Overview of Planned Sled Testing with Autonomous Wheelchair Securement Systems and ATD Restraints

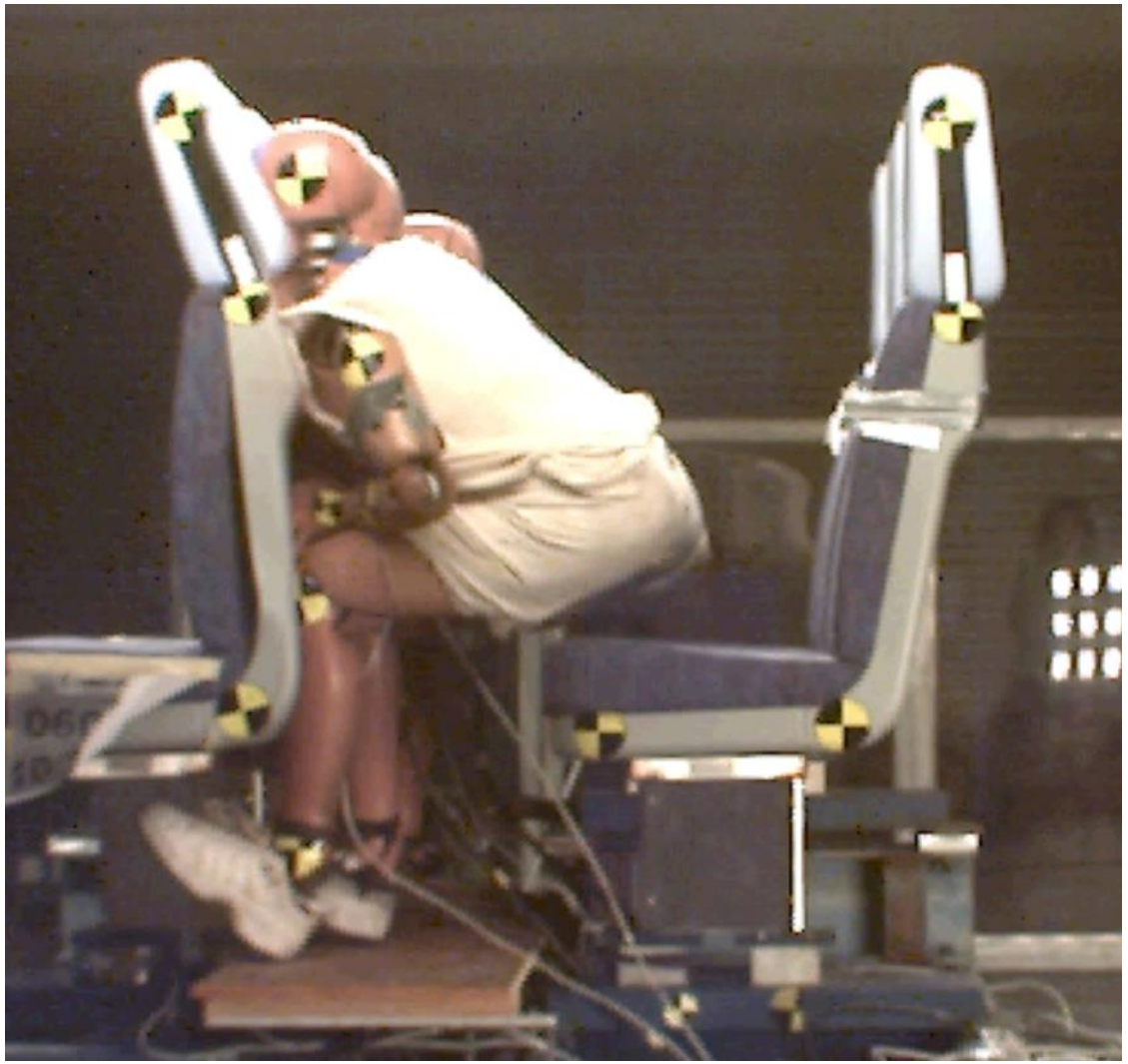
NGEC Technical Subcommittee Meeting

October 10, 2024

Outline

- Interior occupant protection research
- Occupant compartmentalization strategy
- Previous wheelchair full-scale testing
- Planned wheelchair sled testing
- Future work

Interior Occupant Protection Research



Primary Research Objective:

Mitigate the risk of occupant injuries and fatalities during train accidents

Federal Railroad Administration (FRA)
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Research Methodology

- Build understanding of causal mechanisms of injuries and fatalities by investigating passenger rail accidents
- Develop occupant protection strategies to mitigate injury risk
- Measure the effectiveness of occupant protection strategies using computer simulations and testing

