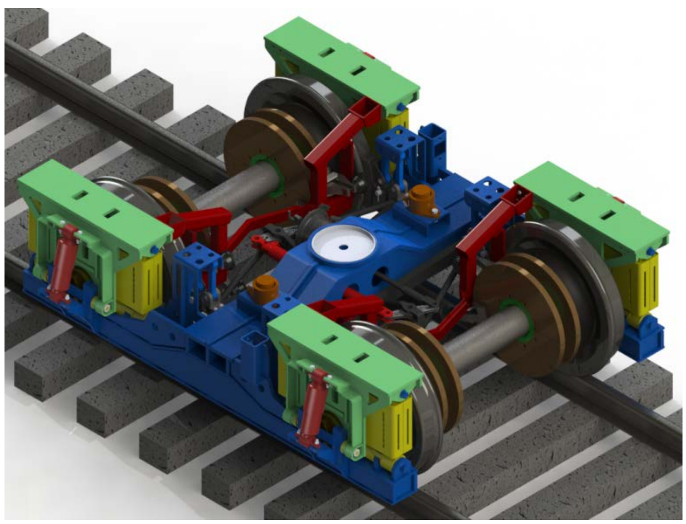
U.S. Department of Transportation

Federal Railroad Administration

HIGHER SPEED FREIGHT TRUCK: VEHICLE DYNAMICS ANALYSIS

Office of Research Development,
and Technology
Washington, DC 20590



DOT/FRA/ORD-15/27

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August 2015

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13. ABSTRACT (Maximum 200 words)
Previously, Sharma & Associates, Inc. (SA) developed a higher speed freight truck design under sponsorship of the Federal Railroad Administration. Under the current contract, SA was tasked with developing performance requirements for higher speed freight trucks, as well as conducting structural and dynamics simulations in accordance with the performance specifications developed in the earlier task components of this project. This report presents the vehicle dynamics analyses of the truck. These analyses follow the performance requirements laid out for this project in a report titled “WBS TASK 1.1, Higher Speed Freight Truck – Performance Requirements.” The requirements were based on the approach presented in FRA’s Notice of Proposed Rulemaking (NPRM) on Vehicle/Track Interaction Safety Standards; High-Speed and High Cant Deficiency Operations published on May 10, 2010. The vehicle dynamics simulations were conducted at speeds between 95 to 130 mph in 5 mph increments on Class 7 track, as well as for 115 mph on a Class 6 track. The simulations showed that the higher speed freight truck meets all previously specified performance criteria. Based on the results discussed in this report, it is recommended that a set of field tests be carried out to evaluate and validate the higher speed freight truck’s performance under Chapter 11 regimes. Further tests should be run at speeds 100 mph or higher at a facility such as Transportation Technology Center, Inc. (TTCI).

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

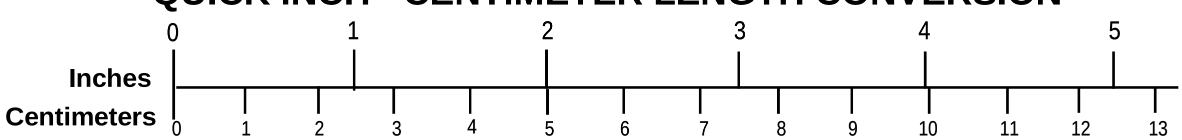
VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSIO

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

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Executive Summary

Previously, the Federal Railroad Administration (FRA) sponsored the development of a freight truck design for higher speed freight operations. Under contract, Sharma & Associates, Inc. (SA) developed a detailed design for such a higher speed freight truck. Vehicle dynamic simulations were also conducted to predict the truck's dynamic performance for hunting stability operations at speeds up to 125 mph and higher (maximum 150 mph), as well as pitch and bounce, twist and roll, and curving dynamics per the Association of American Railroads' (AAR) *Manual of Standards and Recommended Practices* (MSRP), Section C-II, Service-worthiness Tests and Analyses for New Freight Cars.

Under the current contract (BAA-2010-1), SA was tasked with developing structural strength and vehicle dynamics performance requirements for this truck, conducting structural and vehicle dynamics simulations per these requirements, and conducting a market analysis of higher speed rail freight business opportunities arising from the availability of such a truck when considering the implementation of higher speed passenger lines.

This report presents the vehicle dynamics analyses of the truck. These analyses follow the performance requirements laid out as part of this project in a report titled "WBS TASK 1.1, Higher Speed Freight Truck – Performance Requirements." The performance requirements were based on the approach presented in FRA's Notice of Proposed Rulemaking (NPRM) on Vehicle/Track Interaction Safety Standards; High-Speed and High Cant Deficiency Operations published on May 10, 2010.

The vehicle dynamics simulations were conducted at speeds between 95 to 130 mph in 5 mph increments on a Class 7 track, in addition to a simulation over a Class 6 track at 115 mph. These simulations show that the higher speed freight truck design meets all previously specified performance criteria.

Based on the results discussed in this document, it is recommended that a set of field tests be carried out to evaluate and validate the higher speed freight truck's performance under Chapter 11 regimes. That set of performance criteria is well established and accepted for initial qualification of freight equipment.

Further tests should be run at speeds of 100 mph or higher at a facility such as Transportation Technology Center, Inc. (TTCI). This type of testing, in combination with 115 mph computer simulations for Class 6 track (110 mph limit), can be used to validate the performance of the higher speed truck.

SA wishes to ascertain the higher speed freight truck's performance when simulated over measured track from the Northeast Corridor (NEC) route, preceding any Chapter XI testing. Such simulations would provide significant insight into the ability of this higher speed freight truck to operate safely on existing track infrastructure.

Also, after all recommended testing, any design changes identified for improvement should be incorporated into the design, and the simulation plan as recommended in "Higher Speed Freight Truck Performance Requirements" should be repeated, including the simulations over measured NEC Class 6 and 7 tracks.

1. Background

Lateral truck instability, known as hunting, is a significant obstacle against realizing safe higher speed freight operations. The three-piece truck, a workhorse of the railway industry for over 100 years, is inherently susceptible to hunting in empty car conditions above 50 mph. This speed limitation, on any train with lightly loaded cars, leads to restricted operations.

SA developed a higher speed freight truck design in a previous project sponsored by FRA (DTRS57-04-C-10023, Advanced Truck for High Speed Freight Operations). Under Phase I of that project, SA developed a detailed design of the higher speed freight truck. Vehicle dynamic simulations were also conducted to predict the truck's dynamic performance for hunting stability for operations up to 150 mph and pitch and bounce, twist and roll, and curving dynamics per AAR's MSRP, Section C-II, Service-worthiness Tests and Analyses for New Freight Cars. The AAR MSRP requirements define the analyses regimes (i.e., track defect amplitudes, shapes and speeds for operations up to 80 mph (FRA Class 4 Track) only).

On the basis of the design developed in Phase I, two prototype trucks were manufactured and fitted under Amtrak mail/baggage in Phase II of the project and tested at slow speeds in a yard environment for verification of overall design and fitment. A CAD model of the final design is shown in Figure 1 and the truck as assembled for yard track test is shown in Figure 2.

