Wheelset: Less Cost, Less Risk – The Challenge

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

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Overview

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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

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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*

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SCM TECHNOLOGY DEVELOPMENT

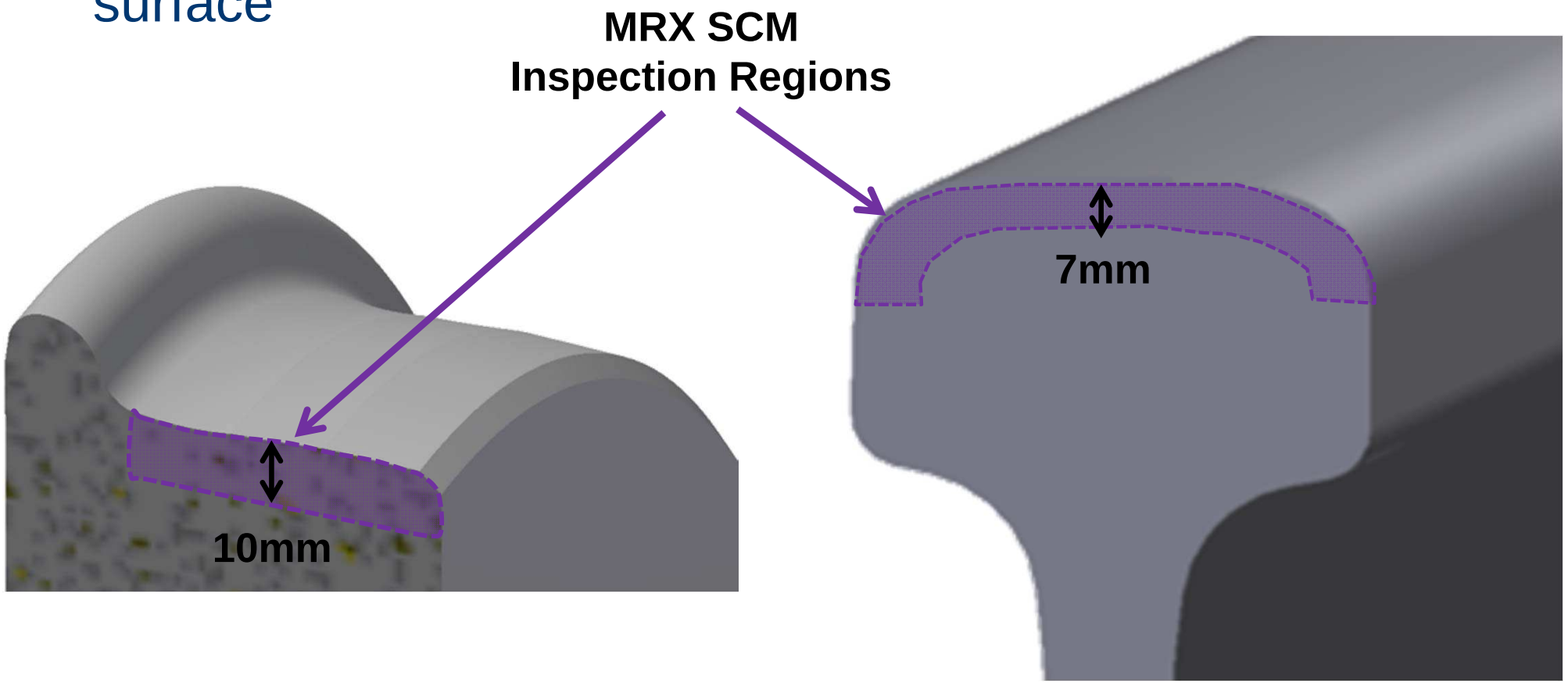
SCM Development

- 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

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

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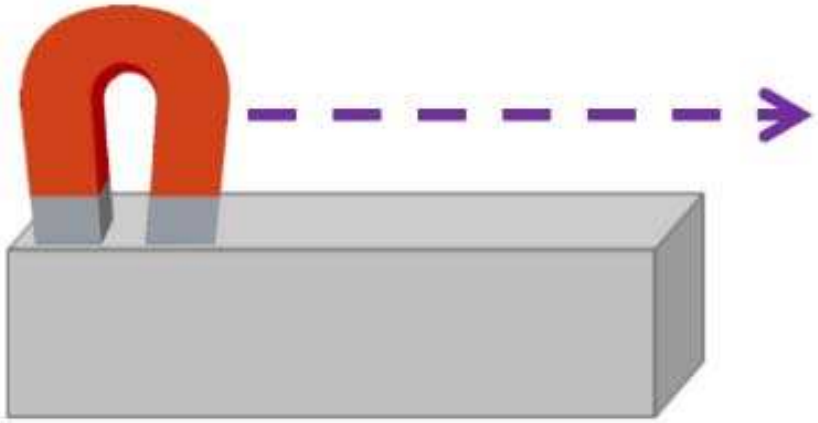
- Wheel HHU reports the depth of the deepest artifact in the entire wheel scan
- Reported depth is the amount of material to remove from the wheel profile to eliminate the deepest artifact in the scanned segment
  - **1mm = Lower detection limit (shallowest)**
  - **10mm = Upper detection limit (deepest)**
  - **+/-0.5mm = System accuracy**

Theory of SCM

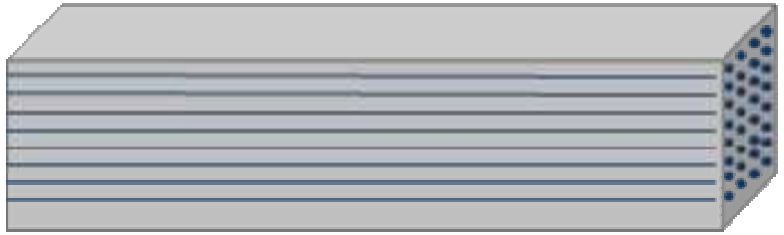
- SCM involves magnetizing the specimen surface



