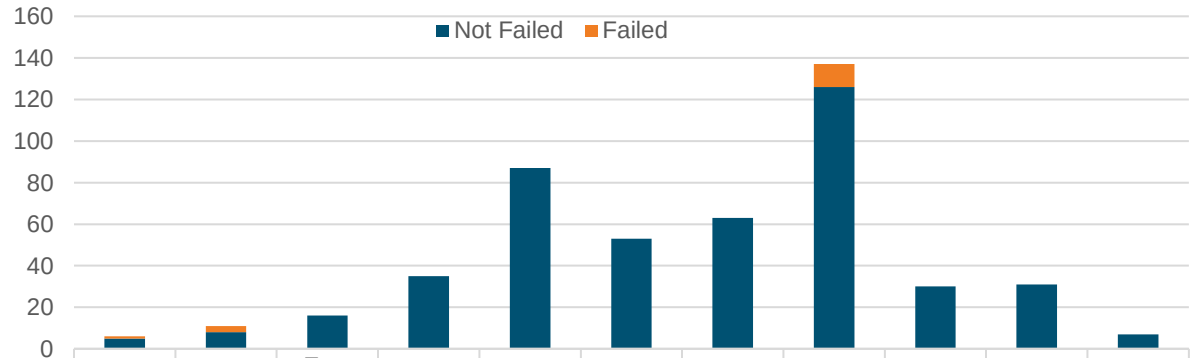
Tara Scott,
Standard and Control Document Owner

Endorsed by:

Stuart Kistruck,
Delivery Function

Published and Issued by Network Rail, 2nd Floor, One Eversholt Street, London, NW1 2DN.

Number of BBRT60 point ends found with failed housings



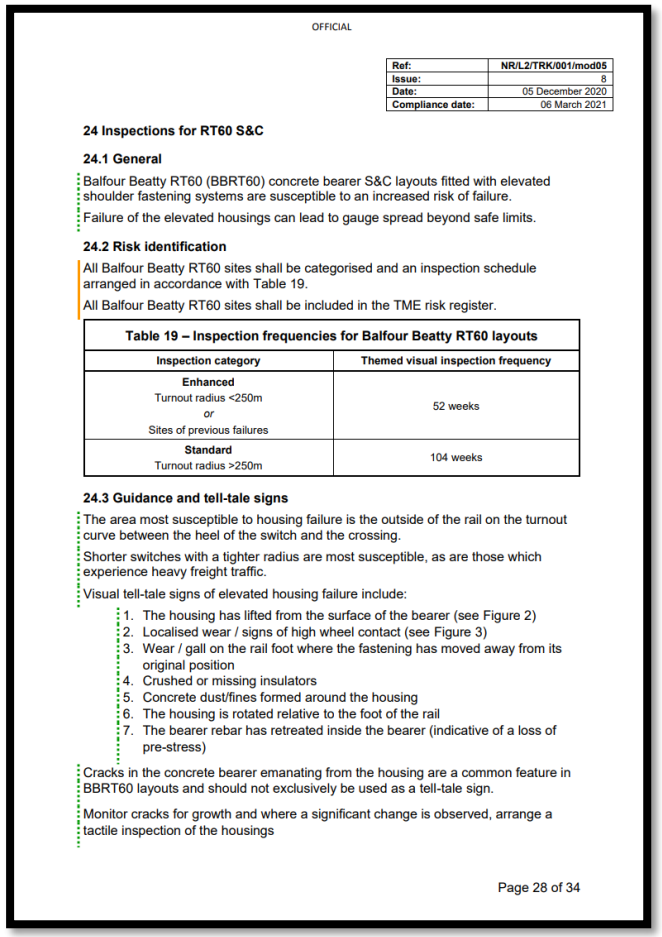
	Anglia	Central	East Midlands	Kent	North West	Scotland	WCMLS	Wessex	Western	East Coast	North and East
Failed	1	3						11			
Not Failed	5	8	16	35	87	53	63	126	30	31	7

Action plan

Short Term (COMPLETE)	
Initial investigations	SIN/191

Medium Term (COMPLETE)	
TRK/001/mod05	Engineering Verification programme

Long Term (ONGOING)
RAIB recommendation action plan



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Ref:	NR/L2/TRK/001/mod05
Issue:	8
Date:	05 December 2020
Compliance date:	06 March 2021

24 Inspections for RT60 S&C

24.1 General

Balfour Beatty RT60 (BBRT60) concrete bearer S&C layouts fitted with elevated shoulder fastening systems are susceptible to an increased risk of failure.

