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for Rail

Rail Profile Evolution with Vampire-in-Loop: Designing Better Rail Profiles

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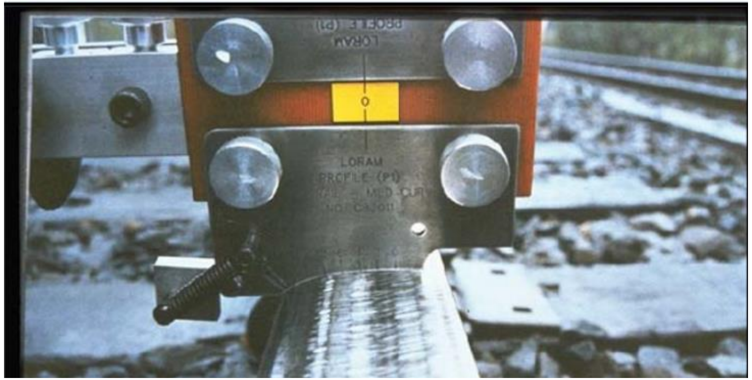
Materials Science. Digitalization. Life Extension.

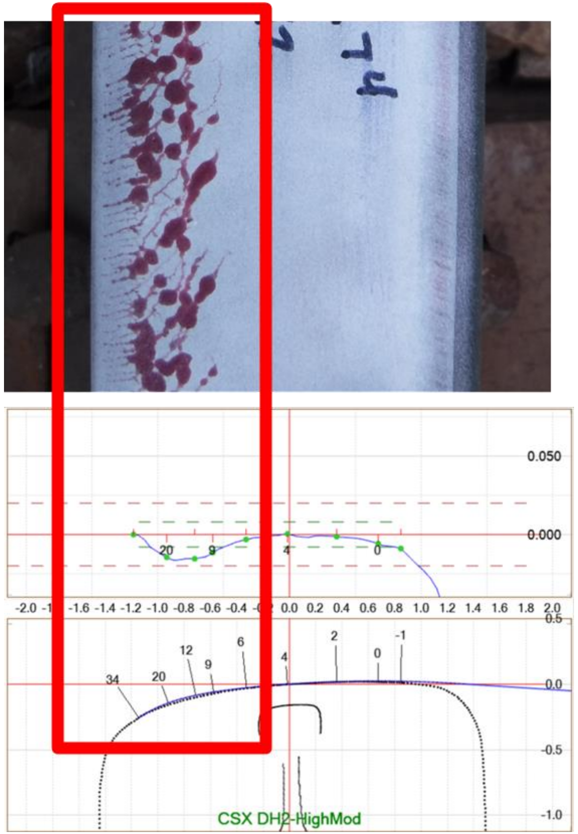
Agenda

1. **Challenge:** Why CSX Needed New Rail Profiles
2. **Opportunity:** New Approach to Design Rail Profiles
3. **Case Study:** First Profile Test for Increased Wear/Costs
4. **Case Study:** Second Profile Test Increased RCF/Risk
5. **Case Study:** Third Profile Test Improved Wear, RCF, & Cost
6. **Summary:** Key Take Aways, Next Steps, and Q&A



Challenge: Current CSX Profiles

- Rail profile challenges:
  - Gauge corner RCF
  - Requires removing excess metal
  - High rail GQI decreasing
  - “Fighting” wheel profiles



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ECONOMIC MODELS | TRACK MODELS | WHEEL-RAIL MODELS | WEAR MODELS | RCF & GRINDING MODELS | ASSET MANAGEMENT

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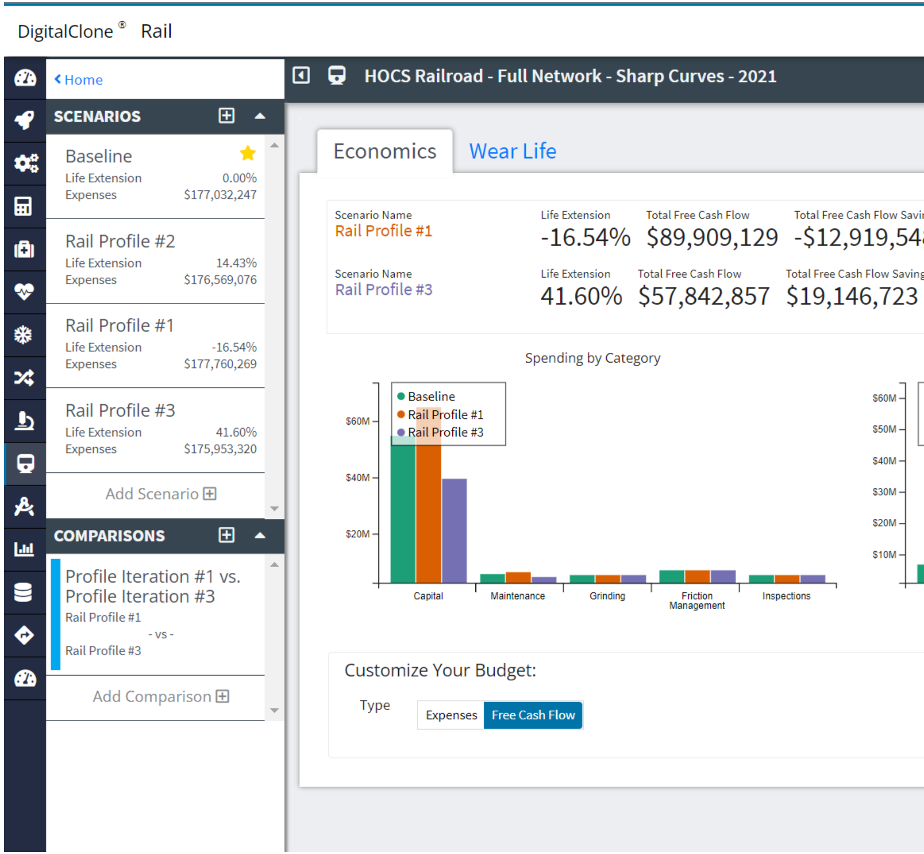
Precision Maintenance (PMx) Software

Decision Support and Investment Prioritization to:

- Prevent Surface Related & Wear Defects
- Protect Maintenance Budgets with Evidence
- Maximize Rail Life Extension



