# ICRI 2019 Workshop

## International Collaborative Research Initiative on RCF and Wear of Wheels and Rail

**VANCOUVER, BC, CANADA**
**JULY 23—25, 2019**

**Brief Summary Notes**

**www.icri-rcf.org**

# Agenda

**Note:** The complete presentations will be available at http://www.icri-rcf.org/downloads/

| start | end | Tuesday, Jul 23 | Wednesday, Jul 24 | Thursday, Jul 25 |
|---|---|---|---|---|
| 8:00 | | | | |
| 8:15 | 8:35 | Welcome and workshop outline<br>***Eric Magel*** | **Paul Gies**, Athena Industrial Services<br>*Detection & measurement of rolling contact fatigue with electro-magnetic field imaging* | **Harold Harrison**<br>*Producing and Measuring the 3rd Body Layer* |
| 8:35 | 9:20 | **Maksym Spriyagin**, CQU<br>*Locomotive traction and its effect on rail wear: methodology, measurements and simulations* | **Deborah DeGrasse**, Transport Canada<br>*Transport Canada's Approach and Research following the Railway Safety Review*<br>**Ali Tajaddini**, FRA<br>*FRA Research plans and priorities* | **Kyle Mulligan**, CP Rail<br>*The effects of wheel shelling on Canadian freight railways and risk mitigation strategies* |
| 9:20 | 9:40 | discussion/followup *(Eric Magel)* | discussion/followup *(Bob Tuzik)* | discussion/followup *(Richard Stock)* |
| 9:40 | 10:10 | coffee break - sponsored by Linsinger | coffee break - sponsored by Whitmore | coffee break |
| 10:10 | 10:40 | **Gerald Trummer**, Virtual Vehicle<br>*Modeling adhesion, carry-down and consumption of friction modifiers in the wheel-rail interface* | **Brad Kerchof**, Norfolk Southern Railway<br>*RCF damage on curve rails* | **Sean Regehr**, Advanced Rail Management<br>*Quality indices for rail grinding* |
| 10:40 | 11:10 | **Davey Mitchell**, LBFoster<br>*Noise Mitigation using Friction Modifiers on Narrow Running Bands* | **Richard Stock**, Linsinger<br>*Rail milling in North American context – opportunities and applications* | **Taking action: wrap up discussion**<br>*(Eric Magel and Kevin Oldknow)* |
| 11:10 | 11:30 | discussion/followup *(Briony Croft)* | discussion/followup *(Louisa Stanlake)* | |
| 11:30 | 13:00 | break for lunch | | |
| 13:00 | 13:30 | **Alok Jahagirdar**, NRC Canada<br>*Quantifying rail surface damage* | **Ben White**, Sheffield University<br>*Assessing the economic costs and benefits of friction management products* | **Optional Technical Tours**<br><br>Tour 1: BCRTC (Skytrain) Operations and Maintenance Center<br><br>Tour 2: LBFoster's Friction Management Research and Manufacturing Center |
| 13:30 | 14:00 | **Alfredo Gay Neto,** University of Sao Paulo<br>*Wheel-rail modeling efforts and needs in Brazil* | **Wesley Thomas**, Sentient Sciences<br>*The ICRI's VTI Economics Model* | |
| 14:00 | 14:20 | discussion/followup *(Mark Reimer)* | discussion/followup *(Gary Wolfe)* | |
| 14:20 | 14:50 | coffee break - sponsored by WRS2020 | coffee break - sponsored by NRC Canada | |
| 14:50 | 15:35 | **Chris Bosomworth**, CQU<br>*Approach for the prediction of rail heat transfer under heavy haul train operation scenario: experiment vs simulation* | **Eric Magel**, NRC Canada<br>*Quantifying Risk* | |
| 15:35 | 16:00 | discussion/followup *(Sheldon Green)* | discussion/followup *(Charles Franz)* | |

| | | | |
|---|---|---|---|
| 16:30 | 19:00 | **Buffet Dinner**<br>*Grouse Mountain* | **WRI 2020 sponsored reception**<br>*Top of Vancouver Restaurant* |
| | 22:30 | | |

# Conference Presentations

## Day 1 – Tuesday, July 23rd

**Eric Magel – NRC Canada**
*Welcome and workshop outline*

- ICRI-RCF brings together interested parties to work on topics of common interest
    - Participants contribute data, expertise, models, ideas, etc. from existing projects, and information is shared amongst all participants
    - Results in better/stronger deliverables, development of professional relationships, and more/stronger/collaborative publications
- **Membership:** 198 participants, 19 countries, 103 organizations + 13 independent consultants
- **5th annual ICRI-RCF workshop:** Istanbul, April 21–23, 2020 (tentative dates)

