Federal Railroad Administration
Research and Development
Program Review

Alternative Equipment Crashworthiness Standards

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March 13, 2009

Outline

- Current FRA Crashworthiness Standards
- Definition of Problem
- Intent of Crashworthiness
- Types of Standards
- Framework for New Standard Development
- Summary/Next Steps

Current FRA Crashworthiness Standards

- Current standards based upon long history in north american railroad industry
- Prescriptive load cases defined for specific components
  - 800,000 buff load (static squeeze)
  - Anti-climbing
  - Coupling
  - End structures
  - Rollover
  - Side structure
  - Truck-to-carbody
  - Glazing
  - Fuel tanks
  - Interior fittings and surfaces
  - etc…
- Pass fail criteria – simple testing and/or analysis

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Current FRA Crashworthiness Standards

Common collision conditions of concern;
Current standards intended to address such conditions

Re-Thinking Current Standards

- Issue: current standards difficult to apply to new designs that implement **C**rash **E**nergy **M**anagement
- Industry is approaching FRA with waiver requests:
  - Caltrain Commuter Rail, CA
  - California High Speed Rail, CA
  - Desert Express, NV
  - Capital Metro Transit Austin, TX
  - Denton County Transportation Authority, TX
  - Dallas Area Rapid Transit, TX
- Waivers are an inefficient process and potentially inconsistent

Everyone wants an exception!

Other Issues

- Carbuilders are looking for guidance before making major investments
  - Siemens
  - Stadler
  - Alstom
  - Talgo
- Operating authorities are looking for new car procurements to replace older fleets for:
  - Greater efficiency (weight savings) versus other designs
  - Compatibility when mixing different equipment types
  - New operational requirements – ADA, low floors, etc…
- Both passenger rail operators and carbuilders need guidance (early in the procurement process) to eliminate the risk of ordering equipment that will not be waived and/or accepted by FRA.

Purpose of Presentation

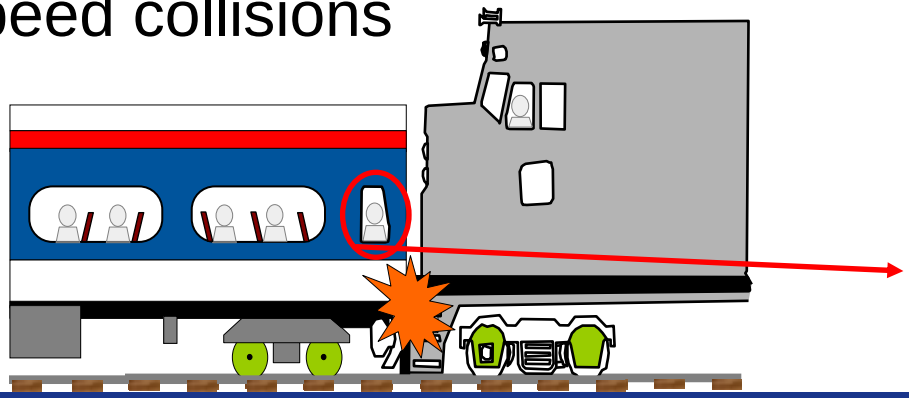
FRA (and the industry) needs clear direction to review use of new and innovative designs

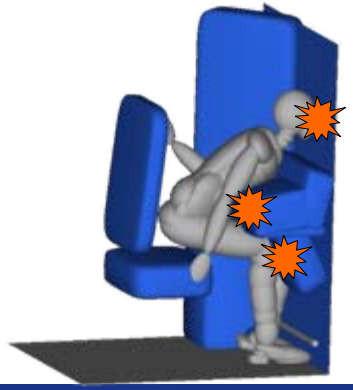
- Define what is meant by equivalent safety
- Performance standards are a means of defining equivalency
- Develop demonstrable compliance values/protocols
- Apply hybrid approach using combination of prescriptive and performance standards

