Monitoring and Managing RCF and Rail Surface Conditions (ICRI and collaborative projects)

Eric Magel – Principal Research Officer, National Research Council, Canada

Outline

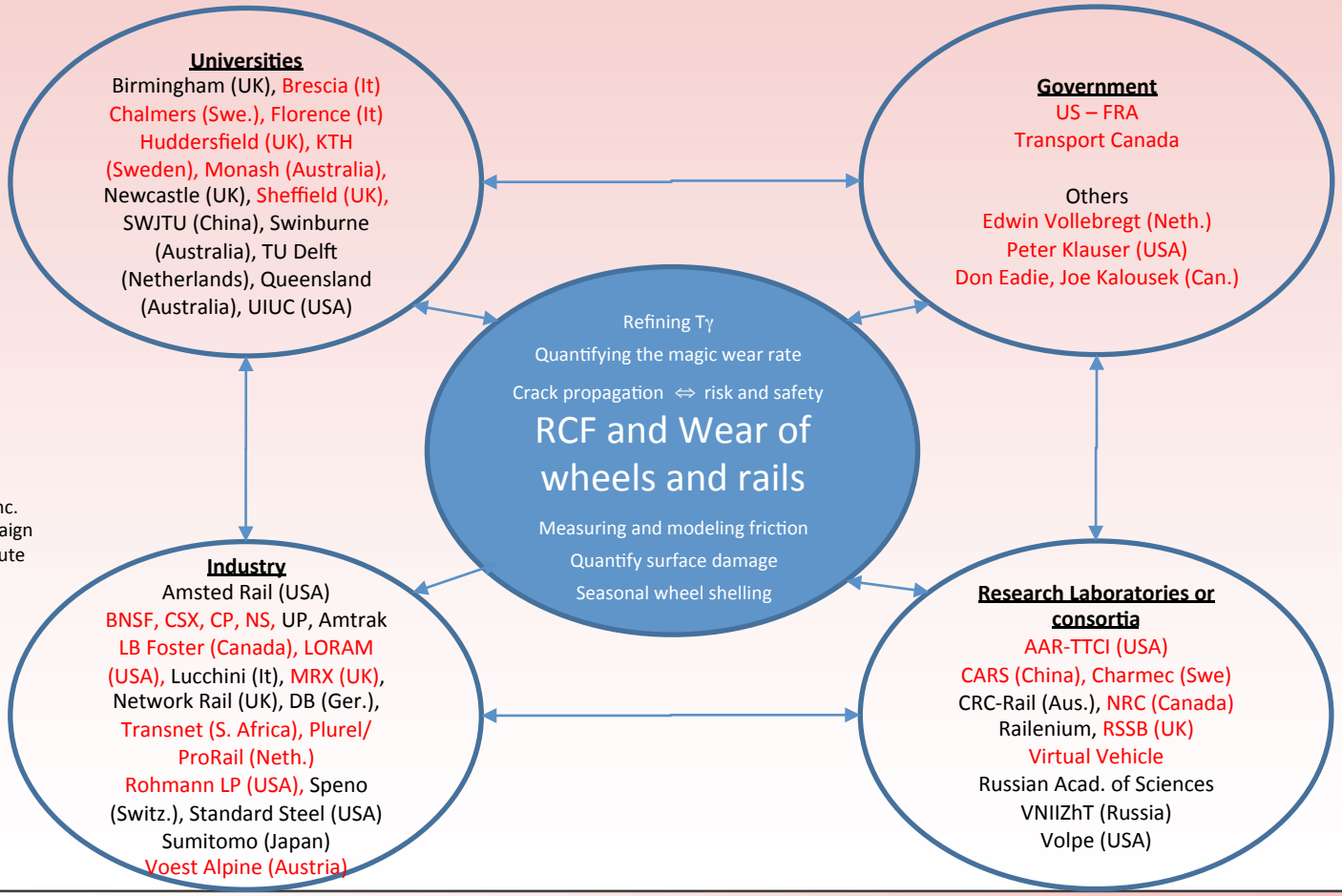
- Origins – the ICRI
- Some ICRI projects
- Wear Mapping, Magic Wear Rate, Quantifying Surface Damage
- Where we go from here

ICRI - how it came about (the short version)

- Summer 2011 FRA/TTCI RCF Workshop in Chicago
- Subsequent discussions at CM2012 in Chengdu
  - Identified Int'l needs for research, recognized overlap, collaboration started there
- Organizing team established
- Outline developed with input from team

"signed up"
Active participants

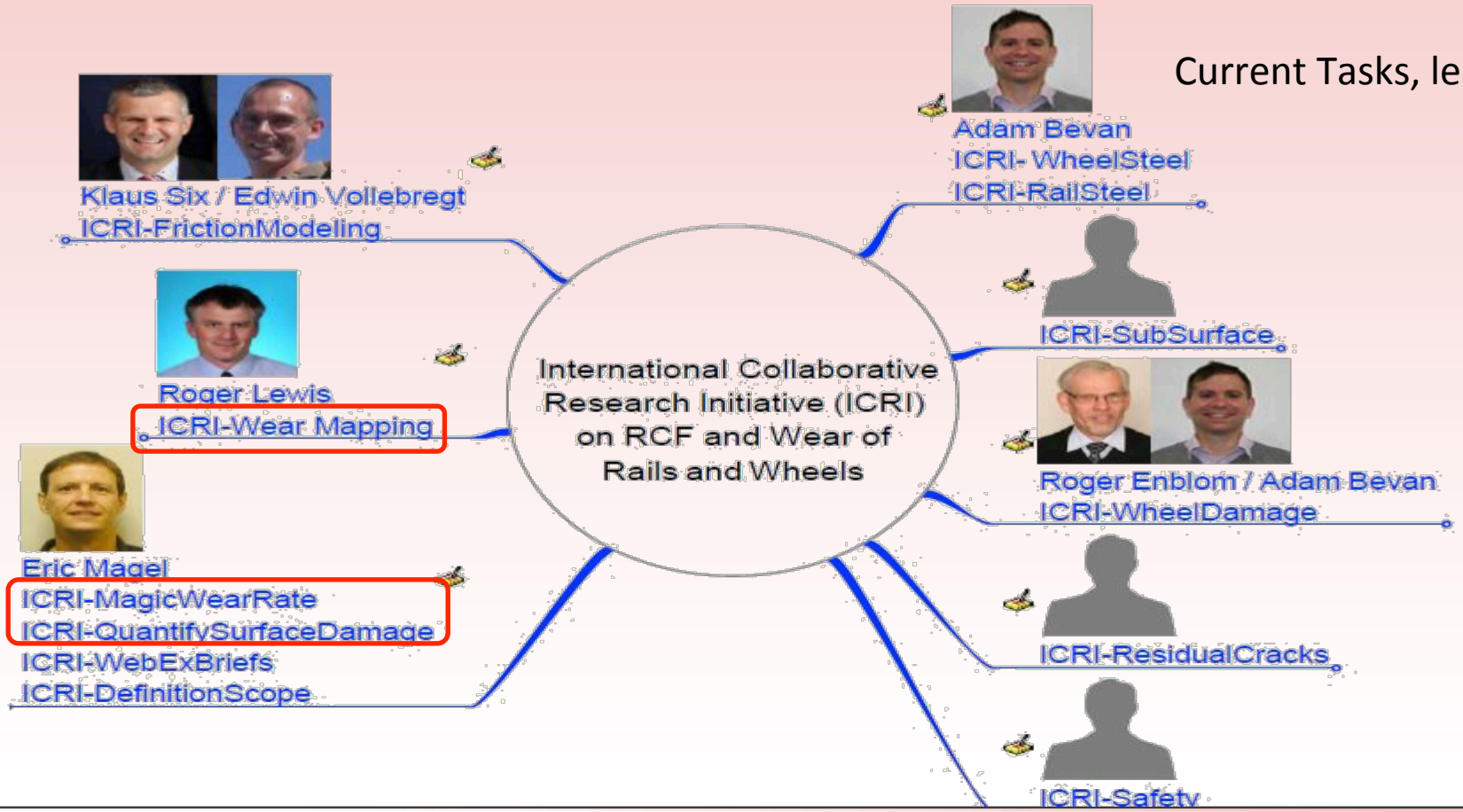
CARS – China Academy of Railway Sciences
CRC – Cooperative Research Centre
FRA – Federal Railroad Administration
NRC – National Research Council
RTRI – Railway Technical Research Institute
RSSB – Railway Safety and Standards Board
SWJTU – Southwest Jiatong University
TTCI – Transportation Technology Center, Inc.
UIUC – University of Illinois, Urbana Champaign
VNIIZhT – All Russia Railway Research Institute