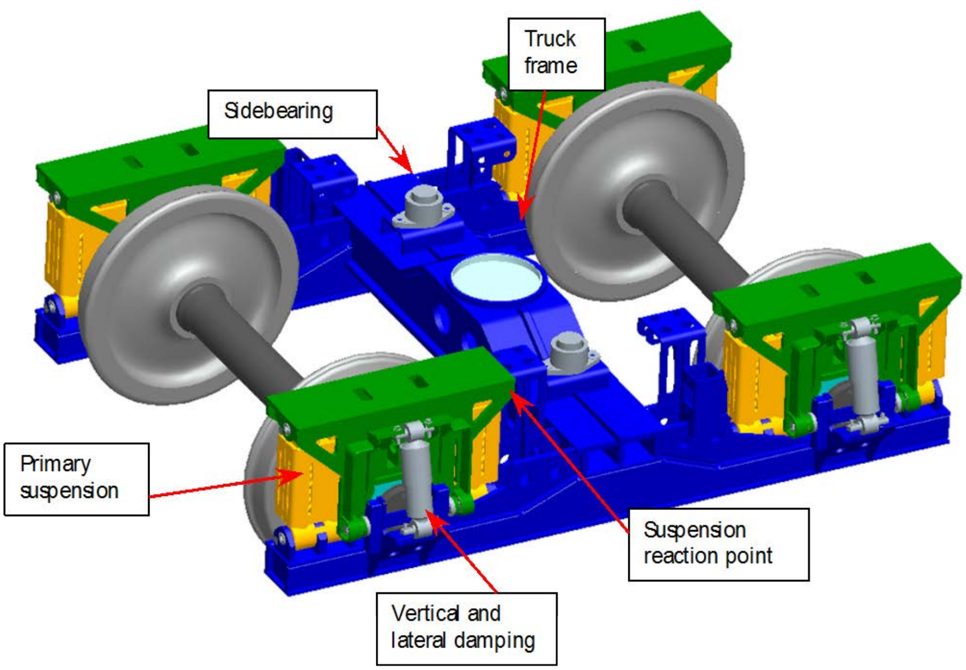

Figure 1 CAD Model of the Prototype HST

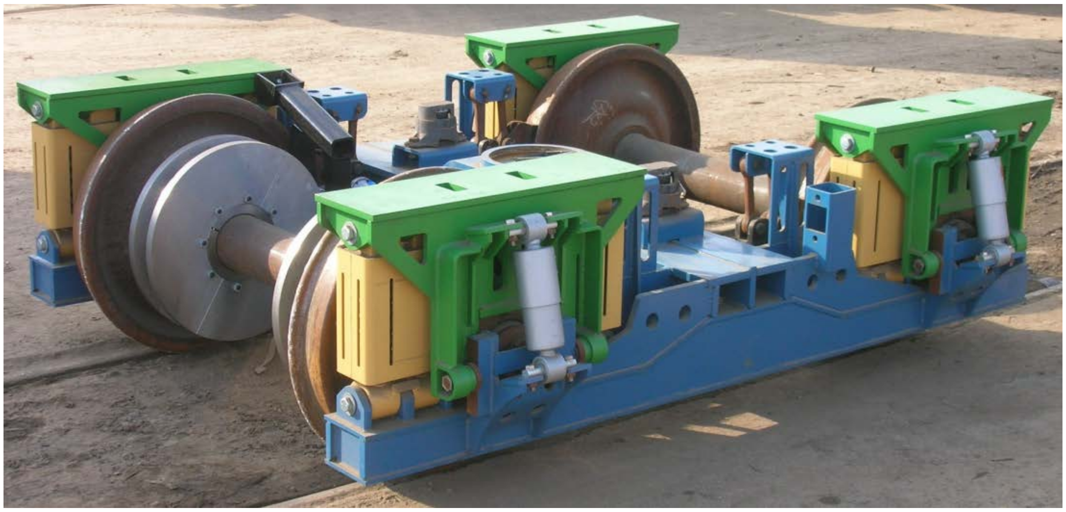

Figure 2. Prototype HST Used for Fitment and Yard On-Track Testing

Under FRA's BAA-2010-1, SA was awarded Contract No: DTFR53-11-C-00009, a project to increase safety in rail operations by further evaluation of this higher speed freight truck. The project scope called for three distinct subtasks as follows:

1. Develop performance requirements to qualify freight trucks for operations up to 125 mph.
2. Conduct market research for viability and implementation of higher speed freight trucks when considering implementation of high-speed passenger train corridors.
3. Conduct vehicle dynamics and structural analyses of the SA designed higher speed truck to assess its performance against the performance requirements developed in Subtask 1 and identify any design changes and/or improvements required to meet the proposed performance requirements.

Under Subtask 1, a performance document was drafted by drawing on the existing AAR, American Public Transportation Association (APTA), FRA NPRM, and European industry standards. The dynamic performance standards were largely based on the newly proposed (and under review) CFR 49 §213 and §238 as outlined in the NPRM issued May 10, 2010.

Dynamic analyses carried out in Subtask 3 are based on the simulation conditions described in the NPRM using the criteria for Class 7 track (maximum speed of 125 mph).

Dynamics simulations were performed using carbody characteristics similar to those of a contemporary 70-ton refrigerated car, identified to be the target car in the market analysis conducted under Subtask 2 of this project.

This document reports the scope, objectives, and findings of the vehicle dynamics completed as part of Subtask 3.

2. Performance Requirements

As mentioned earlier, the vehicle dynamics performance requirements for higher speed operations were developed in Subtask 1 and key criteria are listed below in Table 1.

Table 1. Proposed Vehicle Dynamic Performance Criteria

Wheel-Rail Forces, low pass filtered at ≥ 25 Hz			
Parameter	**Safety Limit**	**Filter/ Window**	**Requirements**
Single Wheel Vertical Load Ratio	≥ 0.15	5 ft	No wheel of the vehicle shall be permitted to unload to less than 15% of the static vertical wheel load for 5 or more continuous feet. The static vertical wheel load is defined as the load that the wheel would carry when stationary on level track.
Single Wheel L/V Ratio	$\leq \left(\frac{\tan(\delta) - 0.5}{1 + 0.5\tan(\delta)} \right)$	5 ft	The ratio of the lateral force that any wheel exerts on an individual rail to the vertical force exerted by the same wheel shall not be greater than the safety limit calculated for the wheel's flange angle (δ) for 5 or more continuous feet.
Maximum Axle Lateral Load	$\leq 0.4V_a + 5.0$	5 ft	The net axle lateral force, in kilo pounds per second, exerted by any axle on the track shall not exceed a total of 5 kips plus 40% of the static vertical load that the axle exerts on the track for 5 or more continuous feet. V_a = static vertical axle load (kips).
Truck Side L/V Ratio	≤ 0.6	5 ft	The ratio of the lateral forces that the wheels on one side of any truck exert on an individual rail to the vertical forces exerted by the same wheels on that rail shall not be greater than 0.6 for 5 or more continuous feet.
Axle Sum L/V Ratio	≤ 1.5	5 ft	The ratio of the lateral forces that the wheels on one axle exert on the rails to the vertical forces exerted by the same wheels shall not be greater than 1.5 for 5 or more continuous feet.

Table 1. Proposed Vehicle Dynamic Performance Criteria (cont.)

