NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

# Occupant Protection

*NHTSA Safety Research Portfolio Public Meeting: Fall 2021*

*October 21, 2021*

# Panel Presentations

1. **Update on NHTSA's OMDB Half Barrier Analysis –** James Saunders
2. **Comparison of Seat Belt Elongation Requirements –** Kedryn Wietholter
3. **Parametric Study of Pre-crash Vehicle Maneuvers and Occupant Safety Performance Response –** Whitney Tatem
4. **Testing of Unattended Child Reminder Systems –** Aloke Prasad
5. **Crashworthiness Research-Special Safety Investigations –** Peter Martin

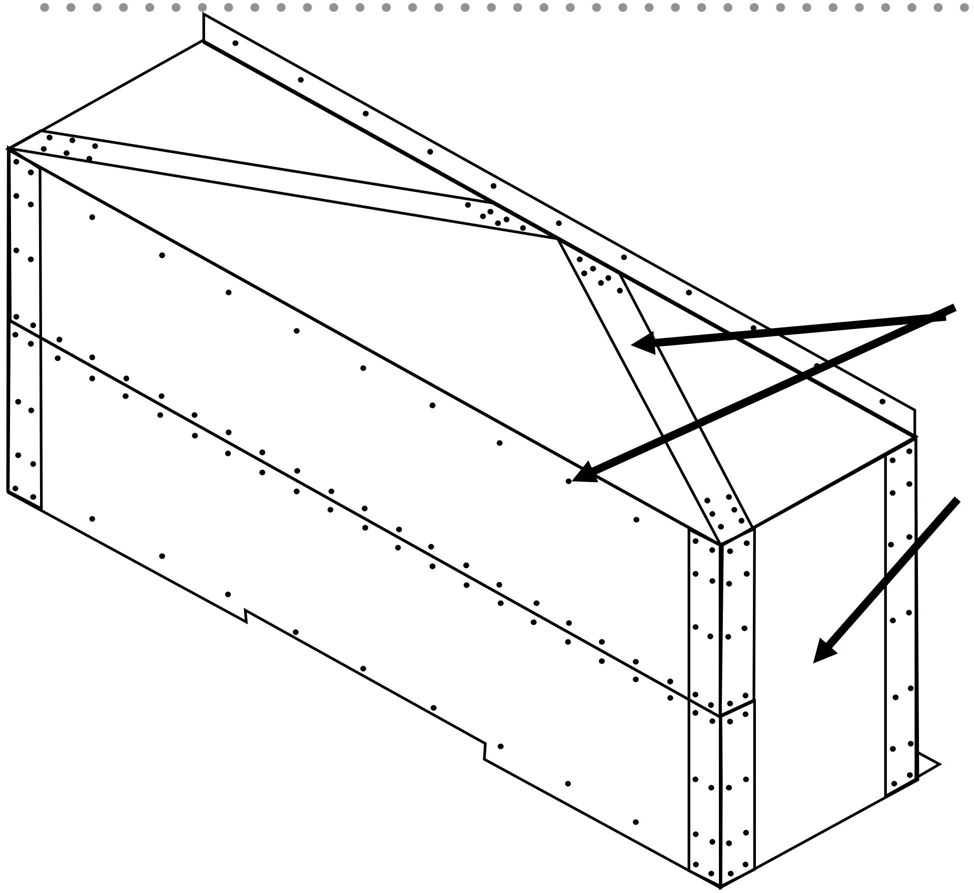
# Update on NHTSA's OMDB Half Barrier Analysis

*James Saunders*

# Background

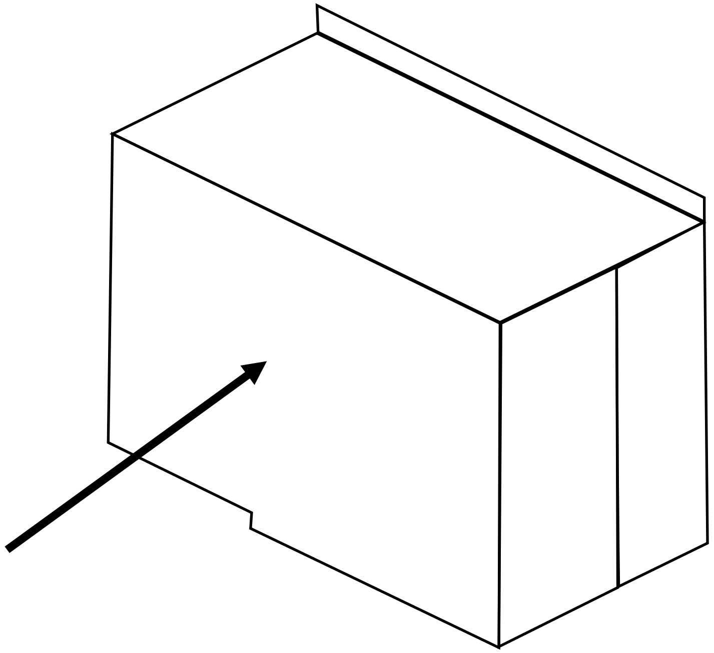
- Performed OMDB test with the full face honeycomb for many years
- Only half the honeycomb is being deformed
- High barrier cost due to how it is manufactured and its size

# Half V0 Honeycomb Definition



- Width slightly > 50%
- Materials the same
- Removed straps and rivets
- Removed side cladding
- Outer cladding one piece

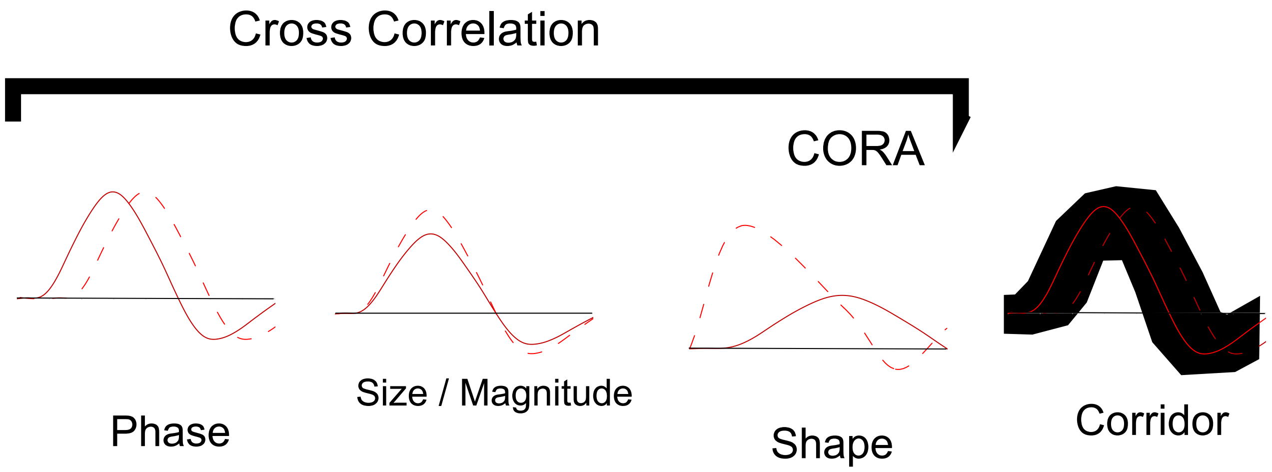
Reduce Cost / Material Waste



# Methodology for Comparison

Calculate correlation between time-histories

- CORrelation and Analysis (CORA) *

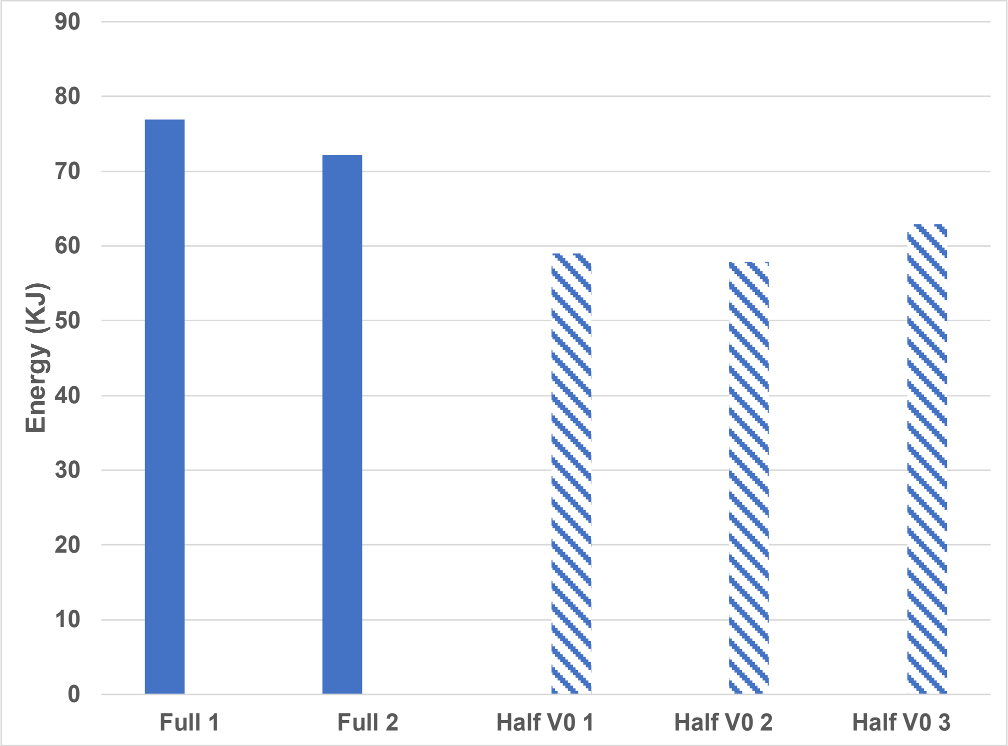



| | |
|---|---|
| Good | R>0.80 |
| Fair | 0.58<R<=0.80 |
| Poor | R<=0.58 |

* CORAplus Release 4.04 User's Manual

# Summary of Previous Testing (Half V0)
## FMVSS 301 Cart as Target Vehicle

Even though the honeycomb crush was different FMVSS 301 Cart response was similar




Energy Absorbed by the Honeycomb

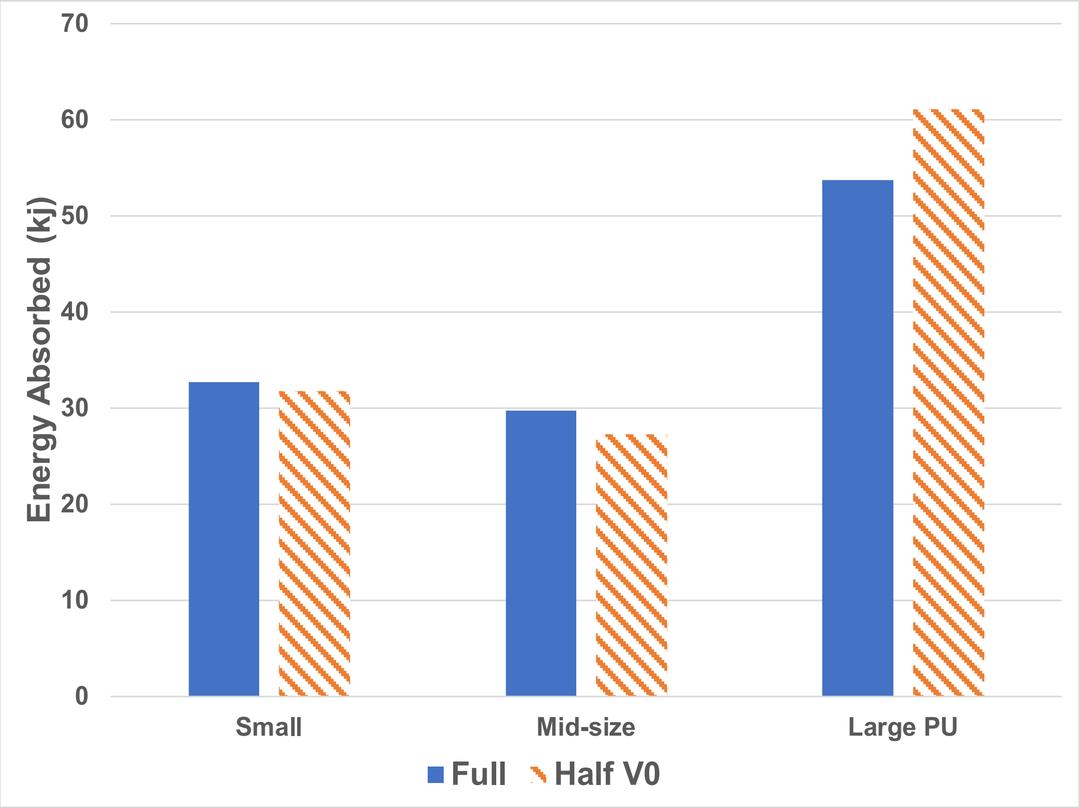

FMVSS 301 Cart

| Name | CORA |
|---|---|
| MCBCGaccRes | 0.887 |
| MCBCGvelRes | 0.954 |
| MCBRearAccRes | 0.820 |
| MCBRearVelRes | 0.908 |
| MCBLeftAccRes | 0.967 |
| MCBLeftVelRes | 0.997 |
| Average | 0.922 |