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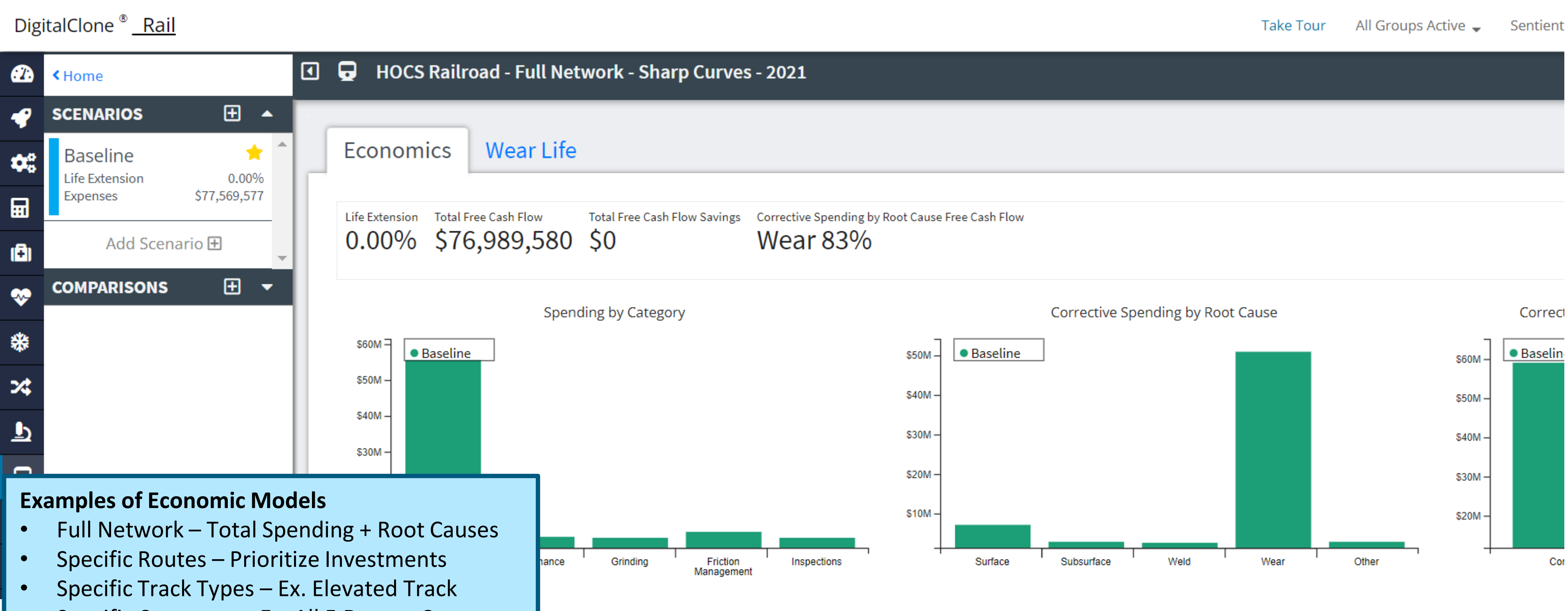
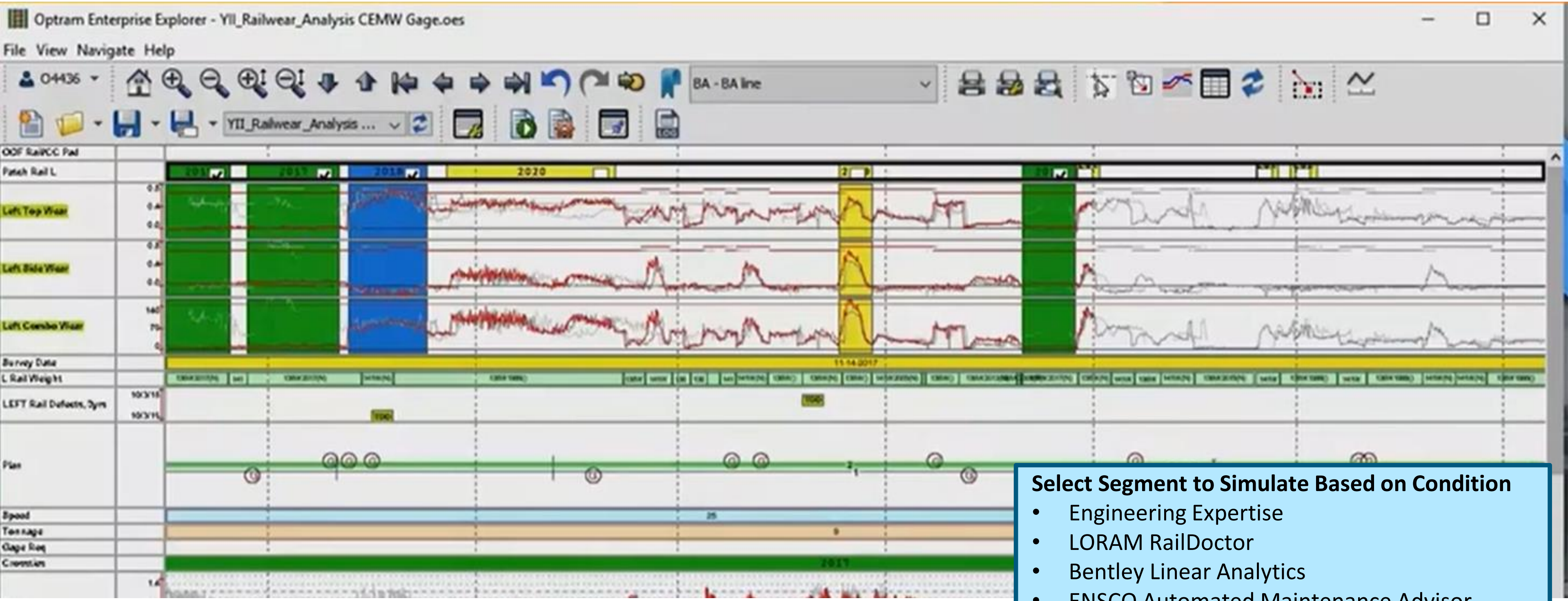
Select Where to Focus – Identify Total Spending and Root Causes for improvement



Examples of Economic Models

- Full Network – Total Spending + Root Causes
- Specific Routes – Prioritize Investments
- Specific Track Types – Ex. Elevated Track
- Specific Curvature – Ex. All 5 Degree Curves
- Specific Locations/Assets – Ex. One Curve

Select High Risk Rail – Identify **High Wear** and **RCF** locations for improvement

