Doublestack Rail Rollover: déjà vu or something new?

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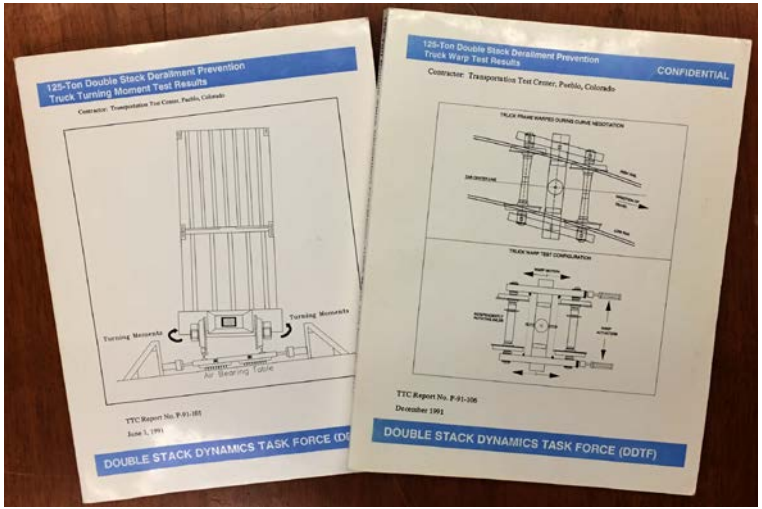
Presentation Outline

- Doublestack derailments of the 1990's
  - DDTF findings and recommendations
- NS rail rollovers of the 2000's
  - Conclusions and corrections
- Recent doublestack derailments
  - What happened?
  - Does two make a trend?

Doublestack derailments of the 1990's

- DDTF findings and recommendations
  - Warp restraint essential
  - Truck turning moment
  - CCSB's – long travel
  - Elastic rail fasteners
  - Others…



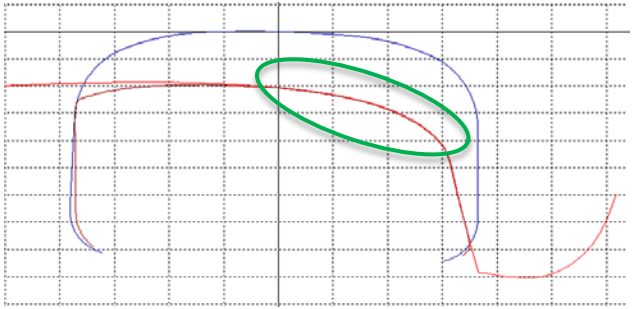
NS Rail Rollovers of the 2000's

- Conditions
  - 6-9 degree curves
  - Both rails rolled out, one rolled over
  - Under loaded/heavy trains
  - Soon after track maintenance
  - Cut spikes, standard 18" plates

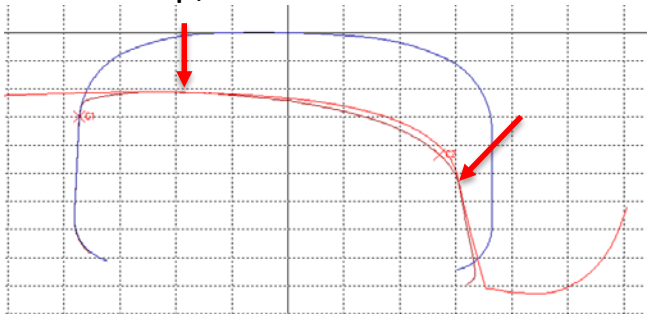
NS Rail Rollovers of the 2000's

- Conclusions
  - "Adverse" rail profiles (usually high rail)
  - Poor contact geometry with most wheels
  - Lack of rolling radius differential (RRD)
  - Generated high gage-spreading forces (truckside L/V)

Rail canted out, Conformal contact



Rail set up, Two-Point contact



NS Rail Rollovers of the 2000's

- Corrections
  - Focus on field relief when grinding
  - Evaluate profile before "setting up" canted rail
  - No setting gage tight
  - Elastic fasteners (Victor plates on curves ≥ 6°)
  - Top of Rail Friction Modifier

Recent Doublestack Derailments

- Common conditions
  - 4-6 degree curves
    - No Victor plates
  - Articulated doublestacks – intermediate trucks
    - No adjacent truck to hold down the rail
  - Hollow-worn wheels
    - What does that mean?

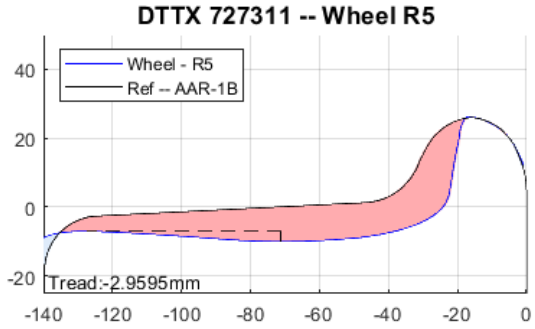
Recent Doublestack Derailments

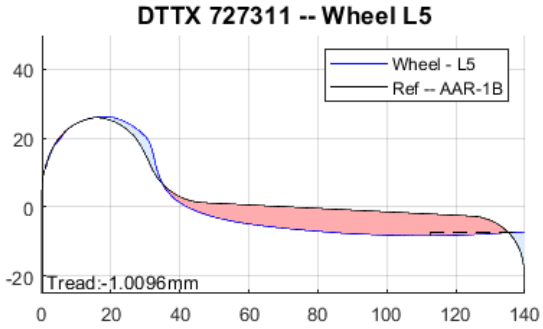
- Excellent track conditions
  - Good geometry
  - No canted rail
  - Minimal plate cutting
  - Optimum GF lube, no TORFM
  - Moderate High Rail wear

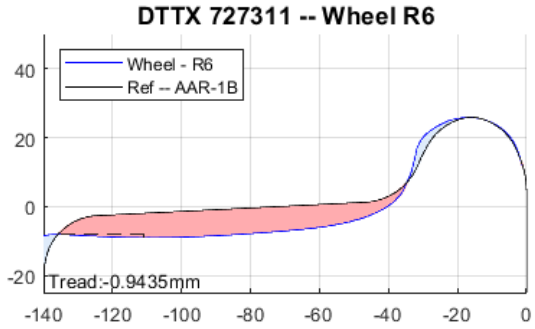
Recent Doublestack Derailments

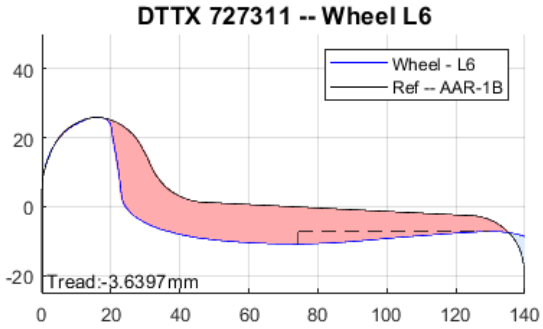
- No equipment problems
  - No sign of truck warp or stiff turning trucks
  - All CCSB's in tolerance (that could be measured)
  - WILD forces nominal
  - Hollow-worn wheels

Wheel Profiles







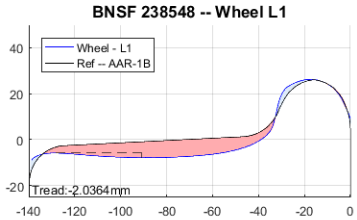


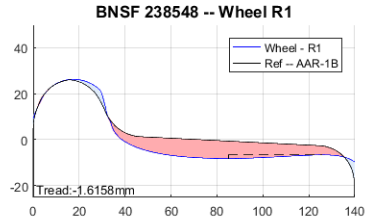
- Hollow wear
- Moderate to near-condemnable
- AAR Rule 41 limit: 4mm on RIP track, 5mm elsewhere

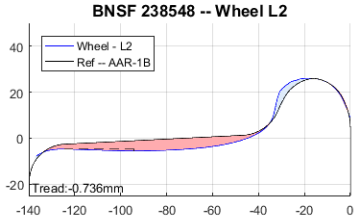
(Note: I will be mixing elements from both derailments.)