Carbody Accelerations low pass filtered at ≥ 25 Hz. Accelerations determined on carbody floor directly above each truck.			
Parameter	Safety Limit	Filter/ Window	Requirements
Carbody Lateral (RMS)	≤ 0.12 g	4 second	The RMS acceleration shall not exceed 0.12 g within any 4-second window.
Carbody Vertical (Transient)	≤ 1.0 g augment	Instantaneous	The instantaneous acceleration shall not exceed 1 g, for loaded car only.

3. Vehicle & Track Dynamics Model

The performance of SA's higher speed freight truck design was evaluated by conducting simulations of the dynamic behavior for both an empty and a loaded 70-ton car over track perturbations defined in the NPRM, the Minimally Compliant Analytical Track (MCAT). These perturbations are detailed in Sections 3.3 and 3.4 describing the track.

The vehicle dynamics simulations were conducted for speeds from 95 to 130 mph in 5 mph increments on Class 7 track. One additional simulation over Class 6 track at 115 mph was conducted as required per Appendix D to Part 213, 3.(c)(2)(iii)(A). All simulations were conducted with the vehicle dynamics program VAMPIRE® using the APTA 340 wheel profile on new 136 pound/yard American Railway Engineering and Maintenance-of-Way Association rail.

3.1 Masses

The vehicle dynamics rigid-body model included masses representing various parts of the truck and one mass for the carbody. Figure 3 shows a representation of the vehicle model. Table 2 summarizes the properties of each mass in the model.

Table 2. Mass and Geometry Properties for Vehicle Dynamics Model

Mass Name	Empty, lb	Loaded, lb
Carbody	64,250	197,800
Frame (2)	3,652	3,652
Journal Housing (4 per truck)	227	227
Wheelset	3,270	3,270
Total Weight	86,450	220,000
Geometry		
Overall length, ft	64	64
Truck center spacing, ft	45.67	45.67
Wheelbase, in	80	80

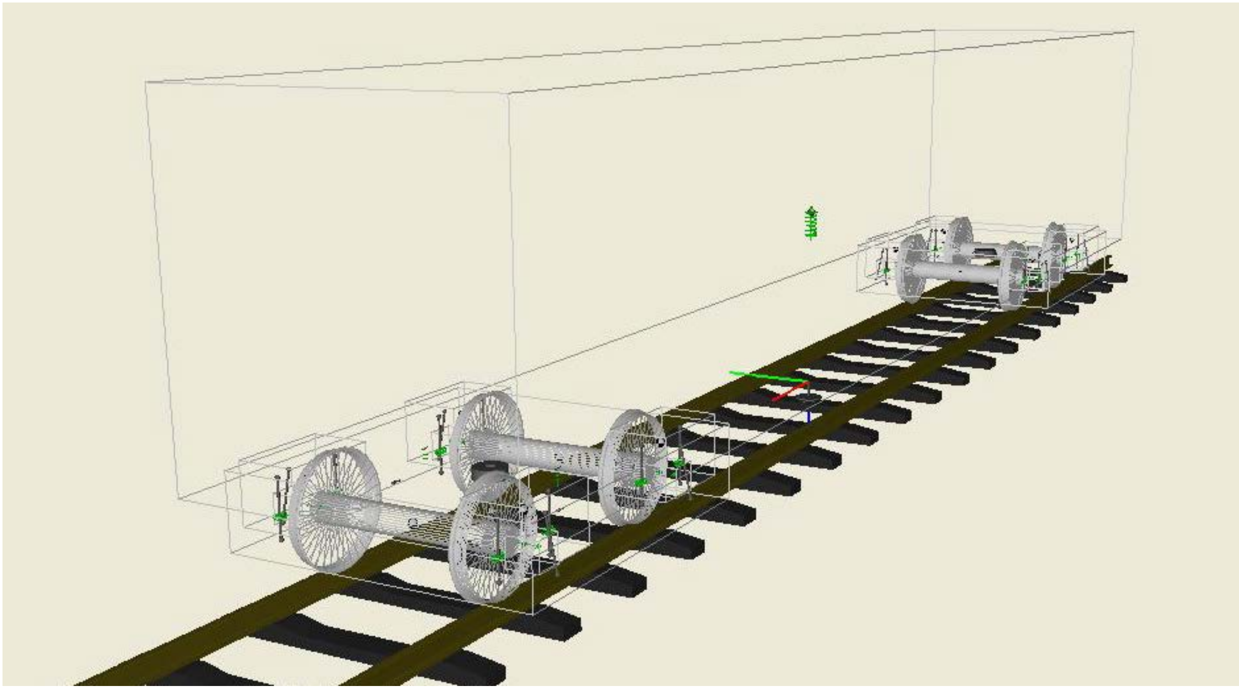

Figure 3. Vehicle representation in VAMPIRE®

3.2 Connections

Figure 4 shows the truck and its connections. The truck frame (blue) supports the carbody and transfers the load to wheels via the yokes (yellow) and pedestals (green). The yoke contains the main suspension components. The pedestal contains the reaction points for the tops of the main suspension components, as well as the primary longitudinal connections.