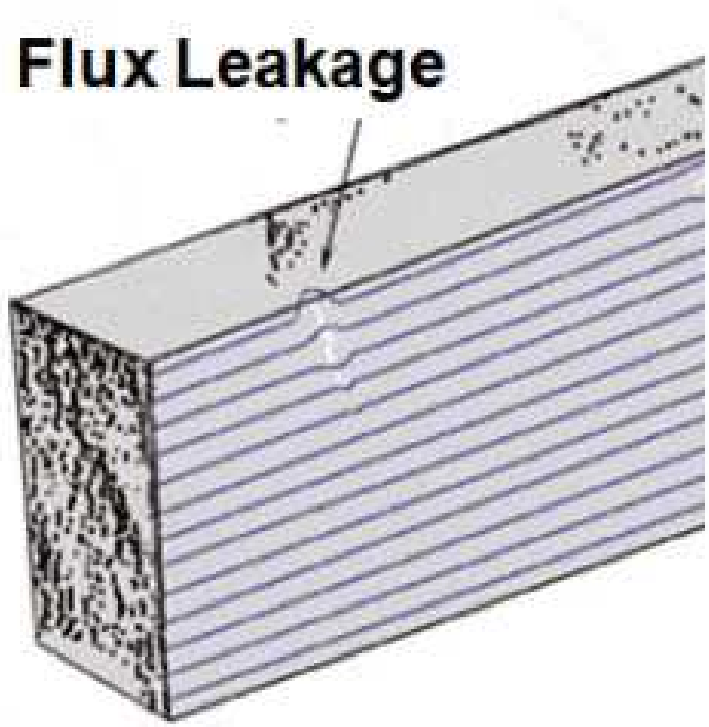
- This introduces lines of magnetic flux into the specimen

Theory of SCM

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

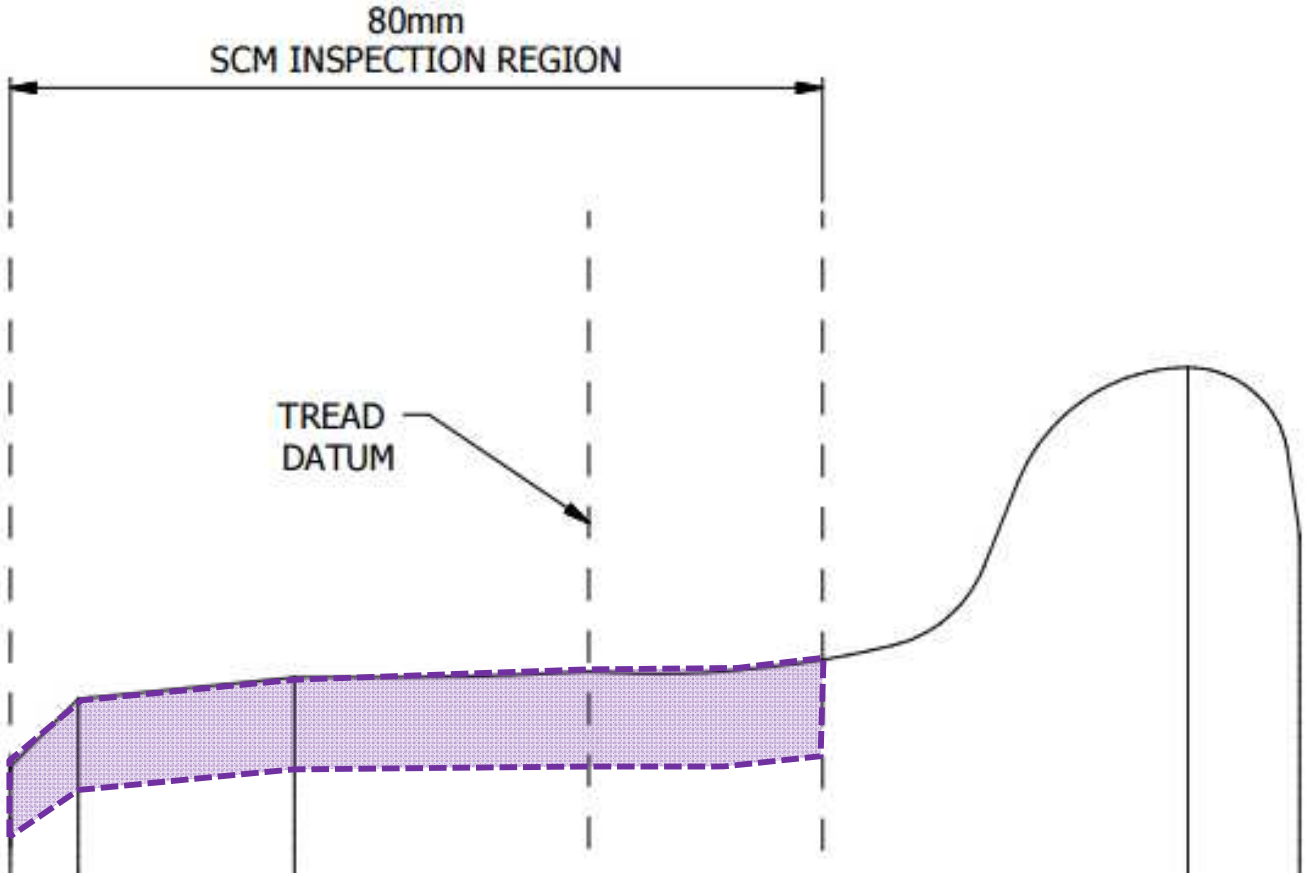


- If a defect is present, the flux cannot travel as easily through it
- This causes some flux to leak at the position of the defect
  - SCM uses sensors to measure and record the leaking flux
  - This data is analysed to quantify the artifacts



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:



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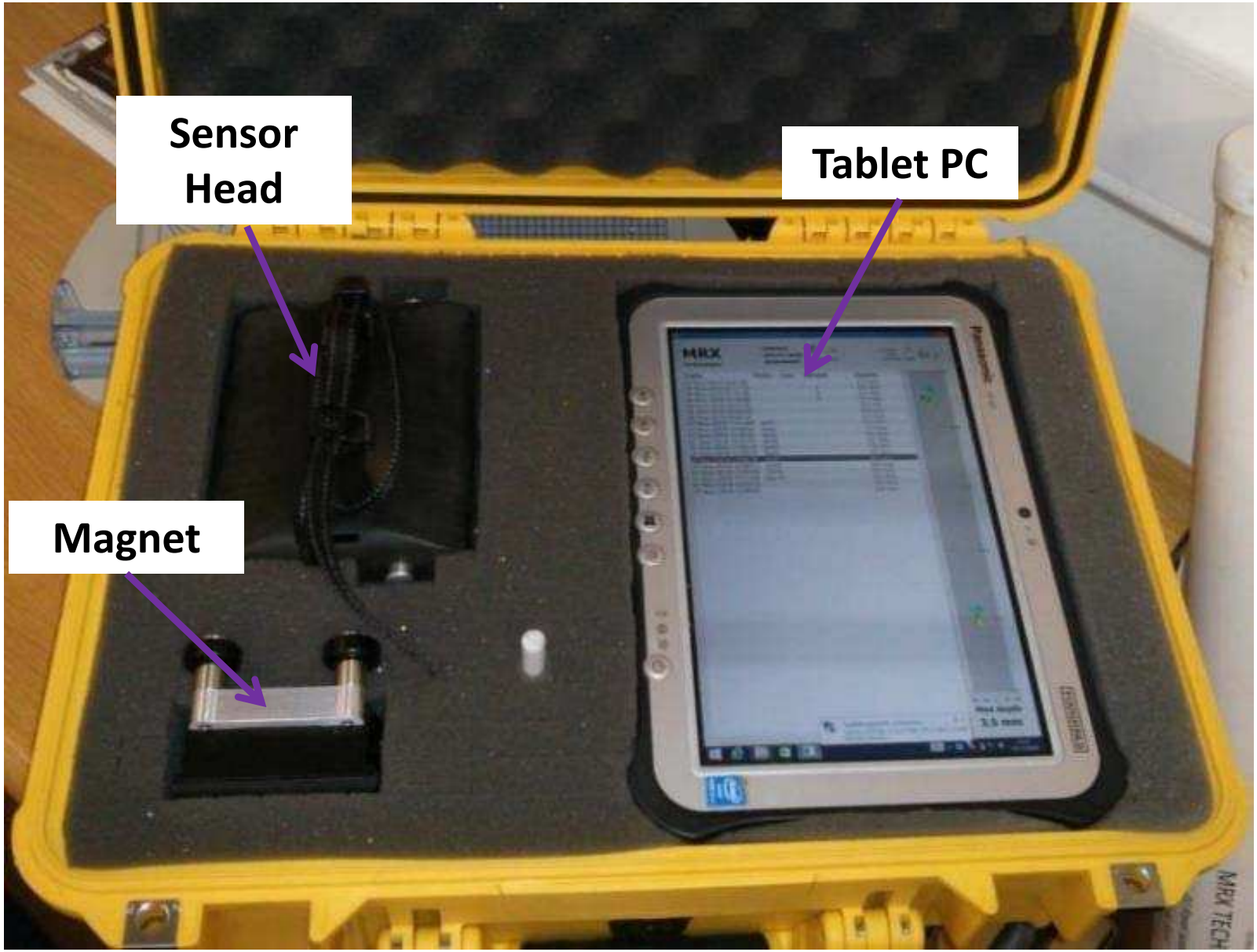
SCM HANDHELD WHEEL UNIT

Wheel SCM HHU



Wheel SCM HHU

