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Mitigating Derailment Risk at Switch Points & Guard Rails

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Background

- Turnouts present unique derailment risk relevant to wheel/rail interaction
- Yard tracks have many turnouts
- AAR Turnout Derailment Technical Advisory Group (TAG)
- Past topic of research and implementation

IDEA
Innovations Deserving Exploratory Analysis Programs

BNSF RAILWAY
MxV RAIL

Wheel Rail Contact

- How to visualize
- How to assess
- Consider track components and wheel profile

Vertical Wear Angle

- How to measure
- Where to measure

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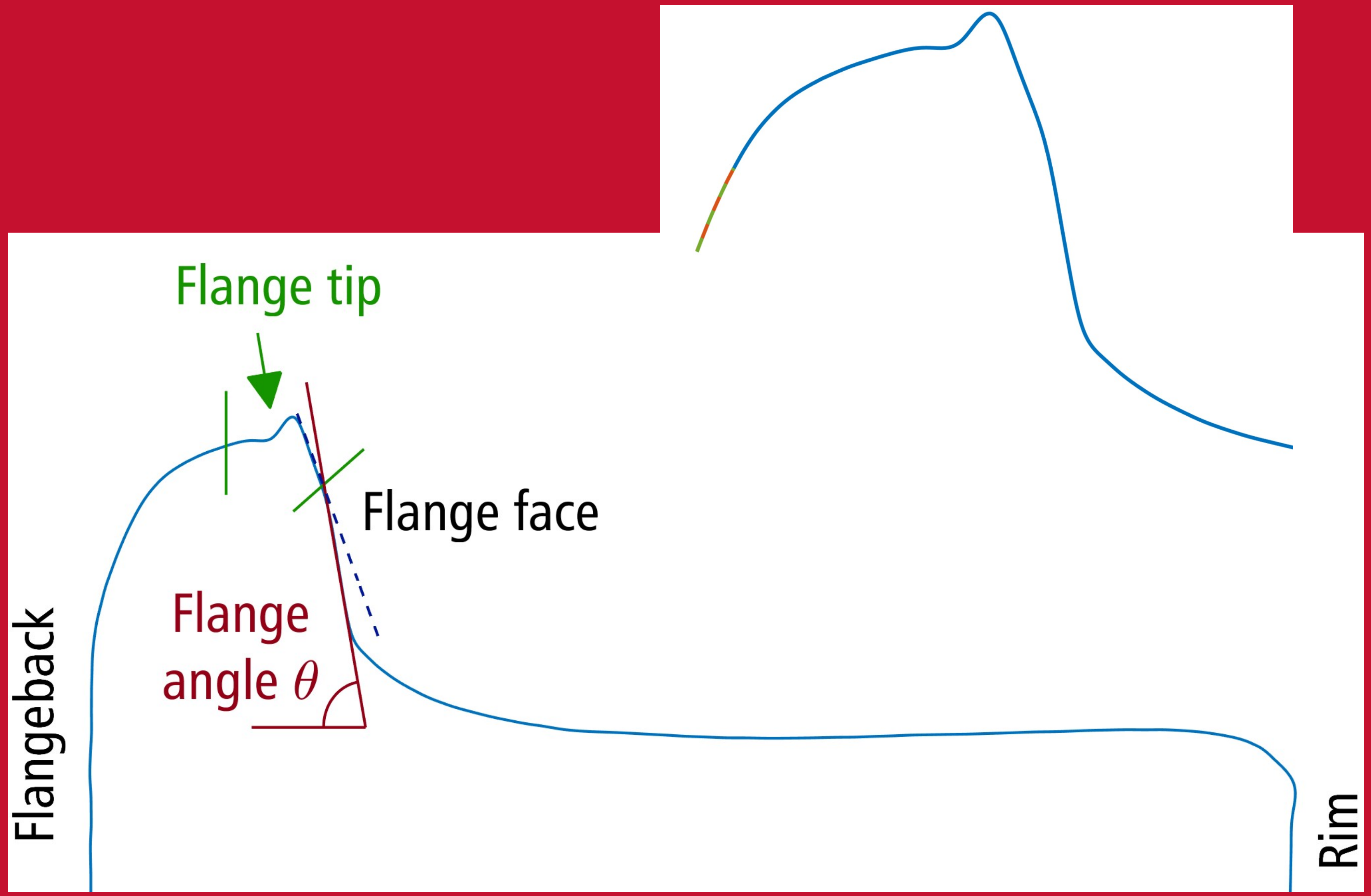
FLANGE TIP FLOW

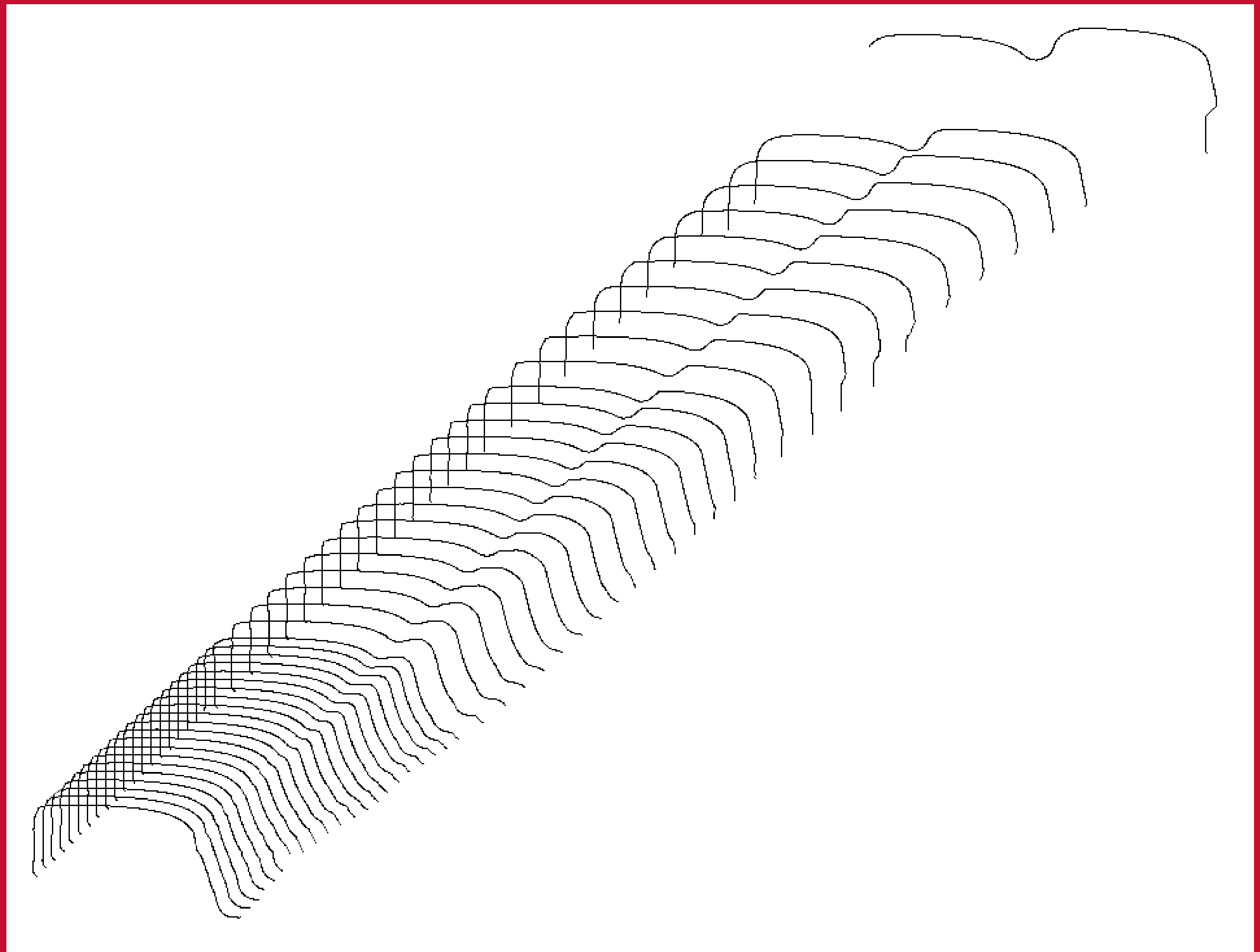
- The Association of American Railroads (AAR) maintains rolling stock related specifications.
- No North American limit on flange tip metal flow, with British Standard limit at ~0.2 inch (5 mm)
- Calculated 1) flange tip metal flow, 2) maximum and 3) bilinear flange angle.
- Identified nine wheel profiles with:
  - Flange tip radius < 0.1 inch (2.5 mm)
  - Maximum flange angle > 77.5°



