



FELIX

FELIX is an Automated Measurement Trolley for the inspection of S&C. It uses non-contact and non-destructive technology: a combination of cameras and lasers. As the trolley moves, a new scan is taken every 2mm to check that the various track geometry and critical rail profile measurements are compliant with S&C inspection standards.

Contacts:

Daisy Daymond, R&D Project Manager

Tom Edge, R&D Programme Manager

Phil Winship, Principal Engineer (Technical Lead)





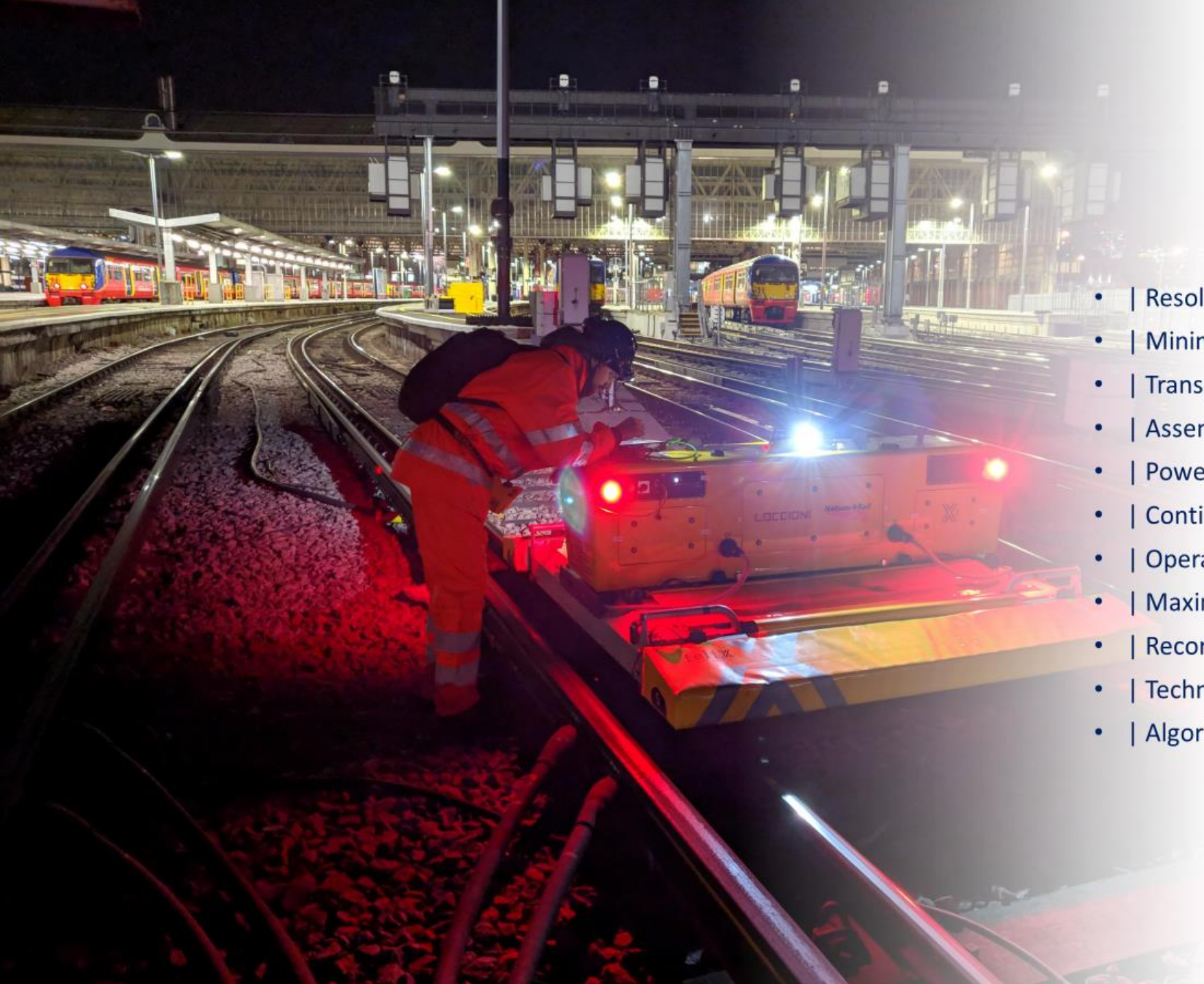
Felix

S&C Automated Measurement
Trolley (AMT)

What is FELIX?

Research and Development
Innovation is in our nature





Felix Parameters

- | Resolution: **0.1 mm**
- | Minimum Scanning pitch: **2 mm**
- | Transportation and operation: **2 people**
- | Assembly: **6 modular elements**
- | Power: **Lithium-ion battery**
- | Continuous working time : **up to 6 hours**
- | Operating temperature range: **-10 C° + 50 C°**
- | Maximum speed: **5 km/h**
- | Recording speed: **1.6 km/h – 3km/h**
- | Technology system: **profilometers**
- | Algorithms for **3D-reconstruction**

Felix Project Timeline

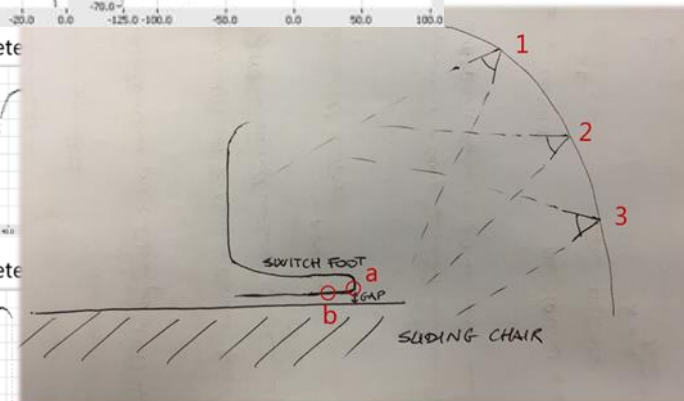
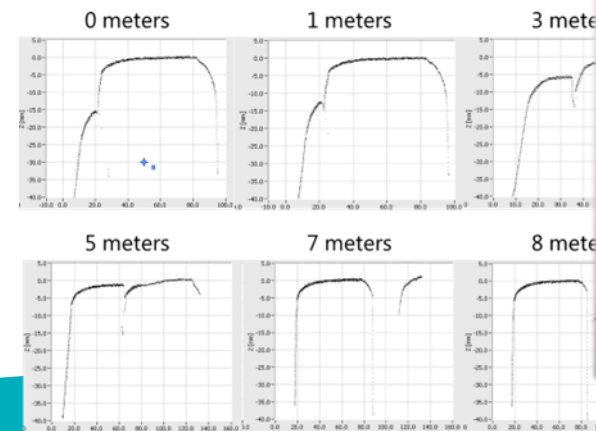
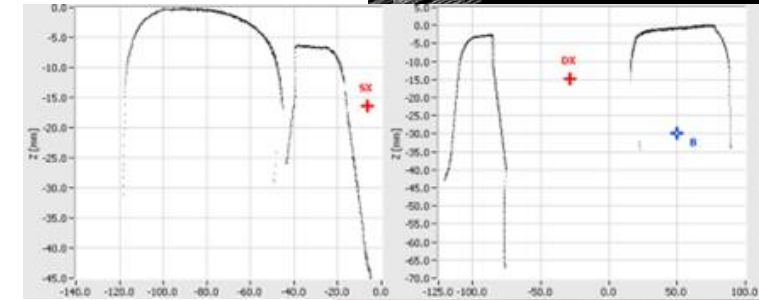
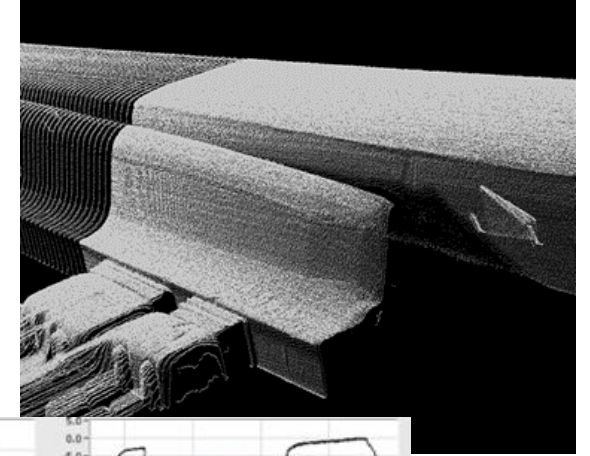
Phase 1 Feasibility Study - 2017