Failure of the elevated housings can lead to gauge spread beyond safe limits.

24.2 Risk identification

All Balfour Beatty RT60 sites shall be categorised and an inspection schedule arranged in accordance with Table 19.

All Balfour Beatty RT60 sites shall be included in the TME risk register.

Table 19 – Inspection frequencies for Balfour Beatty RT60 layouts

Inspection category	Themed visual inspection frequency
Enhanced Turnout radius <250m *or* Sites of previous failures	52 weeks
Standard Turnout radius >250m	104 weeks

24.3 Guidance and tell-tale signs

The area most susceptible to housing failure is the outside of the rail on the turnout curve between the heel of the switch and the crossing.

Shorter switches with a tighter radius are most susceptible, as are those which experience heavy freight traffic.

Visual tell-tale signs of elevated housing failure include:

1. The housing has lifted from the surface of the bearer (see Figure 2)
2. Localised wear / signs of high wheel contact (see Figure 3)
3. Wear / gall on the rail foot where the fastening has moved away from its original position
4. Crushed or missing insulators
5. Concrete dust/fines formed around the housing
6. The housing is rotated relative to the foot of the rail
7. The bearer rebar has retreated inside the bearer (indicative of a loss of pre-stress)

Cracks in the concrete bearer emanating from the housing are a common feature in BBRT60 layouts and should not exclusively be used as a tell-tale sign.

Monitor cracks for growth and where a significant change is observed, arrange a tactile inspection of the housings

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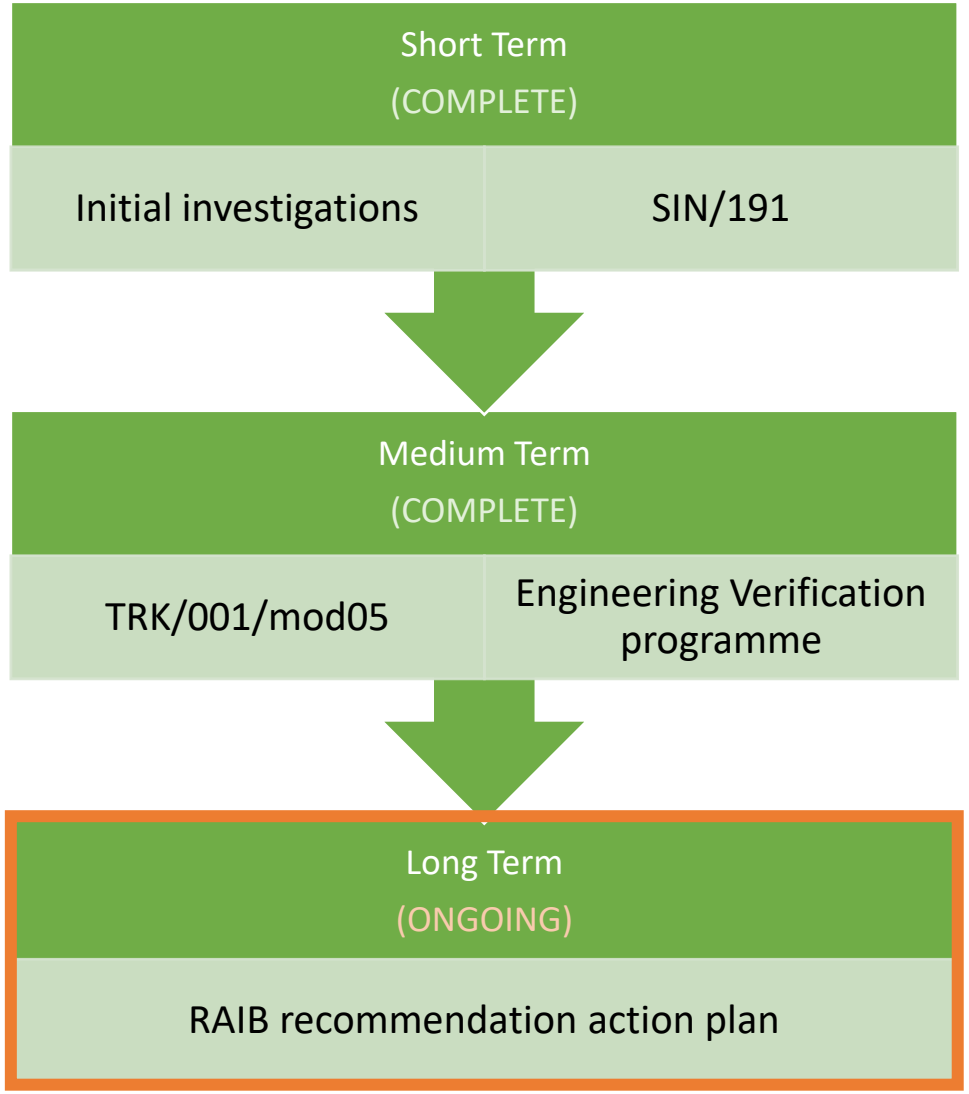
Action plan