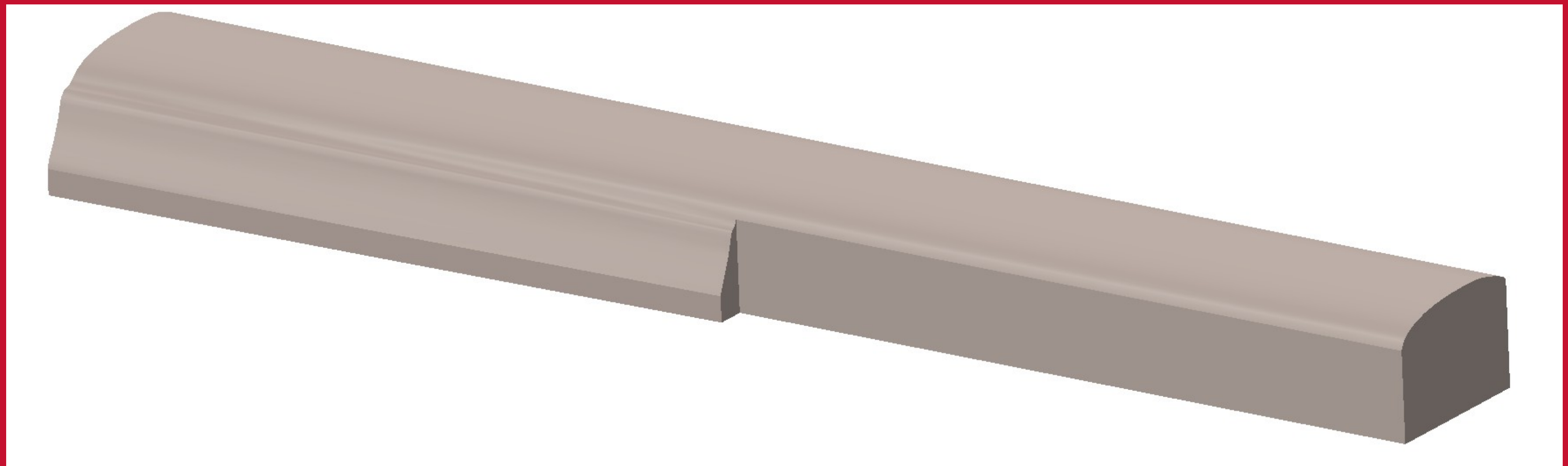
Flange terminology and the calculation of minimum flange tip radius

FLANGE TIP FLOW

- NUCARS®* analysis, empty hopper car and measured profiles to determine:
  - Lateral wheelset displacement
  - Angle-of-attack
- 3D CAD analysis to determine potential 3D interference of flange and switch profiles