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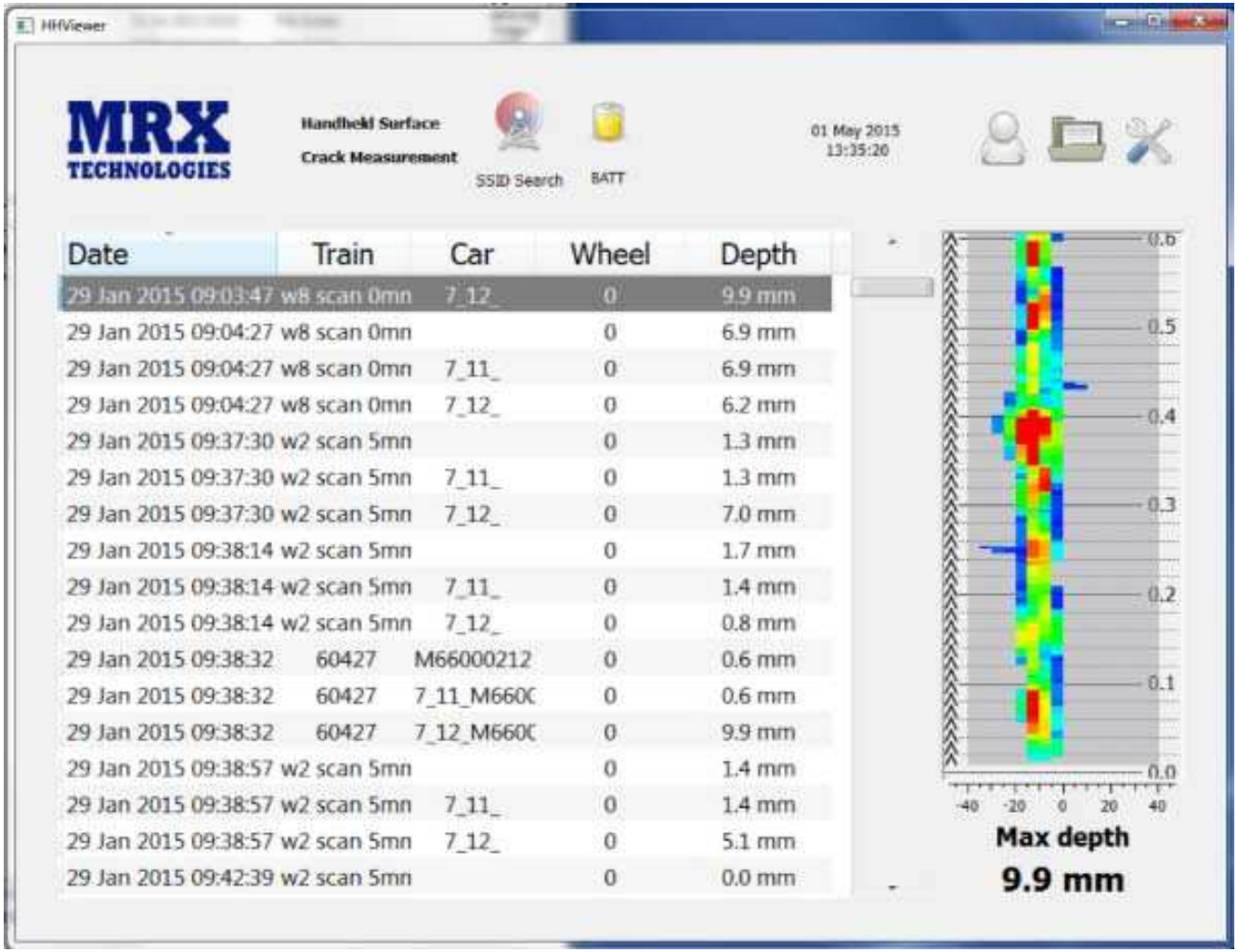
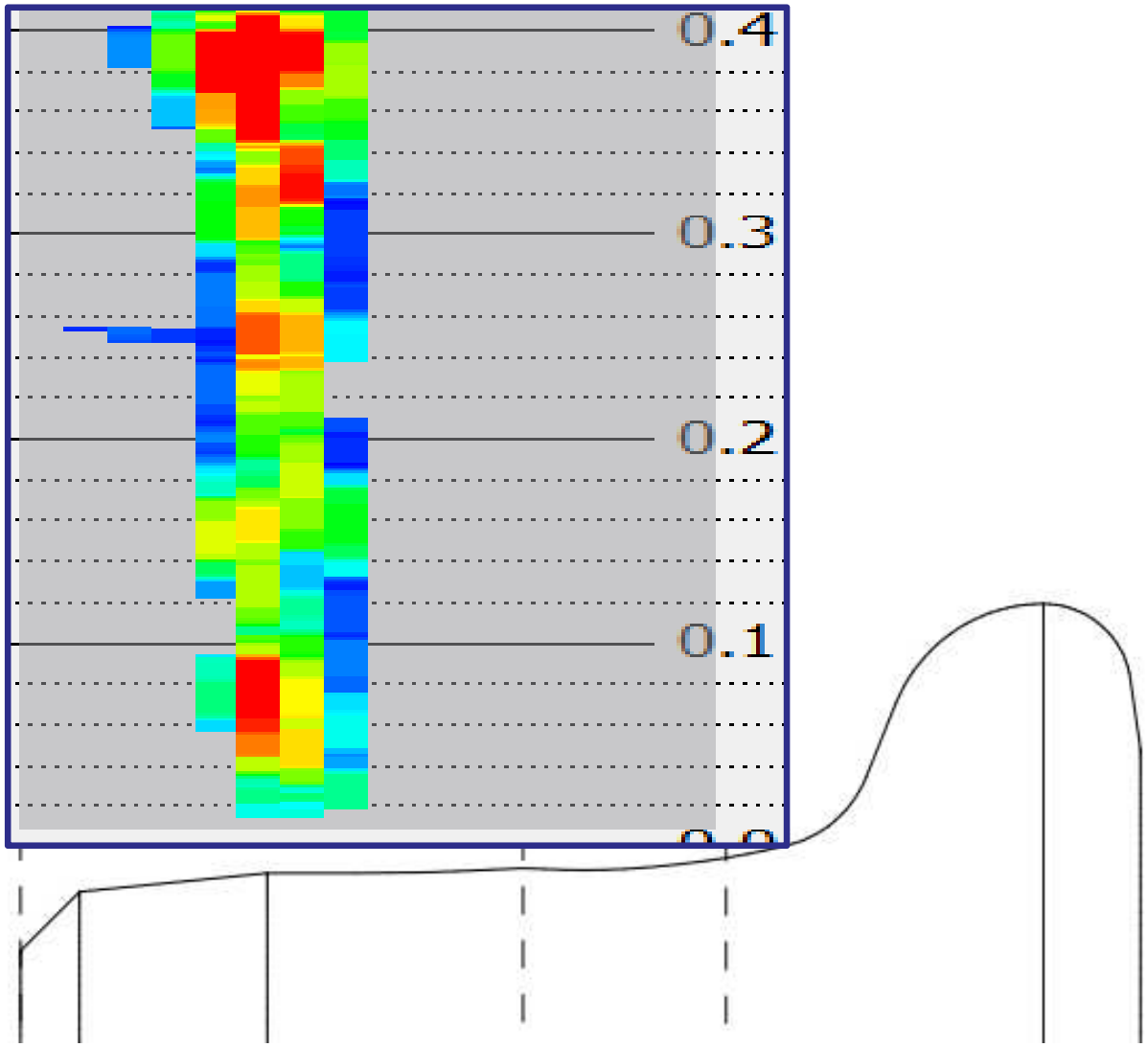
Data is available to the User immediately at the end of a scan