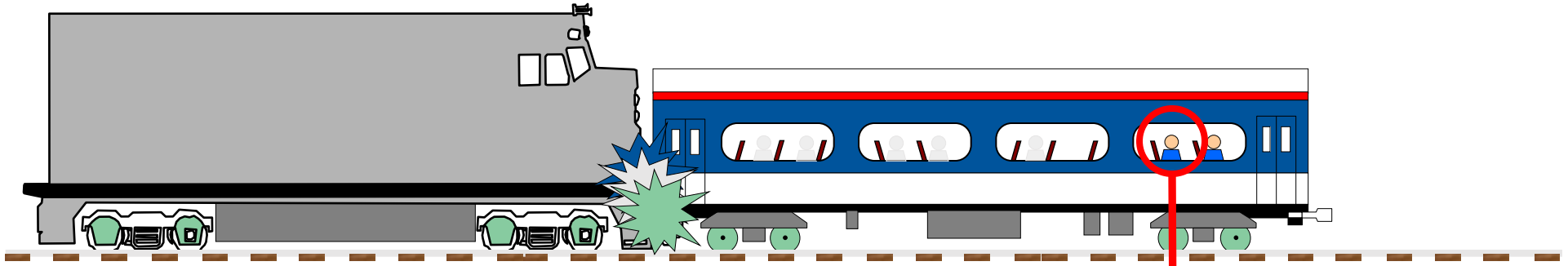
Investigate Accidents

Computer Simulation

Sled Testing

Full Scale Testing

Collision Terminology



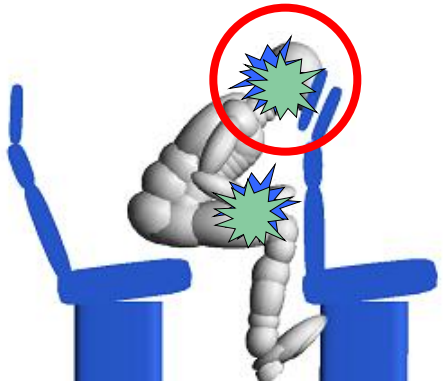
- Primary Impact
  - Interaction between vehicles

  → Affects carbody deceleration

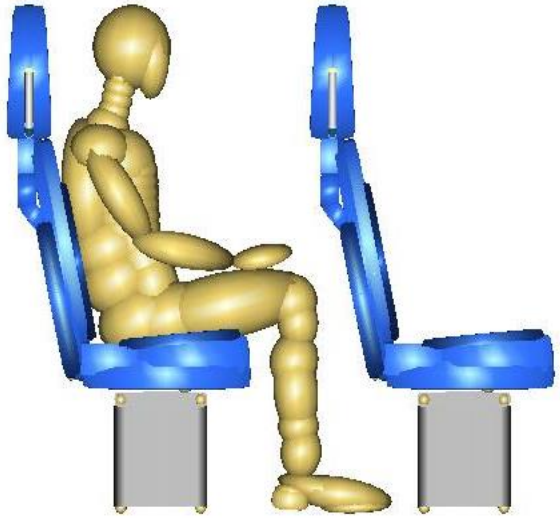
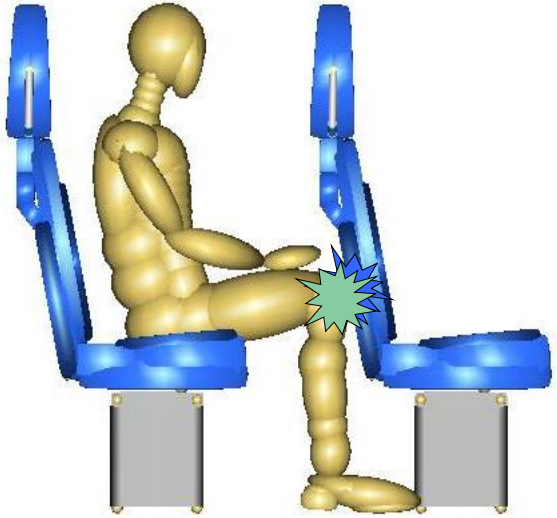
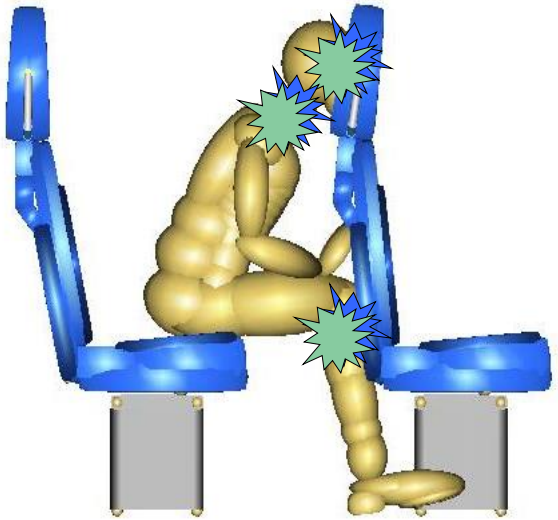
- Secondary Impact
  - Interaction between occupants and interior fixtures