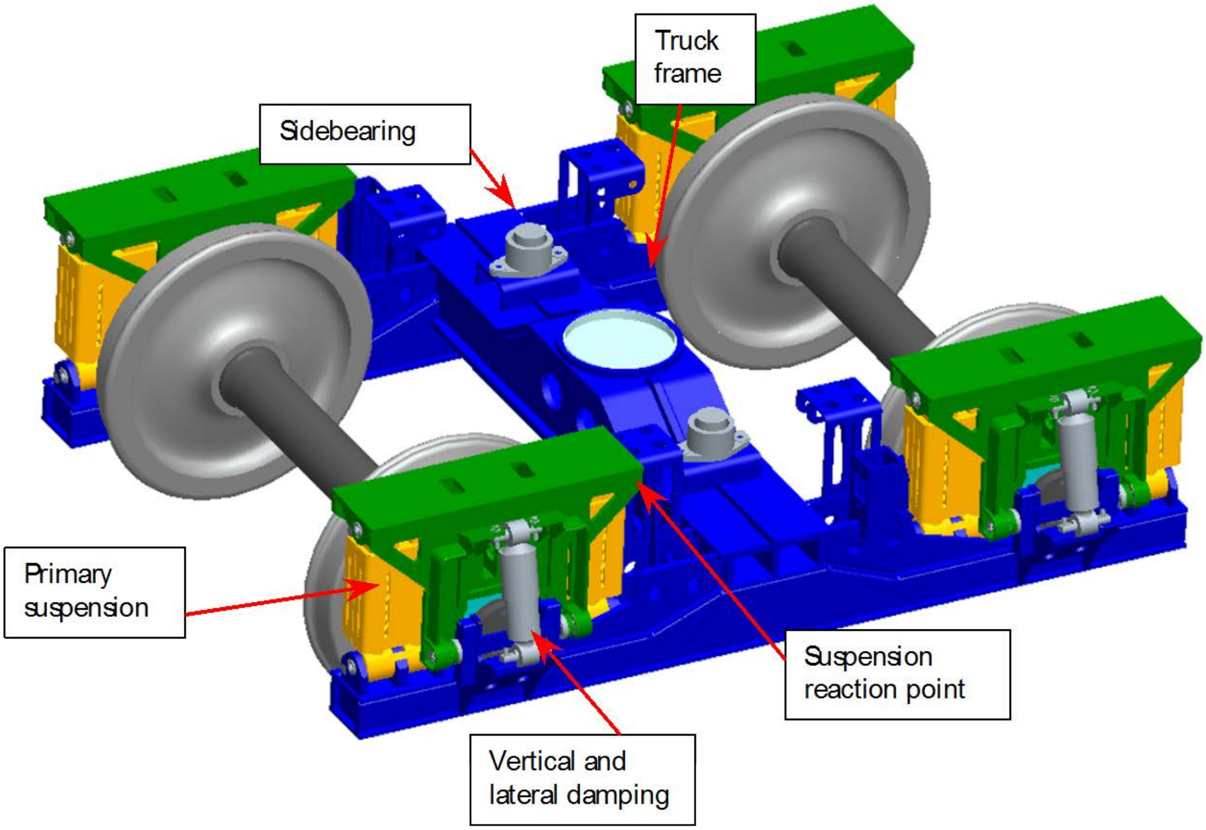

Figure 4. 3D CAD Model showing the key structural components of the truck

In VAMPIRE®, suspension connections are modeled as pinlinks, springs, and dampers. The pinlink is an element that allows large displacements of the end connections as either a spring or damper and maintains the correct force direction. The center bowl is modeled using a combination of vertical springs, linked friction elements, and a bushing to simulate the interaction between the center bowl and the truck center plate, as shown in Figure 5.

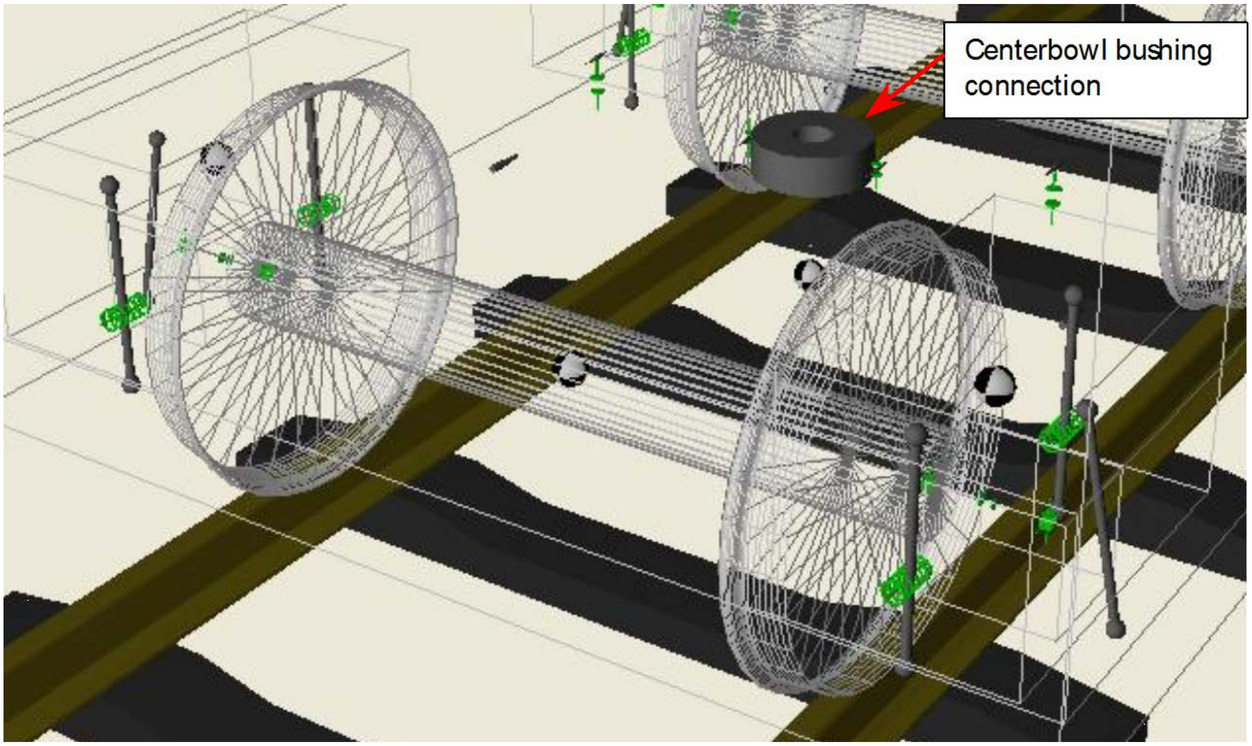

Figure 5. Vehicle dynamics model of truck showing connections

3.3 Tangent Track

The MCAT includes several types of track irregularities as shown in Figure 6 and summarized in Table 3 for the Class 7 tangent track simulations. The number parameters a1 through a11 indicate the amplitude of a specific type of irregularity. When there is one parameter for a particular type of irregularity, both the left and right rails move the same amount in the same direction. If there are two parameters listed for an irregularity, the left and right rails move by different amounts, but in the same direction. For example, the single surface irregularity for tangent track Class 7, 31-foot wavelength, has 1.0 and 0.0 inch amplitudes shown. The right rail dips 1 inch while the left rail does not dip. Class 6 track irregularities are summarized in Table 4.

The irregularities for Classes 6 and 7 were generated using the NPRM-specified versine function (1-cosø) for the specific irregularity wavelength. Figure 7 and Figure 8 show the profiles for all wavelengths for the single and repeated surface irregularity scenarios respectively.