Data Output

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



HHU Data Output

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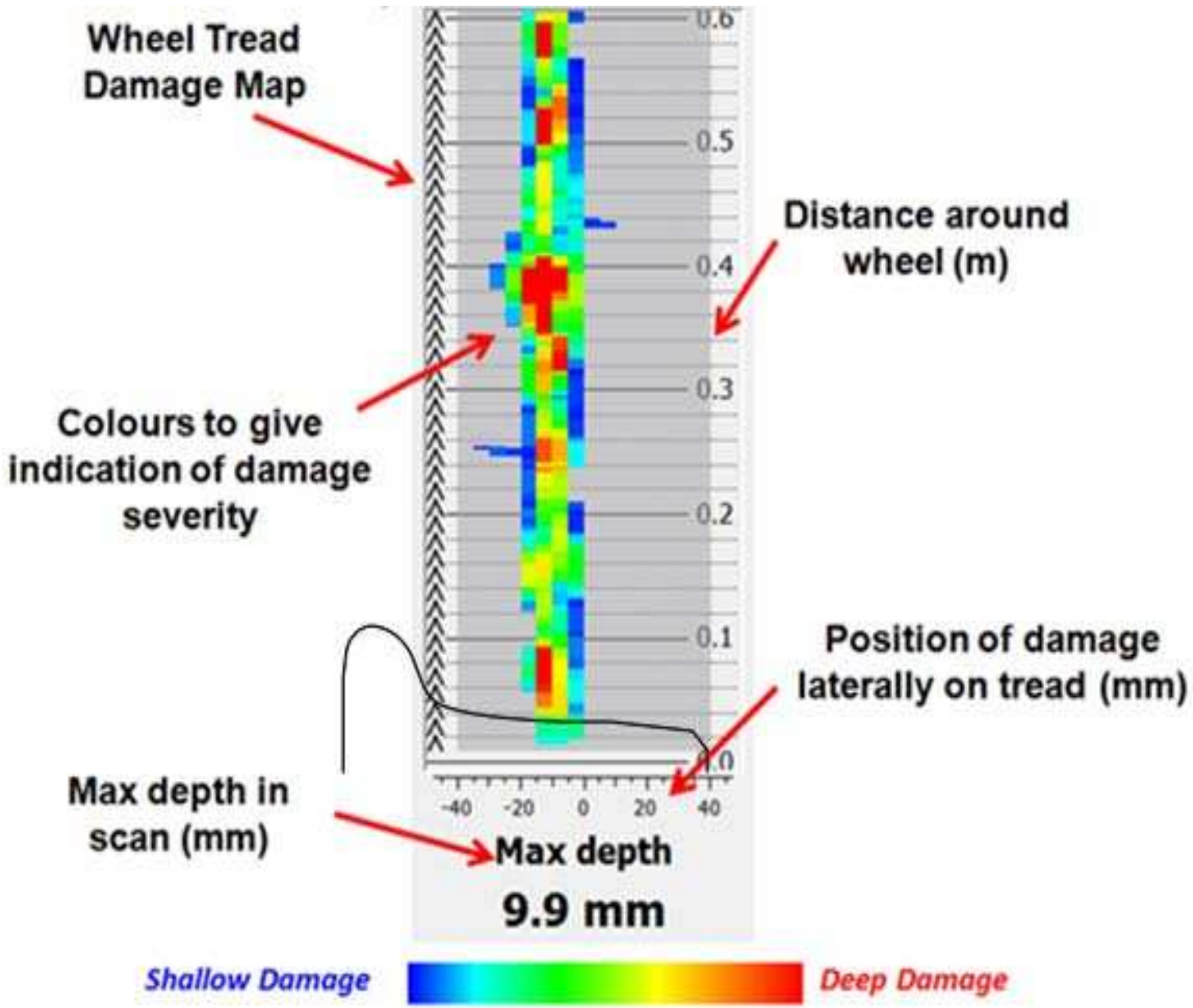