  → Affects occupant deceleration

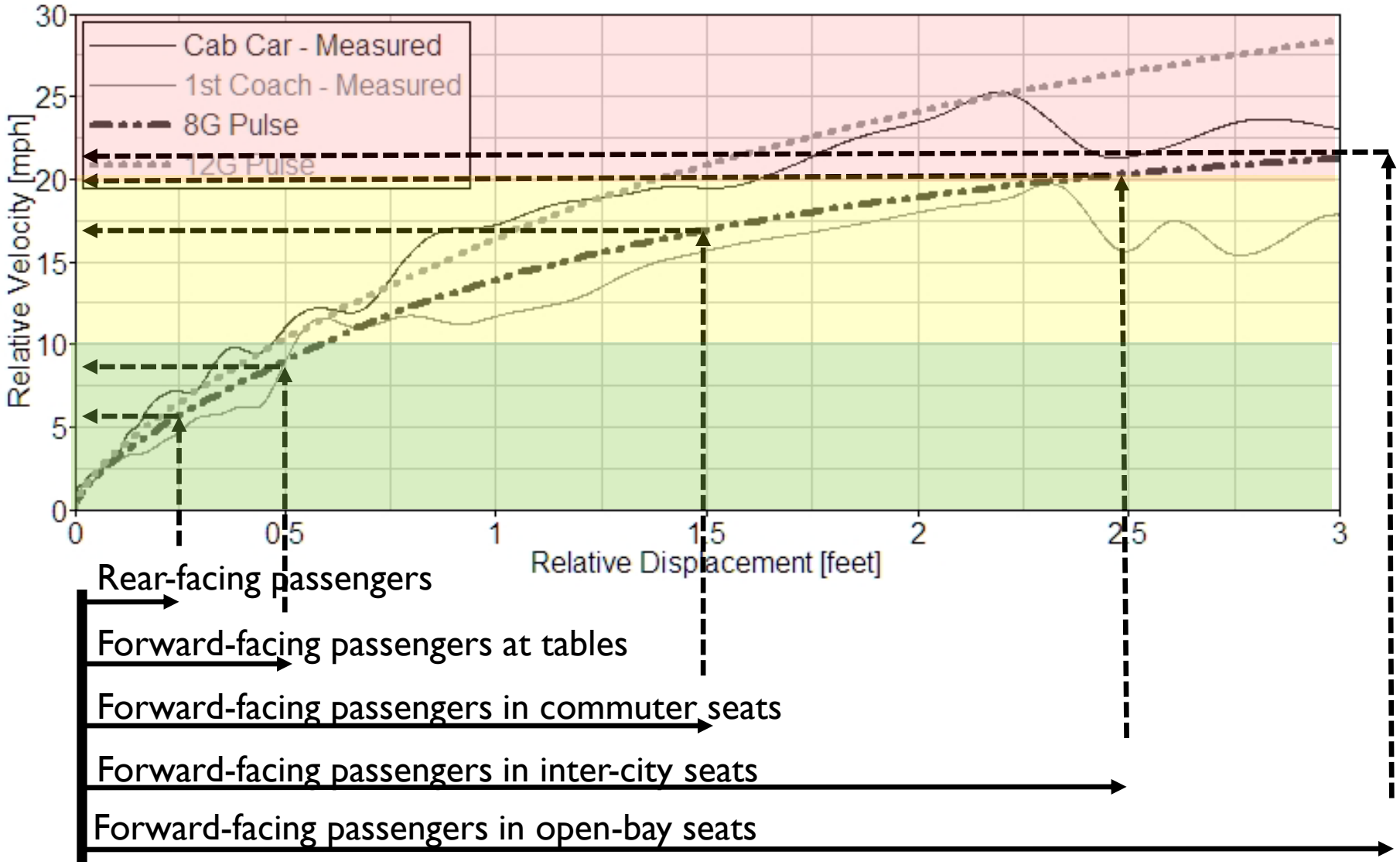
- Compartmentalization
  - An occupant protection strategy to limit the travel distance and relative velocity of an unrestrained occupant



Sequence of Events During a Train Accident

Stage 1	Stage 2	Stage 3
		
Train collision occurs (Primary impact)	Occupant in free flight	Occupant strikes interior (Secondary impact)

