Summary of ICRI Workshop in Tokyo, Japan, September 23, 2025 during CM2025

The one-day ICRI workshop was deemed a success, attended in-person by 50 participants, from 25 different entities and 12 countries (Australia, Austria, Brazil, Canada, China, Italy, Japan, Netherlands, Sweden, Turkey, United Kingdom, United States).

The workshop took place at Sophia University, in Tokyo, Japan, in conjunction with CM2025.

The workshop program is shown the table below. The various presentations will be available on the ICRI website downloads page.

start time	end time	Monday, September 22, 2025	Presenter(s)
9:00	9:10	**Welcome and workshop outline**	Richard Stock (Plasser)
9:10	9:30	Investigation of white and brown etching layers on wheel surfaces generated using laser technology	Klaus Six (Virtual Vehicle)
9:30	9:40	*Q&A*	
9:40	10:00	Post-grinding surface integrity across rail grades: Effects of stone topograpy	Lucas Biazon Cavalcanti (University of Sheffield)
10:00	10:10	*Q&A*	
10:10	10:25	**Coffee break**	
10:25	10:45	Squat-type defects in light rail: Experiences in field inspections, laboratory tests, and maintenance approaches	Mark Reimer (Sahaya Consulting)
10:45	10:55	*Q&A*	
10:55	11:25	**Workshop on WEL and Squats/Studs**	**Chaired by Richard Stock (Plasser) and Eric Magel (EM-WRI Consulting)**
11:25	12:45	**Lunch break**	
12:45	13:05	Exploring the use of surface wave Ultrasonic measurements for near-surface Rolling Contact Fatigue depth characterization	Kevin Oldknow (Simon Fraser University)
13:05	13:15	*Q&A*	
13:15	13:45	**Workshop on Measurement Technology / EM**	**Chaired by Ankur Ashtekar (Loram)**
13:45	14:00	**Coffee break**	
14:00	14:20	Development of rail grinding strategies for noise control	Briony Croft (Acoustic Studio)
14:20	14:30	*Q&A*	
14:30	14:45	ICRI Project Update - Contact Benchmark (15 min)	Edwin Vollebregt (Vtech CMCC)
14:45	14:55	ICRI Project Update - Broken Rails (10 min)	Eric Magel (EM-WRI Consulting)
14:55	15:10	ICRI Project Update - Magic Wear Rate (15 min)	Saeed Nia (NRC) Jonathan Leung (KTH)
15:10	15:20	ICRI Project Update - Cost Action (10 min)	David Fletcher (University of Sheffield)
15:20	15:30	*Q&A / Discussion*	Richard Stock (Plasser) and Sylvie Chenier (NRC)
15:30	16:00	**Wrap Up**	

Presentations and Discussions

1. Investigation of white and brown etching layers on wheel surfaces generated using laser technology

The first presentation of the day, involving generating White Etching Layers (WELs) and Brown Etching Layers (BELs) using laser technology was presented by Klaus Six. Klaus explained how the WELs and BELs were produced using laser technology and how results from hardness, microscopy, and EBSD showed that they are comparable to what can be found in the field. Overall, they found that Laser methods and twin disc testing are a good method to study development of certain damage patterns. Of course the challenge of result scaling persists.

The presentation sparked lots of discussion, identified several complimentary research projects and collaboration opportunities:

- Further investigation of stress patterns between WELs and BELs is recommended. Anders Ekberg (Chalmers University of Technology) has conducted relevant simulations and testing between WEL and BEL which could be a great discussion.
- Cracking in WELs specifically has been studied by Roger Lewis (University of Sheffield), offering another discussion point.
- Ongoing thesis work at Sheffield using arc exposure techniques to create the defects may also compliment this research.
- Increasing creepage may influence results, though this was not explored in the current study.
- The current study focused on the wheel side, but the investigation could be extended to include the rail side to gain a more comprehensive understanding.