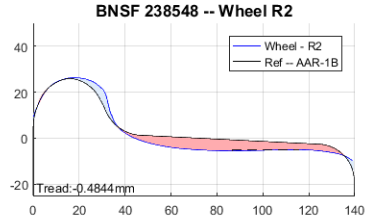
Wheel Profiles

B Truck

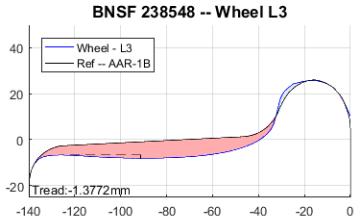


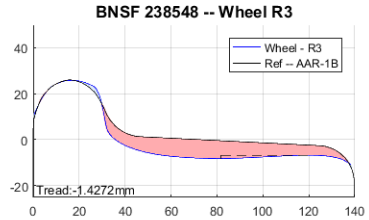


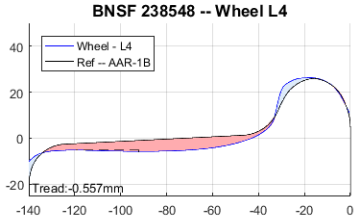


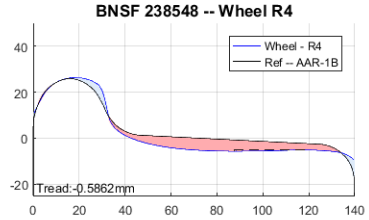


C Truck







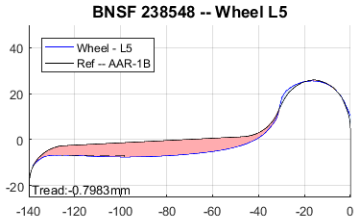


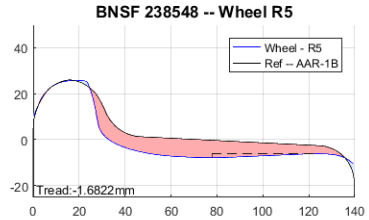
R1 – L1

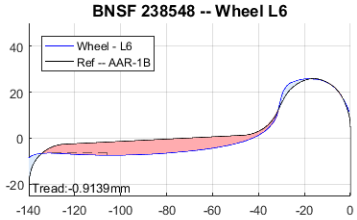
R3 – L3

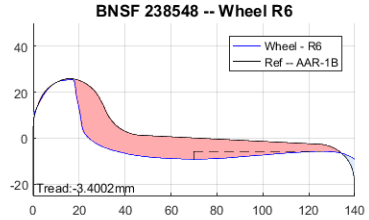
Wheel Profiles

D Truck

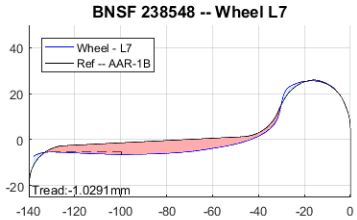


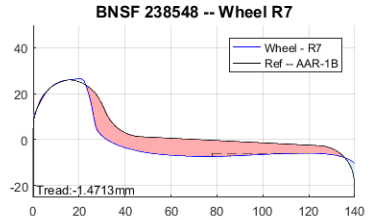


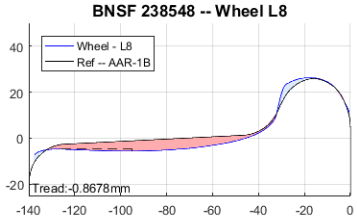


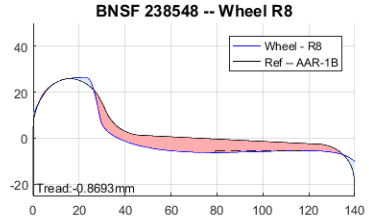


E Truck

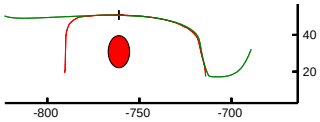


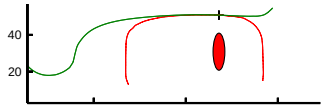




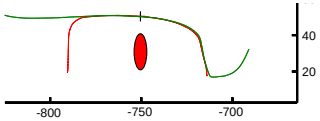


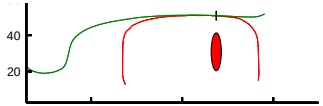
R5 – L5





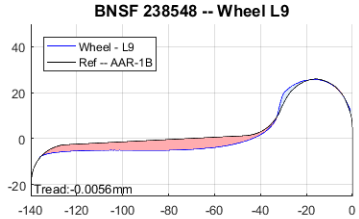
R7 – L7

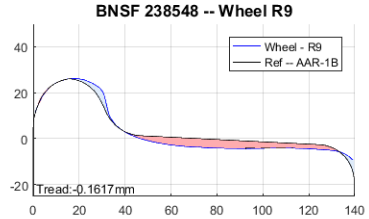


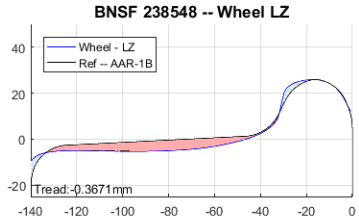


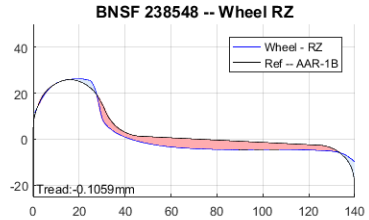
Wheel Profiles

F Truck

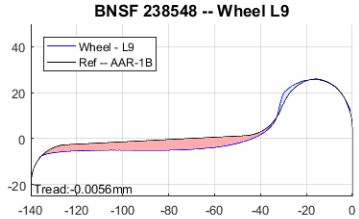


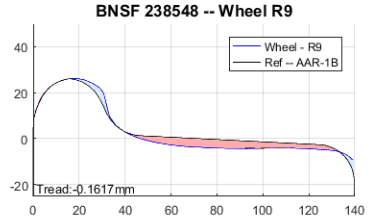


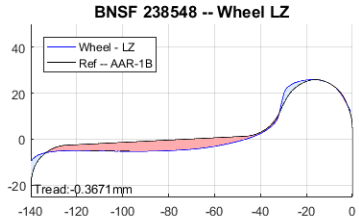


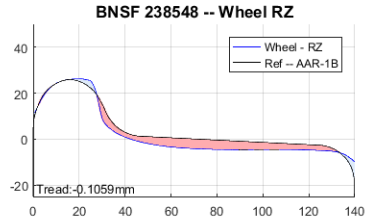


A Truck

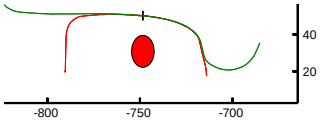


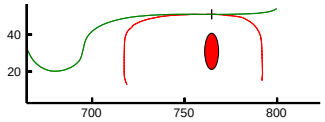




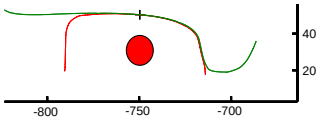


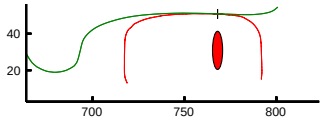
R9 – L9



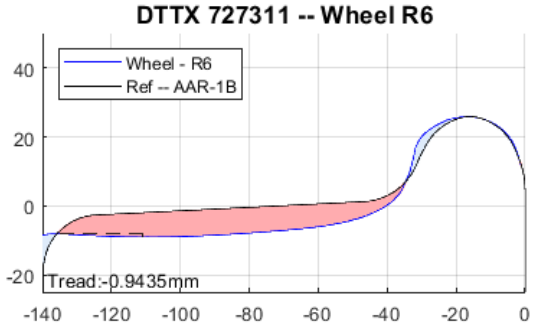


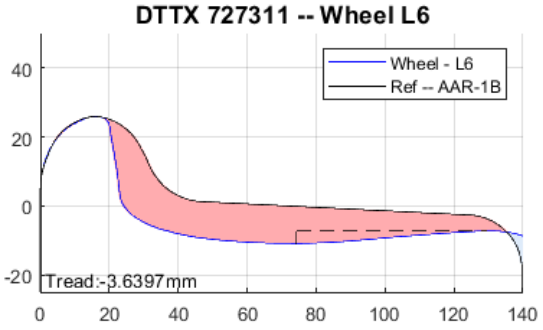
RY - LY

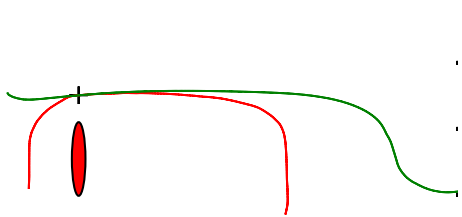




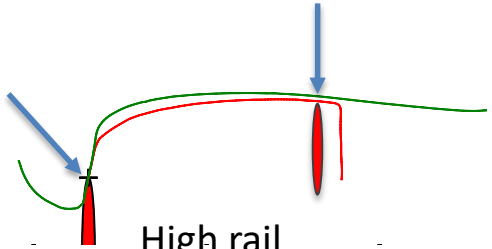
Wheel Profiles







Low rail



High rail

- Extreme 2-point contact
- Extreme field-side contact – both rails
- For ALL wheelset lateral positions

Wheel Profiles

- The question remains: What does this hollow-wear mean?
- What role did hollow-worn wheels play in the derailments?
- Did anything else play a role?

