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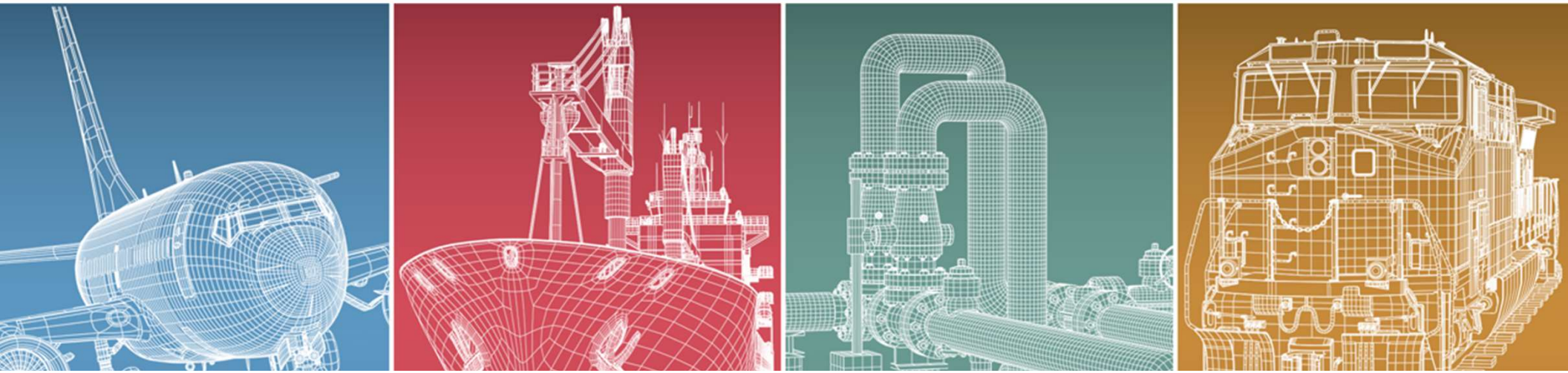

Dynamic Simulation of Locomotive Derailment over Crossover Track

WRI SEMINAR, October 20-21, 2021

Content

- Introduction
- Calibrated and verified sequence of interested events
- Train dynamic simulation
- Vehicle/track dynamic simulation
  - Locomotive model
  - Parameters test and verification
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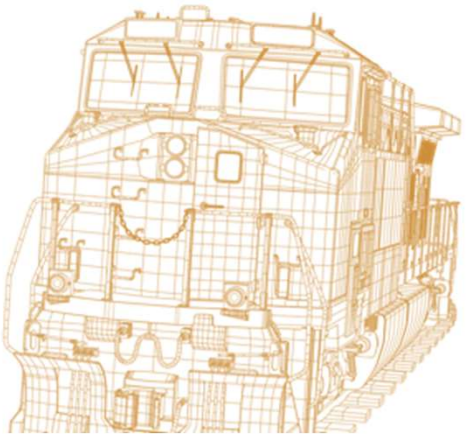
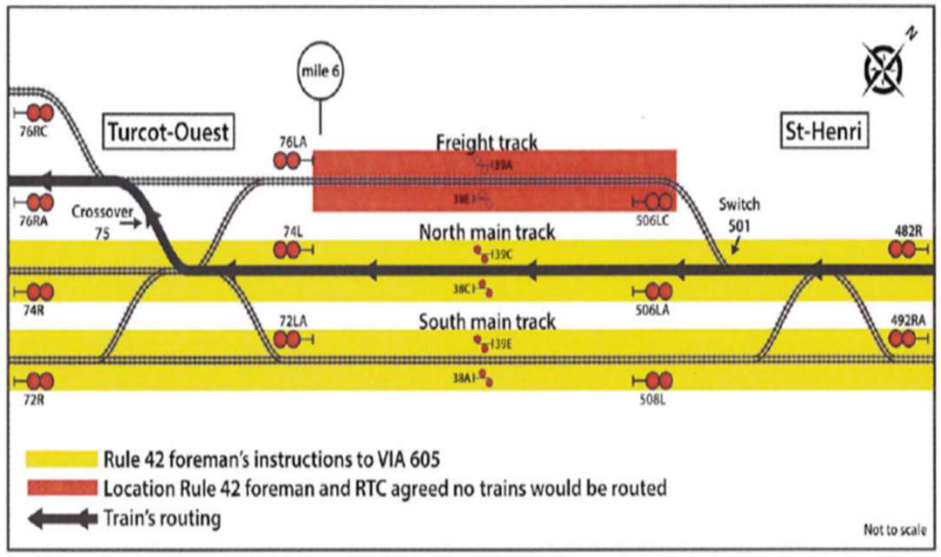


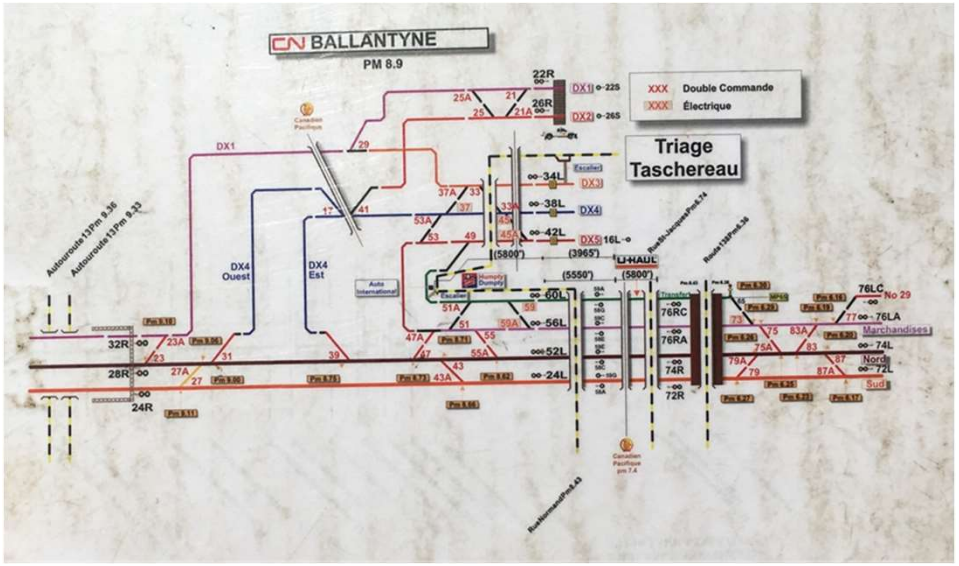
Introduction

- VIA combined train derailed over a crossover track(TSB occurrence #R15D0118)
- Crossover route for protected track work, speed limit 15 mph
- Train consist: head locomotive – 2 coaches – middle Loco -2 coaches
- F40PH-2D, four-axle locomotive
- Front truck of the middle locomotive derailed at tangent section immediately after exit of crossover but remained upright
- Crossover track: connected two reverse No.10 turnouts
- 1600 feet track damaged, one minor jury

Introduction



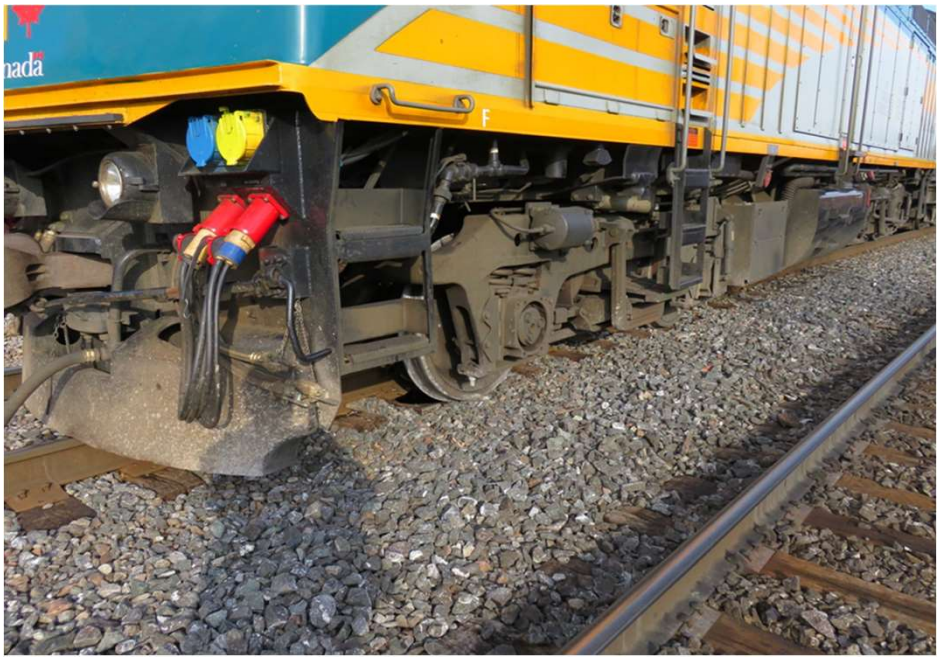
Travel Route of Train VIA 605



Marked Mileages of Switches of Crossover 75

Introduction

Front Truck of Middle Locomotive Derailed to Left



Derailed Truck of VIA 6413

Introduction

- Different from previous accidents Thamesville (R99H0007) and Aldershot (Burlington, R12T0038)
- The point of derailment (POD) was not on the crossover closure curve, as in the previous accidents, but on the tangent track that already exited the crossover.
- The lead locomotive did not derail but the middle locomotive of the combined train derailed.
- The in-train force generated by the brake application might have played a role to cause these two unusual aspects
- Vehicle/track dynamic simulation to investigate derailment mechanism