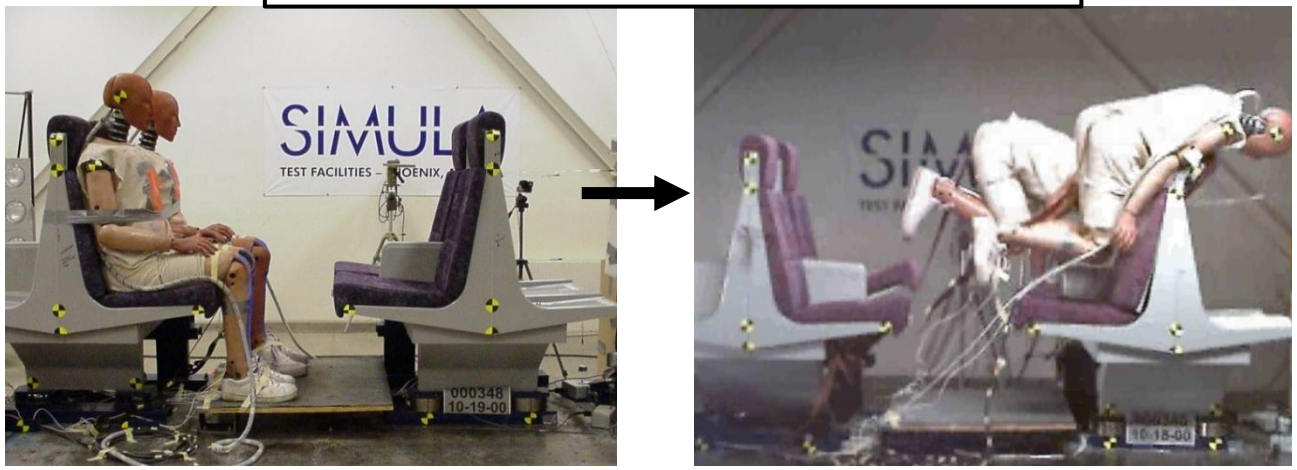
Limit Secondary Impact Velocity



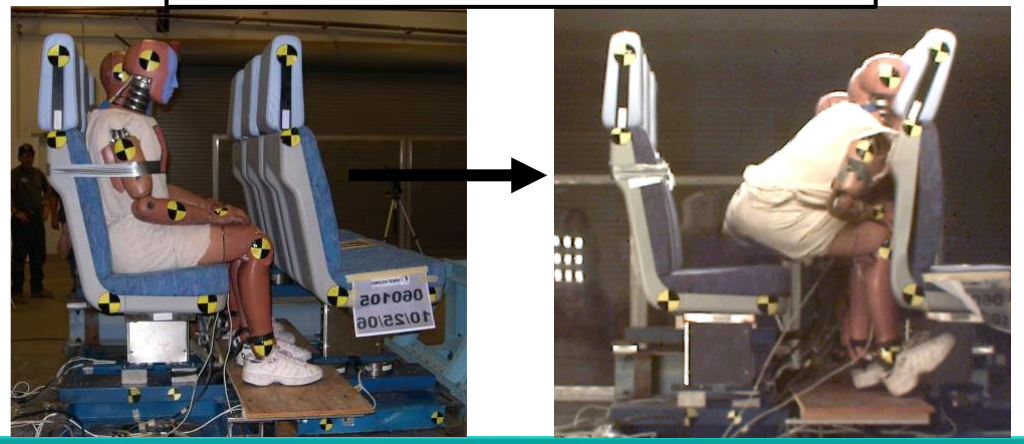
Interior Crashworthiness Objectives

- Limit secondary impact velocity
  - Reduce travel distance between occupants and interior fixtures
- Compartmentalize occupants
  - Contain occupants in small, defined space, i.e., between rows of seats or between table and seat
  - Design seats with tall seatbacks
  - Design seats and tables to deform and absorb energy
  - No loose objects

ATDs not compartmentalized

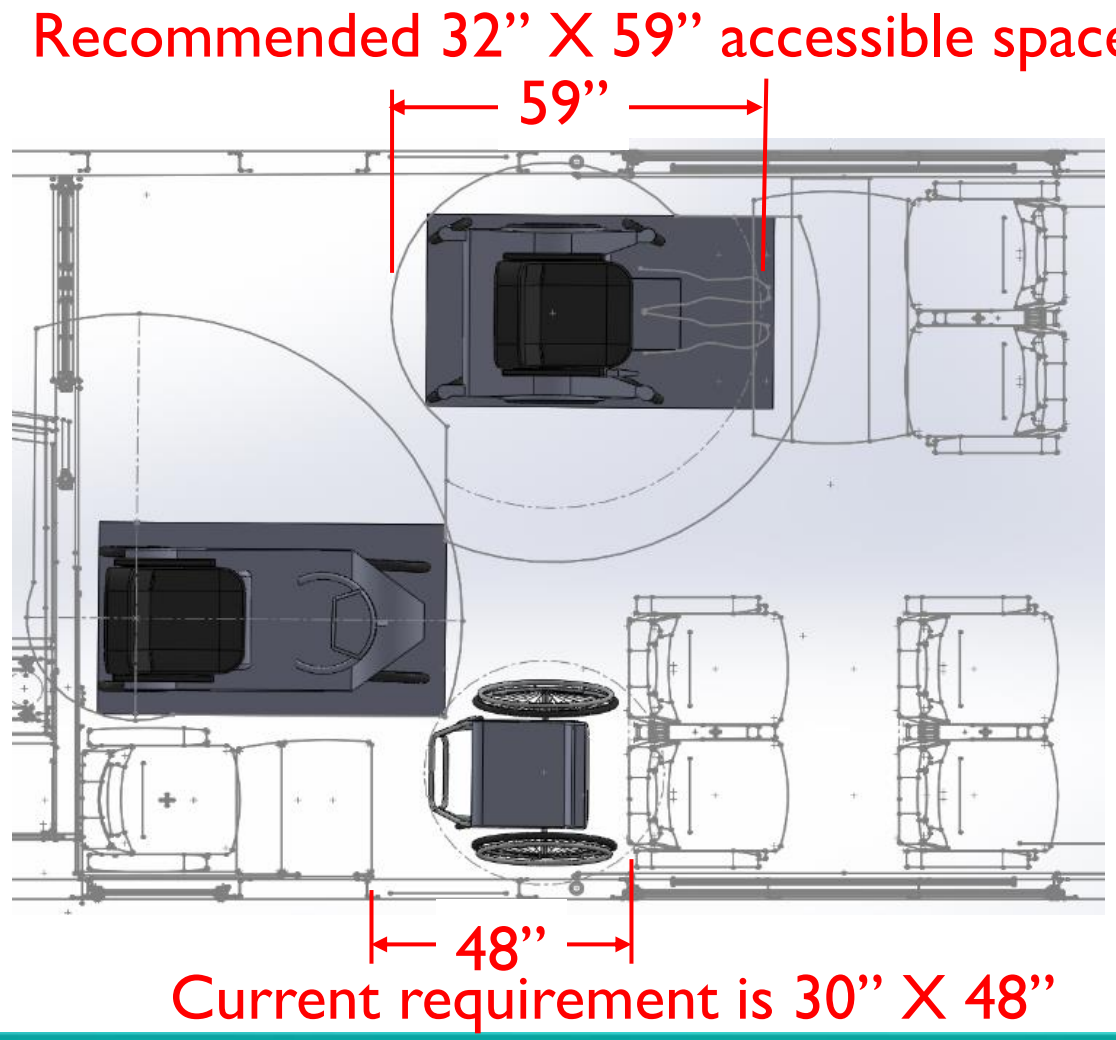


ATDs compartmentalized



Accessibility Recommendations for Next Generation Passenger Rail Cars

- FRA sponsored research to develop universal and inclusive accessibility recommendations for next generation passenger rail cars:
  - Including larger accessible space and room for multiple WhMDs
- Increasing the accessible space exacerbates the collision safety concerns
- FRA sponsored Volpe research to evaluate occupant safety and propose improvement strategies



