Introducing New CEM Designs to Legacy Systems

Chris Walker, PE

Principal Engineer

LTK Engineering Services

Charlotte, NC

Agenda

- CEM Definitions, Devices & Principles
- Recently Issued CEM Based Standards
- Challenges with legacy systems
- CEM Limitations

CEM – What is it?

Crash Energy Management System – any structural system used as a means of dissipating kinetic energy

In braking, kinetic energy is dissipated via:

- Friction Braking: Heat @ brake pads/disc
- Dynamic Braking: Heat @ resistor grids

CEM – What is it?

During collisions, kinetic energy is dissipated via crushing, collapsing, and fracturing of mechanical structures.

CEM systems use this dissipation of kinetic energy to reduce deceleration rates experienced by passengers.

Physics 101

KE = ½mv^2

ΔKE = W = Fd = (m*a)d

ΔKE = ½mv_f^2 - ½mv_i^2 = (m*a)d

$$\frac{{v_i}^2}{2d} = -a$$

Physics 101

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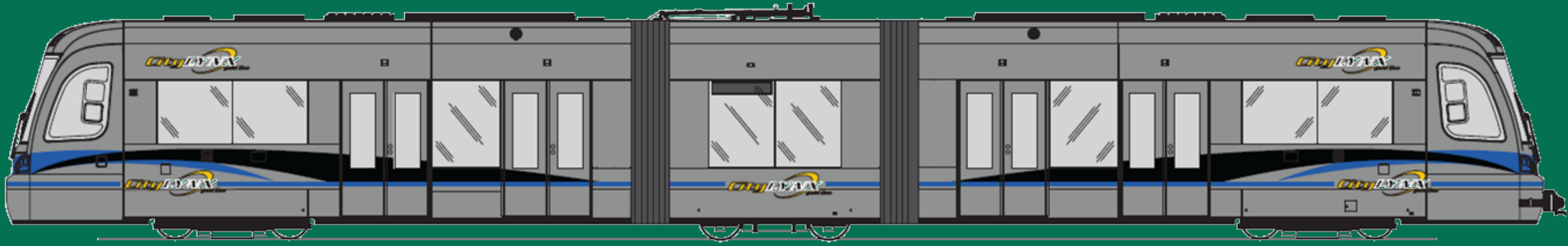
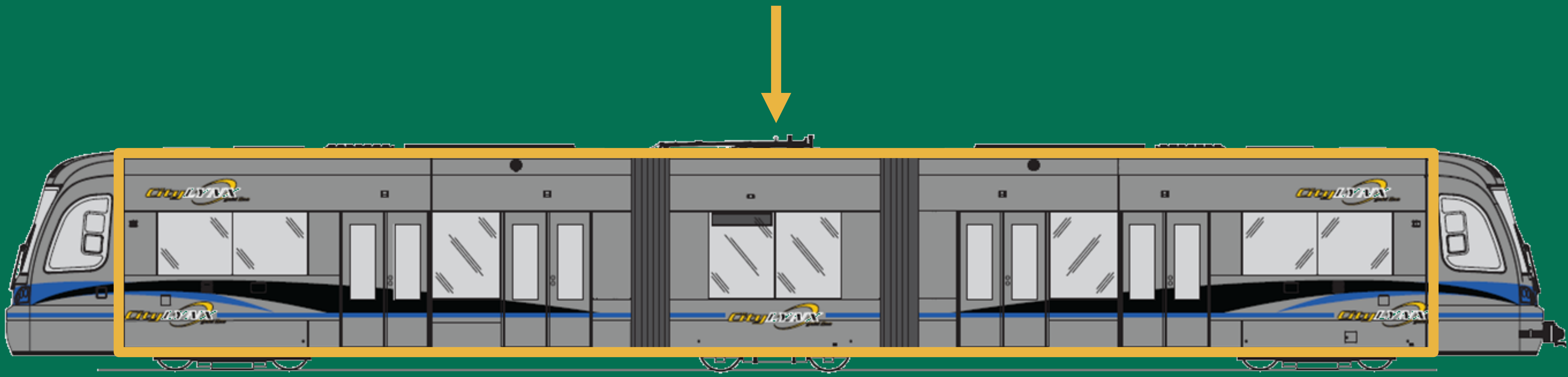
Physics 101