Sequence of Interested Events

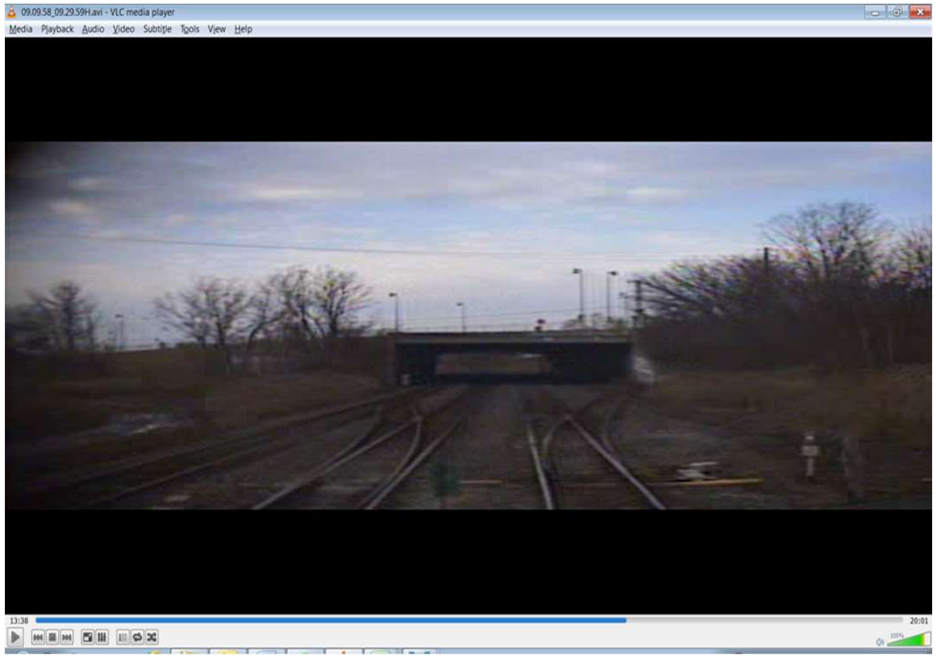
- LER data and LVVR video are synchronized and analyzed, verifying:
- VIA train 605 departed Montreal station on time
- Locomotive engineer did not aware of route change before seeing switch 75A directed to crossover
- Applied full service braking at speed of 59.6 mph
- Lead locomotive entered and exited the crossover at 58 and 56 mph respectively
- Calibrated LER data matched the onsite measured distance and locations
- LER recorded BP and BC history used in train dynamic simulation

Sequence of Interested Events

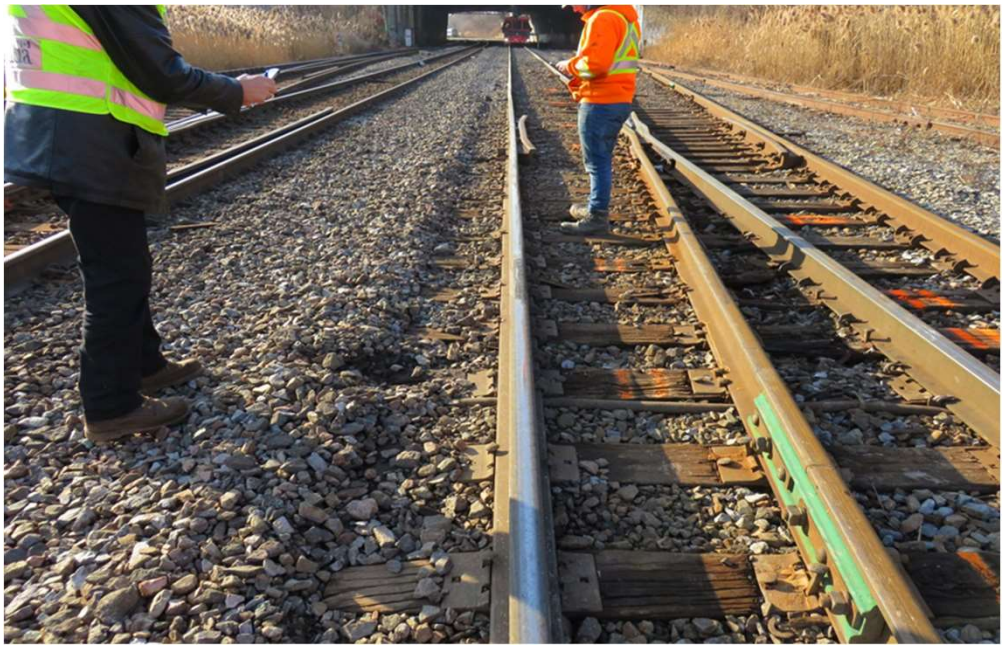
Entering Switch 75A of Crossover 75

Passing through Crossover Seeing the Exit Switch 75

Sequence of Interested Events



Exiting Switch 75 with Switch 73 on Front-Right



POD with Wheel Drop and Rail Top Contamination

Train Dynamic Simulation

- The simulated in-train force F_{in} was minor during the train passing the crossover, insufficient to cause derailment.
- However, the buff in-train force at the derailed locomotive might affect the angle of attack

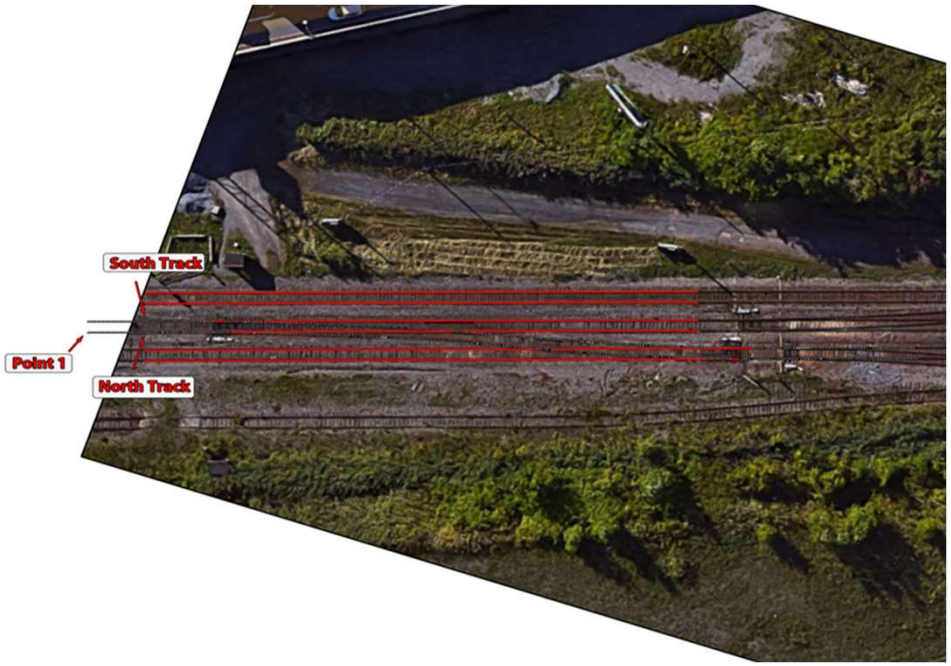
Table 2: Simulated In-Train Force in Train VIA 605

Vehicle	Type	Weight	length	F_b @ 60psi	0923:40		0923:37		
					F_b@59	F_{in}	BC	F_b	F_{in}
		lb	ft	lb	lb	lb	psi	lb	lb
VIA6401	F40PH2D	260000	56.2	24924	24509	-1233	57	23678	-3418
VIA8145	coach	113900	85	10952	10769	-1645	55	10039	-4421
VIA8620	baggage	123200	85	9720	9558	0	52	8424	-3071
VIA6413	F40PH2D	260000	56.2	24924	24509	-1233	49	20355	-3165
VIA8621	baggage	123200	85	9720	9558	412	47	7614	-1005
VIA8147	coach	113900	85	10952	10769	0	44	8031	0

Vehicle/Track Dynamic Simulation

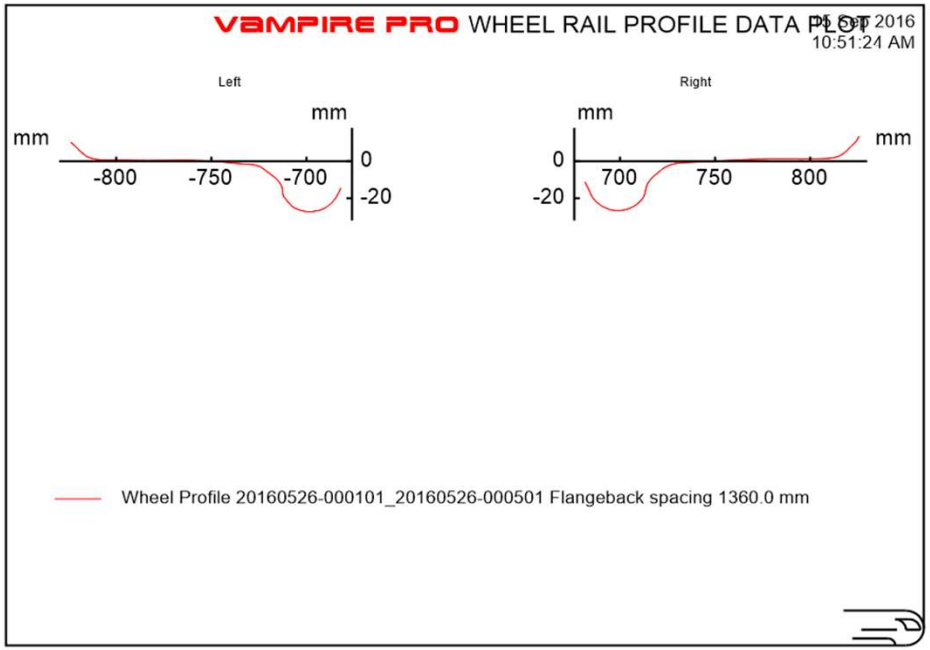
- Collaboration with contractors on vehicle/track dynamic simulation
- Collect the locomotive parameters and survey the track.
- Measured wheel and rail profiles
- A previous locomotive model was modified and verified to match the physical test reports of the locomotives so the revised model is validated to the best available information.
- A number of simulation cases at different speeds and crossovers have been tried to investigate the effects of contributing factors.
- The critical speed for wheel lifting and carbody roll are found out and the derailment mechanism is interpreted very well.