FMVSS 301 Cart Response

# Summary of Previous Testing (Half V0)
## Production Vehicles as Target Vehicle

Even though the honeycomb crush was different vehicle response was similar

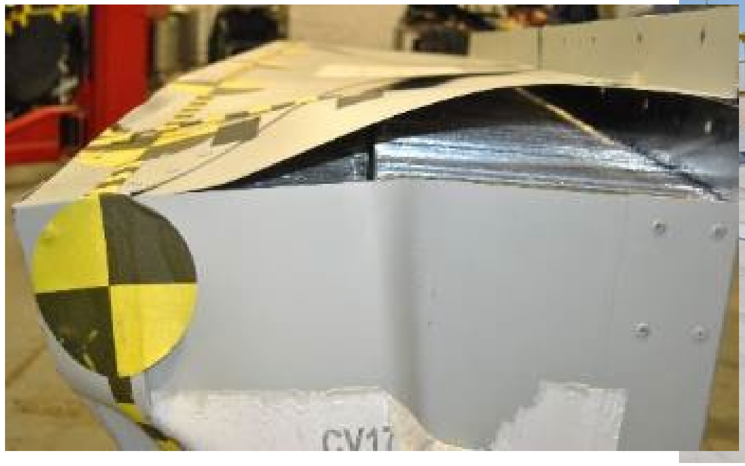



Energy Absorbed by the Honeycomb

| | Small | Mid-size | Large PU |
|---|---|---|---|
| VehLRaccRes | 0.970 | 0.910 | 0.800 |
| VehLRvelRes | 1.000 | 0.970 | 0.990 |
| VehRRaccRes | 0.970 | 0.900 | 0.860 |
| VehRRvelRes | 1.000 | 0.900 | 0.990 |
| VehCGaccRes | 0.980 | ND | 0.830 |
| VehCGvelRes | 1.000 | ND | 0.980 |
| VehCGav | 0.650 | 0.840 | 0.900 |
| VehCGang | 0.810 | 0.920 | 0.990 |
| Average | 0.923 | 0.907 | 0.918 |

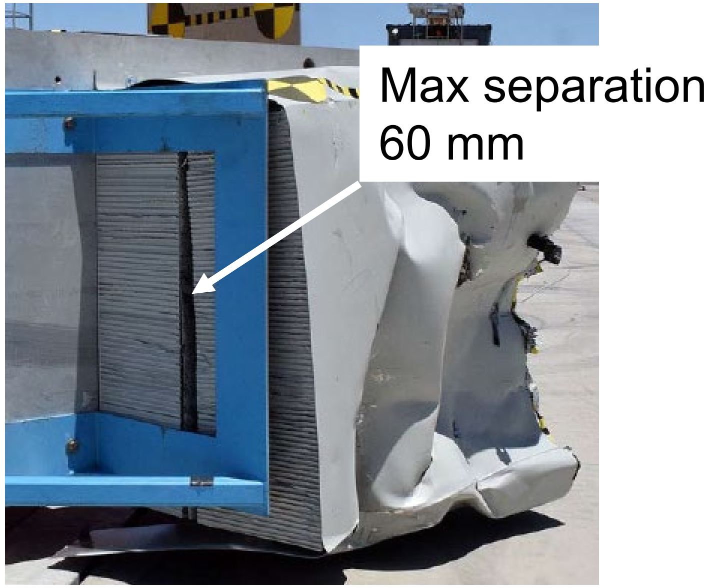
Vehicle Response

# Barrier Separation



Full

Half V0

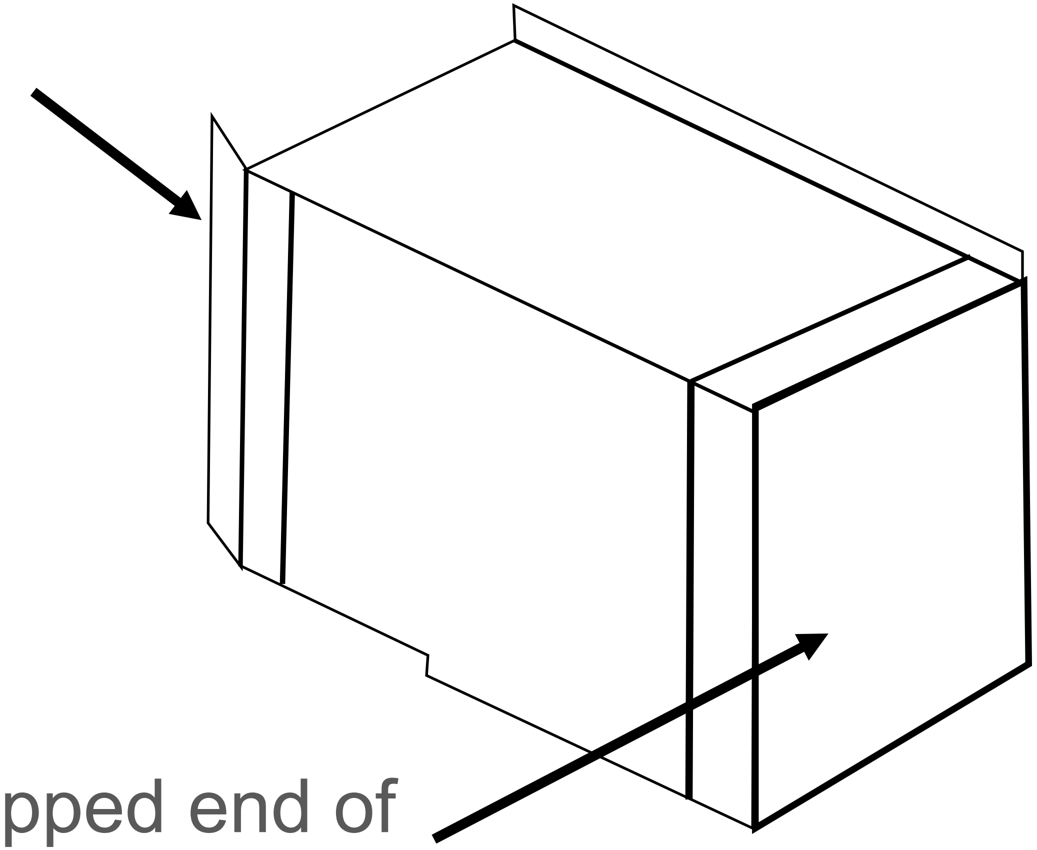



Half V0

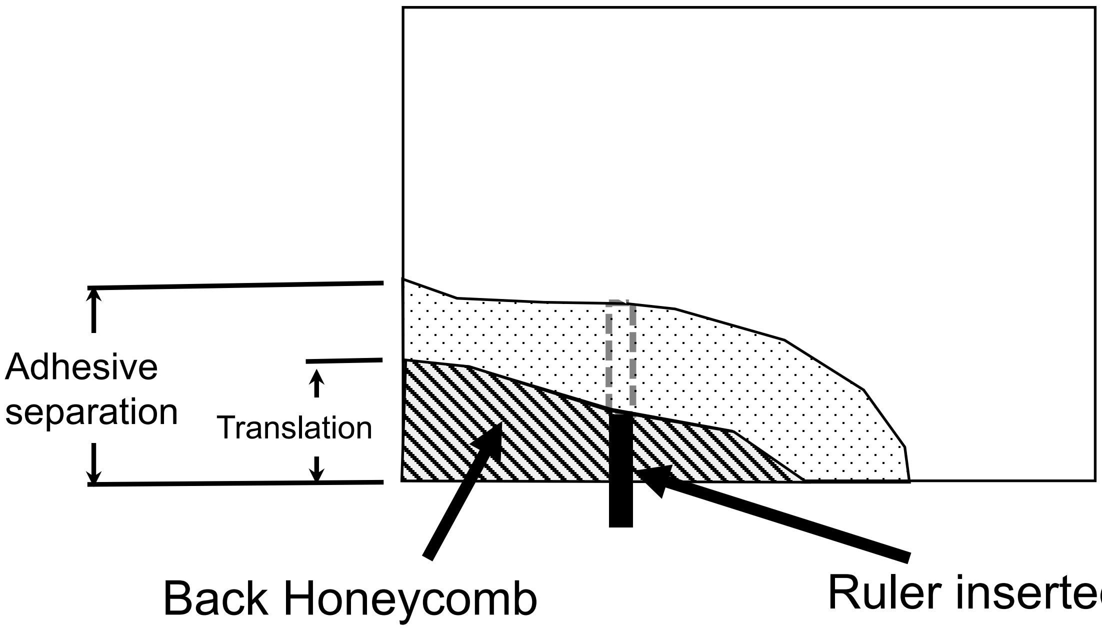
# Summary of Half V0

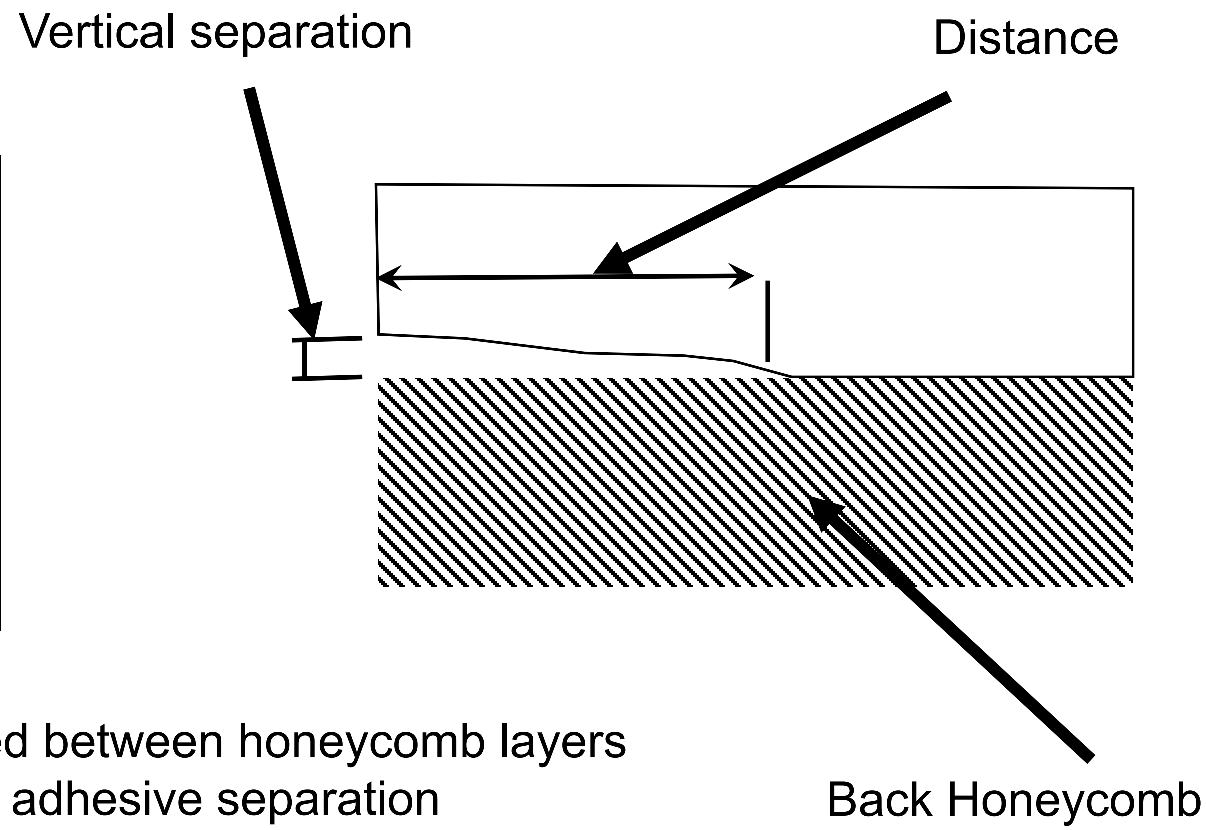
- Even though honeycomb crush was different the Half V0 could be used as an alternative to the full barrier
- Both the Full and Half V0 showed barrier separation

