ICRI RAIL PROFILE SCORING INITIATIVE

OPTIMIZING RAIL PERFORMANCE THROUGH SITE SPECIFIC RAIL PROFILES

ICRI

With the availability of mechatronic grinders with infinite rail grinding patterns and potential target shapes, how to decide which is the most appropriate shape for a given segment of track?

GOAL

Develop a methodology for “scoring” of rail profiles based on:

Economics:
- Rail/wheel life
- Energy consumption
- Rail grinding costs
- Rail Inspection costs
- …

Performance/Risk:
- RCF
- Wear
- Noise
- Corrugation
- …

Select the best template from a family of templates for grinding a site

AND/OR

Assess the compatibility of existing profiles and design new ones for the system

DAN HAMPTON'S VISION

"IF YOU ARE OPTIMIZING FOR AN AVERAGE, THEN YOU ARE NEVER FULLY OPTIMIZED"

Currently CSX is using profiles developed for the whole network

- CSX has four templates: Tangent, Low, High Mild, High Sharp

How much are we compromising by limited templates?

- 4 templates for thousands of curves
- Variation in geometry & traffic = variation in performance
- Science has evolved a lot and more data than ever is available
- Ability to automate implementation is now possible

Can we move to site specific templates

- Matching of wheel shapes, traffic, and track conditions
- Develop family of Condition Based Templates
- Automate selection of the right profile

Customize templates for a segment

Eventually be able to design template on the fly

- Quantify procedures, weights, trade-offs

USING CANT DEFECIENCY INSTEAD OF DEGREE OF CURVATURE TO MORE PRECISELY DETERMINE CONSISTENT FLANGE CONTACT

High Rail Template	Curvature [degree]	Cumulative Curve Length [ft.]	Ratio
mild	0.5	1729601	8%
mild	1	4334994	20%
mild	2	5305008	24%
sharp	3	3640161	17%
sharp	4	2446921	11%
sharp	5	1304734	6%
sharp	7	1607283	7%
sharp	10	1020113	5%
sharp	15	249021	1%
sharp	20	21570	0%
sharp	30	823	0%

41% of all Curves

Cant Deficiency (CD) accounts for variation in

- Velocity (V) – actual speed
- Radius (R) - degree of curvature
- Gauge
- Super elevation

$$CD = \frac{gauge_{se}}{\left(1 + \frac{R^2 g^2}{V_{act}^4}\right)^{\frac{1}{2}}} - super\_el$$

POTENTIAL STAKE HOLDERS

Railroads: CSX, CP, BNSF, NYCT, BART, …

Suppliers: ARM, Sentient, LORAM, …

FRA : A. Tajaddini

INITIAL CALL PARTICIPANTS

Ankur Ashtekar, Sentient Science

Dan Hampton, CSX

Peter Klauser, Vehicle Dynamics

Charles Rudeen, LORAM

Rob Caldwell, NRC

Eric Magel, NRC

Kevin Oldknow, SFU

Mark Reimer, ARM

WHAT PARAMETERS ARE IMPORTANT?

1. RCF
2. Wear
3. Pummelling
4. Lateral and Curving forces
5. Stability/Ride Quality
6. Corrugation resistance:
7. Noise
8. Grinding interval/depth/strategy
9. Wheels
10. Frictional Energy
11. …

Which ones are we missing?

Will we discover more parameters as the project matures?

How do we update our methods as the understanding of the parameters improves and new scientific or data breakthroughs happen?

Are these parameters important for everybody?

How do we ensure this benefits everyone, technically and financially?

APPROACH

A collaborative project

- CSX and other stake holders to provide necessary input data
- Identify experts/organizations to contribute
  - Experts to work in groups, with each group targeting a parameter
  - Groups may work independently or collaboratively with other groups
    - E.g. Wear and RCF groups may work in collaboration with pummelling group, while RCF and Noise may be independent
- Identify organization to implement/demo the scoring methodology
  - Must, at least for demonstration purposes, be able to apply to a small sample of data
- Identify historical data for verification/validation

RAIL PROFILE SCORE

$$Rail\ Profile\ Performance\ Score = 100 * \frac{(S_{rcf}\, W_{rcf} + S_{wear}\, W_{wear} + S_{lateral\ force}\, W_{lateral\ force} + \ \dots)}{(W_{rcf} + W_{wear} + W_{lateral\ force} + \ \dots)}$$