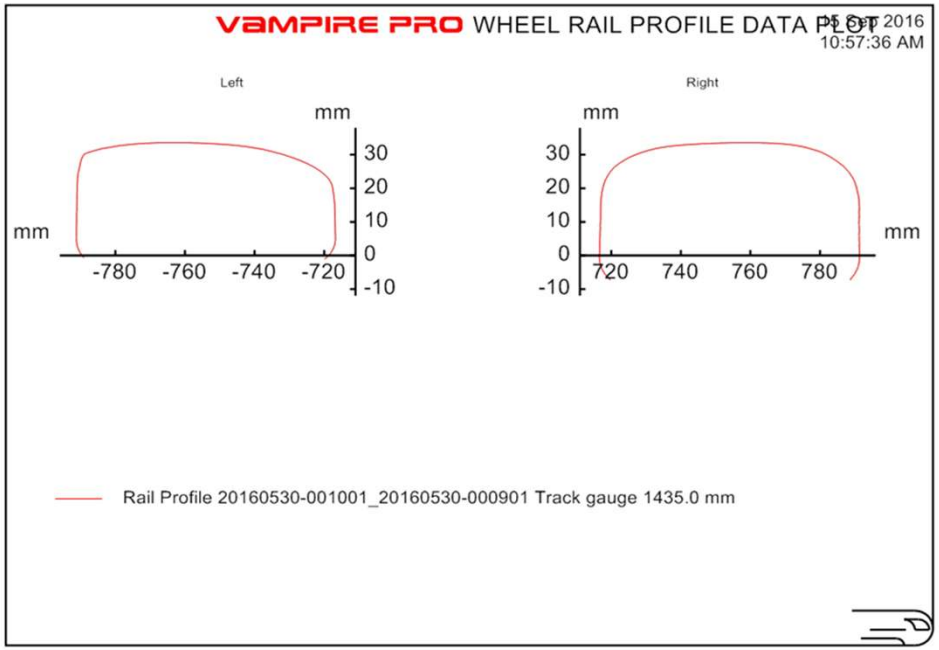
Vehicle/Track Dynamic Simulation



Track survey

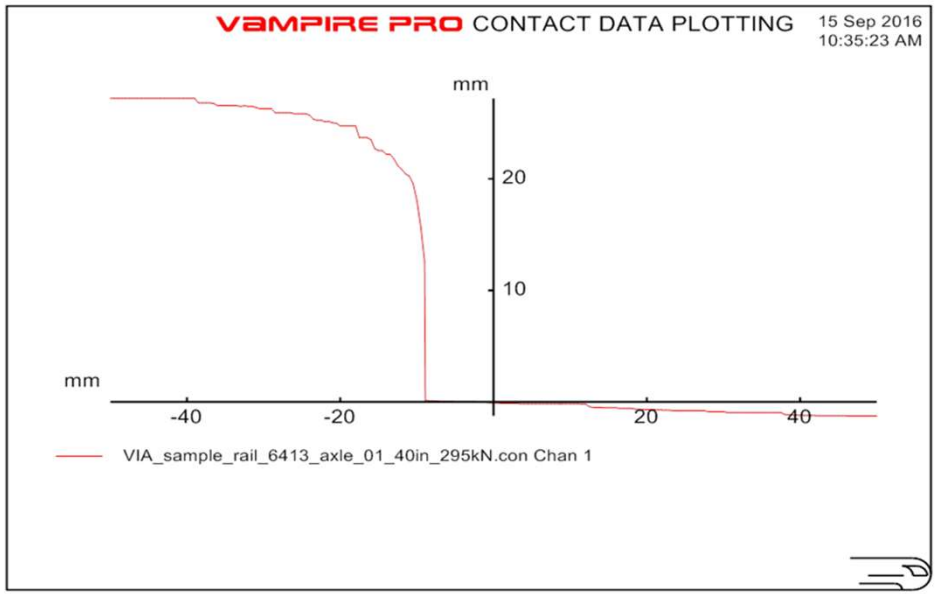
Vehicle/Track Dynamic Simulation

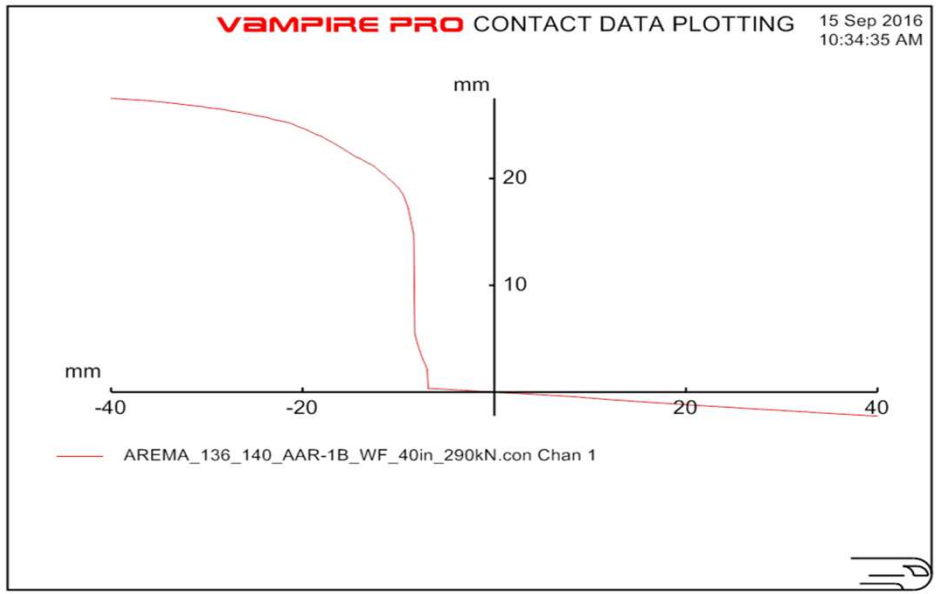




Measured wheel and rail profiles

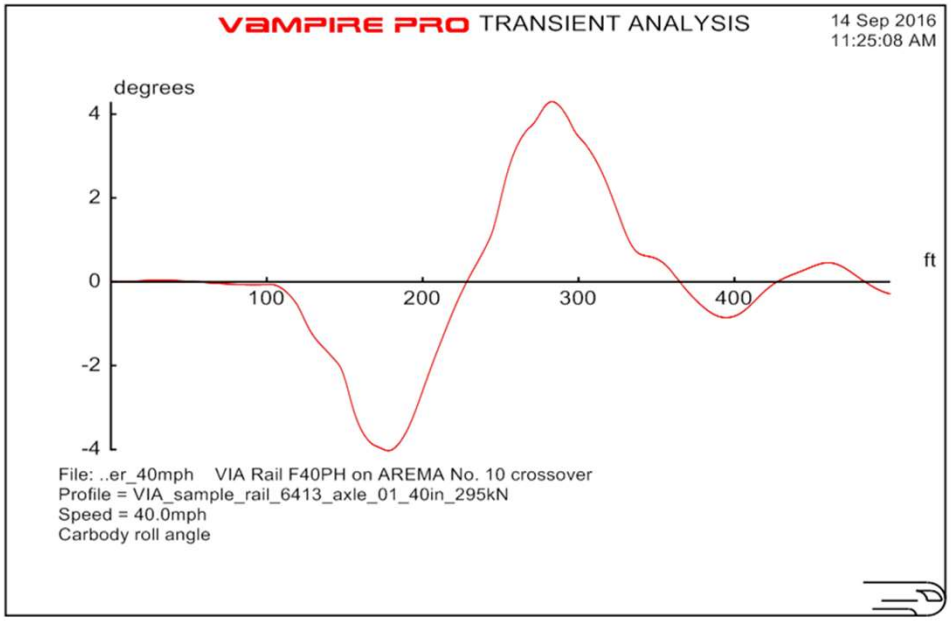
Vehicle/Track Dynamic Simulation

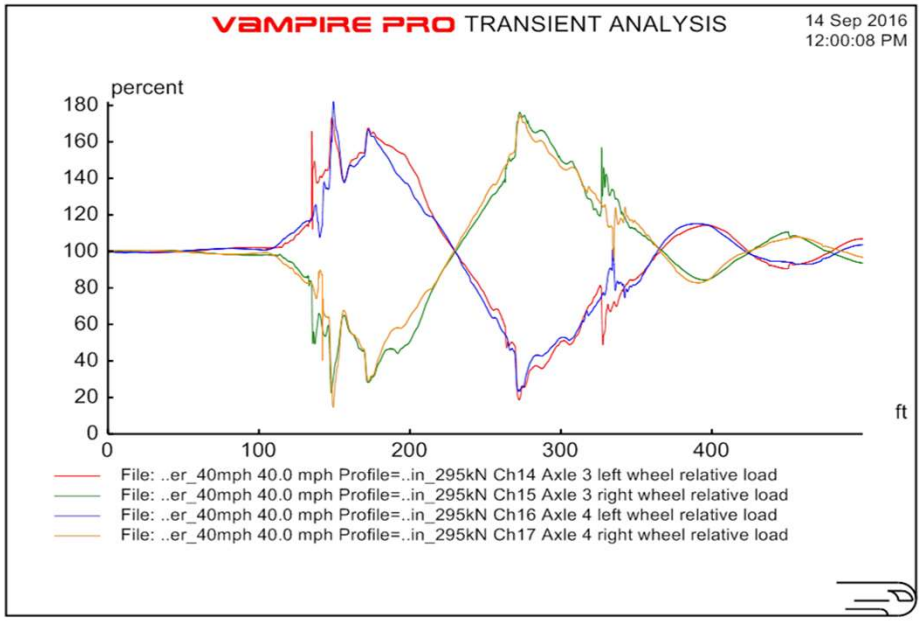




Measured and AAR standard wheel/rail contact