Occupant Compartmentalization Applied to Wheelchair Collision Safety

- Rail passengers seated in WhMDs are exposed to additional hazards during an accident:
  - Larger accessible space leads to higher secondary impact velocities
  - Heavy, unsecured WhMDs are hazards to all occupants during a train accident
- Effective securement and/or compartmentalization of WhMDs and passengers seated in WhMDs can improve collision safety for all passengers

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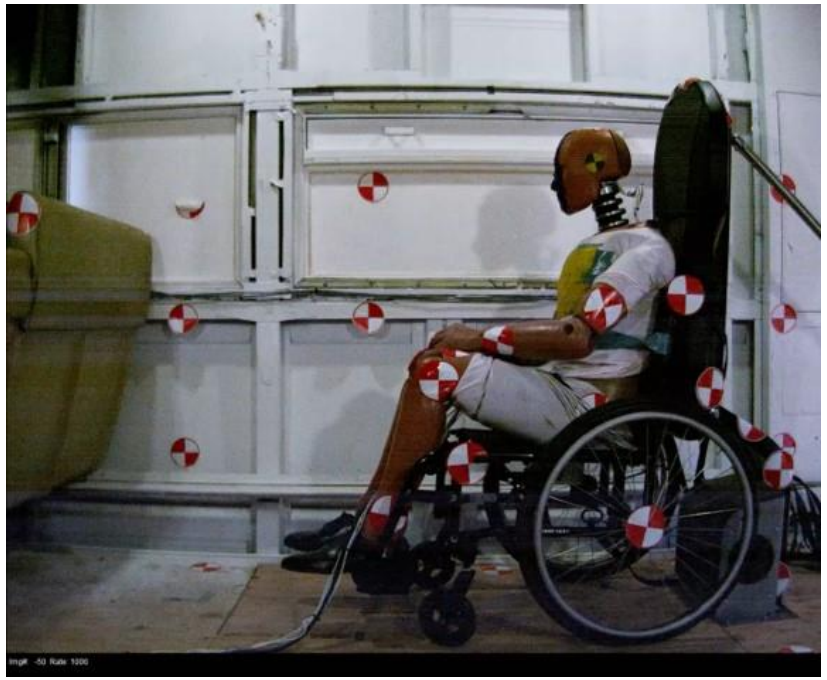
- Three occupant experiments were conducted train-to-train impact test using crash test dummies seated in wheelchairs, with restraint systems used on transit buses

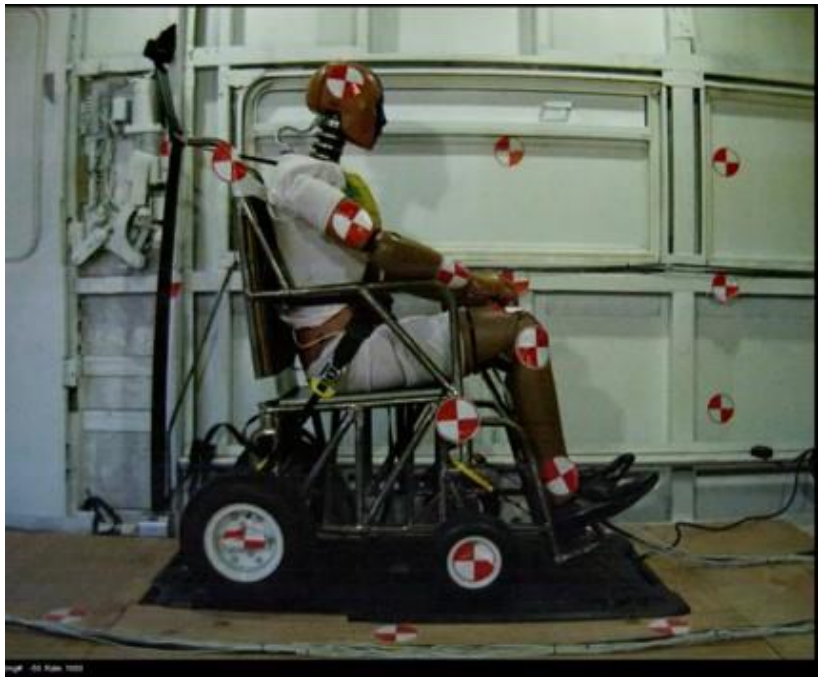
Occupant Compartmentalization Demonstrated in Aug 2022 Wheelchair Experiments