Objectives of Crashworthiness: Intent Behind Standards Development

- Preserve occupant volume
  - Maintain safe space; minimize local compartment penetration; and ensure occupant containment
- Limit forces and decelerations to survivable levels
  - Limit deceleration of occupant volume; restrict secondary impact forces; and maintain secure interior fittings

Note: survivability depends on many factors – goal is to preserve volume and limit forces for moderate and low speed collisions





Types of Standards

- Current FRA crashworthiness standards (prescriptive)
  - Prescribe characteristics of components
  - e.g., Collision post static load cases
  - Pro: performance verified with accepted techniques
  - Con: assumes design approach includes particular components

- Performance standards (as alternative or hybrid standards)
  - Prescribe performance in defined conditions
  - e.g., No loss of occupant volume for ***XX*** mph collision of a cab car led train with a locomotive led train
  - Pro: no assumptions on design approach
  - Con: can be difficult to verify performance

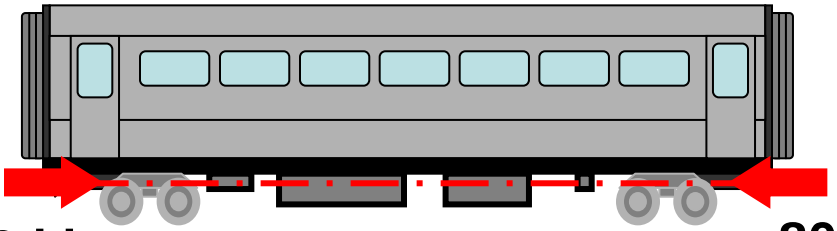
Compliance with Design Standards

- Generally defined as static loads
- Classical engineering analysis approaches used to check:
  - Elastic shear and bending analyses
  - Elastic buckling analysis
  - Limit load analysis
- Criteria:
  - Structure must support load without permanent deformation or without failure

Note: Design Standards for Crashworthiness are Well Established in the Railroad Industries

Efficacy of the Traditional Buff Strength Requirement

- Advantages
  - Proxy for robust occupant volume
    - Dictates high compression strength
    - Provides variable bending strength
  - Provides strong foundation for other crashworthiness features
  - Non-destructive test
- Drawbacks
  - Load applied inboard of occupant volume
  - Can only be applied to conventionally-coupled equipment



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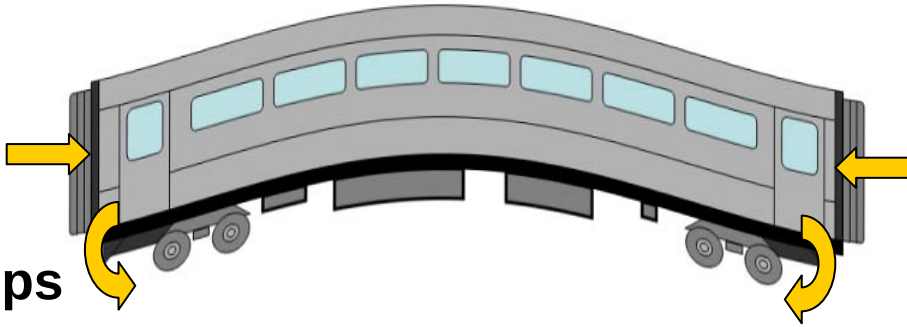