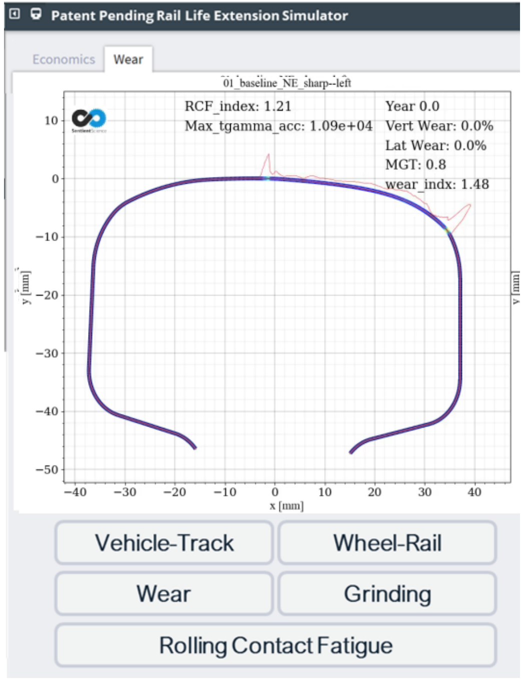


Select Segment to Simulate Based on Condition

- Engineering Expertise
- LORAM RailDoctor
- Bentley Linear Analytics
- ENSCO Automated Maintenance Advisor
- VisioStack RailLinks® Infrastructure
- In-House Linear Analytics Systems

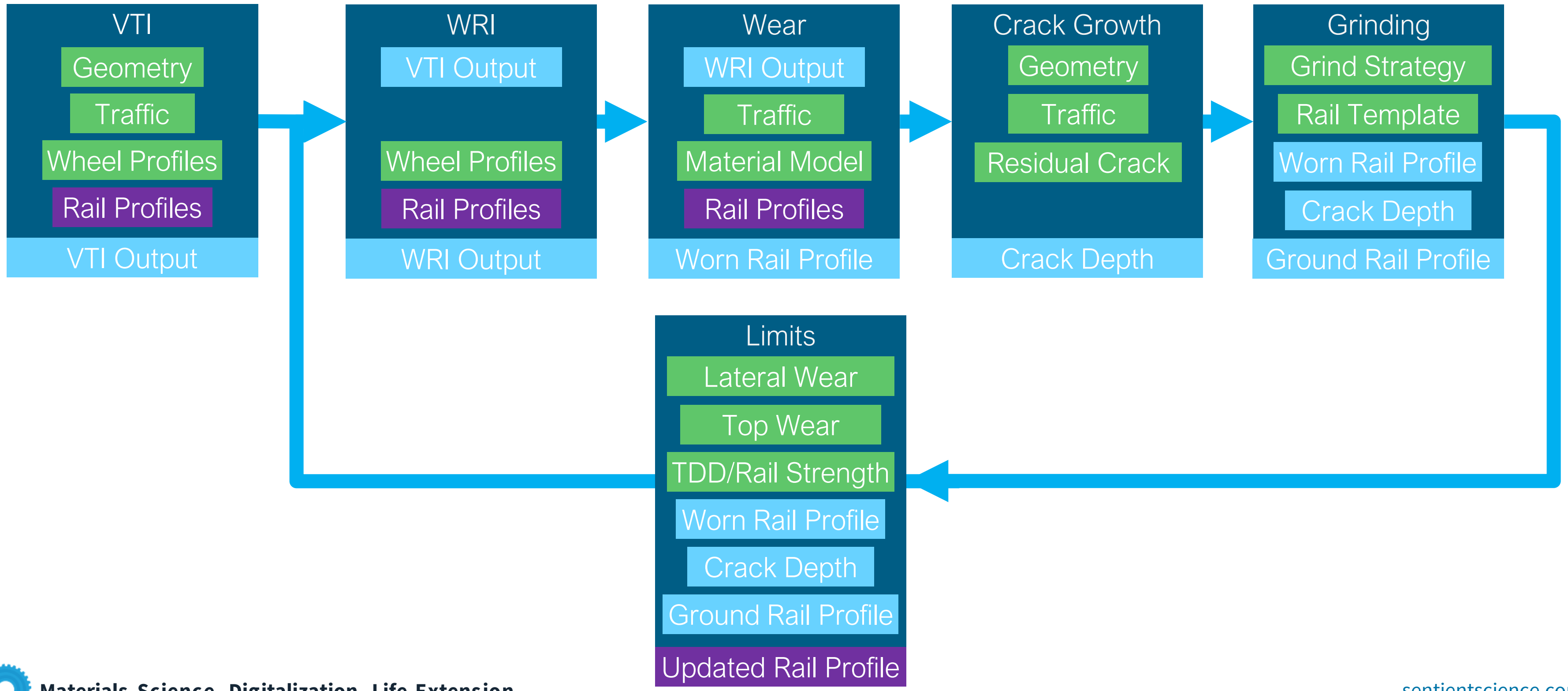
Opportunity: New Rail Profiles

- New profile design approach:
  - NRC-C to design profiles with dynamic pummeling analysis
    - Contact stress, conicity, RCF risk…
  - Sentient Science to test profiles with DigitalClone for Rail
    - Wear life, grinding, economics…



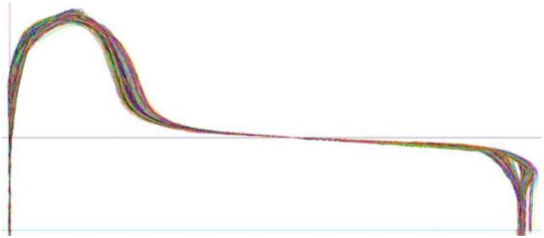
Profile Evolution Model Architecture

Wear Profile and Crack Initiation and Growth without VTI Loop



Required Data – Set-Up DigitalClone Models

1. **Track Geometry** – curvature, gauge, and super-elevation design
2. **Rail Profile** – rail profile and rail cant
3. **Rail Material** – rail material hardness and modulus of elasticity
4. **Rail Standards** – vertical wear limit, horizontal wear limit, combined wear limit
5. **Traffic** – MGT, speed, traffic direction, and traffic type (i.e. hopper, flat, tanker etc.)
6. **Wheel Population** – wheel profile shapes
7. **Grinding Strategy** – grinding target profile, grinding frequency, grinding depth of cut
8. **Friction Management** – gauge face friction coefficient, top of rail friction coefficient
9. **Guard Rail** – rail profile and guard rail spacing



