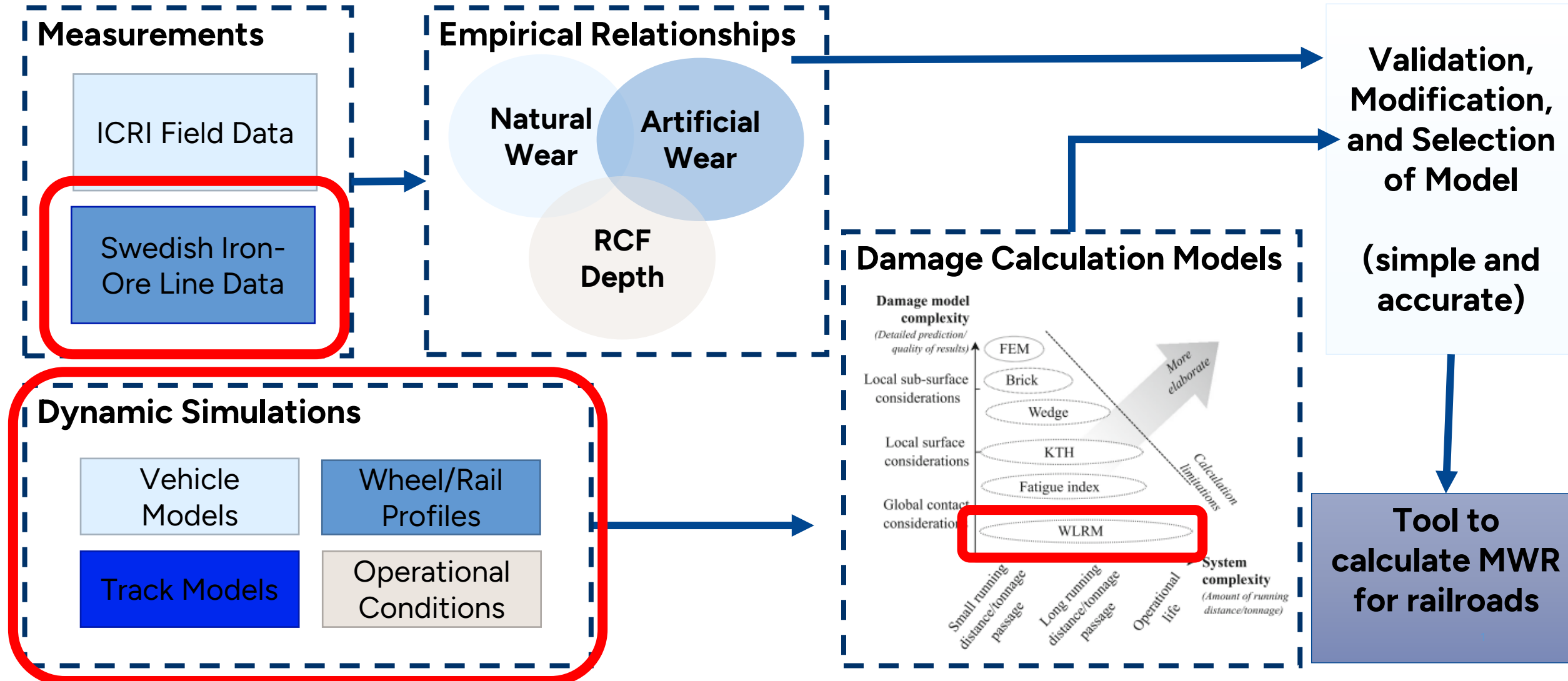


# ICRI Magic Wear Rate

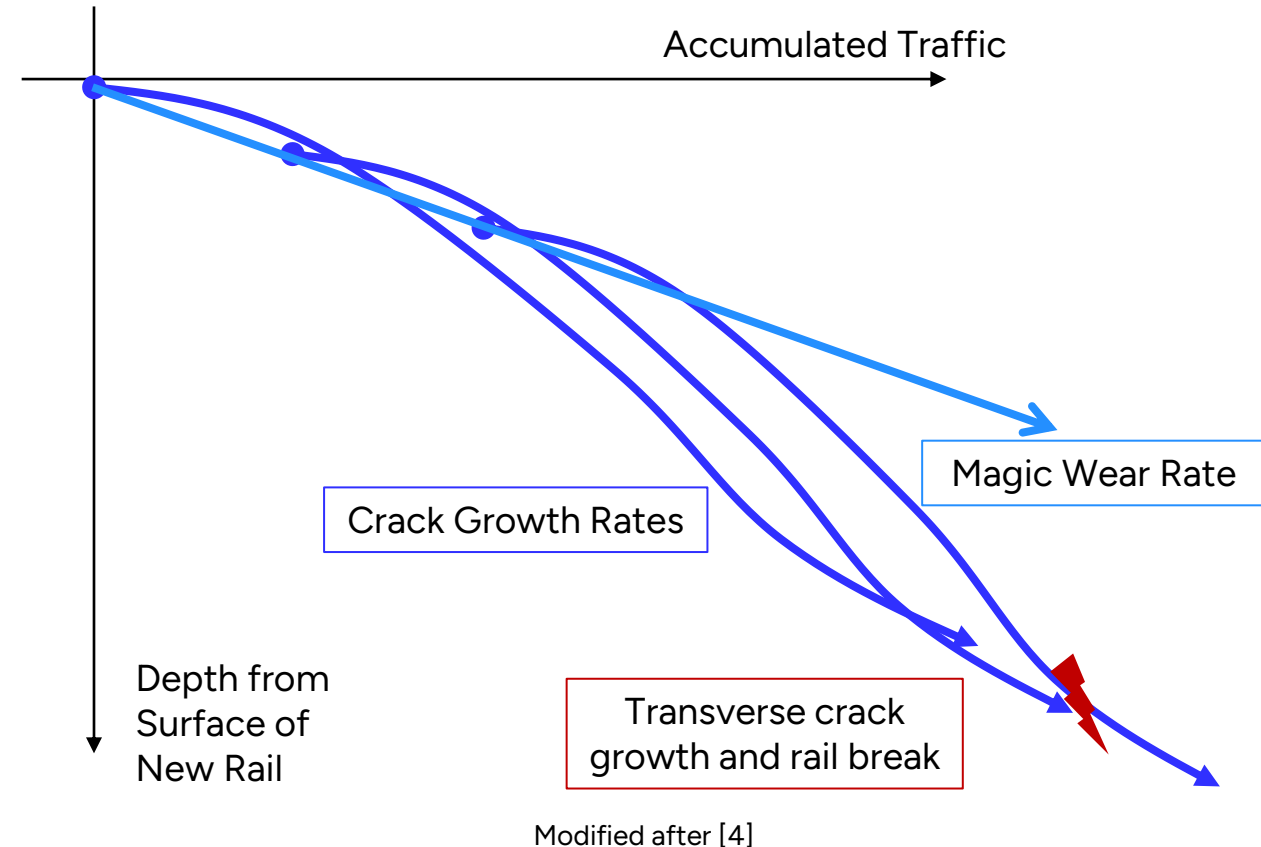


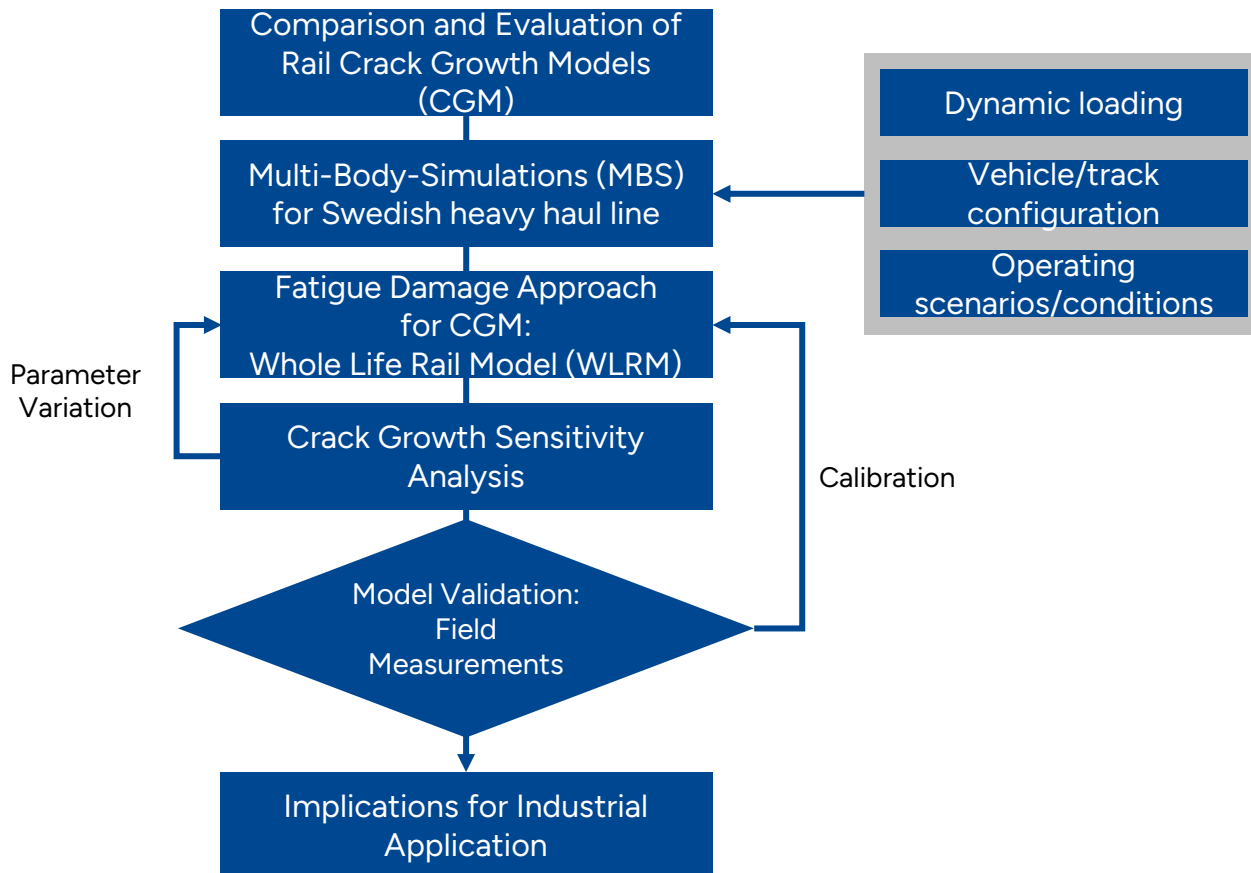
# KTH M.S. Thesis: Leon Steimle

## Magic Wear Rate: Crack Growth Rate Model for the Swedish heavy haul line

### Research Questions

1. How to accurately estimate RCF crack growth rates considering dynamic loading, different vehicle-track configurations, and operating conditions?
2. How can CGMs be effectively integrated into existing predictive maintenance frameworks?

