FDOT / TRIPS Crashworthiness and Safety Assessment of Cutaway Buses

Testing and research conducted by CIAL at:

- TRIPS Bus Testing & Inspection Facility Tallahassee, FL
- FAMU-FSU College of Engineering Tallahassee, FL
- CAPE / IMMI Indianapolis, IN

Overview

Cutaway buses are constructed using a two stage build process and often have Gross Vehicle Weight Rating (GVWR) exceeding 10,000 lbs. In combination, these two factors exempts them from most federal safety standards.

Crashworthiness and Safety Assessment of Cutaway Buses

Goal: To continually improve the passenger safety of all cutaway buses purchased through FDOT / TRIPS contracts.

Current Required FDOT / TRIPS Standards

Structural based standards intended to reduce passenger injury by preventing collapse of the passenger compartment during rollover accidents.

- PRE-QUAL
- FL-STANDARD

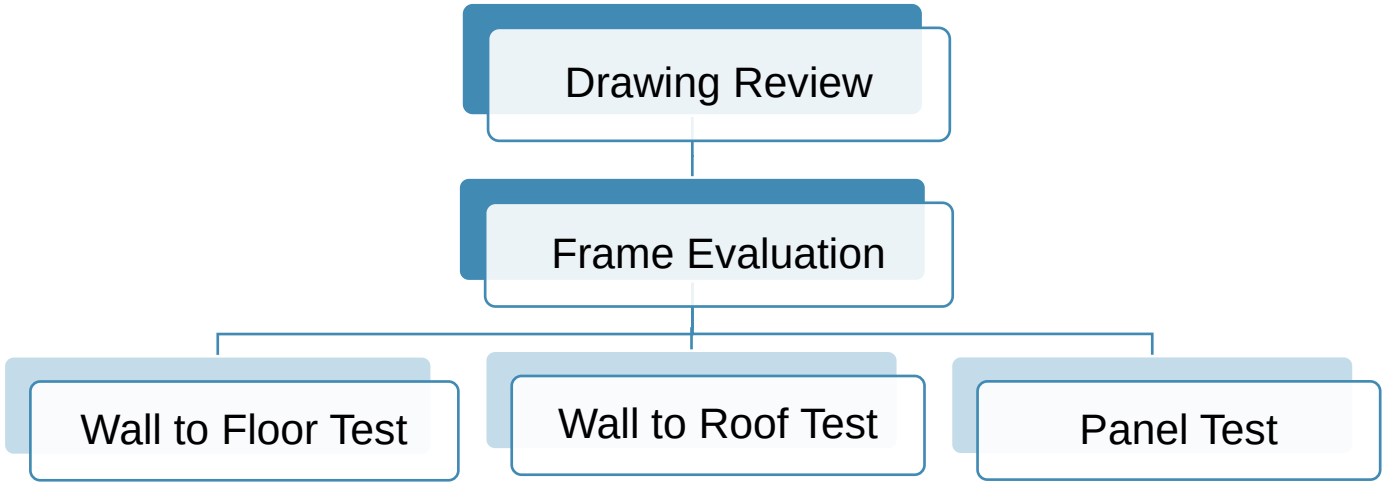
Current CIAL Research

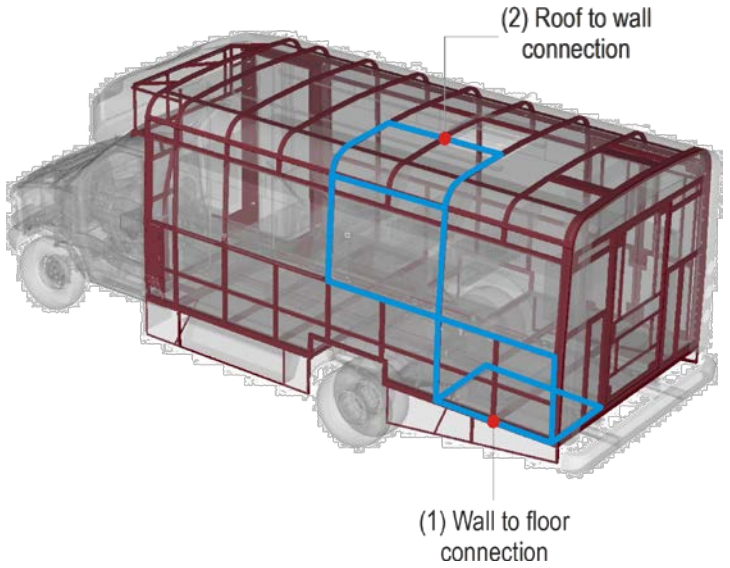
Use of ATD's (test dummies) to answer the following questions:

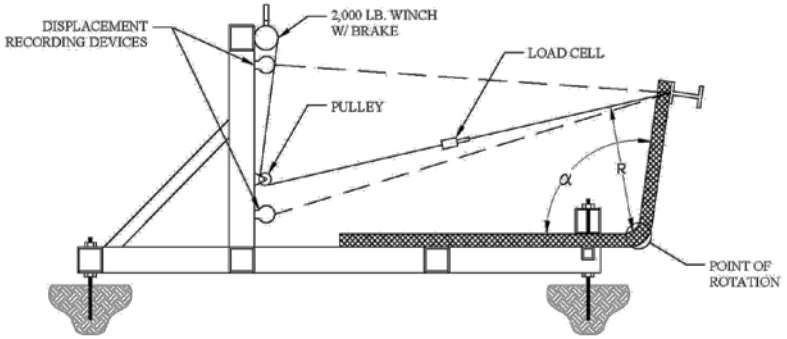
- What happens to passengers during rollover crashes?
- What are the sources of passenger injury?
- How we can prevent the injuries?

FDOT / TRIPS PRE-QUAL Inspection and Testing

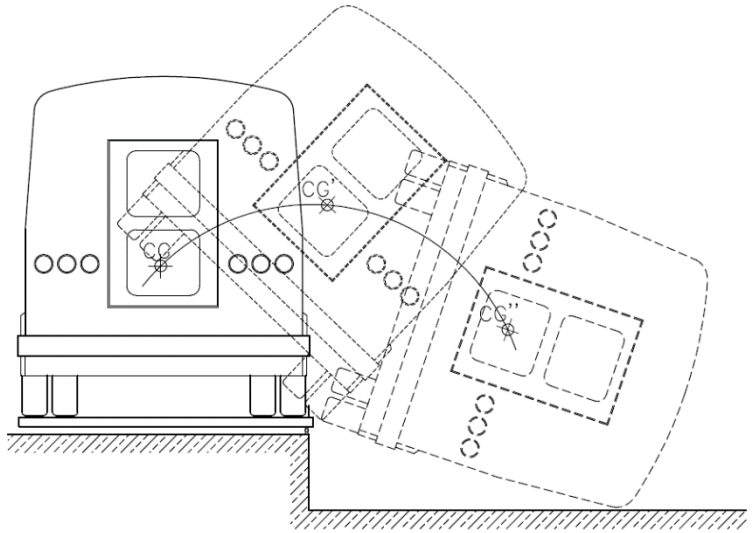
The purpose of the PRE-QUAL inspection and testing is to document the design and assembly methods of the particular bus model while also ensuring it has a minimum level of structural integrity. PRE-QUAL must be completed before first build for all cutaway buses acquired through FDOT / TRIPS contracts.





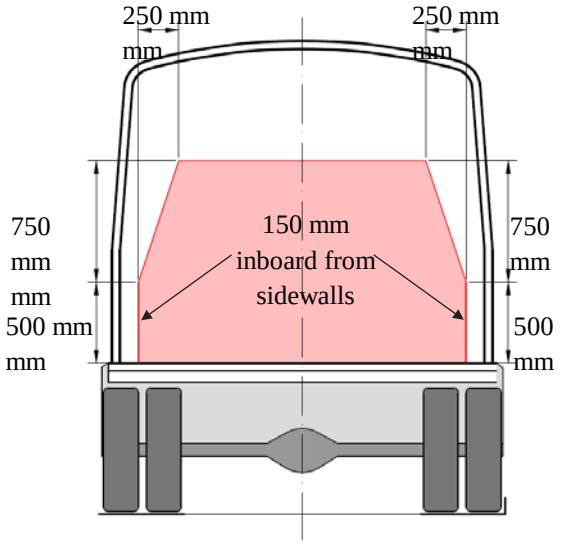


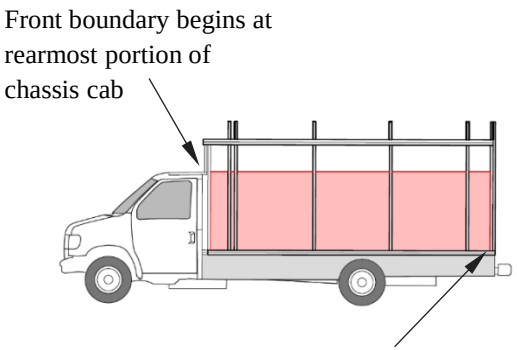
FDOT / TRIPS FL-STANDARD Tilt Table Rollover