**Maksym Spriyagin – Central Queensland University**
*Locomotive traction and its effect on rail wear: methodology, measurements and simulations*

- **Project:** Using simulation and modelling to examine additional track maintenance efforts that may be required with the implementation of higher-traction locomotives on heavy haul routes
- **Conclusions:** The leading locomotive and remote locomotive have similar operational speeds and similar traction forces, but experience very different coupler forces
    - The T-gamma approach was insufficient to capture wear and RCF differences between the leading locomotive and remote locomotive. Other approaches were explored that better identified the differences.
- **Future research and needs:**
    - Further progression of the development of the friction scaling factor (i.e., extending small-scale test results to full-scale operations)
    - Improvements of simulation speed through parallel computing
    - Comparison of friction vs. slip curves from locomotive adhesion tests with results measured by a tribometer (esp. for cases modelling a variable friction coefficient)
    - More validations on track component forces and wear rates, taking into account Australian heavy haul track design and train operation experience
    - Determining the importance of the rail cleaning effect (early wheels in a train consist remove or modify the interfacial layer seen by subsequent wheels)

**Gerald Trummer – Virtual Vehicle**
*Modelling adhesion, carry-down and consumption of friction modifiers in the wheel-rail interface*

- **Project:** Produce a model for predicting the adhesion characteristic, dependent on TOR production/amount of application, position on the track, and the number of wheel passes
- **Purpose:** Models could be applied to choose the right location for application devices, and/or to choose the right type/amount of material dependent on the scenario of interest
- **Further research:** Further validation of models with field data; considering variations of the lateral position of contact patches
- **ICRI members can help by:** Providing field data for product carry down, lateral force improvements, etc. to help verify models; comparison runs against other models

**Davey Mitchell – LB Foster**

*Noise mitigation using friction modifiers on narrow running bands*

- Currently facing the issue of how to maintain ride quality while improving friction modifier carry down to address noise
    - Top of rail friction modifiers help with corrugation and noise → 'Peaked rail' helps with corrugation and ride quality → Resulting narrow contact band of 'peaked rail' inhibits friction modifier carry down
- **Further research:** Two main questions…
    - How far are friction modifiers carrying at different locations/under what conditions?
    - What are the major factors that determine carry distance?

**Alok Jahagirdar – NRC Canada**

*Quantifying rail surface damage*

- **Project:** Testing the use of the eddy current probe as a non-destructive way to measure crack lengths in rail with RCF
- Currently comparing the results of destructive metallography to eddy current probe results.
    - For 1° curves, the true depth of cracks was underestimated by ~50% compared to metallurgical sectioning
- **Conclusions:** Eddy current can be used to measure RCF, but there are several challenges and multiple factors have to be taken into account (readings change depending on settings and operator; errors are compounded with increasing crack length, etc.)
- **Further research:**
    - Determine the effect of crack width and branching on eddy current readings (do they have a large impact?)
    - More data needs to be collected to fill the RCF matrix (a table of results for different steel types, curvatures, accumulated tonnage, etc.)
    - Further comparisons between metallography and eddy current results, to determine whether eddy current results can be scaled up by a constant amount

**Alfredo Gay Neto – University of São Paulo**

*Wheel-rail modelling efforts and needs in Brazil*

- Vale heavy haul railways suffer from excessive wear and RCF of rail and wheels
- The wheel-rail chair initiative aims to create local knowledge on WRI, and provide a direct interaction between Vale technical teams and research groups at Brazilian universities
- **Current work:**
    - Developing wheel-rail contact mechanics models through 3D computer modelling/ simulation in GIRAFFE, and application of the master-master contact model
        - Obtain the location of contact points and normal contact forces
    - Developing a wear numerical model for a pair of discs under rolling contact and various kinematic conditions
- **Next steps for the wheel-chair initiative:**
    - Improve material knowledge of wheels, rails, switches and other important railway parts
    - Improve predictive modelling of aspects related to geometry, loads and materials (e.g., geometric profiles of wheels/rails, dynamic models, maintenance)

**Chris Bosomworth – Central Queensland University**

*Approach for the prediction of rail heat transfer under heavy haul operation scenarios: experiment vs. simulation*

