4th Meeting of the Northeast Corridor Safety Advisory Committee (June 13)

48th Meeting of the Railroad Safety Advisory Committee (June 14)

Vehicle/Track Interaction Safety Standards Final Rule

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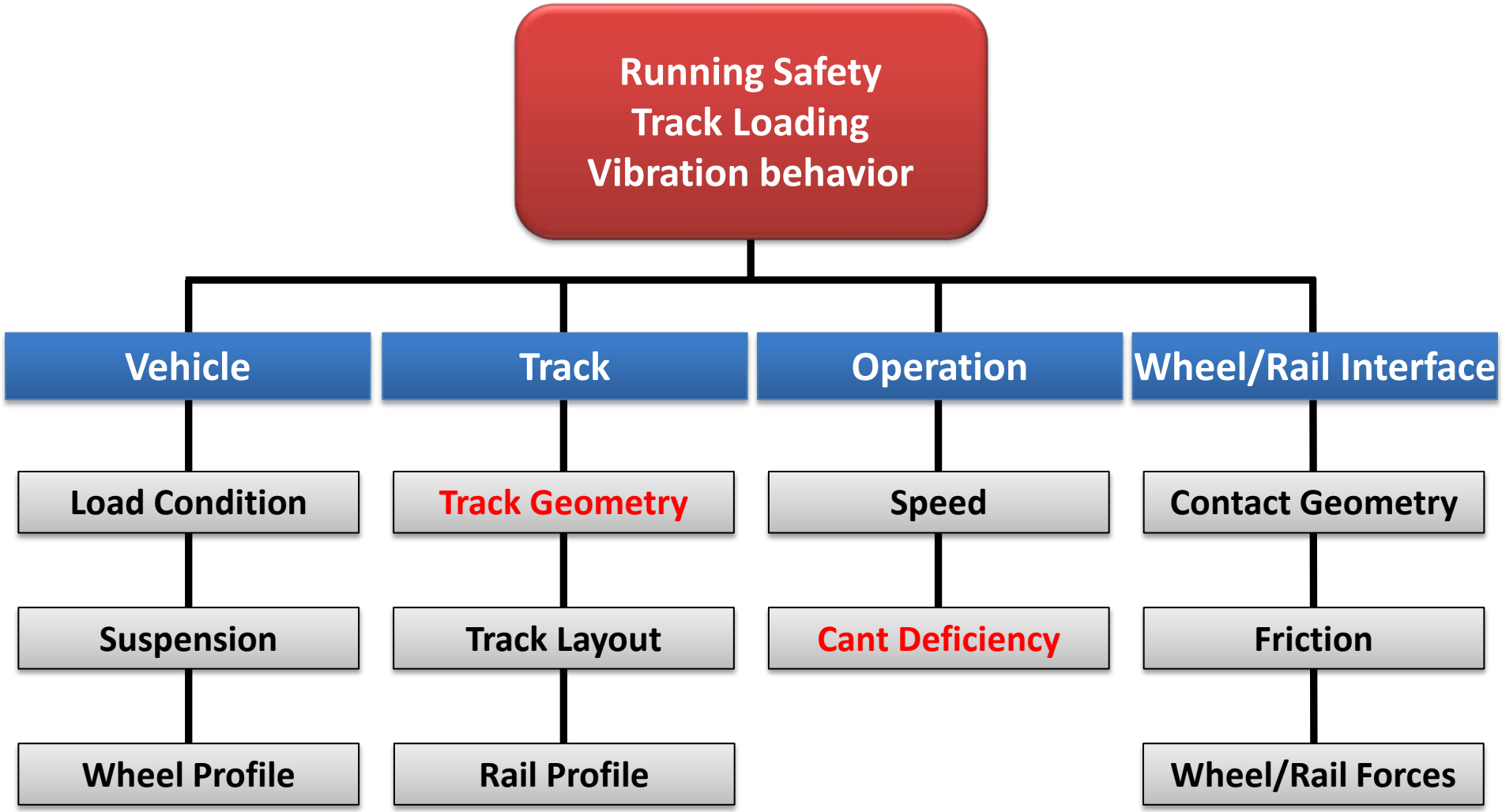
Purpose of VTI Safety Standards

Vehicle/Track Interaction (VTI) Safety Standards aim to reduce the risk of derailments and other accidents attributable to the dynamic interaction between moving vehicles and the track over which they operate.