The FDOT / TRIPS Standard Rollover test is similar to the European Regulation 66 (ECE R66).
The test is performed by placing a prepared bus on a tilt table which then rotates bus to point of unstable equilibrium and allows the bus to fall under its own weight 31.5” onto a flat concrete slab.

Pass-fail criteria for the rollover test is based on the concept of Survival Space which is a three-dimensional volume defined within the passenger compartment. In order for the bus to gain approval, the Survival Space cannot be compromised by any structural part of the bus during impact.





CIAL Dolly Rollover Research Test

The dolly rollover test is intended to be more representative of what occurs in “real world” rollovers. This test was conducted at CAPE/IMMI located in Indianapolis, IN.

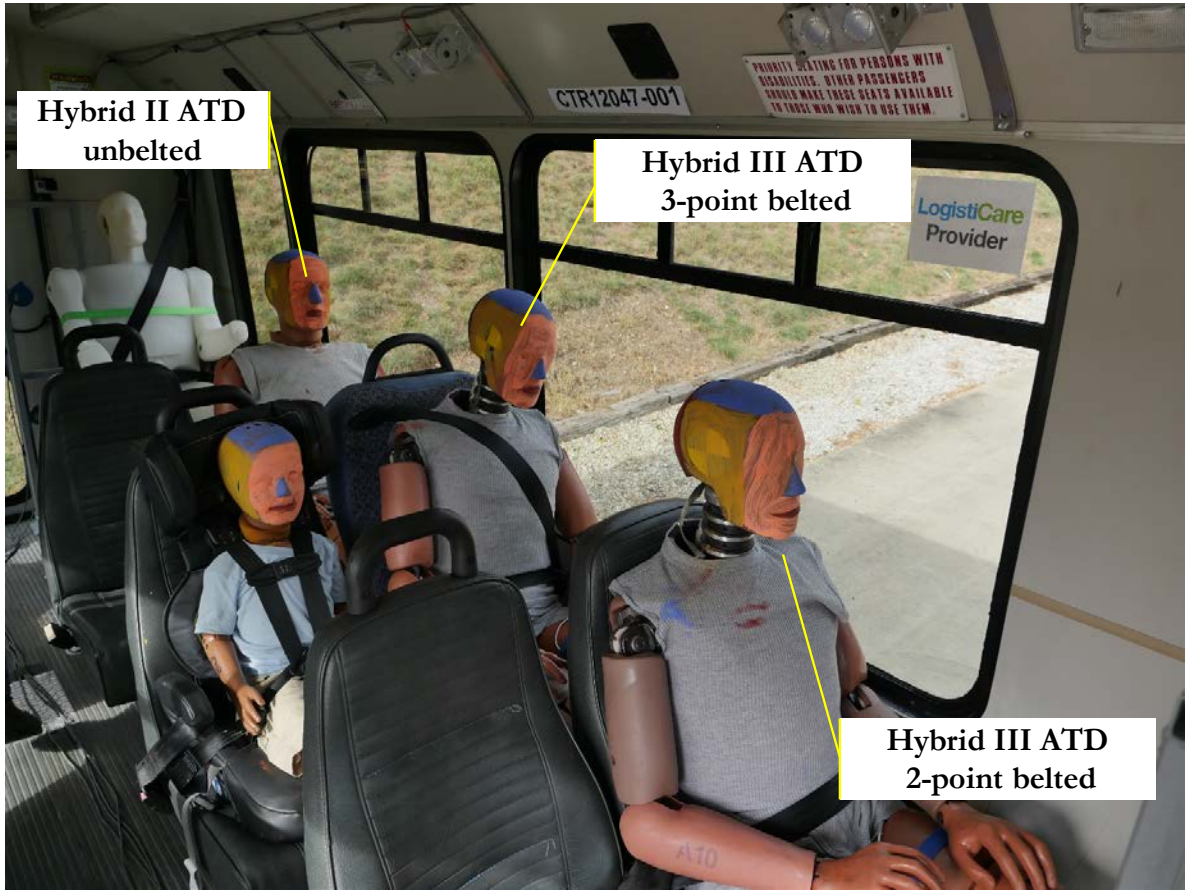
The bus is loaded on a sled which accelerates to 25 mph before being rapidly stopped. The momentum of the bus in combination with ramps on the sled and the rough surface of the impact area initiate the bus roll.

