Bevan, Adam

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Wheelset: Less Cost, Less Risk – The Challenge

Inspecting the Depth of Wheel Tread Surface Damage Using Magnetic Flux Leakage

Stephanie Klecha – MRX Technologies

Dr Adam Bevan – Institute of Railway Research

Overview

1. Wheelset Management Challenges
2. Development of Surface Crack Measurement Technology
3. Summary of Wheel Handheld Unit
4. Example Damage Outputs
5. Data Uses and Case Studies

WHEELSET MANAGEMENT CHALLENGES

Wheelset Management

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- Wheelsets are expensive:
  - Manufacturing
  - Reprofiling
  - Inspections
  - Renewal
  - Environmental impact
  - Costs of trains out of service
- Strong demand to reduce the rate of wheel damage
  - Extend wheel reprofiling intervals
  - Better wheelset life
  - Lower costs

Challenges

- Inspecting and quantifying surface condition:
  - Surface damage is difficult to classify visually
  - Highly subjective and poor repeatability
  - Not possible to establish depth of defects
  - Makes data assessment and trending difficult
- Wheel lathe best practice:
  - Reducing the time the vehicle is on the wheel lathe
  - Preventing excessive material removal to maximise wheelset life
  - Consistency between wheel lathe operators
- *Ability to reliably and accurately measure the depth of damage on the wheel tread would significantly assist in the decision making and optimisation of the management of wheel surface damage*

SCM TECHNOLOGY DEVELOPMENT

SCM Development

- MRX's Surface Crack Measurement (SCM) technology has been in use on rails for 8 years+

- 2014: MRX adapted the technology to measure surface cracking on wheels

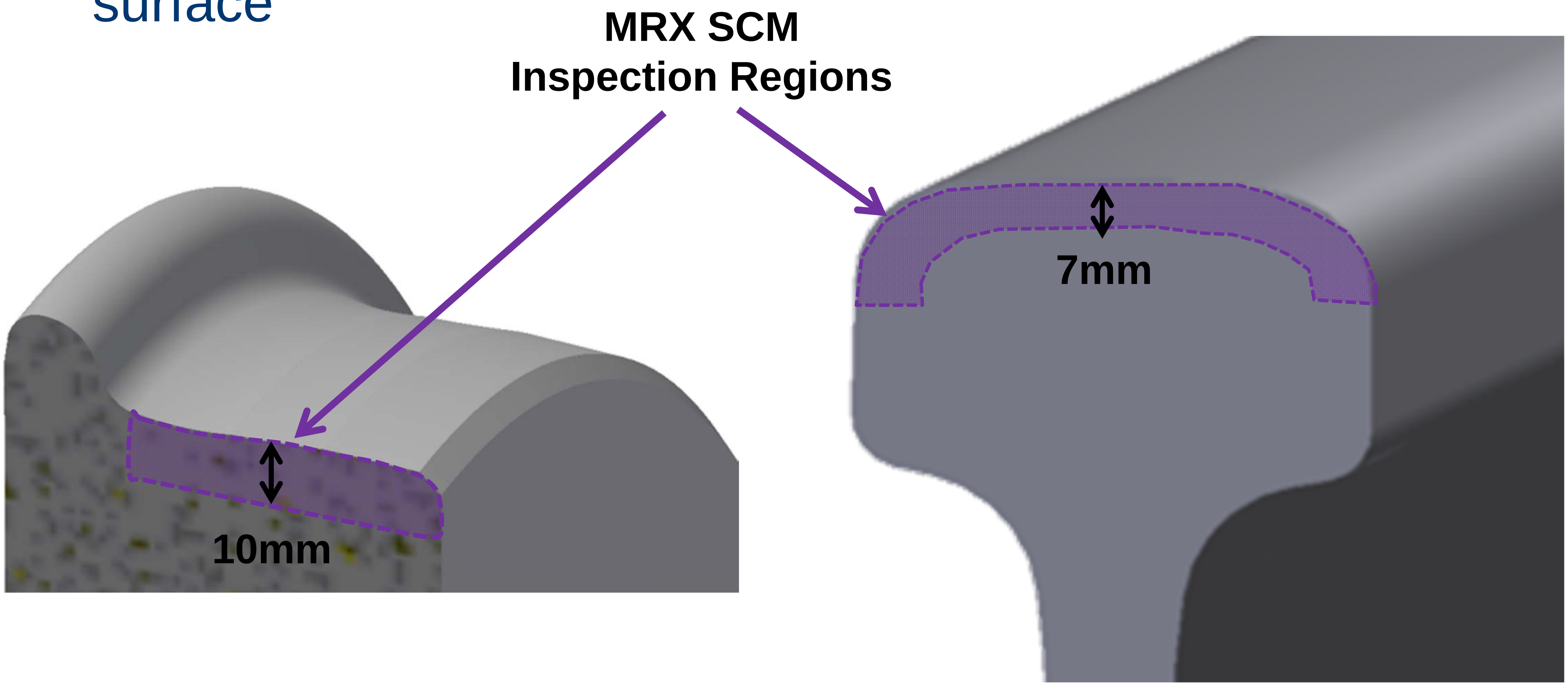
- 2015: MRX awarded funding through the RSSB to validate the hand held product

  →collaboration with Bombardier Transportation and University of Huddersfield

FUTURE RAILWAY

SCM Technology

- MRX's SCM technology currently quantifies defects in the top 7mm of the rail surface and the top 10mm of a wheel surface



SCM Technology Summary

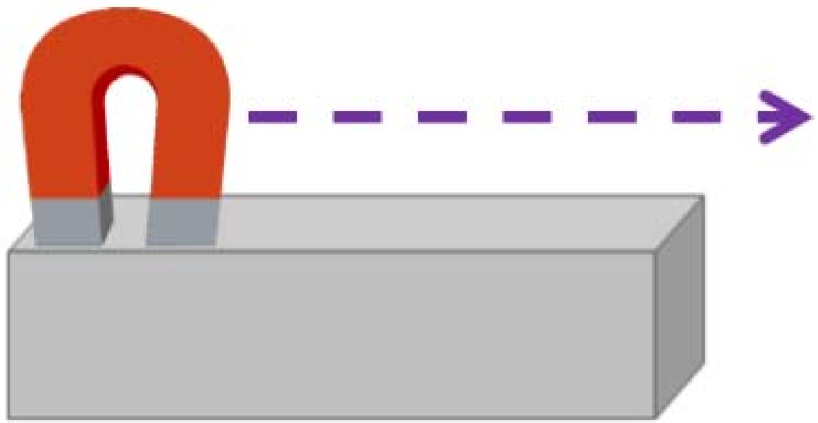
- Wheel HHU reports the depth of the deepest artifact in the entire wheel scan

- Reported depth is the amount of material to remove from the wheel profile to eliminate the deepest artifact in the scanned segment

  - **1mm = Lower detection limit (shallowest)**
  - **10mm = Upper detection limit (deepest)**
  - **+/-0.5mm = System accuracy**