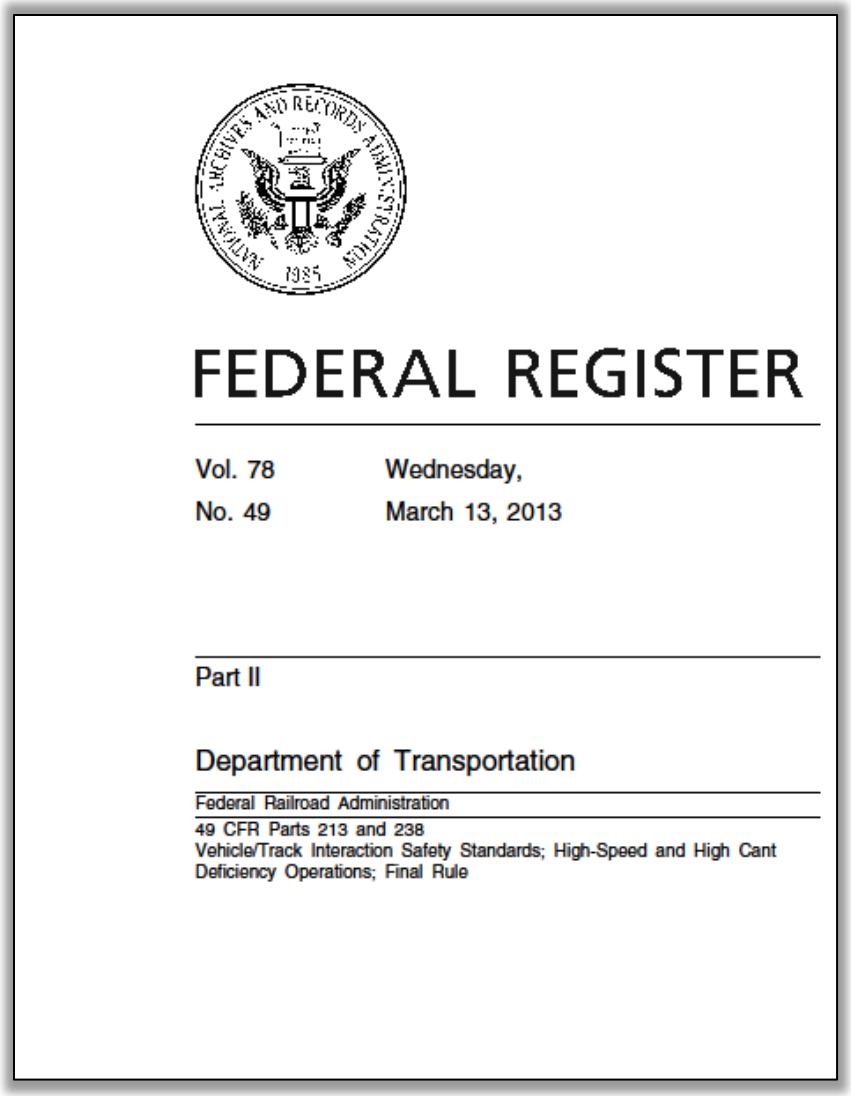
VTI Safety Dynamics



VTI Safety Standards Final Rule

The final rule was published on March 13 and is intended to promote VTI safety under a variety of conditions at speeds up to 220 mph. The final rule—

1. Revises standards for vehicle response to track conditions.
2. Revises standards for track geometry.
3. Revises requirements for operations at high cant deficiency.
4. Enhances qualification procedures for demonstrating vehicle trackworthiness to take advantage of computer modeling.



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Part II

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49 CFR Parts 213 and 238
Vehicle/Track Interaction Safety Standards; High-Speed and High Cant Deficiency Operations; Final Rule

VTI Safety Standards Final Rule – General

The final rule—

- **Is a product of unanimous RSAC consensus**.
- Becomes effective July 11, 2013.
- Is based on operational and vehicle qualification experience (data), the results of simulation studies (modeling), research, and consideration of international practices.
- Amends both the Track Safety Standards (49 CFR Part 213) and the Passenger Equipment Safety Standards (49 CFR Part 238).
- Will help promote the safe implementation of nationwide, high-speed passenger rail service.

VTI Safety Standards Final Rule – Specifics

Among its main accomplishments, the final rule—

- Revises performance standards and specifications.
  - FRA reviewed the performance standards in light of advanced simulations that were developed to support the rulemaking effort and refined those standards to focus on identified safety concerns and remove any unnecessary costs
- Establishes consistent requirements for high cant deficiency operations for all track classes, and addresses combined track alinement and surface deviations.
- Institutes more cost-effective equipment qualification requirements.
  - Adds flexibility for safely permitting high cant deficiency operations on the lower-speed track classes, track Classes 1 through 5, without the need for obtaining a waiver
  - Makes it easier to qualify vehicles on additional segments of track once they are qualified on any track, extending territories in which qualified equipment may operate
  - Adds a new appendix providing for the use of computer simulations for vehicle/track system qualification testing

VTI Safety Criteria

- The final rule revises VTI safety criteria.
- VTI safety criteria are limits on wheel/rail forces and vehicle accelerations to promote the safe interaction of rail vehicles with the track over which they operate.
  - Wheels stay on track
  - Vehicle dynamics do not overload track, vehicle, or cause injury to passengers

Revised VTI Safety Criteria (49 CFR 213.333)

Parameter	Safety Limit		Filter/Window
	Passenger Cars	Other Equipment	
Carbody Lateral Acceleration (Transient)	≤0.65g P-P[1]	≤0.75g P-P[1]	1 sec window
Carbody Lateral Acceleration (Sustained Oscillatory)	≤0.10g RMS_t[2]	≤0.12g RMS_t[2]	4 sec window 4 sec sustained
Carbody Vertical Acceleration (Transient)	≤1.0g P-P[1]	≤1.25g P-P[1]	1 sec window
Carbody Vertical Acceleration (Sustained Oscillatory)	≤0.25g RMS_t[2]		4 sec window 4 sec sustained
Truck Lateral Acceleration (Sustained Oscillatory)	≤0.30g RMS_t[2]		2 sec window 2 sec sustained
Single Wheel Vertical Load Ratio	≥0.15		5 foot window
Single Wheel L/V	$\leq \frac{\tan(\delta) - 0.5}{1 + 0.5\tan(\delta)}$ [3]		5 foot window
Net Axle L/V	$\leq 0.4 + \frac{5.0}{Va}$ [4]		5 foot window
Truck-side L/V	≤0.60		5 foot window