Note: vehicle reference for visual aid only

Physics 101

Occupied Volume



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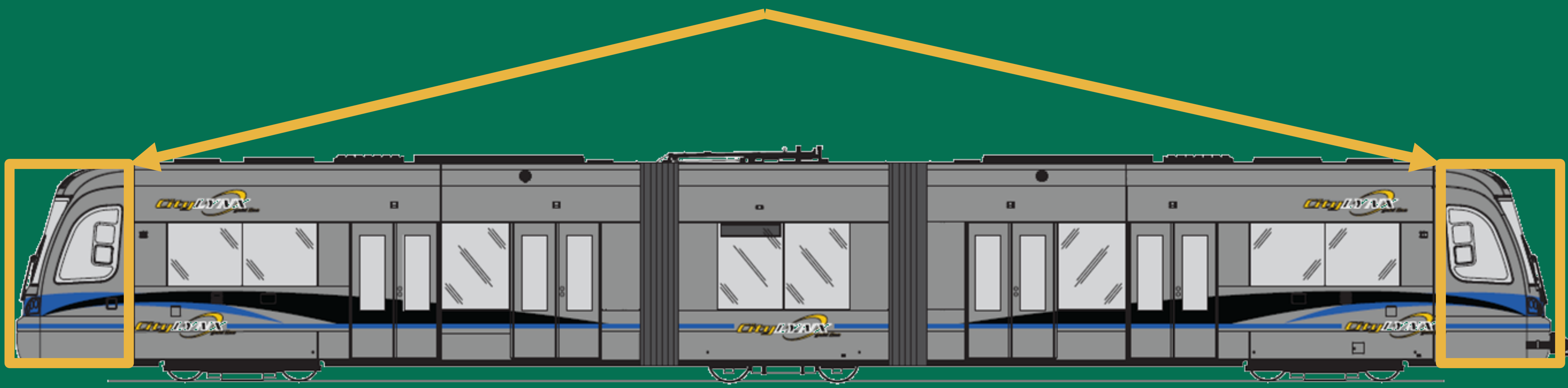
Physics 101

Crush Zones



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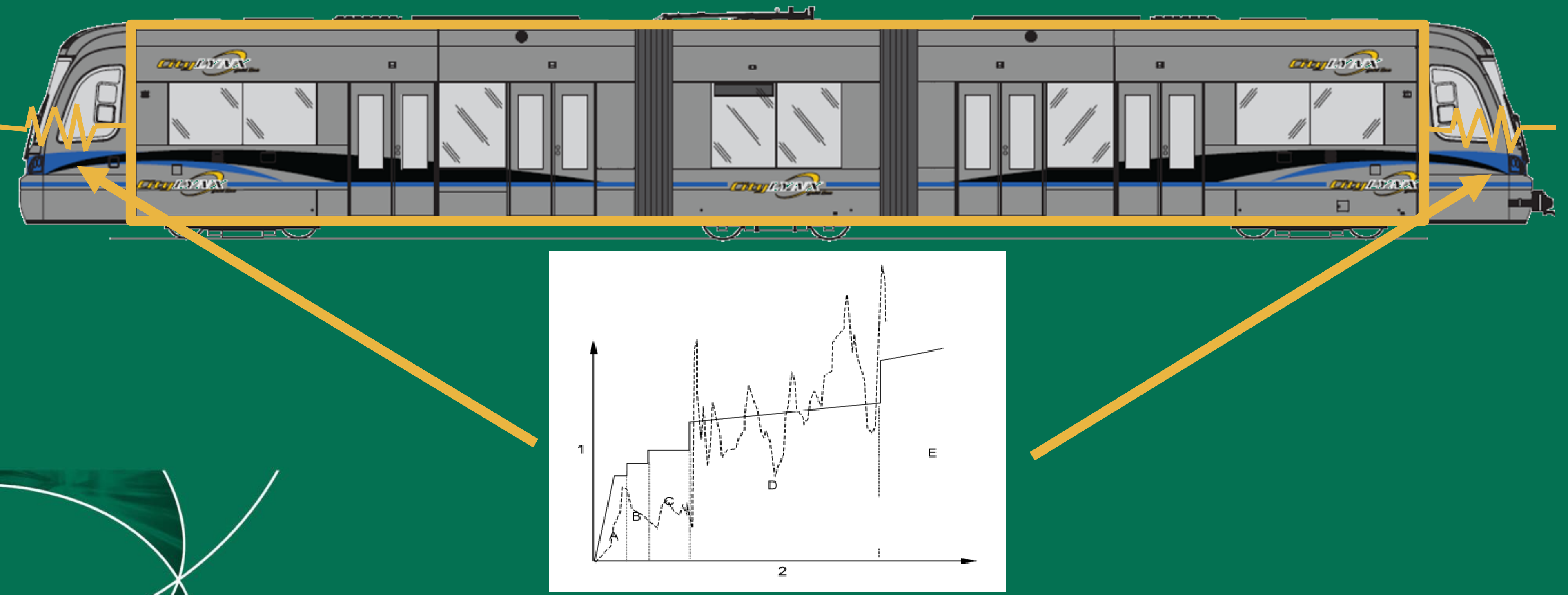
Physics 101