Recommendation 1

Network Rail should develop a strategy to assess and control the risk of failure of track fastening systems incorporating elevated shoulders in RT60 switch and crossing layouts.

Recommendation 2

Network Rail should review its arrangements for the dynamic measurement of track geometry on the parts of its infrastructure not covered by its track measurement trains.

Eastleigh Recommendations

Recommendation 1

Action 1.1	Action 1.2	Action 1.3	Action 1.4	Action 1.5
Undertake design assessment of BBRT60 elevated housing and implement alternative design if necessary	Trial and implement use of NR60 equivalent bearers as an alternative design at failed sites	Undertake an assessment of CC RT60 housings to understand if any failures have taken place at these sites	Conduct a review into the use of drill-and-glue as a manufacturing method for the shoulders	Undertake feasibility study for NDT technologies to identify failed elevated housings
November 2022	Complete	Complete	Complete	November 2022

Recommendation 2

Action 2.1	Action 2.2	Action 2.3
Conduct a review of historic gauge spread derailments, including a review of the relevant bow-tie controls	Undertake assessment of existing technologies / devices to monitor gauge spread	Review existing standards on gauge measurement
Complete	November 2022	July 2022

Eastleigh Recommendations

Action 1.1

Undertake design assessment of BBRT60 elevated housing and implement alternative design if necessary