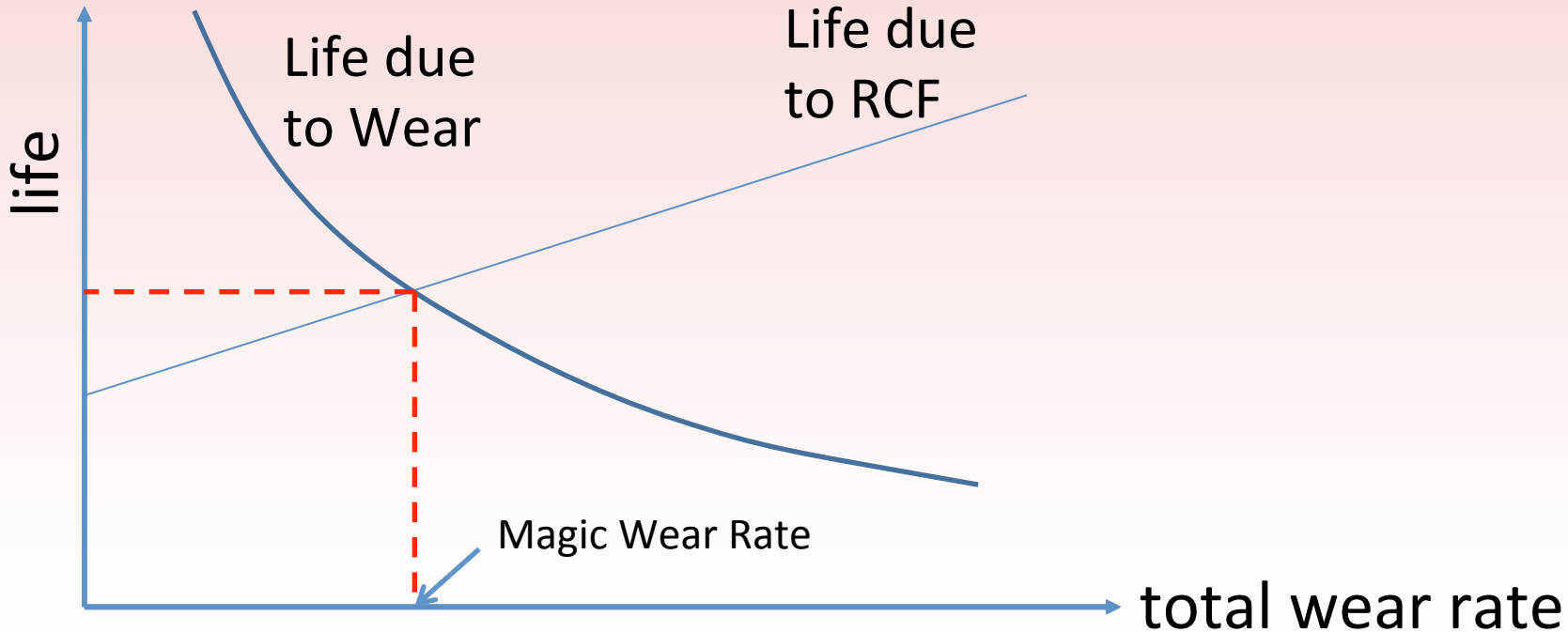
An International Collaborative Research Initiative

- Develop “open” source modules
  - coding
  - calibration data (field and test)
  - validation

Current Tasks, leaders



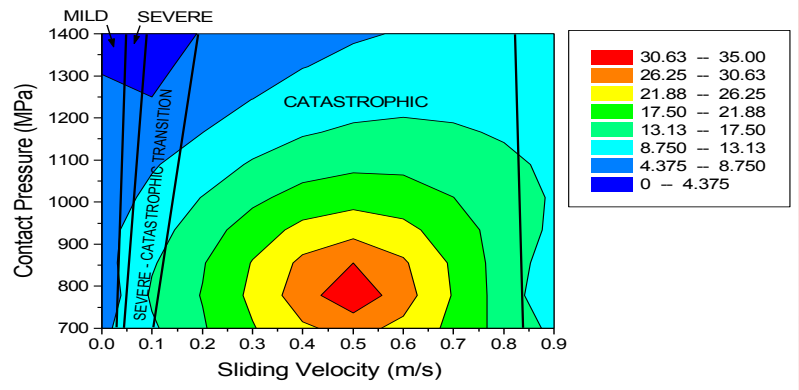
Description

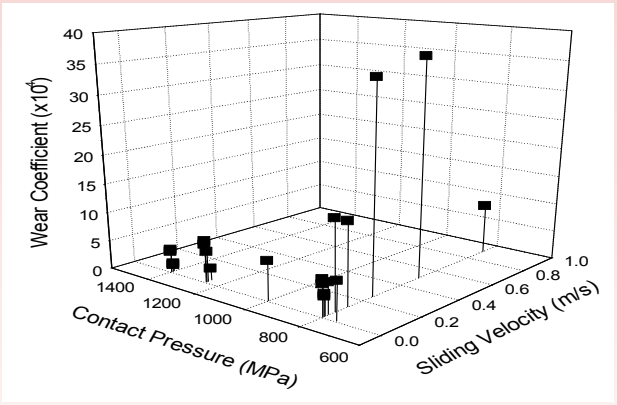


The Development of Universal Wear Maps

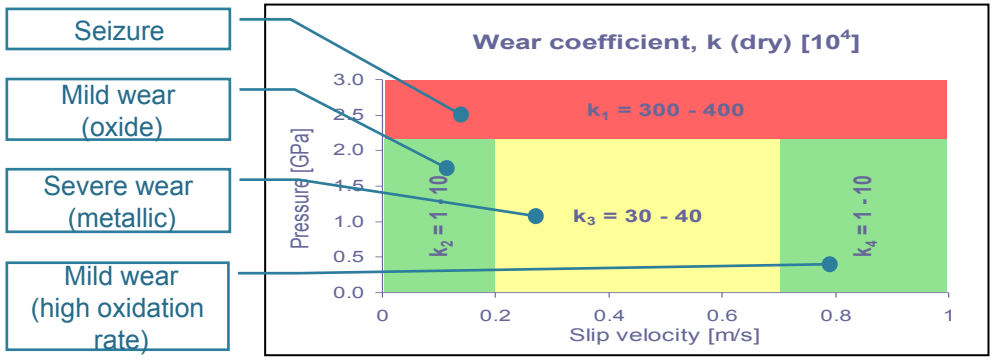
Roger Lewis (Sheffield University)