Direction of travel →



Q'Straint backboard

Q'Straint Quantum w/ lap & shoulder belt



Q'Straint One w/ lap & shoulder belt

Experiment Results and Feedback

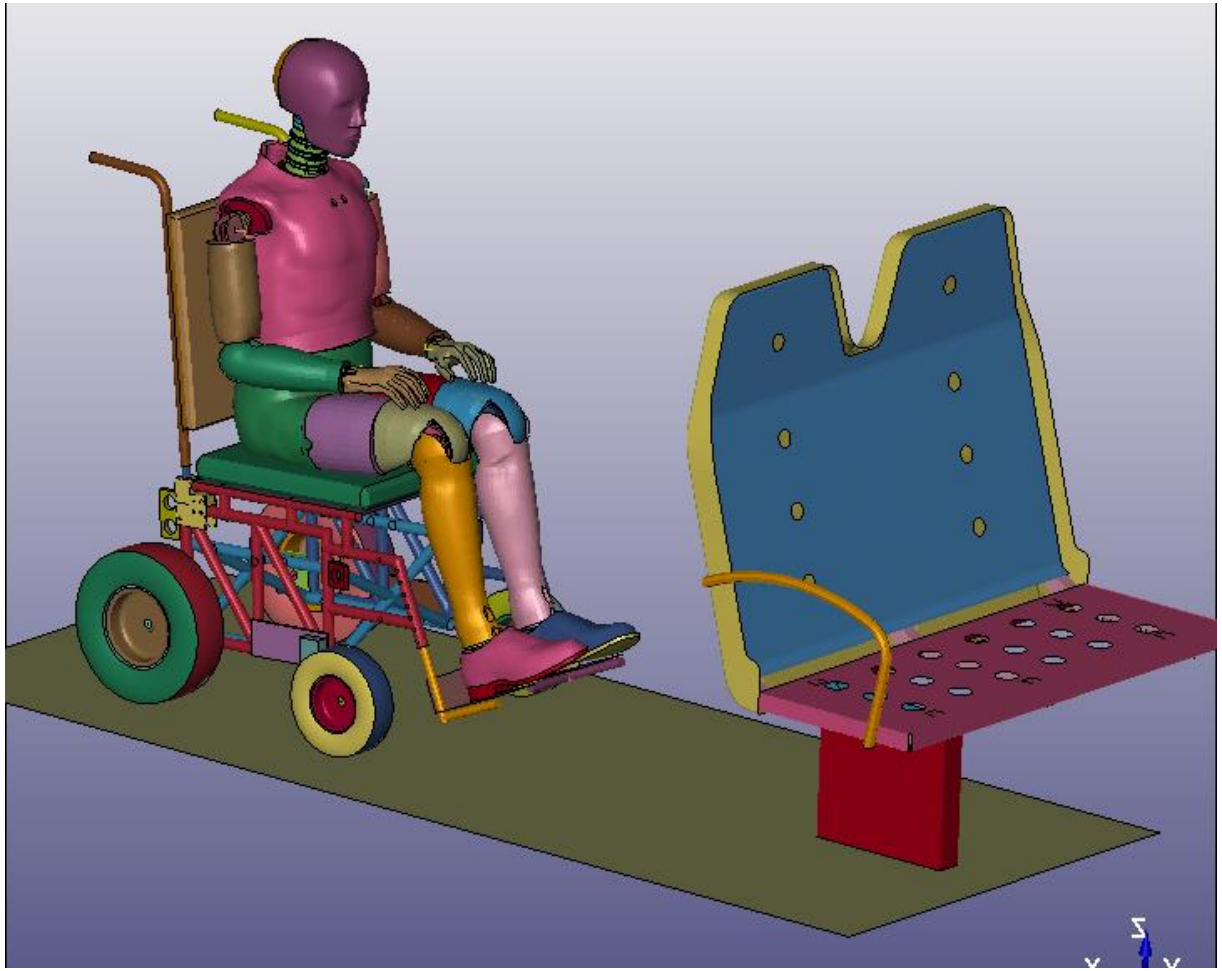
- Experiments demonstrated that existing transit bus retention devices performed well in a train collision conditions:
  - ATDs were all compartmentalized
  - Injury measurements were well below threshold values
- Test results were shared with FRA, FAA, FTA, APTA, RVAAC, Amtrak, NGEC, and others
- Feedback from WhMD user community:
  - Desire to face direction of travel
  - Desire to use safety devices independently