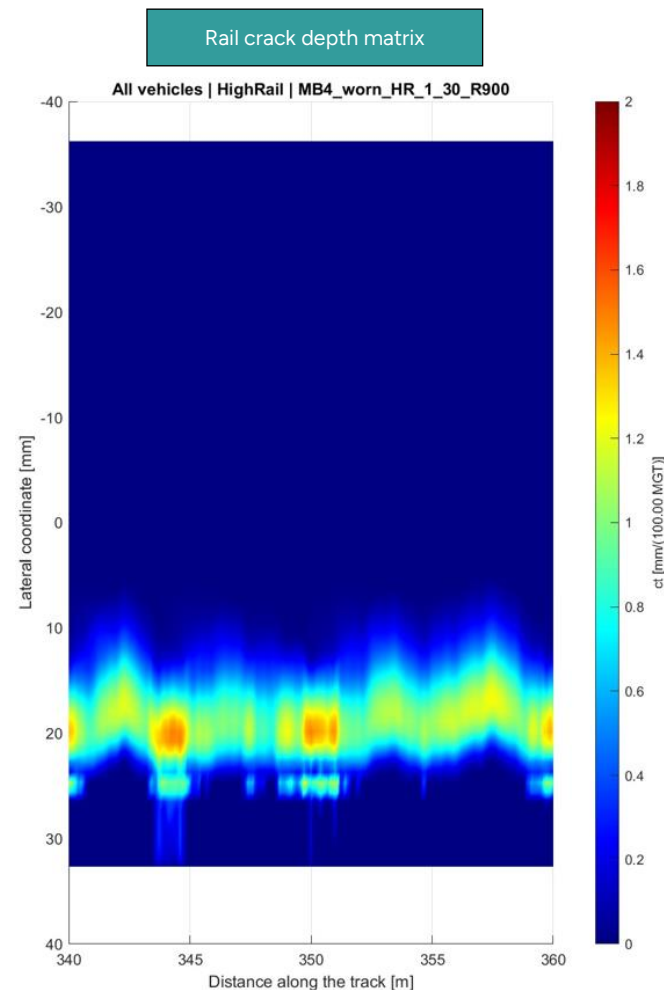
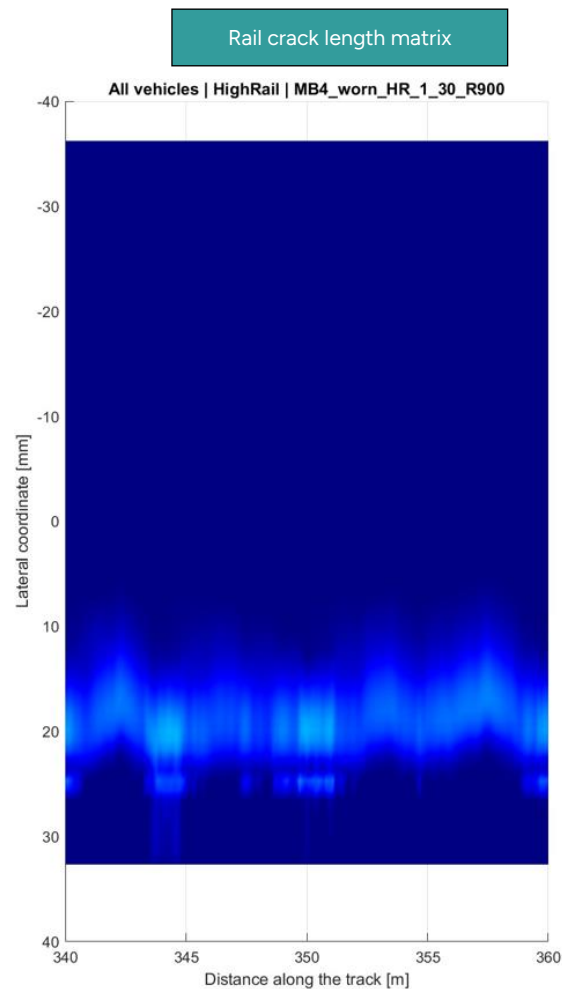
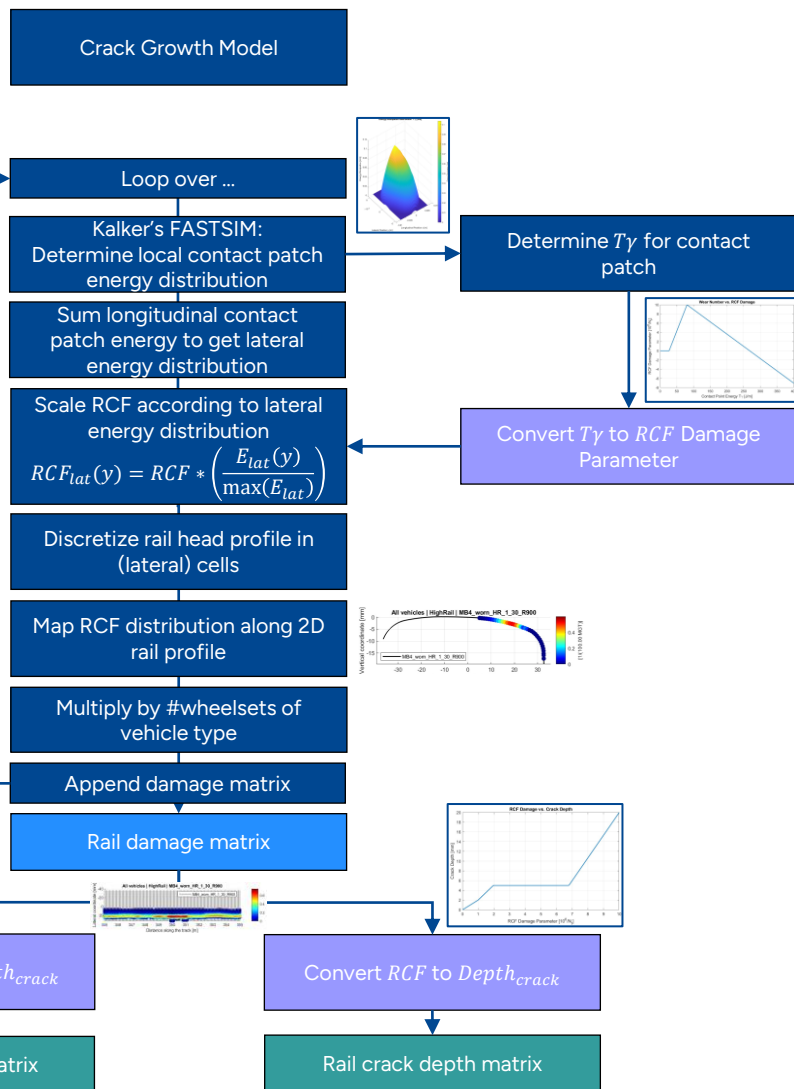