- **Project:** Readying industry for the implementation of new technologies in broken rail detection.
  - E.g., infrared imaging for detecting temperature changes at rail foot flaws, laser induced ultrasonic guided wave techniques for rail foot flaw detection
  - Despite significant technological advancements, rail foot flaws resulting in breakages of rails still occur and can lead to train derailments
- **Conclusions:** Project demonstrates why a full train simulation approach is required when thinking about rail heat transfer (as opposed to just a single or few vehicles)
- **Current work:** Refinement/validation of rail heat transfer model against recorded track data

# Day 2 – Wednesday, July 24th

**Paul Gies – Athena Industrial Services**

*Detection and measurement of rolling contact fatigue with electro-magnetic field imaging*

- **Problem:** Data from inspection vehicles acquired prior to grinding can be highly subjective and qualitative; need quantitative data that can be used for predictive maintenance programs
  - Athena has developed a rail shaped sensor (RSS), based on revolutionary shaped electromagnetic field imaging technology (EMFI).
- **Conclusions:**
  - EMFI had good results at inspection speeds to 20 mph (32 kph)
  - Defect detection rate very high, RCF severity measurement consistent for all speeds.
  - EMFI technology is a good candidate for continuous testing
- **Current research:**
  - Wheel scanning using EMFI technology for detection of cracked and damaged wheels (working with Class I railway)
  - Development of shaped sensors using EMF shape measuring tools
- **Further research:** Additional validation studies for hardware/software refinement

**Deborah DeGrasse – Transport Canada**

*Transport Canada's approach and research following the Rail Safety Review*

- Advancing a 3-year Rail Work Plan with 25 research projects that are aligned with several federal government priorities
- **Key projects:**
  - Prioritization of promising technologies for rolling stock and track flaw inspections
  - Automated Train Brake Effectiveness (ATBE)
  - Factors that increase severity of outcomes for derailments involving dangerous goods
  - Evaluation of cognitive impacts of in-cab warning systems
  - Canadian Railway Research Laboratory Program (CaRRL)
  - Railway Ground Hazards Research Program (RGHRP)
  - Lignin-derived 'drop-in' renewable diesel fuels for rail applications
  - Hydrail standards development; freight electrification
- Collaborations with centres and organizations in the US, UK, and Australia

**Ali Tajaddini – Federal Railroad Administration**

*FRA research plans and priorities*

- FRA is conducting research in a large number of areas, including:
  - Human factors, train control and communications, rolling stock, track research, rail performance, predictive analytics, track stability, track inspection
- Vehicle and track performance research includes:
  - WRI research (RCFS – collaboration with TTCI; rolling load test machine scaled model; friction modelling; RCF and the wheel/rail profile)
  - Influence of track irregularity and surface conditions on vehicle dynamics
  - Improving modeling capabilities (e.g. modeling wheel/rail friction)
- **Broad Agency Announcement (BAA):** A vehicle utilized by the FRA for contracting R&D
  - $150 000 to $1 000 000 award for research proposals and concept papers
  - Announced via the Federal Business Opportunities website

**Brad Kerchof – Norfolk Southern Railway**

*RCF damage on rail curves*

- Presentation discussed three cases of gage-side RCF on the high rails of curves, their treatment with grinding (gage-side relief), and the results of the first grind cycle
- **Future work:** Next grind cycle to occur in August 2019
  - Determine the effectiveness of the 2nd grinding cycle by visual observation and measuring crack length with eddy current
  - Continue a corrective grinding program 2x per year
- **Questions for discussion:**
  - How important is it that we remove all of the cracks (to their full depth)?
  - Is our long-term plan – a combination or grinding and work hardening – reasonable?

**Richard Stock – Linsinger**

*Rail milling in North American context – opportunities and applications*

- **Advantages of milling:**
  - Highly applicable for transit systems (higher frequencies/longer operation times with more damage = less time for rail maintenance, efficient technology required)
  - Compared to grinding: spark-free process, no water or chemical additives required, clean tunnel environment, low noise process and complete corrugation removal; 100% removal of rail defects and 100% match to template (PQI = 100%)
- **Conclusions:** Milling is not grinding (fundamentally different technologies), however it has many advantages and would be useful as a complementary technology to grinding, or to treat hot spots (areas that cannot be controlled by grinding/cannot be ground)
  - Could be applied in fire sensitive areas (useful in the face of climate change and increased dry periods)
  - Question of milling as an addition vs. a substitution
- Future research/potential collaborations:
  - Measurement technology – adapting EC for NA requirements
    - Additional input data for ICRI project “Quantify Surface Fatigue”
  - Acoustic performance of milled versus ground surfaces
  - Application of milling to the freight environment