Phase 2 Trial and Development of Felix 2019 – 2023

Identify areas where NR requirements needed system modifications

- Measurement of switch rail seating gap.
- Squareness of switch toes.
- Residual switch opening.
- P8 profile measurement.
- Gauge 1 & 2 assessment
- Back-to-back gauge measurement

Phase 3 Deployment 2024 - Present



Felix Project Timeline

Phase 2 Trial and Development of Felix 2019 – 2023

Identify areas where NR requirements needed system modifications

- Measurement of switch rail seating gap.
- Squareness of switch toes.
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- Back-to-back gauge measurement

Felix with the prototype module fitted



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CHANGE



Manual
Inspection



Use of
gauges



Decision
making

Change Parallels - The Banking Experience ...



Queueing at a bank



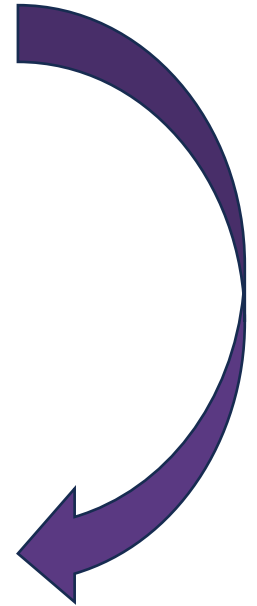
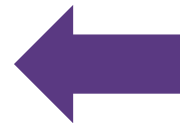
Queueing at an ATM



Using internet banking



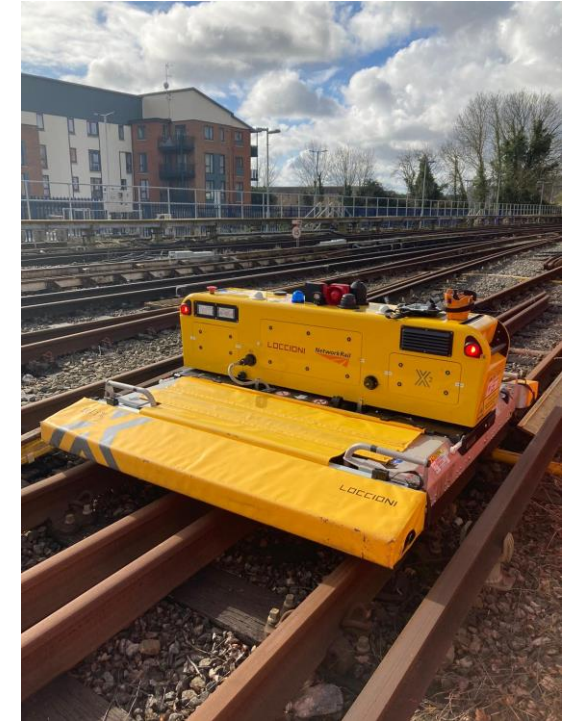
Using card machines





Change – Manual Gauges to Precision lasers and cameras...

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Changing Ways of Working

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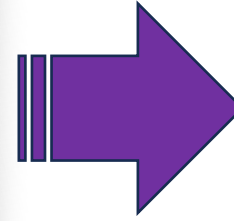


Changing Ways of Working

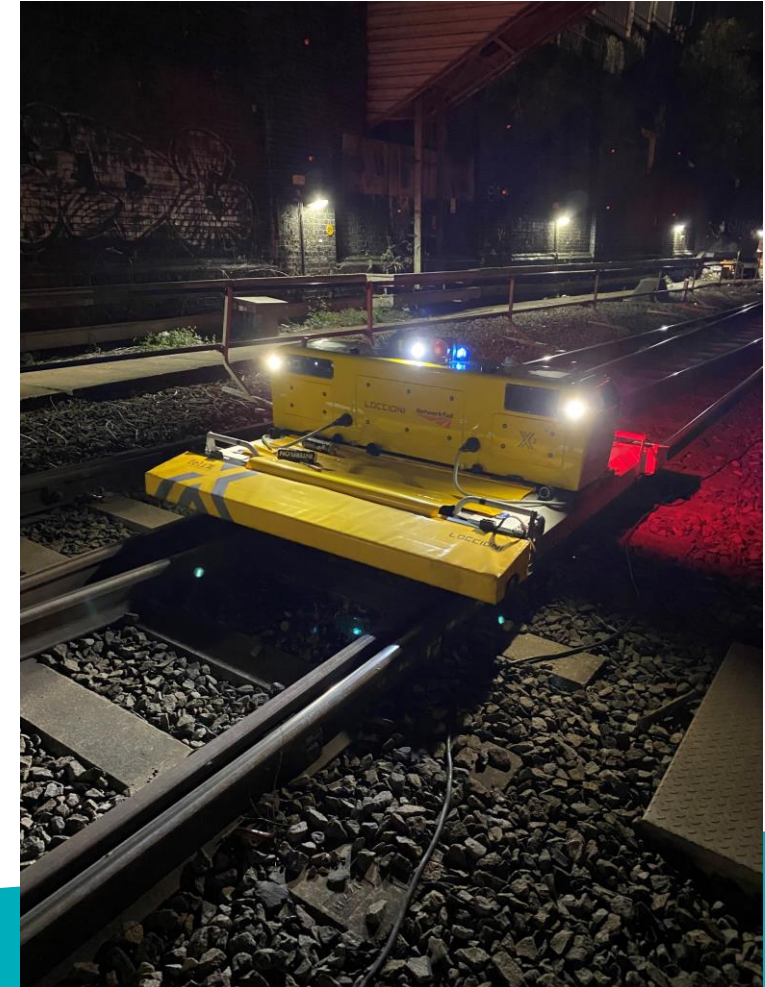
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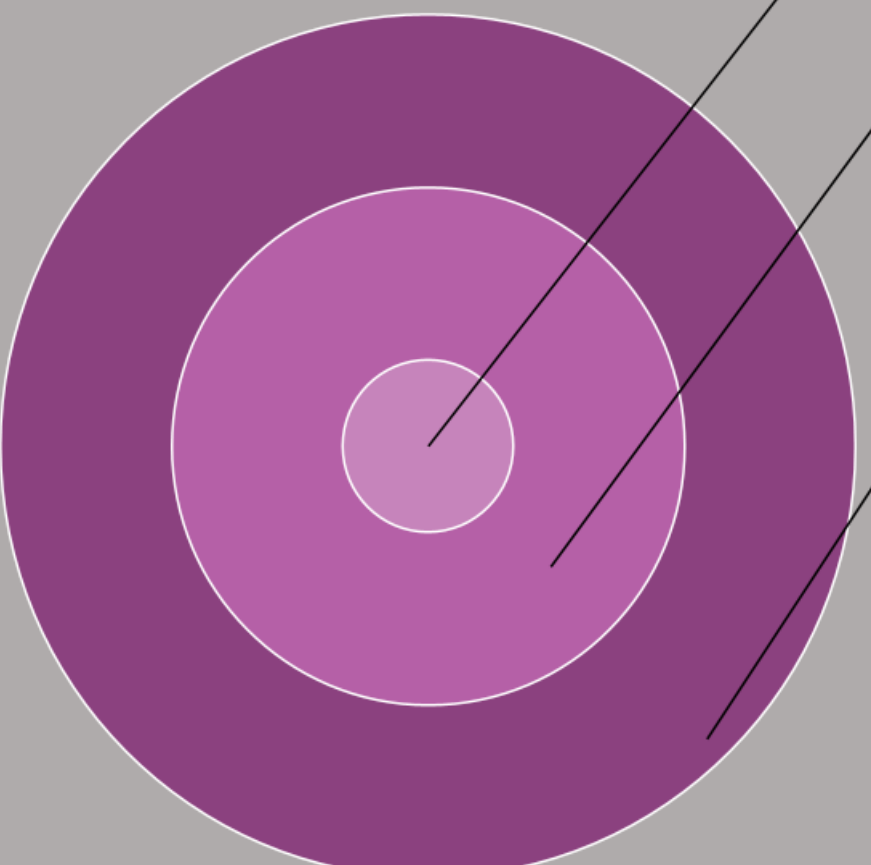
From this.....