[1] Peak to peak value
[2] Root mean squared with linear trend removed
[3] δ – Flange angle
[4] Va – Vertical axle load in kips

Vehicle Design & Track Geometry

- The final rule revises limits on track geometry.
- Safe performance of rail vehicles necessitates maintaining track geometry within preset limits.
- The Track Safety Standards provide limits for maximum allowable track geometry variations for all nine track Classes—i.e., safety "minimums."
  - Include Alinement, Surface, Gage, Crosslevel, and Track Warp limits, which are progressively tighter for higher speeds
  - Serve to identify conditions that require immediate attention because they pose or create a potential safety hazard
  - Help provide a railway infrastructure that supports a variety of rail vehicles (interoperability)

VTI Final Rule Revises FRA Track Classes

Class	Max. Freight Speed (mph)	Max. Passenger Speed (mph)
1	10	15
2	25	30
3	40	60
4	60	80
5	80	90
6	*	110
7	*	125
8	*	160**
9	*	220

* Existing regulations provide that freight equipment may be authorized to travel at the same speeds as passenger equipment if specified conditions are met.

** Final rule clarifies that 160 mph is the safe maximum speed for Class 8 track.

Revised Track Geometry Limits

- Establishes consistent requirements for high cant deficiency operations (> 5 inches) for all track classes.
  - In sharper curves for which cant deficiency is high but vehicle speeds are reflective of a lower track class, it was found that stricter track geometry limits are necessary, for the same track class, in order to provide an equivalent margin of safety for operations at higher cant deficiency

Track Alinement – 213.55, 213.327

Existing

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9
31 ft			C 1.25	C 1.0	C 0.5	0.5	0.5	0.5	0.5
62 ft	5	3	1.75	1.5	C 0.625 T 0.75	0.75	0.5	0.5	0.5
124 ft						1.5	1.25	0.75	0.75

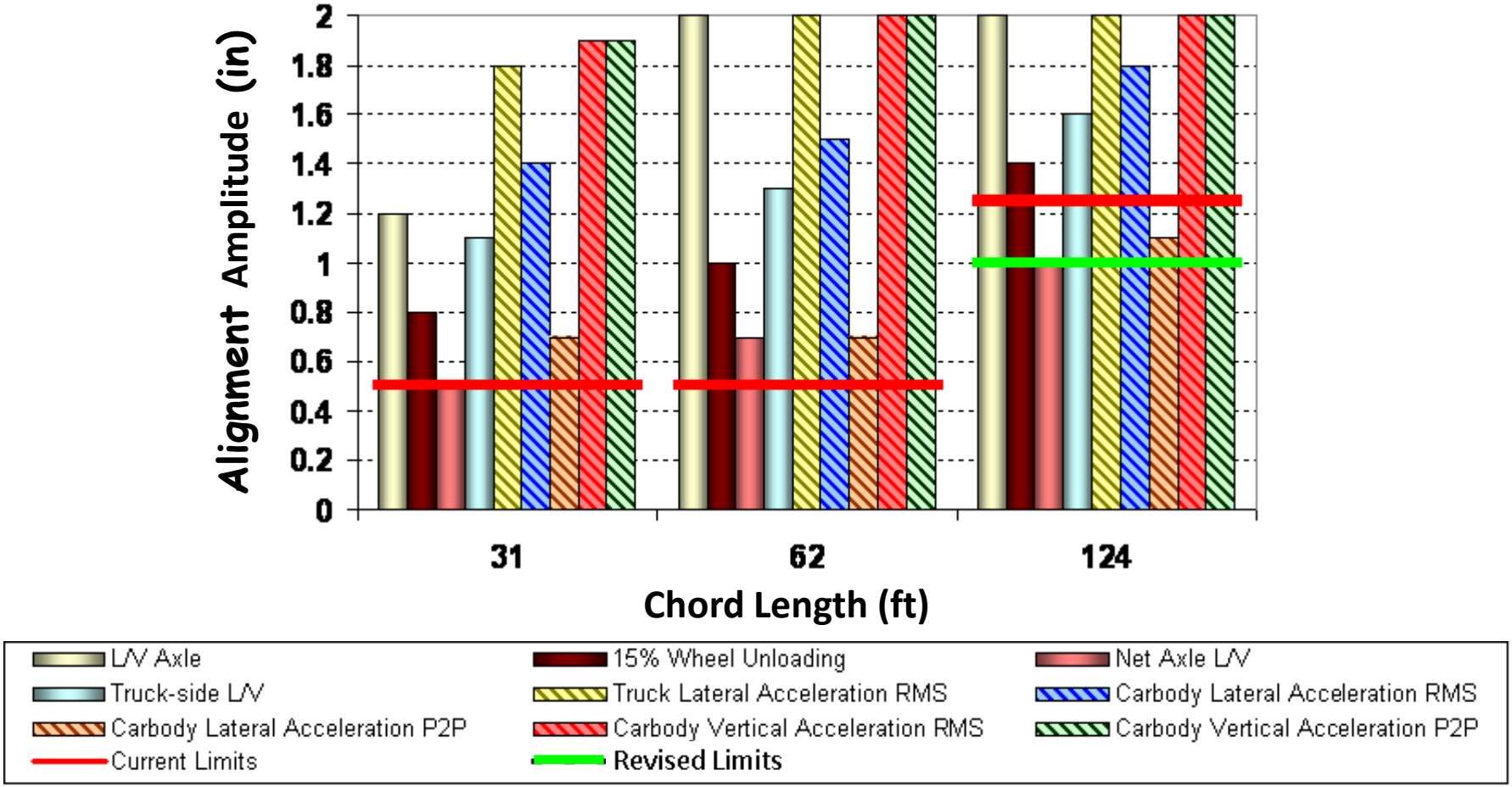
Revised

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9
31 ft			C 1.25	C 1.0	C 0.5	0.5	0.5	0.5	0.5
62 ft	5	3	1.75	1.5	C 0.625 T 0.75	C 0.625 T 0.75	C 0.5 T 0.75	C 0.5 T 0.75	0.5
124 ft						1.5	1.25	C 0.75 T 1.0	0.75