Transverse rail profiles measurements of a turnout switch and stock rails

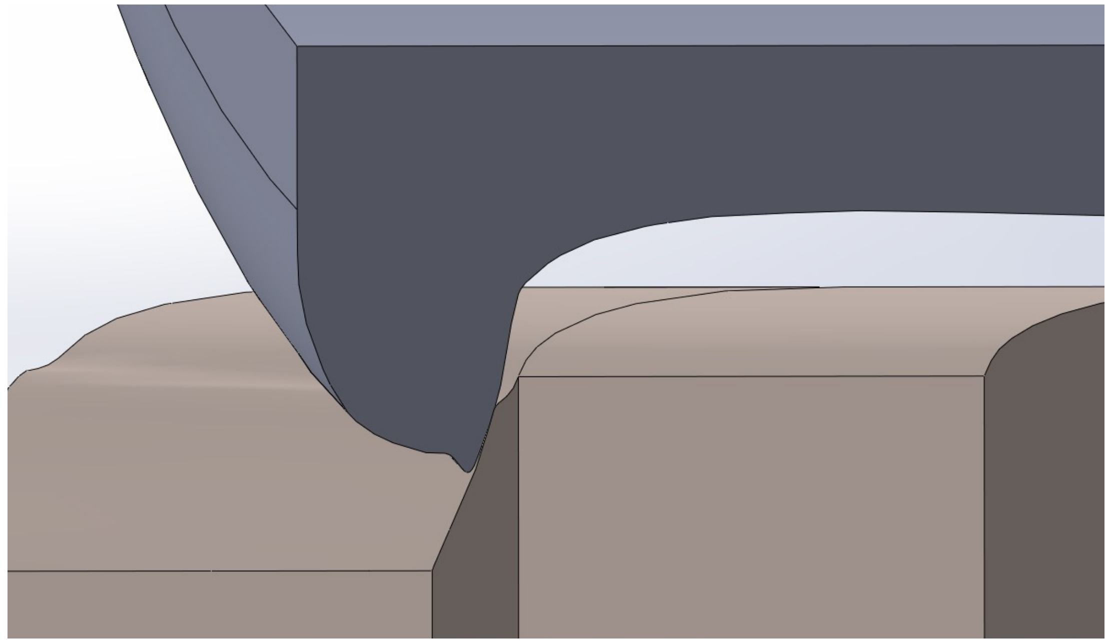


3D CAD model of turnout switch and stock rails

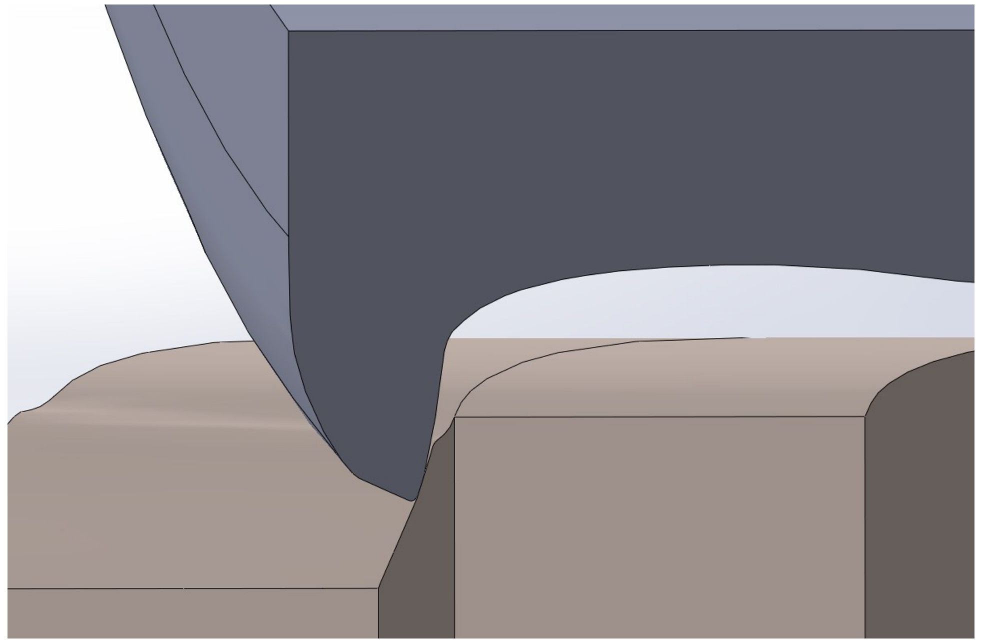
*NUCARS® is a registered trademark of MxV Rail

FLANGE TIP/SWITCH INTERACTION

#	Flange tip radius [inch] (mm)	Flange Angle [°]	Lateral displacement [inch] (mm)	Angle of attack [mrad]
1	0.059 (1.5)	80.1	0.49 (12.4)	1.95
2	0.067 (1.7)	78.3	0.47 (11.9)	0.46
3	0.079 (2.0)	83.2	0.68 (17.3)	1.49
4	0.091 (2.3)	78.7	0.55 (14.0)	0.15



Wheel 1 contacting switch



Wheel 3 contacting switch

NUCARS ANALYSIS

- For nominal wheel and rail, clearance between flange and gage face 0.46 inches (11.7 mm)
- Angle of attack typical of curving through 1 to 2 degree curves

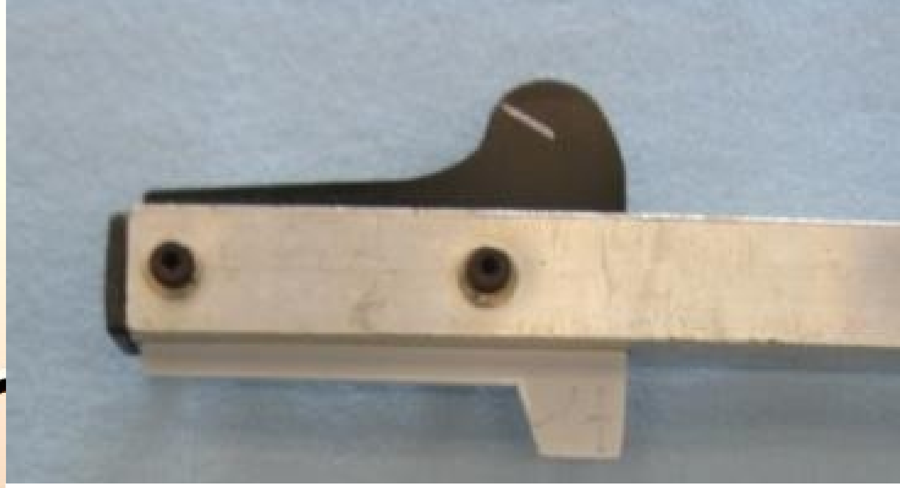
WHEEL 1

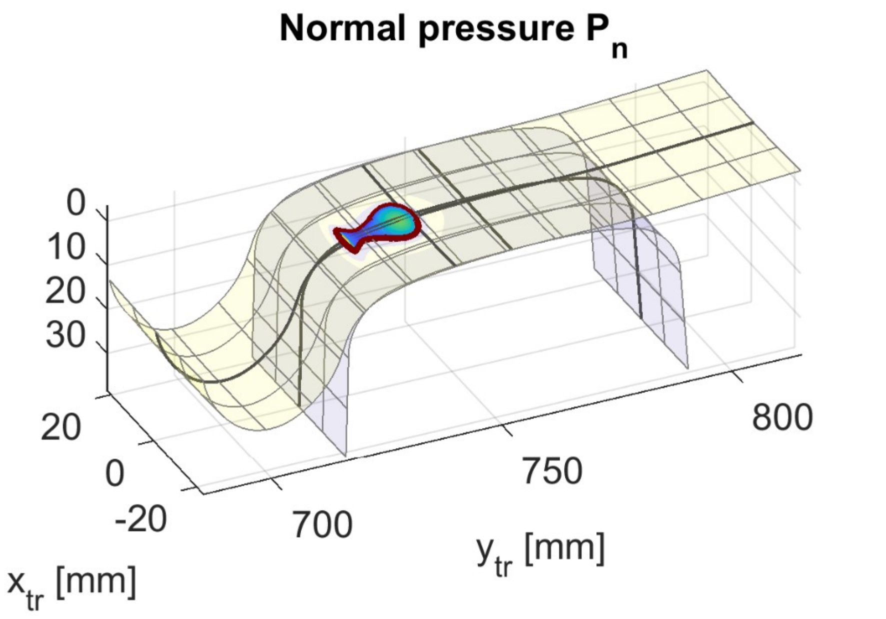
- Flange contact ahead of tread contact point
- Was not able to pick the switch point
- Contact on bi-linear flange with lower flange angle

WHEEL 3

- No flange tip flow
- Flange contact ahead of tread contact point without picking the switch
- Contact on bi-linear flange with lower flange angle

CONCLUSIONS & FUTURE WORK





- 6.8% of studied wheel population would be condemnable by British standards
- Likelihood of derailment due to worn wheels with flange tip metal flow may increase when the switch 1) maintenance and adjustment is poor, 2) is chipped or broken and 3) contact with bilinear flange.
- Assessment of worn wheels together with limits suggested by IDEA gauges
- Assessment of wheel-rail interaction in NUCARS® with 3D contact calculation with CONTACT