Planned completion

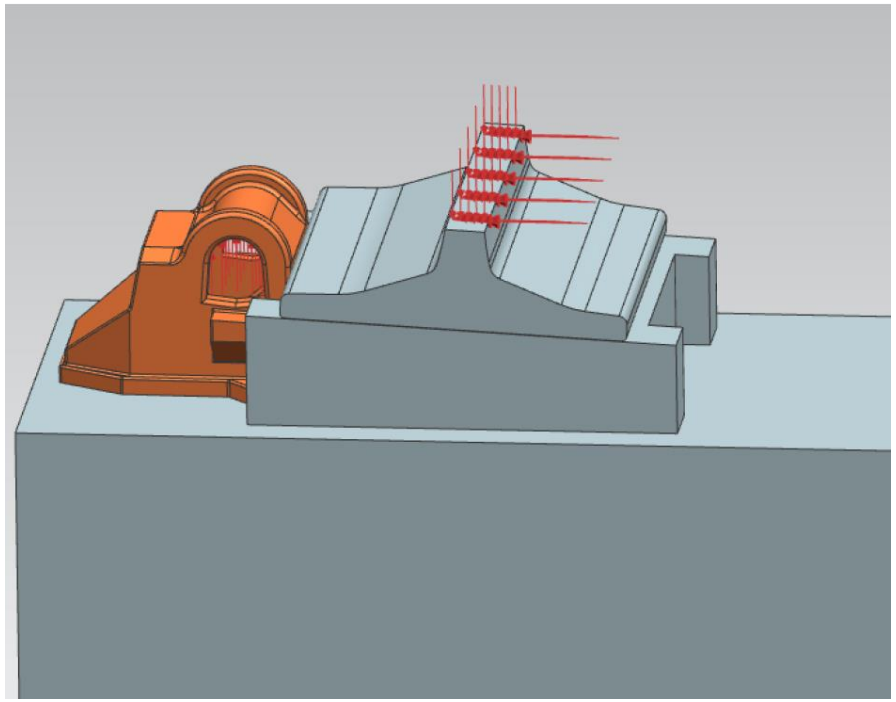
November 2022

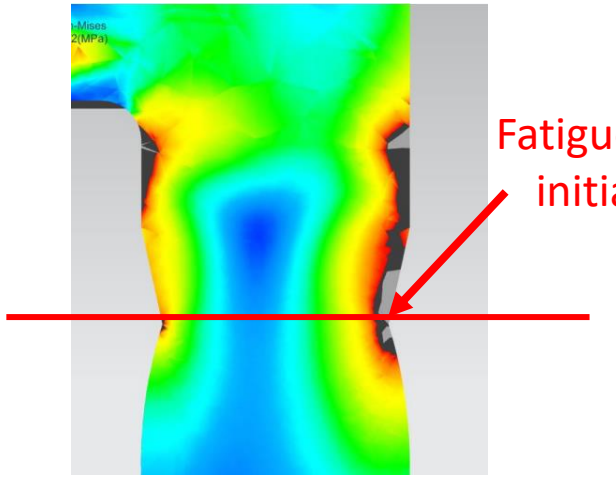
Work in progress with OEM to undertake design assessment and investigate alternatives

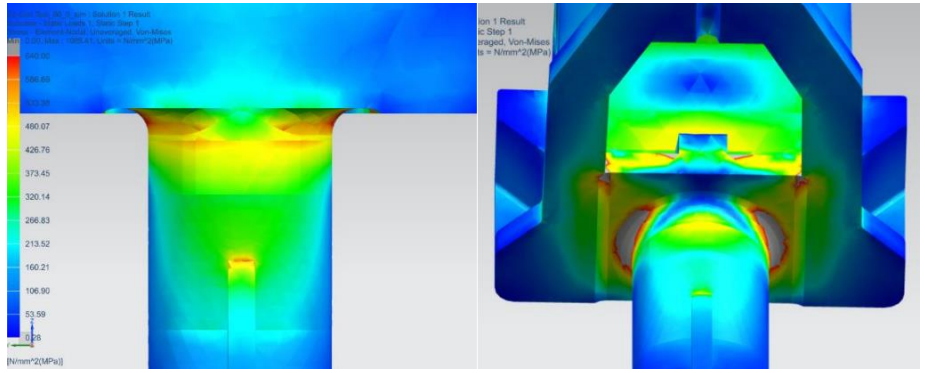
FEA conducted on existing design in an attempt to emulate current failure modes

Optioneering study has selected optimal design modifications to improve resilience

Chosen modifications will be prototyped and mechanically tested before implementation in rail







Finite Element Analysis of existing housing stem

Eastleigh Recommendations

Action 1.1

Undertake design assessment of BBRT60 elevated housing and implement alternative design if necessary

Planned completion

November 2022

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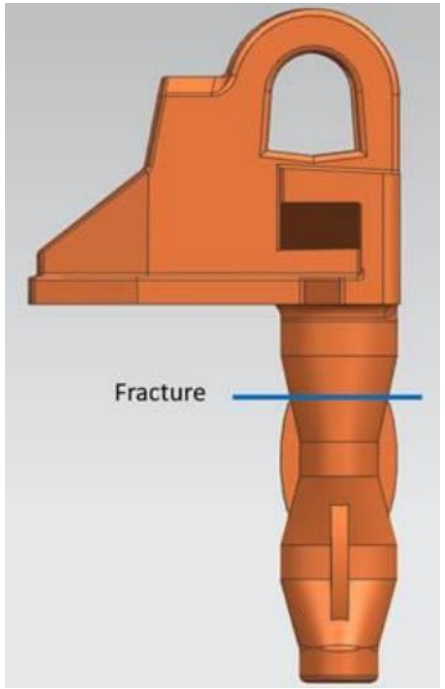
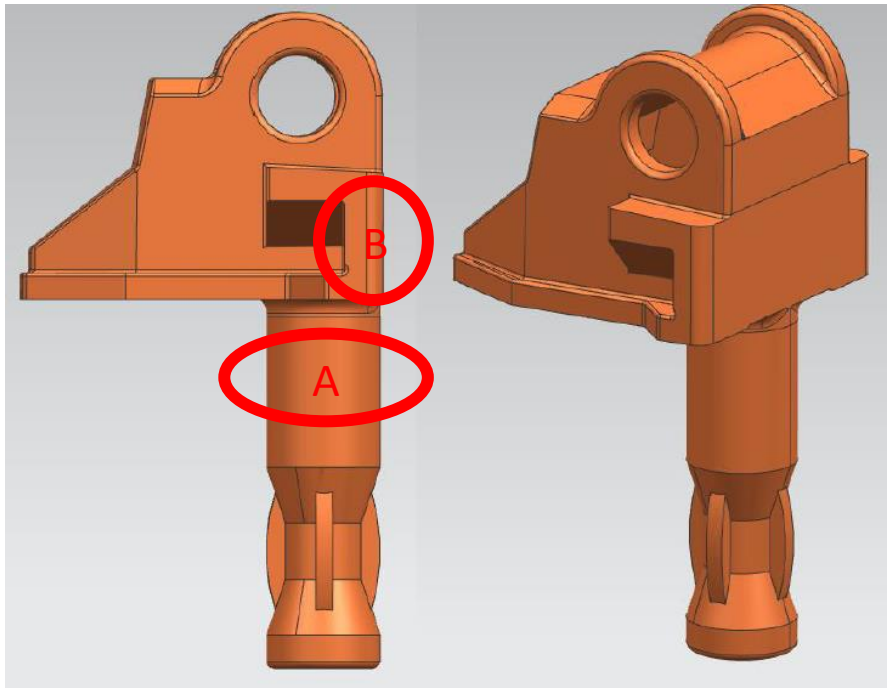