Previous Wear Maps

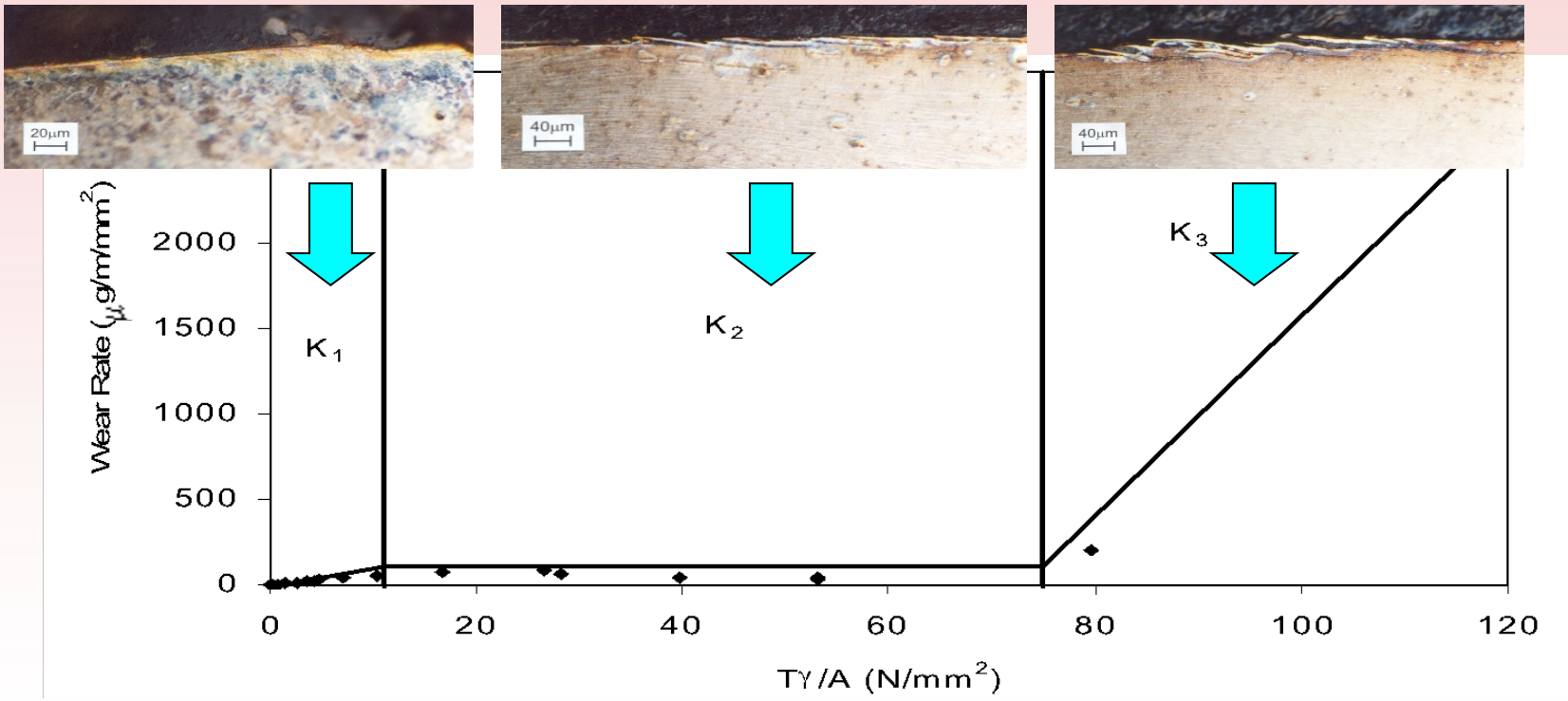




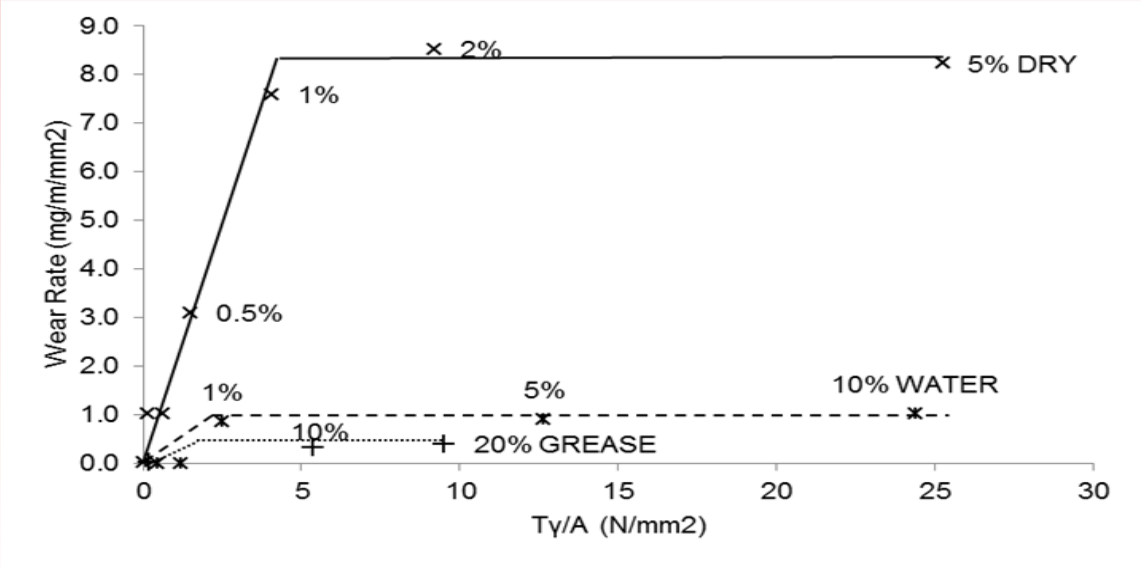
- KTH Archard wear coefficient map extensively used



Wear Regimes and Transitions



Effect of Third Body Materials



- Wet and grease conditions compared with dry

Summary of Progress

- Specs. produced for data collection
- Contact modelling in progress
- Wear data collection underway
- Wear debris collection packs developed
- Wear debris collected from full-scale tests
- Full-scale vs lab scale data compared
- New data on hardness effects
- Abstracts submitted for Railways 2016 on hardness effects and scaling

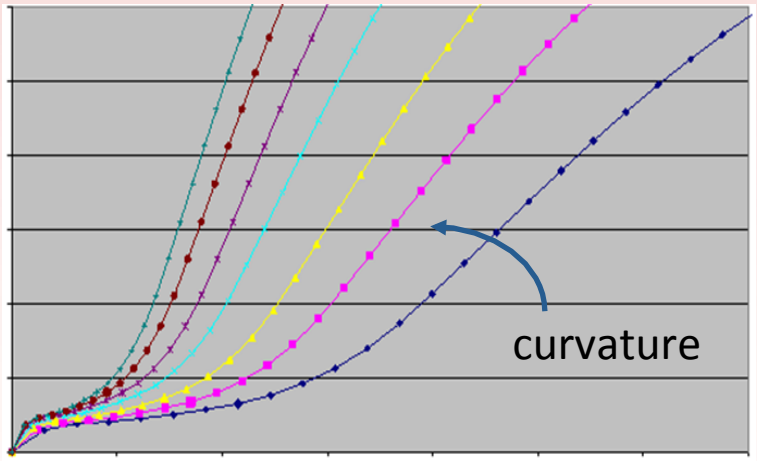
ICRI Wear Mapping Project: Needs

- More wear data
- More contact data
- More wear debris
- Input on scenarios – where are the issues?
- Have we missed anything?