Vehicle Dynamics (VAMPIRE) analysis

```
*****************************************
  VAMPIRE Version 6.50.13.1557  (June 2017)
       CONTACT DATA GENERATION PROGRAM
*****************************************
**
VAMPIRE WHEEL/RAIL CONTACT DATA
**
*WHEEL
C:\Users\hgkn7\Documents\P7634\MiniProf_profiles\DTTX727311-R6-aligned.whl and C
FLANGEBACK   1347.79 mm
DIAMETER      914.40 mm     US tread datum (2 27/32in from flangeback)
YAW ANGLE       0.00 mrad
**
*RAIL
C:\Users\hgkn7\Documents\P7634\MiniProf_profiles\D140+4870-low.ban and C:\Users\
TRACK GAUGE  1435.00 mm     US gauge point (5/8in below rail crown)
**
*AXLELOAD
              318.00 KN
**
*LATERAL OFFSET
**    YREL      DRL      DRR   DELTL   DELTR    CONYL    CONYR    CONXL    CONXR  LIFTL
    -50.00   30.342    5.330    5.67    3.14 -692.83   809.06     0.00     0.00  29.46
    -49.50   30.342    5.363    6.18    3.15 -692.83   808.56     0.00     0.00  29.40
    -49.00   30.370    5.371    5.22    2.92 -692.34   808.45     0.00     0.00  29.35
    -48.50   30.342    5.371    5.43    2.71 -692.83   808.45     0.00     0.00  29.32
    -48.00   30.406    5.341    5.03    2.75 -691.75   808.94     0.00     0.00  29.27
    -47.50   30.375    5.369    5.03    2.94 -692.25   808.47     0.00     0.00  29.23