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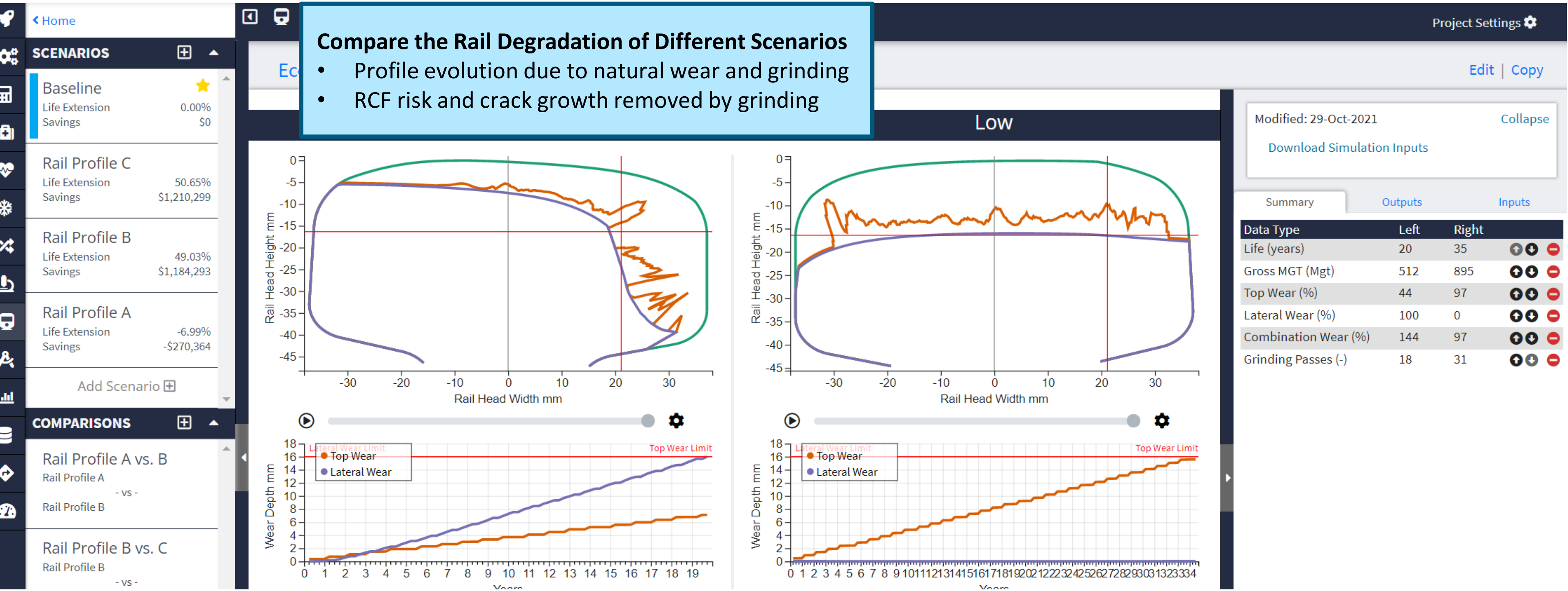
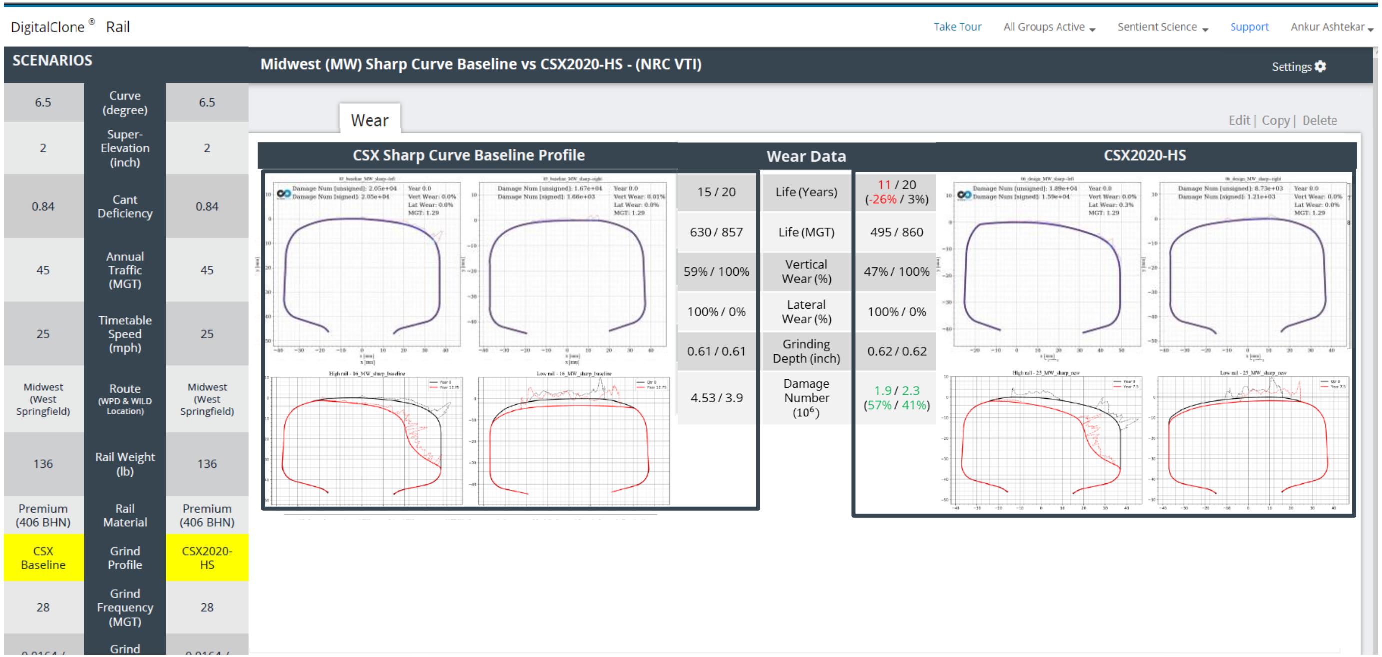
Compare Rail Life – Quantify Life Extension of different rail maintenance investments