# Difference between half barrier V0 and V1



# Barrier Separation Definition



# Barrier Separation Large PU Left Side

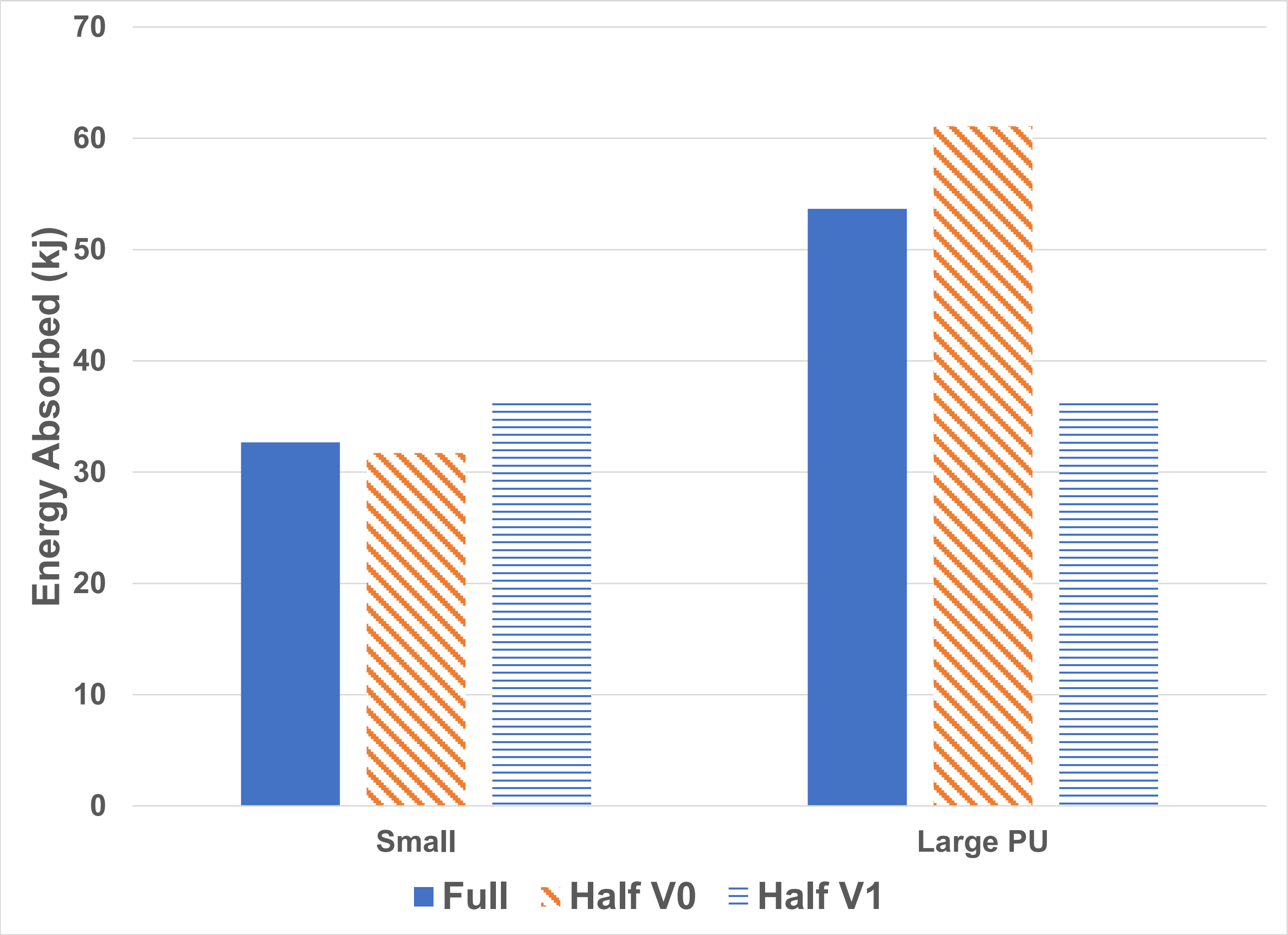

| Type | Max (mm) | Total Distance (mm) |
|---|---|---|
| Translation | None | None |
| Adhesive | 50 | 900 |
| Vertical | 5 | 900 |

# Barrier Separation Small PC


Top right rear

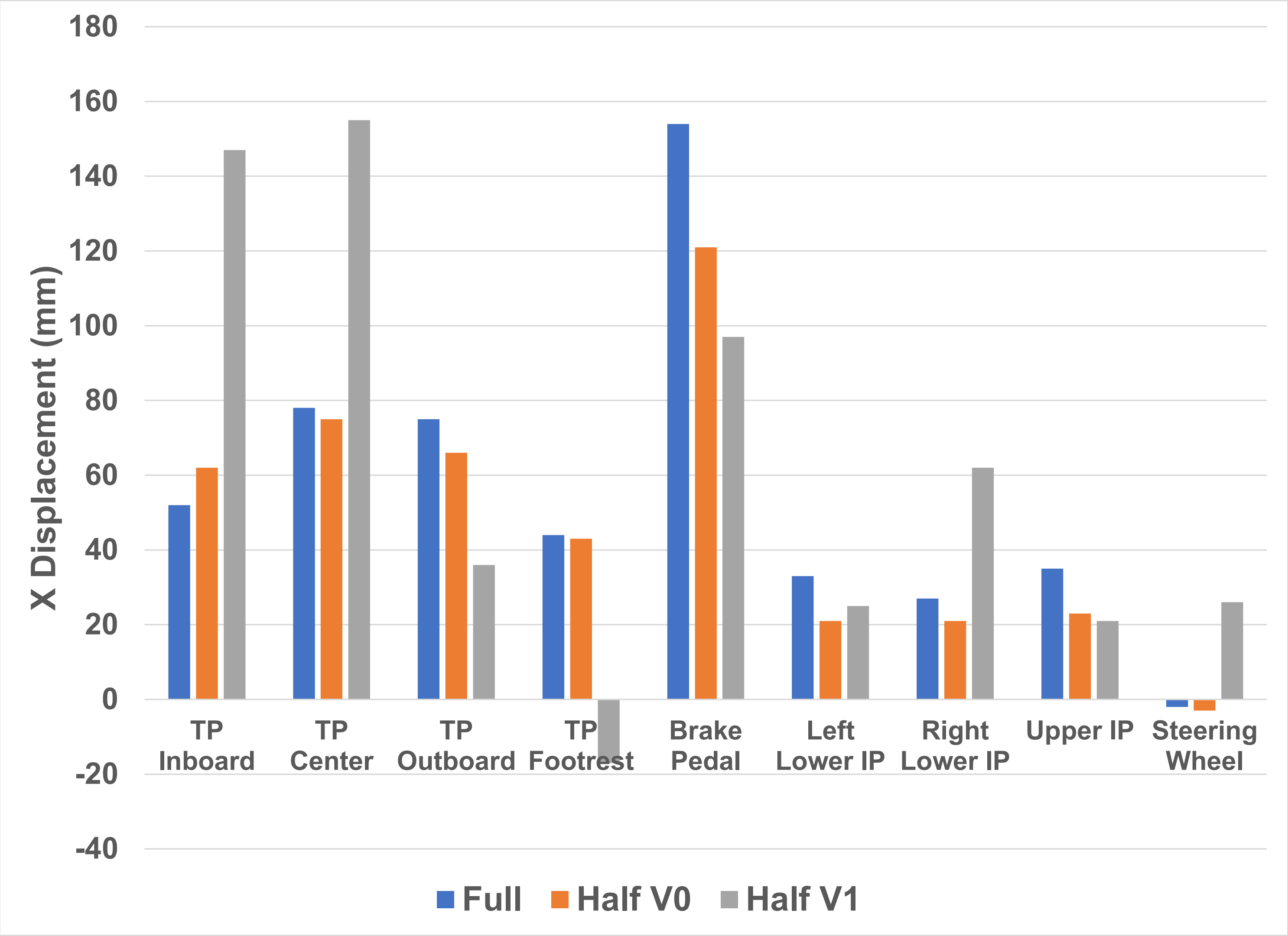
| Type | Max (mm) | Total Distance (mm) |
|---|---|---|
| Translation | 24 | 550 |
| Adhesive | 103 | 550 |
| Vertical | 5 | 350 |

# Summary Half V1




| | Small | | Large PU | |
|---|---|---|---|---|
| | V0 | V1 | V0 | V1 |
| VehLRaccRes | 0.970 | 0.920 | 0.800 | 0.702 |
| VehLRvelRes | 1.000 | 0.998 | 0.990 | 0.993 |
| VehRRaccRes | 0.970 | 0.912 | 0.860 | 0.915 |
| VehRRvelRes | 1.000 | 0.989 | 0.990 | 0.996 |
| VehCGaccRes | 0.980 | 0.831 | 0.830 | 0.818 |
| VehCGvelRes | 1.000 | 0.978 | 0.980 | 0.969 |
| VehCGav | 0.650 | 0.734 | 0.900 | 0.745 |
| VehCGang | 0.810 | 0.923 | 0.990 | 0.681 |
| Average | 0.923 | 0.911 | 0.918 | 0.852 |

# Large PU Interior Intrusions



# Summary

- Energy absorbed by the OMDB in Large PU was lower for Half V1, which caused more interior intrusions
- Barrier still separated
- Half V1 would not be an acceptable replacement to the full barrier