The Whole Life Rail Model (WLRM) is used to estimate the crack growth rates for the Swedish Haul Line

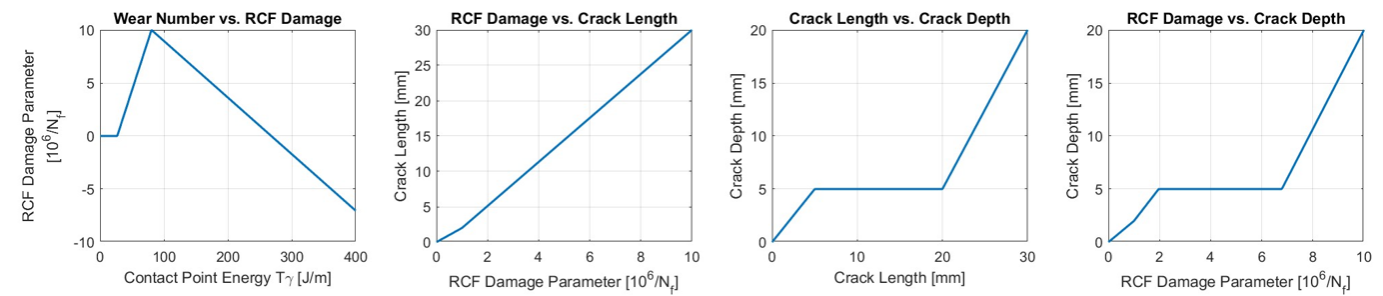
### Completed Tasks

- **Sensitivity Study** on the influence of the WLRM model parameters on the estimated crack growth rates
- **Calibration of WLRM parameters** with measured crack depth data from the Swedish Heavy Haul Line
- **Computational framework** to simulate RCF and the necessary types of parametric studies needed to have a system specific crack growth rate