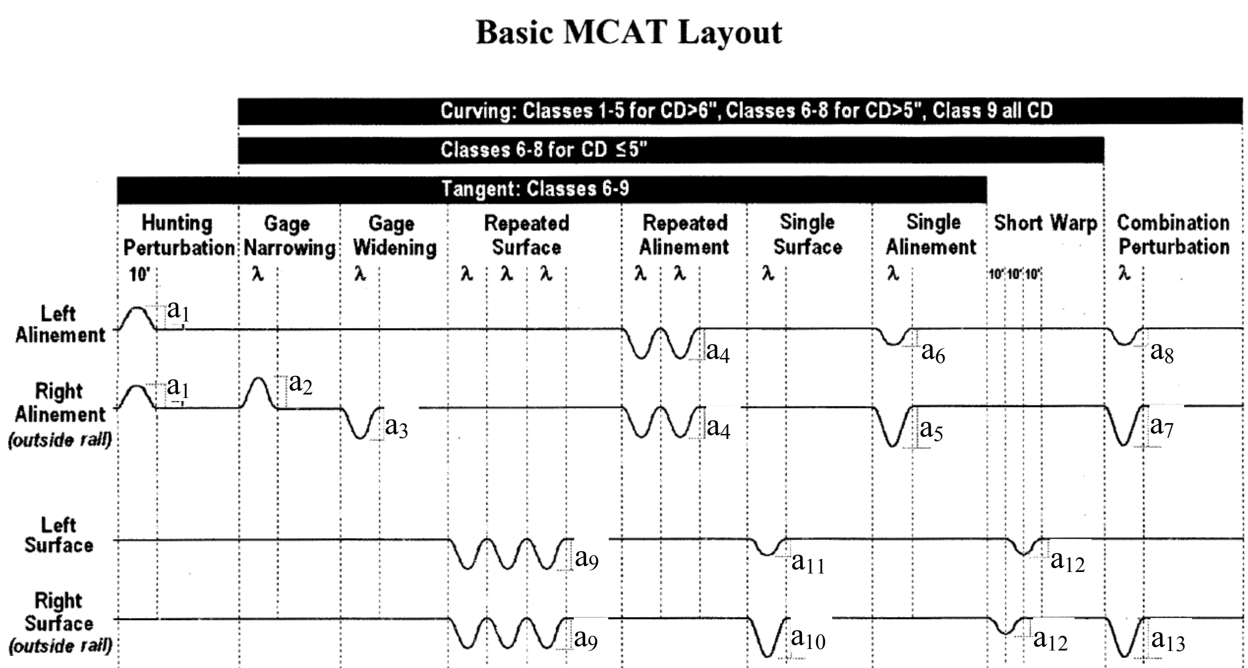

Figure 6. Basic MCAT Layout

Table 3. Irregularity Amplitudes—Tangent Track (Class 7)

Regime	Gage Narrowing	Gage Widening	Repeated Surface	Repeated Alinement	Single Surface	Single Alinement	Hunting
Amplitude Parameter	a2	a3	a9	a4	a10, a11	a5, a6	a1
10-foot wavelength	N/A	N/A	N/A	N/A	N/A	N/A	0.5
31-foot wavelength	0.5	0.5	0. 75	0.375	1.0, 0.0	0.5, 0.0	N//A
62-foot wavelength	0.5	0.5	0.75	0.375	1.0, 0.0	0.75, 0.5	N/A
124-foot wavelength	0.5	0.5	1.0	0.875	1.5, 0.0	1.25, 0.5	N/A

Table 4. Irregularity Amplitudes—Tangent Track (Class 6)

Regime	Gage Narrowing	Gage Widening	Repeated Surface	Repeated Alinement	Single Surface	Single Alinement	Hunting
Amplitude Parameter	a2	a3	a9	a4	a10, a11	a5, a6	a1
10-foot wavelength	N/A	N/A	N/A	N/A	N/A	N/A	0.5
31-foot wavelength	0.5	0.5	0.75	0.375	1.0, 0.0	0.5, 0.0	N/A
62-foot wavelength	0.5	0.5	0.75	0.5	1.0, 0.0	0.75, 0.5	N/A
124-foot wavelength	0.5	0.5	1.25	1.0	1.75, 0.25	1.5, 0.75	N/A