2. Post-grinding surface integrity across rail grades: Effects of stone topography

Next Lucas Biazon presented research results from an investigation on the effects of grinding stone topography (sharp, worn, dull) on rail surface integrity, with a focus on the formation of WEL. Some key take-aways are that:

- Grinding stones can produce varying surface facets, burns, and WEL patches.
- For standard grade-grade rail, WEL is typically worn off after grinding but in premium-grade rail, WEL is more likely to remain and if subsequent cracks are not removed with timely grinding, they can cause issues.
- Stone Condition Effects:
    - Sharp stone produce worn surfaces with high surface roughness and large WEL present.
    - Worn stones produce a more intermediate condition, with shallow WEL patches that are usually worn away thereafter.
    - Dull stones produce large burn marks, a polished finish, with the largest WEL patches.
    - During the discussion, it was mentioned that worn condition accounts for ~95% of operational time.
- Future research could focus on simulations using existing stone topography/heat partition models and there are plans to investigate the effects on sections of used rails next.

3. Squat-type defects in light rail: Experiences in field inspections, laboratory tests, and maintenance approaches

In the third presentation Mark Reimer focused on experience investigating squat-type defects in light rail systems, with a particular focus on detection challenges and preventative maintenance strategies.

- Similar to previous findings, WELs do not wear away / wear away slow in premium-grade rails, potentially contributing to the defects.
- Ongoing efforts are being made to determine how to detect stud initiation in order to apply preventative maintenance, but so far, once various measurement technologies picked up and map the defects, it's past the point of prevention:
    - UT could be used to map out where the studs exist but not as much for severity
    - Corrugation measurement devices and EC devices might find the defects sometimes but at this stage defects already too far gone to do preventative maintenance.
    - Accelerometers/on board monitoring would be difficult to get precision location. By the time they show, they are too big.
    - Others working on this issue also confirmed that we do not know where the crack initiates.
- After significant metal removal (milling), and short-cycle grinding strategies, the defects have not reappeared.

4. Workshop on WEL and Squats/Studs

The third presentation and subsequent discussion played right into the workshop on WEL and Squats/Studs. This topic had been previously identified as an ICRI topic of interest at the 2024 ICRI Workshop held in Vienna Austria, with a follow-up web meeting held in February 2025.

During the workshop, many questions arose, including whether there is any fundamental difference between squats and studs.

Examples of questions that arose, including some proposed by the discussion facilitators follow:

- Are the distinctions expressed by Grassie that distinguish squats from studs generally agreeable?
- Do inclusions in steel contribute to squat/stud formation?
- Is there evidence that friction management (e.g. friction enhancement or friction modifier application) can reduce squat/stud formation?

<u>Detection</u>

- Are there ways to detect and quantify martensite in situ?
- Is there any effective way of monitoring wheel slip that contributes to martensite formation?
- Is there a means to identify incipient squats and studs, so that they may be preventively maintained? Note: ideally this means detection before they reach a depth of about 0.2 mm/
- Is anyone having success in mapping studs/squats in situ using eddy current or any other technology?

Modelling

- Studs and squats are known to be associated with a v-shaped crack. Is the initiation of such a crack amenable to modelling? Has it already been done? Note that in the case of studs the v-crack can sometimes point to field and sometimes to gauge.
- How deep or extensive must martensite be so that there is high risk of developing a crack that propagates into the parent material instead of stopping at the interface or simply wearing away?
- Are the factors associated with martensite formation already known and understood for precipitating a squat type crack?
- Is there a relationship between corrugation and stud formation? Is corrugated rail more likely to develop studs?
- Can steering forces cause sufficient creep to form martensite?

Maintenance

- Is there any "best practice" for dealing with studs and squats?
- Is there any evidence that rough-grinding precipitates studs or squats?
- Is there evidence that softer rail steels, all other conditions being equal, are less prone to stud formation? And if so, how does one trade off the greater propensity of soft steels for plastic flow, RCF, and corrugation?
- In the case of studs: if they do not cause broken rails is there an (economic) argument for leaving them in track?
- Are reliable repair procedures available?