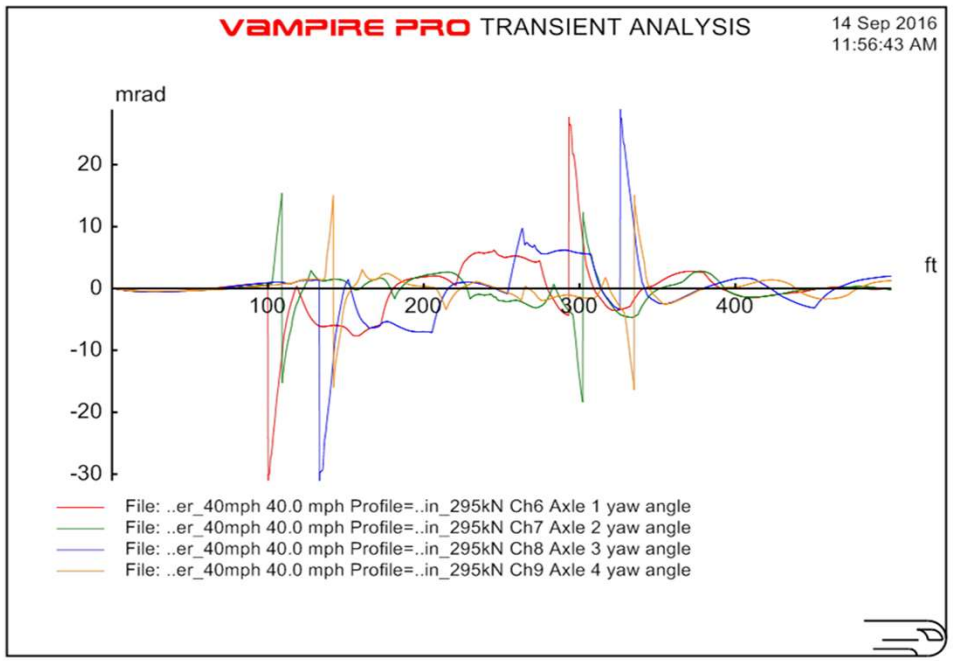
Vehicle/Track Dynamic Simulation

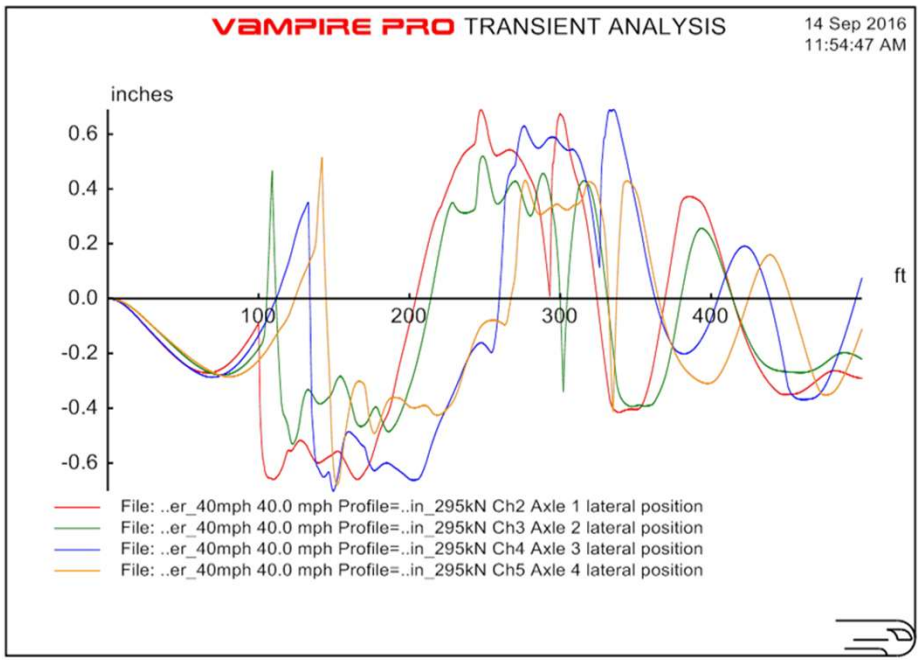




Simulated carbody roll angles and wheel relative loads of No.10 crossover at 40 mph

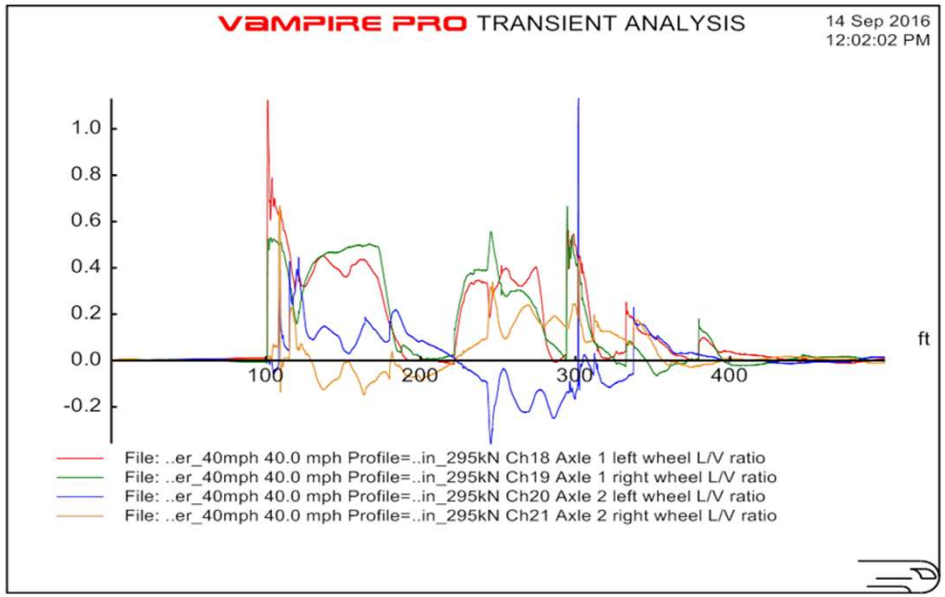
Vehicle/Track Dynamic Simulation

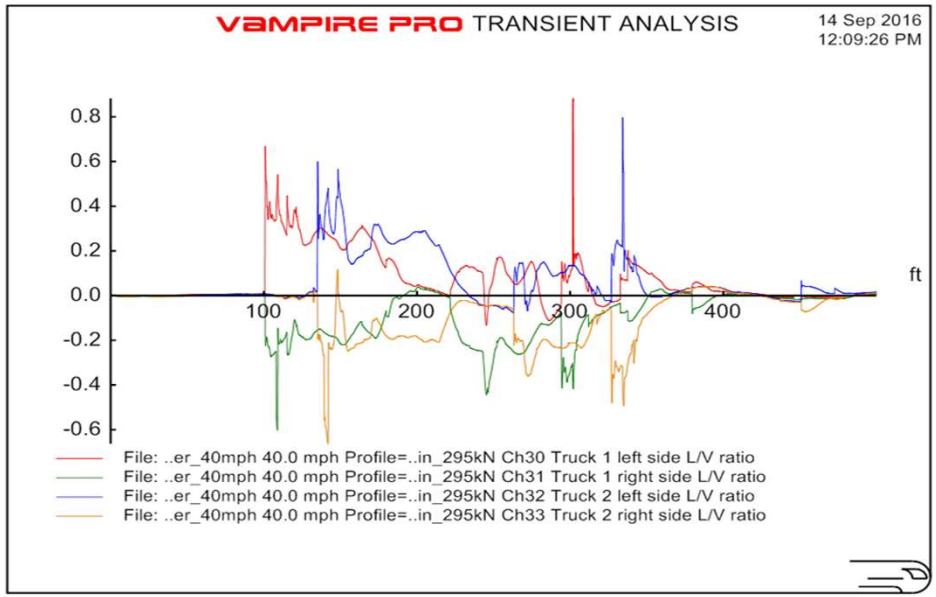




Simulated axle yaw angles and axle lateral positions of No.10 crossover at 40 mph