Existing design



Proposed new design, including:

A. Movement of anti-rotation features away from the peak stress zone
B. Wall thickness increased, raising overall stiffness of the stem

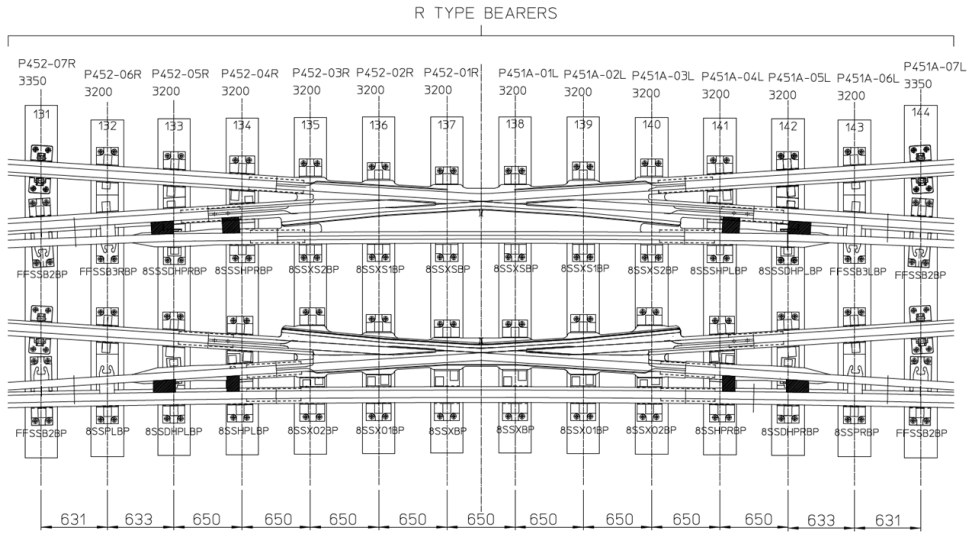
Eastleigh Recommendations

Action 1.2

Trial and implement use of NR60 equivalent bearers as an alternative design at failed sites