.....To this !



Barriers to Deployment



Culture

- Systematic reluctance to change
- Risk-averse
- 'try before you buy' approach

Resources

- Increasing pressures due to modernising maintenance
- Funding availability
- Manufacturing restraints

Inspections

- Geographical restraints
- Critical junctions
- Classification of FELIX affecting usage

- Formed a National Community of Practice
- Invested in First-in-Class deployment support
- Invested in Business Change Support
- Hosting Demonstration Days
- R&D funding for x4 units
- Incentivised pricing for any route-funded units before the end of CP6
- 1:1s with the routes
- Commissioned a pre and post-deployment toolkit for the routes

Parameters Felix Measures

FELIX takes a profile of all rails at 2mm intervals as it travels over the S&C.

What parameters does FELIX measure?

- Gauge
- Twist
- Twist over 3m
- Cross level
- P8 profile measurement
- Gauge 1 & 2
- Switch radius gauge
- Back-to-back gauge through moving parts of switch
- Switch opening throughout the length of the open switch
- Residual switch opening
- Switch toe squareness
- NR4 sidewear gauge
- Height difference between wing rail and crossing nose



Sussex Deployment... so far - Mid 2024



Sections:

Barnham
Horsham
Three Bridges

Croydon
Norwood
Victoria

Junctions:

Horsham
Redhill
Victoria Central
Victoria Eastern
Norwood
Tattenham Corner
Streatham Common

Tulse Hill
Dorking
Pulborough
Earlswood
Bromley
Sutton

5
Users
trained

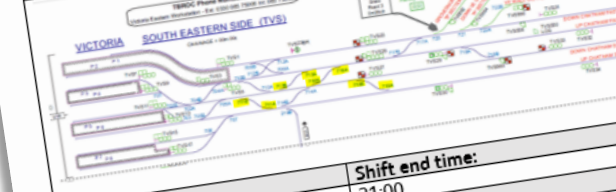
28
Shifts
completed

103 *Of which...* **17**
Defects
found
Ban to facing
moves

FELIX- End of Shift Report

Date:	18/02/24
FELIX User 1:	James Swift
FELIX User 2:	Riccardo Fava (Loccioni) David Cocklin (Network Rail)
Shift Support:	Victoria Eastern

Location: Junction Diagram:

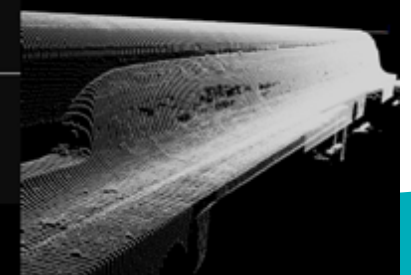
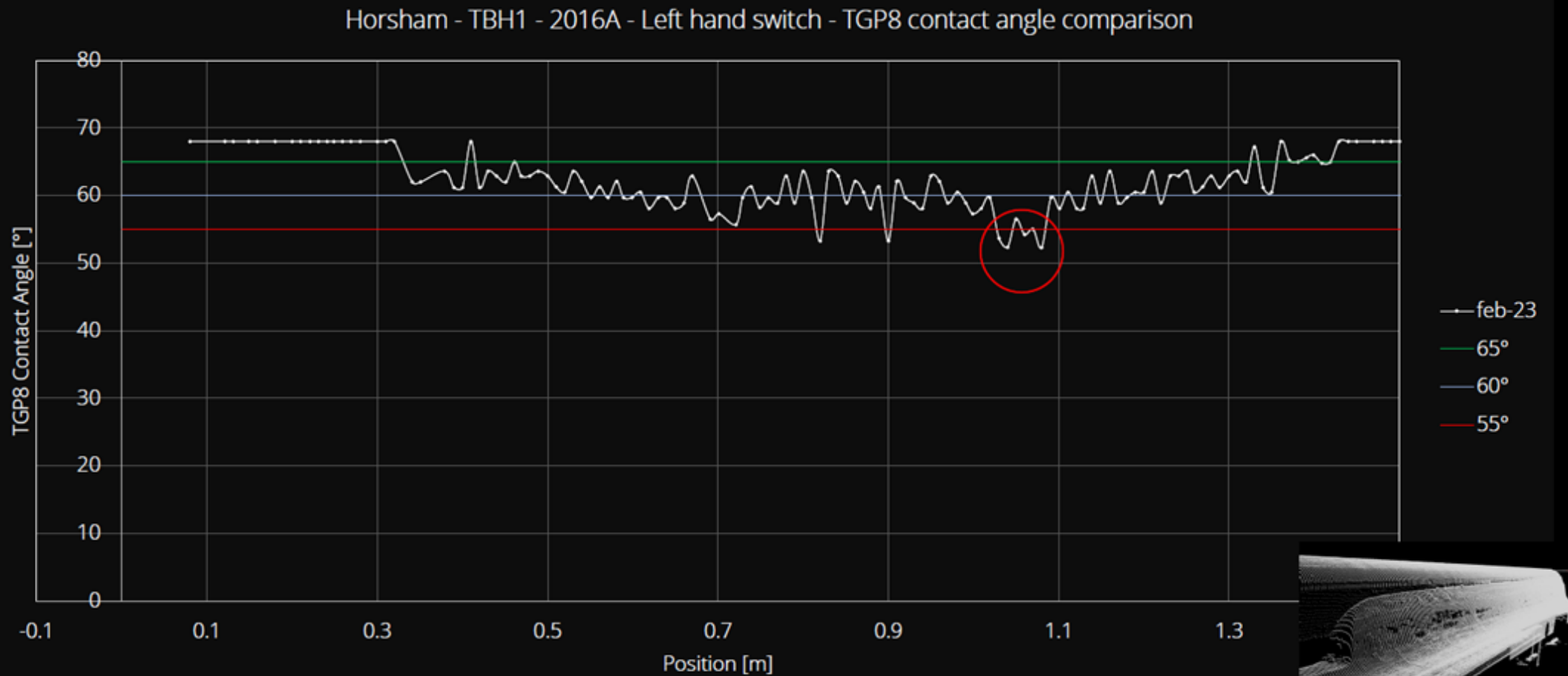


Shift start time:	Shift end time:
07:00	21:00
Time onto track:	Time off track:
10:00	17:30
Planned point ends inspected:	Actual point ends inspected:
Priority points 711B, 713A, 716B, 719A with the other associated ends as primary goal, then work through other priority points and associated ends.	711A+B, 713A+B, 716A+B, 719A+B