New
High CD more than 5”

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
31 ft			0.75	0.75	0.5	0.5	0.5	0.5
62 ft	1.25	1.25	1.25	0.875	0.625	0.625	0.5	0.5
124 ft						1.25	1	0.75

Example: Responses of Acela Power Car to Class 7 Alinement limits (perturbations)



Isolated Track Surface – 213.63, 213.331

Existing

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9
31 ft						1	1	0.75	0.5
62 ft	3	2.75	2.25	2	1.25	1	1	1	0.75
124 ft						1.75	1.5	1.25	1.25

Revised

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9
31 ft						1	1	0.75	0.5
62 ft	3	2.75	2.25	2	1.25	1	1	1	0.75
124 ft						1.75	1.5	1.25	1

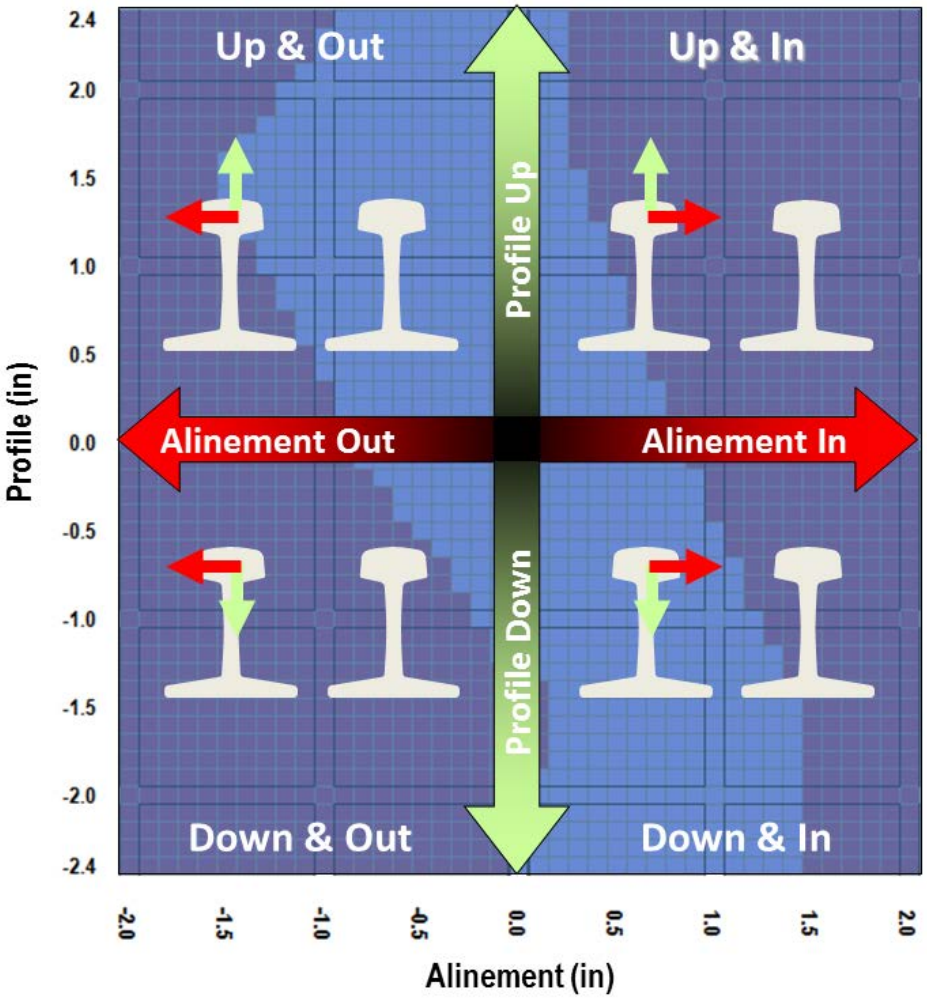
New
High CD more than 5”