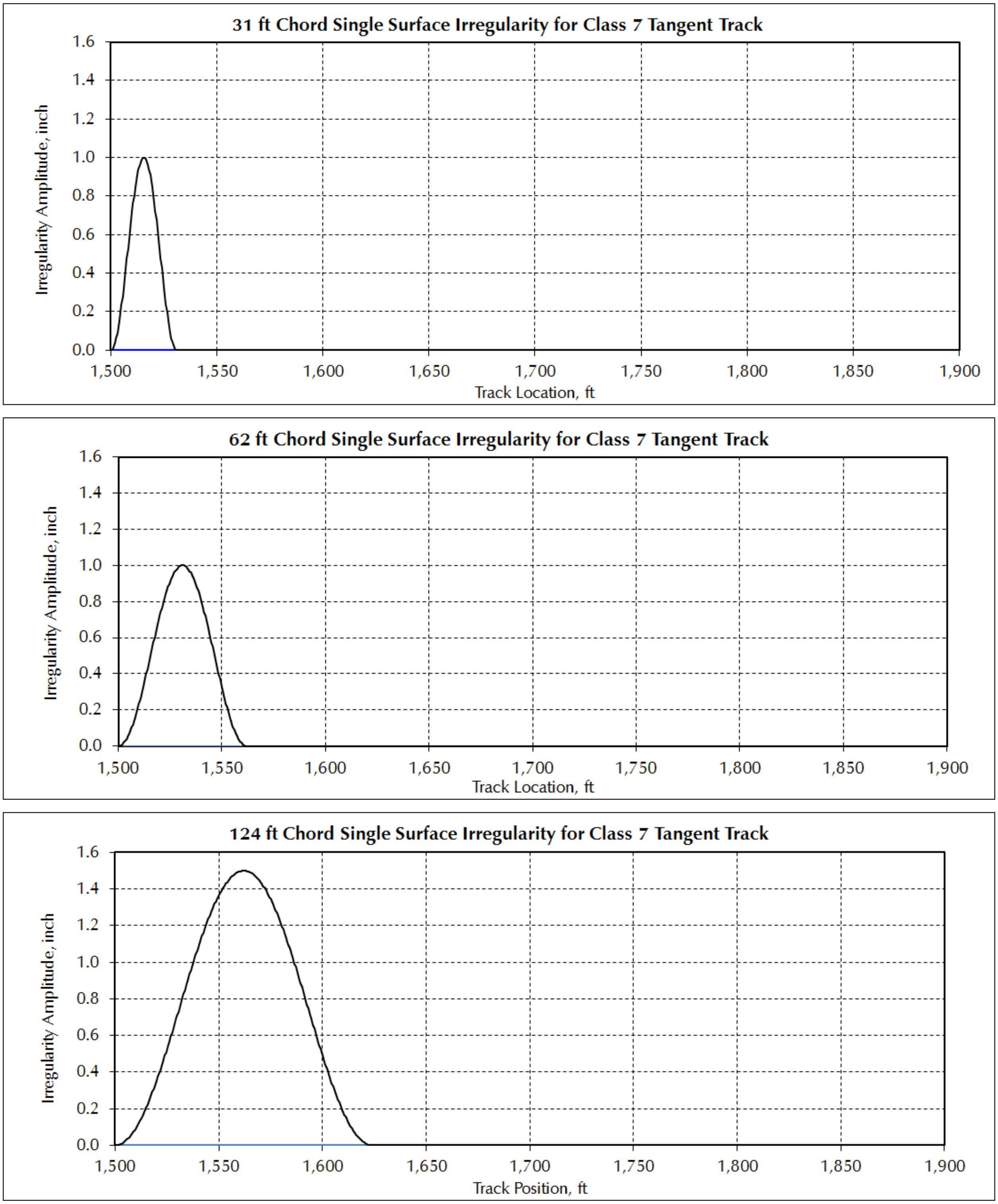

Figure 7. Single Surface Irregularity Profiles

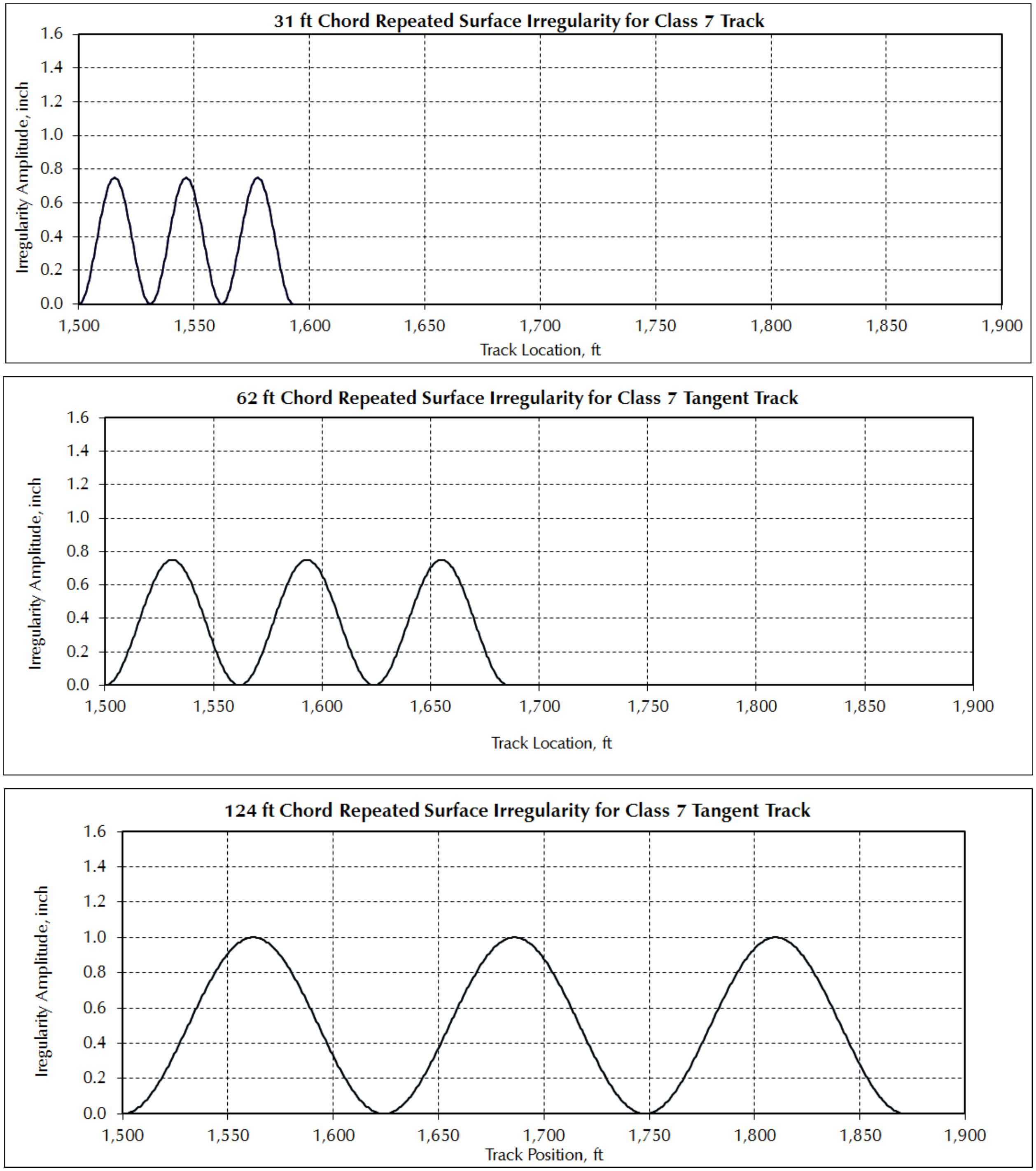

Figure 8. Repeated Surface Irregularity Profiles

3.4 Curved Tracks

The MCAT track includes several types of irregularities as shown in Figure 6 and summarized in Table 5 for the Class 7 curved track simulations. Table 6 summarizes the Class 6 irregularities.

Table 5. Irregularity Amplitudes—Curved Track (Class 7)

Regime	Gage Narrowing	Gage Widening	Repeated Surface	Repeated Alinement	Single Surface	Single Alinement
Amplitude Parameter	a2	a3	a9	a4	a10, a11	a5, a6
31-foot wavelength	0.5	0.5	0.75	0.375	1.0, 0.0	0.5, 0.0
62-foot wavelength	0.5	0.5	0.75	0.375	1.0, 0.0	0.5, 0.0
124-foot wavelength	0.5	0.5	1.0	0.875	1.5, 0.0	1.25, 0.5

Table 6. Irregularity Amplitudes—Curved Track (Class 6)

Regime	Gage Narrowing	Gage Widening	Repeated Surface	Repeated Alinement	Single Surface	Single Alinement
Amplitude Parameter	a2	a3	a9	a4	a10, a11	a5, a6
31-foot wavelength	0.5	0.5	0.75	0.375	1.0, 0.0	0.5, 0.0
62-foot wavelength	0.5	0.5	0.75	0.375	1.0, 0.0	0.625, 0.125
124-foot wavelength	0.5	0.5	1.250	1.0	1.75, 0.25	1.5, 0.5

The speeds simulated along with the required degrees of curvature simulated are summarized in Table 7. Appendix D to Part CFR 49§213, 3.b. (3) specifies that the curvature be calculated according to the equation:

$$D = \frac{6 + E_u}{0.0007V^2}$$

Where:

E_u is the cant deficiency (4 inches for the simulations conducted here)

V is the speed, mph

Table 7. Simulation Speeds and Degrees of Curvature

Speed, mph	Degree of Curvature
95	1.58
100	1.43
105	1.30
110	1.18
115	1.08
120	0.99
125	0.91
130	0.85
115 (Class 6)	1.08

4. Dynamic Simulations

4.1 Simulation Matrix

Table 8 through Table 14 show the simulation matrix completed in the evaluation of the high-speed truck. There were a total of 664 VAMPIRE® simulations conducted per the combinations of car configurations (empty and loaded), irregularity wavelengths (31 and 62 ft), and various performance regimes on tangent and curved track and required speeds.

Table 8. Gage Narrowing Simulations

Gage Narrowing	31-foot chord	62-foot chord	124-foot chord
Tangent Empty & Loaded Curve Empty & Loaded	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)

Table 9. Gage Widening Simulations

Gage Widening	31-foot chord	62-foot chord	124-foot chord
Tangent Empty & Loaded Curve Empty & Loaded	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)

Table 10. Repeated Alinement Irregularity Simulations

Repeated Alinement	31-foot chord	62-foot chord	124-foot chord
Tangent Empty & Loaded Curve Empty & Loaded	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7) 115 mph (Class 6)

Table 11. Repeated Surface Irregularity Simulations

Repeated Surface	31-foot chord	62-foot chord	124-foot chord
Tangent Empty & Loaded	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)
Curve Empty & Loaded	115 mph (Class 6)	115 mph (Class 6)	115 mph (Class 6)

Table 12. Single Alinement Irregularity Simulations

Single Alinement	31-foot chord	62-foot chord	124-foot chord
Tangent Empty & Loaded	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)
Curve Empty & Loaded	115 mph (Class 6)	115 mph (Class 6)	115 mph (Class 6)

Table 13. Single Surface Irregularity Simulations

Single Surface	31-foot chord	62-foot chord	124-foot chord
Tangent Empty & Loaded	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)	95, 100, 105, 110, 115, 120, 125, 130 mph (Class 7)
Curve Empty & Loaded	115 mph (Class 6)	115 mph (Class 6)	115 mph (Class 6)

Table 14. Hunting Simulations

Single surface	31-foot chord
Tangent Empty & Loaded	95, 100, 105, 110, 115, 120, 125, 130 mph

All data were low-pass filtered at 25 Hz. The data were then exported and postprocessed to complete the window analysis for all of the parameters monitored. It should be noted that whereas the measured parameter values may exceed the allowable limits for a short period within the associated distance or time window, the limit value must be exceeded for the entire window for the criterion to be considered exceeded during that regime.