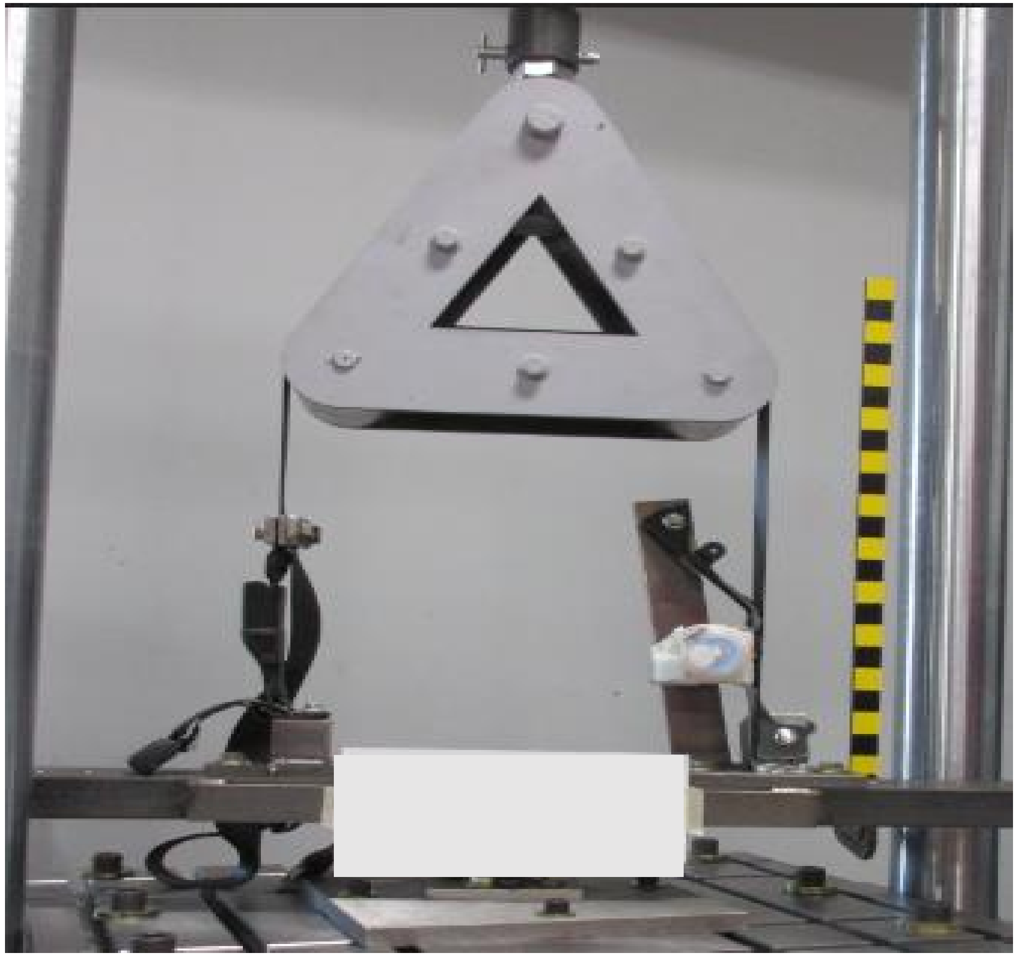
# Possible Next Steps

- Use half V0 as the final honeycomb face for the OMDB test procedure
- Try redesigning the half barrier again to eliminate barrier separation
  - It is unknown how much this barrier separation effects repeatability and reproducibility
- Investigate the use of the current progressive deformable barrier used in the current European regulation
  - Barrier already designed and would harmonize the barrier face

# Comparison of Seat Belt Elongation Requirements

*Kedryn Wietholter*

# Background



§571.209 Standard No. 209; Seat belt assemblies.

Safety-Belts and Restraint Systems Regulation No. 16-05

# Research Objectives

- To understand if there is a relationship between the quasi-static requirements of US regulation and dynamic requirements in European regulation for seat belts. Additionally, to gather injury prediction metrics from ATDs. [1]
- Specific aims:
  - Compare FMVSS No. 209 quasi-static requirements with observed belt loads and elongation results in the sled tests
  - Compare ATD injury metrics, excursions, and kinematics between ATDs (R16 manikin, HIII-50th and THOR-50M) in rear seat environment and to ECE R16 test results

[1] Corinn Pruitt and Kedryn Wietholter. Comparison of Seat Belt Elongation Requirements. (January 2020 SAE Government Industry Meeting).

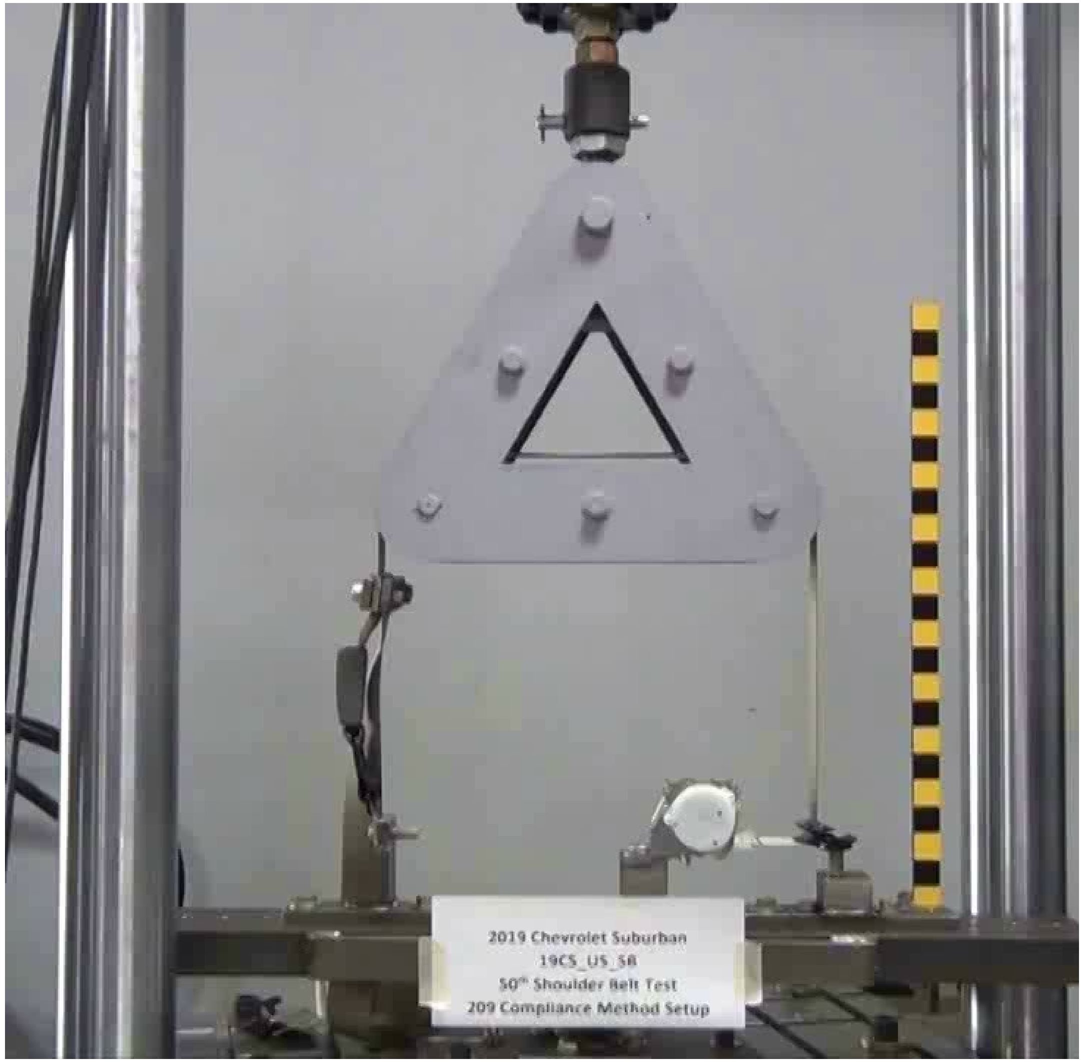
# Research Status

- Completed FMVSS No. 209 tensile tests
  - 9 rear seat belt assemblies: 3 matched pairs (US/EU), 3 for misc. comparisons
- Completed in-use angle tensile tests
  - 3 matched pairs (US/EU)
- Completed ECE R16 sled testing with R16 manikin, HIII-50th, and THOR-50M
  - 3 matched pairs (US/EU)
- Completed rear seat sled testing with R16 manikin and HIII-50th
  - 1 matched pair (US/EU)

# FMVSS No. 209 Tensile Tests

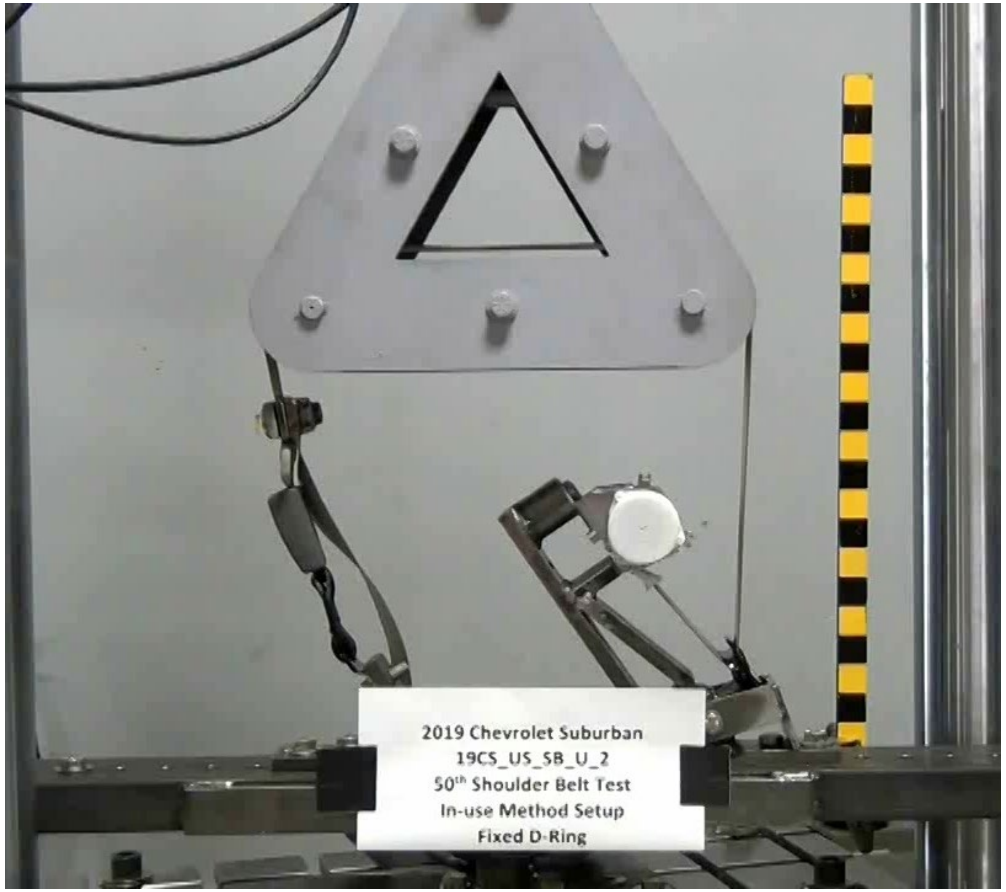
- Completed tensile tests, both lap and shoulder belt set-ups, per FMVSS No. 209 test procedure
  - Mounted hardware at 0 or 90 degree angles

  Test Criteria
  - Lap belt force = 22,241 N
  - Shoulder belt force = 13,345 N
  - Elongation limit of 508 mm
- NHTSA Component Database Nos. 01889 to 01907



# In-use Angle Tensile Tests

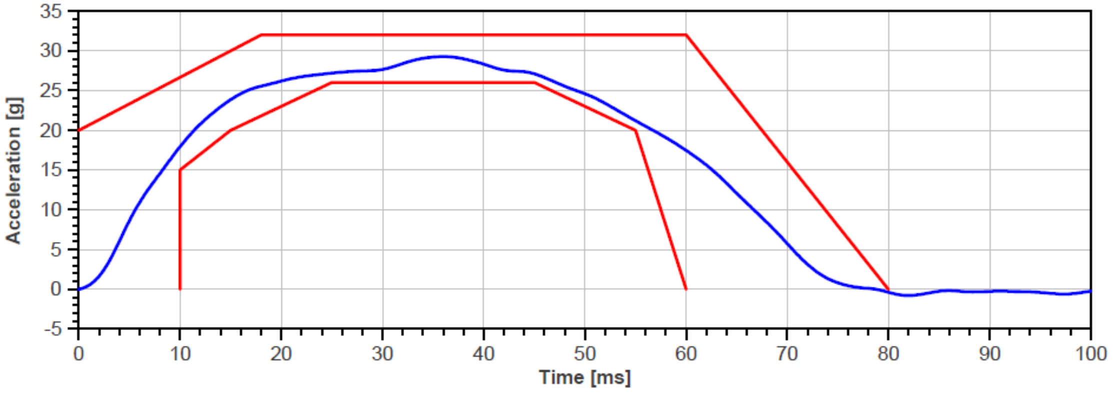
- Completed tensile tests, both lap and shoulder belt set-ups, following a method which mounts the seat belt hardware at in-use angles [2]
  - In-use angles measured and translated for use in tensile test
  - Tensile tests at **50th male** seat belt angles and with measured length of belt on the spool
- NHTSA Component Database Nos. 01980 to 01993