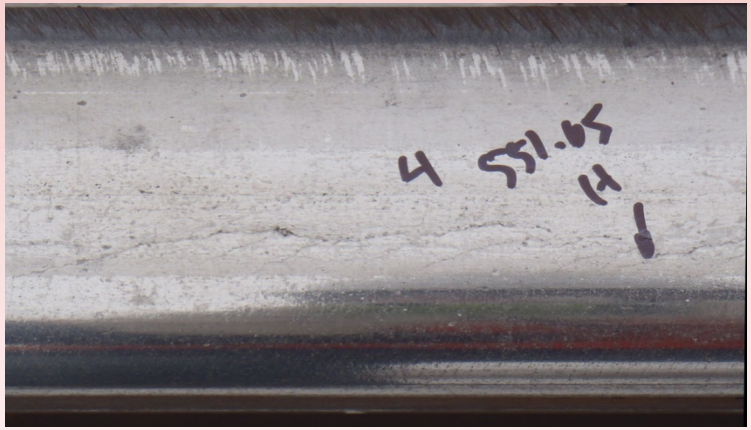
Quantifying the Magic Wear Rate

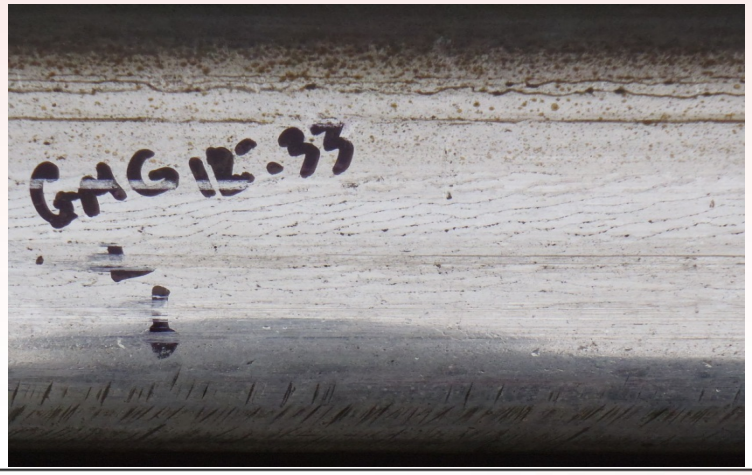
A family of crack growth curves

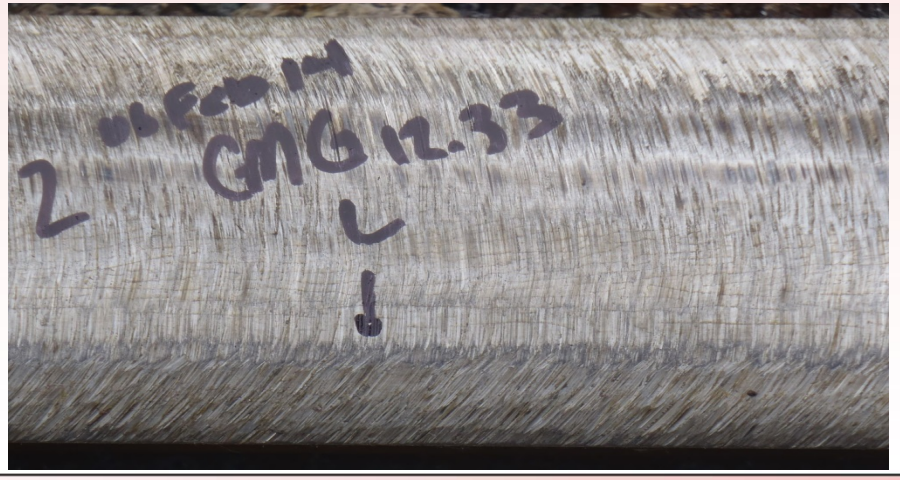
- probably differs for
  - rail steels
  - curvatures
  - traffic types (e.g. passenger, transit, freight)
  - environmental conditions
  - friction regimes



Quantifying Surface Damage







High Rail
1.55 mm
of metal
removed
at crack
location
(6 passes)

Low Rail
0.67 mm
of MR at
crack
location
(3 passes)

Electromagnetic Measuring Systems

MRX

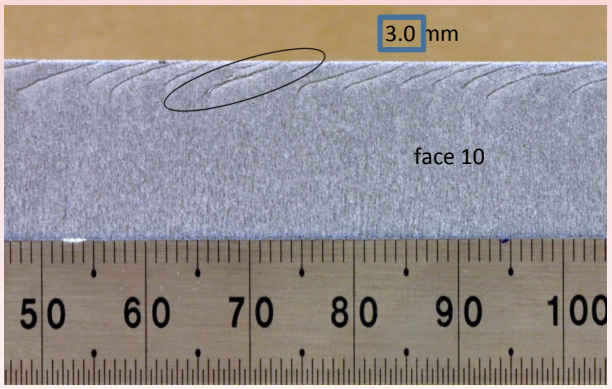
Sperry

Rohmann

Participating Railroads

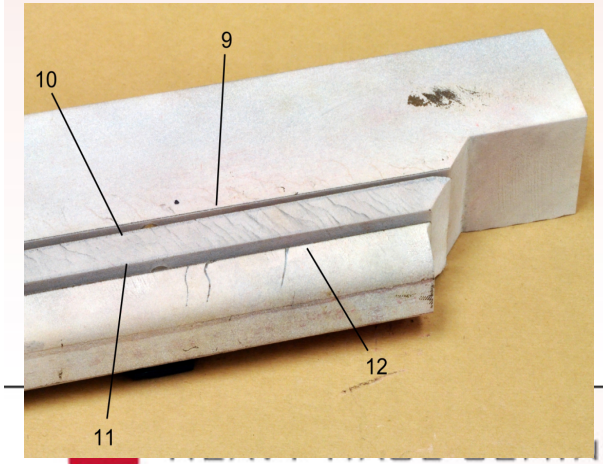
- CP (2012-2014), BNSF (Nov 2014): Minnesota
- CN (Current): Wisconsin
- NS (Feb 2014): Virginia
- CSX
  - June 2013 – Bluefield Mountains, TN
  - Feb 2014 - Cincinnati and Big Sandy
  - Current – Waycross, GA

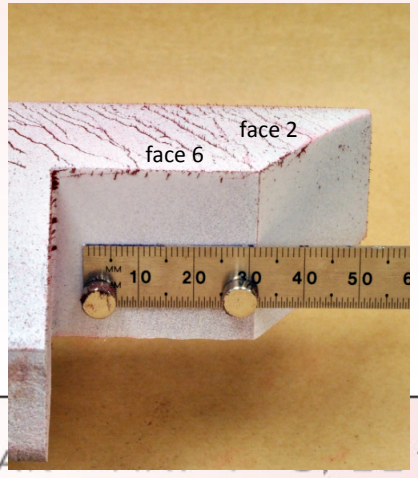
CSX Blue Ridge Subdivision Sample #12



MP T247.79 RIGHT
Rail Manufacturer: Tennessee
Rail Year: 1975
Rail Type: CC
Rail Weight: 132