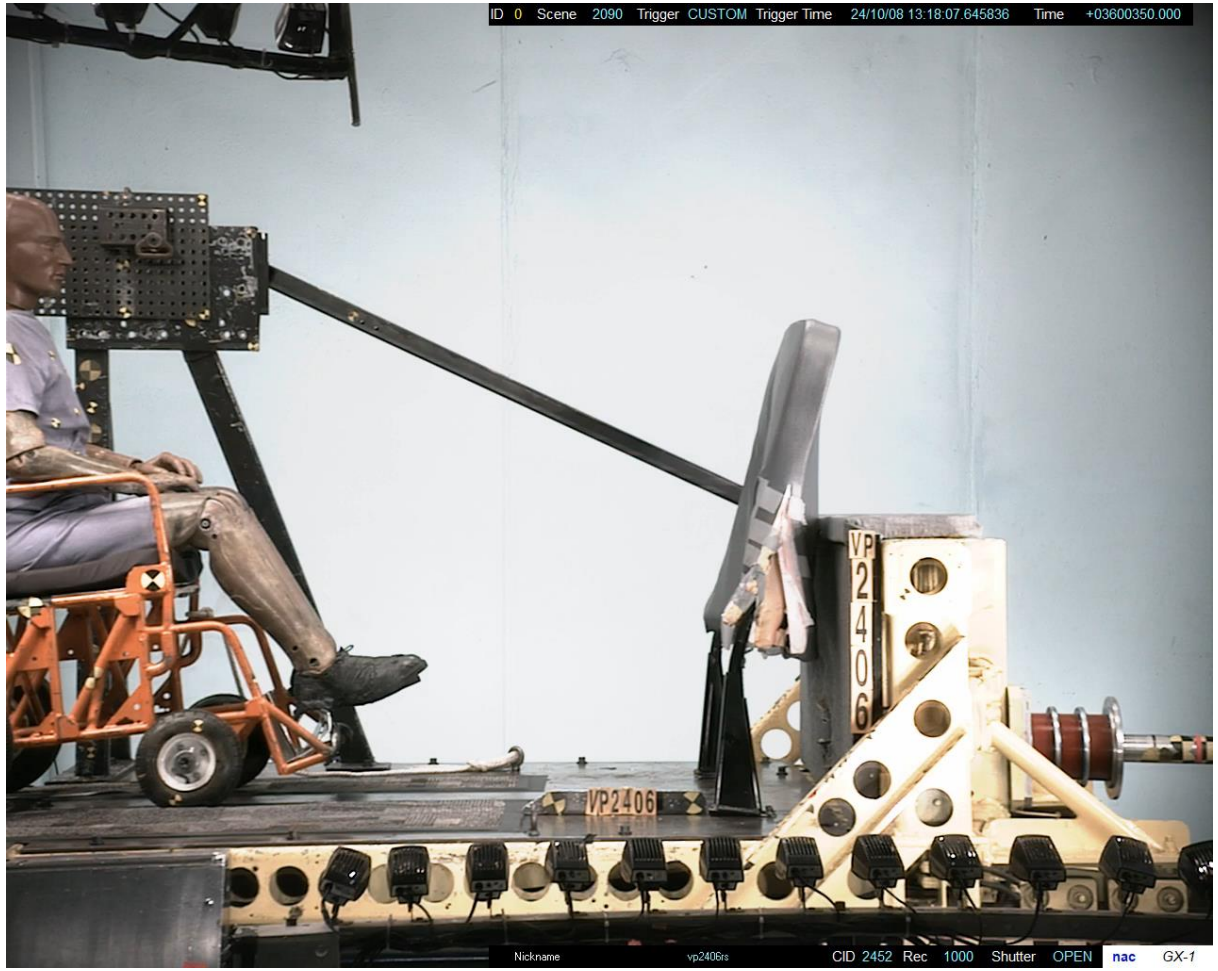
Wheelchair Testing – Round 2

- Conduct sled tests with wheelchair restraints and occupant securement devices developed for autonomous use in automobiles
- Each test uses a WC-19 compliant surrogate wheelchair and 50th percentile Hybrid III male ATD
  - Test 1 – Unrestrained wheelchair and ATD with traditional passenger seat to provide compartmentalization (baseline case)
  - Test 2 – UMTRI Universal Design Interface Geometry (UDIG) compliant wheelchair securement with lap and shoulder belt
  - Test 3 – Q'Straint QLK wheelchair securement with lap and shoulder belt

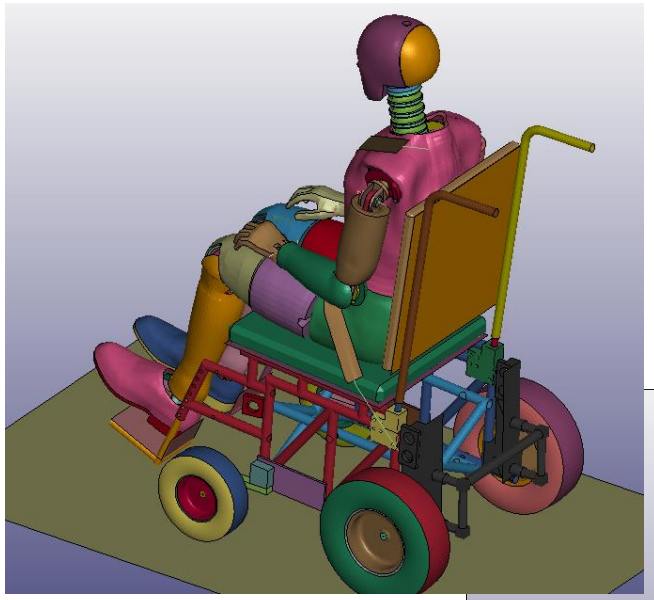
UMTRI Autonomous Restraint System

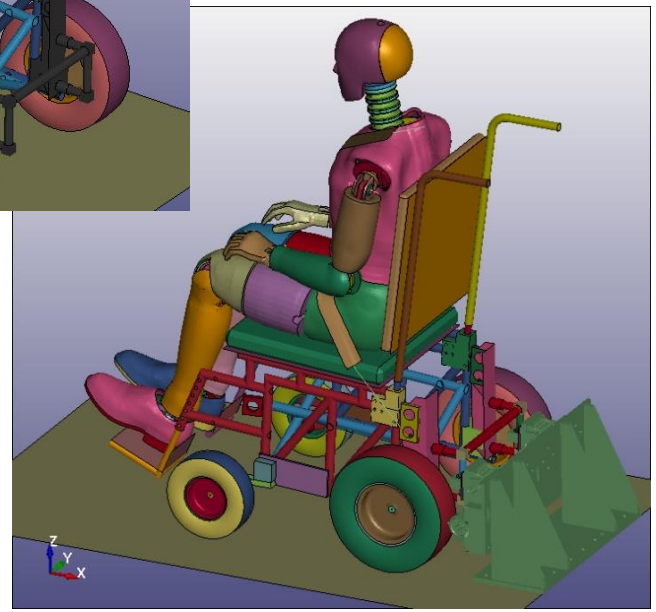
Test 1 – Unrestrained Wheelchair and ATD (baseline case)