Compare the Rail Degradation of Different Scenarios

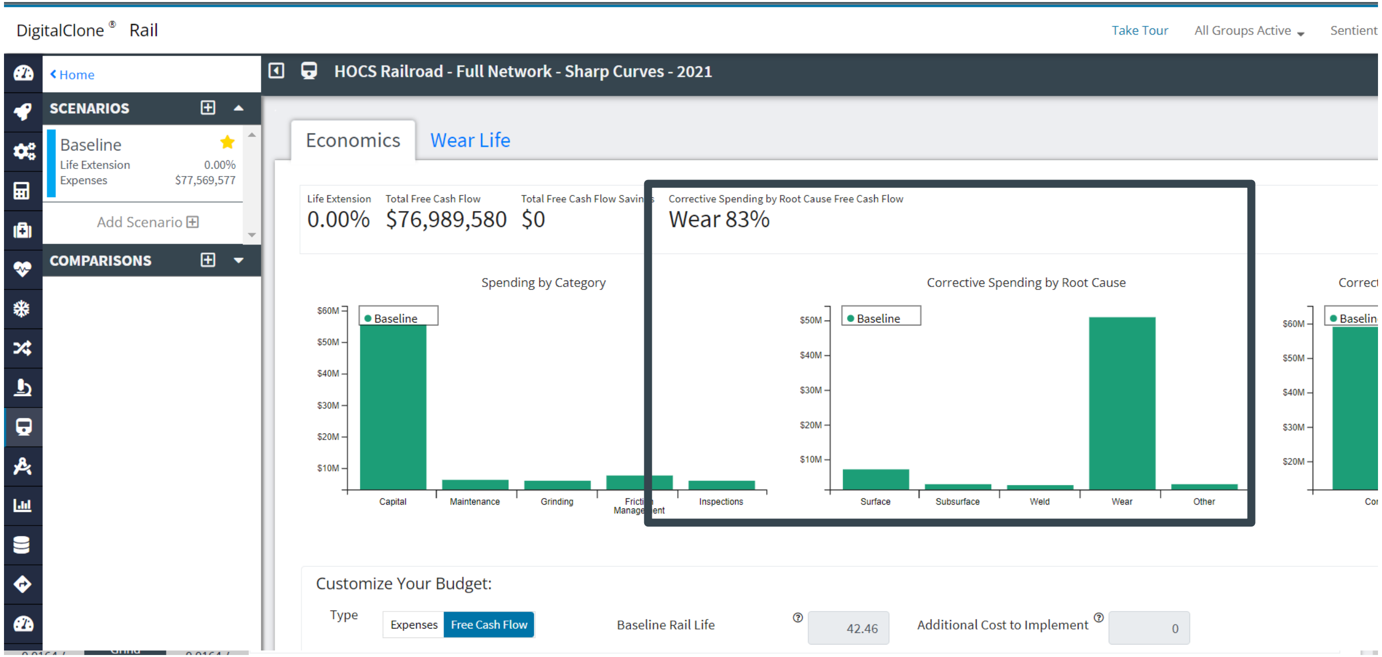
- Profile evolution due to natural wear and grinding
- RCF risk and crack growth removed by grinding





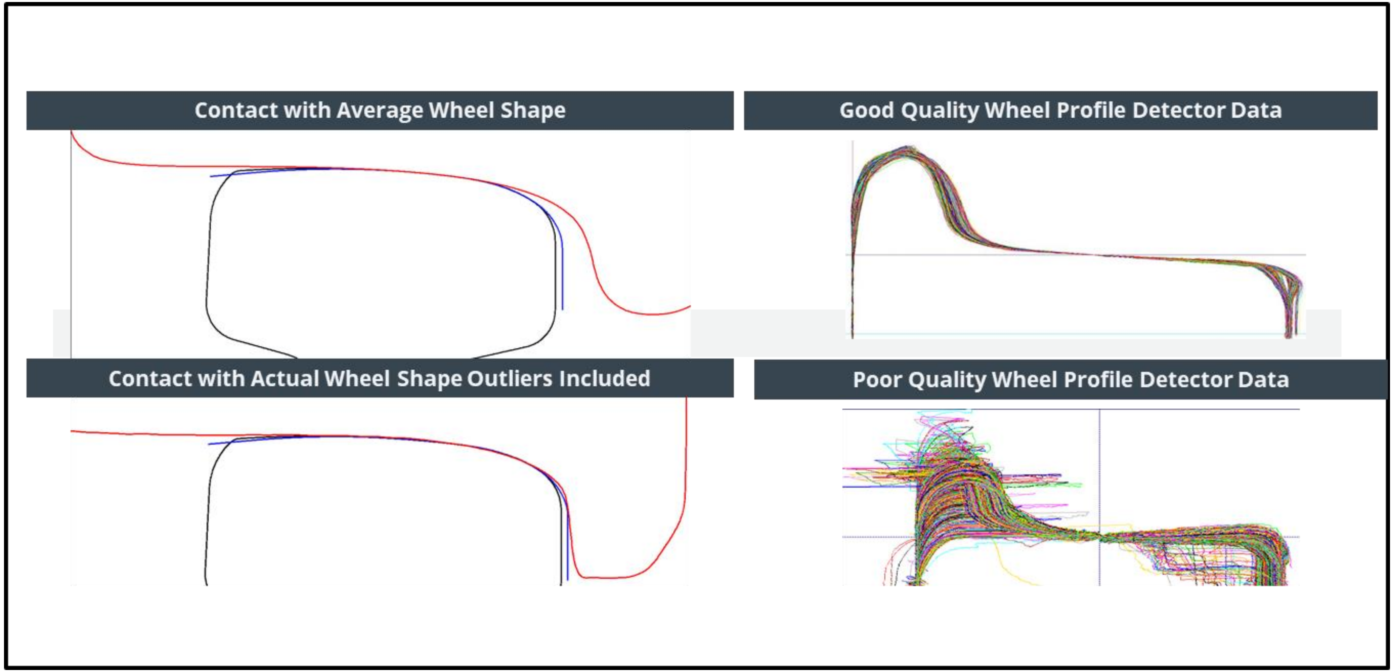
Case Study: New Profile Design Iteration #1

- **41% - 57%** Improved RCF, but **-26% to -42%** Wear Life



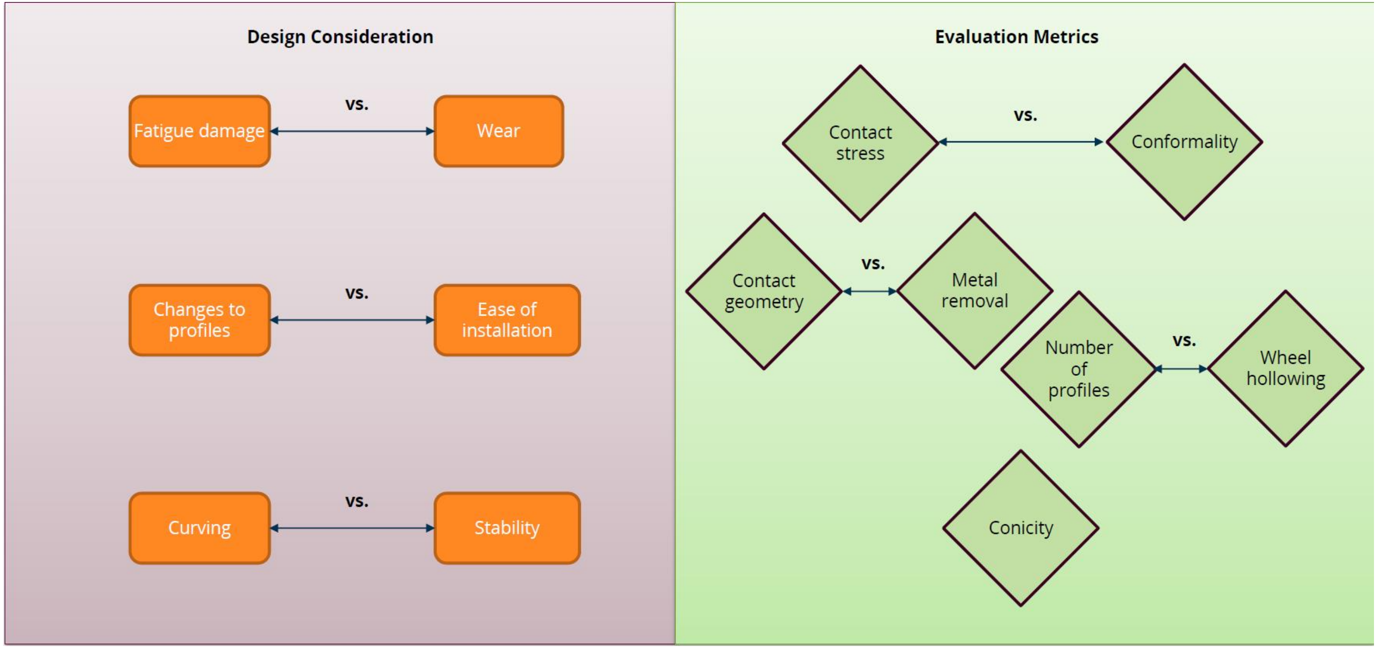
Case Study: New Profile Design Iteration #1 - Economics