Proposed literature and current research initiatives discussed:

- **Paper comparing the growth patterns vs. location of squats: (**http://dx.doi.org/10.1016/j.engfracmech.2025.111322) Ex. squats at the corner of the rail tend to extend downwards into the rail slowly; but a crack at the TOR grows perpendicular to surface, quickly.
- Another paper by Robin Andersson discussing simulations on the effect of WEL in https://doi.org/10.1016/j.ijfatigue.2018.05.023 is also available
- In partnership with Network Rail, the University of Sheffield is leveraging five years of track video footage to study the development of squat/stud-type defects. The project focuses on tracing affected rail sections back to their earliest visible signs of defect initiation.

An action was agreed on that the ICRI would host an online 2-hour workshop focused around this, to try to decide on a common understanding/definition.

5. Exploring the use of surface wave ultrasonic measurements for near-surface Rolling Contact Fatigue depth characterization

Next Kevin Oldknow presented work from his PhD student on a promising new method to measure crack depths using surface wave ultrasonics. This measurement does not give the exact location of the crack but would give a more accurate depth measurement. The technology and research is still in an early stage.

6. Workshop on Measurement Technology / EM

Kevin's presentation fed nicely into the next workshop on the use of Electromagnetic Measurement Technology to classify damages. This topic had also been identified as an ICRI topic of interest at the 2024 ICRI Workshop held in Vienna, Austria, with a follow-up web meeting held in February 2025. Ankur presented some of the current technologies being used by or available to railways along with some known limitations. Some of the key discussion points included:

- All of these technologies are not native to rails, we are trying to take another application and use it for rails.
- We have all these technologies but we don't have a good understanding – which ones are good for which defects, calibration, accuracy, reliability, repeatability, what are their limitations.
- Some specific technology discussion points:
    - MxV has been using and evaluating EMFI, and have done head to head testing with other systems. Many results have been published on MxV's Technology Digest: https://www.mxvrail.com/technology-digest/. Some examples are:
        - TD23-004: Evaluating Electromagnetic Field Imaging for Use in RCF Crack Depth Analysis - MxV Rail
        - TD21-012: Validation of In-Motion ECHO-Rail System for RCD Crack Depth Measurement
        - TD18-016: Measuring Rolling Contact Damage in Rails Using EMFI
        - TD14-007: Evaluation of an Eddy Current System for RCF Measurements - MxV Rail
    - New technologies:
        - Magnetic Barkhausen – new and used in different industries where they're looking at WEL.
        - Measurement Solutions using surface wave ultrasonics
- In some cases crack location is of less importance compared to accurate crack depth. Other cases might focus on defect classification with exact depth being of secondary importance.
- A workshop to compare technologies where the suppliers would bring their equipment was proposed. The group would need to discuss and define requirements – defining test, what data we would expect, etc. Would want sample rails with squats and martensite, some with RCF. **The action of hosting an online workshop to discuss these requirements further was taken.**

7. Development of Rail Grinding Strategies for Noise Control

Briony gave an overview of a rail grinding strategies for noise control and an example of how it was successfully applied to a light rail system in North America. Currently there is no set standard that the industry can use, so ISO 3095 is often used, but a standard for noise control after grinding might be something that could be useful to the industry.

8. ICRI Project Updates

Four project updates were given:

1. ICRI Project Update - Contact Benchmark: Follow-up action to host an online meeting to identify the applications of interest to members and compile a corresponding list of relevant models.
2. ICRI Project Update - Broken Rails: We are seeking a lead for this initiative; please let us know if you are interested in taking on this role.
3. ICRI Project Update - Magic Wear Rate: Latest project updates were presented from KTH and NRC.
4. ICRI Project Update - Cost Action: The proposal will be submitted in October and stay tuned for updates on whether we are successful in receiving the funding.

9. Wrap up and next steps

The final ICRI project updates ran long and there was not enough time left for a proper wrap up but several topic follow-up actions were identified throughout the workshop:

1. **The ICRI will host an online 2-hour workshop focused around WEL and Squats/Studs, to try to decide on a common understanding/definition and discuss next steps.**
2. **The ICRI will host an online workshop to discuss the requirements (test, what data we would expect, etc.) in hosting an in-person technology comparison workshop where suppliers of EM/similar measurement technologies would bring their equipment.**