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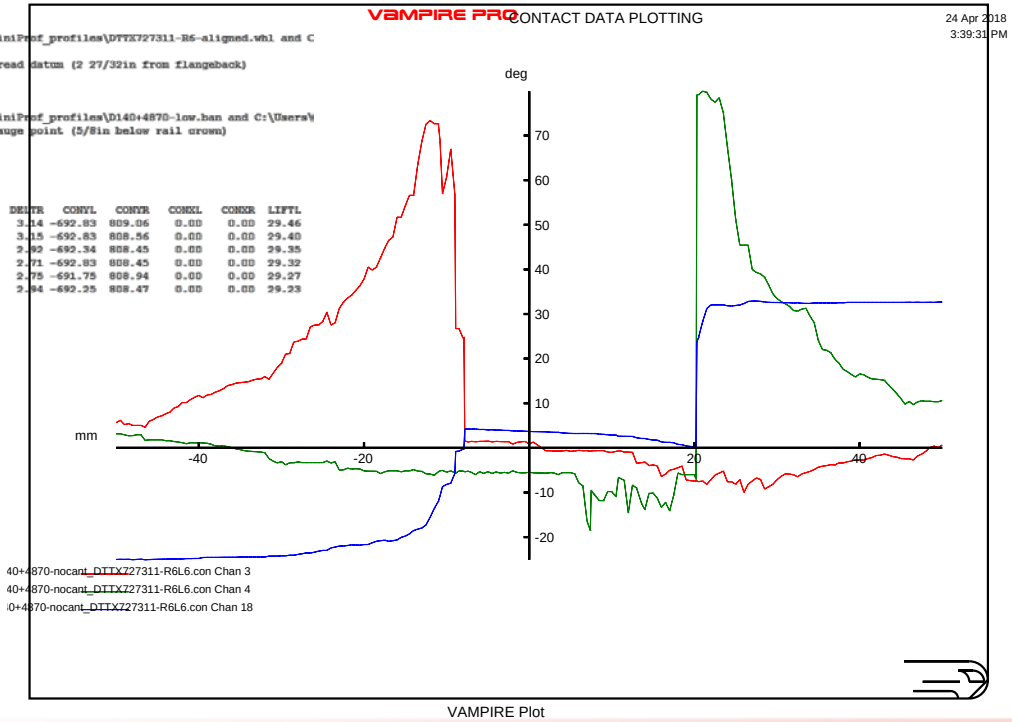
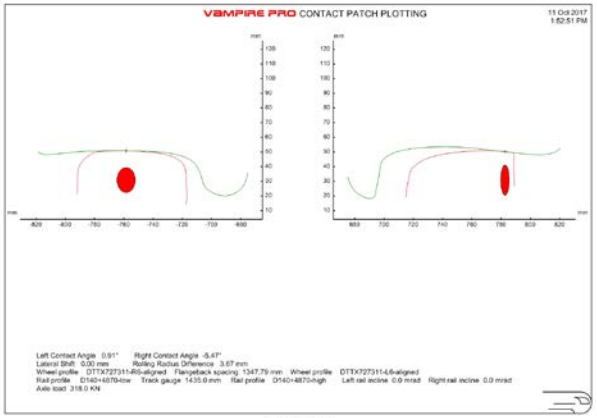


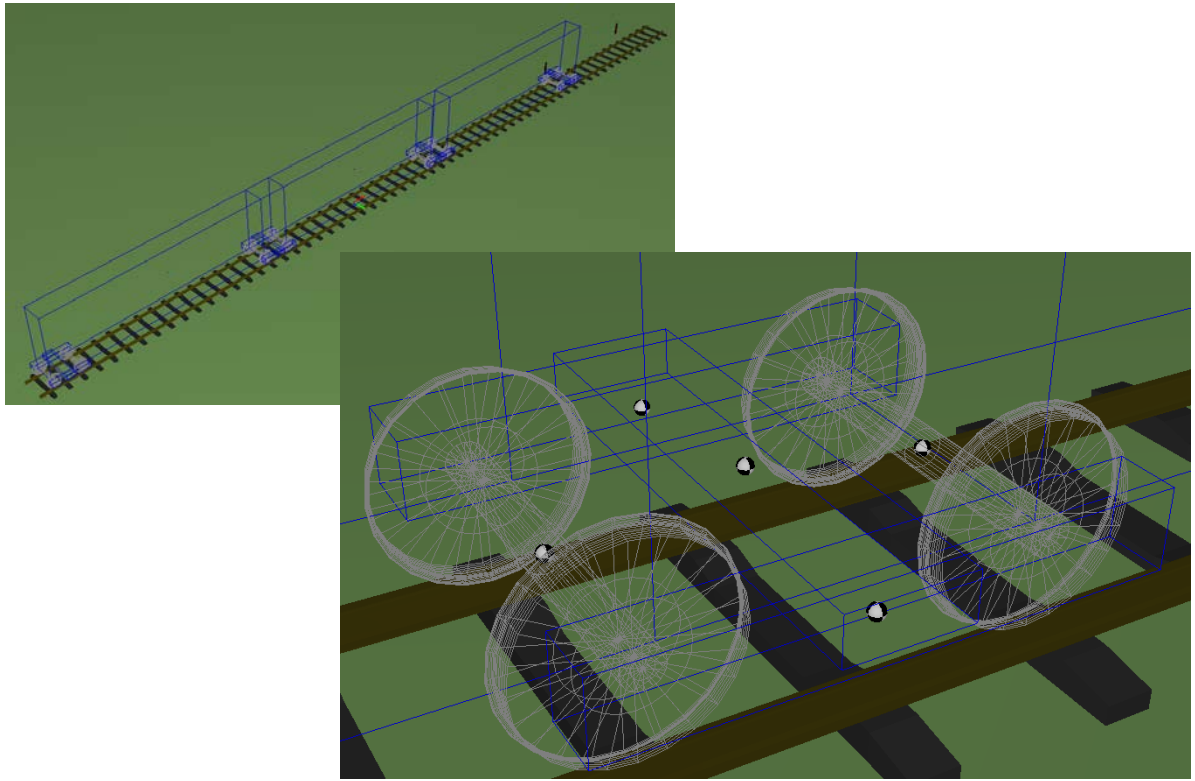
VAMPIRE Plot

- Start by generating wheel-rail contact geometry tables



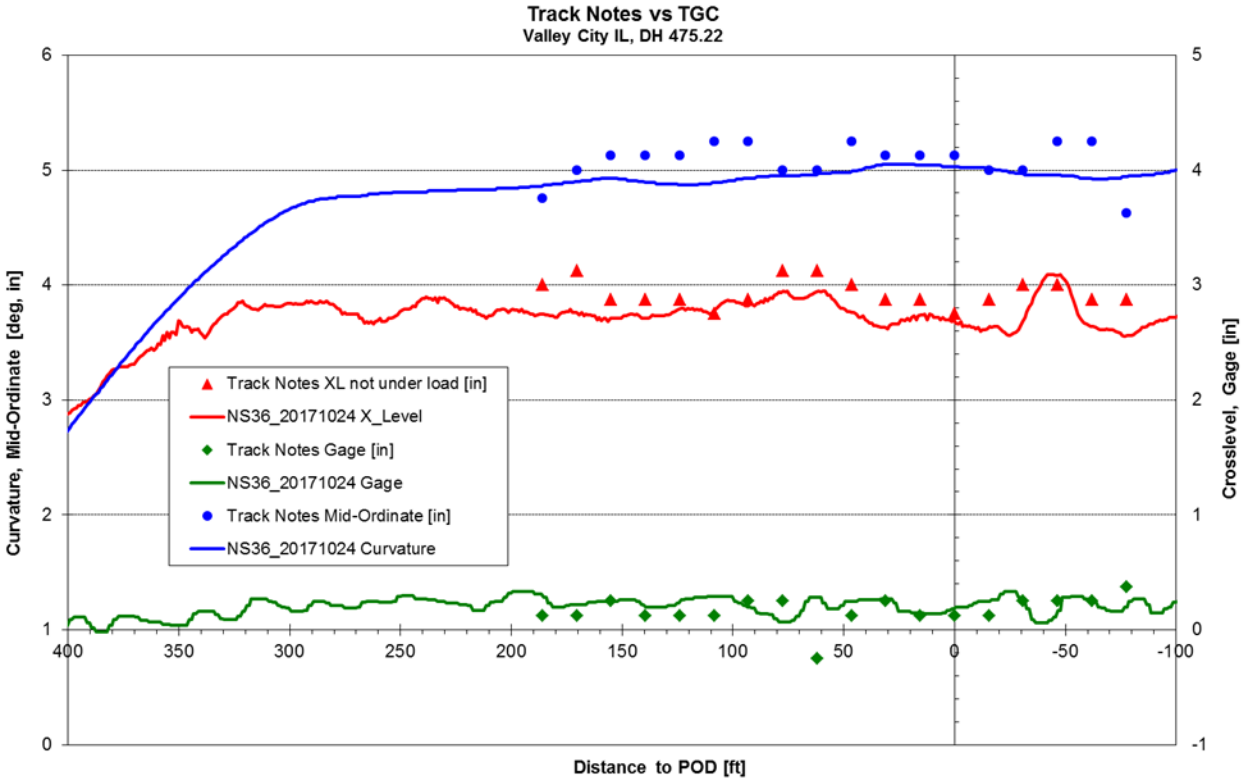
VAMPIRE Plot

Model vehicle

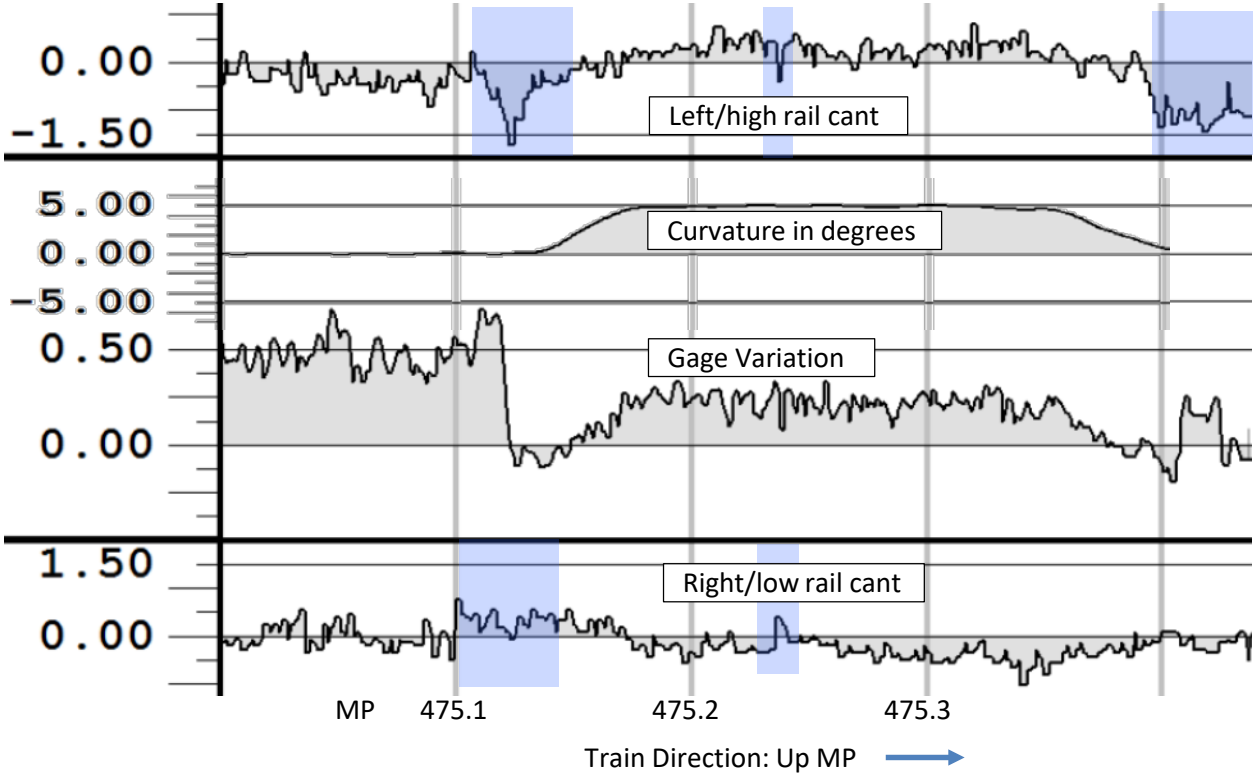


- Masses connected by spring, damper, friction elements
- Model wedges, side bearings, centerbearings, articulation connections
- In actual conditions

Model track conditions

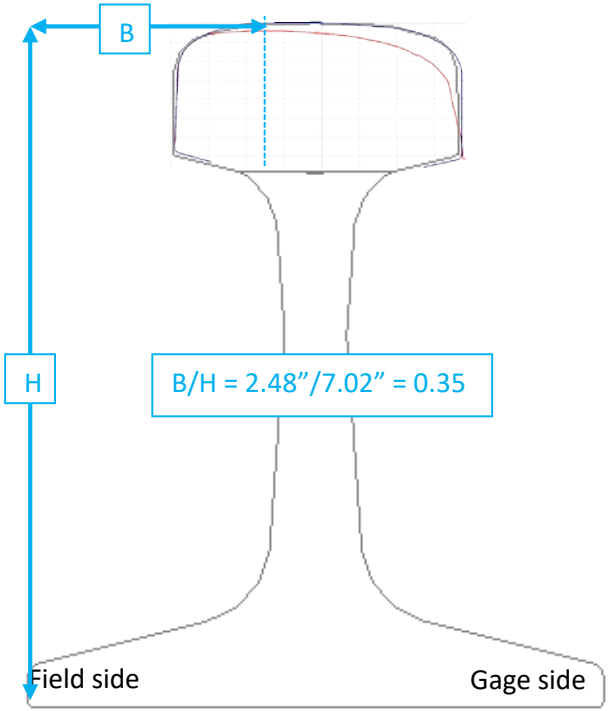