- S is a qualitative score indicator of the impact of a rail profile on a parameter
  - Scores are site and condition specific
  - E.g., How much will Profile A affect RCF risk of the rail at a site for given operating conditions
  - Each expert group works on developing a scoring scale 0 -1 for their area of expertise
    - 0 is very bad and 1 is very good
  - Method to evaluate a profile for a score may be quantitative, evaluated from physics-based simulations or data science driven algorithms
    - Scores must be presented in qualitative form
    - Guide nontechnical user to make impactful decisions without tedious math, e.g. consider using grades

E	D	C	B	A
0 – 0.2	0.2 – 0.4	0.4 – 0.6	0.6 – 0.8	0.8 – 1

SCORING PARAMETER WORKING GROUPS

1. **RCF : Kevin Oldknow,** Richard Stock*, Darrien Welsby*, Mark Reimer, Charles Rudeen, Eric Magel
2. **Wear : Ankur Ashtekar,** Mark Reimer, Eric Magel
3. **Lateral and Curving Forces: Peter Klauser,** Kevin Oldknow, Charles Rudeen
4. **Stability/Ride Quality: Peter Klauser,** Charles Rudeen
5. **Corrugation resistance:** ?
6. **Noise: Mark Reimer**
7. **Grinding: Charles Rudeen,** Mark Reimer
8. **Frictional Energy: Rob Caldwell**

RAIL PROFILE SCORE, CONTD…

$$Rail\ Profile\ Performance\ Score = 100 * \frac{(S_{rcf}\,W_{rcf} + S_{wear}\,W_{wear} + S_{lateral\ force}\,W_{lateral\ force} + \ \ldots)}{(W_{rcf} + W_{wear} + W_{lateral\ force} + \ \ldots)}$$

- W is a qualitative weight indicator of the impact of a parameter to a user's needs
  - E.g., Does Noise affect the Class 1 End User as much as a Transit End User
  - An End User Working Group will provide guidelines for weight scale, 0 -1 for their network types and use cases
    - 0 means a parameters doesn't matter much and 1 means the parameter is very important
    - Guide nontechnical user to make impactful decisions without tedious math, e.g. consider using grades

E	D	C	B	A
0 – 0.2	0.2 – 0.4	0.4 – 0.6	0.6 – 0.8	0.8 – 1

WEIGHTING OF SCORING PARAMETERS

Heavy haul : Dan Hampton

- More tolerant of risk?
- More economics sensitive?

High Speed : ?

- Extremely risk averse => minimal RCF tolerate?
- Ride quality and noise are paramount?

Transit : Mark Reimer

- Focus may be more on ability to minimize corrugation and noise?