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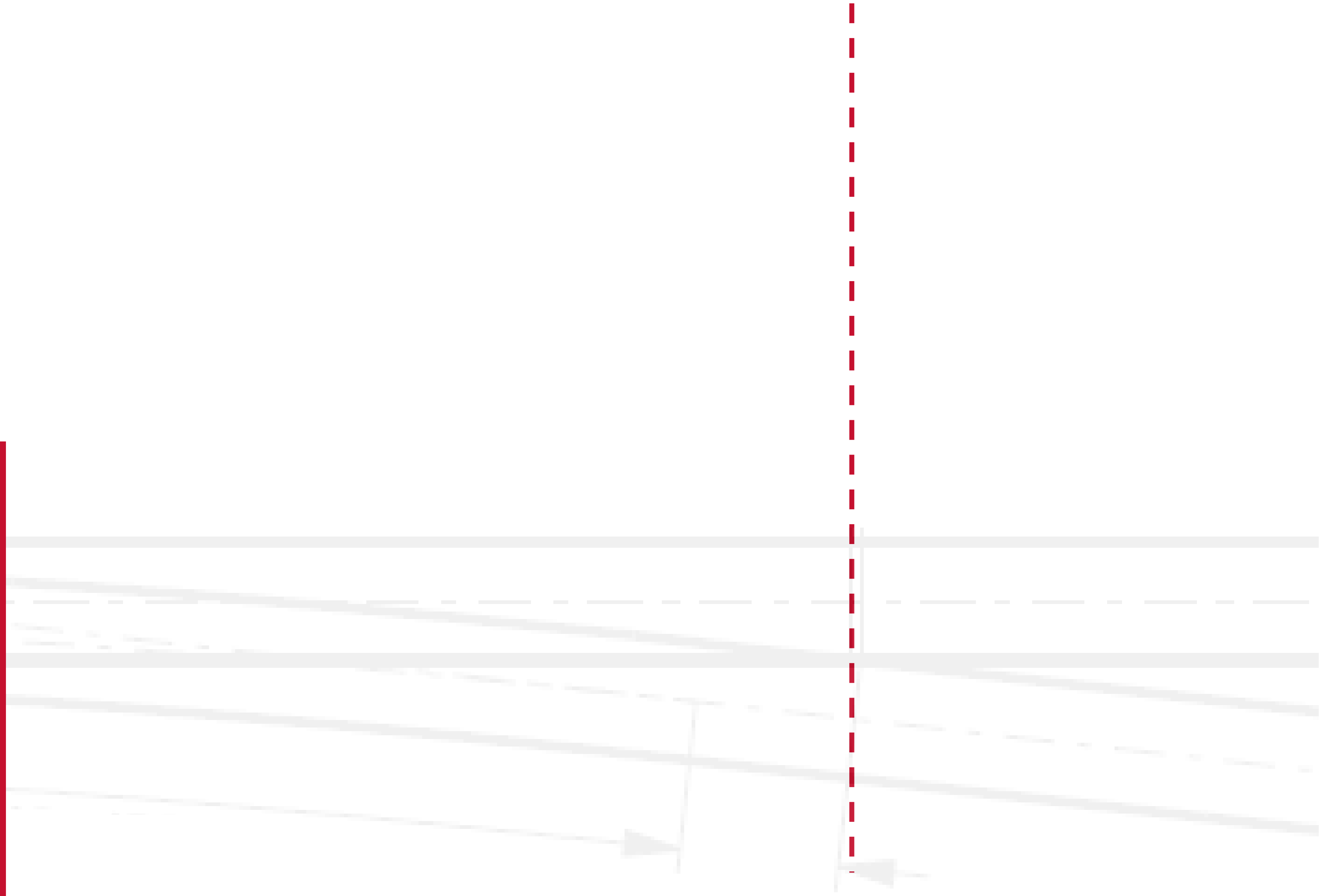
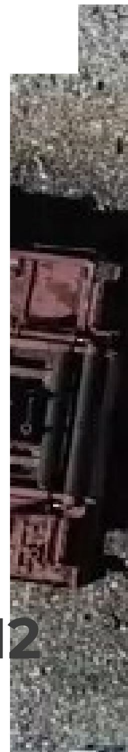
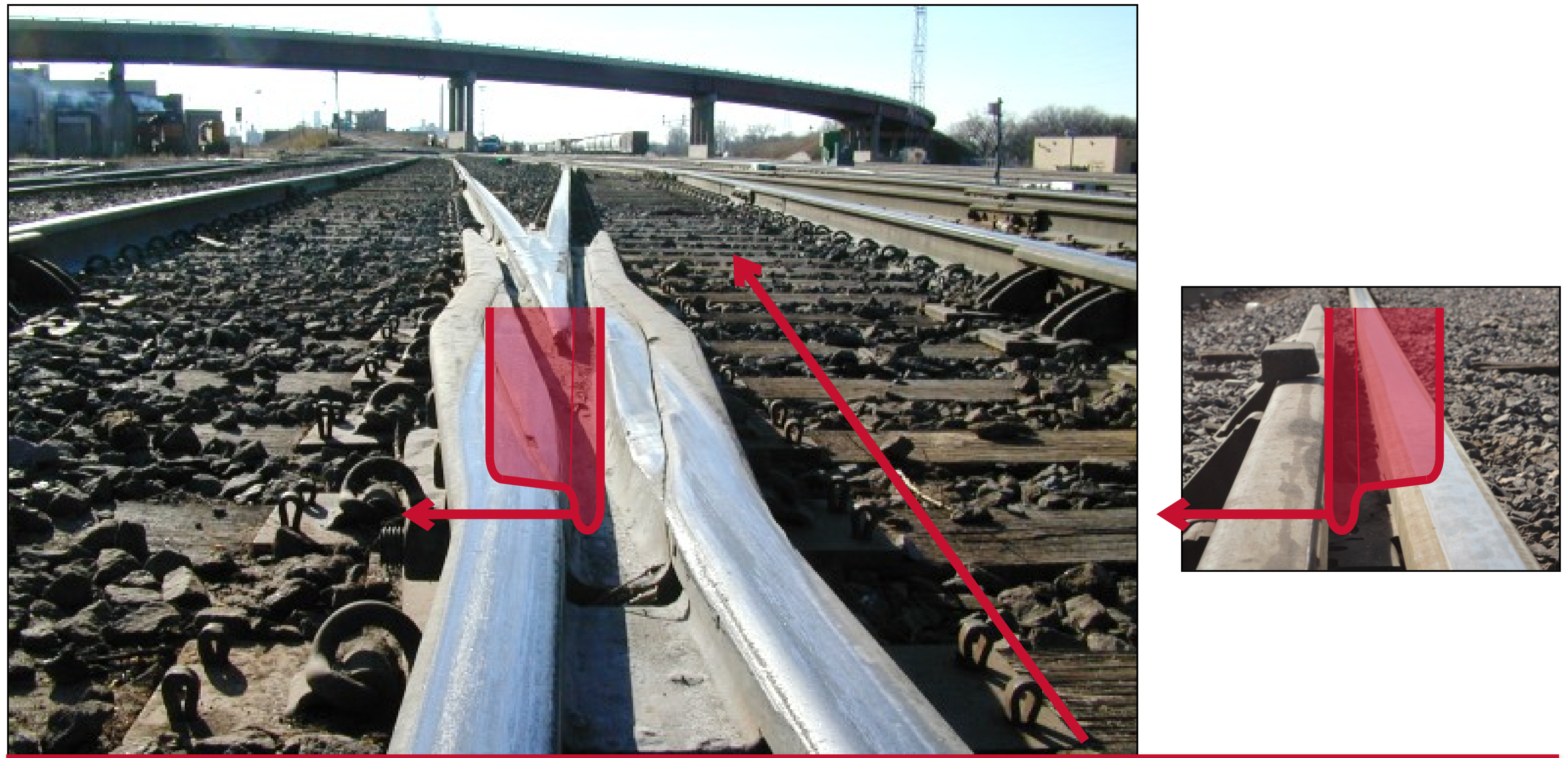