Point Number	Rail	Defect	MAC Code
711B	RH	Sidewalk, 12mm	3Y8
711B	RH	60 degree PB failure	Y1W13
711B	LH+RH	Sharpe edge	3W
713A	LH+RH	Sharpe edge	3W
713A	LH	Gauge 1 not pass over switch (therefore gauge 2 fault also)	3W2
713A	LH	Horizontal damage (TEF wrong was less than 200mm, pressed the wrong button but cannot change after TEF saved). Previously found and planned to be removed by VIC p-way (DC)	Plan maintenance
713A	LH	Damage at toe	3F1
713B	RH	Horizontal cracking (already found, actioned and planned by Vic p-way (DC))	3W13
713B	LH+RH	Sharpe edge	3W2
713B	LH	Gauge 1 not pass over switch (therefore gauge 2 fault also)	
716B	RH	Horizontal cracking (already found, actioned and planned by Vic p-way (DC))	

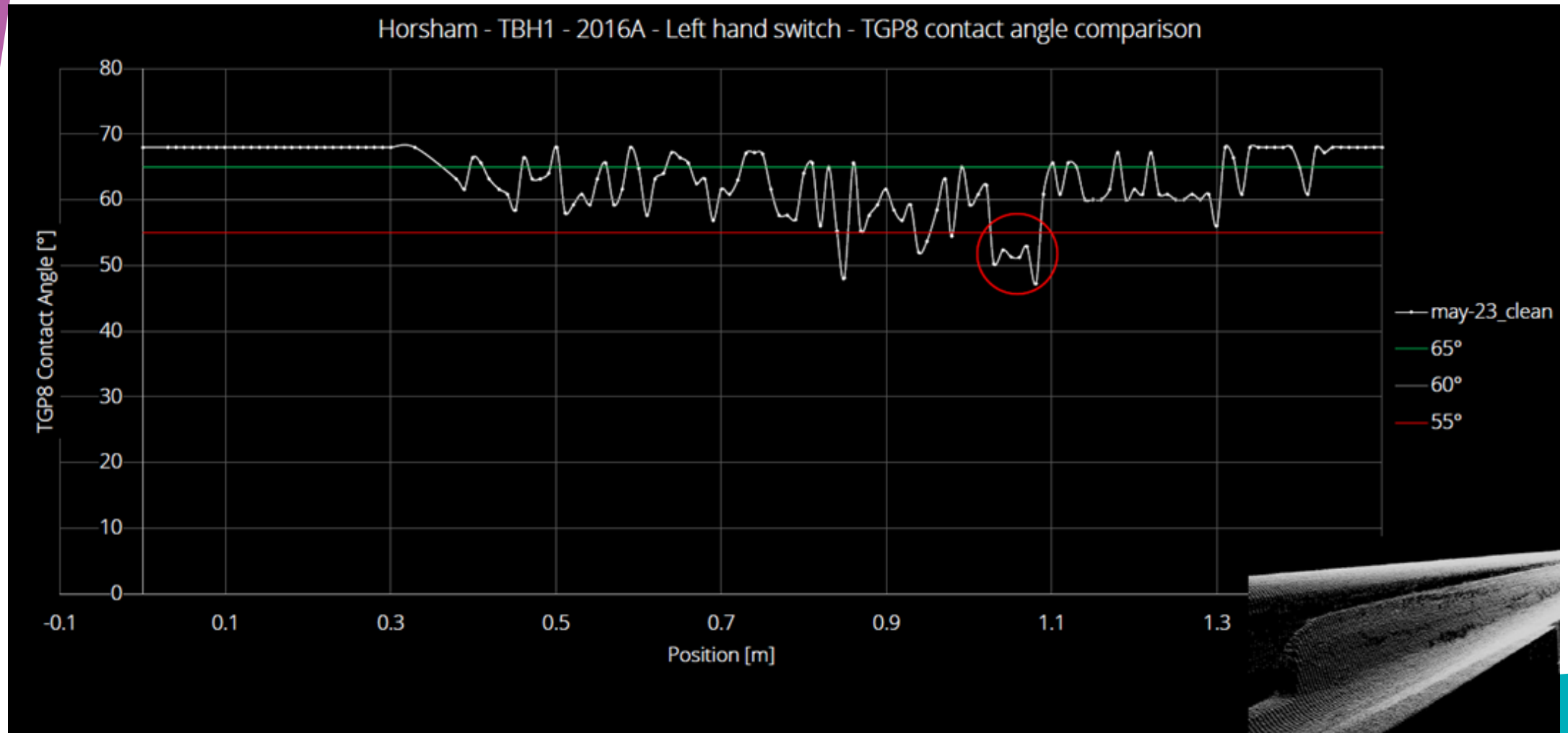
Case Study

Horsham 2016A, Feb 23



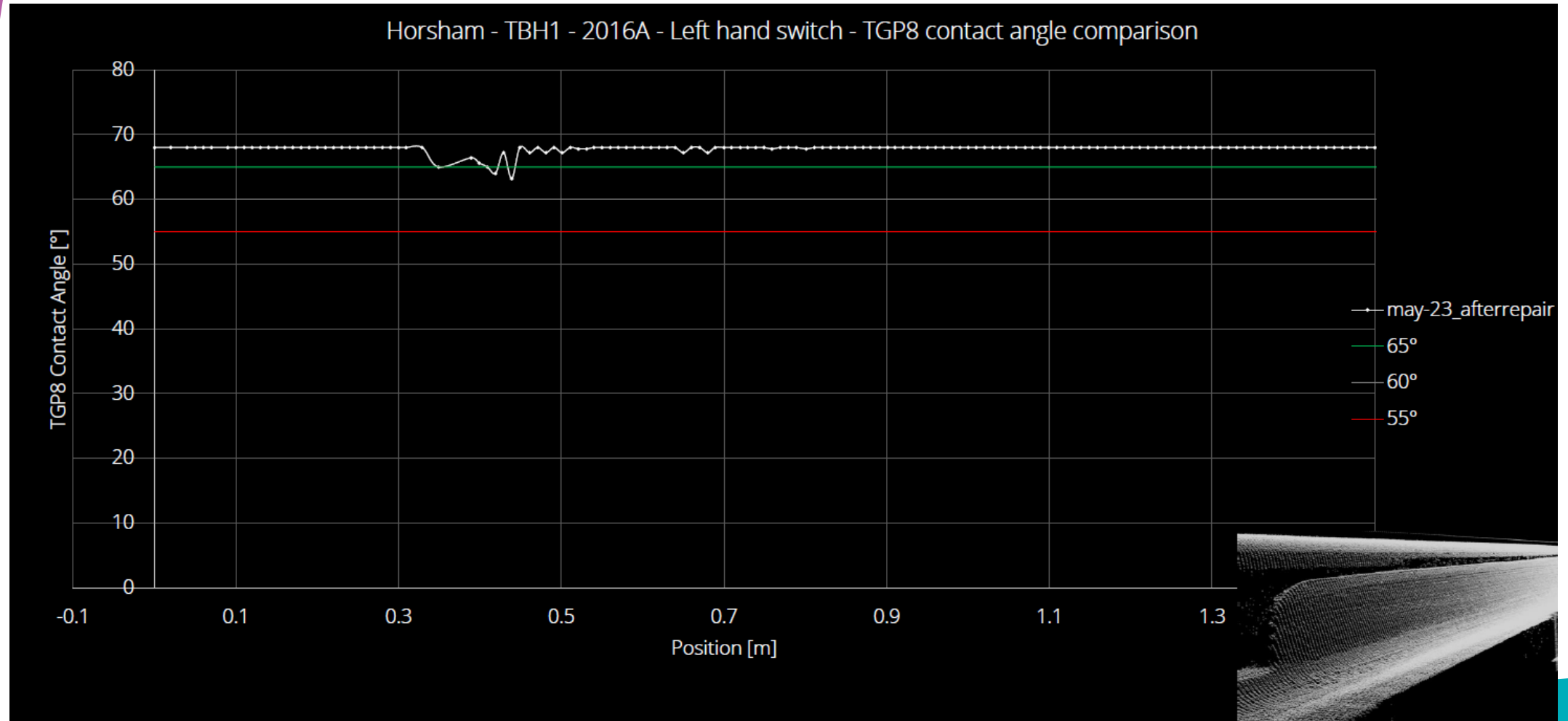
Case Study

Horsham 2016A, May 23



Case Study

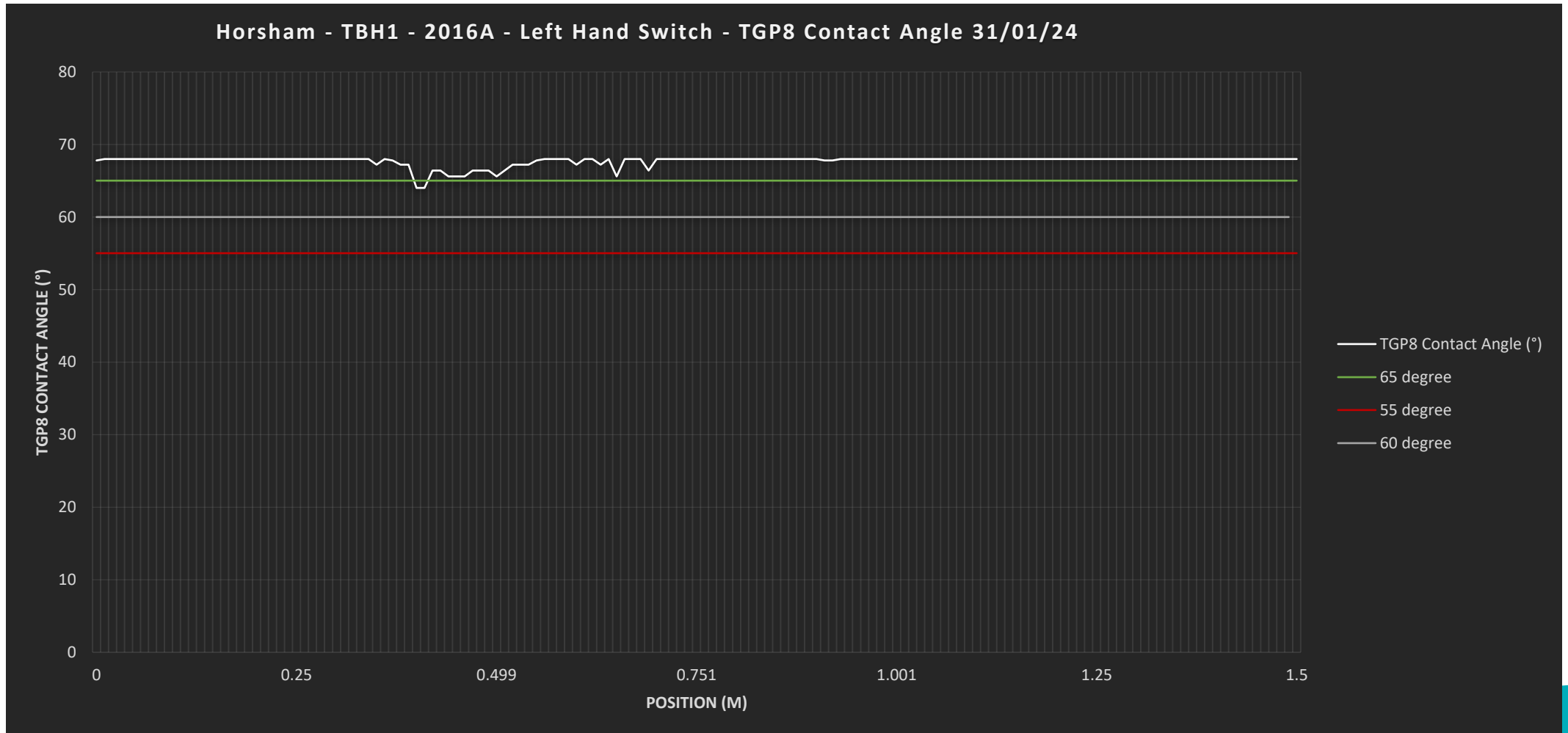
Horsham 2016A, May 23 – After grind repair



Case Study

Horsham 2016A, Jan 24

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Case Study

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Felix App



Sussex Successes

- Accurately and objectively identifying defects so they are visible in the system
- Developing more efficient working practices
- Completing mentorship of newly trained staff