- Wear Represents **80%+** of Sharp Curve Costs



Case Study: New Profile Design Iteration #1 – Root Cause

- Outlier Wheel Gauge Contact and Wear



Case Study: New Profile Design Iteration #1 – Trade-Offs

- ICRI Rail Profile Scoring Initiative – aashtekar@sentientscience.com

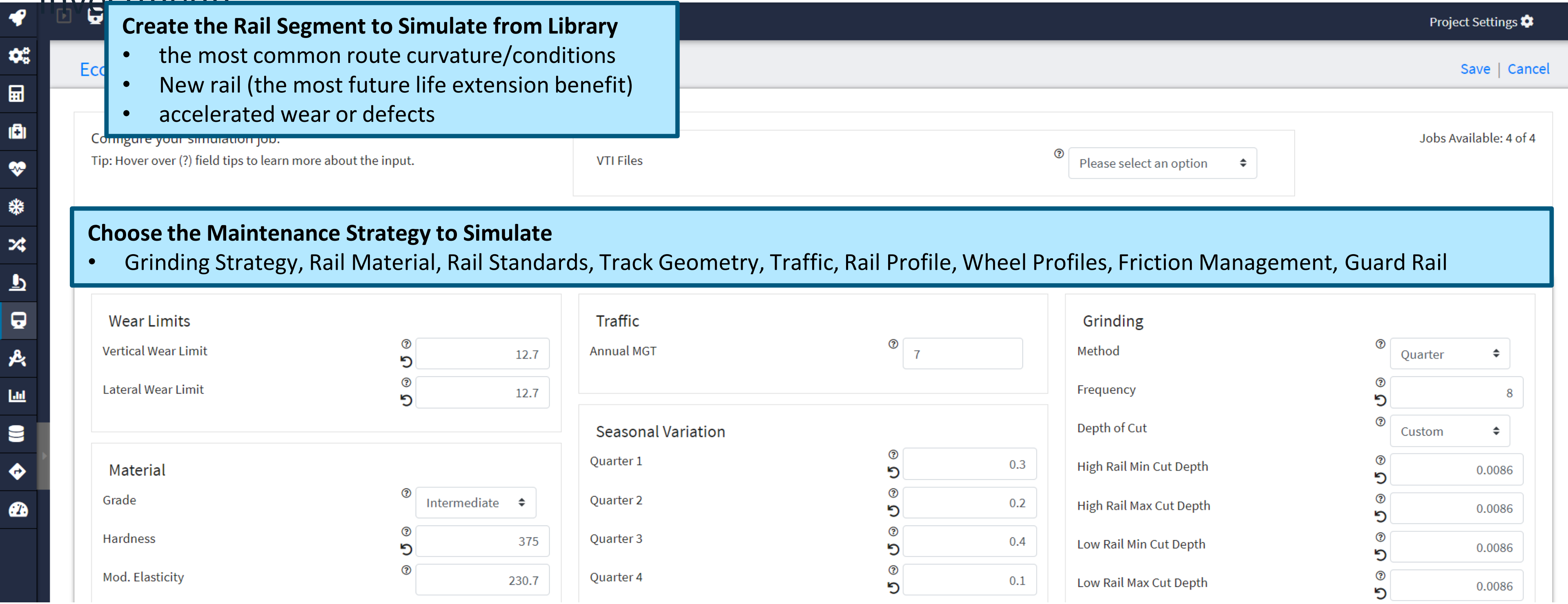
Select Maintenance – Compare **Life Extension** of different rail maintenance investments

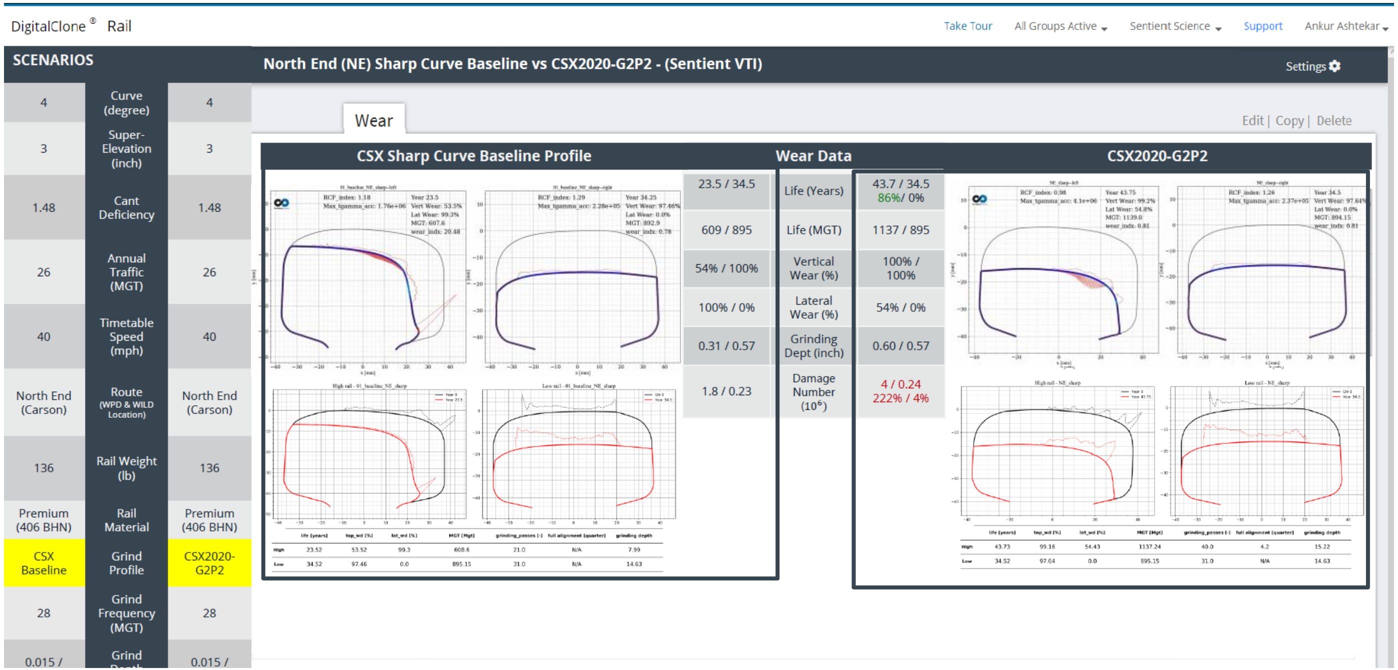
Create the Rail Segment to Simulate from Library