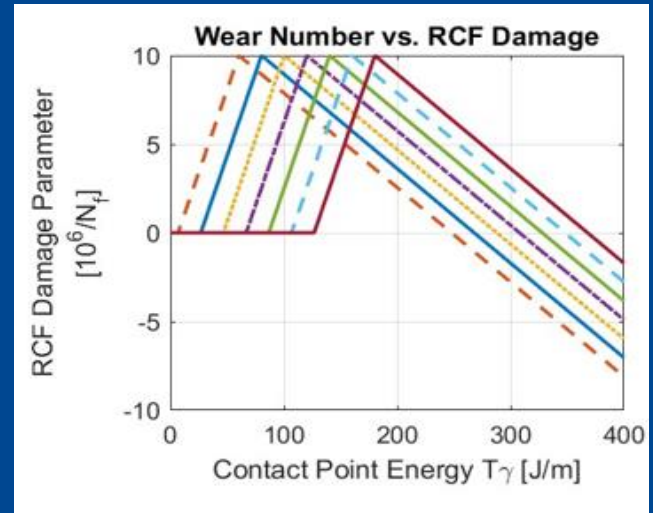




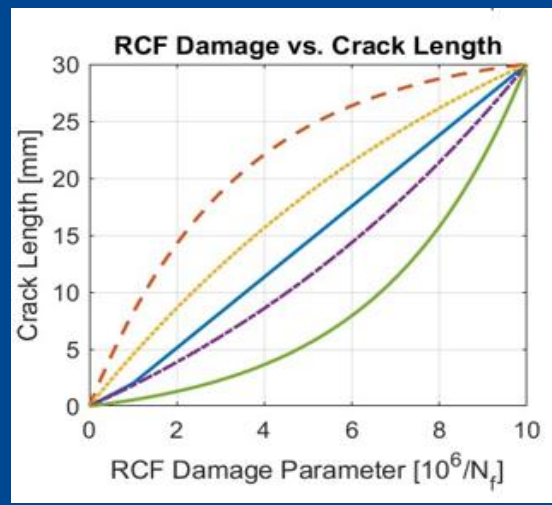
# Sensitivity Analysis



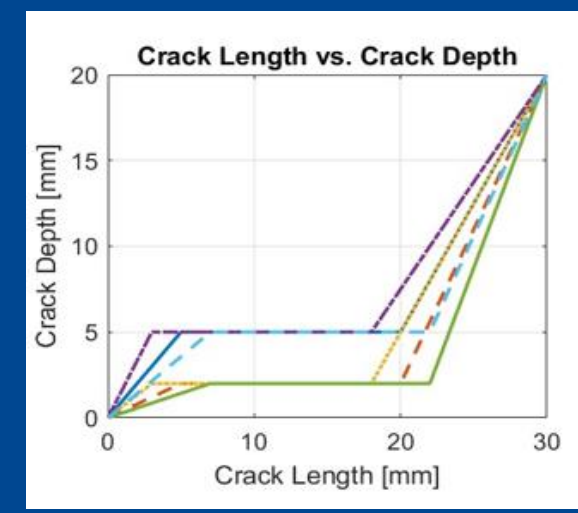
## Case 1



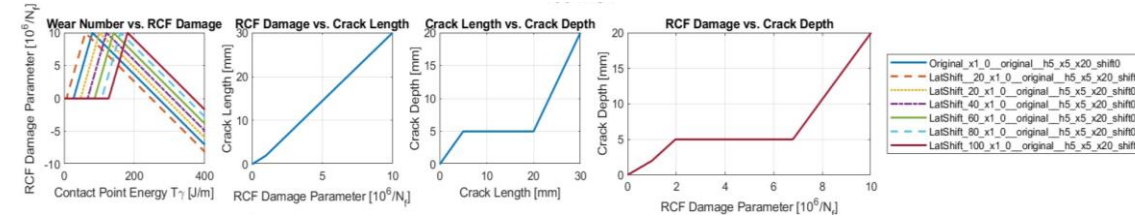
## Case 2



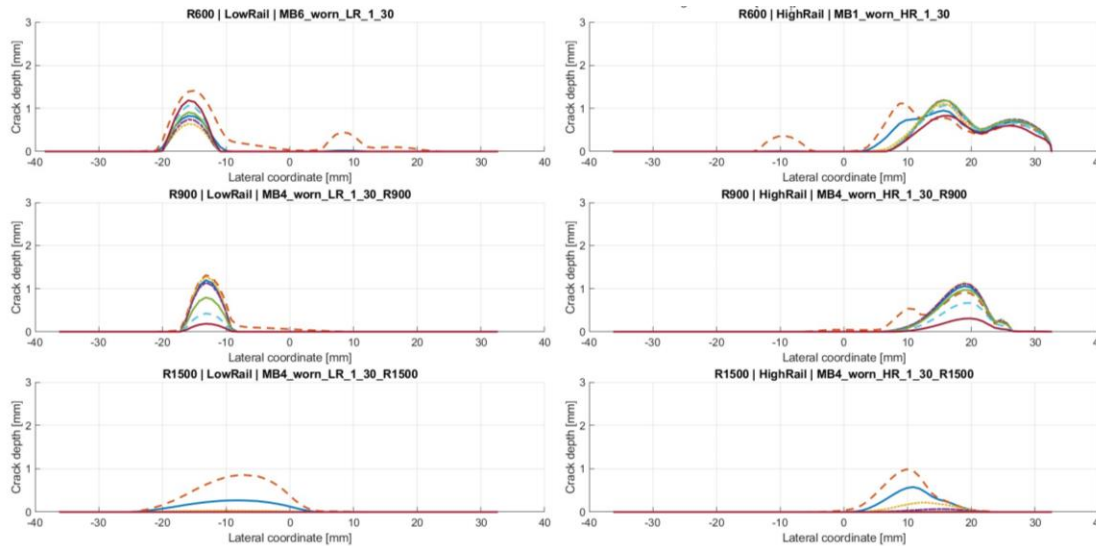
## Case 3



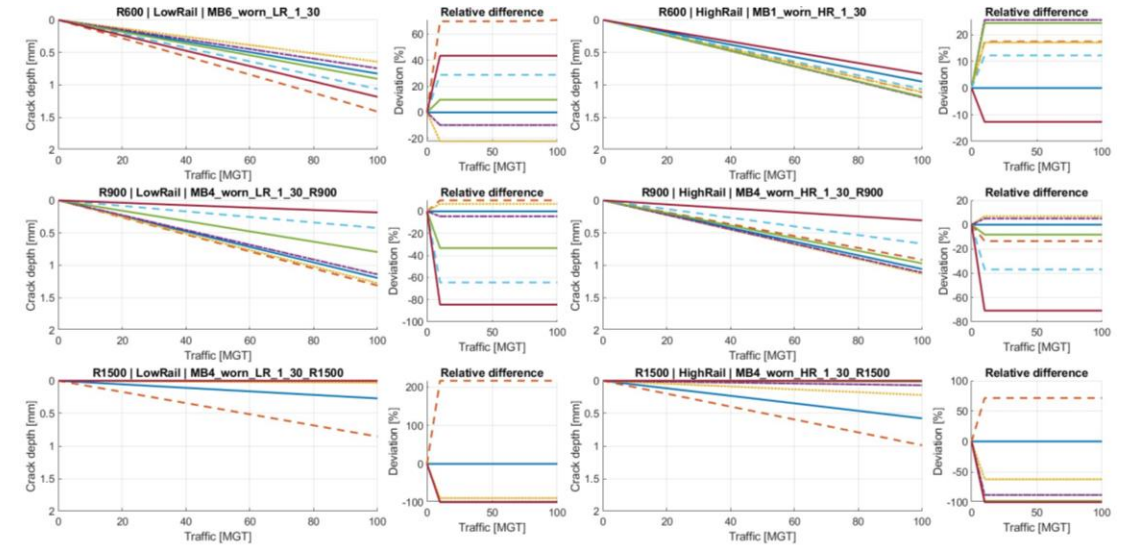
# Sensitivity Analysis – Case 1



## Crack Depths @ 100 MGT



## Crack Growth Rate



### Key findings:

- Shifting the curves influences the damage location.