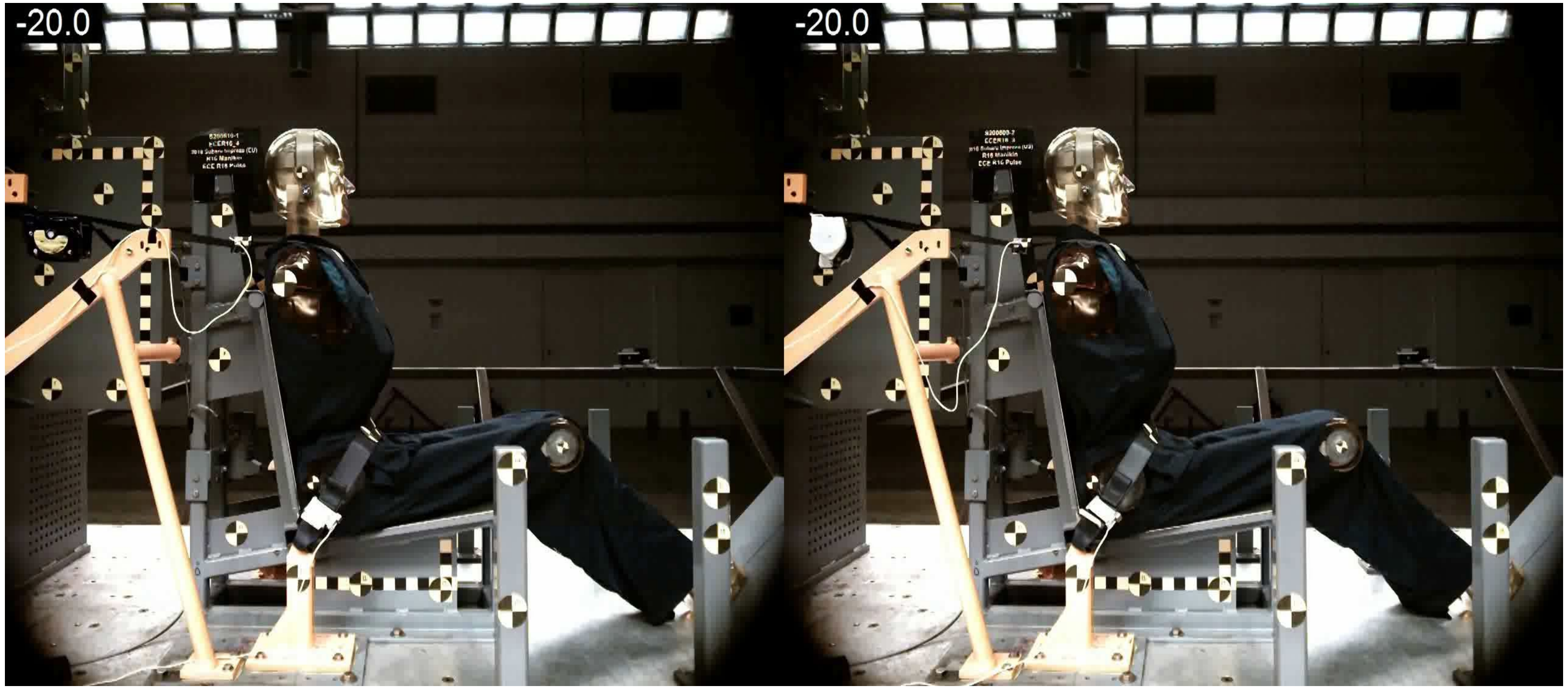

[2] Wietholter, K., & Wetli, A. (2020, June). *Seat belt assembly tensile test procedure development.* (Report No. DOT HS 812 925). National Highway Traffic Safety Administration.

# ECE R16 Sled Testing

- ECE R16 dynamic test
  - Used vehicle specific seat belt mounting locations provided by OEMs
  - Pulse corridor and ΔV = 51 +2/-0 km/h (31.7 +1.2/-0 mph)
- Test criteria
  - No part of assembly or restraint system shall break, and no buckles or locking system shall release
  - Forward displacement of manikin (string potentiometers)
    - Pelvis within 80 – 200 mm
    - Torso within 100 – 300 mm
- NHTSA Vehicle Database Nos. 11246 to 11263

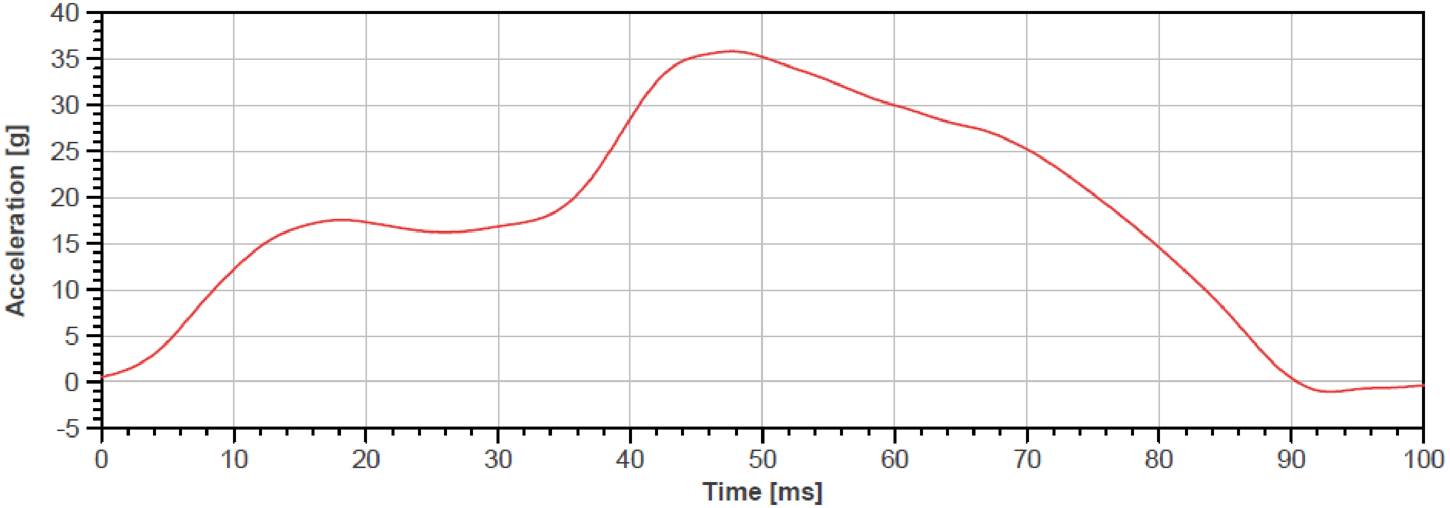


# ECE R16 Sled Testing

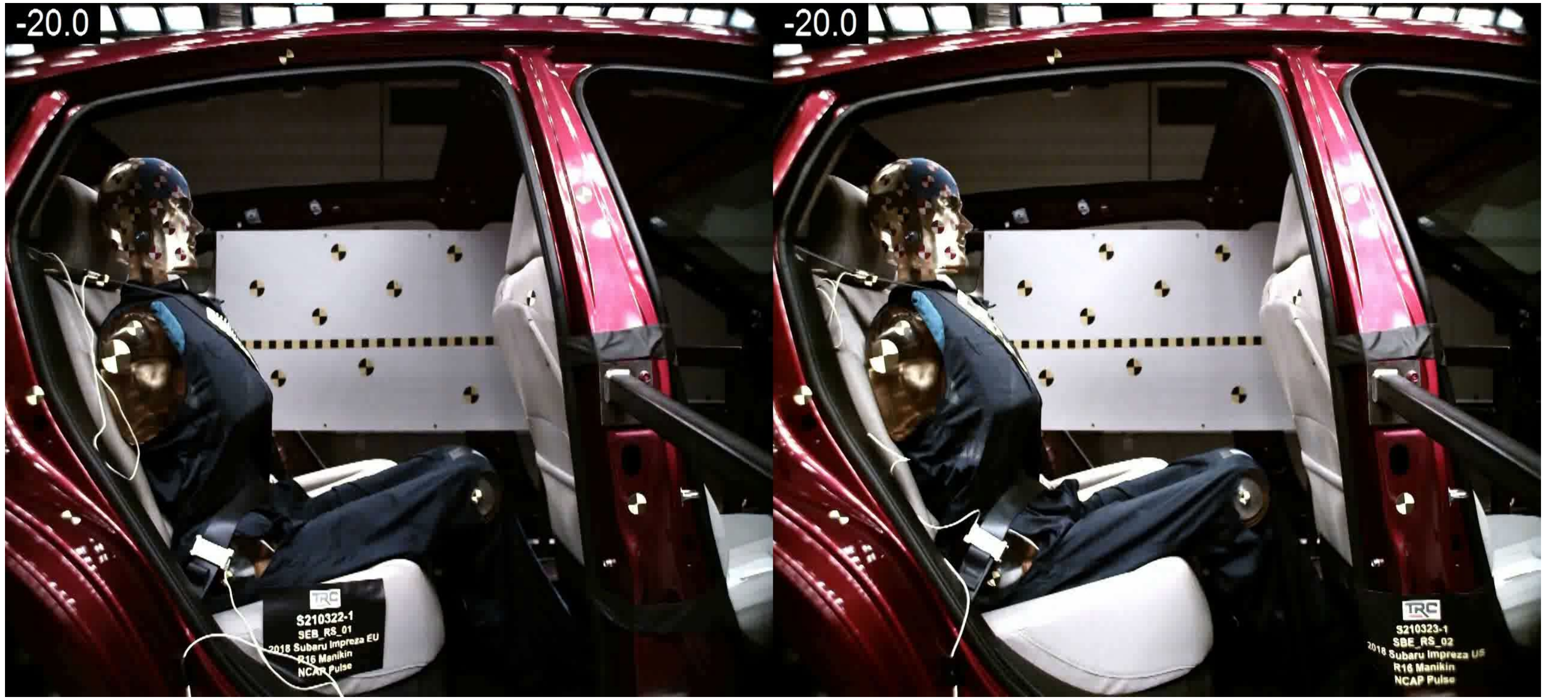


# Rear Seat Sled Testing

- Selected vehicle platform
  - US belt has no LL/PT, EU belt has LL/PT
- Fabricated rear seat sled buck
- Pulse = 35.9 g and velocity = 63.7 km/h (39.6 mph)



# Rear Seat Sled Testing



# Next Steps

- Rear seat sled testing with THOR-50M
- Additional rear seat sled buck fabrication and sled test series with R16 manikin, HIII-50$^{th}$, and THOR-50M

Thank you for your attention.

# Parametric Study of Pre-crash Vehicle Maneuvers and Occupant Safety Performance Response

*Whitney Tatem*

# Parametric Study of Pre-Crash Vehicle Maneuvers and Occupant Safety Performance Response

**Purpose:**

The aim of this research is to use a finite element (FE) human body model to determine how a range of pre-crash occupant kinematics and seat positioning impacts occupant safety performance response.