EXAMPLE DAMAGE OUTPUTS

Damage Types

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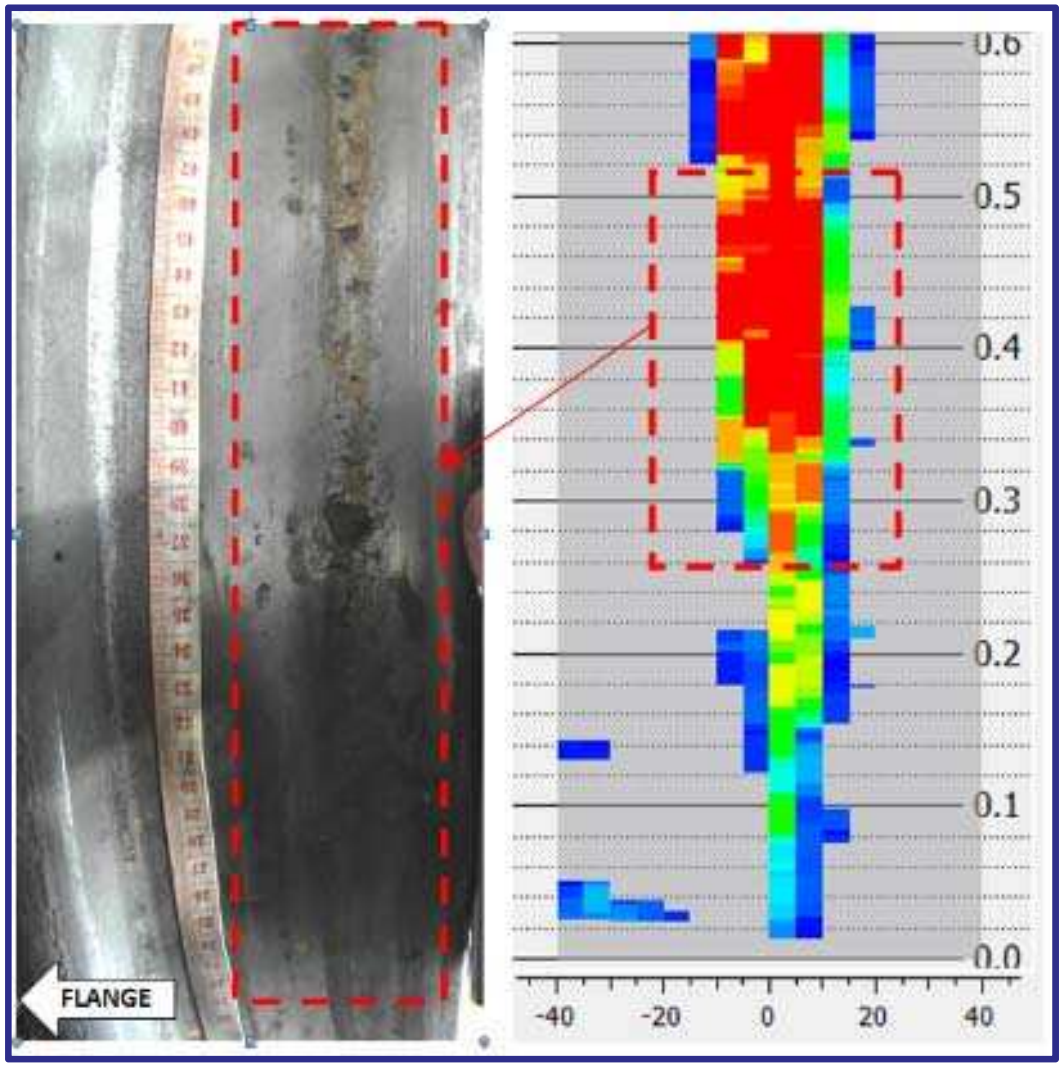
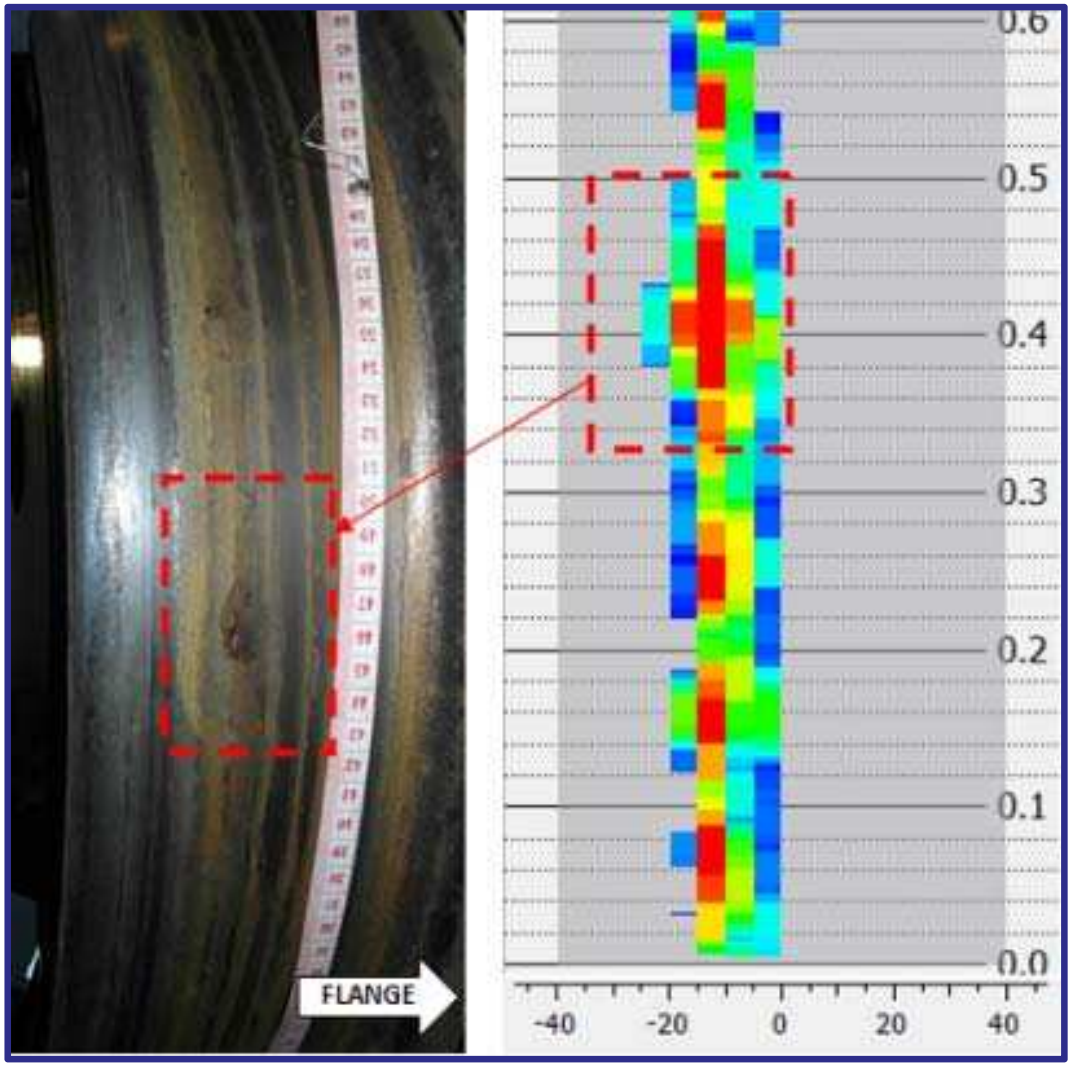
- Surface breaking and near-surface damage
  - Rolling contact fatigue (RCF) cracking