4.2 Tangent Track Simulation Results

There were a total of 340 tangent track simulations, from which all cases of various speeds, irregularity amplitudes, and wavelengths were found to meet the criteria laid out in Section 2. Figure 9 shows a graph of axle 2's left wheel load for the multiple surface irregularity at 130 mph with the empty car. The wheel load does not drop below 30 percent.

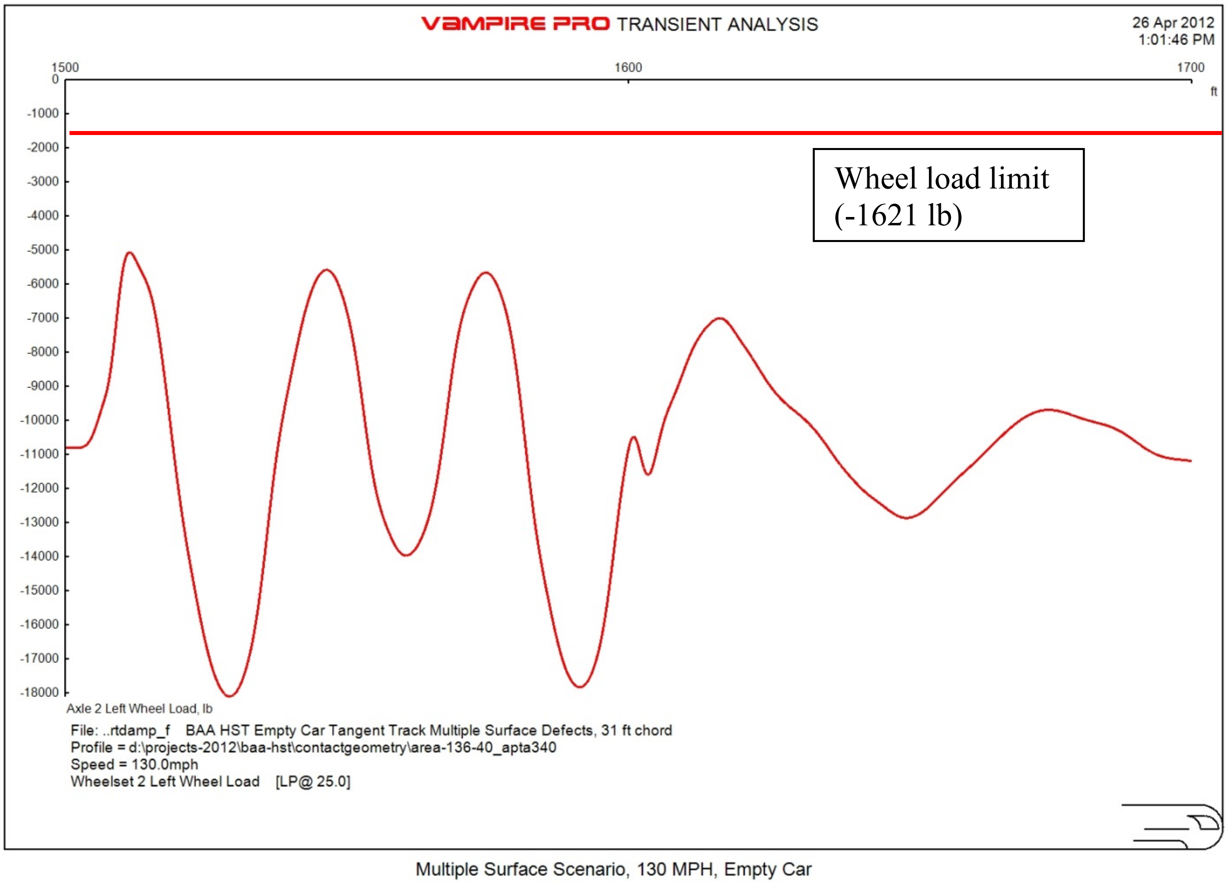

Figure 9. L2 wheel load, empty car, 130 mph, multiple surface irregularities

4.3 Curved Track Simulation Results

There were a total of 324 curve track simulations, out of which all scenarios satisfied all of the performance criteria. Figure 10 shows the axle sum L/V ratio at 130 mph for the empty car.