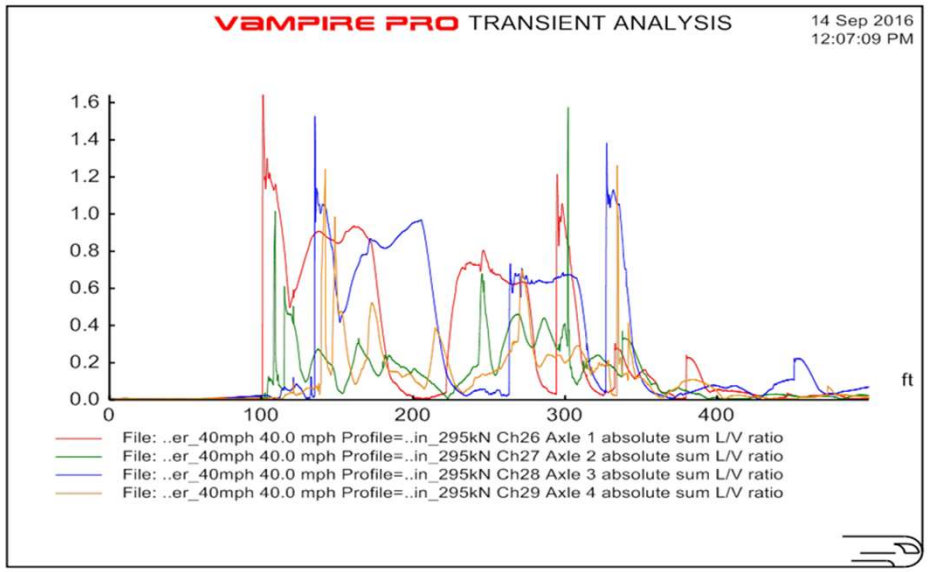
Vehicle/Track Dynamic Simulation

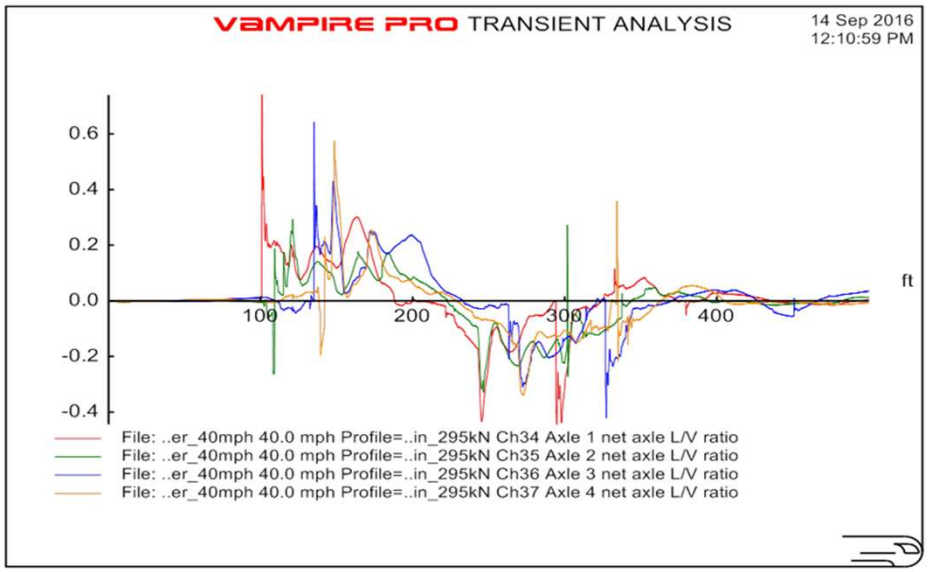




Simulated wheel and truck side L/V ratios of No.10 crossover at 40 mph

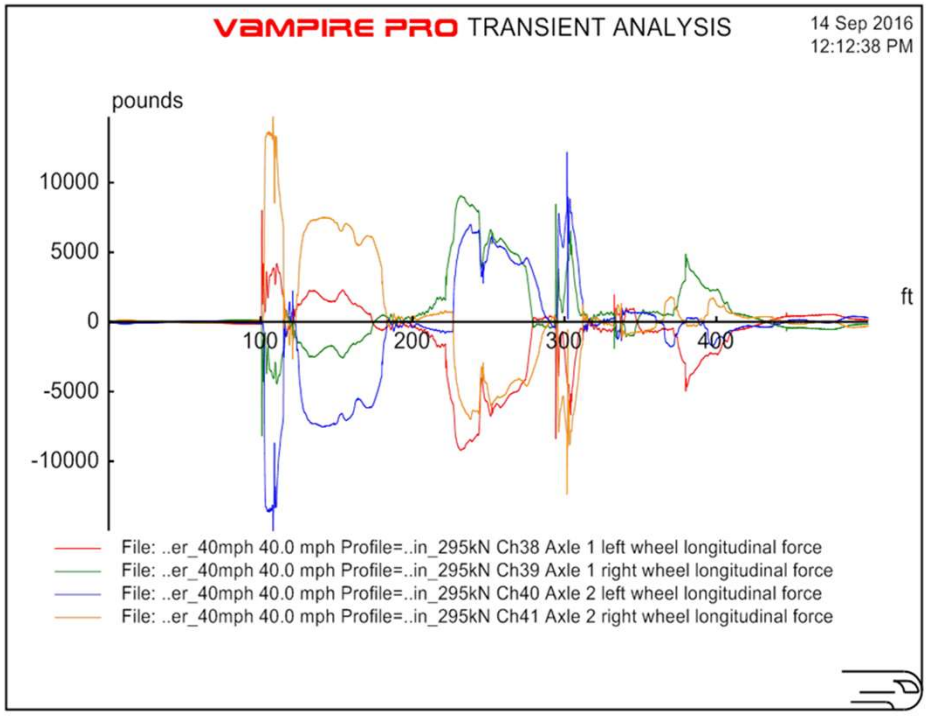
Vehicle/Track Dynamic Simulation

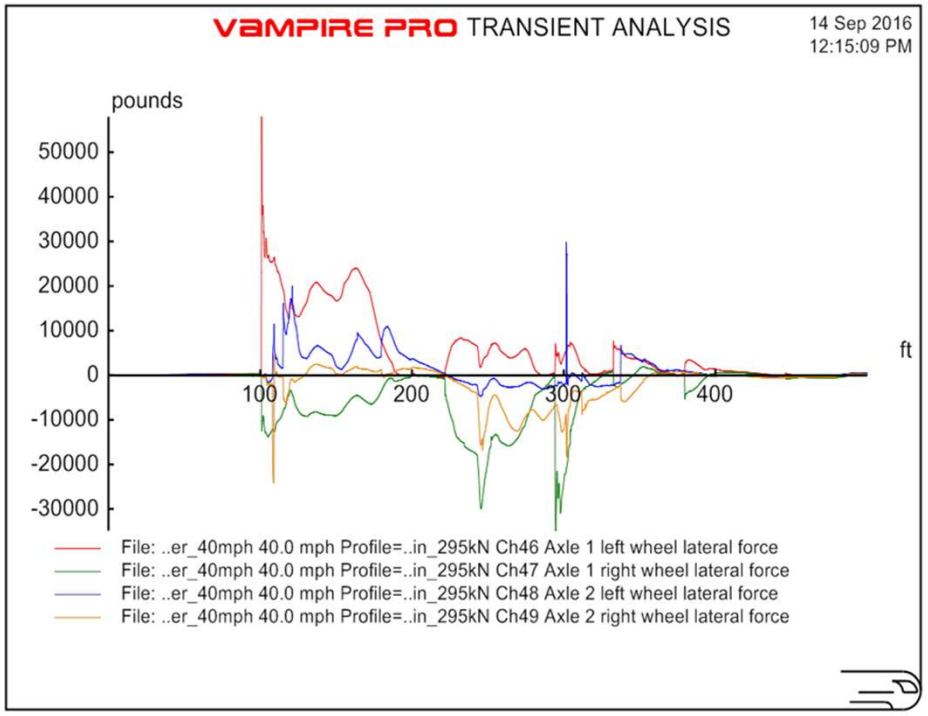




Simulated absolute sum and net axle L/V ratios of No.10 crossover at 40 mph

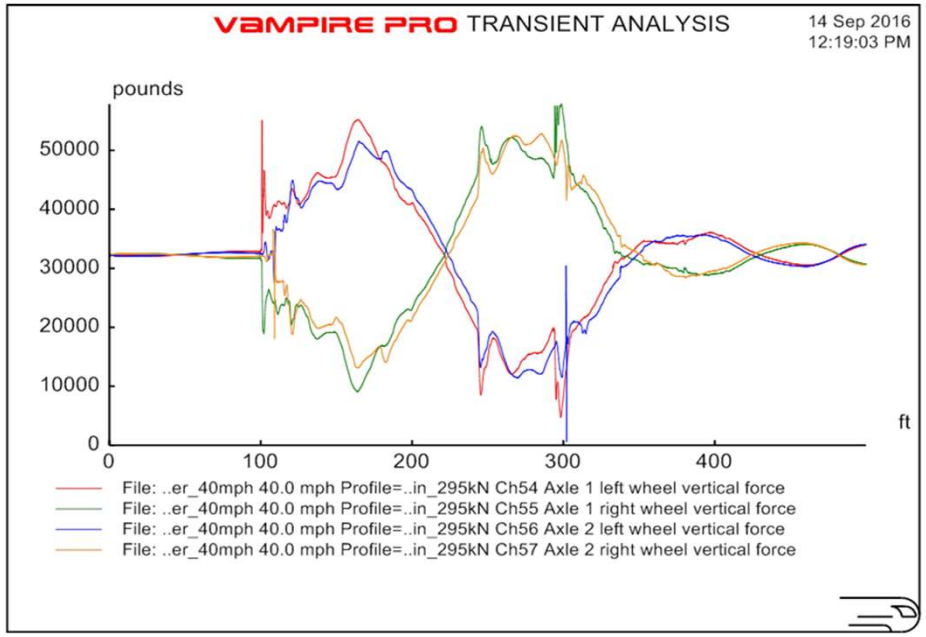
Vehicle/Track Dynamic Simulation

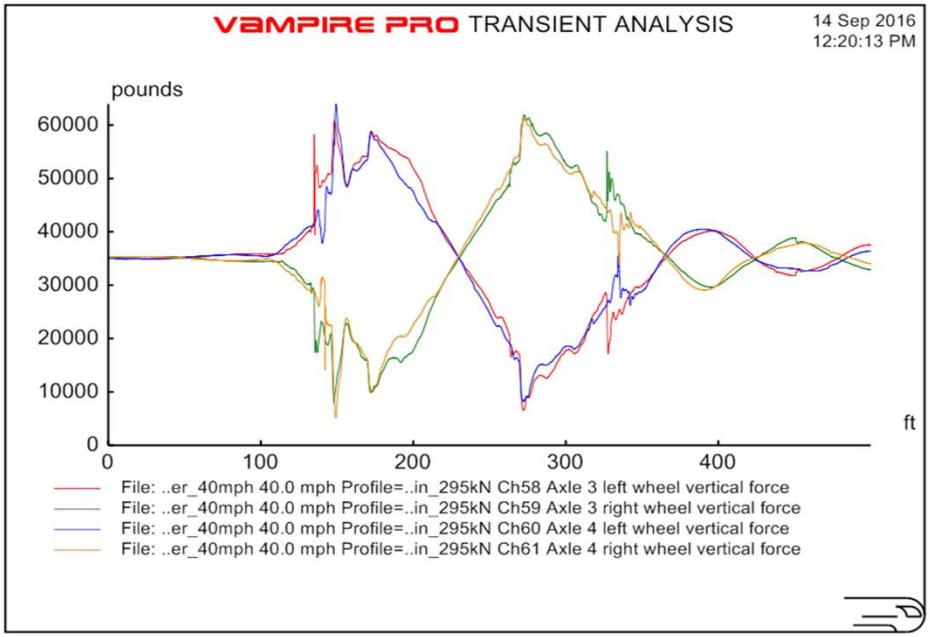




Simulated longitudinal and lateral forces of No.10 crossover at 40 mph