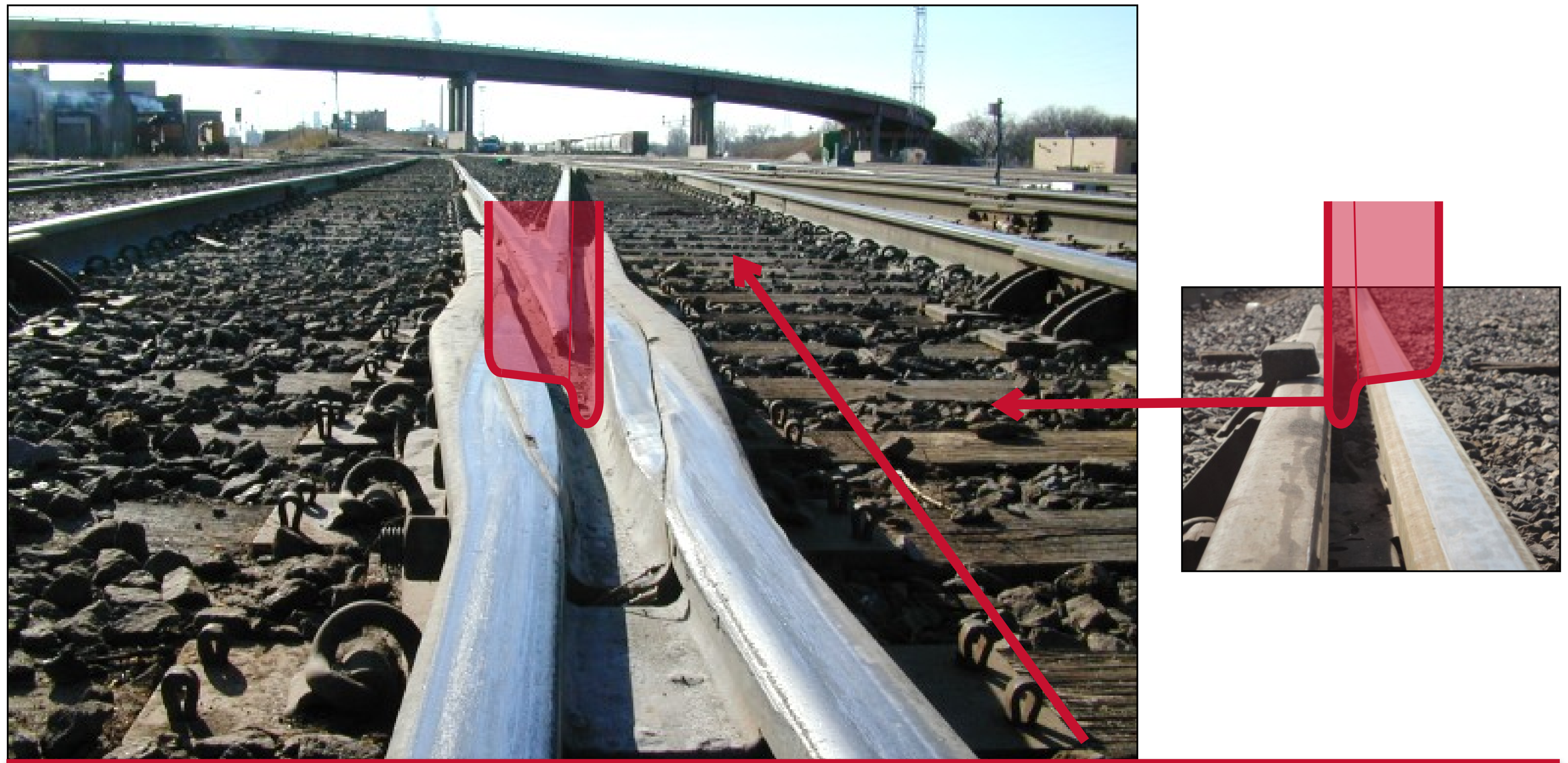
Common Factors:

1. Diverging route of tight turnout
2. Light car, often long
3. Car operating under buff (compressive) load
4. Wheel climb at guard rail with climb marks just prior to frog point