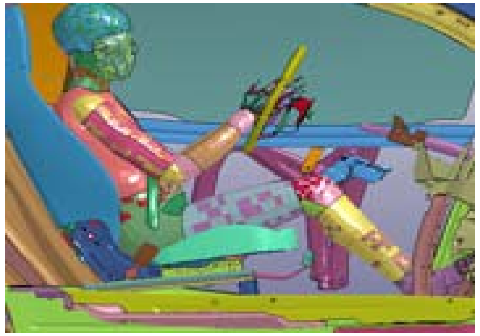
ADAS pre-crash systems (e.g., AEB) + occupant's muscle contraction

→

Occupant's posture, position, and velocity relative to the car interior and restraint systems

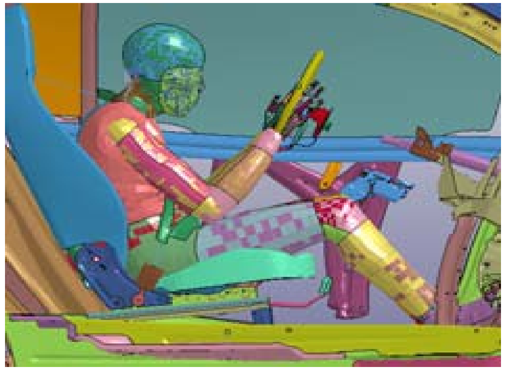
# Technical Approach Overview

***t < t**$_a$* ***(t**$_a$ **~-1500/-2000 ms)***



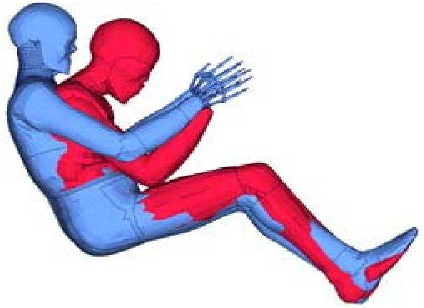
A pre-crash simulation with **Pre-Crash HBM**

***t= 0 ms (crash starts)***



A pre-crash simulation with **In-Crash HBM**

All simulations will be run in the front passenger seat environment of a 2014 Honda Accord model (pictured left).



**End of the crash**

**(*t*$_f$ *~ 150 ms*)**

# Design of Experiments (DOE) for Simulations

*This research will consider a variety of occupant characteristics, seating positions, and pre-crash maneuvers.*

**Design variables**

**Occupant characteristics**

- Age
- BMI
- Stature
- Sex

**12 models**

**Seat Positioning**

- Seat track
- Seat recline angle
- Seat cushion angle

**Seat positions ?**

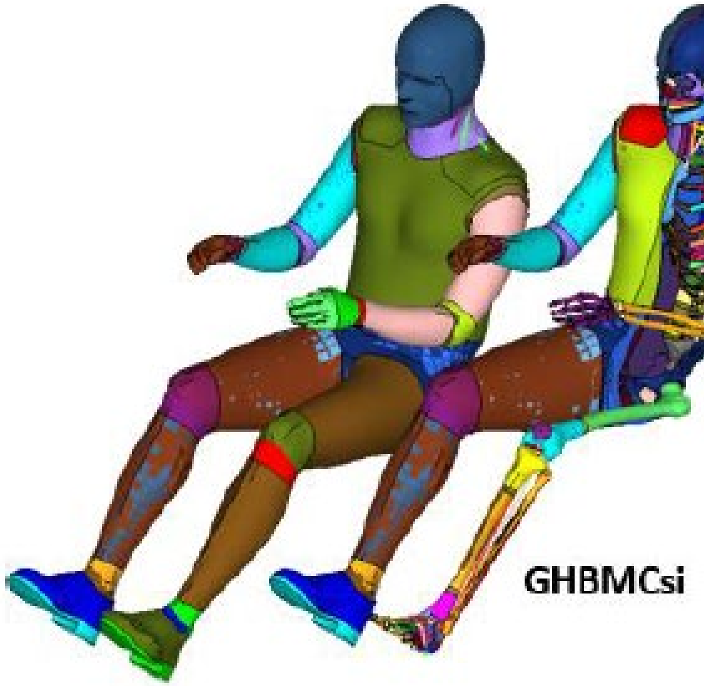
**Pre-crash maneuvers**

- Braking
- Turn-and-brake

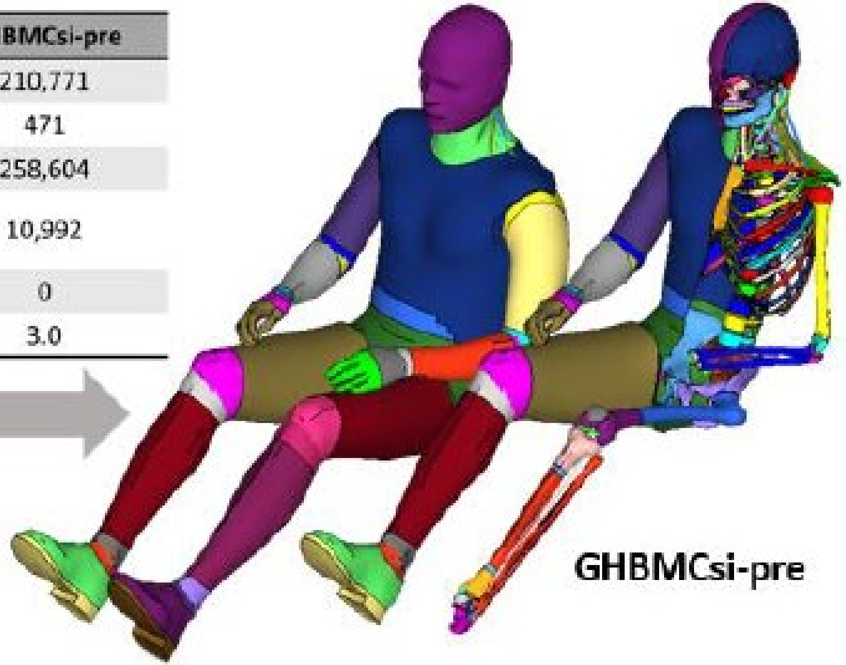
**2 maneuvers**

# Active Human Body Models

*GHBMCsi-pre models developed by UMTRI (Hu et al)*



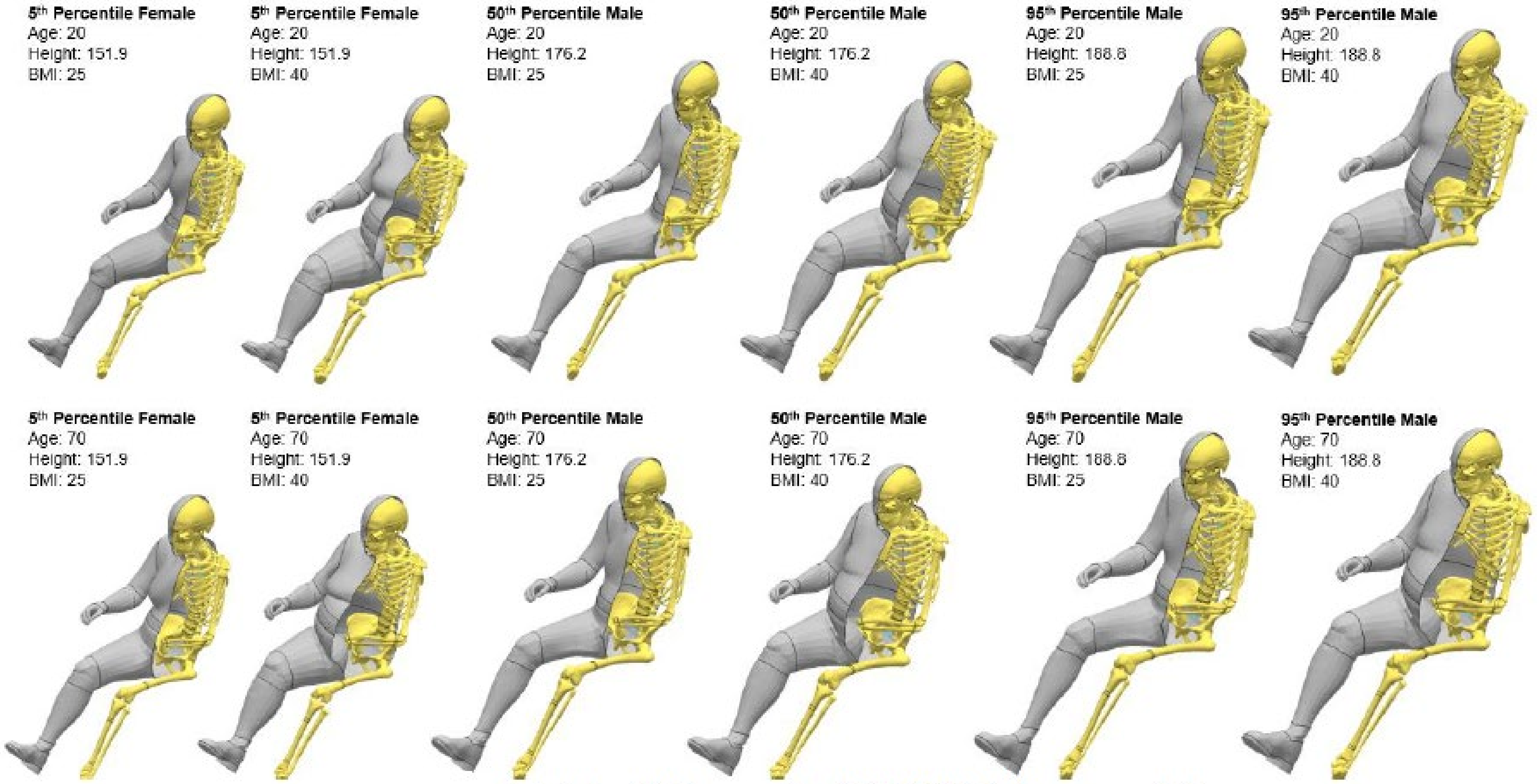

| | GHBMCsi | GHBMCsi-pre |
|---|---|---|
| Active Nodes | 296,324 | 210,771 |
| Active Parts | 544 | 471 |
| Rigid Shell Element | 182,101 | 258,604 |
| Deformable Shell Element | 36,929 | 10,992 |
| Solid Element | 138,202 | 0 |
| Time Step (μs) | 1.0 | 3.0 |




Source: Hu, J., Lin Y., Boyle, K., Reed, M. (2020) *Parametric Model for Simulating Occupant Responses During Pre-Crash Vehicle Maneuvers.* Ann Arbor, MI. University of Michigan Transportation Research Institute.

# Occupant Characteristics

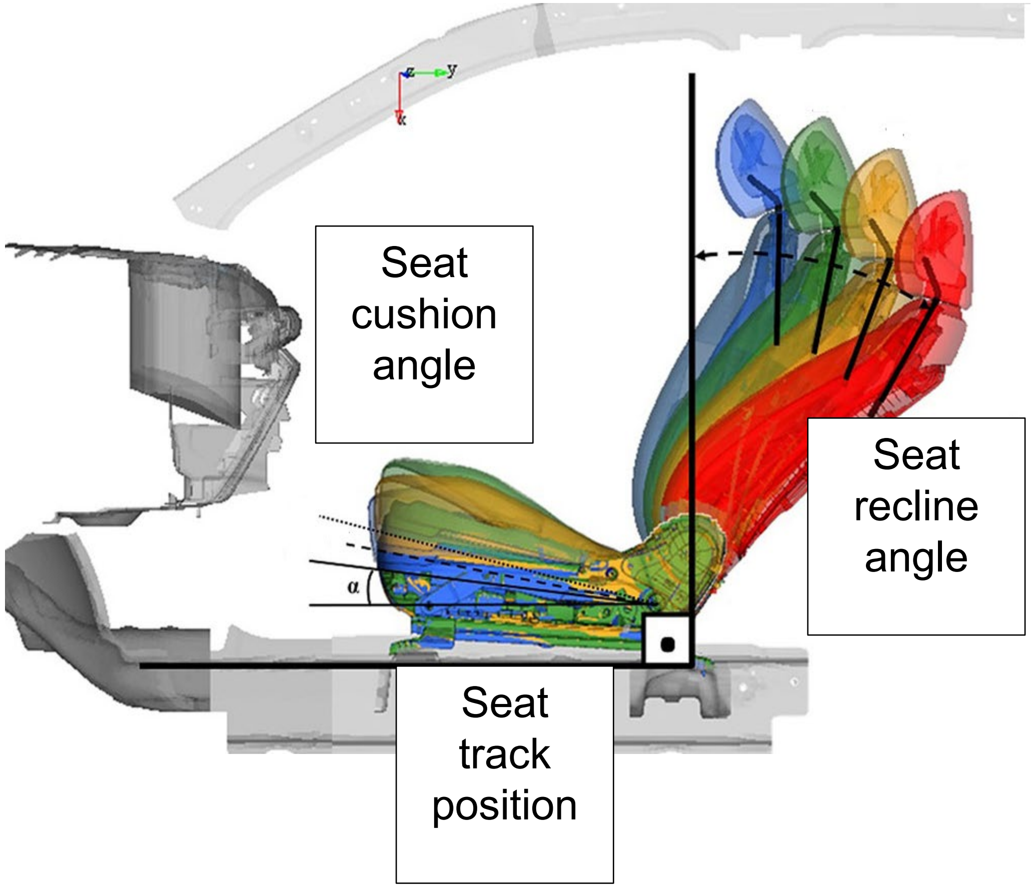
*As part of this research, twelve (12) morphed versions of the GHBMCsi are being developed to match the anthropometries of the GHBMCsi-pre, as shown below.*