CAPE Dolly Rollover Research Test

ATD (test dummy) passengers were included to study injury differences between passengers wearing:

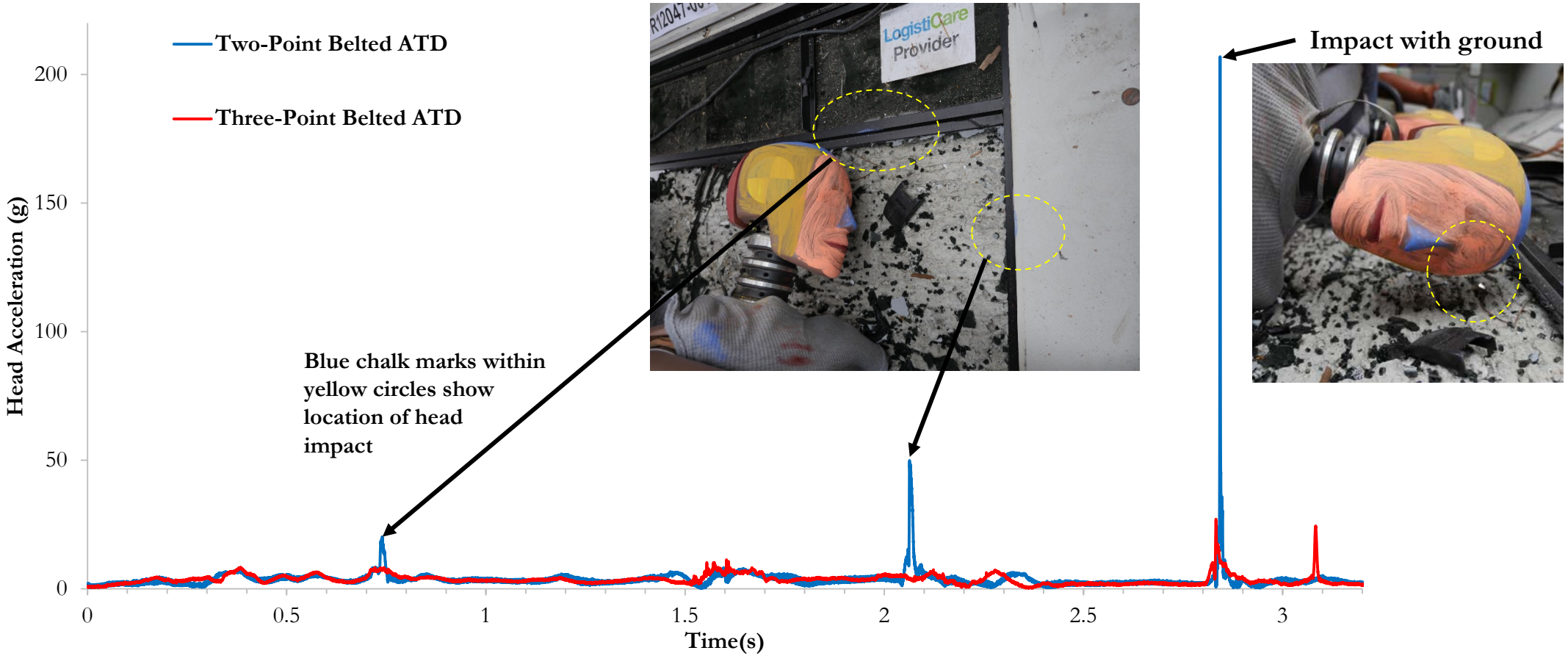
- 2 point seatbelt
- 3 point seatbelt
- No seatbelt

In order to compare results between the dolly test and the FL-STANDARD tilt table test, a follow-up test has been scheduled. It will use an identical vehicle with the same ATD load-out and will be conducted at TRIPS Springhill in April.



2 pt. vs. 3 pt. Seatbelt Head Injury - Dolly Rollover Test

During the Dolly rollover the 2 pt. belted ATD experienced more severe head injury than the 3 pt. belted ATD - likely due to greater allowed movement of the upper torso by the 2 pt. (tentative results).