Simplified Mass-Spring Model



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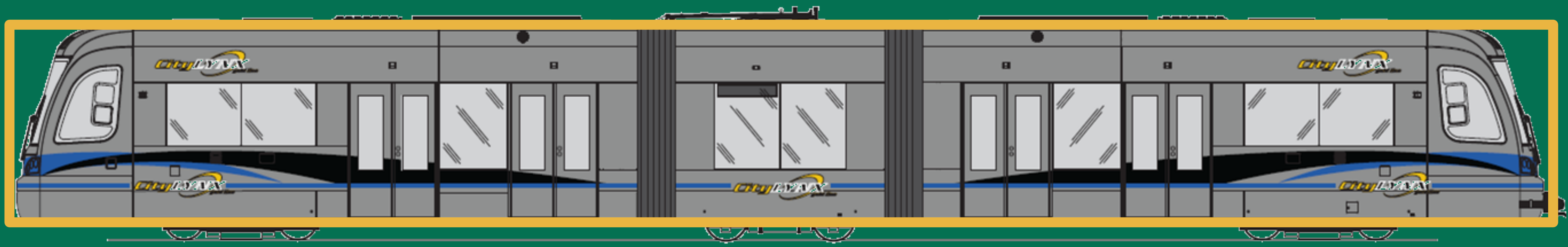
Physics 101

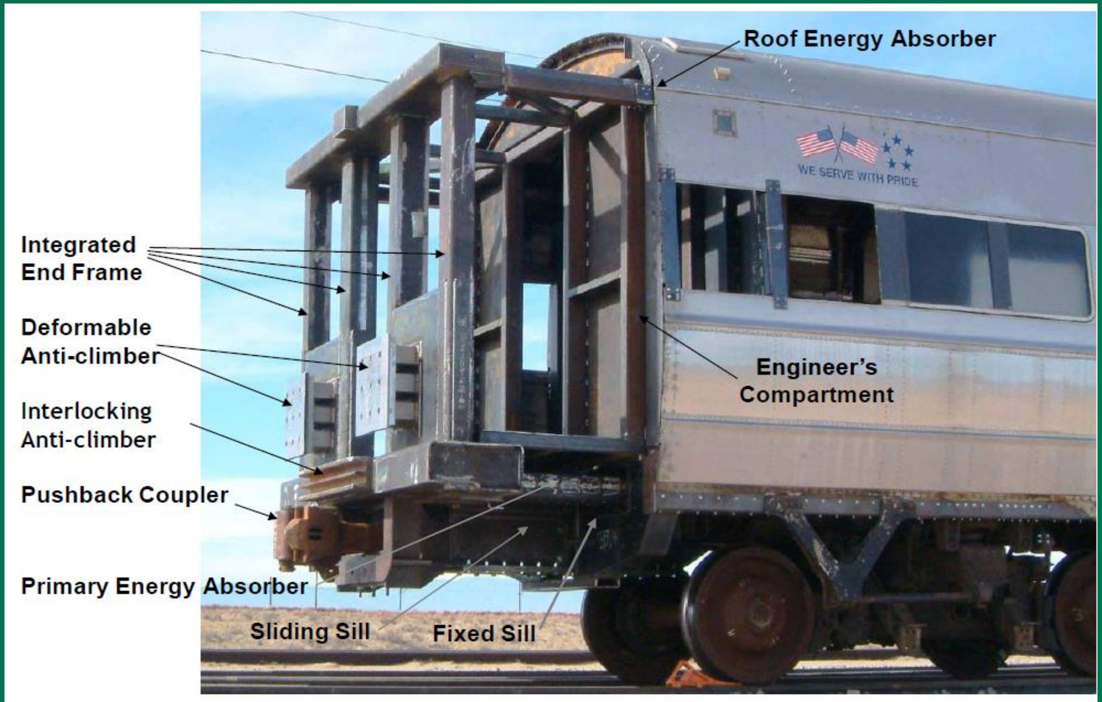
Old Model



Note: vehicle reference for visual aid only

CEM Devices

- Anti-climber
- End Frame Devices
  - Structural fuse
  - Crush tube
  - Crash box
  - Structural hinge
- Coupler
  - Draft gear
  - Expansion tubes
  - Shear bolts



CEM Design Principles

- Maximize energy absorption
- Minimize deceleration rates
- Maintain underframe alignment

CEM Design Principles

- Preserve occupied volumes
- Ensure progressive collapse of CEM devices
- Maintain operator survival space

Standards for CEM Design

- ASME RT-1
  - Streetcars
  - LRVs
- ASME RT-2
  - Heavy Rail Transit
- NPRM 49 CFR 238 (RSAC ETF Guidelines)
  - Tier I vehicles

Integrating New CEM Designs to Legacy Systems

- Match colliding interface of legacy equipment
  - Anti-climber height & arrangement
- Use approximations of underframe stiffness in spring-mass models to simulate legacy equipment performance

Limitations of CEM

- CEM is not a panacea for passenger safety
- CEM cannot supplant or replace safe operating practices
- Standard collision scenarios analyze impact speeds of 15-25 mph

Questions?

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