A total of 12 morphed GHBMCsi-pre models

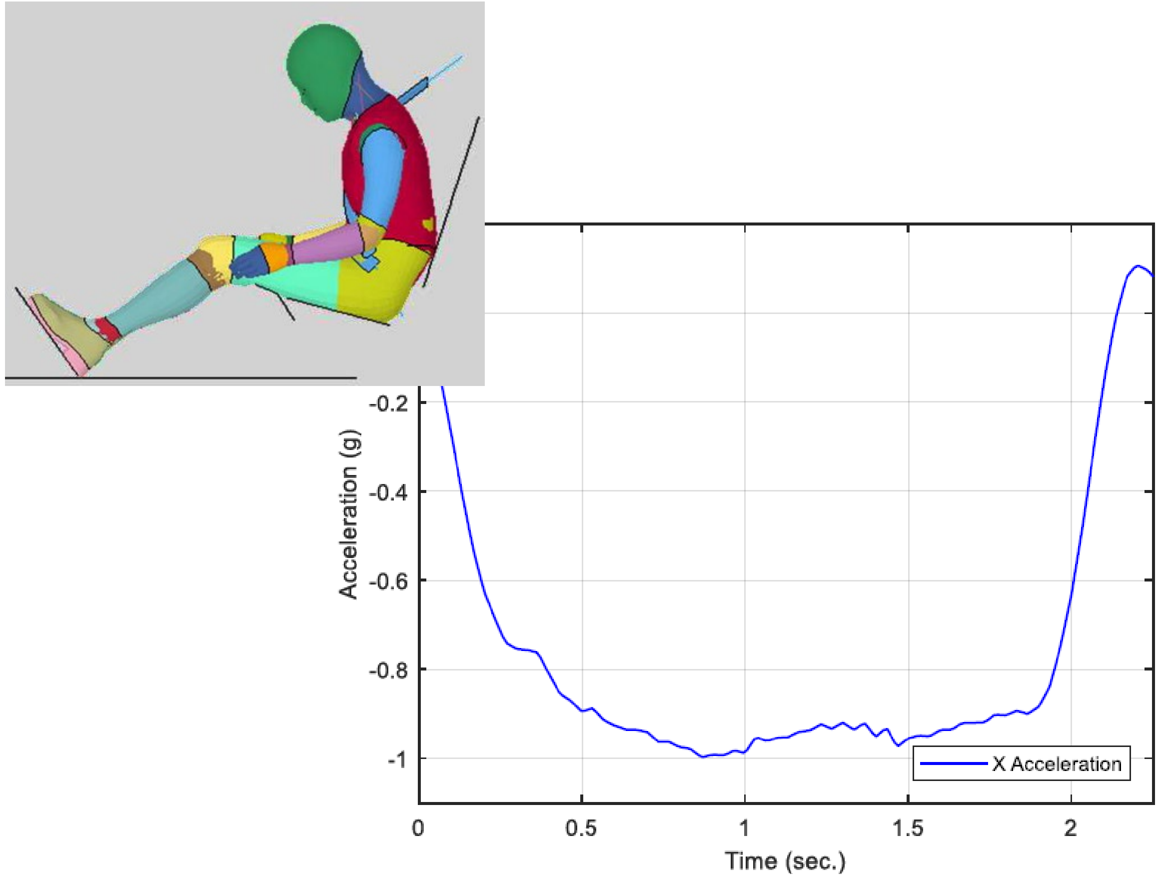
# Seating Parameters

*At a minimum, three seating parameters will be evaluated, as shown below.*

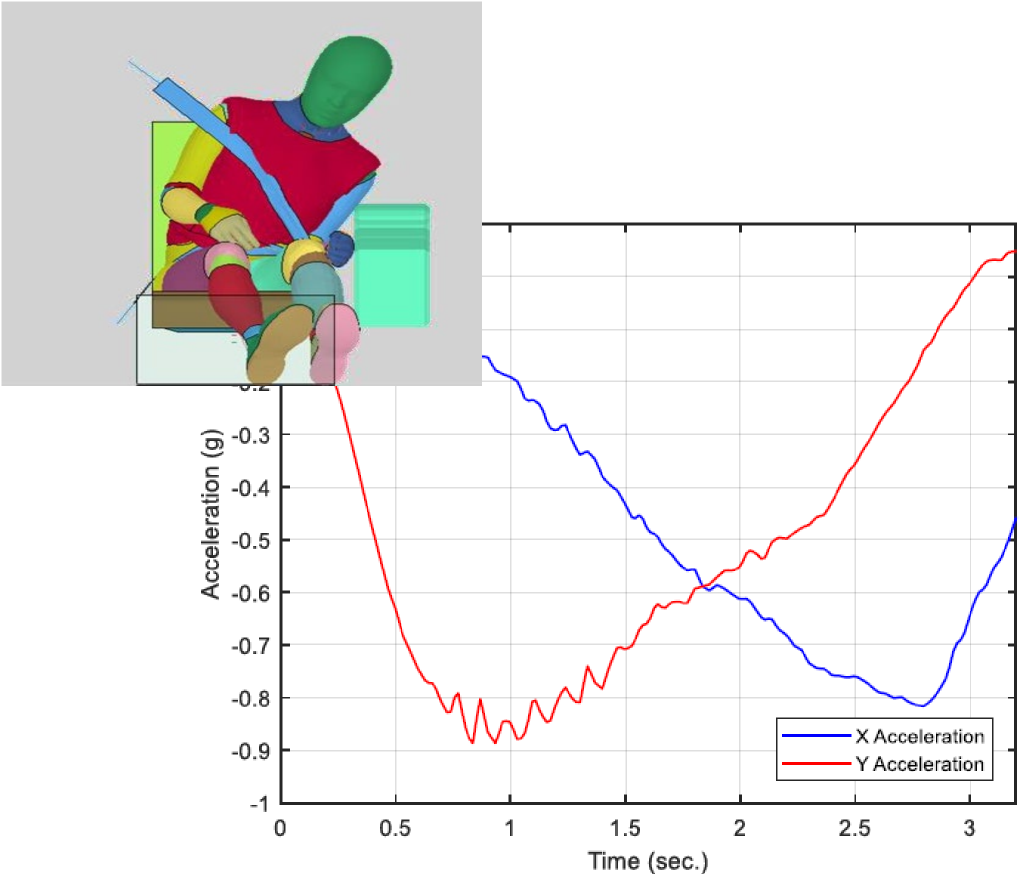


# Pre-Crash Maneuvers

*Two (2) pre-crash maneuvers will be evaluated, as shown below.*




a) Abrupt braking




b) Turn-and-brake

# Goals and Outcomes of This Research

- Develop 12 morphed GHBMCsi models to pair with existing GHBMCsi-pre models

- Evaluate vehicle safety performance via simulation considering:
    - Various pre-crash maneuvers,
    - A range of occupant demographics, and
    - Numerous seating positions.

- Quantify the effect of these parameters on outcomes such as:
    - Occupant kinematics,
    - Restraint engagement, and
    - Injury metrics.

# Testing of Unattended Child Reminder Systems

*Aloke Prasad*

# Background

- A heatstroke can occur when the body temperature exceeds 104 degrees Fahrenheit.
  - This high temperature overwhelms the thermoregulatory mechanism in the human body.
  - Children's thermoregulatory systems are less efficient than an adult's, causing their body temperatures to warm at a rate potentially three to five times faster.
- From 1998 to 2019, there was an average of 39 pediatric vehicular heatstroke (PVH) fatalities per year in the United States.[1]
- In 2019, there were 53 PVH deaths recorded in the United States.
- In 2019, vehicle manufacturers committed to equipping essentially all passenger vehicles with rear designated seating positions and adjacent doors with a rear seat reminder as a standard feature by 2025.[2]

[1] Jan Null - https://www.noheatstroke.org/
[2] Alliance Of Automobile Manufacturers, Inc., & Association of Global Automakers, Inc. (2019, September). *Leading Automakers' Commitment to Implement Rear Seat Reminder Systems*. Heat Stroke Prevention & Safety Tips | Alliance For Automotive Innovation (autosinnovate.org)

# Objective

- To update NHTSA 2015 functional assessment study[3] by testing  new and enhanced aftermarket and in-vehicle (OEM) alert technologies that have since been developed.

[3] DOT HS 812 187 -
https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812187_unattendedchildremindersystems.pdf

# Literature Review and Market Research

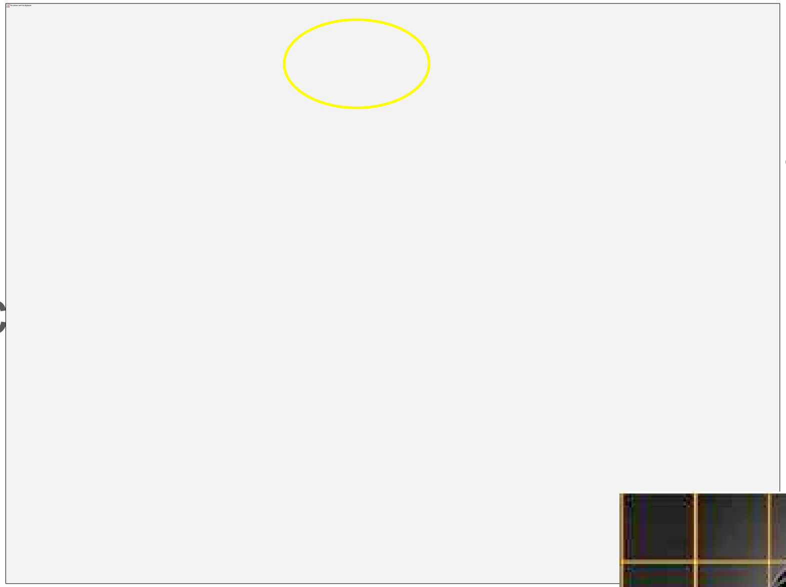
The goal of the literature review and market research was to identify unattended child reminder systems (UCRS) on the market (and available for testing) that were not included in the 2015 Functional Assessment Study Report.