- the most common route curvature/conditions
- New rail (the most future life extension benefit)
- accelerated wear or defects

Choose the Maintenance Strategy to Simulate

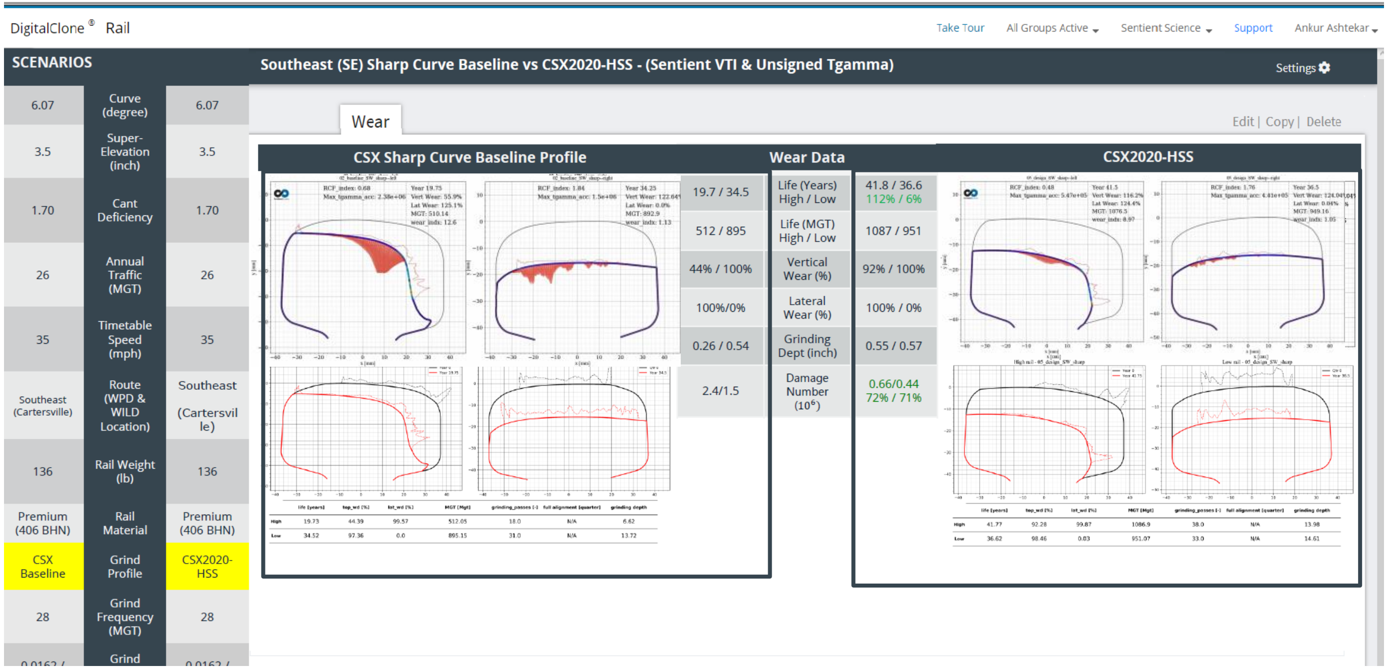
- Grinding Strategy, Rail Material, Rail Standards, Track Geometry, Traffic, Rail Profile, Wheel Profiles, Friction Management, Guard Rail





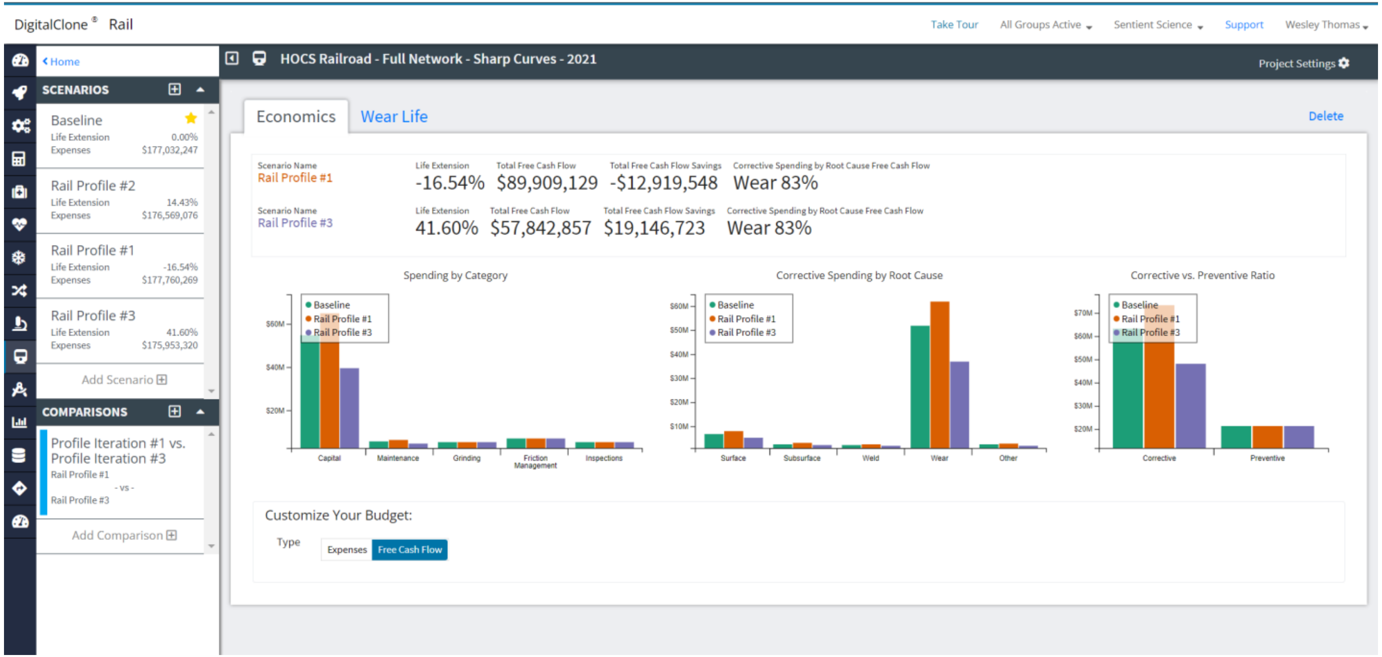
Case Study: New Profile Design Iteration #2