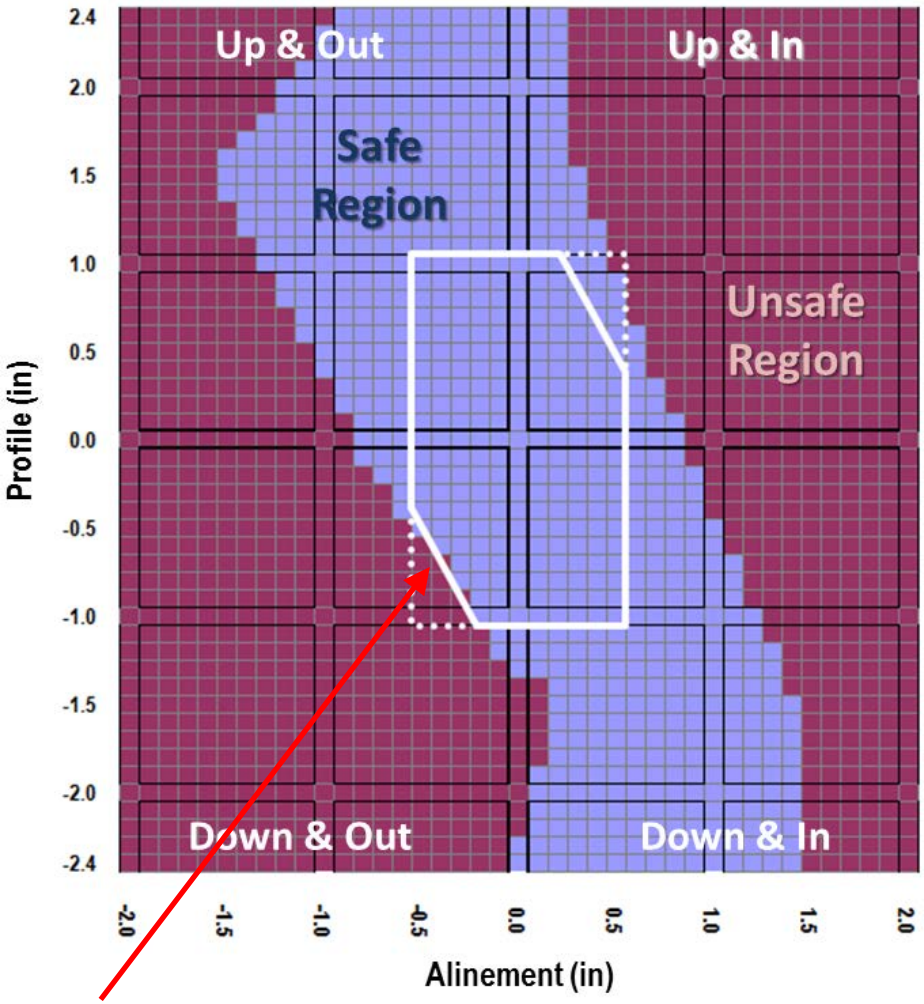
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
31 ft			1	1	1	1	1	0.75
62 ft	2.25	2.25	1.75	1.25	1	1	1	1
124 ft						1.5	1.25	1.25

Revised Track Geometry Limits

- Adds new combined track alinement and surface deviation requirement for high cant deficiency operations (> 5 inches).
  - Although FRA has prescribed limits on track geometry variations existing in isolation, research/modeling has shown that a combination of track alinement and surface variations, none of which individually amounts to a deviation, may nonetheless result in undesirable vehicle response
  - Moreover, trains operating at high cant deficiencies will increase the lateral wheel force exerted on track during curving, thus decreasing the margin of safety

Combined Track Surface & Alinement – New 213.65, 213.332





Combined Limit

Short Warp – 213.63, 213.331

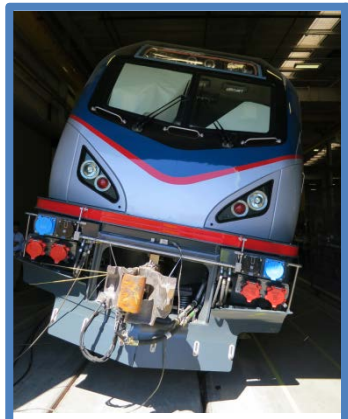
- For Track Classes 6 through 9 and high cant deficiency operations (> 5 inches), new limits have been added for the difference in cross-level between any two points less than 10 feet apart.
- Class 8 and 9 limits for the difference in cross-level between any two points less than 62 feet apart were revised.

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9
62' Warp	3	2.25	2	1.75	1.5	1.5	1.5	1.25	1
10' Warp CD <= 5						1.25	1.125	1	0.75
10' Warp CD > 5	2	2	1.75	1.75	1.5	1.25	1	1[a]	

a. On curves with Eu (qualified cant deficiency) more than 7 inches, the difference in crosslevel between any two points less than 10 feet apart (short warp) shall not be more than 3/4 inch