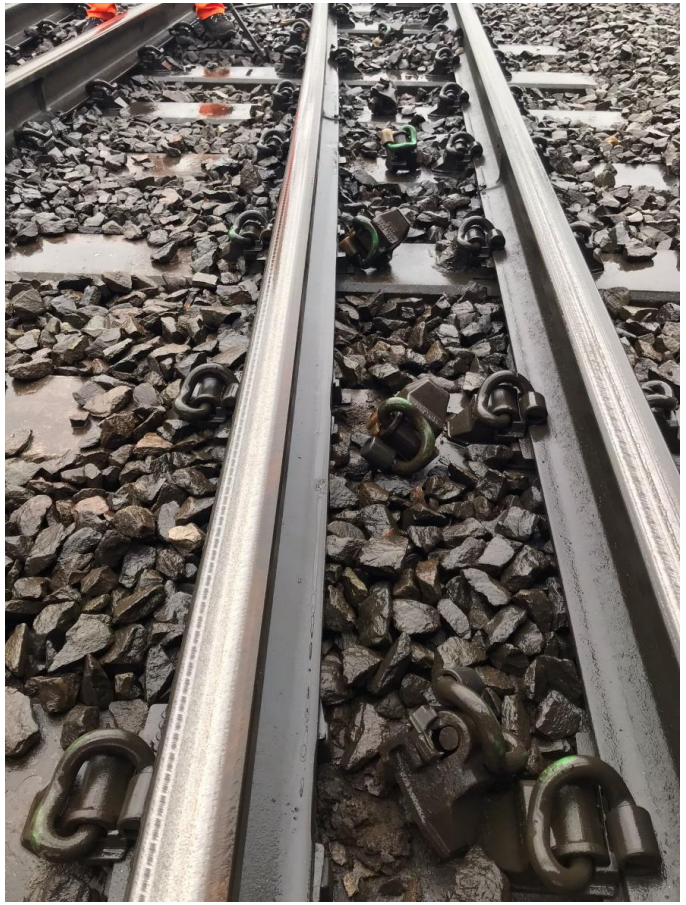
Complete

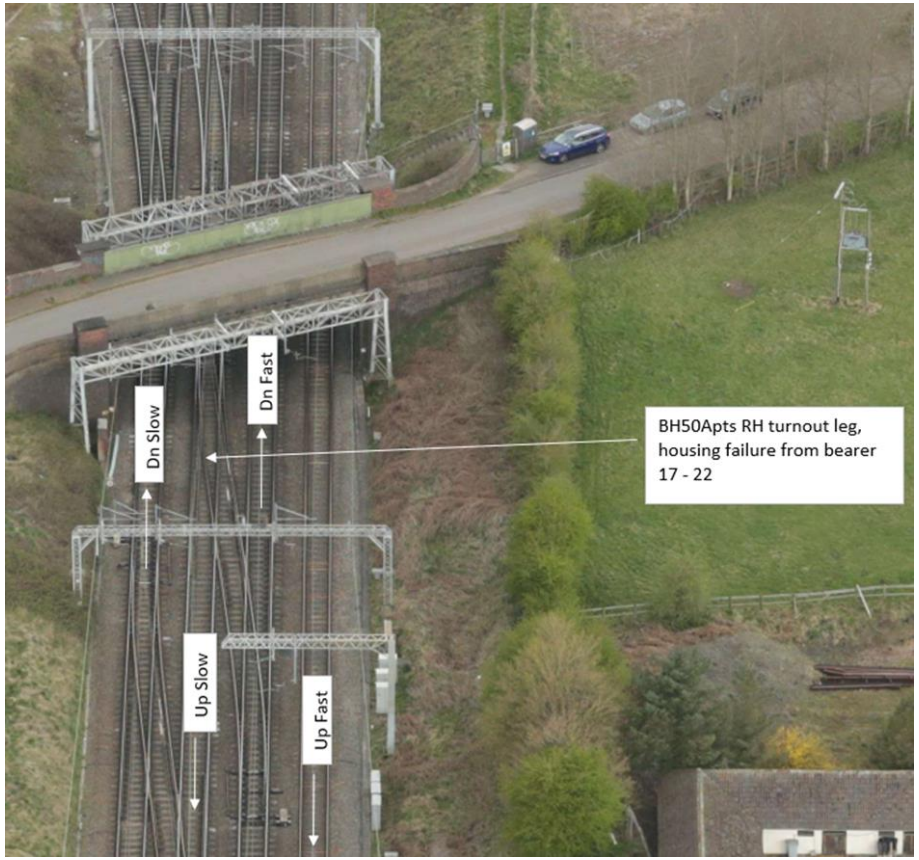
- Trial site identified at Eastleigh 451pts (diamond crossing)
- Design work commissioned with Progress Rail (ex Balfour Beatty)
- Installation over Christmas period successful
- Additional sites identified, work to improve compatibility with 3rd rail ongoing



Trial site photos from Eastleigh 465 SD

The risk isn’t going away…





Ongoing Work In TA…

SHC sleepers

- Further PLPR development, local site risk assessments, switch to PLPR where suitable, continued manual inspection on risk sites

LBS

- DELB development, TWI suite development, timber preservative completion & national trial, Community of Practice Open Forums

Timber layout screws

- Sheffield recommendations, FEA

Concrete layout screws

- Further analysis following findings from Sheffield FEA

BBRT60 elevated housings

- RAIB recommendation actions
  - Redesigned housing
  - Baseplated bearers
  - UT pilot

everyone home safe every day

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Technical Authority

Providing technical leadership