CIAL Injury Mitigation Research Examples

Based on preliminary ATD testing results a major concern is head injury due to contact with the bus interior or ground (after a window has broken).

Several mitigation methods to address this are currently being investigated using both experimental tests and computer simulations:

- Type of window glazing (tempered vs laminated)
- Side Airbags

Though not addressed here these mitigation methods are also being studied in regards to their effect on the primary source of serious injury during rollover – partial or full ejection.

CIAL Injury Mitigation Research - Side Airbag

This experimental research is currently undergoing. Two Ford Transit side curtain airbags were acquired after being removed from a bus undergoing conversion:

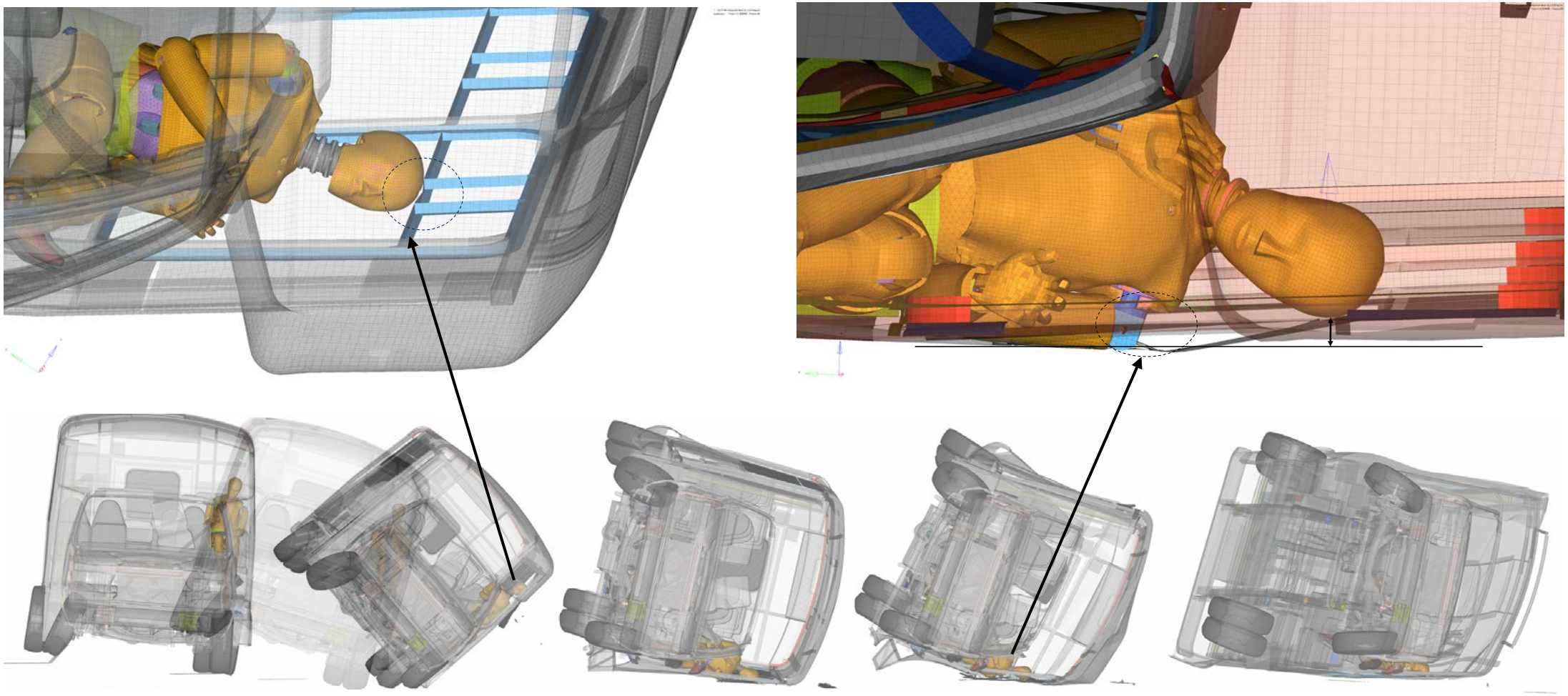
- The first airbag has been installed in a retired bus and will be activated to observe how it deploys and interacts with the water ballast dummy passengers.

- A second airbag is planned to be tested in combination with an HIII M50 ATD in a single seat rotation drop test that will be conducted following the FL-STANDARD rollover in April.