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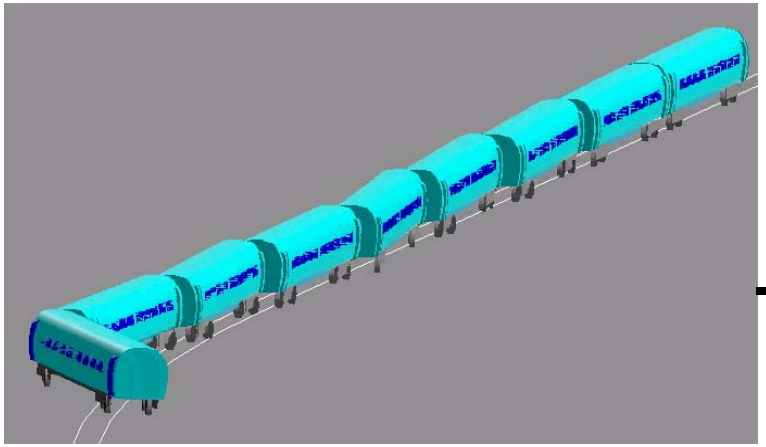
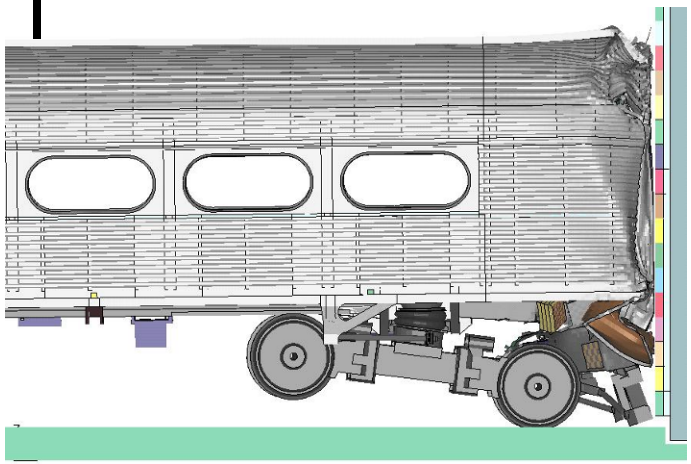
Ideal Occupant Volume Specification Provides

- Strong occupant volume
  - Equal protection throughout entire occupant volume
- Foundation for other features
- Demonstrable compliance
  - Straightforward criteria, preferably non-destructive test
- Compatibility
  - Different pieces of equipment to be operated together should provide equivalent occupant protection
- Applicability to range of equipment