Theory of SCM

- SCM involves magnetizing the specimen surface

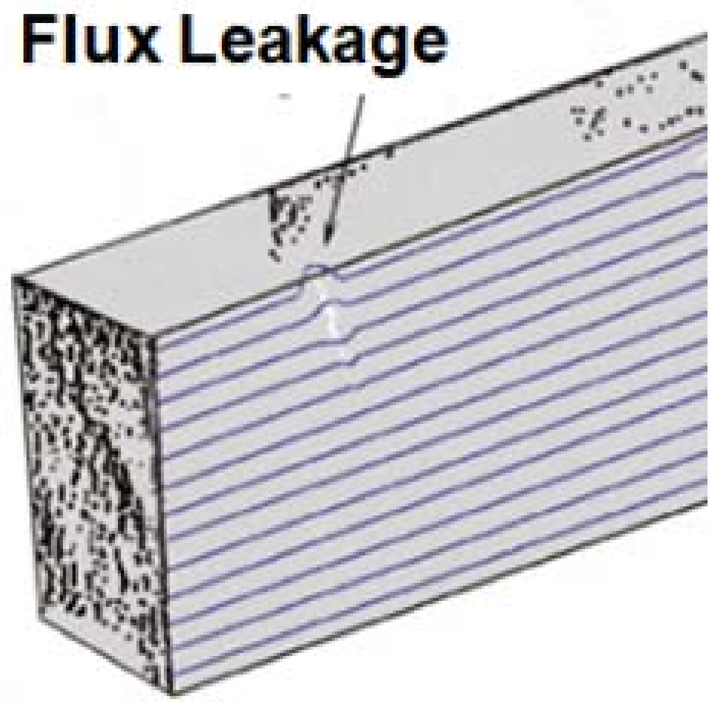


- This introduces lines of magnetic flux into the specimen

Theory of SCM

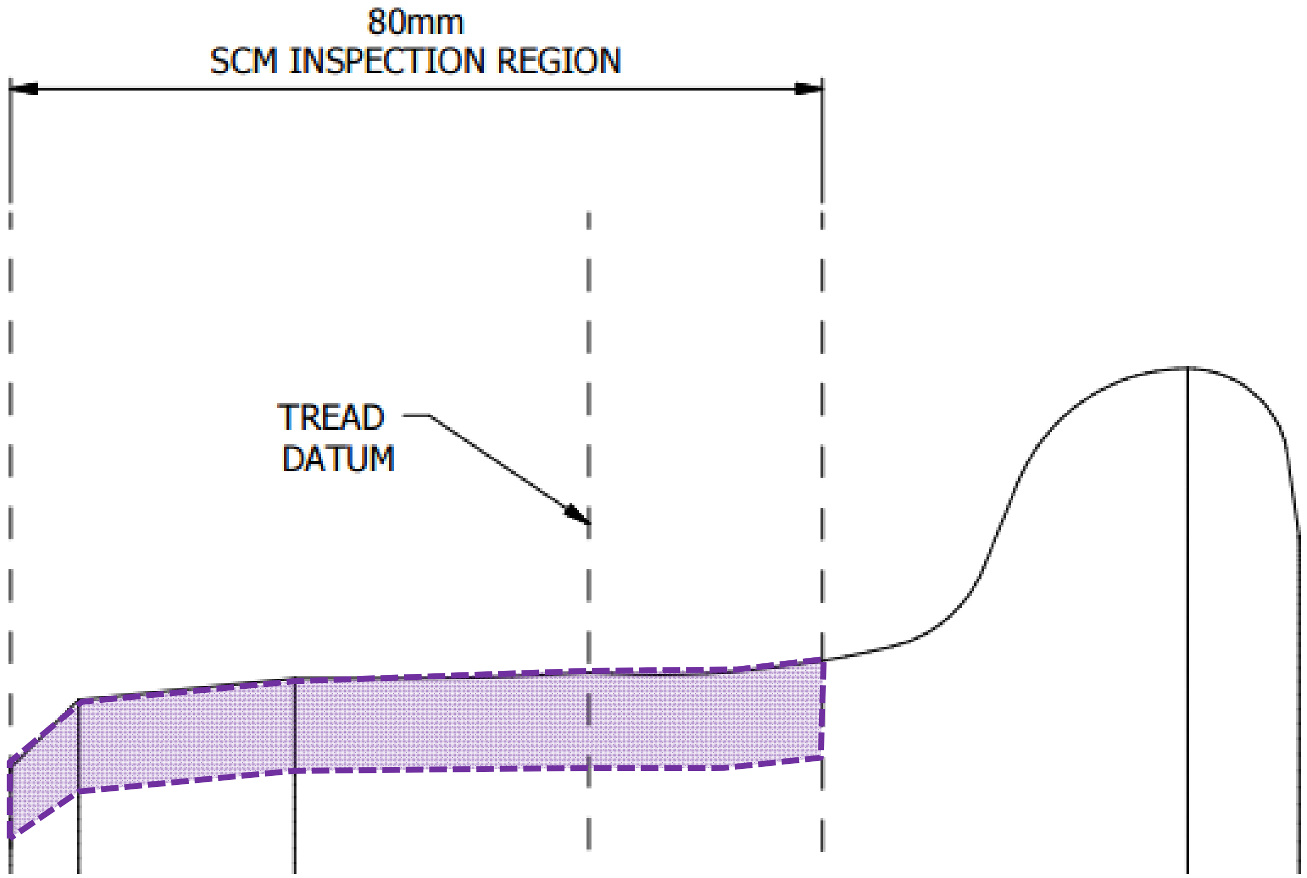
- In a defect free specimen, these lines travel undisturbed through the specimen

- If a defect is present, the flux cannot travel as easily through it
- This causes some flux to leak at the position of the defect
  - SCM uses sensors to measure and record the leaking flux
  - This data is analysed to quantify the artifacts