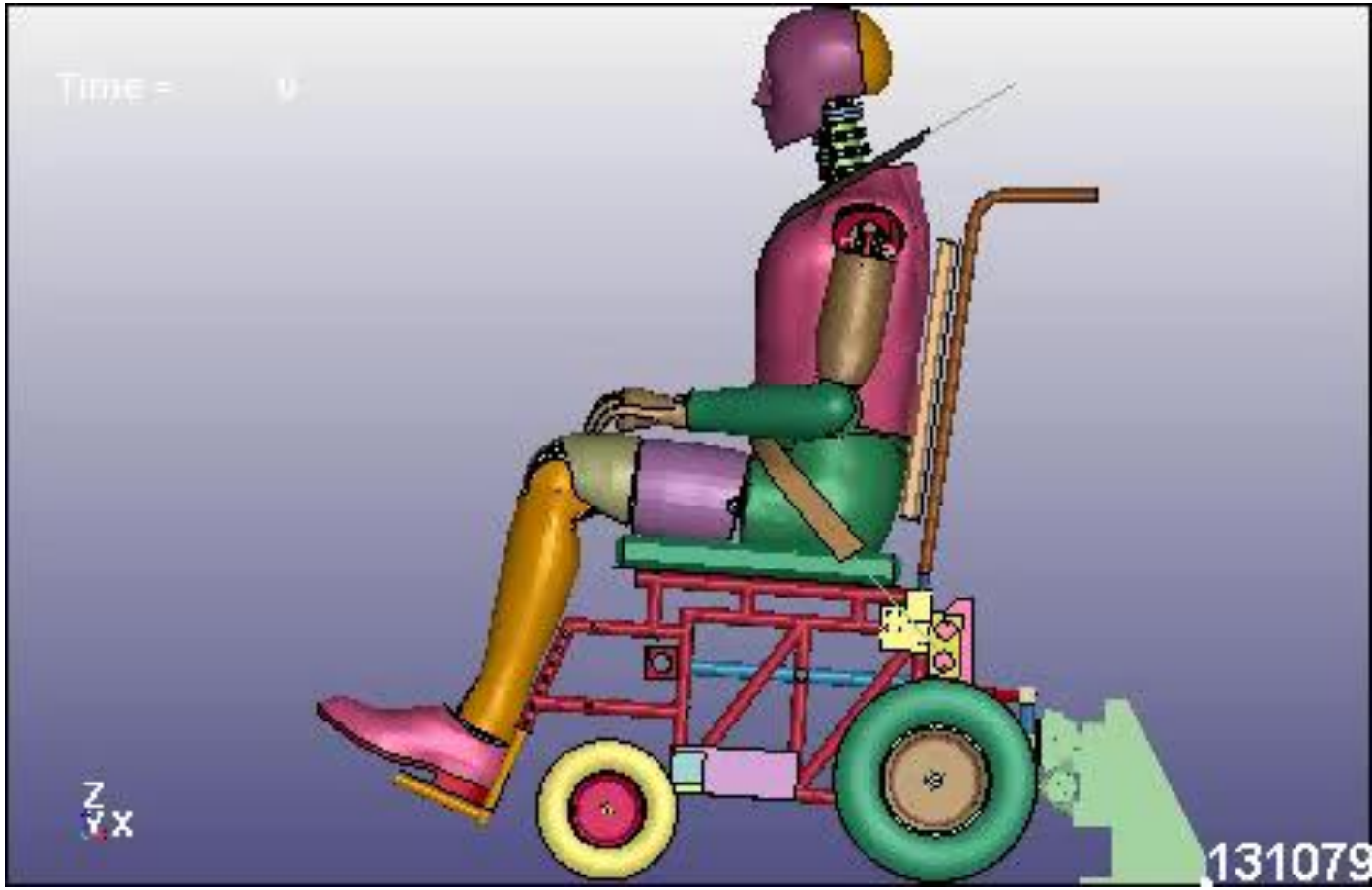




Test 2 – UMTRI UDIG-Compliant Wheelchair Securement with Autonomous Lap/Shoulder Belt







Test 3 – Q'Straint QLK Wheelchair Securement with Autonomous Lap/Shoulder Belt

Q'Straint QLK
docking system

Next Steps

- Perform sled tests in at UMTRI October or November
- Continue to collaborate with UMTRI, NHTSA, FAA, FTA, rail operators, OEMs to develop and test universal autonomous trans-modal wheelchair safety solutions
- Support the work of SecureRide Coalition to develop a wheelchair securement standard that can be applied to personal vehicles, rideshares, public transit, buses, trains, and low-speed shuttles.

Questions?

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