- Promoting confidence in the technology
- Working with sections to complete MST inspections
- Positive working relationship with the supplier
- Proactiveness from the users and the project team

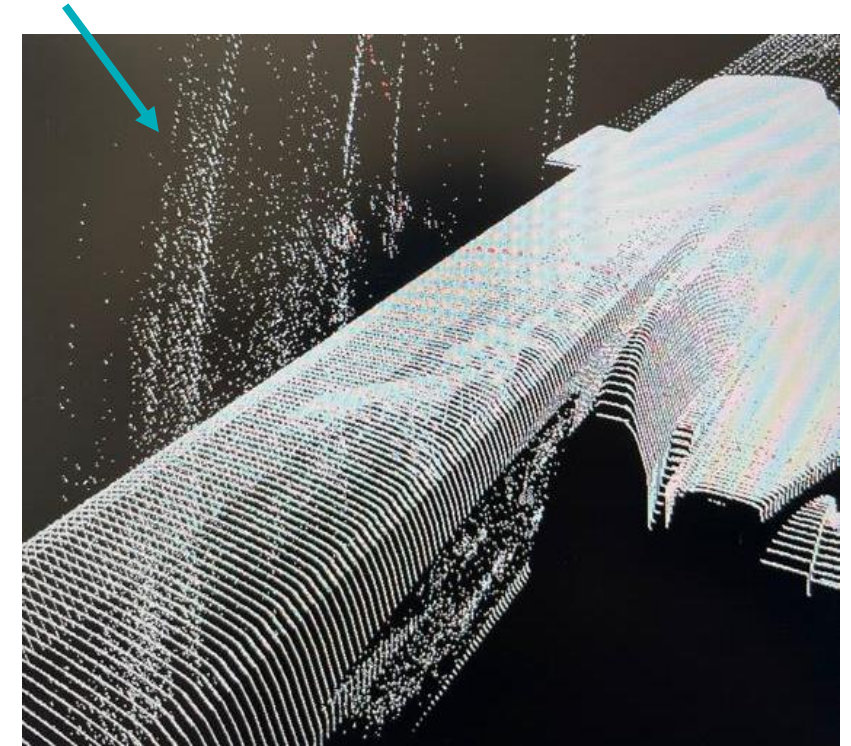


- ✓ Improving asset condition
- ✓ Extending asset lifespan
- ✓ Increasing safety (of both assets and individuals)
- ✓ Increasing productivity and efficiency
- ✓ Provision of more consistent, accurate, and detailed data
- ✓ Adding to staff competencies
- ✓ Alleviating workload pressures



Sussex Issues 2023/24

- Technical issues
 - Working with Loccioni to improve the functionality (of both the hardware and software)
- Heavy grease at certain locations
 - Wheel flange modification to be retrospectively fitted to all units
- Reflections affecting the camera (due to direct bright sunlight)*
 - Software update to rectify this issue
- Lack of trained staff
 - Additional training sessions held
- Competence not live with Network Rail
 - Delay in the competence being configured onto Oracle
- Lack of location knowledge visiting locations for the first time
 - Building up site knowledge to improve planning and efficiency on shift



*Reflections affecting camera

Future Plans in Sussex



Looking at the possibility of forming a dedicated team.