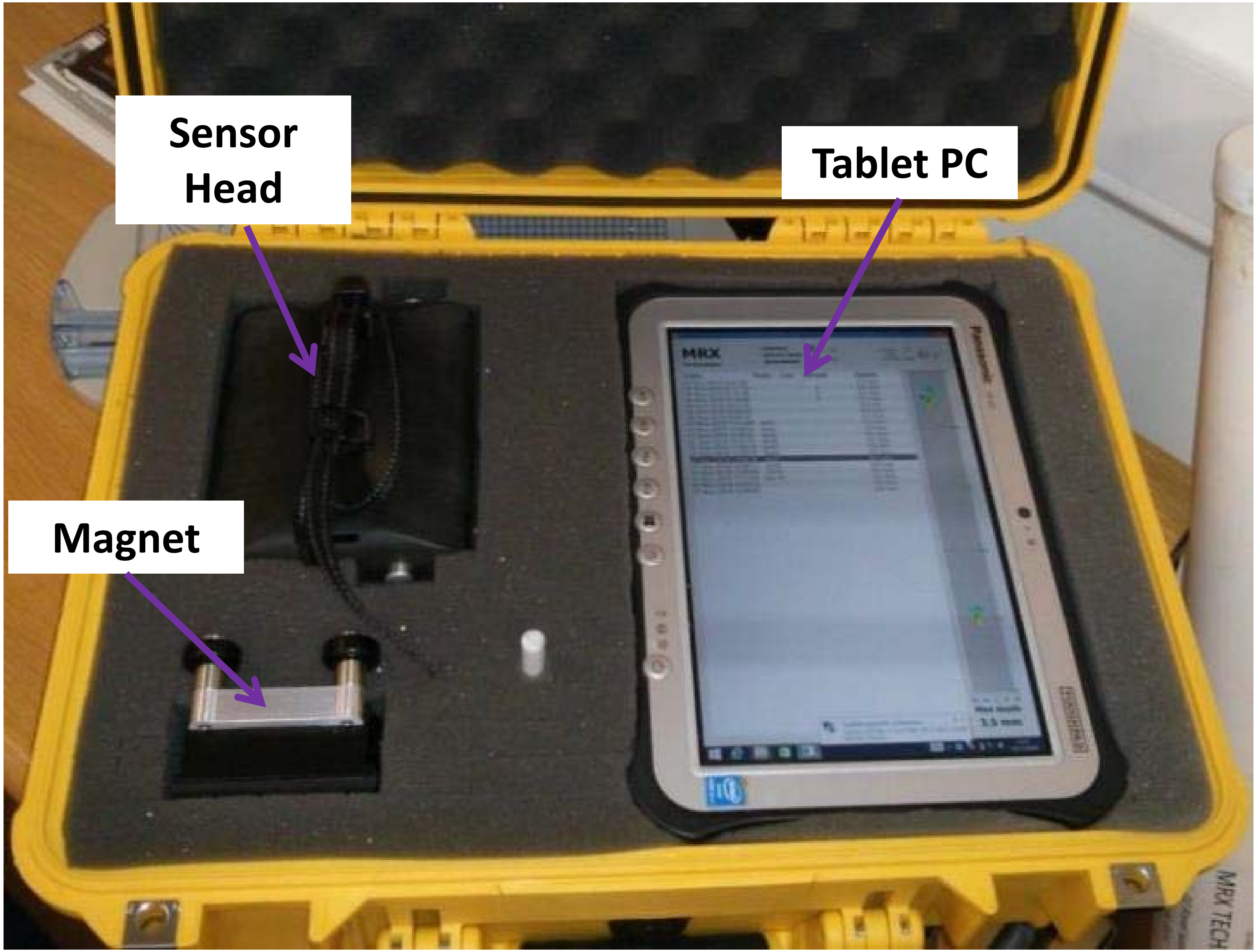
Wheel Sensor Layout

- Wheel SCM contains 16 magnetic field sensors spaced at 5mm pitch across the wheel tread
- These cover a typical P8 profile as shown:



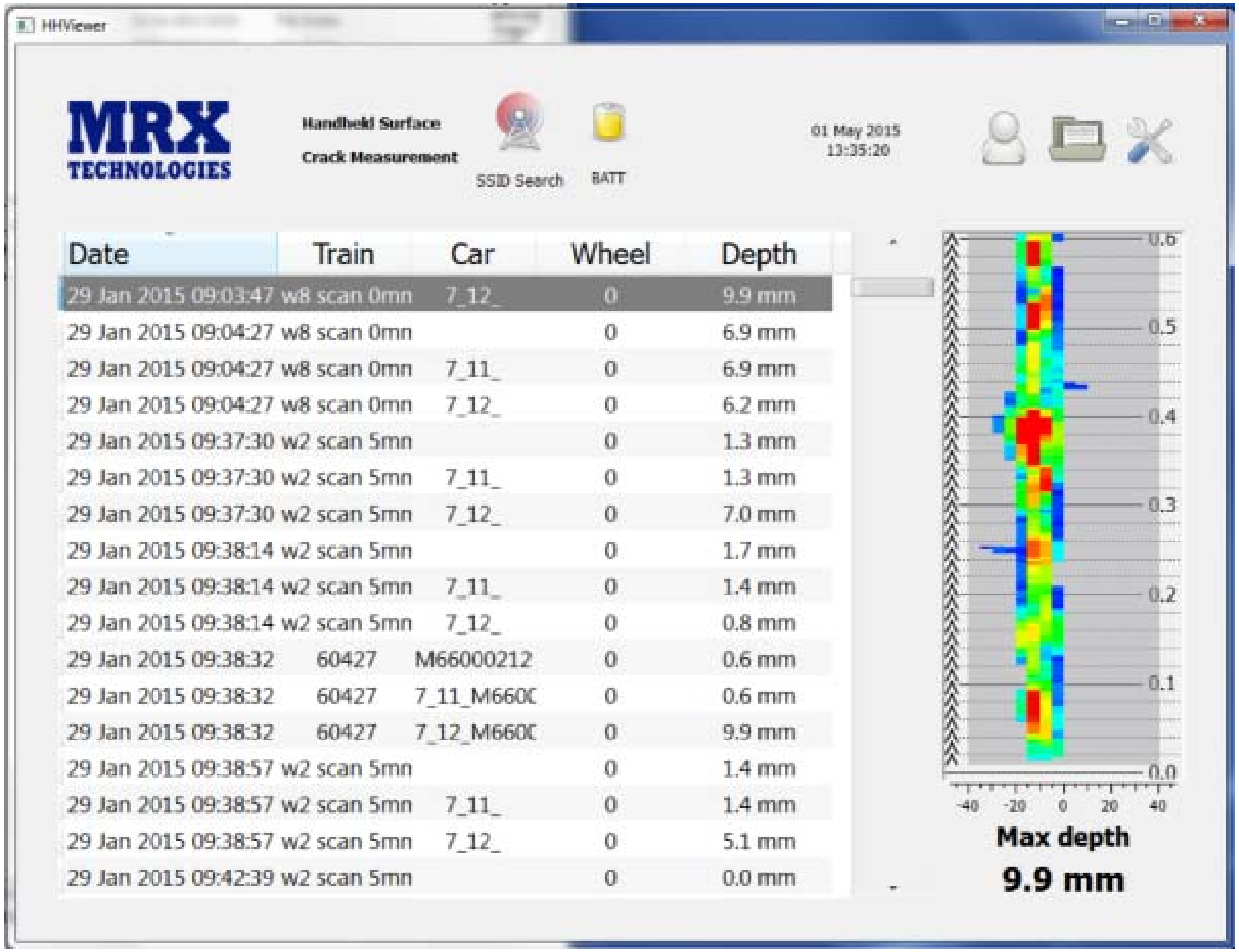
SCM HANDHELD WHEEL UNIT

Wheel SCM HHU



Wheel SCM HHU

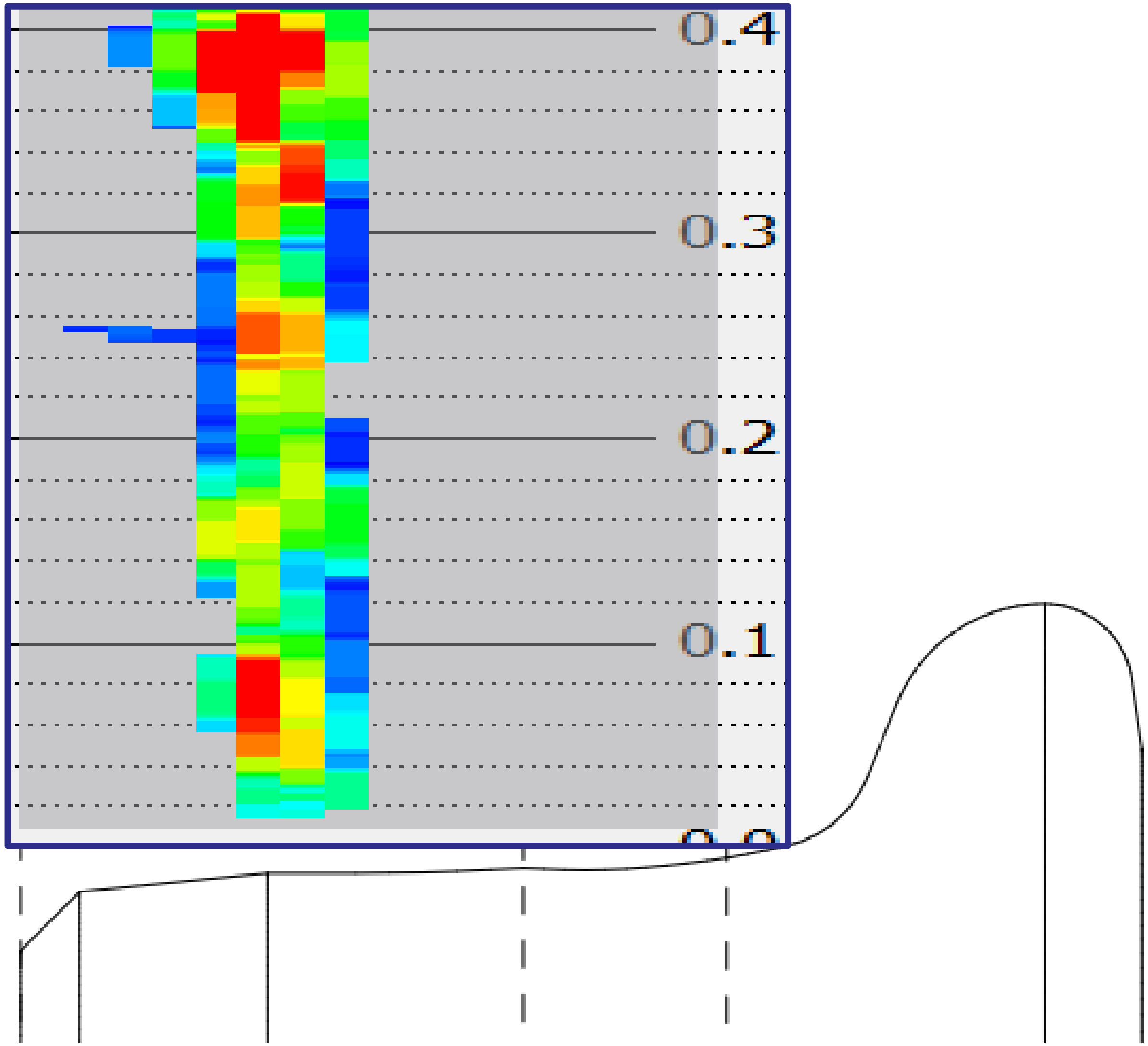
Data is available to the User immediately at the end of a scan



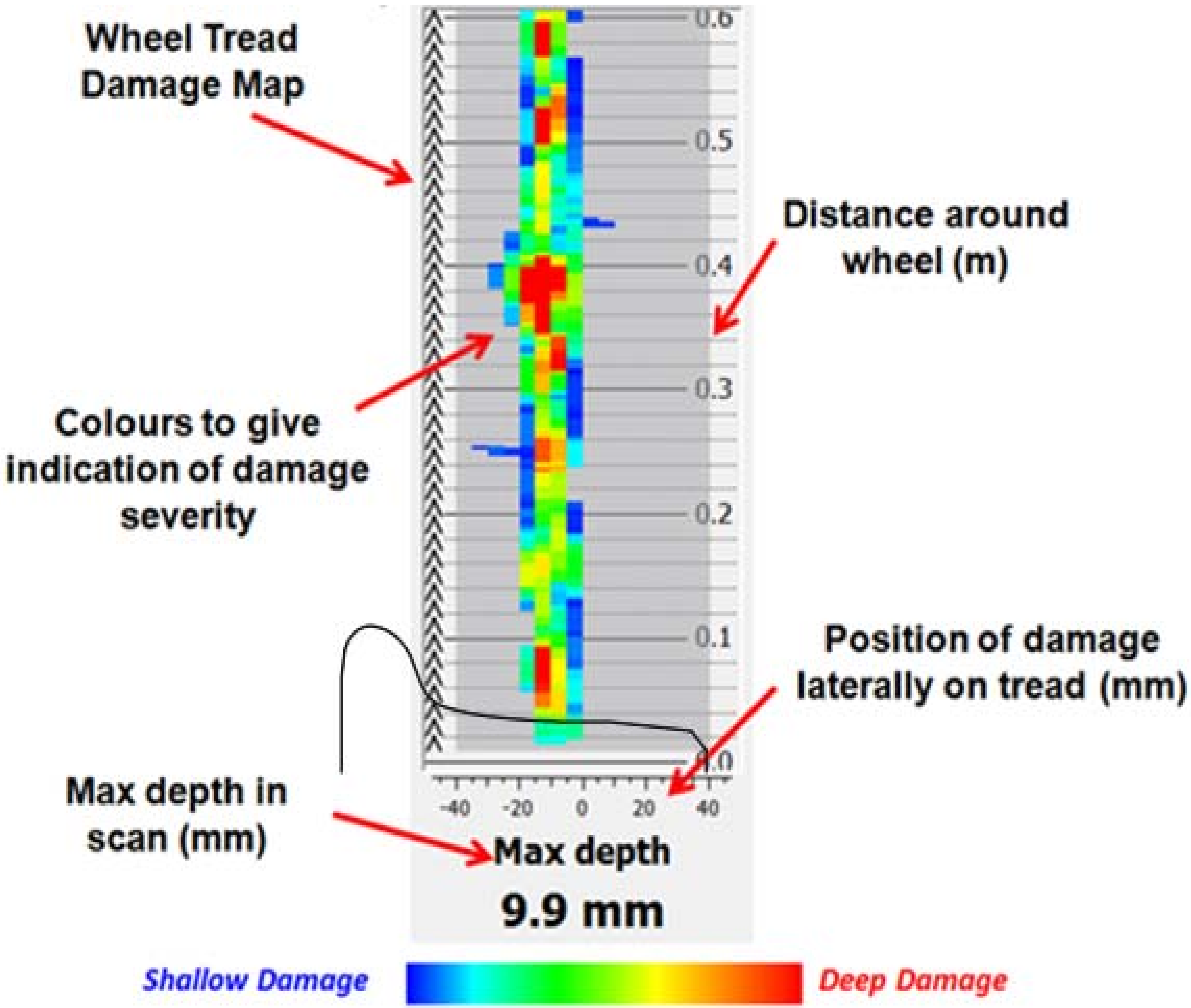
Date	Train	Car	Wheel	Depth
29 Jan 2015 09:03:47	w8 scan 0mn	7_12_	0	9.9 mm
29 Jan 2015 09:04:27	w8 scan 0mn		0	6.9 mm
29 Jan 2015 09:04:27	w8 scan 0mn	7_11_	0	6.9 mm
29 Jan 2015 09:04:27	w8 scan 0mn	7_12_	0	6.2 mm
29 Jan 2015 09:37:30	w2 scan 5mn		0	1.3 mm
29 Jan 2015 09:37:30	w2 scan 5mn	7_11_	0	1.3 mm
29 Jan 2015 09:37:30	w2 scan 5mn	7_12_	0	7.0 mm
29 Jan 2015 09:38:14	w2 scan 5mn		0	1.7 mm
29 Jan 2015 09:38:14	w2 scan 5mn	7_11_	0	1.4 mm
29 Jan 2015 09:38:14	w2 scan 5mn	7_12_	0	0.8 mm
29 Jan 2015 09:38:32	60427	M66000212	0	0.6 mm
29 Jan 2015 09:38:32	60427	7_11_M660C	0	0.6 mm
29 Jan 2015 09:38:32	60427	7_12_M660C	0	9.9 mm
29 Jan 2015 09:38:57	w2 scan 5mn		0	1.4 mm
29 Jan 2015 09:38:57	w2 scan 5mn	7_11_	0	1.4 mm
29 Jan 2015 09:38:57	w2 scan 5mn	7_12_	0	5.1 mm
29 Jan 2015 09:42:39	w2 scan 5mn		0	0.0 mm