Vehicle/Track System Qualification

Stationary Tests

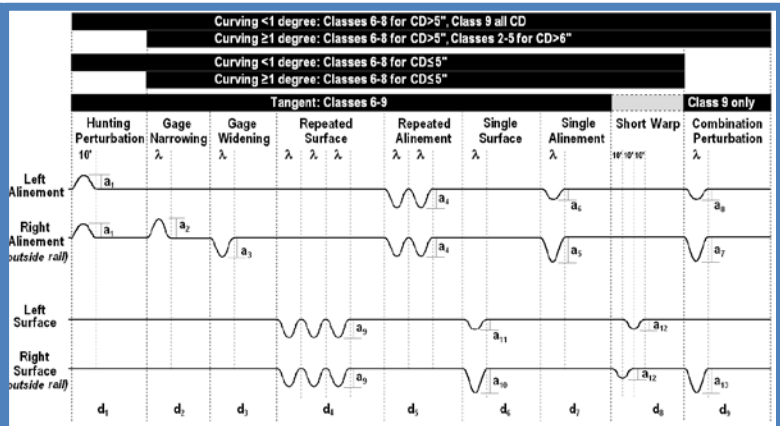


ACS64 Locomotive
April 18, 2013

On-Track Tests

Acela 160 mph; 2012 - 2013

Simulation/Modeling



Minimal Track Geometry Deviations

Wheel/Rail Forces
Truck Acceleration
Carbody Acceleration

Evaluate

Running Safety
Track Loading
Vibration behavior

VTI Final Rule – Vehicle/Track System Qualification

- The final rule institutes more cost-effective equipment qualification requirements. The final rule—
  - Makes it easier to qualify vehicles on additional segments of track once they are qualified on any track, extending territories in which qualified equipment may operate
  - Adds flexibility through procedures for safely permitting high cant deficiency operations on the lower-speed track classes, track Classes 1 through 5, without the need for obtaining a waiver. In order to take advantage of this flexibility, the equipment must be qualified and the track must be maintained to more stringent standards to permit the higher speeds through curves
  - Adds a new appendix providing for the use of computer simulations for vehicle/track system qualification testing. These simulations are intended to be performed using a model containing defined track geometry perturbations at the limits that are permitted for a class of track and level of cant deficiency. This track model is referred to as MCAT, Minimally Compliant Analytical Track

Vehicle/Track System Qualification

Vehicle/Track System Qualification - New Equipment

Cant Deficiency (in)	Existing Rule									New Rule								
	Maximum Allowable Operating Speed (mph)																	
	15 10[1]	30 25[1]	60 40[1]	80 60[1]	90 80[1]	110	125	160	200	15 10[1]	30 25[1]	60 40[1]	80 60[1]	90 80[1]	110	125	160	220
	Track Class																	
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Eu ≤ 3	No Testing					A + T + W				No Testing					A + T + (W or S)	A + T + W + S		
3 < Eu ≤ 4	L					L + A + T + W				L^2					L^2 + A + T + (W or S)	L^2 + A + T + W + S		
4 < Eu ≤ 5	*Waiver Required* *Unless Contiguous to HS Track (A)*																	
5 < Eu ≤ 6										L^2 + A								
Eu > 6										L^2 + A + W + S								

L = Lean Test

A = Car Accelerometers

T = Truck Accelerometer

S = Simulation (MCAT & Segment)

W = Wheel-Rail Force Measurement

Eu = Cant Deficiency

[1] Max allowable operating speed for freight trains

[2] Lean test requirements may be met by static or dynamic testing (W+A)

Vehicle/Track System Qualification

Vehicle/Track System Qualification - Qualified Equipment

Cant Deficiency (in)	Existing Rule									New Rule								
	Maximum Allowable Operating Speed (mph)																	
	15 10[1]	30 25[1]	60 40[1]	80 60[1]	90 80[1]	110	125	160	200	15 10[1]	30 25[1]	60 40[1]	80 60[1]	90 80[1]	110	125	160	220
	Track Class																	
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Eu ≤ 3	No Testing					A + T + W				No Testing or Simulations						A + T		
3 < Eu ≤ 4	L					L + A + T + W												
4 < Eu ≤ 5	*Waiver Required* *Unless Contiguous to HS Track (A)*																	
5 < Eu ≤ 6										A						A + T + (W or S)		
Eu > 6										A + (W or S)								

L = Lean Test

A = Car Accelerometers

T = Truck Accelerometer

S = Simulation (MCAT & Segment)