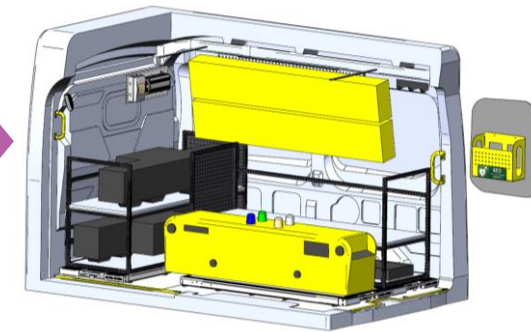
Training more staff to be able to use the equipment which will increase productivity and efficiency in shifts.



Planning putting shifts on Live planning sheets to improve visibility.



Dedicated van for transportation making the equipment more secure and safe in transit.



Develop information packs on lessons learnt from first deployment to help subsequent deployments in other routes.



Record plain line black holes, all track geometry measurements that we currently measure can be recorded with another add on module.

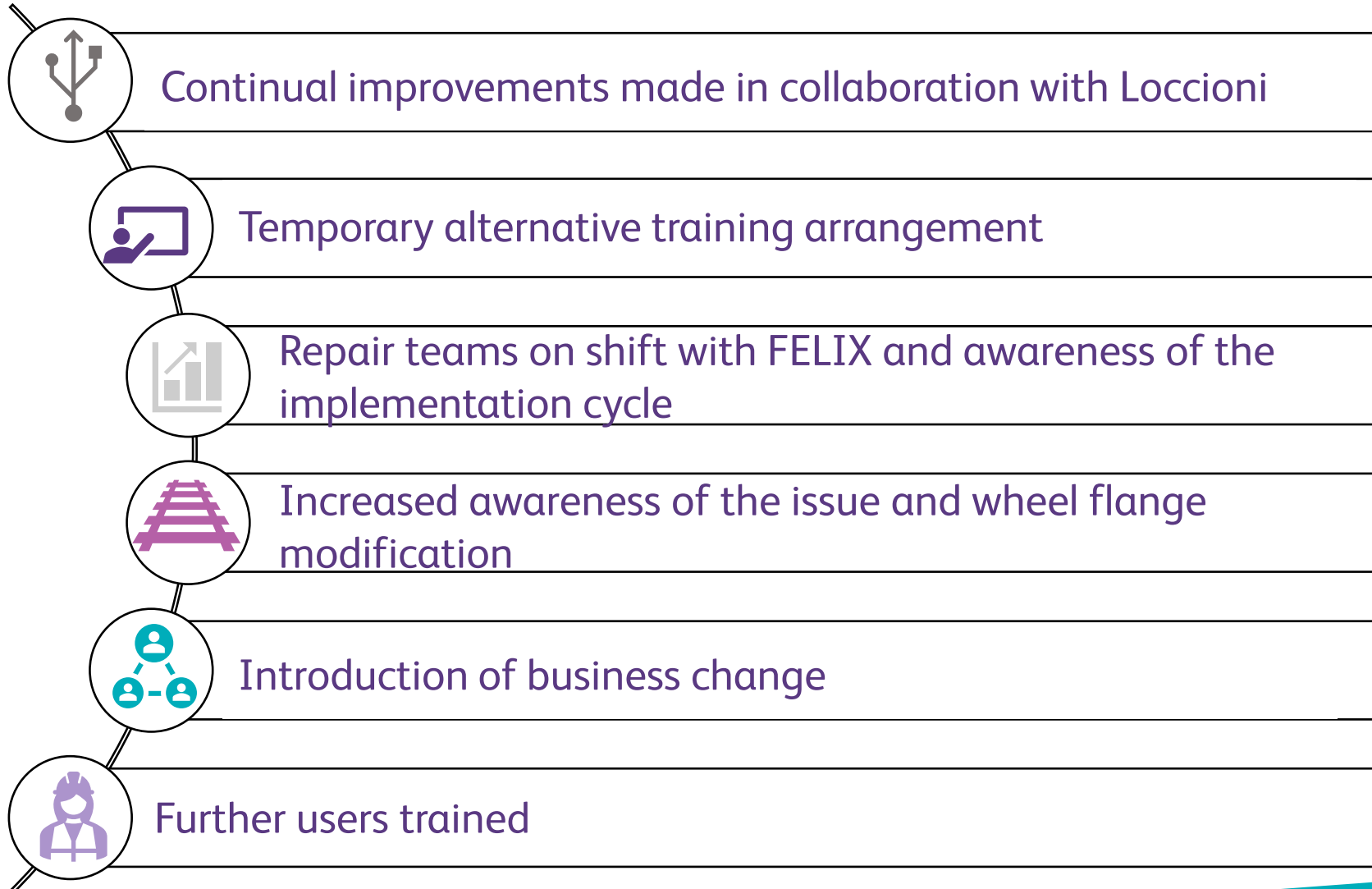


Update Standards to separate from manual gauge,



Move to evidence based proactive not reactive maintenance

Learning Opportunities



Supporting the Routes

Purpose:
This document is a question...
This will ultimately help...
We therefore request a decision on the unit...
Please note, at this stage... unsuccessful and would...
Please complete this...
If you have any questions...

Topics covered:

- Introduction
- Readiness
- Stakeholder engagement
- Additional/ supplementary

Introduction

1) Full name
Mike Groves / Ed Ho...

2) Job role
Special Projects Man...

3) Route
Western

Readiness

4) When would you like to start?
(please note, the following are indicative timelines)

- a. April 2024
- b. October 2024

See Wales (comment...)

FELIX

Route Deployment Proposal Form

Project Team:

Daisy Daymond Project Manager, R&D	Phil Winship Technical Lead, TA
Tom Edge Programme Manager, R&D	James McNamee Senior Engineer, TA
Jack Ranson Business Change Manager, R&D	Wei Lim Engineer, TA

Routes that submitted a 'Route Deployment Proposal' form:

- Scotland
- Anglia
- North East
- North and West
- Wales
- Western

Supporting Routes that did not receive an R&D-funded unit:

- Operation under the protection of the 'NR13D Framework Agreement for Goods & Services'
- Procurement support (nationally and locally)
- Economy of scale benefits
- Discounted unit pricing (time-limited)
- Circa 12-month manufacturing lead time
- Stakeholder engagement and the deployment of business change

**Some of the
ways R&D are
supporting
deployment...**

01**Governance****02****Community of Practice****03****Pre-Deployment Toolkit****04****Deployment Workshops****05****Communications**

Governance

OFFICIAL



Research and Development
Innovation is in our nature

FELIX- End of Shift Report

Date: 18/02/24
James Swift
FELIX User 1:
Riccardo Fava (Loccioni) David Cocklin
FELIX User 2:
(Network Rail)
Shift Support:
Victoria Eastern

Location:
Junction Diagram:



Shift start time: 21:00
Time onto track: 07:00
Planned point ends inspected: 10:00

Shift end time: 21:00
Time off track: 17:30
Actual point ends inspected: 711A+B, 713A+B, 716A+B, 719A+B
Priority points 711B, 713A, 716B, 719A with the other associated ends as primary goal, then work through other priority points and associated ends.