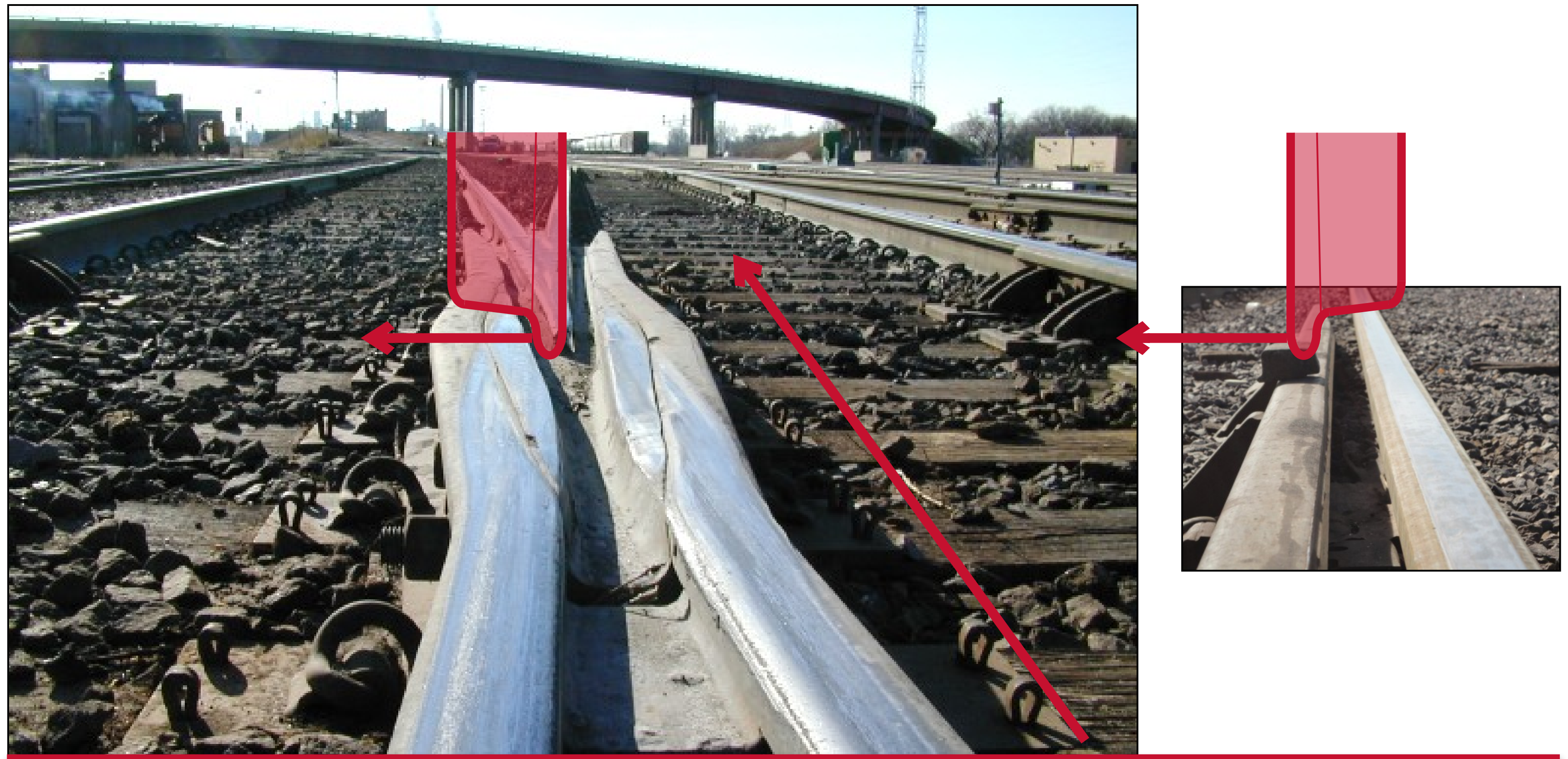




1) Wheelset entering frog throat

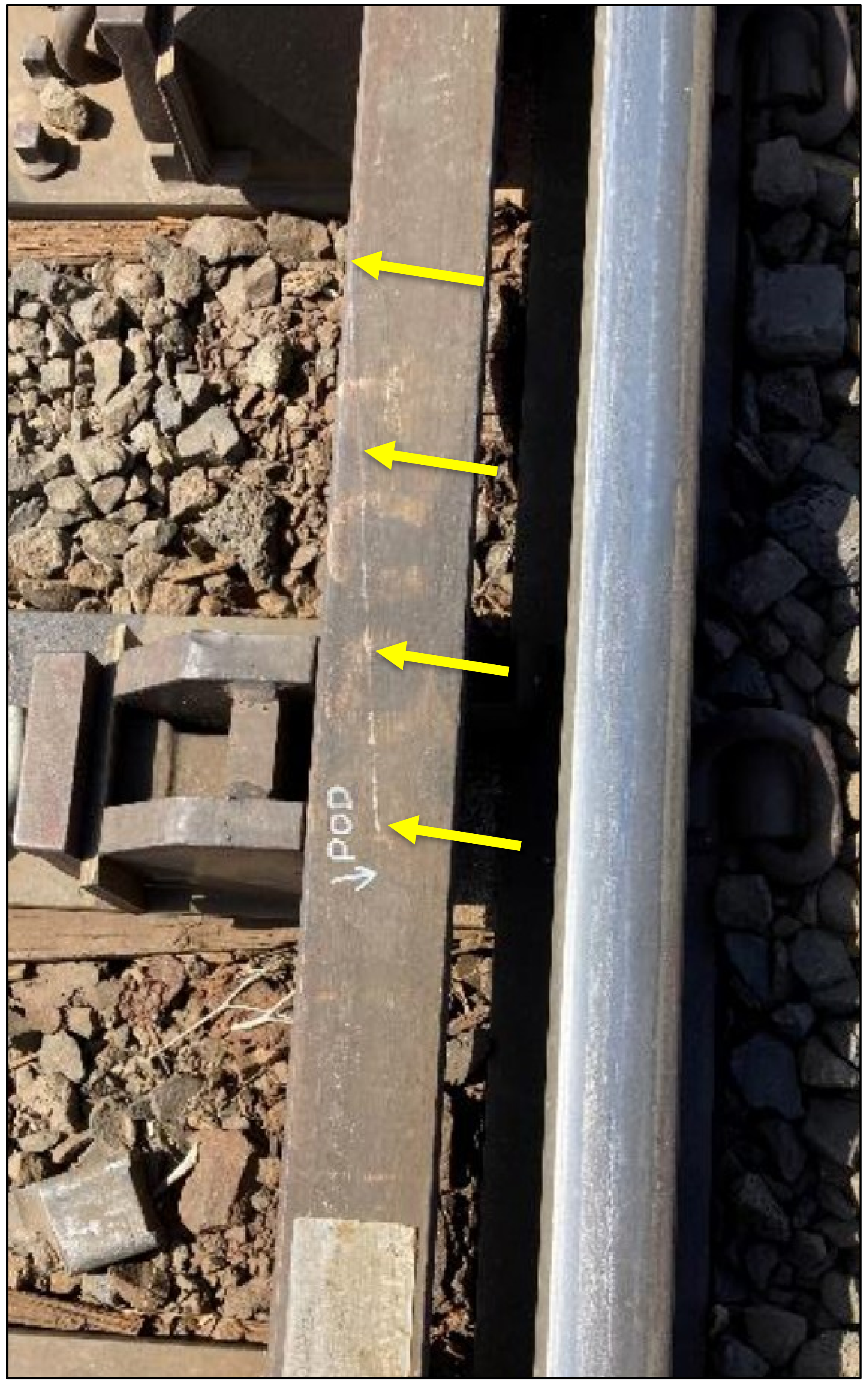


2) Lateral force reacted at guard rail only



3) Wheel climb at guard rail (rock at POD)

Example Wheel Marks



Long wheelmarks indicate an absence of large lateral wheel load.