Data Output

16 SCM sensors produce a damage map of the wheel surface:



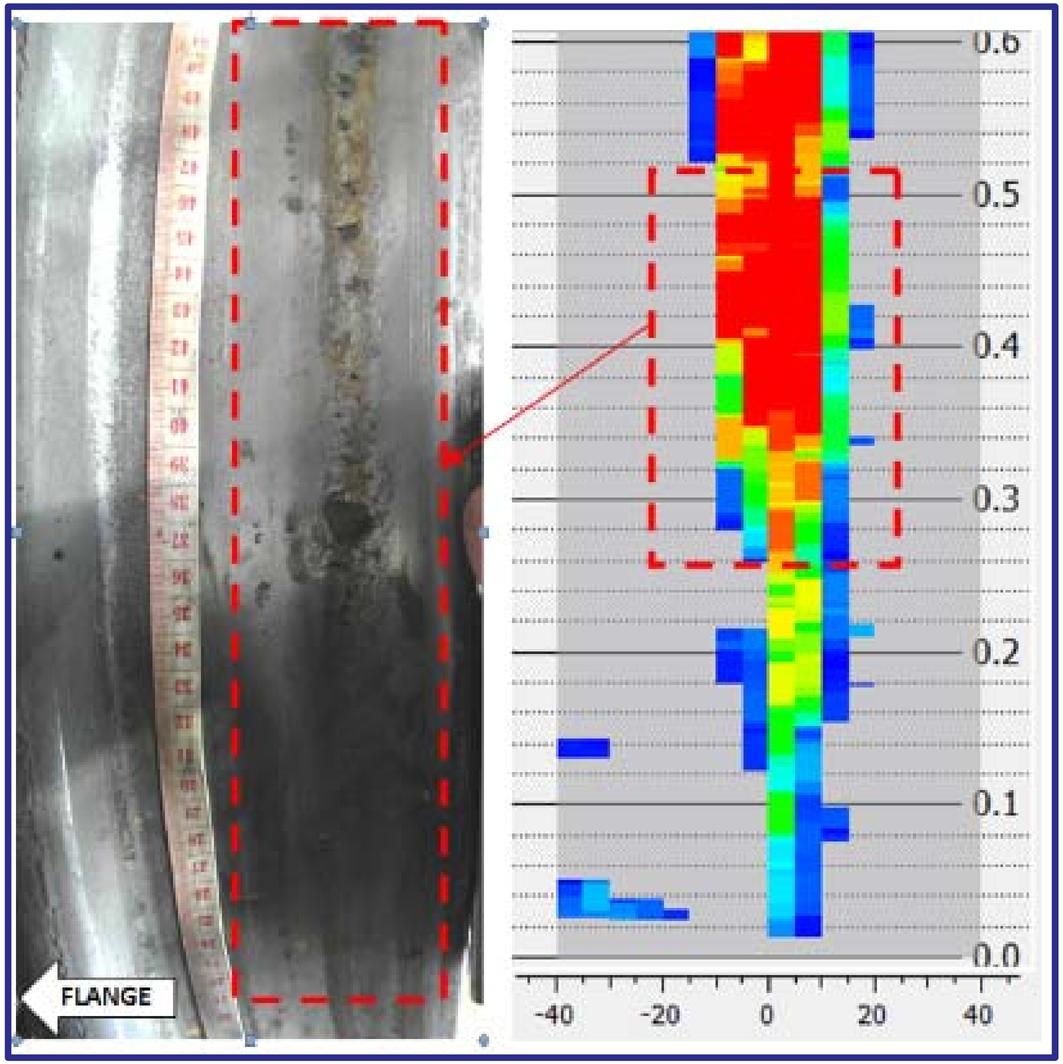
HHU Data Output



EXAMPLE DAMAGE OUTPUTS

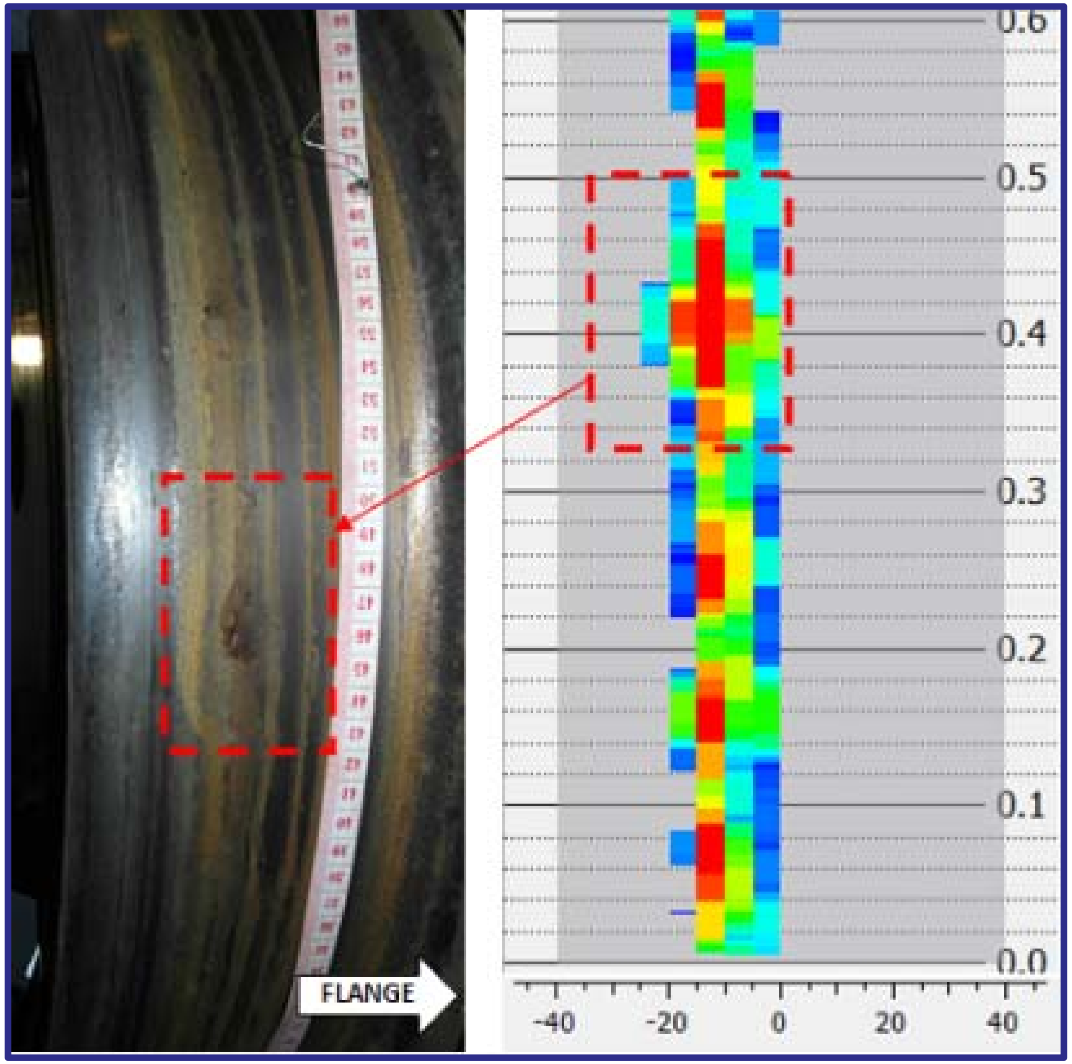
Damage Types

- Surface breaking and near-surface damage
  - Rolling contact fatigue (RCF) cracking