Point Number	Rail	Defect	MAC Code
711B	RH	Sealant 12mm	31B
711B	RH	60 degree PB failure	Y1W13
711B	LH+RH	Sharp edge	SW
711B	LH+RH	Sharp edge	SW
713A	LH	Gauge 1 not pass over switch (therefore gauge 2 fault also)	SW2
713A	LH	Horizontal damage (TEF wrong was less than 200mm, pressed the wrong button but cannot change after TEF p-way)	3F1
713A	LH	Previously found and planned to be removed by VEC p-way	
713A	LH	Damage at site	3B13
713B	RH	Horizontal cracking (already found, actioned and planned by DCL)	3W2
713B	LH+RH	Sharp edge	
713B	LH	Gauge 1 not pass over switch (therefore gauge 2 fault also)	
716B	RH	Horizontal cracking (already found, actioned and planned by VEC p-way (DCL)	

FELIX- Sussex Success Criteria

This document outlines the success criteria for First in Class deployment, applicable to Sussex, based on the deployment plan. It covers a range of areas such as utilisation, productivity, accuracy, effectiveness and satisfaction. For more information, please contact

Operations:		Case Studies:		Staff Satisfaction:	
	6 month Target	Actual (at 6 months)	Case studies from the route to showcase:		Target
Number of shifts completed	130		• Accuracy of data	Ease of transportation and set up	4.0
Average point ends inspected per shift	4		• Degradation of an asset	Ease of use of the app	4.0
Total TEFs generated	2,340		• Productivity and efficiency (transportation, set-up, and operation)	Confidence in data	4.0
			• Staff satisfaction	Physical demands	4.0
			Method of Measuring and Monitoring:	Overall experience	4.0
			• End of shift reports		
			• FELIX Deployment tracker		
			• User feedback surveys		
			• User interviews		
			• Bi-weekly checkpoints		
			• Post-implementation reviews		

'Targets' are based on current understanding, using the FELIX Deployment Plan as a guide. 'Actuals' will be recorded after a period of 6 months and 12 months of use of FELIX, with regular monitoring over this period. This is dependent on available data to the project team. Month 1 will start when the users are formally competent in using FELIX and can do so independently. Regions are to measure improvement estimations outlined in the R&D L3 benefits case

Shift reporting
Fault log
Success criteria
Loccioni/NR technical review meetings
Bi-weekly route checkpoints



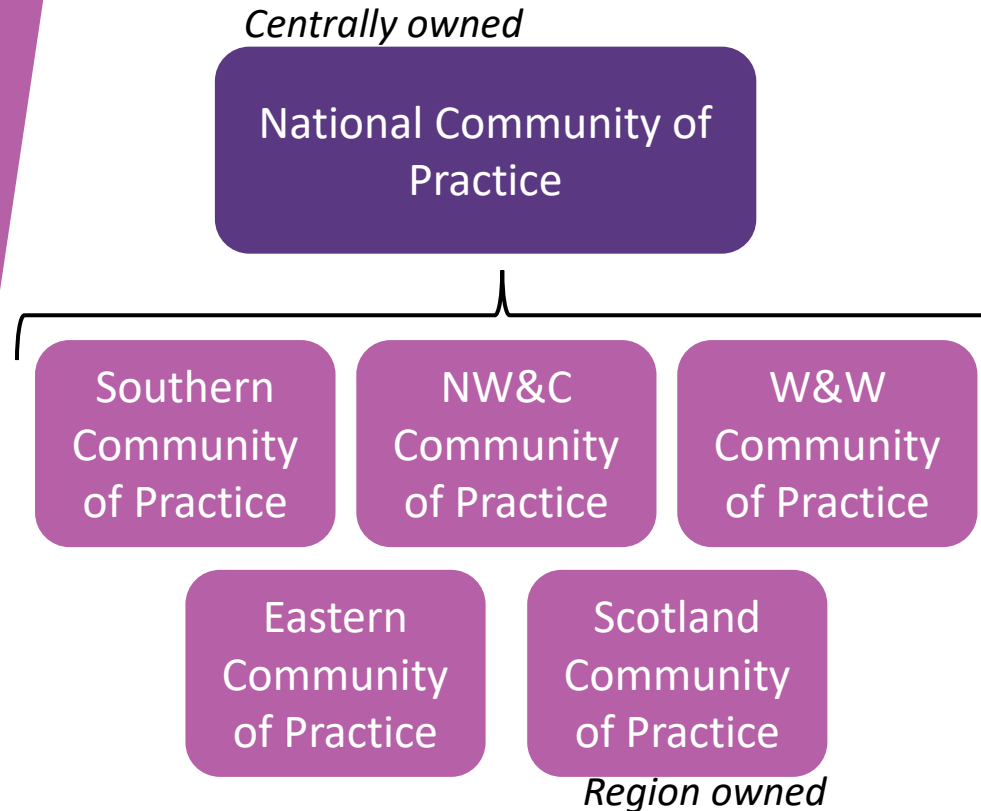
LOCCIONI

Loccioni/NR – Felix Review

Weekly meeting 03
08/03/2024

	A	B	C	D	E	F	G
	Date	Location	planned	achieved	Faults	Ban to facing moves	Issues / Comments
1	18/02/2024	Vic Eastern	5	8	18	1	Grease caused delays, wheel flange got blocked by grease, had to be cleaned
2	20/02/2024	Norwood Jcn	3	2	5	1	Late set-up, helped team deal with banning a set to facing movements, App was losing connection
3	21/02/2024	Norwood Jcn	3	2	3	0	Late set up, RRV movements and welders working on points, one fault found and rectified on shift
4	22/02/2024	Dorking	4	7	1	0	App disconnection
5	23/02/2024	Dorking	4	4	1	0	App disconnection causing small delays, all point ends done in location

Community of Practice



How will this benefit the routes?

- ❖ Gain knowledge from the collection of previous discussions and resources
- ❖ Learn from the routes where Felix is/ is being deployed
- ❖ Build an innovation network
- ❖ Opportunity to deploy technology that will drive resource optimisation, safety and efficiencies
- ❖ Contribute towards deployment
- ❖ Raise any risks/ issues
- ❖ Hear from guest speakers



Pre-Deployment Toolkit

What is FELIX?



FELIX

Deployment Toolkit

FELIX is a new Automated Measurement Trolley (AMT) that can automate detailed inspection around Switches and Crossings (S&C). It is designed to improve safety, drive efficiency and facilitate improved performance.

This document is designed to be used by routes as they plan for and then deploy this new technology. It does not replace the user manual or the training course.

Contact:

Daisy Daymond, R&D Project Manager

Phil Winship, Technical Lead

Tom Edge, R&D Programme Manager

Jack Ranson, R&D Business Change Manager

End user modelling

view of the stakeholders involved in the Operational a model for future deployment:

responsible for fulfilling the work

signs off or approves the testing

le who provides input to the testing

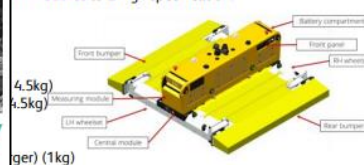
le who should be kept up to date / Informed about testing progress

TA	Business	Route	Route	Section	Supervisor /	Loccom
lineers	Change	Programme	Project	Manager	TL /	
	Manager	Manager	Manager		Operative	
C	C	C	C	C	C	C
C	C	I	R	C	C	C/I
C	I	I	C	A	R	C
A	C	I	C	R	R	R
I	R	I	C	C	A	I
I	R	I	C	A	C	I

FELIX replicates a number of standard Network Rail inspections:

- 9006 – TEF3029a Examine Switch
- 9009 – TEF3029 Inspect Switch Running Edge
- 9245 – TEF3060-63, 68 Record S&C Gauge
- 9383 – TEF3074 Examine Switch for FBC
- 9050 – TEF3041 Record Track Geometry Manually

in modules to a high specification:



f a remote radio control, with up to 50m connectivity portable device (iPad) wirelessly connected to the FELIX from a safe position.