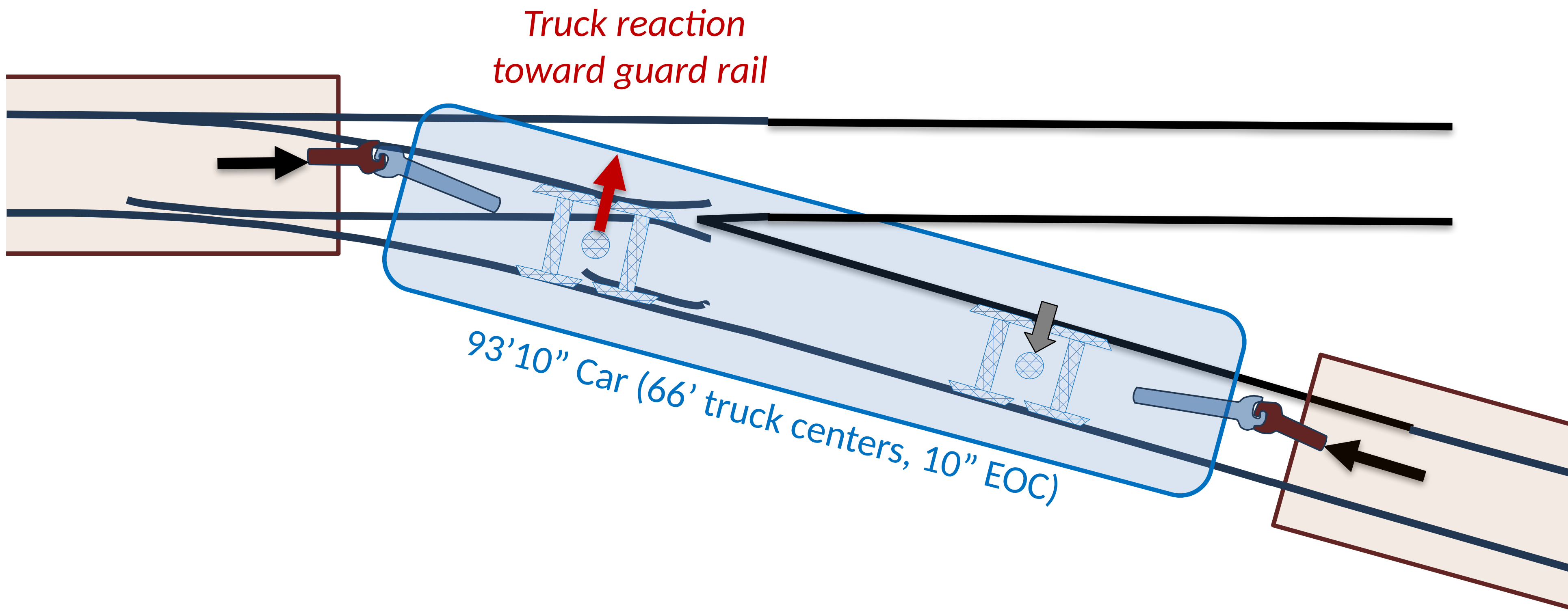
3 Guard Rail Climb Derailment Mechanisms*

1. Excessive buff force
2. Angled/Sloped wear of the vertical guard rail face
3. Guard face gage and back-to-back wheel spacing interference

*Selected due to wheel/rail interaction focus and recent mitigation findings

1) Excessive Buff Force

- Lateral truck bolster forces generated due to car-to-car / coupler angularity
- With little/no lateral restraint in the throat of the frog, most of this force is reacted at the guard rail
- Depending on turnout size and car geometries, axle angle of attack at the guard rail can be significant
- Becomes an L/V wheelclimb mechanism, but acting at the back of the wheel flange



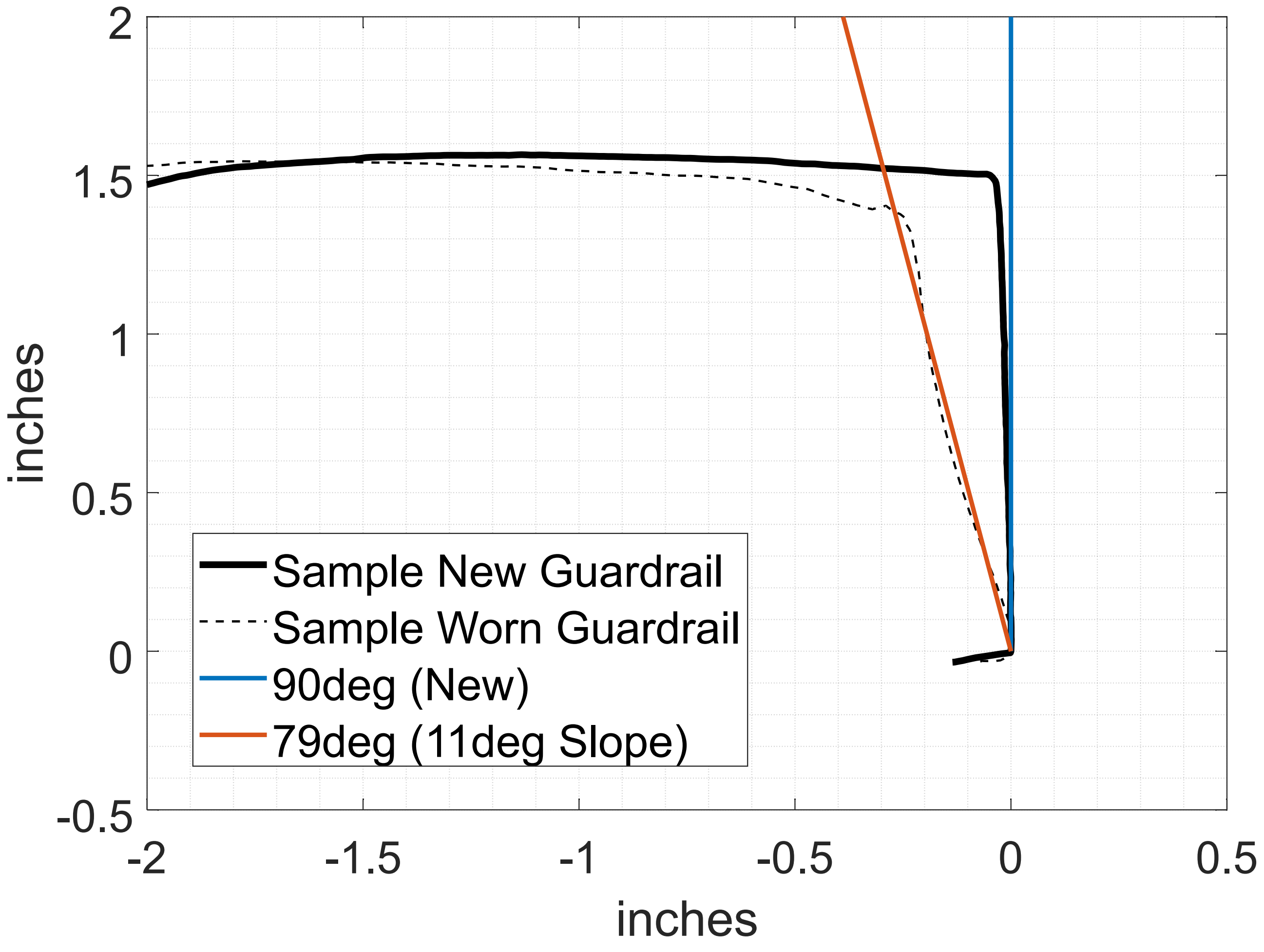
Mitigation opportunities

- **Manage in-train forces relative to turnout size, yard operations and maintenance condition**
- **Consider self-guarded frog**