### Key findings:

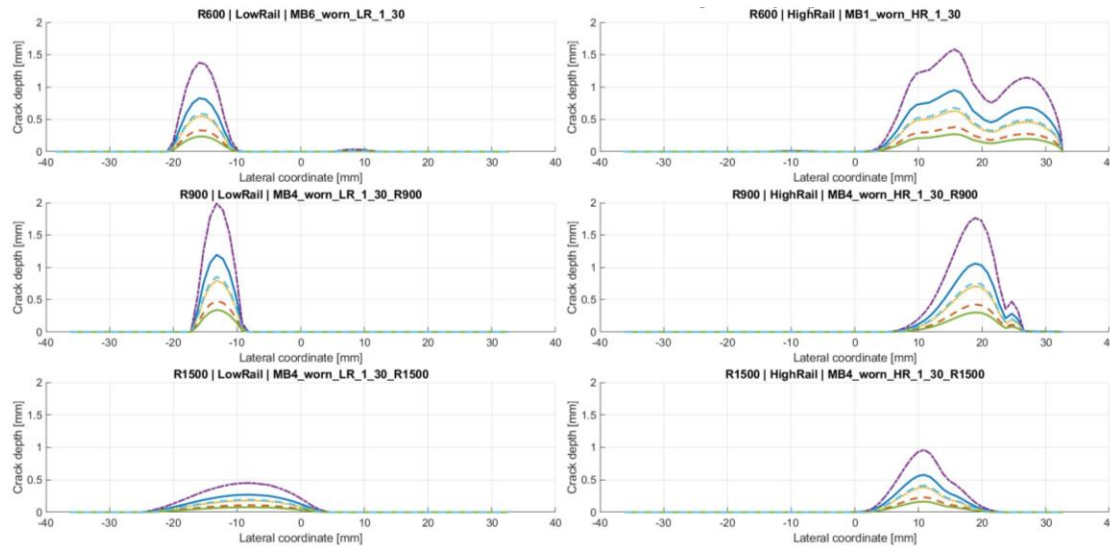
- Contact point energy band determines crack growth rate.
  - Shifting curve to right: higher energy causes RCF
  - Shifting curve to left: lower energy causes RCF
- Lower contact point energies lead to increased crack growth rates in wider curves.



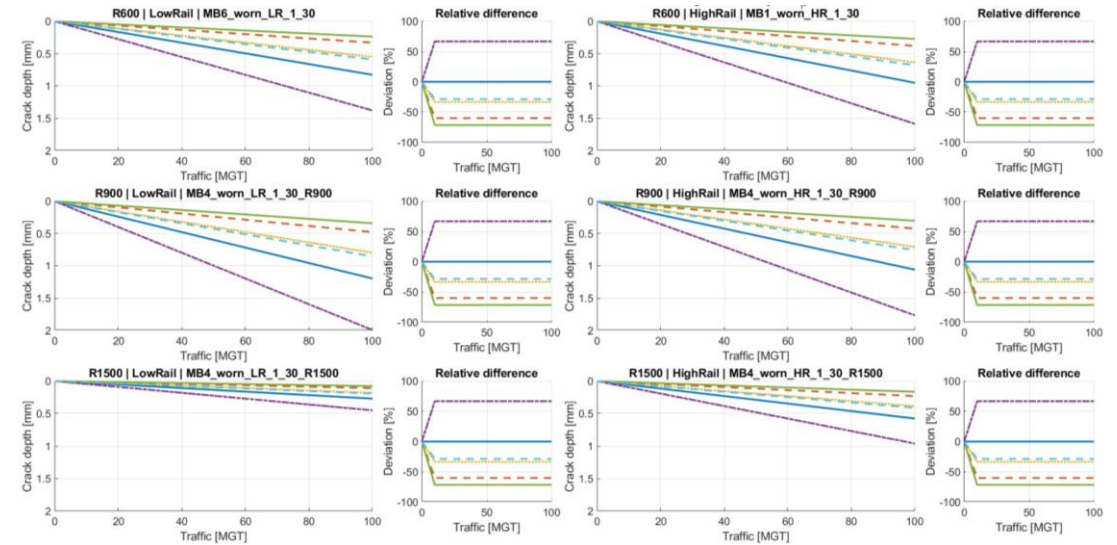


# Sensitivity Analysis – Case 3

## Crack Depths @ 100 MGT



## Crack Growth Rate



### Key findings:

- Consistent damage location and similar crack growth behavior ...
  - for low and high rail.
  - for different curve radii.