Include rail cant conditions

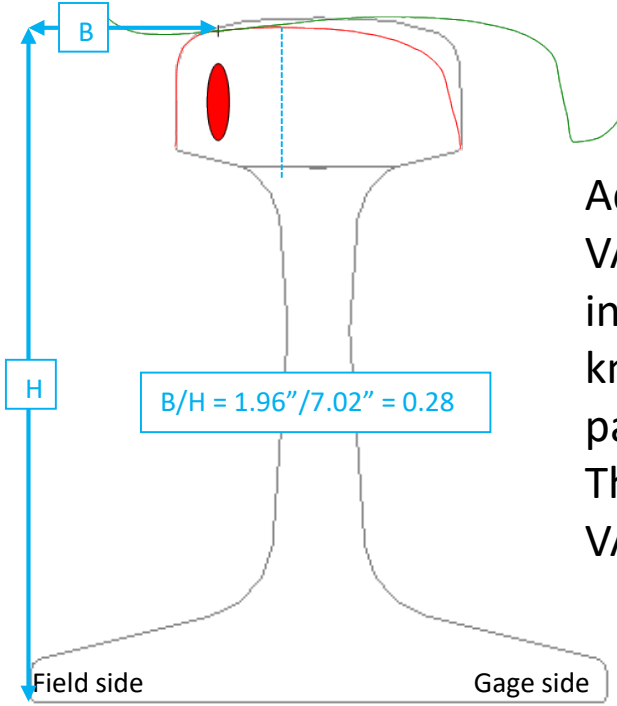


Inward rail cant

Calculating B/H for High Rail



Geometry car method

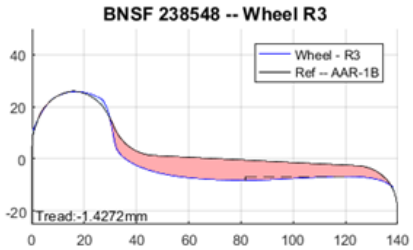


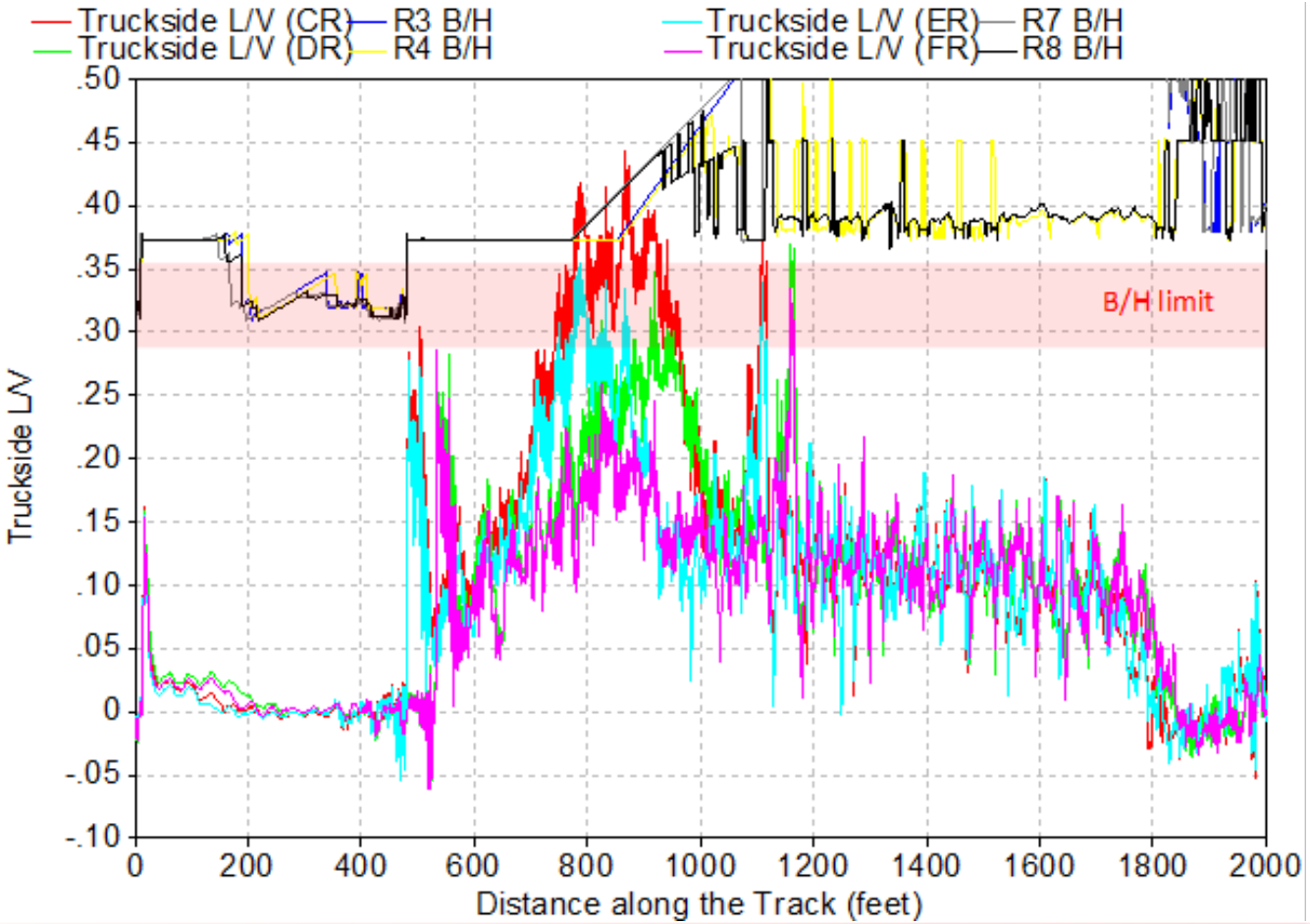
VAMPIRE contact location

Additionally, we can use VAMPIRE to estimate an instantaneous B/H, since it knows where the contact patch is relative to the rail. This will be shown on the VAMPIRE output graphs.

Truckside L/V and B/H, high rail

- Actual wheel profiles
- Actual Rail profiles from POD (constant)
- 1 deg average outward cant

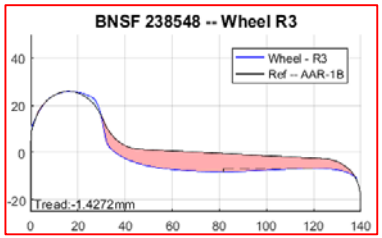