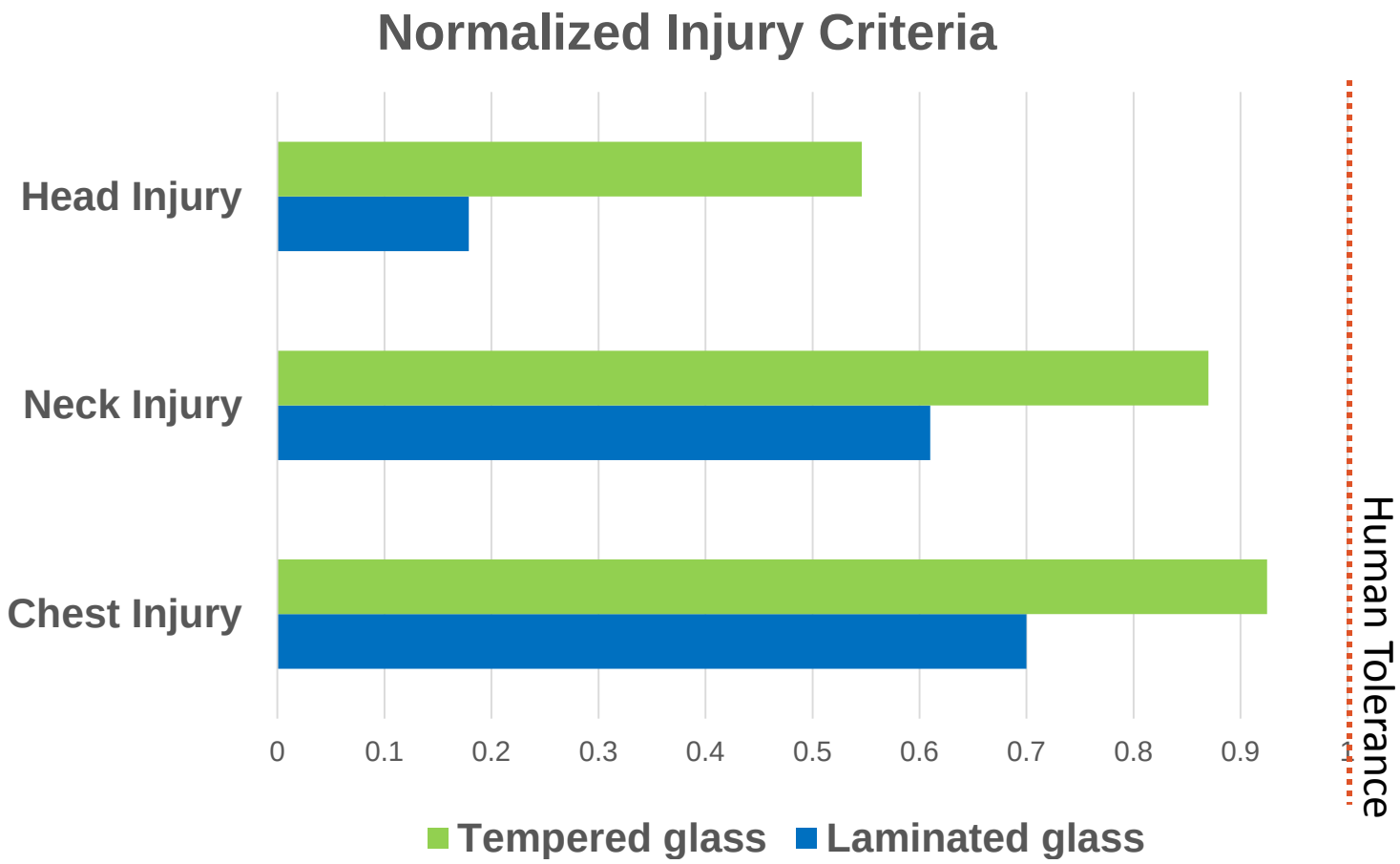
CIAL Finite Element Computer Simulations

Many different rollover scenarios may be simulated and analyzed.

Allows for more detailed study of the injury mechanism.



CIAL Computer Simulation - Effect of tempered vs. laminated glass windows in the tilt table test using finite element HIII M50 ATD.



Preliminary results of computer simulated testing show that laminated glass (glass with a bonded interlayer) which cracks but remains intact reduces head injury when compared to tempered glass (stronger but shatters into small pieces when cracked).

Thank You!