W = Wheel-Rail Force Measurement

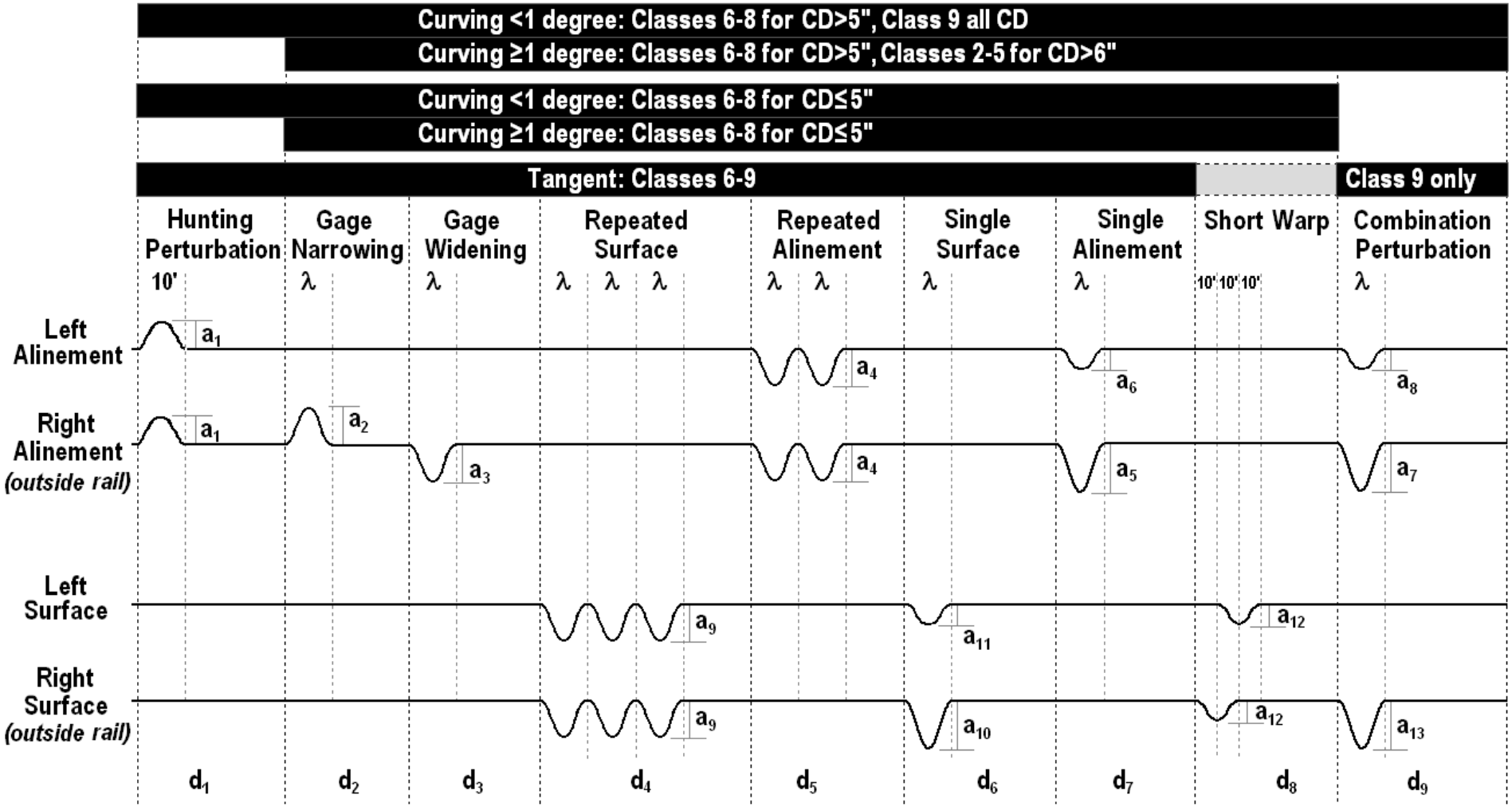
Eu = Cant Deficiency

[1] Max allowable operating speed for freight trains

Vehicle/Track System Qualification: Use of Simulations to Demonstrate Performance

- Simulation objectives:
  - Identify vehicle dynamic performance issues prior to service and validate suitability for operation of a vehicle type at a particular class of track and level of cant deficiency
  - Augment on-track vehicle performance assessment
- Simulations will be conducted using:
  - Measured track geometry segment representative of full route
  - A model containing defined track geometry perturbations at the limits that are permitted for a class of track and level of cant deficiency
    - This track model is referred to as MCAT, Minimally Compliant Analytical Track

Minimally Compliant Analytical Track (MCAT)



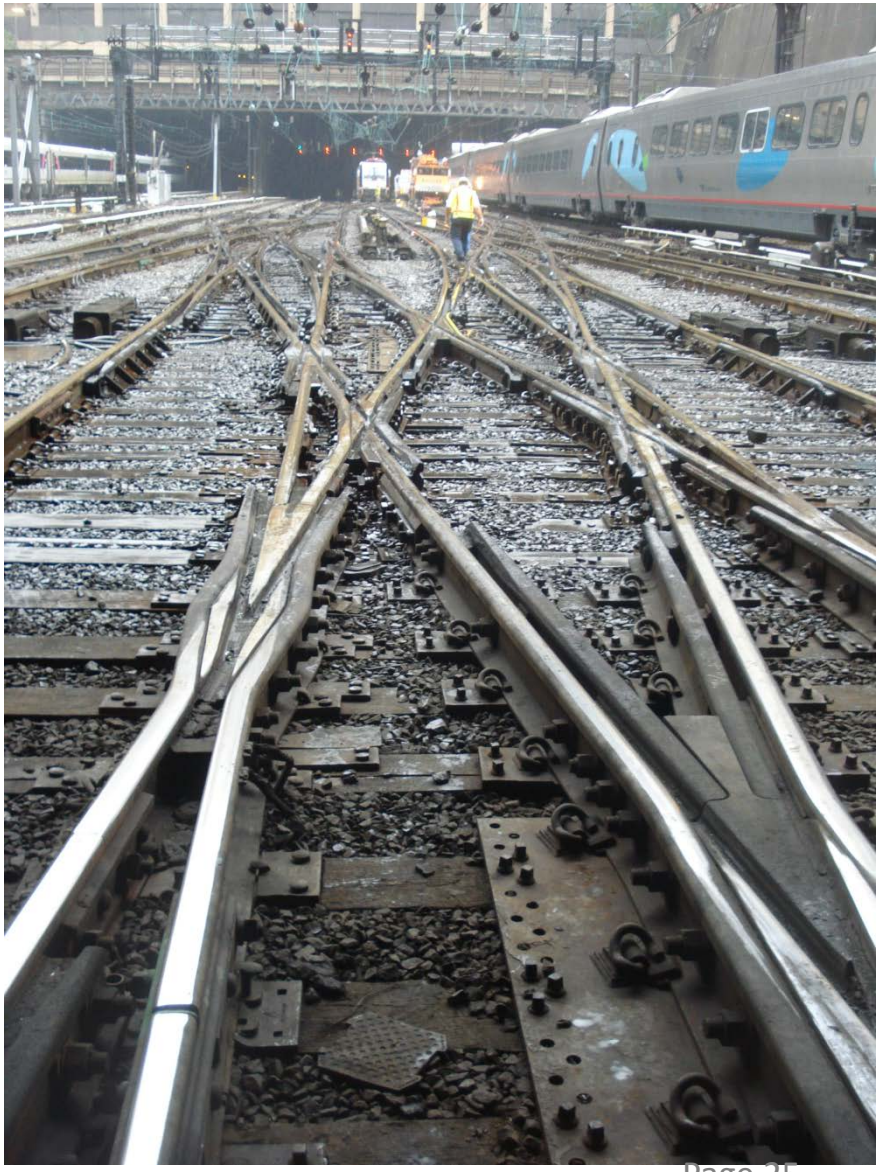
VTI Safety Standards Final Rule – Other Changes