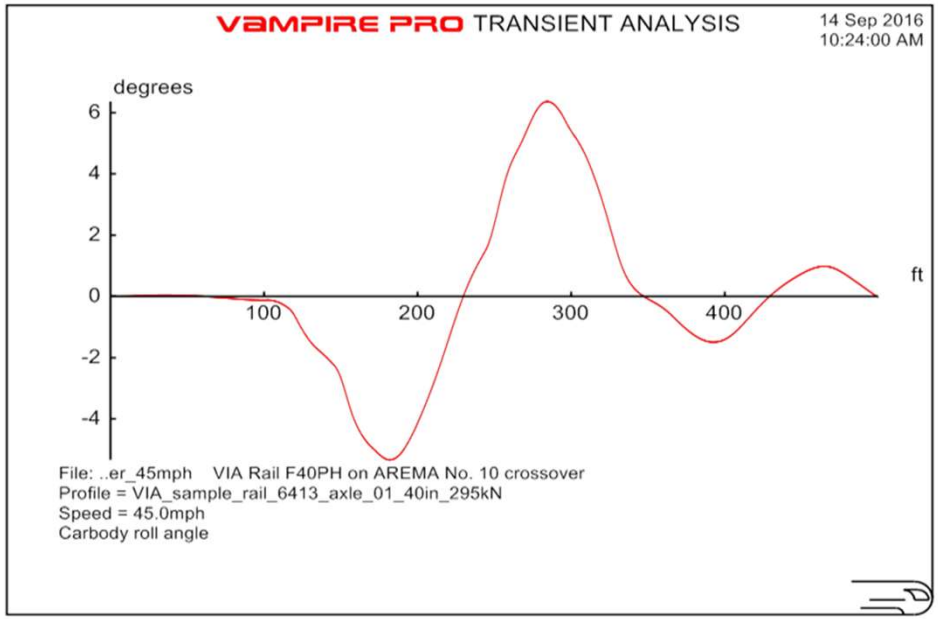
Vehicle/Track Dynamic Simulation

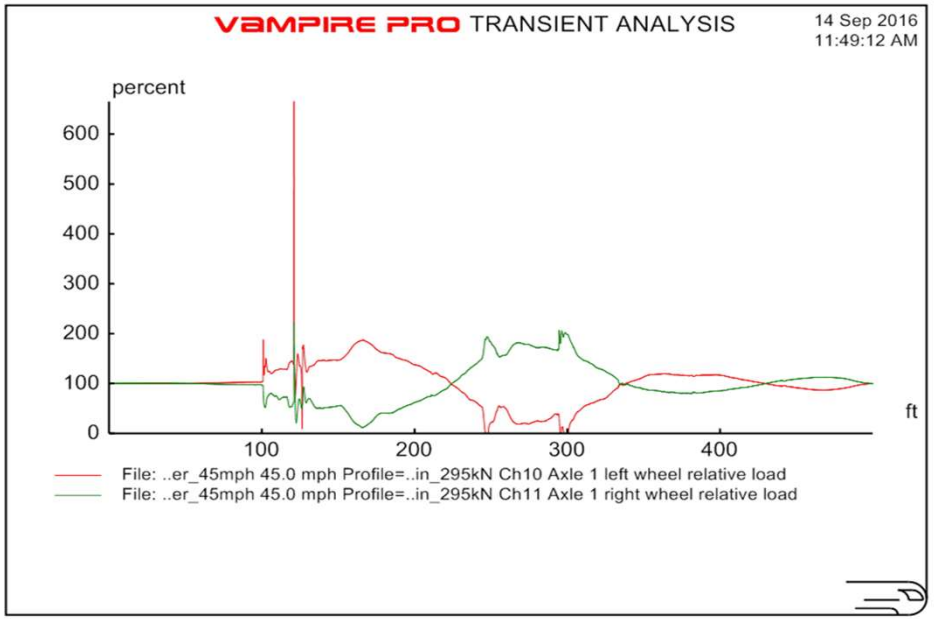




Simulated Vertical forces of No.10 crossover at 40 mph

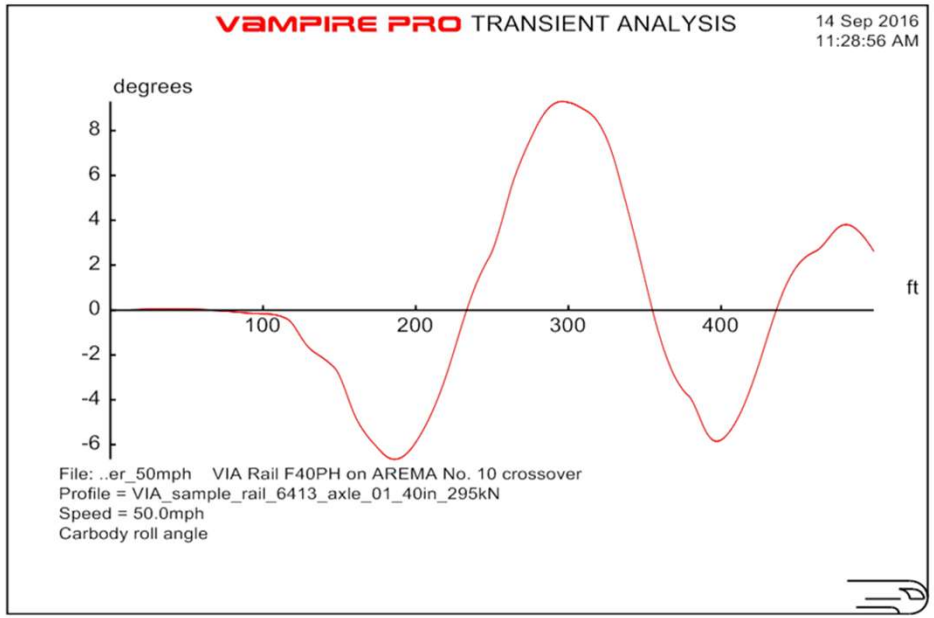
Vehicle/Track Dynamic Simulation

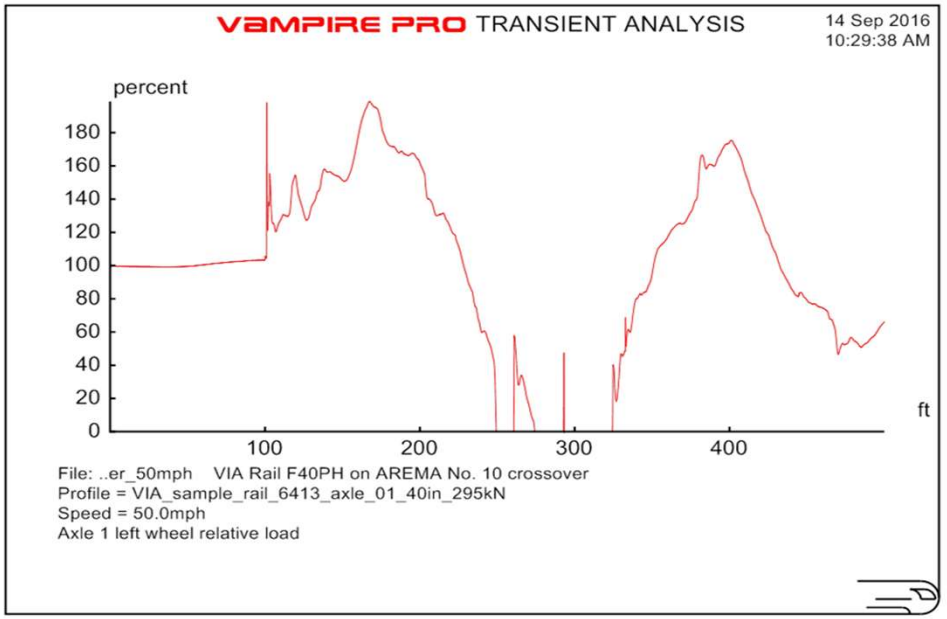




Simulated carbody roll angles and wheel relative loads of No.10 crossover at 45 mph

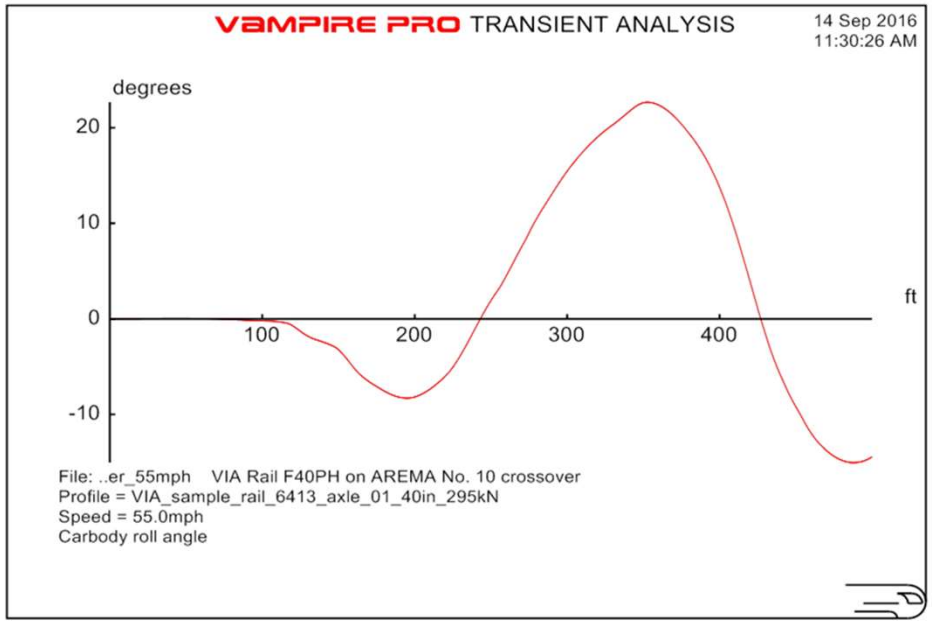
Vehicle/Track Dynamic Simulation

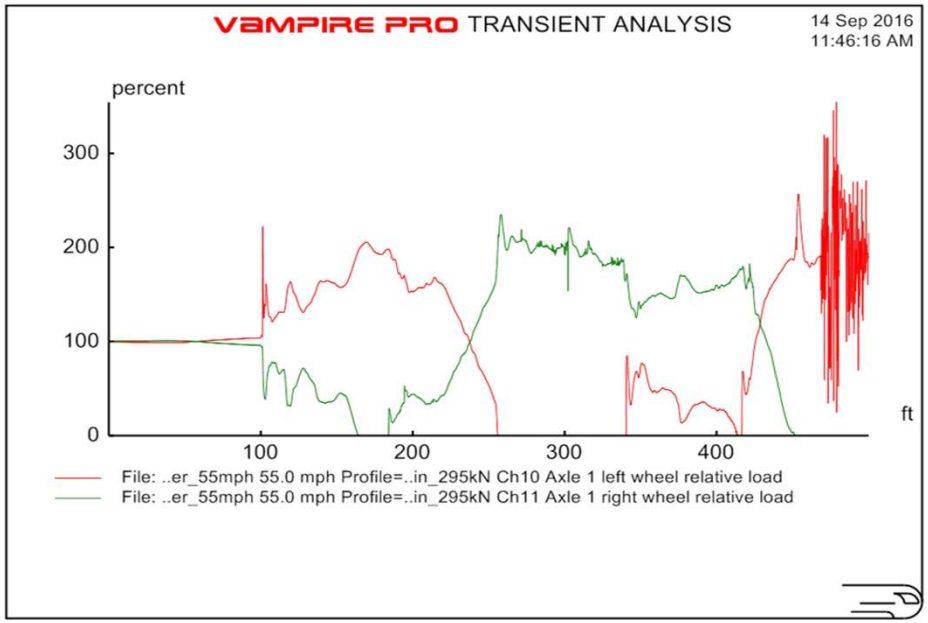




Simulated carbody roll angles and wheel relative loads of No.10 crossover at 50 mph