<u>Measured crack depth</u>
MRX: 6.9
Rohmann: >5.0

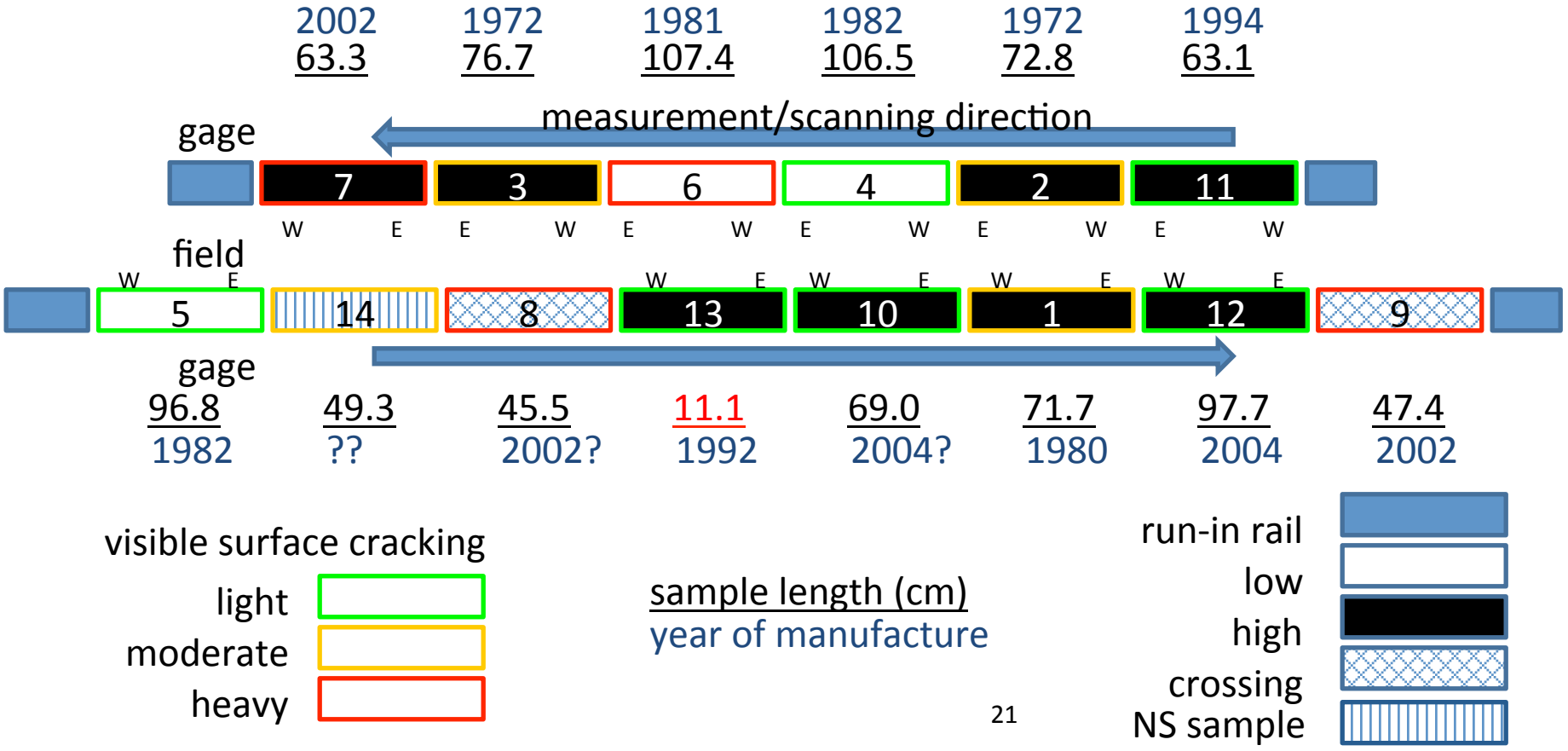




<u>Magnetic Particle Inspection</u>

	Face 2	Face 6
Max Length (mm)	3.8	2.0
Crack Angle (deg)	23	75
Max Depth (mm)	1.5	2.0
Surface Angle (deg)	46	46

BNSF Staples Subdivision Rail Samples



visible surface cracking

light

moderate

heavy

sample length (cm)