- Clarifies that individuals qualified to inspect track need only understand the portions of the regulation relevant to the inspections and the work for which they are responsible.
  - In particular, the addition of vehicle qualification and testing requirements for high cant deficiency operations in lower-speed track classes adds a level of complexity that may be outside the purview of track foremen and inspectors in fulfilling their duties
- Resolves and reconciles inconsistencies between the Track Safety Standards and Passenger Equipment Safety Standards.
  - For example, the rule makes uniform what were differences in vehicle qualification test speed requirements
- Institutes more cost-effective in-service monitoring requirements.
  - Annual use of instrumented wheelsets for in-service validation is no longer a general requirement – the performance of such testing will be determined by FRA on the basis of annual accelerometer monitoring data submitted to FRA
  - Avoids some tests that have not provided useful data

VTI Safety Standards – Current Activities

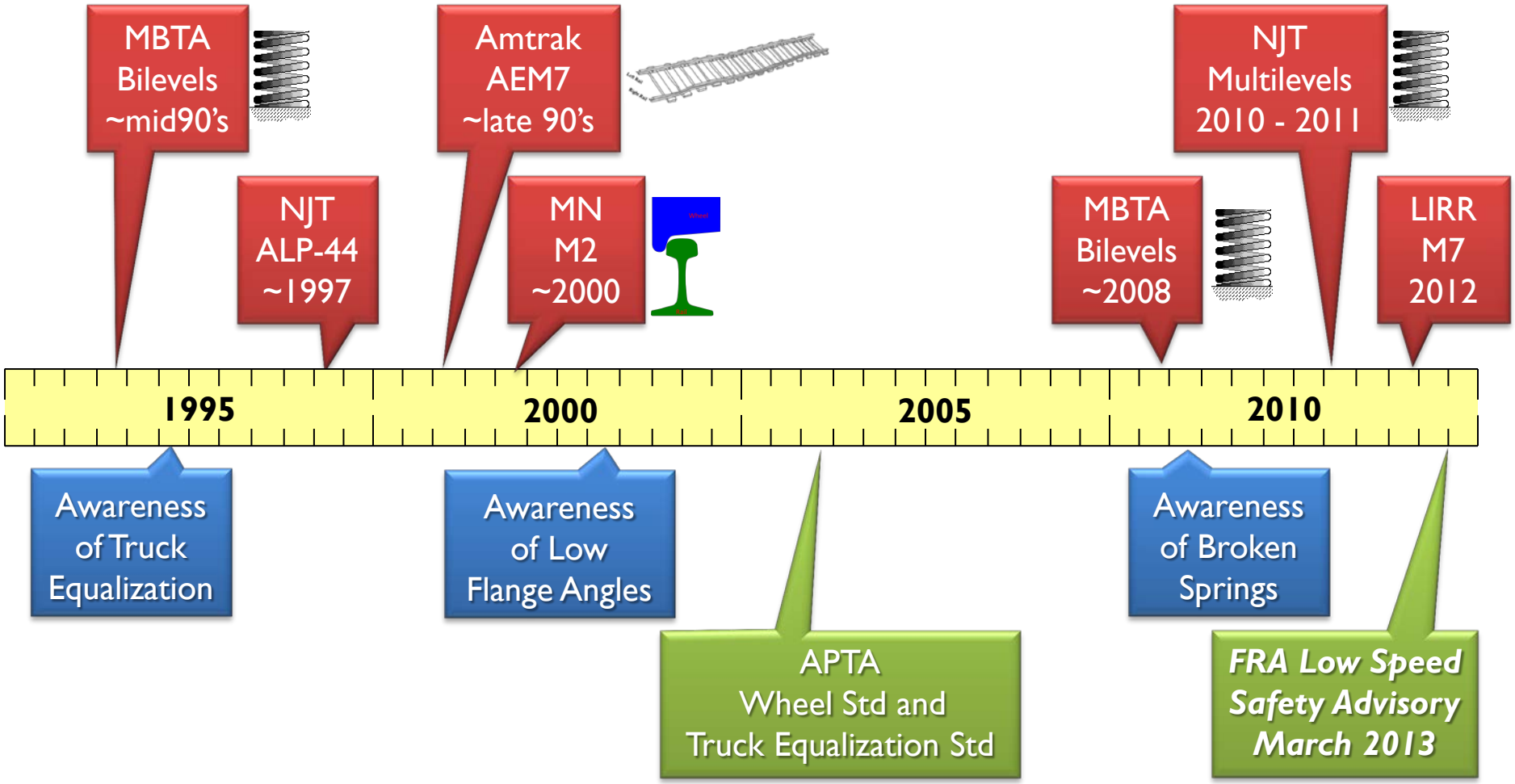
1. Support of Vehicle/Track System Qualification Testing
   - Amtrak Acela at 160 mph
   - Amtrak ACS64 Locomotive 125 mph
   - Amtrak LDSL cars 125 mph
   - Talgo Series 8
   - NJT Bombardier Multilevel 100 mph
   - MARC MP36 Locomotives 100 mph

2. Safe Track Geometry Limits for Interoperable High-Speed Equipment
   - Review track geometry limits for track Classes 1-5, initially for “Tier III” passenger equipment



VTI Derailment Prevention

Brief Summary of Low Speed Derailments*



**Not a comprehensive summary*

Questions?