ment:



Change Impact Assessment

CHANGE IMPACT ASSESSMENT: FELIX		PEOPLE IMPACT	PROCESS IMPACT	TECHNOLOGY IMPACT	Possible supporting actions to transition to FELIX and help mitigate potential resistance to change
Estimate of impact	Impact	What processes may need to change as a result?	How will this impact existing systems, systems required or access to a systems?	Imp Overall impact Rating (RAG)	
-1-2	Planning further in advance	Risk assessment carried out	No change to current technology stack		
-1-2	Planning further in advance	Optimal FELIX route consideration (using track inspection diagrams)	No change to current technology stack		Route/region workshop with planners ahead of deployment
Various	Driver rules around other track access while using plant		No change to current technology stack		
-1-2	Planning will need to consider how to best consolidate inspections in order to maximise efficiency		No change to current technology stack		
-3-5	Ongoing data analysis to support annual review of S&C	Physical inspection schedule change	Felix will need to be integrated with Network Rail insights tool to fully maximise the value and benefits		Working group with Risk Based Maintenance lead, to understand impact of Felix and how best to communicate with route/region
-5-10	Reprioritisation of repair work		Felix will need to be integrated with Network Rail insights tool to fully maximise the value and benefits		
N/A	No change		No change		
-1-2	May initially require more time to clean the asset, depending on condition		No change		FELIX training course
-1-2	FELIX must be assembled on track	Removal of need for manual gauge processes	Multiple manual gauges no longer required	Use of FELIX app required	
-1-3	Removal of manual recording of data		TEP forms will be generated in the same format on iPad		FELIX training course
-1-2	Inspector(s) operates FELIX from the side of the track using an iPad		Use of FELIX app required		Additional data training for Section Managers and other stakeholders as required
-1-2	No change		No change		
-1-3	Additional repair work may be required initially to fully realise benefits	Reprioritisation of repair work	Use of Power BI or similar dashboard to view results	FELIX will need to be integrated with Network Rail insights tool to fully maximise the value and benefits	
-3-5	Inspection schedule change		Felix will need to be integrated with Network Rail insights tool to fully maximise the value and benefits		Working group with insights lead to understand impact of Felix and how best to communicate with Route/Regions

tion of the changes which will occur in relation to specific

Change Anticipated

The Section Manager will continue to be responsible for ensuring the inspection and subsequent maintenance is carried out on Switches and Crossings (S&C). An annual plan of the Felix delivered inspections will be available to allow the SM to manage resources and works

This role will conduct the inspection with use of FELIX as opposed to manually. They will input necessary track data and review the data outputs. Will be required to attend Felix Training (Track Engineering Forms)

These individuals will operate FELIX, for example assisting with the assembly and disassembly, and support the Section Supervisor (or delegated competent person). Will be required to attend Felix training.

No change- planning will still be required for FELIX inspections

Deployment Workshops

Planning for FELIX

The session will cover:

- **Pre-deployment planning** (e.g. how to identify the best areas for FELIX use)
- **Individual shift planning** (e.g. what to consider before, during and after individual shifts)
- **Logistics** (e.g. storage and transportation)

Length: **60mins**

Lead: **TBC**

Recommended attendees: **Route Project Team, Planners, Section Managers**

Data management

The session will cover:

- **What the outputs of FELIX are** (e.g. examples of the TEF forms and other data outputs of FELIX)
- **The data process** (e.g. how FELIX data is transferred from the machine)
- **Ongoing data management** (e.g. best practice for managing data to gain insight)

Length: **60mins**

Lead: **Wei Lim**

Recommended attendees: **Route Project Team, Section Managers, Users**

FELIX in use

The session will cover:

- **Key lessons learned** (e.g. how users have got the best out of FELIX)
- **User process** (e.g. how to optimise the process of inspection)

Length: **45mins**

Lead: **James Swift**

Recommended attendees: **Route Project Team, Section Managers, Users**

Operations

The session will cover:

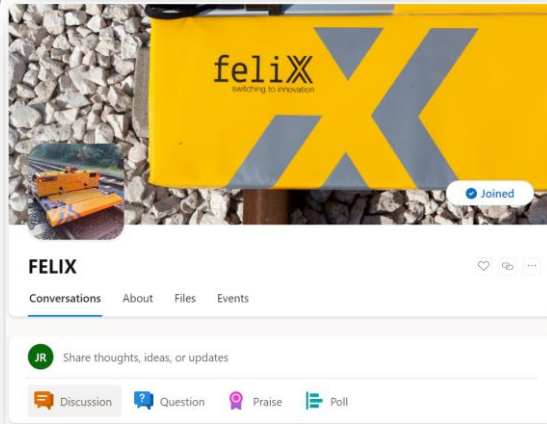
- **Ongoing maintenance** (e.g. tips for how to best look after FELIX)
- **Dealing with issues** (e.g. where to go for support)
- **Warranty** (e.g. what is covered by warranty and how to claim)

Length: **45mins**

Lead: **TBC**

Recommended attendees: **Route Project Team, Section Managers, Users**

Communications Strategy



Viva Engage

Who?

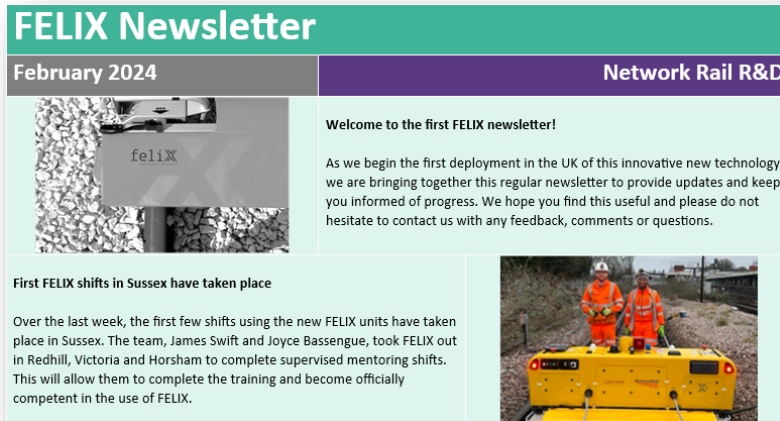
Group made up of Community of Practice and any other interested stakeholders within the business, focused on practical use of FELIX.

What?

Approx. 1 post per week, sharing best practice and learnings from operational use.

How?

Page managed by R&D, with posts from anyone in the community



Monthly Newsletter

Who?

Distribution list, made up of anyone in the business who has previously expressed an interest in updates on FELIX.

What?

Approx. 1 email per month, sharing updates, relevant news and documents.

How?

Newsletter managed by R&D, with input from a variety of sources.

Automated / Semi- Automated S&C Measuring Systems – The Future is Here !



Revise Standards

- Currently focus on the manual method of inspection with a TGP8 gauge.
- **Temporary Variation** in place to permit the use of the actual point of contact of the P8 wheel profile. No need to use the 100 micron feeler gauge.
- New 053 module being written for the use of automated/semi-automated systems.
- Move from a fix when failed to a more proactive, preventative method of managing S&C
- Trending of data to predict faults and intervene before a failure occurs.

Data Management

- Project in flight to transfer Felix data to Insight.
- DU's will be able to utilise Insight to trend asset degradation.

Future Developments

- 054 - Crossing profile management – replace the 7 point check
- Side wear
- Plain line use.
- Black holes, where track recording vehicles don't travel



A yellow Network Rail maintenance vehicle, likely a track inspection or maintenance unit, is shown from a side-on perspective. It has a control panel with a red light and several buttons. The vehicle is mounted on a rail track. The background is a gradient of purple and blue.

Thank You

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