year of manufacture

run-in rail

low

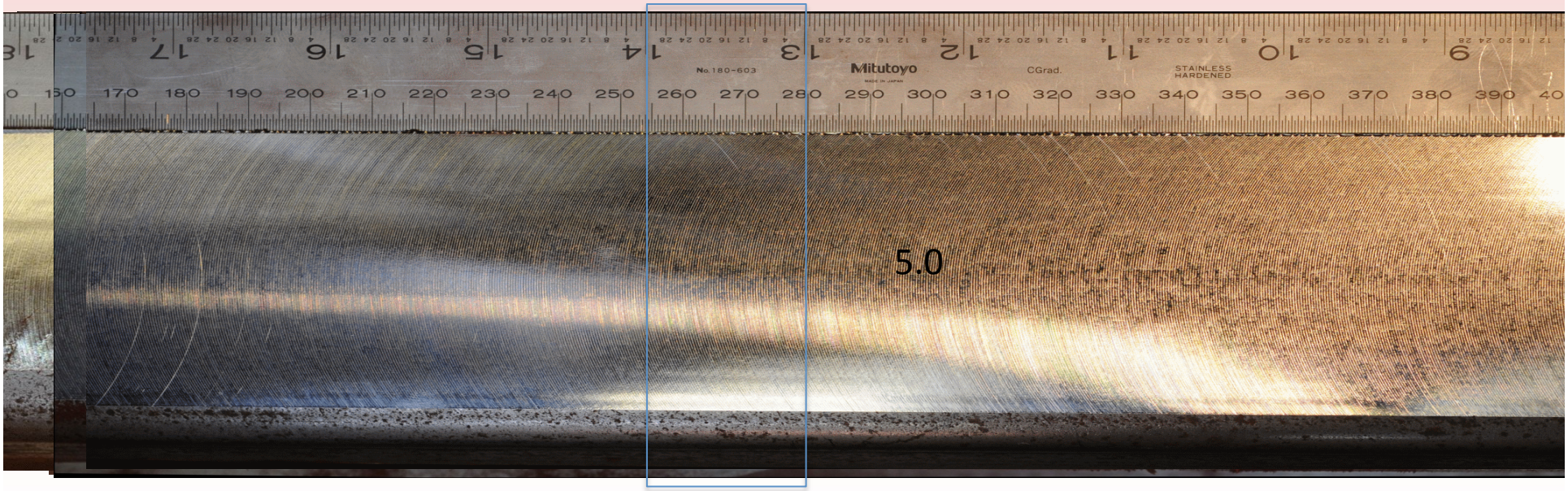
high

crossing

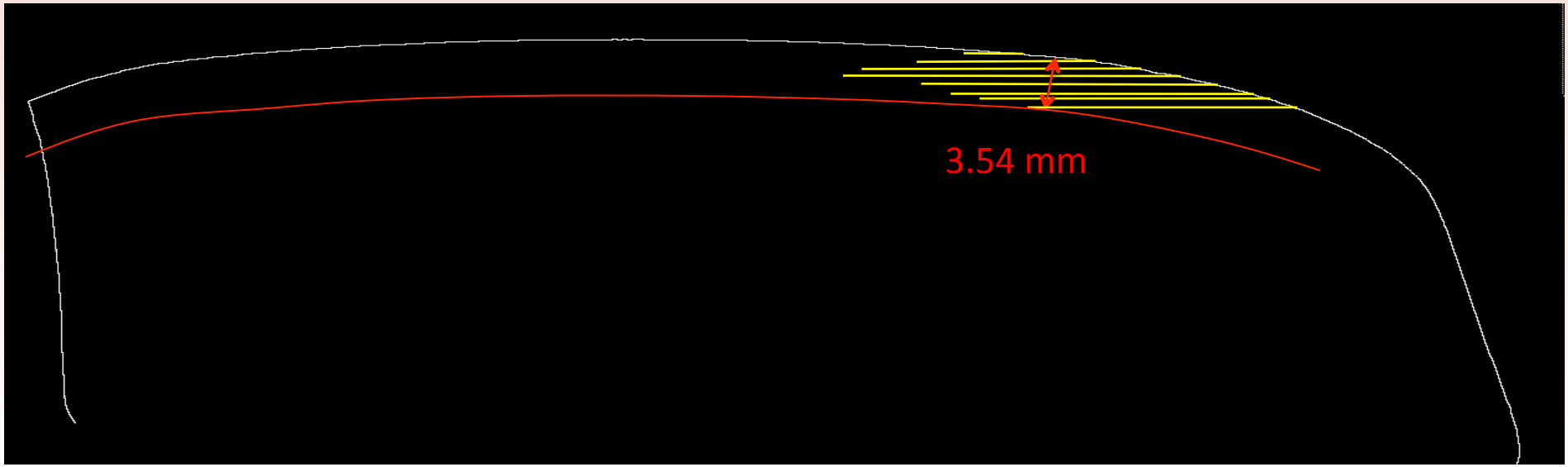
NS sample

Sample 3

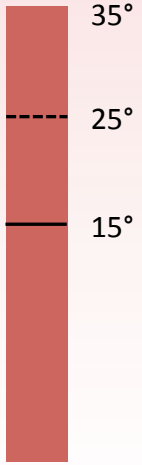
field side

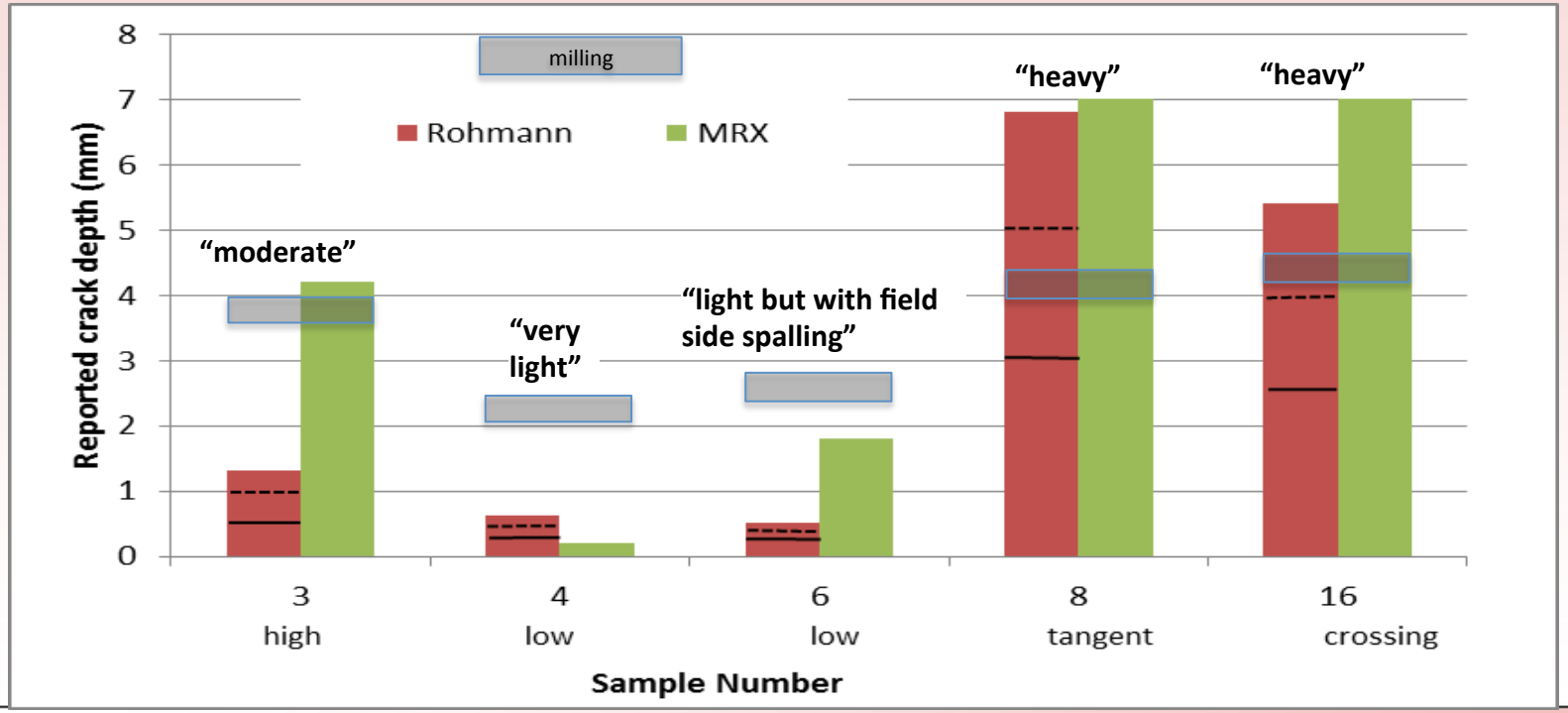


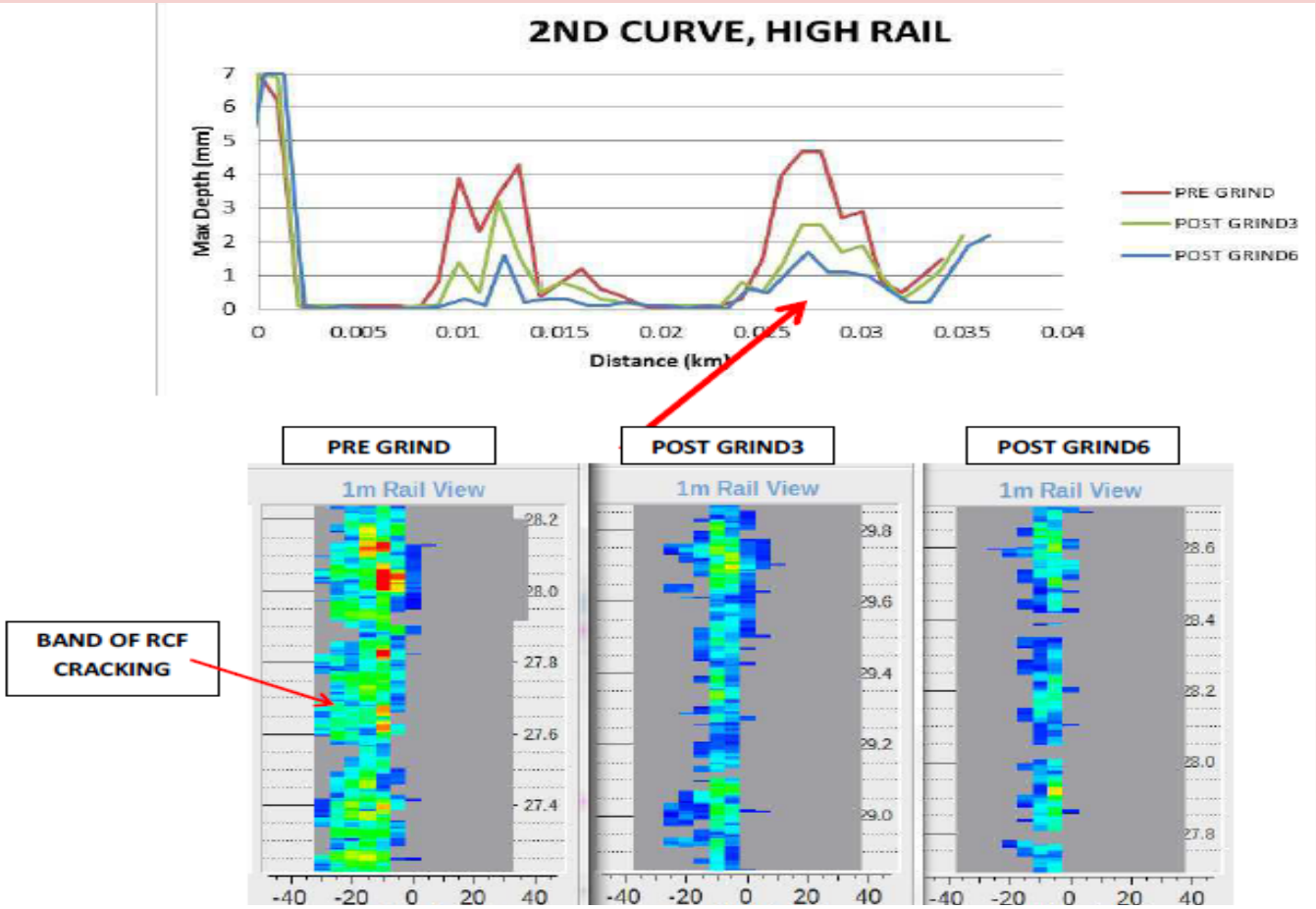
Sample 3: Crack depth



BNSF Staples - Results





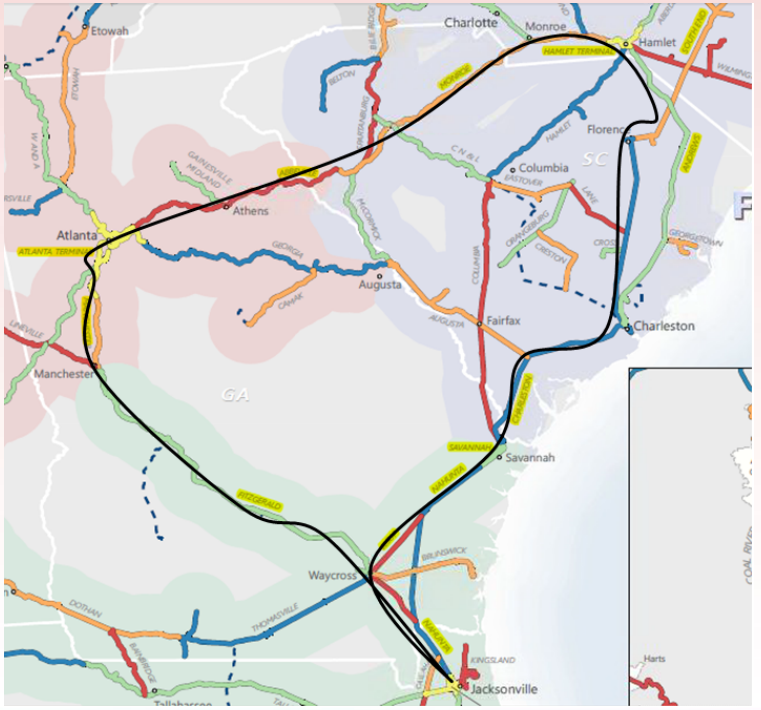


Accept that

- "measurements" are indicators
  - light
  - moderate
  - heavy
- trends are valid

CSX RCF monitoring

- 1000 mile loop
- Loram grinding, RIV
- MRX, Rohmann, Sperry
- Will review broken rails, SSC, defects where/when possible



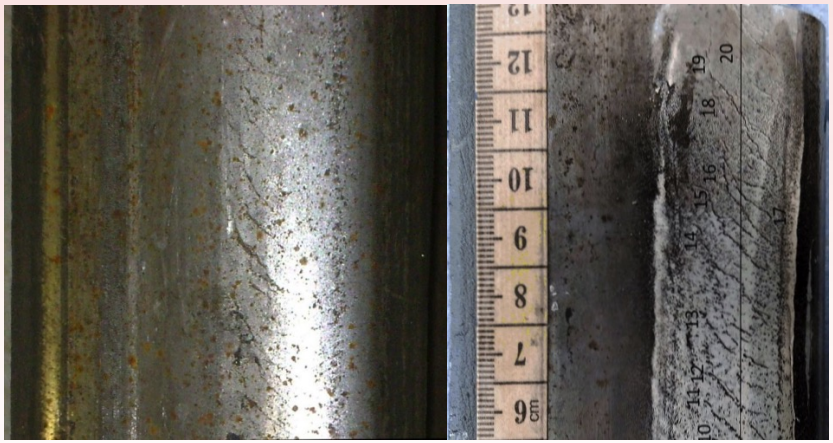
CN Steelton Hill

- Regular monitoring (photos, profiles, MRX)
- Brand new rail installed – will monitor
- So Far: November 2015, April 2016
- Rail samples from Exeland Subdivision
  - "moderate" and "light" RCF on samples
  - Will be sectioned

Atlas of Rail Surface Fatigue

- FRA Project