**Ben Whilte – Sheffield University**

*Assessing the economic costs and benefits of friction management products*

- **Current problems:** Friction management products (TOR vs. traction gel) do not have clear standards, users do not know how effective the products are, and confidence in products is generally decreasing across the UK
- **Project aims:** Analyze economic costs/benefits of friction management products → Gain evidence of performance → Generate benchmark test methods → Form part of product approvals/standards → Improve consumer confidence and supplier delivery
- **Future research:**
  - Create a cost/benefit analysis of friction management products
  - Develop a series of accessible test methods that can be used as a standard and both new and current products
  - Validate these tests using full-scale laboratory testing, field testing, and modelling
- **Data that is needed:** Information on any previous economic models, information on wear/ RCF reduction, cost savings when using friction management products

**Wesley Thomas – Sentient Sciences**

*The ICRI's VTI economics model*

- The ICRI VTI economics model is a decision-support tool for costs and benefits
  - Third-party "open source" model; data available from different departments/specialties
  - Can be used to find new savings and innovations, complete and protect important projects, and improve partnerships between the railroad and suppliers
- The model can help to answer the question of whether railroads should invest more in preventive maintenance (and if so, where and how much?)
- Since Feb. 2018, a number of track, wheel, and freight models have been created
- ICRI Economics Model beta test launched as online application in July 2019
  - Email wesleythomas@sentientscience.com for beta testing
- **Next steps:** add non-US factors to economics model, as well as other factors (e.g., fuel efficiency, fasteners, safety and rick management); use economic model for decisions (e.g., preventive grinding optimization, rail material, lubrication investments)

**Eric Magel – NRC Canada**

*An ICRI task: quantifying risk and safety*

- **Goal:** Provide a methodology for quantifying the risk reduction/safety improvements associated with new technology or process adoptions → Derive a monetary value
  - Possible processes/technologies to examine = TOR friction management, rail grinding to remove RCF, improved rail profiles and their management, monitoring of RFC using electromagnetic systems, better steel rails, a better welding process, optimizing super-elevation, lower or increase speed
- **Next steps:** Identify an appropriately sized project for the ICRI to tackle (relevant, within our capabilities/expertise, can expect to make substantial progress on within 3 years)
  - Looking for a small team of volunteers to support this (~2 hours)

# Day 3 – Thursday, July 25th

**Harold Harrison – OnTrak**

*Producing and measuring the 3rd body layer*

- Friction has been measured in the past using the BR tribometer train (instrumented wheelset – obsolete) and salient push tribometer
    - New approach = OnTrak HO tribometer
- **Future research:**
    - What is the saturation limit now? What could it be?
    - Should we be concerned with the shape of the creep curve?
    - How well does all of this follow the Archard Law?

**Kyle Mulligan – CP Rail**

*The effects of wheel shelling on Canadian freight railways and risk mitigation strategies*

- Wheel shelling is problematic within the Canadian Freight Industry, but decreasing
    - Wayside detection/advanced analytics have helped reduce the impact of shelling
- A bigger concern is broken wheels, which account for approx. 3 derailments per year on CP
- Automated train brake effectiveness – the use of hot wheel detectors to determine malfunctioning brakes, is an innovation that the industry should consider
- Considerations for long train makeup and DP placement also assist in mitigation

**Sean Regehr – Advanced Rail Management**

*Quality indices for managing rail through grinding*

- To gain the maximum benefit from rail grinding (an expensive and disruptive process), it is important to apply quality assurance processes
    - PQI (Profile Quality Index; aka., Grind Quality Index) is a commonly used measure, but it does not tell the whole story
    - Two rail profiles with the same PQI value can give strong differences in performance
    - Also developing the: Surface damage index (SDI) using eddy current and machine vision data; Rail corrugation index (RCI) results
- **Conclusions:**
    - PQI is a commonly used index that provides practical measures for rail grinding but gives little practical insight into suitability for performance; improved PQI required
    - New technologies = improved opportunities for meaningful quality indices
    - Combining the PQI with SDI and RCI into an Equivalent Grinding Index (EGI)
        - Not actually applied yet, but seems to be a reasonable approach
- **Future research:**
    - Regarding PQI – Are the current definitions appropriate and sufficient? Is using an average profile sufficient? How important is PQI? For example, is it worth spending money to improve 80% average to 90%?
    - Regarding EGI – Need to do trial calculations (currently, don't have high enough resolution on profile)