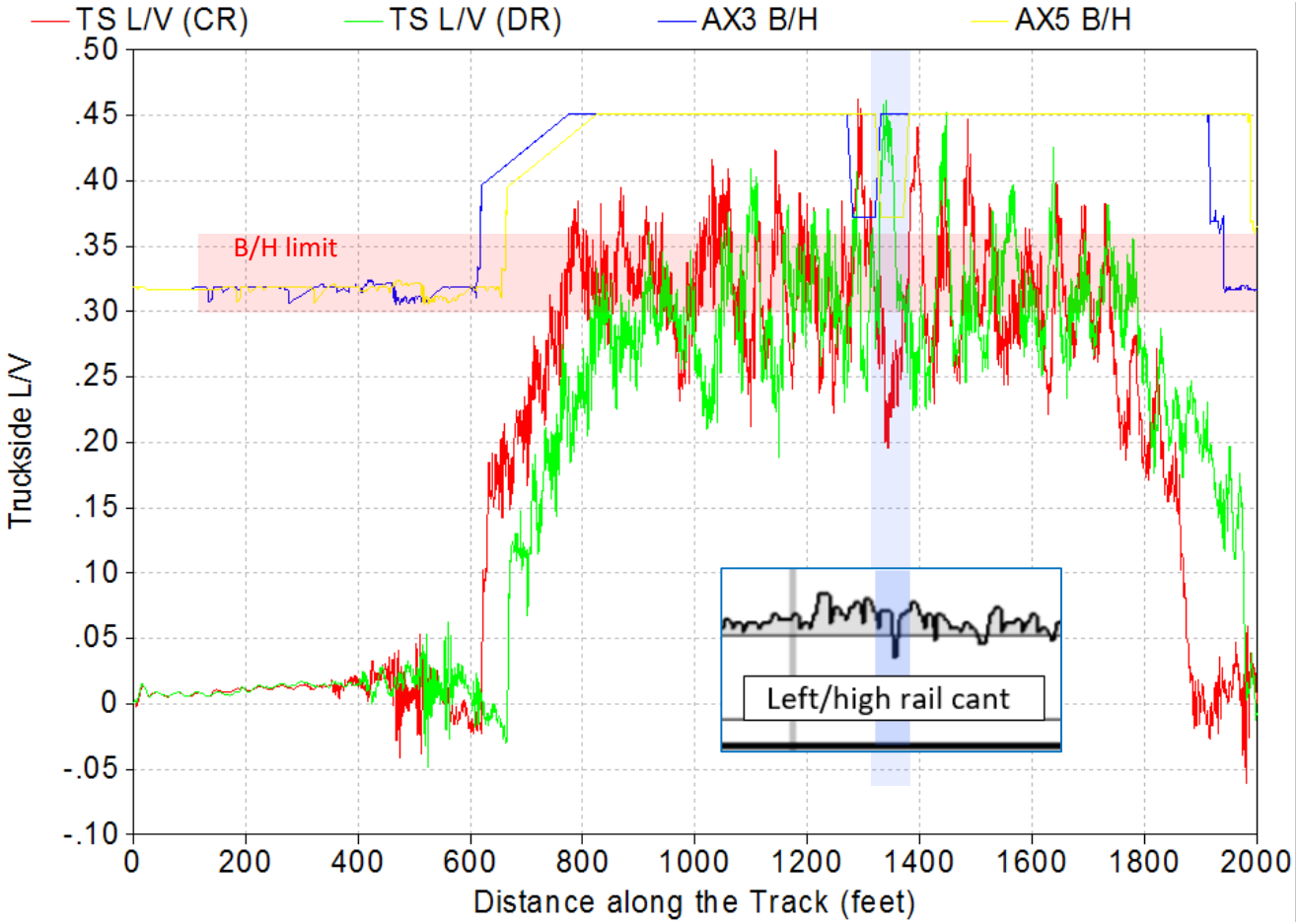


Truckside L/V and B/H, high rail

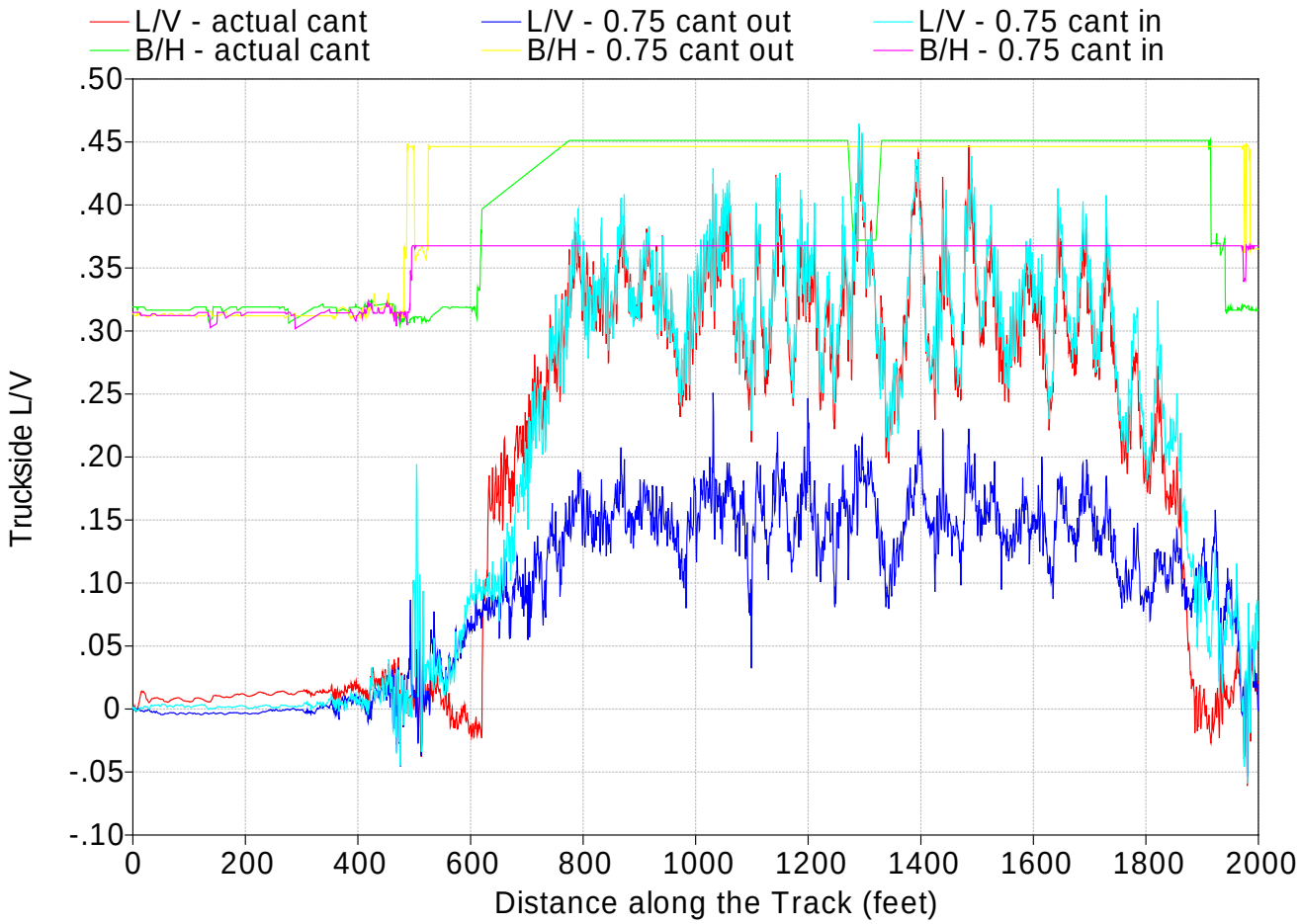
- R3 profile on all wheels
- Actual rail profiles and cant angles defined per TGC data along distance of simulation

Blue shaded region shows the inward canted area identified in slide 19.

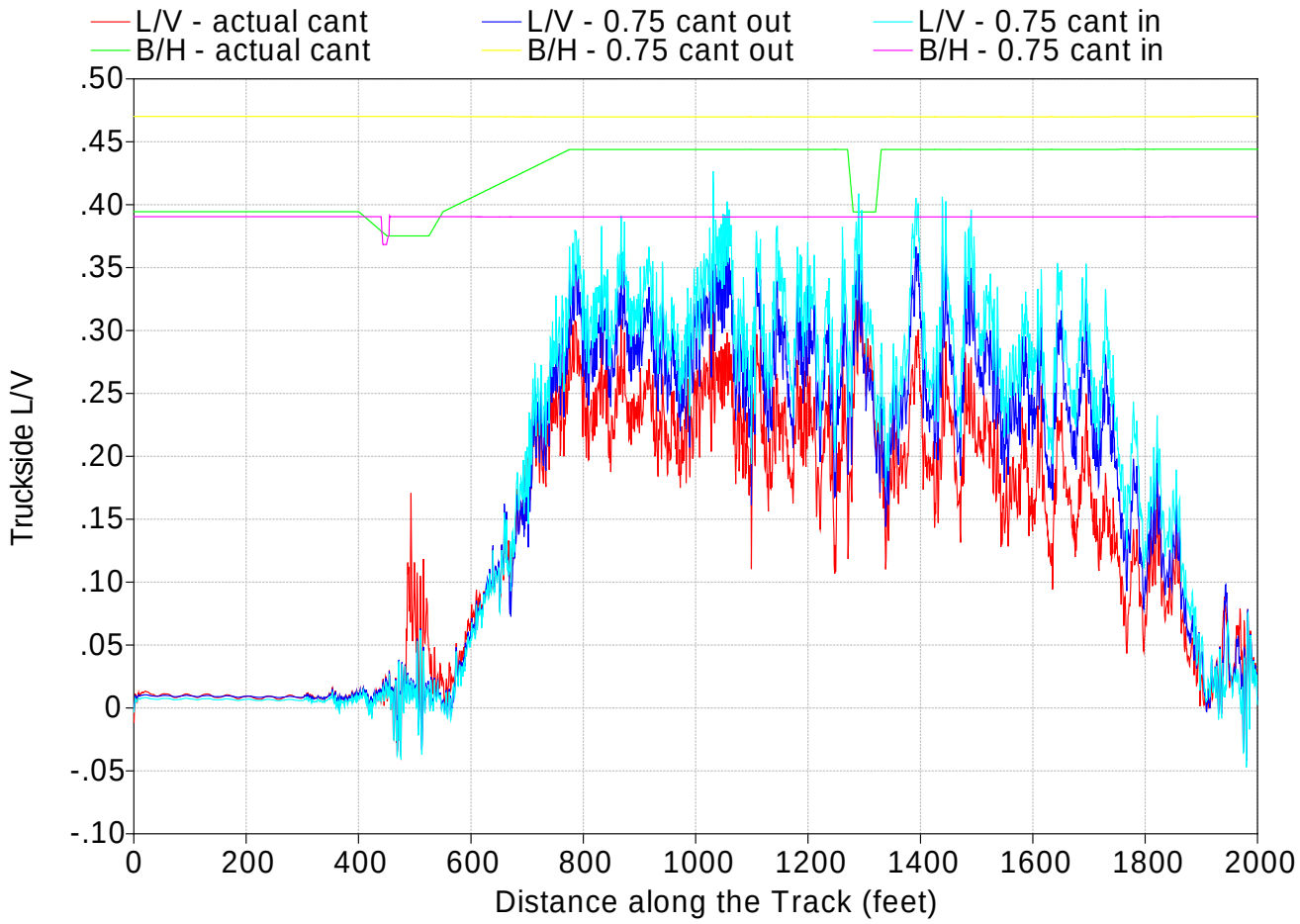




Truckside L/V sensitivity to hollow treads

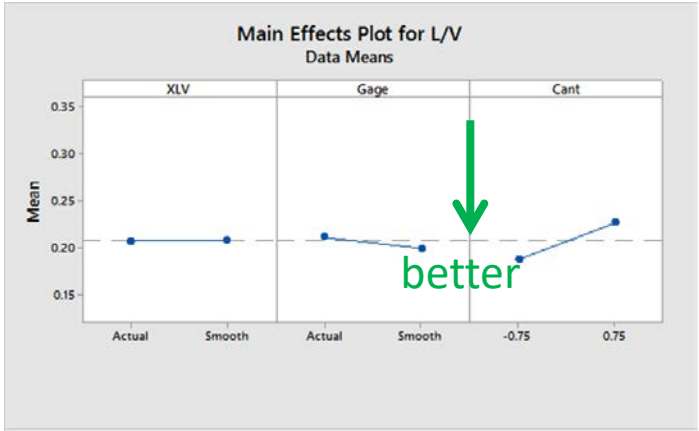


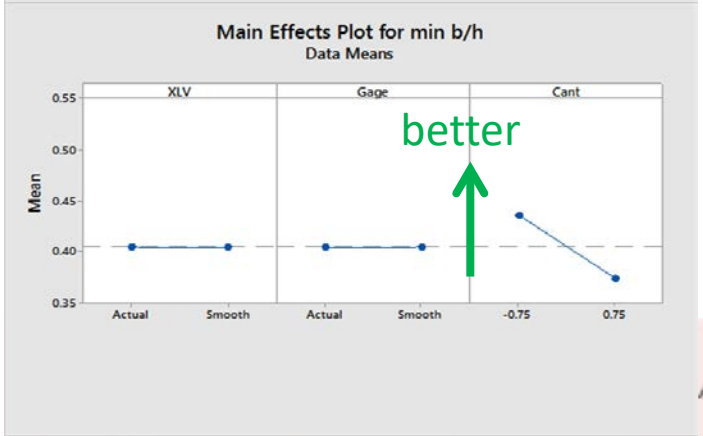
Truckside L/V sensitivity to 1B wheels



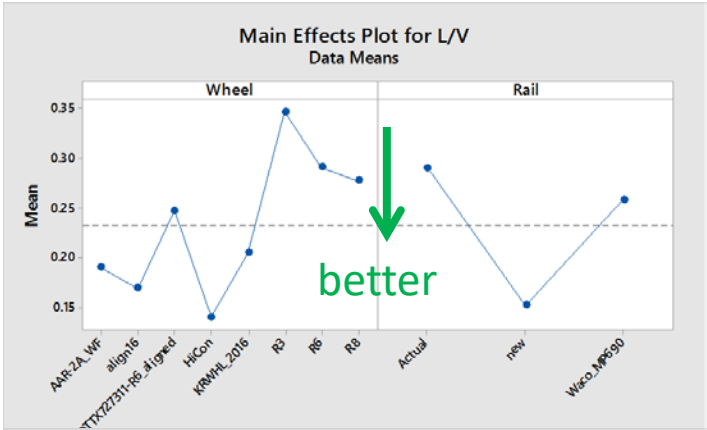
Sensitivity Analysis of VAMPIRE Results

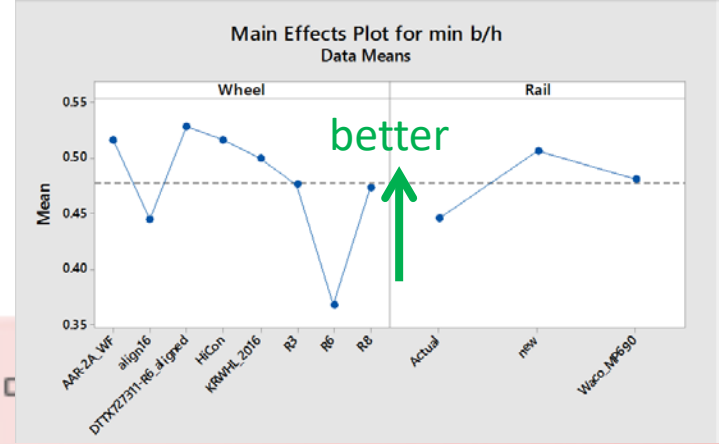