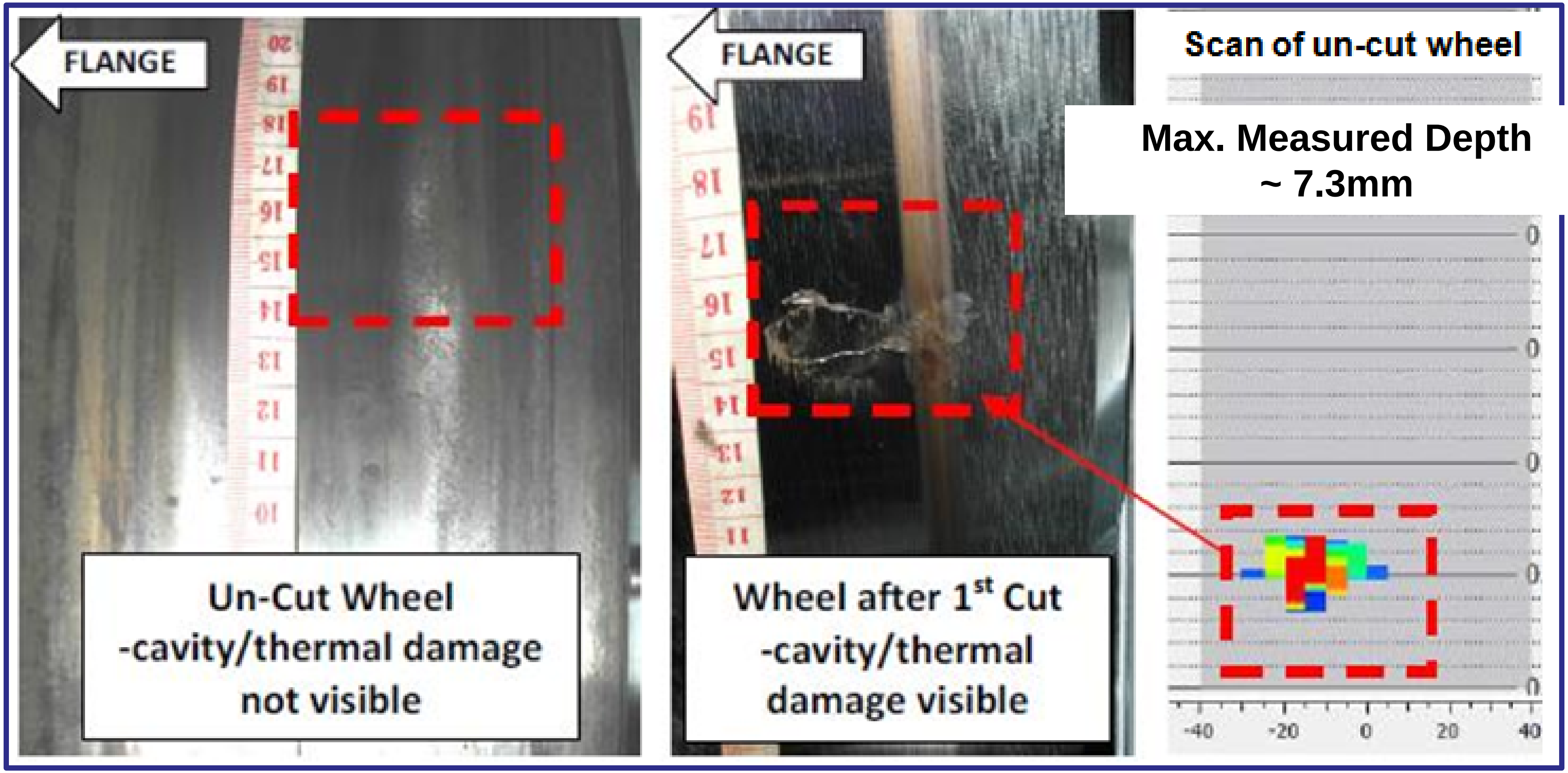
Damage Types

- Surface breaking and near-surface damage
  - Rolling contact fatigue (RCF) cracking
  - Thermal cracking and cavities