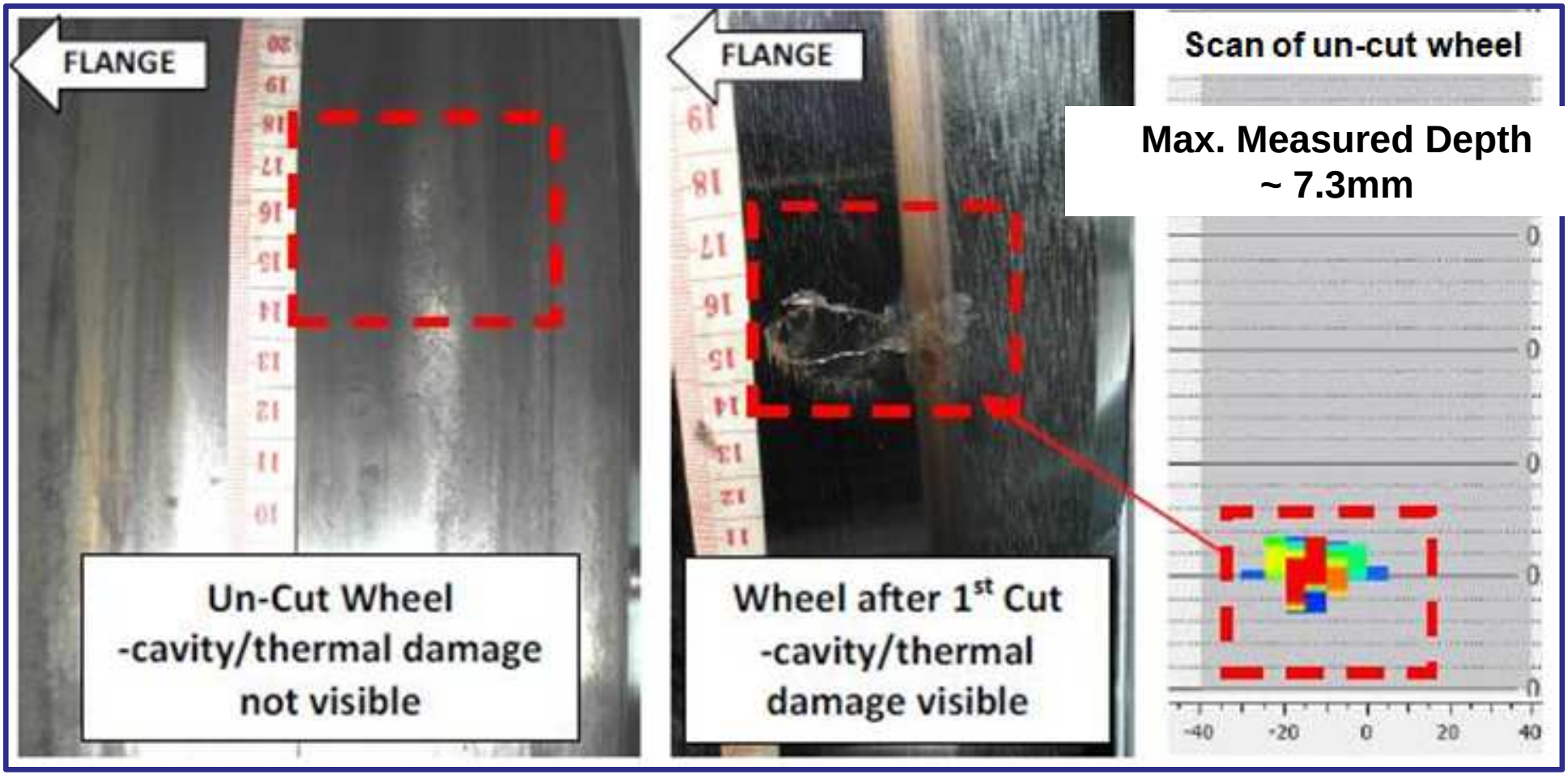
Damage Types

- 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

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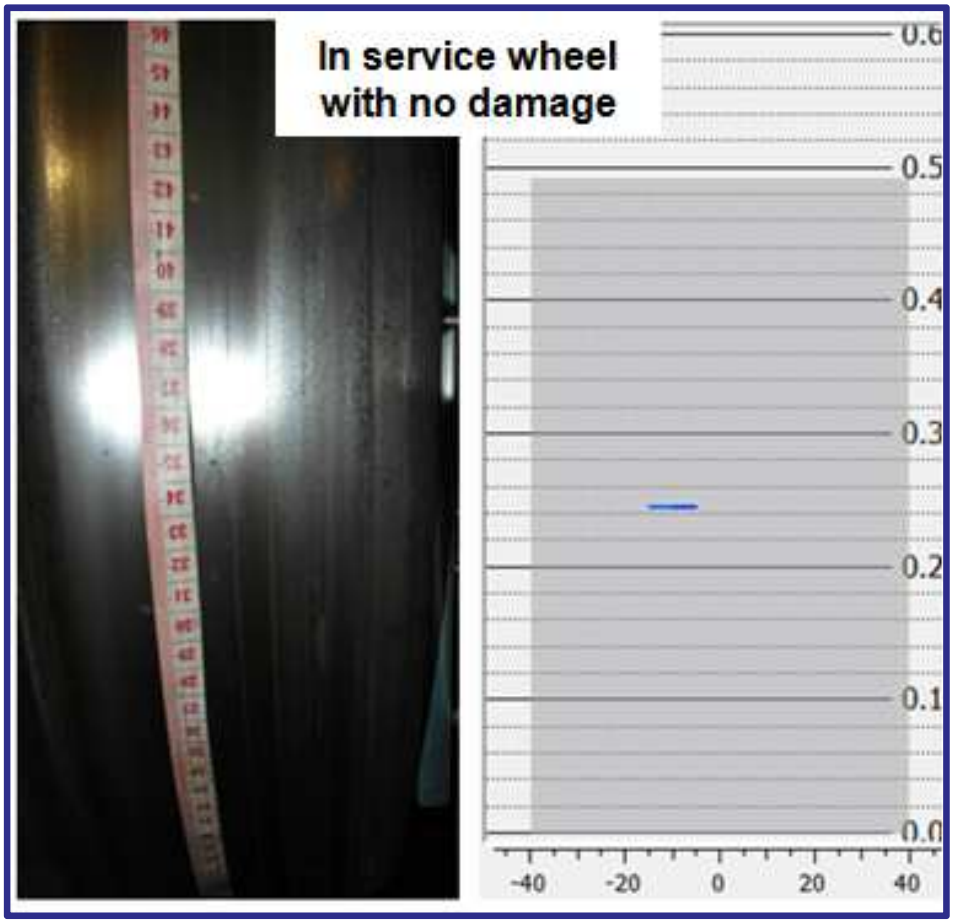
- Confirms when wheel is damage free



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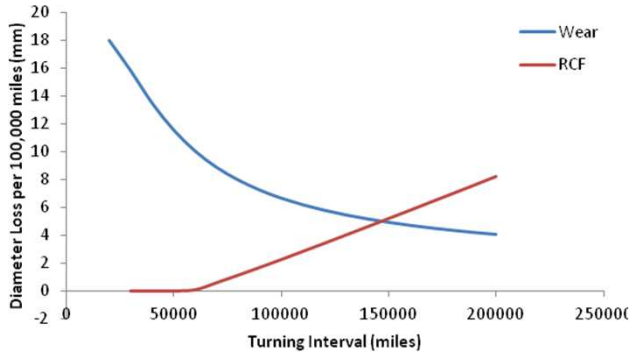
DATA USES AND CASE STUDIES

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

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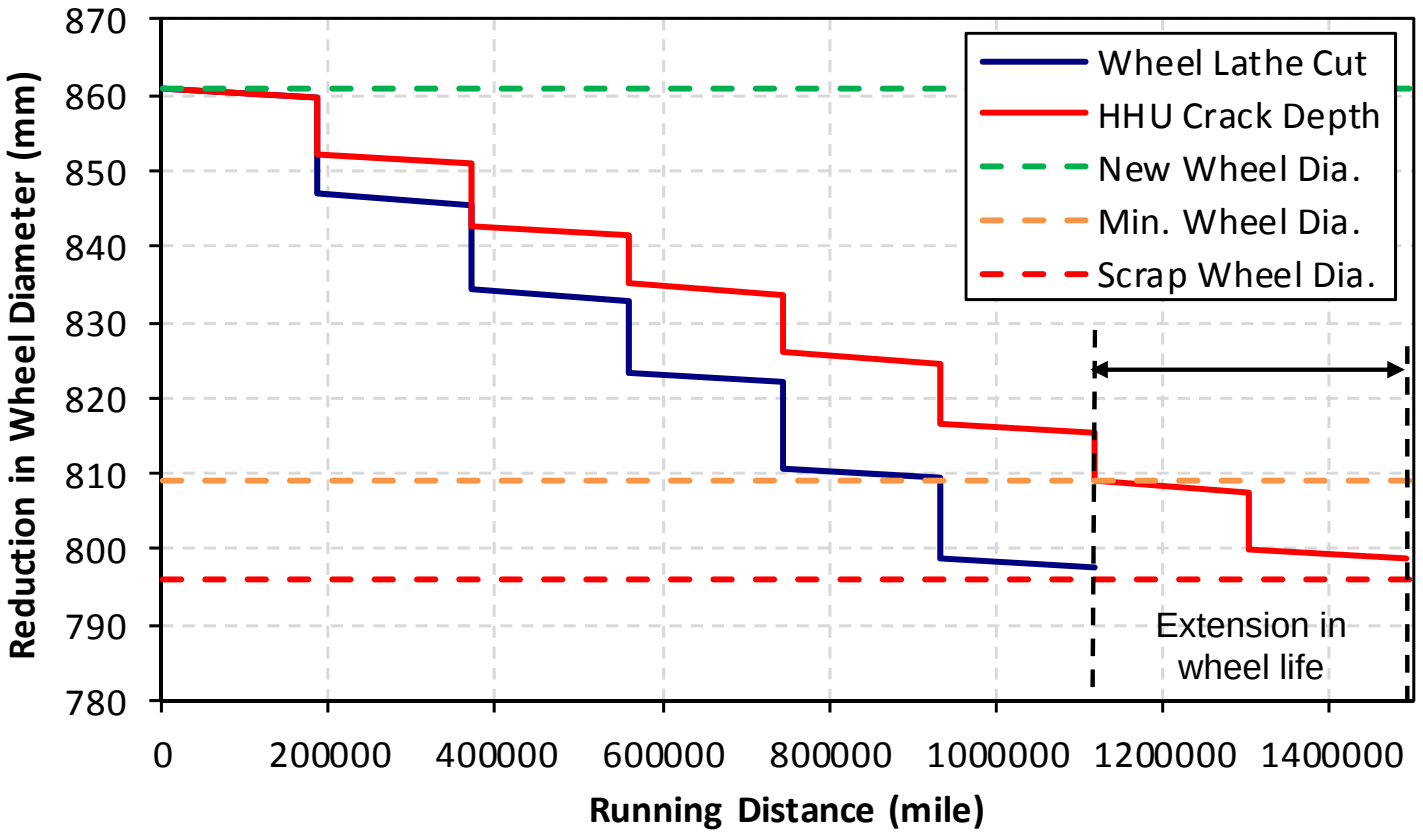
Case Study 1:

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 2additional turning activities (~370kmi) and potential saving in wheelset costs of ~25%



Maintenance Decisions

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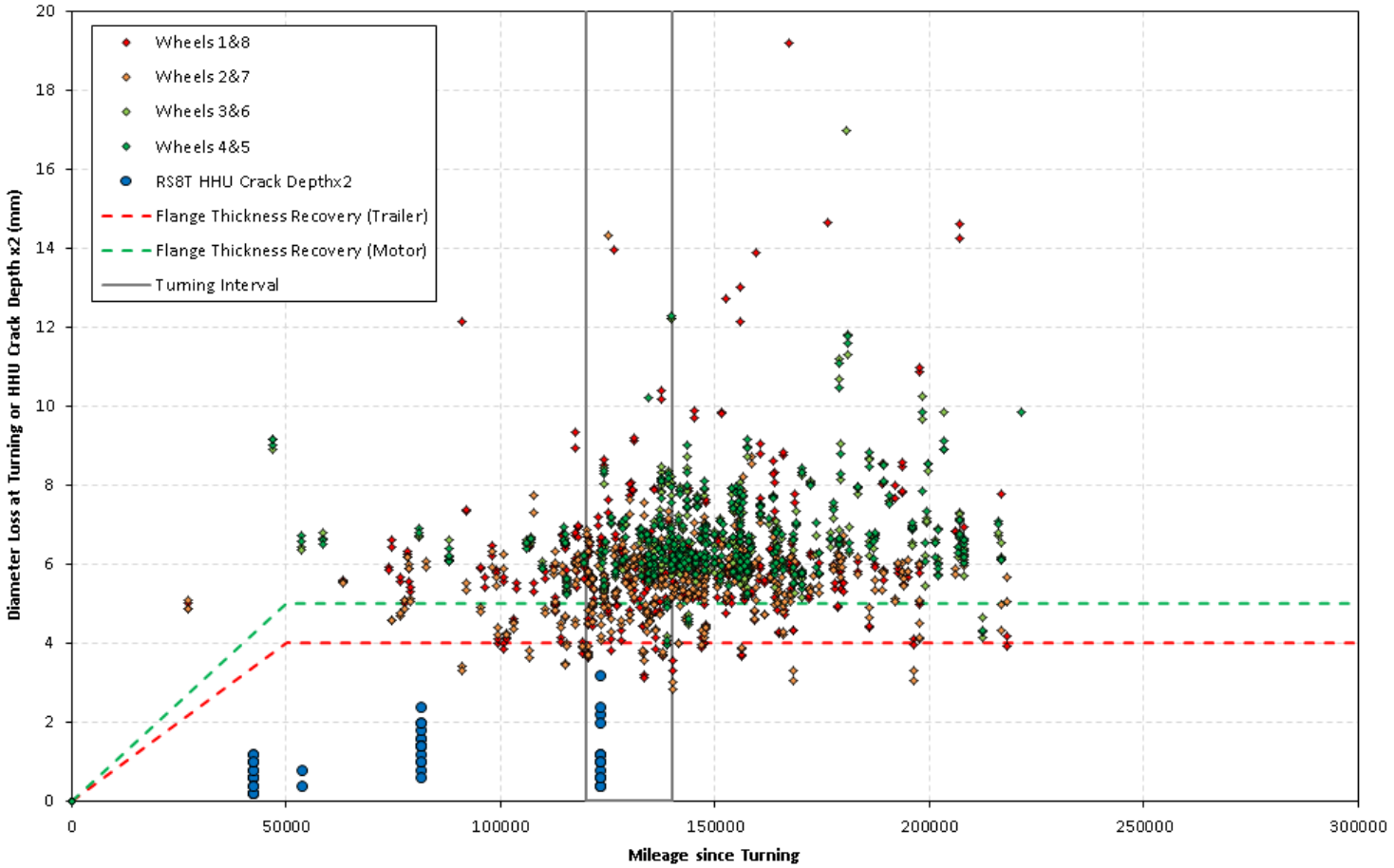
Case Study 2:

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

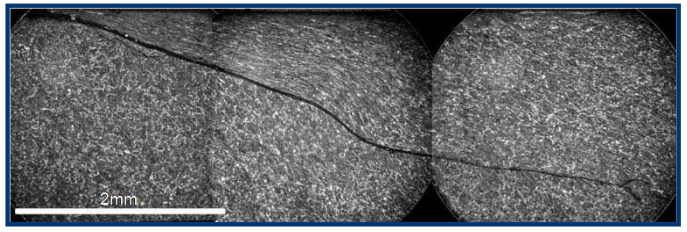
Maintenance Decisions

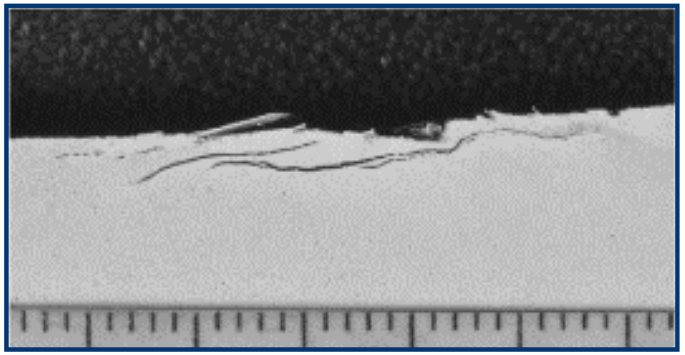
- Benefits of alternative wheel steel (RS8T) quantified in short timeframe using more repeatable HHU data
- Decisions whether to apply to the entire fleet can be made sooner ~ greater savings in costs during franchise



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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