- **+86%** to **+133%** Wear Life, but **2x** to **5x** Higher RCF Risk



Case Study: New Profile Design Iteration #3

- **+40%** to **+110%** Wear Life, **70%+** Lower RCF Risk

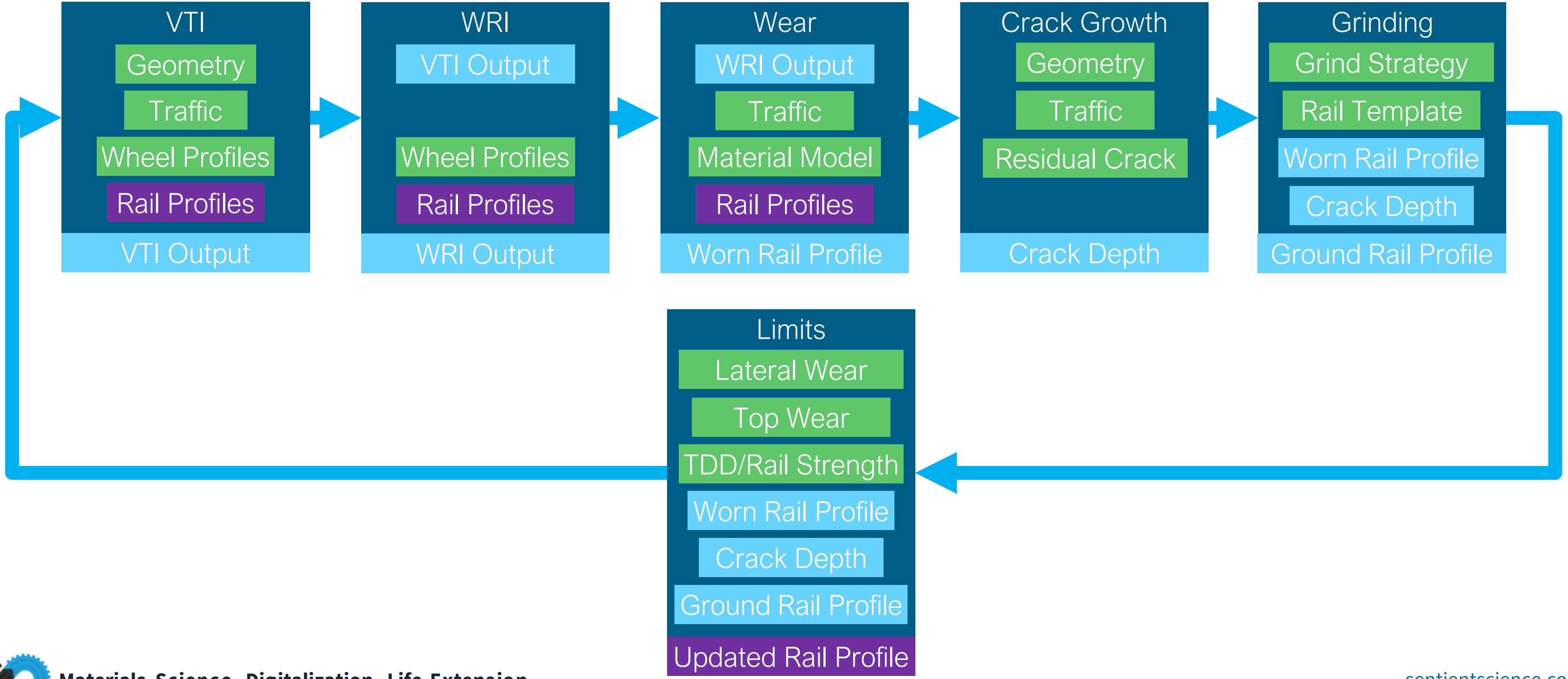


Case Study: New Profile Design Iteration #3 - Economics

- **$13M+** Annual Savings and Avoided **$2M+** Annual Loss

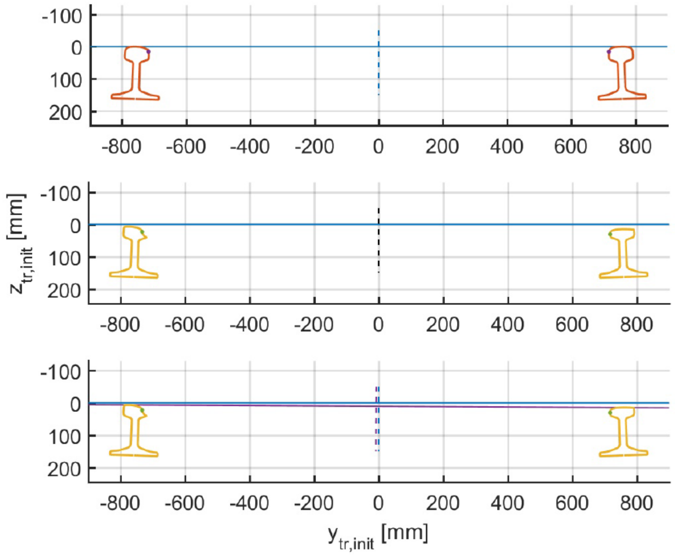
Profile Evolution Model Architecture

Wear Profile and Crack Initiation and Growth with VTI Loop



Challenges

- Vampire Rail Orientation
  - Vampire aligns rails using the gauge width
  - Gauge width will evolve, unsymmetrically, as rail profiles evolve
  - Currently working with track irregularity “hack” to keep the rail position constant
  - Any better options, we should explore?
- Vampire Network Licensing
  - Enable Cloud deployment
  - Network wide scaling
  - Bespoke Site-Specific Profiles and maintenance



Key Take Aways & Next Steps

1. Test profiles with life extension and economics before field
2. “Scoring” metrics enable optimization + automation

- ICRI Rail Profile Scoring Initiative
- Curve groups -> condition group -> asset specific profiles

3. Measure field improvements & monitor triggers to change template:

- Wheel Profiles, Traffic Speeds / Cant Deficiency, Track Geometry…

4. Optimizing system maintenance requires optimizing specific locations

Thank you!

Acknowledgements

Dan Hampton (CSX), Alexandre Woelfle (NRC-C), Eric Magel (NRC-C), Charles Rudeen (LORAM), Edwin Vollebregt (CMCC), Peter Klauser (Vehicle Dynamics Group), Wesley Thomas(Sentient), Ashkan Darbani (Sentient)