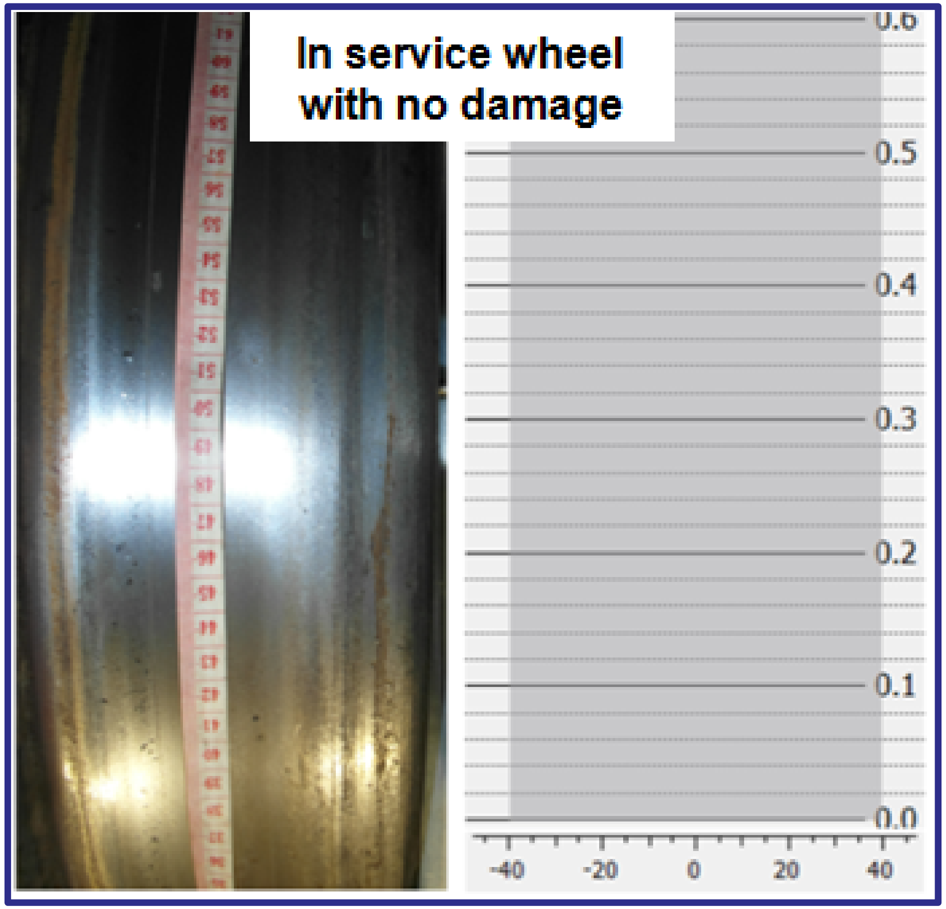
Non-visible Damage

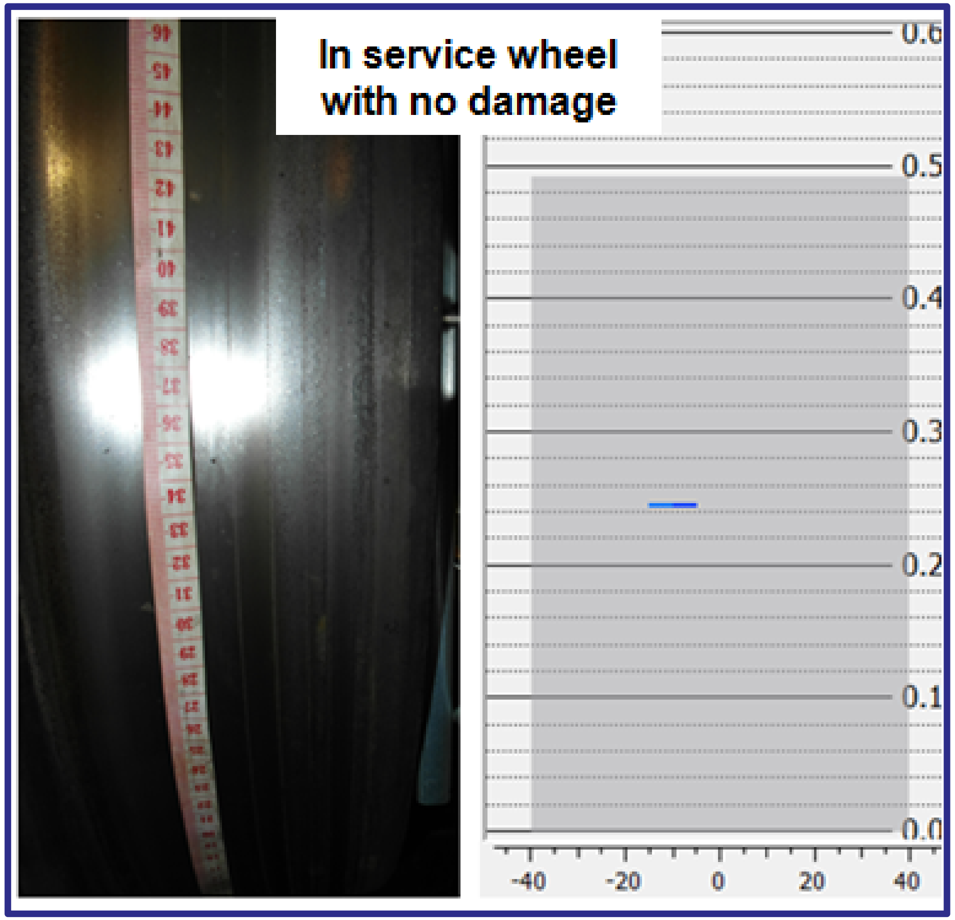
- HHU reveals damage not visible on uncut wheel



Damage Free Wheel

- Confirms when wheel is damage free





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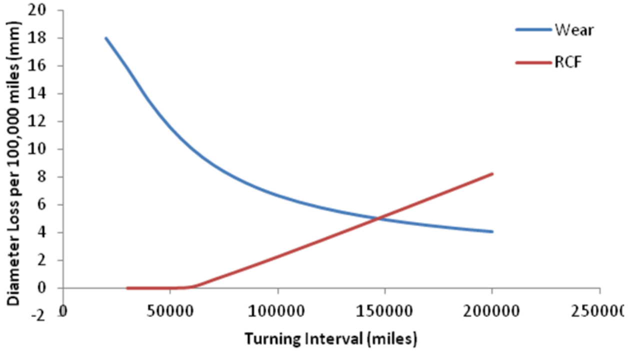
DATA USES AND CASE STUDIES

Typical Data Uses

- Routine exams to replace visual inspection
  - Repeatable, not reliant on experience/judgement
  - Reveals damage that is not obvious/visible on uncut tread
- Used to optimise lathe cut depths
  - Reduce risk of overcutting, saves time chasing defects
  - Minimum cut depth to maintain parity
- Understand RCF development and growth rates
  - Plan maintenance in advance (rather than reactionary)
  - Highlight problem wheels/vehicles
  - Optimise periodic turning intervals
- Used for specific case studies
  - Monitoring performance of vehicle changes



Optimise Cut Depths

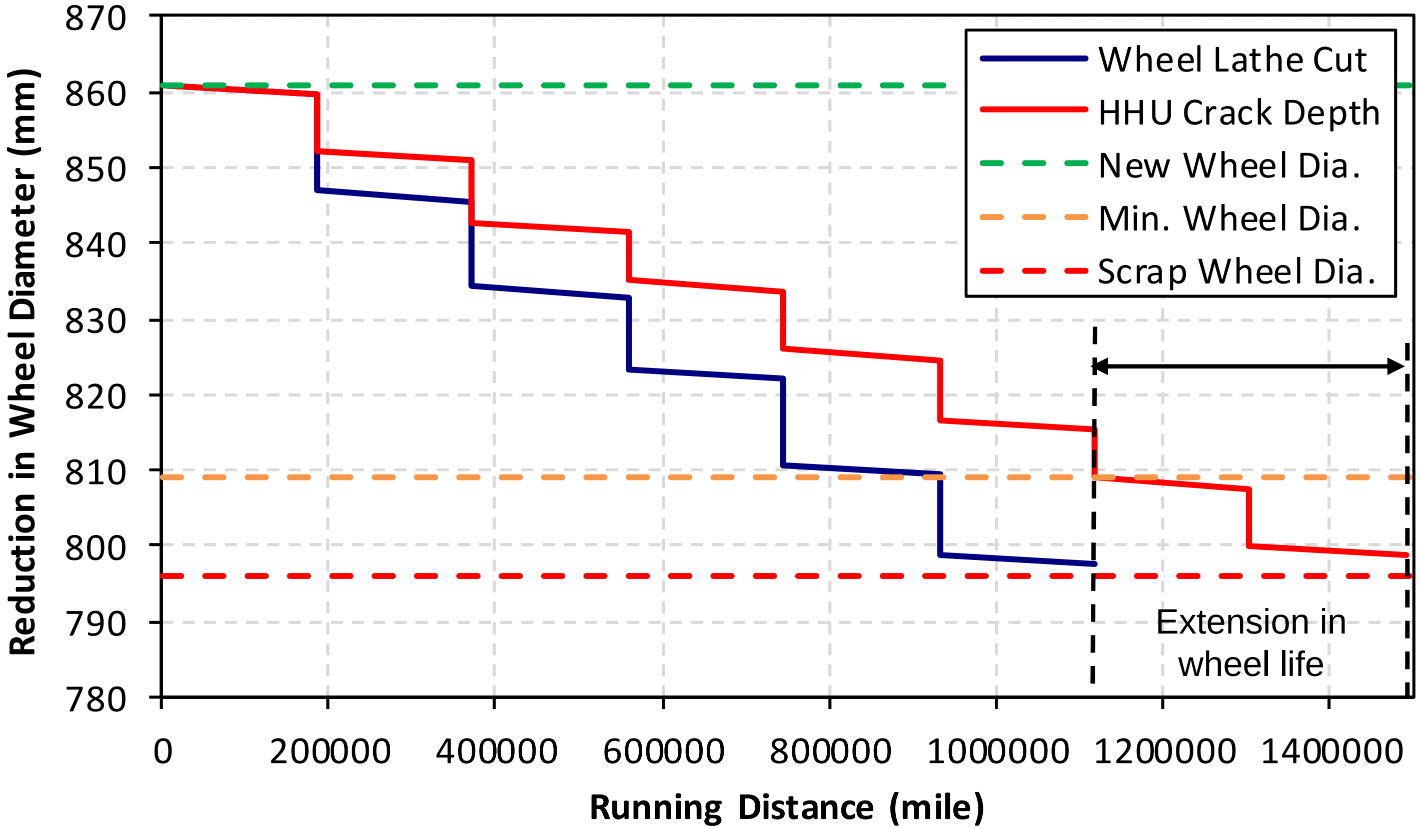
Case Study 1:

Use of HHU during regular inspection (prior to wheel turning) to optimise cut depths at the wheel lathe

- Potential benefits:
  - Cut depths identified prior to reprofiling
  - Sub-surface damage not-visible during visual inspection identified
  - Confirm wheelsets requiring largest cuts and minimum cut depth required to maintain parity (prior to reprofiling)
  - Less time at wheel lathe
  - Extended wheel life (up to 2 reprofiling activities)

Optimise Cut Depths

- Wheelset life tracked based on observed average wear rates and cut depths (with and without use of HHU). 40 wheels observed during the study
- Potential increase in wheel life by 2 additional turning activities (~370kmi) and potential saving in wheelset costs of ~25%



Maintenance Decisions

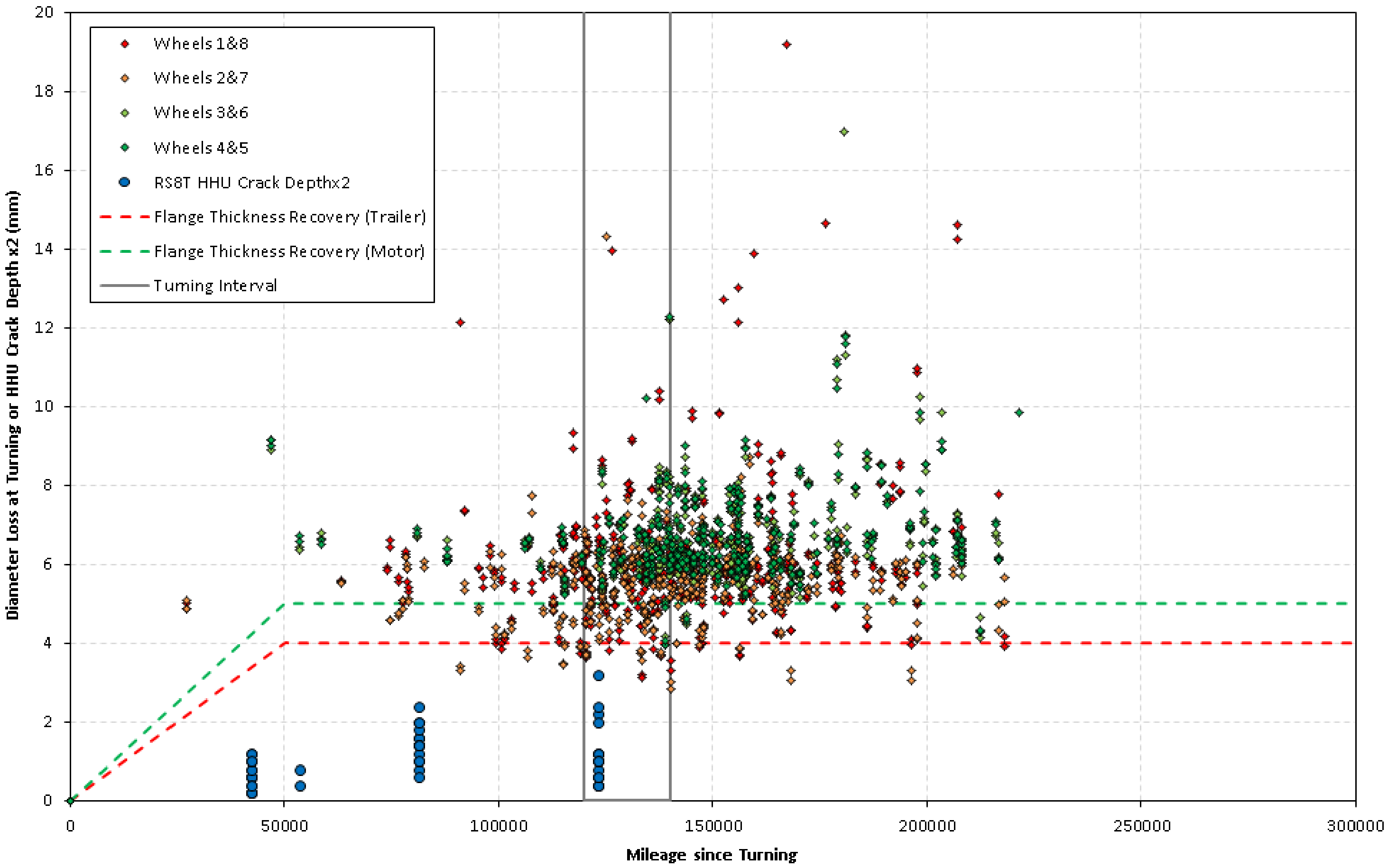
Case Study 2:

Use of HHU to optimise fleet maintenance and quantify the benefits of potential damage mitigation measures

- Potential benefits:
  - Repeatable measurement of the severity of wheel tread damage
  - Data trends and performance of mitigation measures (e.g. vehicle changes, alternative wheel steels) can be realised much quicker
    - Do not have to wait until wheels are turned
  - Optimise turning interval based on damage depth rather than diameter reduction (or cut depth) at the wheel lathe
    - Removes variation associated with different wheel lathe operators and different damage types

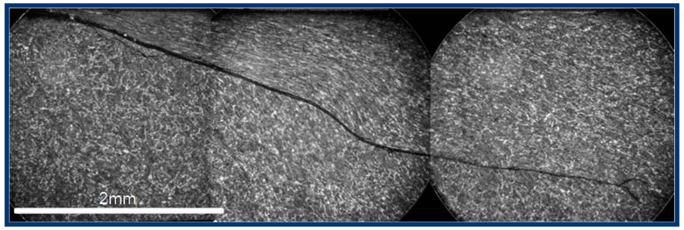
Maintenance Decisions

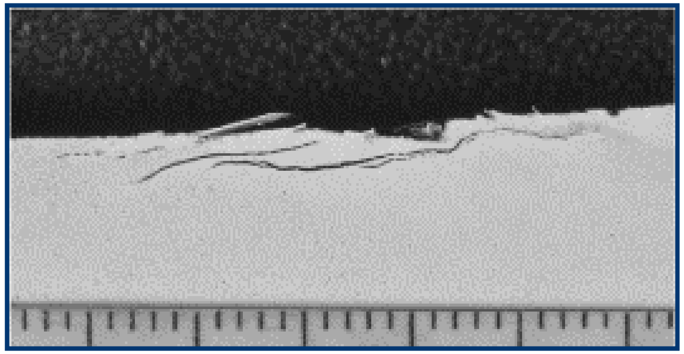
- Benefits of alternative wheel steel (RS8T) quantified in short timeframe using more repeatable HHU data
- Decisions whether to apply to the entire fleet can be made sooner ~ greater savings in costs during franchise



Next Steps

- Assessment of scrap wheels:
  - Samples to be examined optically to determine deformation depth, crack length and crack depth
  - Micro-hardness testing
  - Correlation HHU readings with measured damage
- Further wheel lathe trials to assess damage types and access constraints on different fleets
- Pilot study on selected fleets
  - Business case assessment





Acknowledgments

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- The results and findings presented were developed as part of the RSSB/Future Railway managed ‘*Rail Operator Challenge Competition*’

BOMBARDIER the evolution of mobility

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crosscountry

- For further information contact:
  - a.j.bevan@hud.ac.uk
  - sek@mrxtech.co.uk

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