2) Angled/Sloped wear of the vertical guard rail face

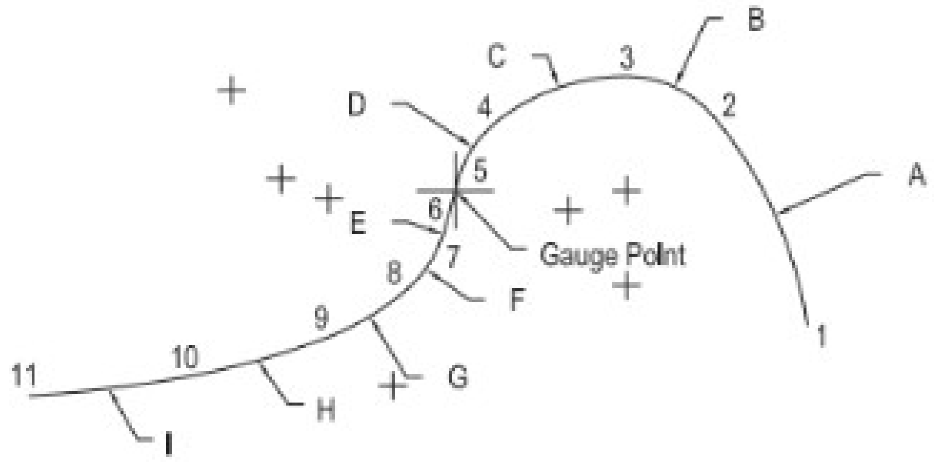
Guard rail wear decreases L/V required to climb

- Turnouts which take significant diverging route traffic
- Wear may be concentrated; measure the wear angle near the POD / just prior to frog throat
- Contact angle at back of the wheel flange is less than that of the flange root



Mitigation Opportunities

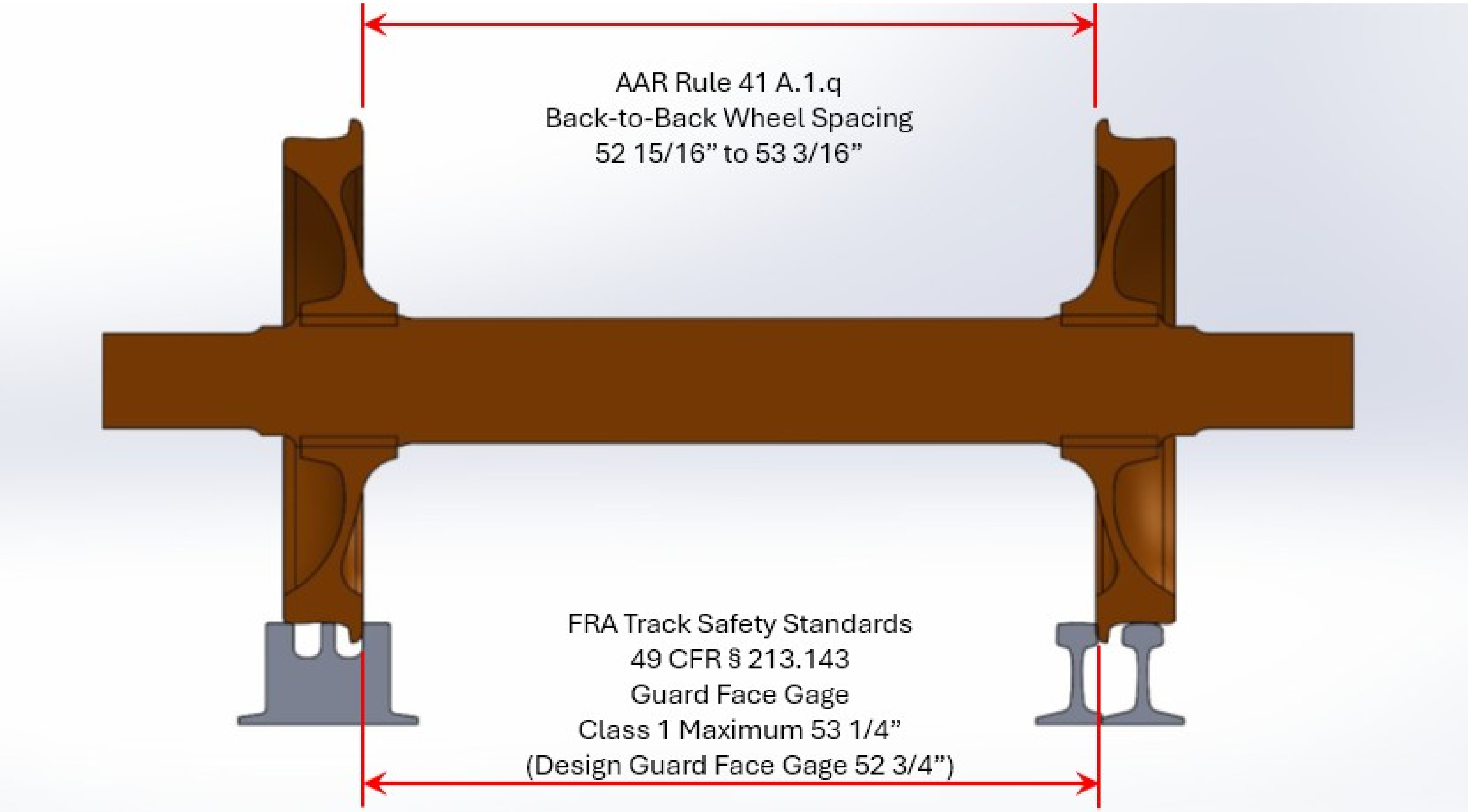
- **Monitor guard rail wear and securement**
- **Consider raised guard rails**



3) Guard face gage / back-to-back wheel spacing interference

When the back-to-back wheel spacing is smaller than the guard face gage, one of the following happens:

1. The interference causes a displacement of the track components
2. The wheelset climbs the guard rail to make clearance
3. Some combination thereof



Mitigation Opportunity

- **Maintain both guard face and guard check with respect to back-to-back wheel spacing requirements.**

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Top-of-rail friction control in yards

Use of Self-guarded Frog.

Maintenance and Inspection Training and Practices

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Related Research

www.mxvrail.com/technology-digest/

TD23-011, "*Assessment of Wheel Profiles and Switch Point Derailments*"

www.railresearchweek.com

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