- Document all samples
- Provide reference photographs
- Represent wide range of conditions
- Possible analytics

High Low Tangent S&C Metallurgy: 13225 USS Illinois 1972 I	Railroad: BNSF Subdivision: Staples MP: 210.7 M1 Curvature: 1°	Date: removed from track 25NOV14



Surface crack length	10 to 17 mm
Start/end position	8 to 22 mm
Surface Angle	Approx. 45 degrees
Crack depth (milling)	1.7 to 2.8 mm
Spacing (avg) = 4.14 mm	

Machine Vision Systems

0 None

1 barely perceptible, but clearly regular pattern (preventive grinding < 0.5mm).

2 clear, well-defined, distinct individual cracks – but no pitting at tip (maintenance, depth < 1.0 mm)

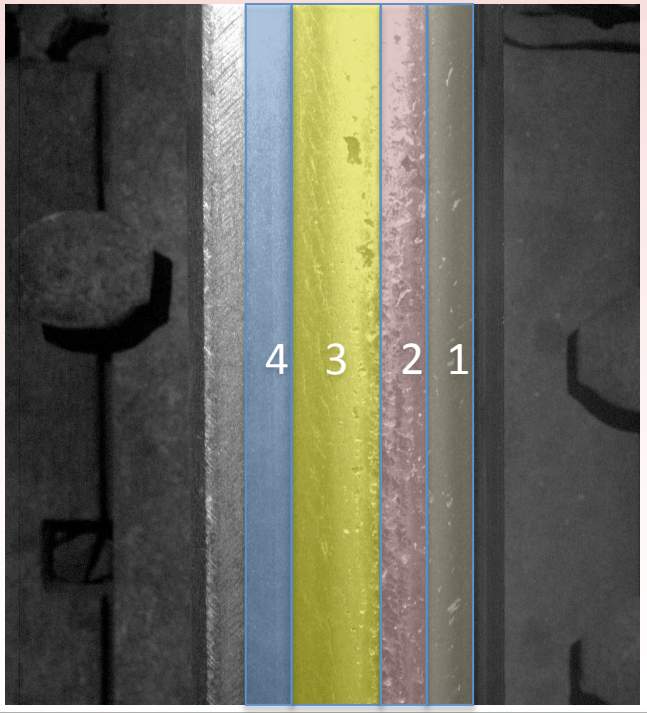
3 clear cracking, pits up to 4 mm diam (corrective grinding 1.0-2.5 mm deep),

4 pitting greater than 4mm < 10 mm (preventive gradual, up to 3.5 mm deep), or "heavy" cracks with clear lifting of metal or separation of crack faces

5 isolated pitting/shelling/spalling > 10, diam (up to 5 mm deep)