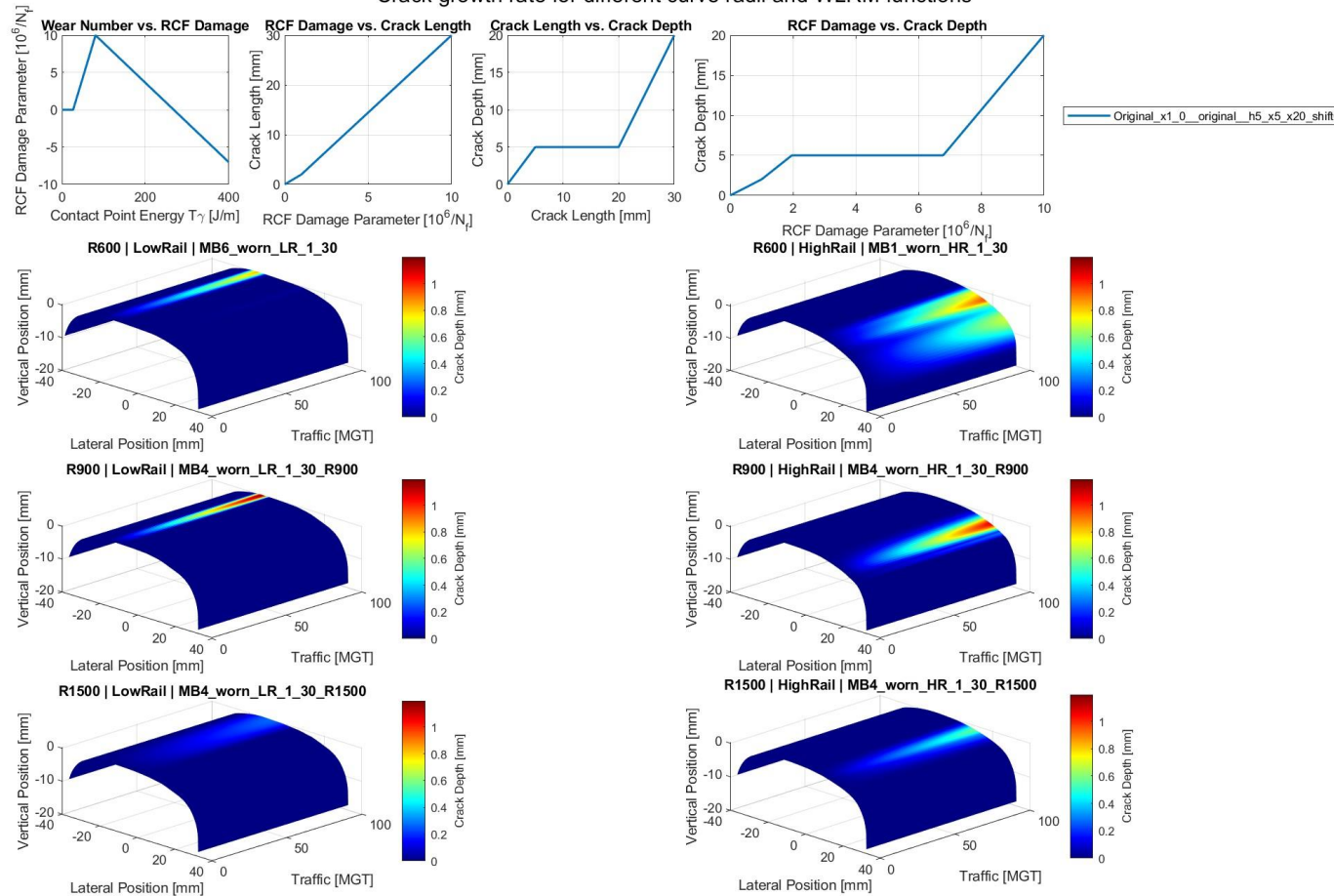
### Key findings:

- Indicator for crack growth angle:
  - The steeper the slope, the more vertical the crack growth.
- Investigation is limited to initial growth stage.

# Key Takeaways Sensitivity Study

## Sensitivity Study

Crack growth rate for different curve radii and WLRM functions

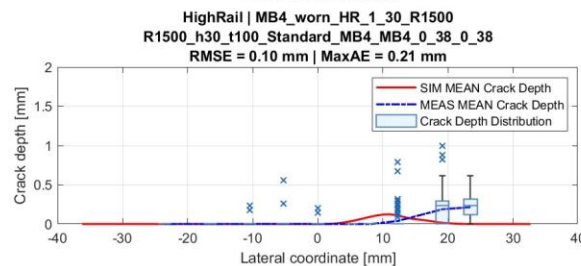
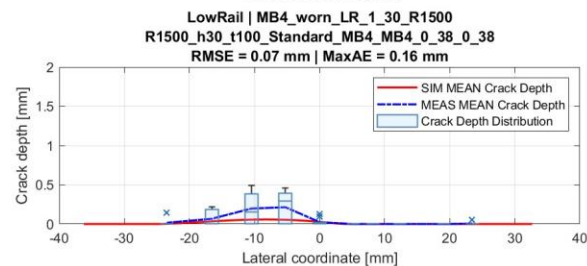
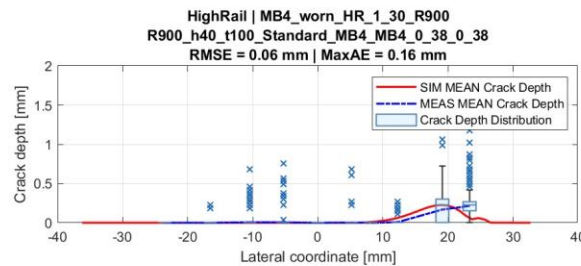
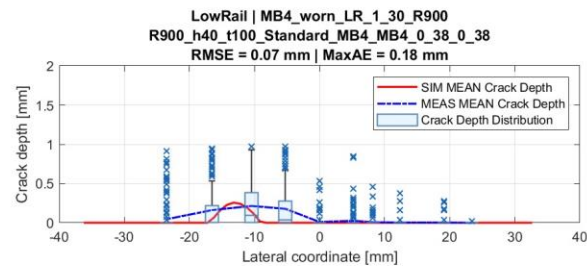
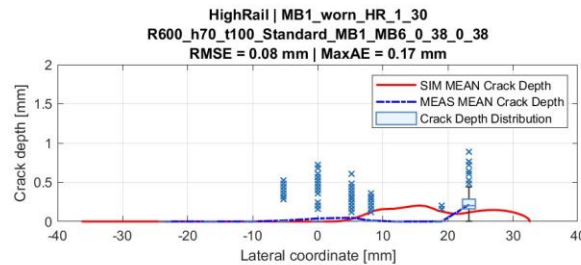
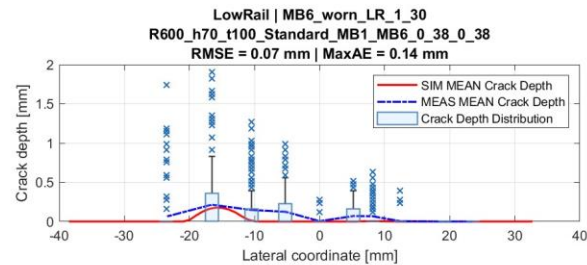


- Dissipated energy at wheel/rail interface dictates the damage initiation  
→ Accurate estimation with MBS of great importance, localized energy dissipation models are preferred
- Crack Growth is a 3D problem:
  1. Crack Depth
  2. Traffic
  3. Lateral rail coordinate



# Simulation vs. Measurement Data

Crack depths | Comparison Simulation vs Measurement Data  
21.47 MGT  
Grinding meas | Scaling moderate



## Low Rail:

1. Damage location coincides between simulated and measured data
2. Considering scaling: crack magnitude matches for narrow radius curves

## High Rail:

1. Measurement data: high gauge corner crack depth for all curve radii.
2. Simulated data: damage location shifts toward center of rail with increasing curve radius.