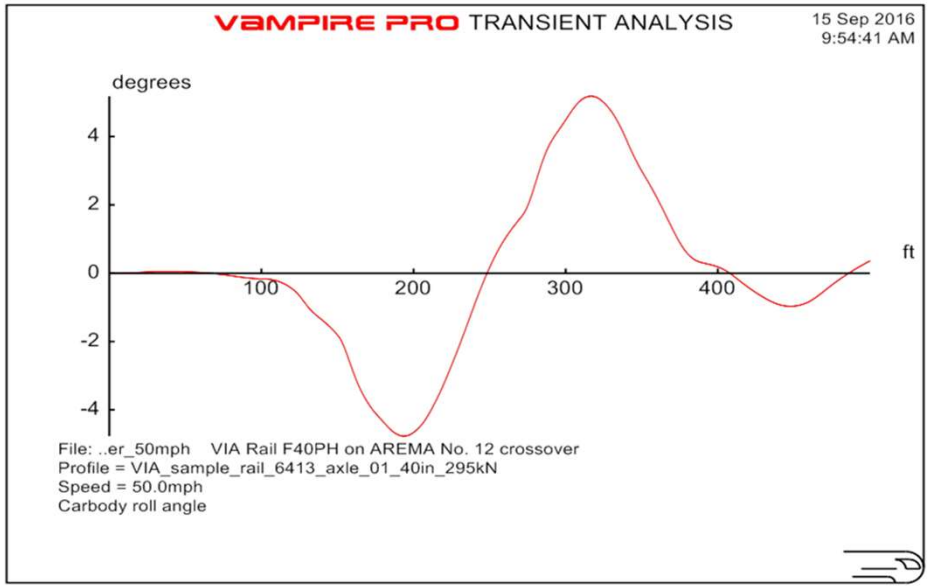
Vehicle/Track Dynamic Simulation

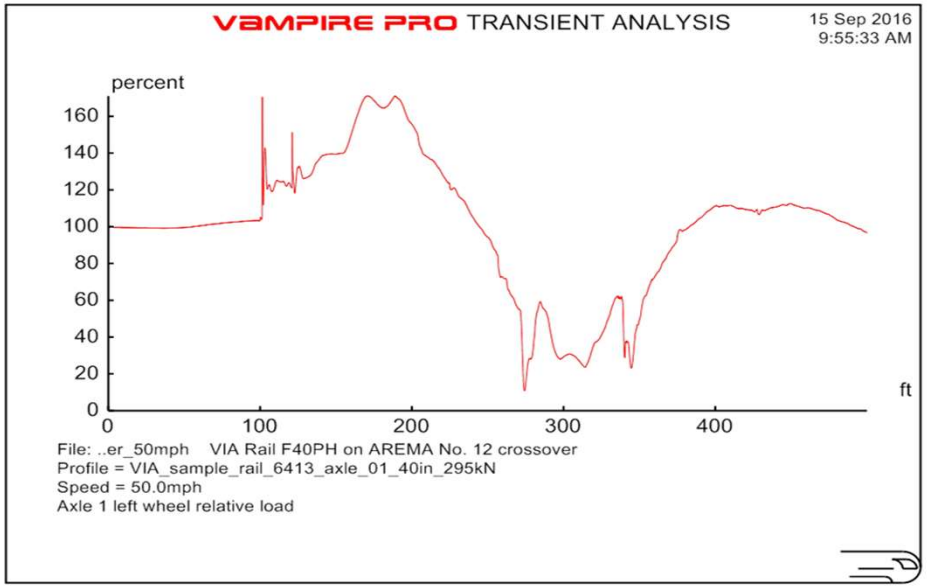




Simulated carbody roll angles and wheel relative loads of No.10 crossover at 55 mph

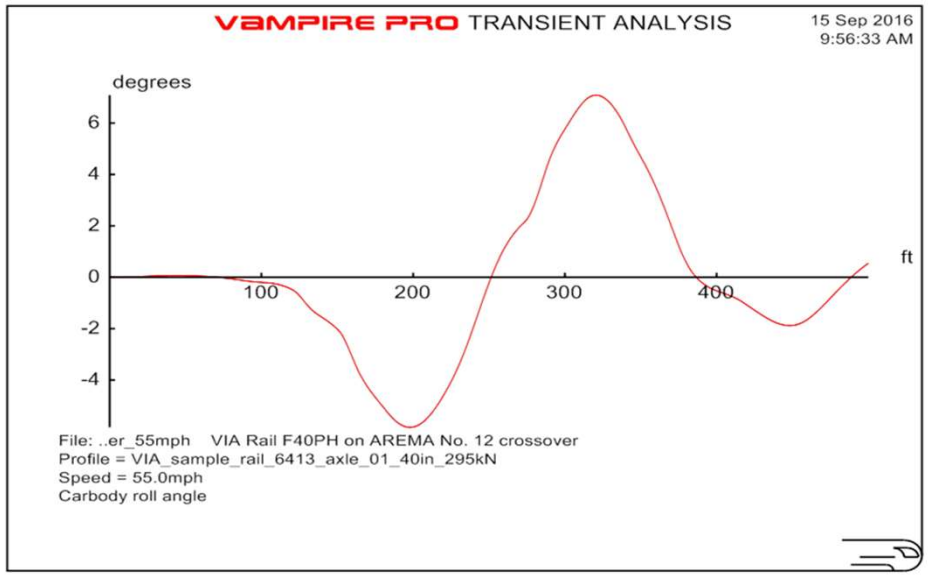
Vehicle/Track Dynamic Simulation

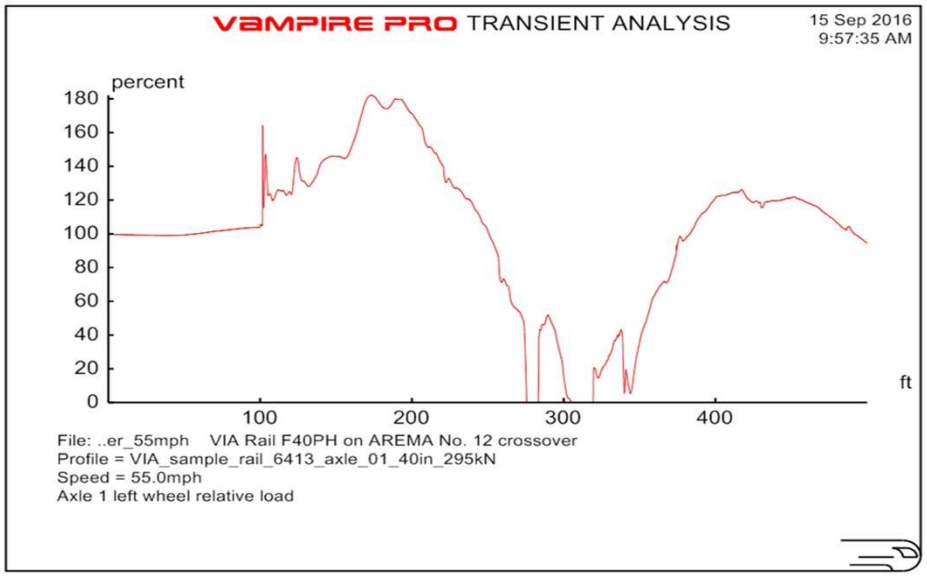




Simulated carbody roll angles and wheel relative loads of No.12 crossover at 50 mph

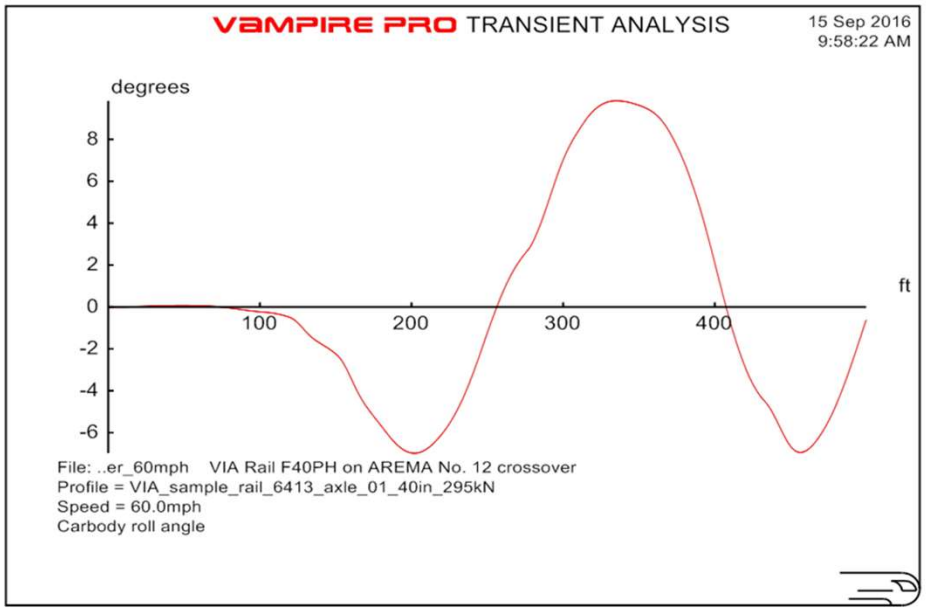
Vehicle/Track Dynamic Simulation

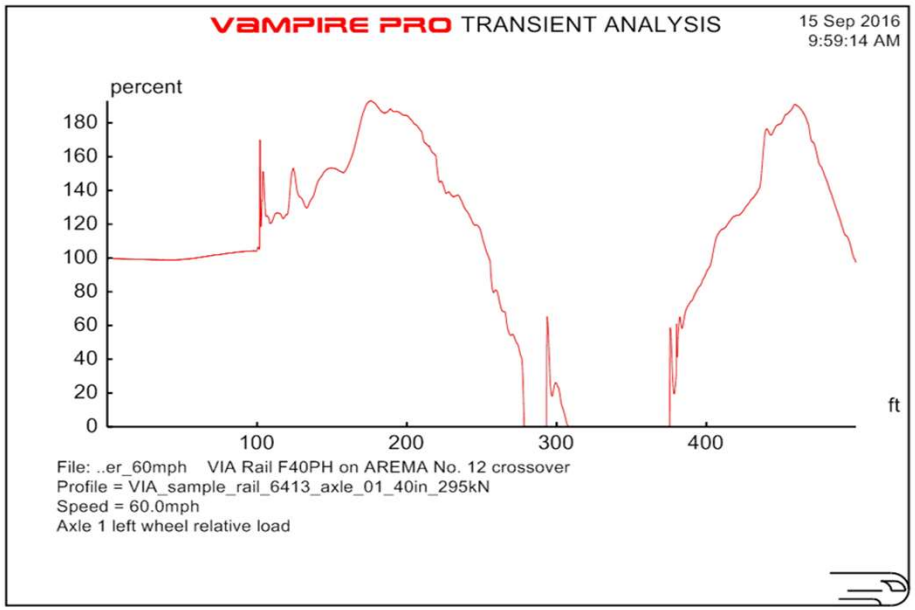




Simulated carbody roll angles and wheel relative loads of No.12 crossover at 55 mph