Track Factors





Profile Factors

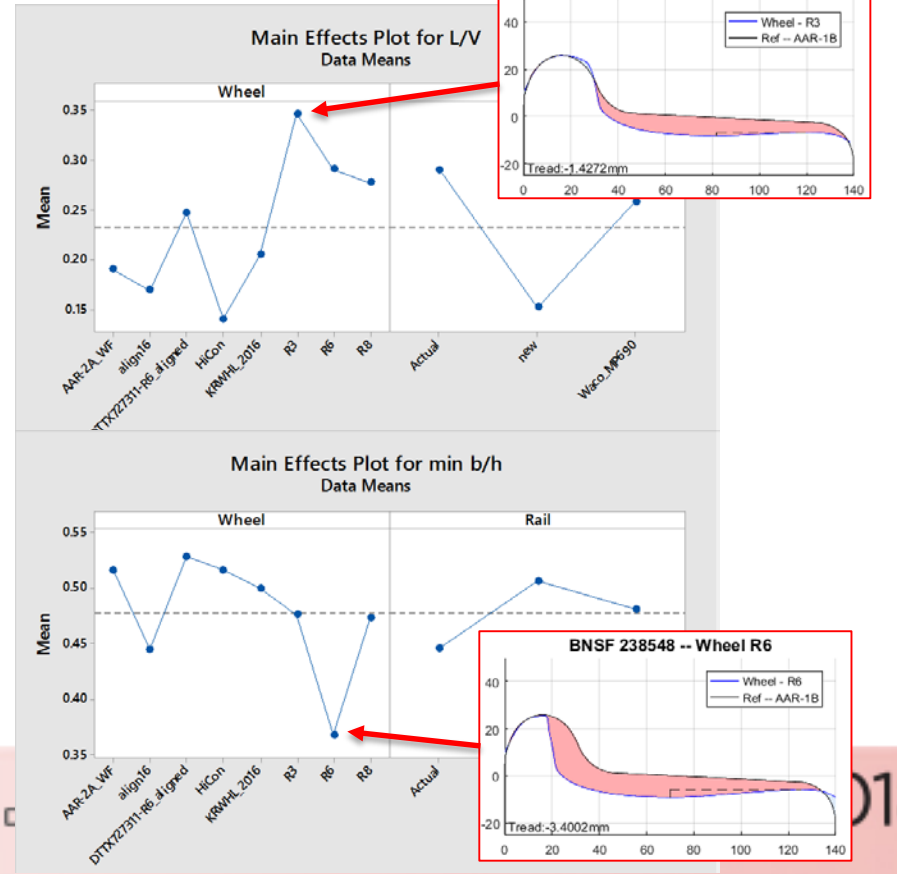




Sensitivity Analysis of VAMPIRE Results

- Hollow-worn treads
  - Two main effects:
    - Increase truckside L/V
    - Decrease safe B/H
  - Subtle differences between the profiles that cause either one

Profile Factors



Conclusions

- Recent derailments are fundamentally different than 1990's DDTF, and 2000's NS rail rollovers.
  - Much has improved as a result of them
  - Hollow-worn wheel profiles
  - Single trucks
- Is it time to re-evaluate the AAR Rule 41 hollow-wear limits?

Questions, Comments, Discussion