# Publications and Presentations with the ICRI

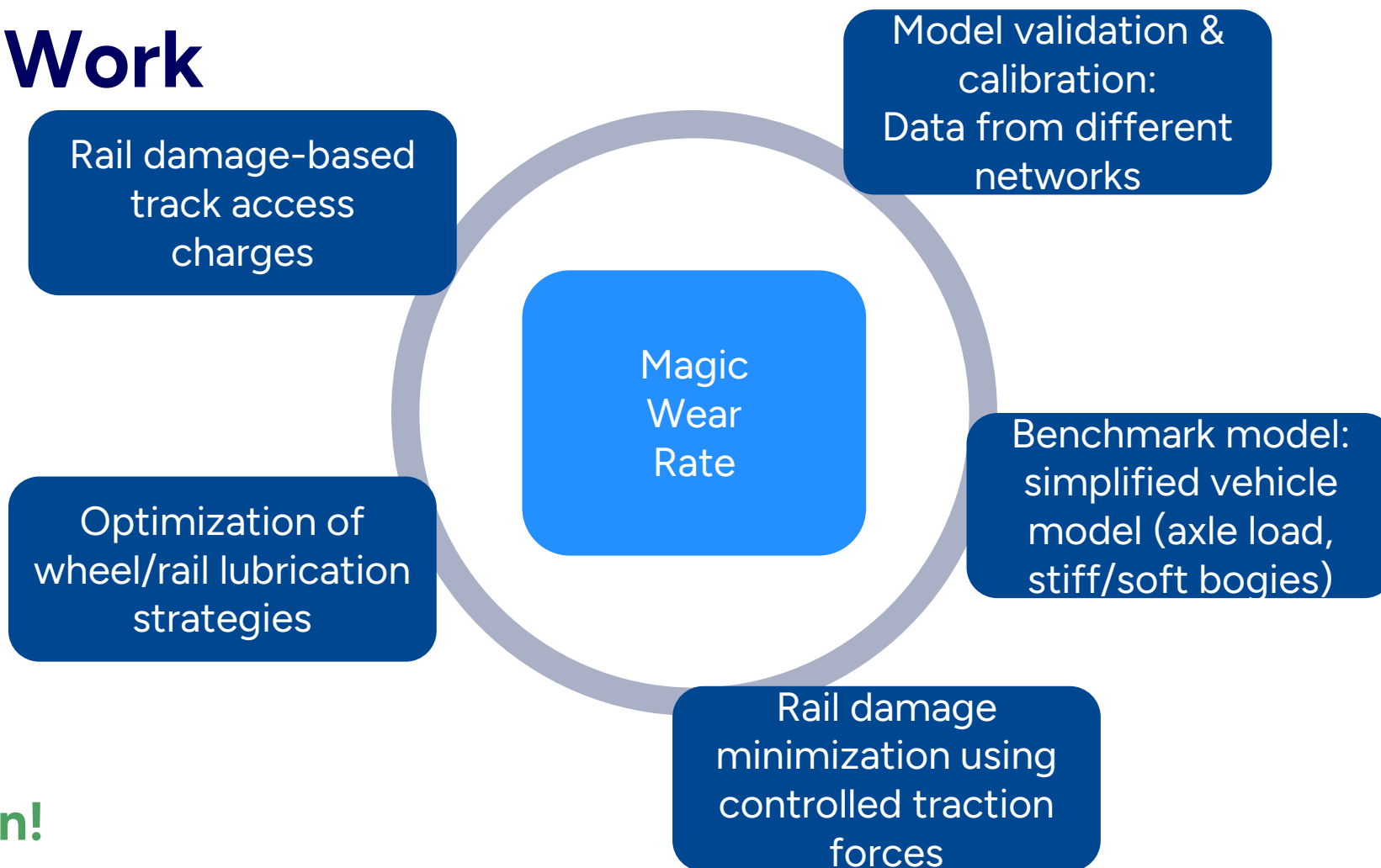
**ICRI Webinar:** Magic Wear Rate: Crack Growth Rate Model for the Swedish heavy haul line (24JUN25)

[https://www.icri-rcf.org/wp-content/uploads/2025/08/2025\\_06\\_25\\_magic\\_wear\\_rate\\_sweden.pdf](https://www.icri-rcf.org/wp-content/uploads/2025/08/2025_06_25_magic_wear_rate_sweden.pdf)

[https://www.icri-rcf.org/wp-content/uploads/2025/08/Magic\\_wear\\_rate\\_sweden.mp4](https://www.icri-rcf.org/wp-content/uploads/2025/08/Magic_wear_rate_sweden.mp4)

- **M.S. Thesis** : Crack growth rate sensitivity study for optimized rail maintenance procedures (Accepted, online publication with be availble soon)
- **IHHA Presentation** : Crack Growth Guidelines for Magic Wear Rate – Swedish Case Study (Colorado Springs, November 2025)

# Future Work



Open to  
Collaboration!

# Thank you

# Questions?

[jleung@kth.se](mailto:jleung@kth.se)