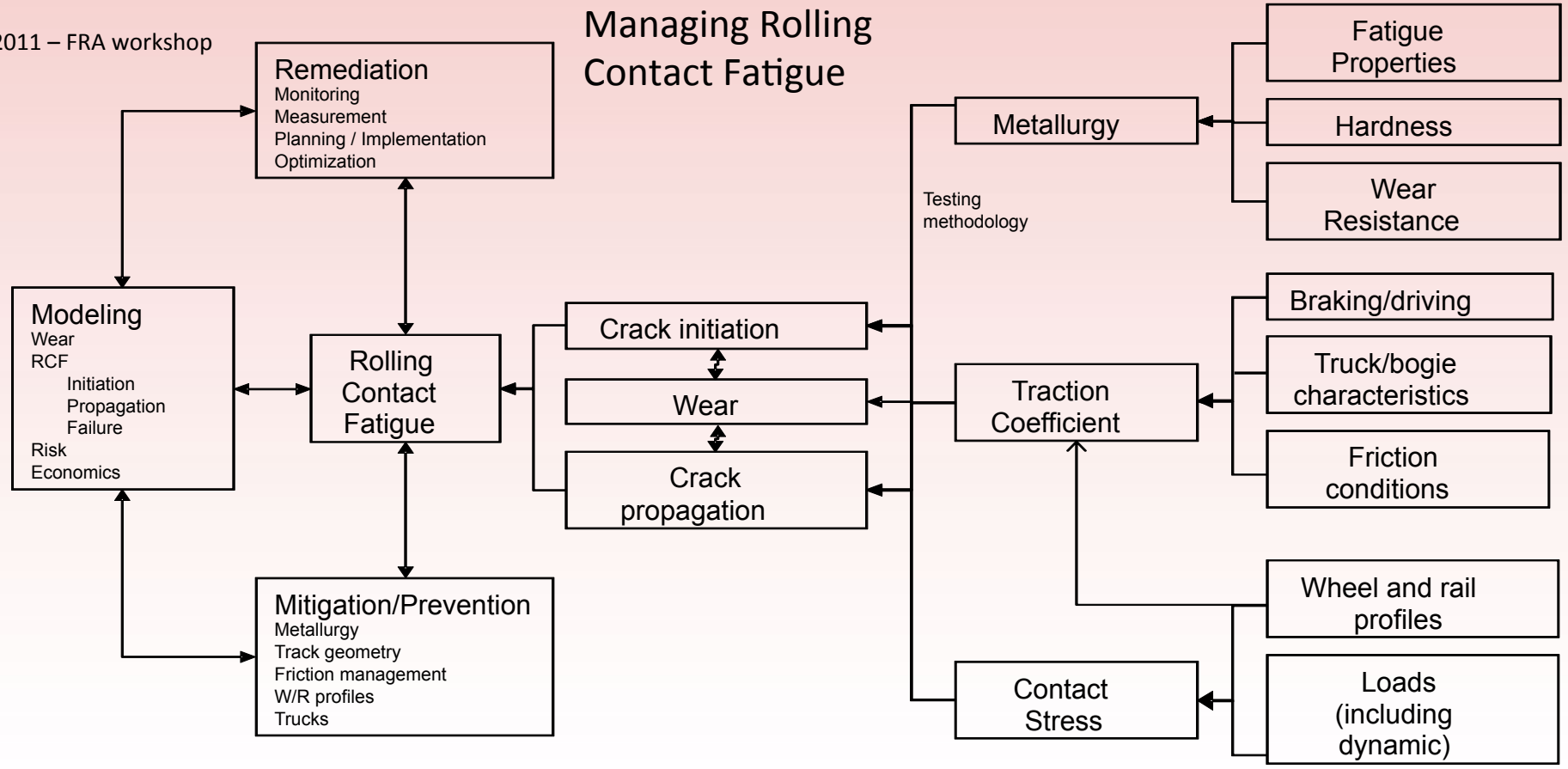
6 Shelling/spalling: regular pitting, >10mm diam (busted, near impossible to catch up on)

7 Shelling/spalling: any defect > 16 mm diam, >20mm length



2011 – FRA workshop

Managing Rolling Contact Fatigue



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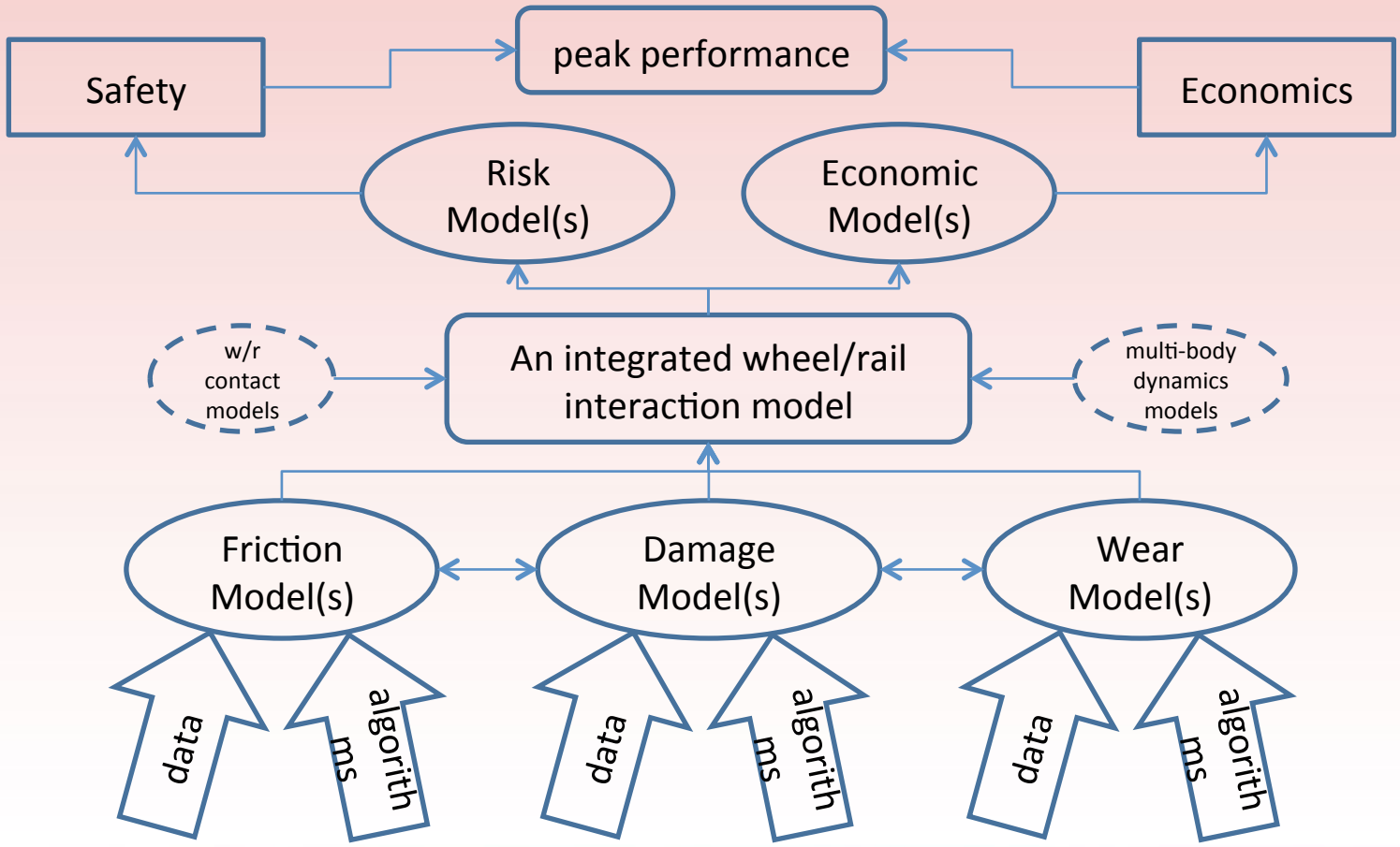
AWRISE


Safety
peak performance
Economics
Risk Model(s)
Economic Model(s)
w/r contact models
An integrated wheel/rail interaction model
multi-body dynamics models
Friction Model(s)
Damage Model(s)
Wear Model(s)
data
algorithms
data
algorithms
data
algorithms

Notice: ICRI workshop

Vancouver, Canada

August 2-4

$100 US registration fee

Sponsors: ARM, Loram, LB Foster

Organizers: Eadie, Kalousek, Magel, Stock

Thank you!

Eric Magel

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