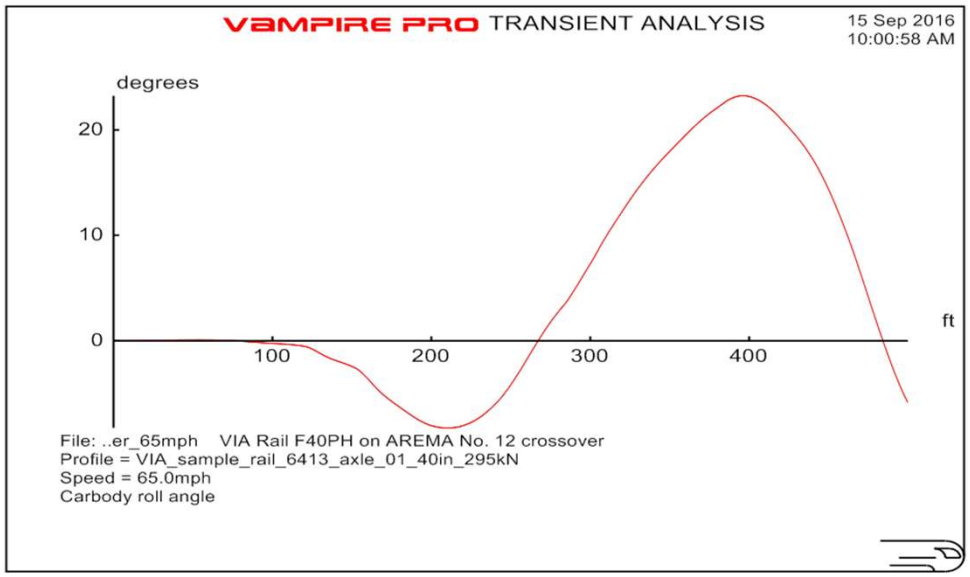
Vehicle/Track Dynamic Simulation

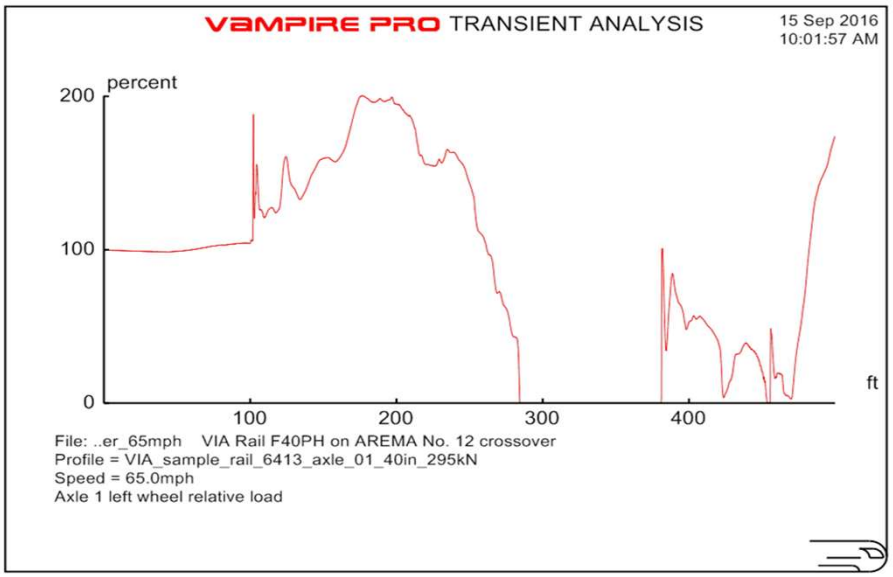




Simulated carbody roll angles and wheel relative loads of No.12 crossover at 60 mph

Vehicle/Track Dynamic Simulation

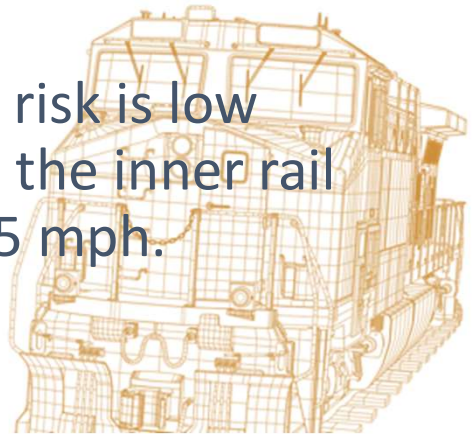




Simulated carbody roll angles and wheel relative loads of No.12 crossover at 65 mph

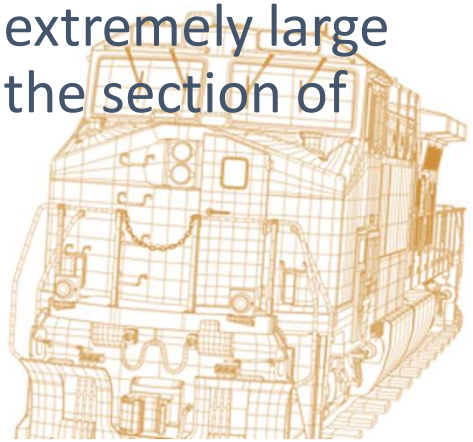
Conclusions

- The kinks and reverse closure curves without super- elevation and transition spiral of the crossover track generated high accumulating rock and roll dynamic response on the locomotives and reached the maximum at the exit end of the crossover.
- The rock and roll dynamic response increases with speed, presented by the impact L/V at the kinks, wheel lifting on the inner rail and the carbody roll angle outward on the closure curves.
- On the No 10 crossover in the occurrence, the derailment risk is low when the speed is below 40 mph, but the wheel lifting on the inner rail of the closure curve would appear when speed exceeds 45 mph.



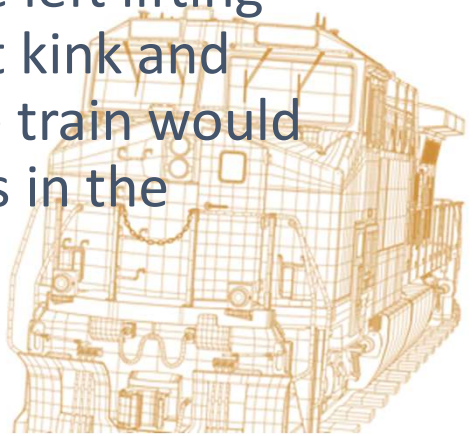
Conclusions

- The distance of wheel lifting extends and the carbody roll angle enlarges as speed increases. The locomotives might tip over outward on the closure curve as the extremely large carbody roll angle indicates at speeds over 55 mph.
- On the day of occurrence, at the recorded speeds reducing from 58 to 53 mph over the crossover section, both the lead and middle locomotives most likely experienced long distance of wheel lifting and extremely large roll angle, and were in danger of derailment, especially in the section of the second closure curve and exit Switch 75.



Conclusions

- The derailment was caused by the accumulating rock and roll generated by the locomotive at the high speed through the crossover track. The reason why the POD was on the exit tangent track instead of on the closure curves as in the previous accidents was that the speed just reached the level to cause wheel lifting but still below the carbody rollover speed on the curve. The rock and roll dynamic response reached the maximum at the exit location of the crossover and the left lifting wheel rebounded from the impact at the exit switch point kink and derailed on the tangent. If the speed had been higher, the train would have tipped over on the closure curves of the crossover as in the previous accidents.

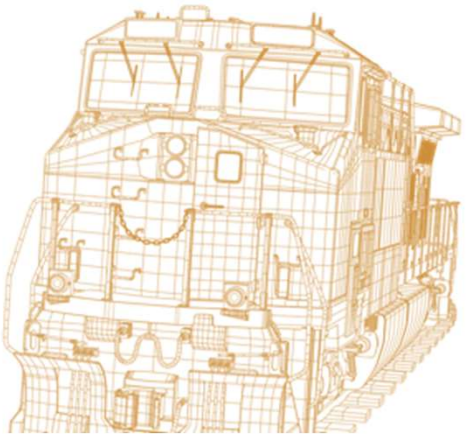


Conclusions

- The reason why the lead locomotive did not derail but the middle locomotive of the combined train did might lie in the different states of the locomotives i.e. wear, gap, maintenance and position. The middle locomotive was in a compressive state, its front coupler could be in a zig-zag position, and its wheelsets could be at a larger angle of attack rebounding from the impact at the exit switch point than those of the lead locomotive whose front coupler was free. These slight differences might affect the behavior of the already wheel lifting locomotives and result in the different consequences.

Conclusions

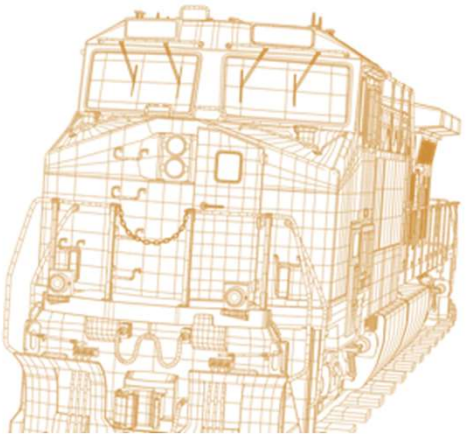
- Comparatively on No.12 crossover, the derailment risk is low at speed below 50 mph, and wheel lifting appears at speed 55 mph and extremely large carbody roll angle (greater than 20 degrees) shows up at speed over 65 mph. These simulated results confirmed the mechanism of tip over on the closure curves at speed of 67 to 70 mph in the previous accidents.



Acknowledgement

- The author would like to thank all the TSB colleagues who were involved in and contributed to the investigations quoted in this presentation.
- The cooperation from the contractors and involved railways are appreciated.

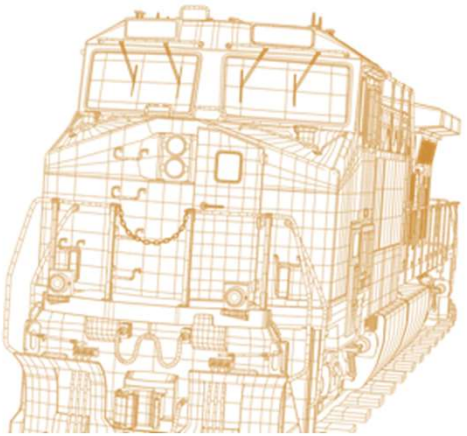
Thank you!



References

For more details of the occurrence and dynamic simulation please refer:

- TSB occurrence report R15D0118
- TSB lab report LP102_2016

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