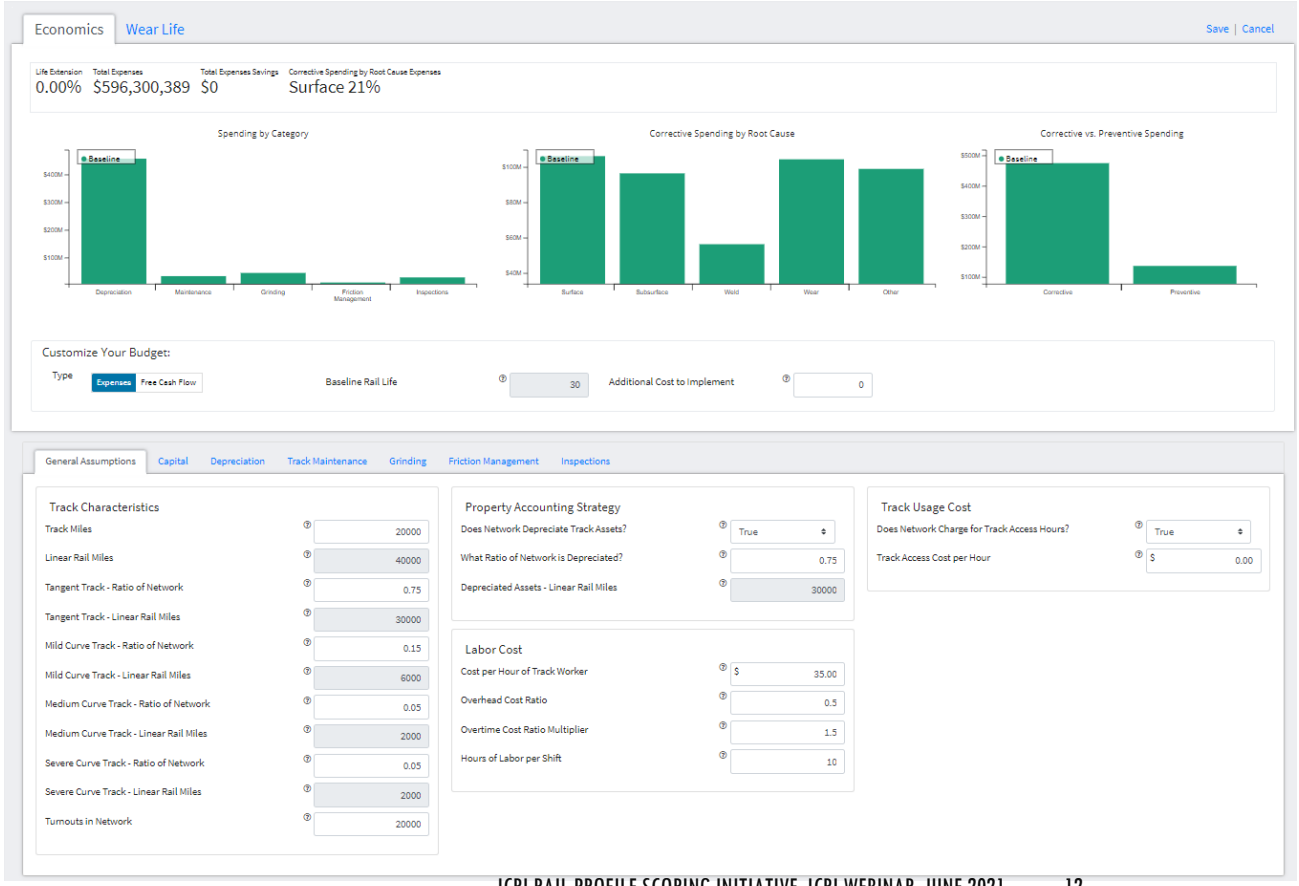
RAIL PROFILE ECONOMIC SCORE

$$Rail\ Profile\ Economics\ Score\ = f(Rail\ Performance\ Score, implimentation\ costs, maintenance\ costs, savings, \ldots)$$

ICRI Economic Group to leverage the current Economic Model to add Rail Profile Economic Score

Scoring based on how will a rail profile's performance and implementation impact the direct and indirect cost and savings?

Model will need to be customer specific



Wesley Thomas, Lyn Williams

INTELLECTUAL PROPERTY AND MONETIZATION

Experts can develop their Scoring product/ IP and publish them to the community or package them as products

- They need to follow the guidelines of the scoring methodology
- How they calculate/simulate and map to the scoring can be proprietary
  - Burden of validation and proof will be with the expert
- End users can license the scoring product/IP from experts they feel confidant about

Software platforms can work with Experts to license their scoring products and package them into their workflows and offer as a product/service to End Users

Types of Users

- Expert:
  - A Person, University, Corporation that has the knowledge and expertise to develop scoring methodologies for a particular factor. e.g., RCF expert
- End User:
  - A person from one of the Rail Operators evaluating profile templates
  - A supplier, e.g., grinding operators using profile templates, expert designing profile templates
  - Could be a non-technical person
- Software Platforms/Services:
  - Organization that provides tools to End Users to manage their rail network

VERIFICATION AND OR VALIDATION

If there is enough historical data, to correlate past profiles with their performance in track?

- Is the historical data available?
  - Install date
  - Regular profile (or at least wear) measurements
  - Other track data (geometry, friction)
  - Loading data
  - Past wheel profiles
  - …
- How to account for the natural variations known to arise in the real world?

INPUT DATA WISH LIST

- Track gauge
- Friction
- Curvature
- Speed of trains
- Cant Deficiency
- Car type
- Rail hardness/quality
- Current rail condition
- Wheel profiles
- Wheel loads
- Rail rotation under load
- Geometry perturbations
- Rail grinding interval
- Rail grinding plan
- Ultrasonic inspection
- …

OUTCOMES

Technical documentation – an ICRI report

- Provides the methodology for implementation into appropriate (probably proprietary) analysis systems

Presentations – ICRI and conference

White Papers/ Publications – on individual plus joint aspects

We **Do not** plan to develop a publically available software system – will leave that to organizations to do commercially.

MOVING FORWARD

Identify Leaders for Work Groups: 1 month

Work Groups to decide on Data Needs: 2 months

Work Groups to finalize initial methods: 3 months

- Lay out as series of research questions to frame the work: 2-6 months
- Establish scoring methods: 6 months – 1 year?
- Develop scoring Grades: 8months – 1 year?

Weighting group to develop weight guides: 2-6 months?

Monthly check in with POC/leaders

Quarterly Review Meetings

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