Compliance with Performance Standards



Car Crush



Train Collision Dynamics

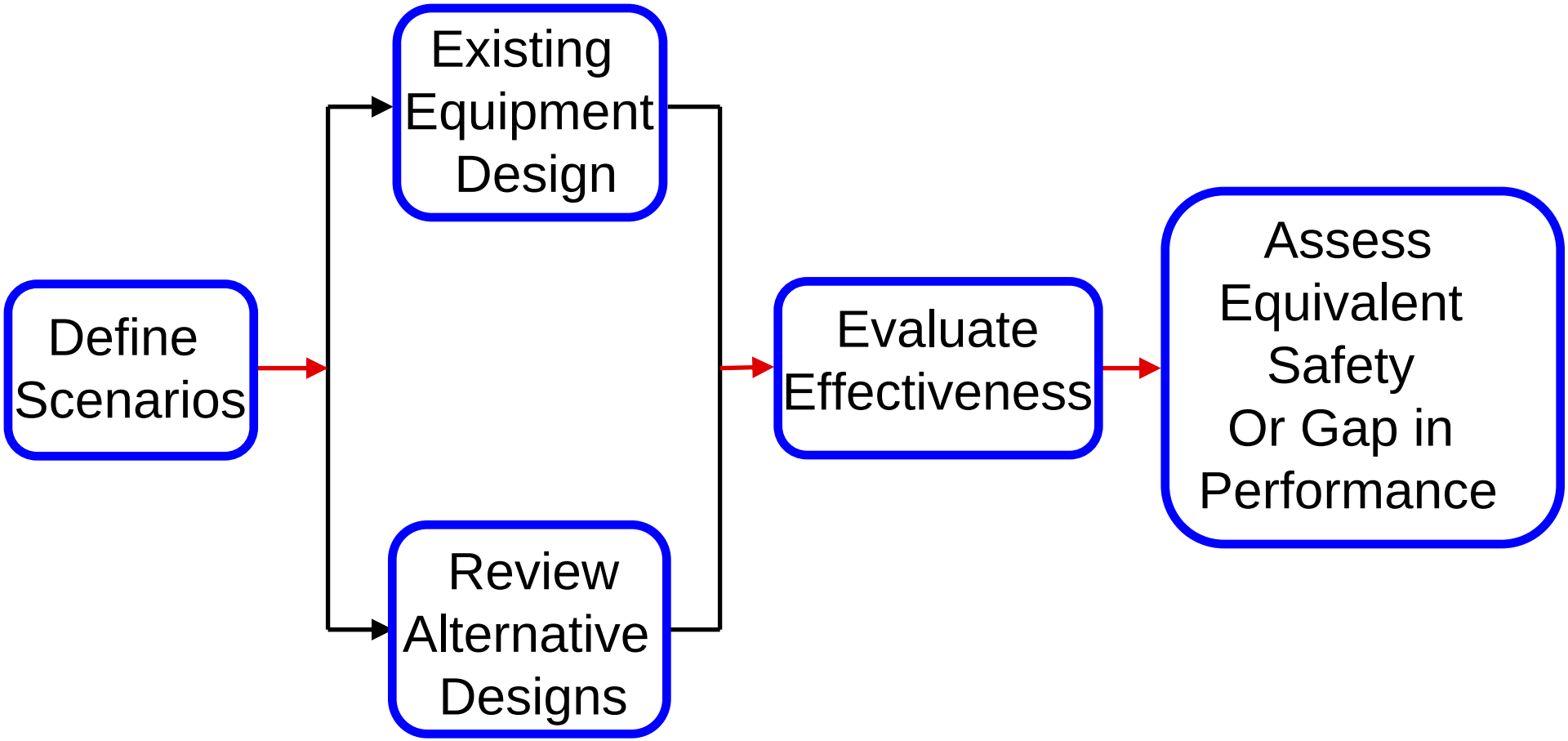
Occupant Dynamics

Compliance with Performance Standards

- Train collision dynamics
  - Motions of the cars during collision
  - Distribution of damage
- Car crush
  - Force required to collapse structure
  - Geometry of collapsing structure
- Occupant dynamics
  - Motions of occupants
  - Forces imparted to occupants

Note: Performance Standards for Crashworthiness are a More Recent Development in the Transit and Railroad Industries

Framework for Comparison of Crashworthiness Standards



Note: Framework needs to be applied to specific corridor of interest and operational conditions

Steps for Alternative Standard Development

- Step 1. Develop scenarios
  - Based on heuristic review of past accidents
- Step 2. Decide standard framework
  - Using hybrid of existing design/performance approaches similar to FRA/APTA/metrolink and EN12663/EN15227
  - Borrow from existing standards and use relevant research results
- Step 3. Develop evaluation/compliance procedures
  - Evaluate options for tests and analyses
  - Select criteria for evaluating results of tests and analyses
- Step 4. Determine compliance criteria values
  - Based on reasonably achievable level of performance
- Step 5. Produce standard(s)

Collision Scenarios of Concern

Step 1. Develop Scenarios

- Scenarios address range of concerns
  - New equipment devastates old equipment
  - Locomotives devastates new equipment
  - Integrity of end frame
  - Integrity of side structure
  - Rollover
- Scenarios developed in sufficient detail to draft specification

Step 2. Decide Standard Framework

- Existing standards address most of the scenarios
- Pertinent research provides additional detail to complete specification

Summary/Next Steps
Alternative Standard Development

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Summary

- Hybrid design/performance standards
  - Address features currently lacking in existing standards
    - **Compatibility** between different types of equipment potentially operating on the same corridor
    - Applicable to wide range of equipment – no assumption as to what structure looks like
  - Establish clear definition of equivalent safety
  - Provide clear guidance to car builders on allowable new/innovative designs
  - Application of CEM a potential means of achieving desired performance goals