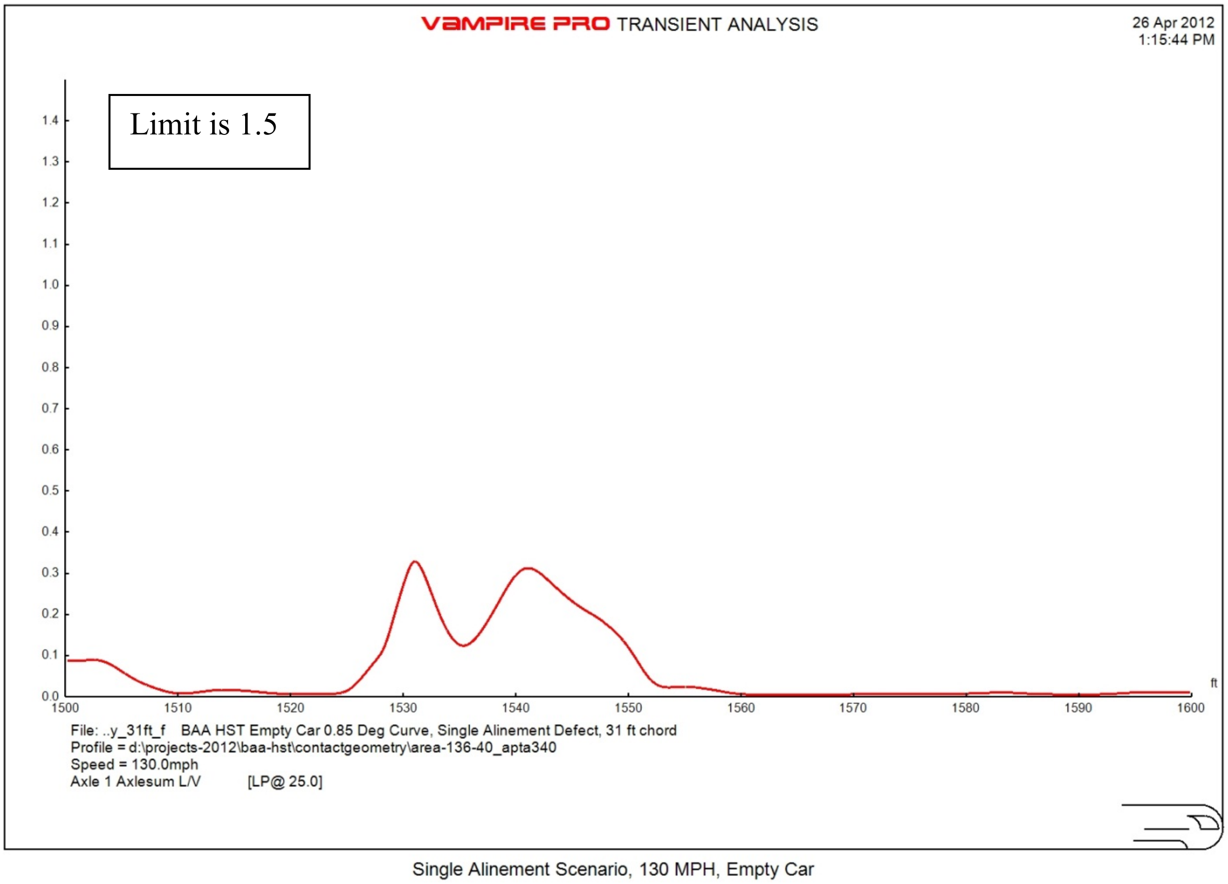

Figure 10. Axle sum L/V ratio on axle 1, left wheel

4.4 Short Warp Simulation Results

Although the current NPRM includes "short warp" as a regime to be used as a part of MCAT simulations, SA understands from the ongoing Engineering Task Force (ETF) that the work is being revised. This revision is due to the fact that many of the vehicles approved to be service worthy and presently in service do not meet the short warp performance criteria. For this reason, SA has not included any short warp simulation results in this report.

4.5 Hunting Simulation Results

The truck did not exhibit any lateral instability or hunting behavior at any of the speeds from 95 to 130 mph simulated on tangent track. This is consistent with the original design goal of the higher speed truck to exhibit lateral stability for operations up to 150 mph. The lateral acceleration at 130 mph is shown in Figure 11, demonstrating that the amplitude quickly dies out.

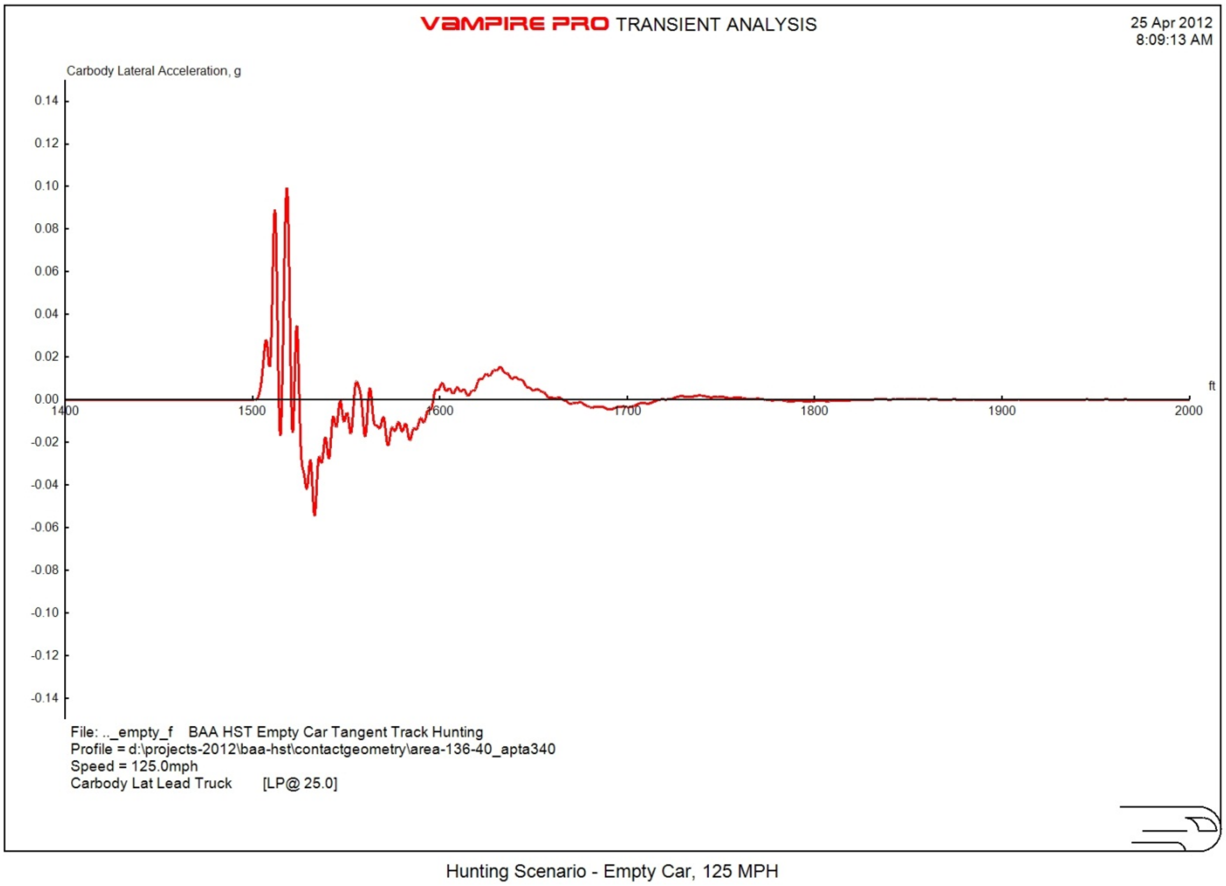

Figure 11. Carbody lateral acceleration at 130 mph; the HST does not hunt

5. Conclusions

On the basis of the simulation regimes and acceptance criteria identified by SA as part of this effort [Higher Speed Freight Truck Performance Requirements], vehicle dynamics simulations were conducted for both empty and loaded car configurations over the track perturbations defined as MCAT by FRA for qualification on Class 7 track for speeds ranging from 95 to 130 mph.

The refrigerator car equipped with the higher speed rail freight truck designed by SA met all the criteria for both configurations. The hunting, wheel unloading, vertical and lateral acceleration, and wheel L/V ratio criteria were met with a good margin relative to the safety criteria limits.

SA desires to ascertain the higher speed freight truck's performance when simulated over measured track from the NEC route, preceding any Chapter 11 testing. Such simulations would provide significant insight into the ability of this higher speed freight truck to operate safely on existing track infrastructure.

6. Recommendations for Future Work

Based on the results discussed in Section 4 and the conclusion in Section 5, SA recommends that a set of field tests to evaluate SA's designed higher speed freight truck be carried out to validate the performance under Chapter 11 regimes.

Further tests should be run at higher speeds at TTCI where equipment for at least 110 mph is available. This type of testing, in combination with 115-mph computer simulations for Class 6 track (110-mph limit), can be used to validate the performance of the higher speed truck.

Also, after all recommended testing, any design changes identified for improvement should be incorporated and the simulation plan, as recommended in "Higher Speed Freight Truck Performance Requirements," should be repeated, including the simulations over the measured NEC Class 6 and 7 tracks.

Abbreviations and Acronyms

AAR	Association of American Railroads
APTA	American Public Transportation Association
CAD	Computer Aided Design
ETF	Engineering Task Force
FRA	Federal Railroad Administration
HST	Higher Speed Truck
L/V	Lateral Load over Vertical Load (ratio)
MCAT	Minimally Compliant Analytical Track
MSRP	Manual of Standards and Recommended Practices
mph	miles per hour
NEC	Northeast Corridor
NPRM	Notice of Proposed Rulemaking
SA	Sharma & Associates, Inc.
TTCI	Transportation Technology Center, Inc.