- Vehicle manufacturers
  - Rear Door Logic (Nissan, Chevrolet, and GM)
  - Combination of Rear Door Logic and Ultrasonic Sensor (Hyundai-Kia)
- Identified aftermarket child reminder systems
  - Radar-Based System (Panasonic-Ficosa)
  - GPS Phone Application (Waze Application)
  - Pressure and Seat Belt Sensors (Steelmate Baby Reminder)
  - Temperature Monitor (Elepho eClip)
  - CRS Chest Clip (Evenflo SensorSafe)

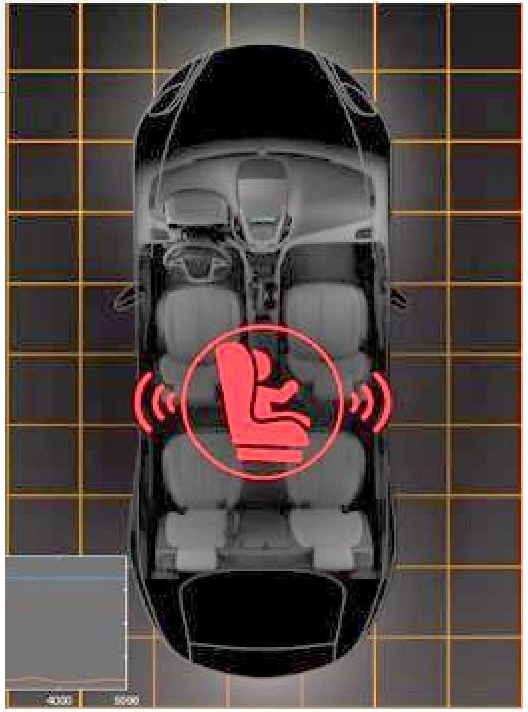
**Using the data from the literature review and market research, 9 UCRS systems representing 7 different UCRS technologies were selected for testing.**

# UCRS Technologies Tested

*Radar-Based System*



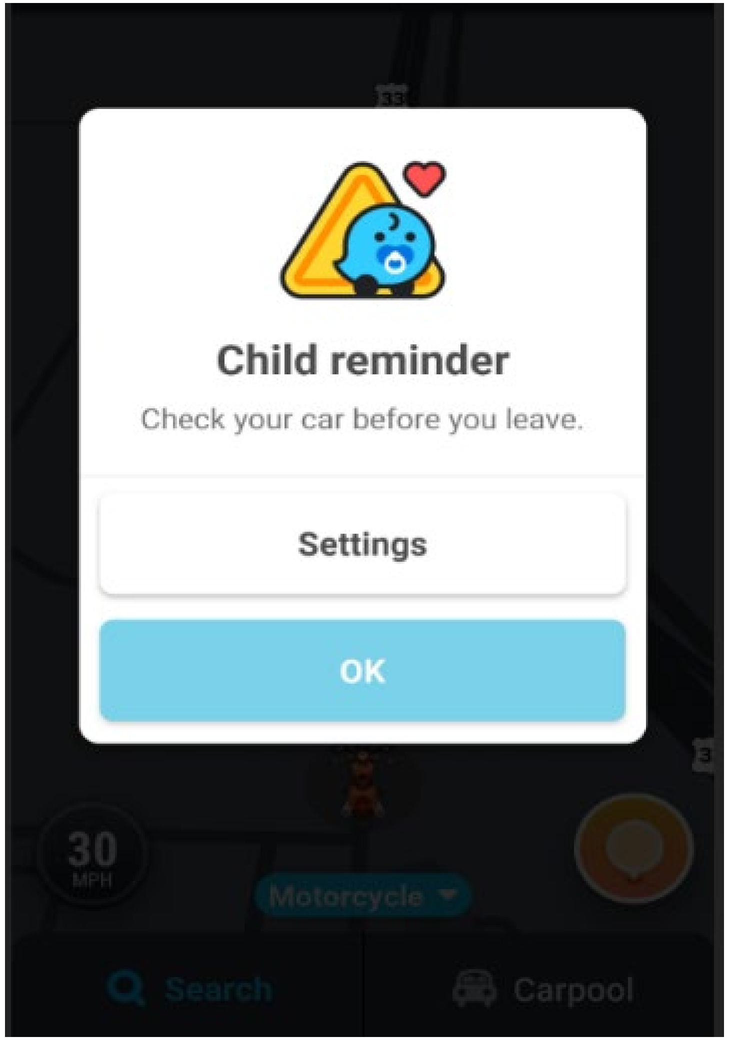
- Uses millimeter wave radar sensor to detec motion, as small as breathing, inside the entire vehicle
- Prototype system currently under development; will vary on alert capabilities and sensor(s) location based on manufacturer
- Consists of one sensor, located above the second row of the vehicle used in this testing
- Alerts the caregiver by both an audio and visual alert when 3 motions are detected



# UCRS Technologies Tested

*GPS Phone Application*

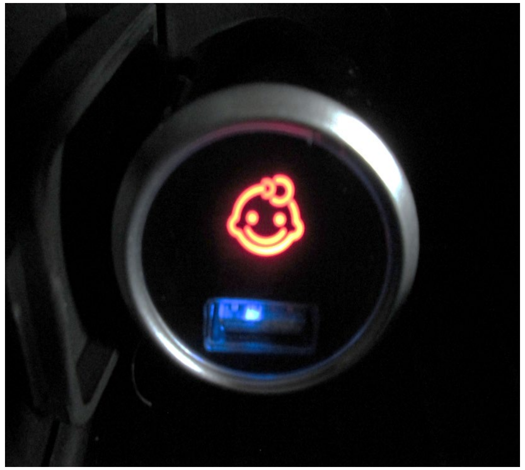
- Smartphone traffic and navigational application that determines how and when you have reached the entered destination
- Must be turned on in the settings of the application of the phone
- Uses a phone screen message to display the alert upon reaching destination



# UCRS Technologies Tested

## *Pressure and Seat Belt Sensors*

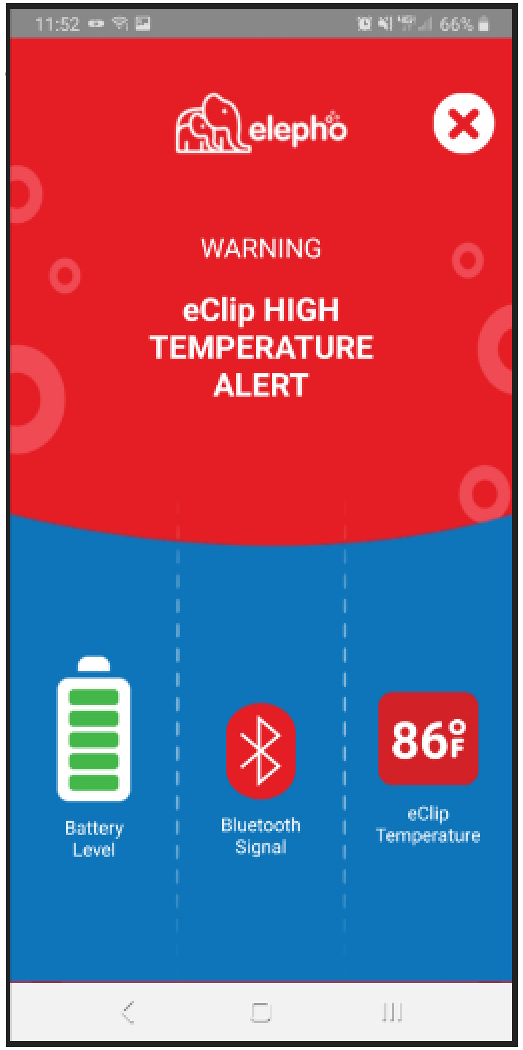
- Consists of three components: a cigarette (CIG) lighter display, a pressure pad disc, and a seat belt detection clip
- Uses radio frequency to communicate from either the seat belt clip or pressure pad to the CIG lighter display. The belt clip and pressure pad signals determine if a child is still detected in the vehicle.
- Alerts the caregiver through an audio alarm and visual alert via the CIG lighter display
    - When there is pressure on the pad, but clip is un-clipped and vehicle is off
    - When there is no pressure on the pad and the belt is clipped and vehicle on

# UCRS Technologies Tested

## *Temperature Monitor*

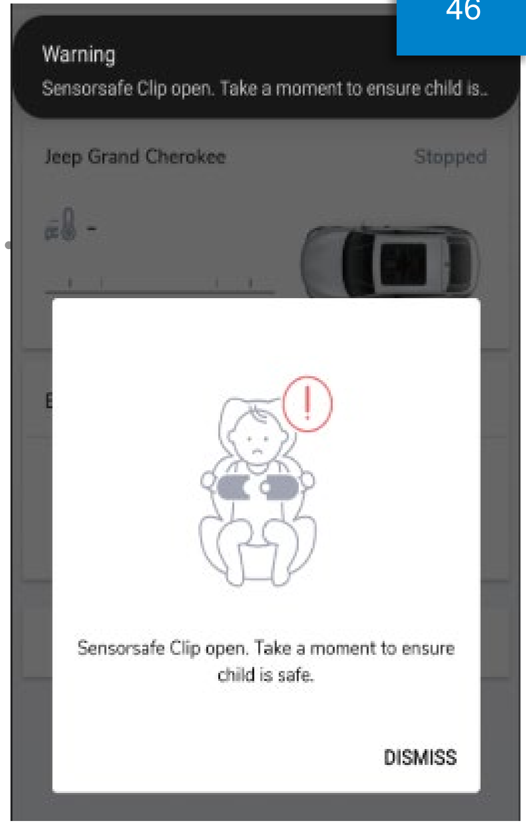
- Consists of a temperature monitoring clip installed on the seatbelt, CRS, or an interior component of the vehicle
- Uses Bluetooth to connect with a smartphone application to report the vehicle's internal temperature
- Once activated, monitors the vehicle's interior temperature every few seconds
- Alerts the caregiver, if within Bluetooth range, by audio alarm and smartphone screen display when the temperature has exceeded the set limit

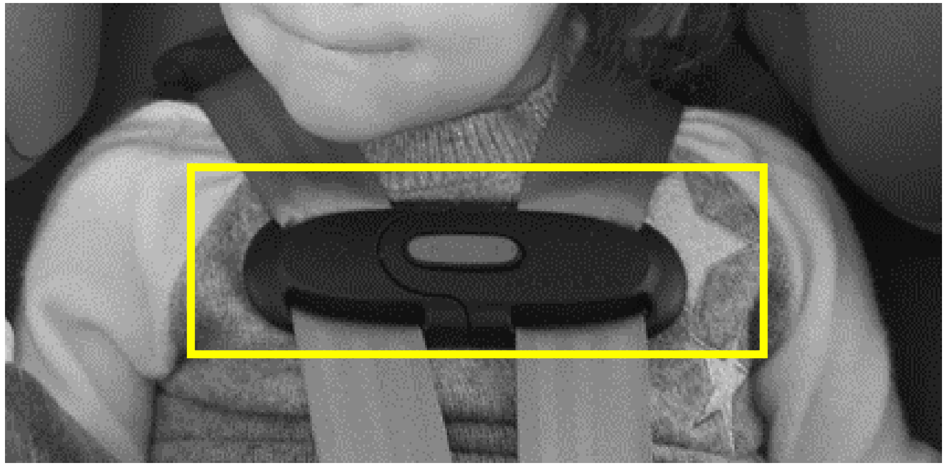



# UCRS Technologies Tested

## *CRS Clip Sensor*

- Consists of 2 components: an on-board diagnostic (OBD) port sensor and a CRS chest clip sensor
- Uses radio frequency to communicate between OBD port and chest clip
- Alerts the caregiver by an audio chime from the OBD receiver and through a phone screen display within the running application
    - When the CRS clip is unbuckled during a drive (above 5 mph)
    - When the CRS clip is buckled and the car is turned off after drive (5 mph or above)
    - When the CRS clip is buckled, the vehicle is turned off after drive (5 mph or above), and the phone is moving away from the CRS clip (if within Bluetooth range of approximately 30 feet)
    - Alerts if the temperature exceeds factory preset temperature

# UCRS Technologies Tested

## *Rear Door Logic*

- Uses detection of a rear door opening within a specified time of the starting of the ignition or a front door opening and shutting

- Alerts the caregiver by a dashboard display message for all vehicle platforms
  - For one vehicle platform, an audio alarm can also be activated to alert the caregiver via the vehicle's horn



# UCRS Technologies Tested

*Combination of Rear Door Logic and Ultrasonic Sensor*

**Rear Door Logic**

- Consists of same arming and alerting mechanism as other rear door logic platforms
  - Uses detection of a front door opening within a specified time of a rear door opening and shutting and starting of the ignition
- Alerts the caregiver by a dashboard display message

**Ultrasonic Sensor**

- After the rear door logic dashboard display has been activated and the doors are shut and locked, the ultrasonic sensor begins to monitor for any movement in the vehicle
  - Monitors for 24 hours
- Alerts the caregiver when movement is detected by sounding the horn for approximately 25 seconds 8 times

# Test Matrices

## Tests for Scenarios as Designed by the UCRS Manufacturer

- Each system's manual includes a description of the situations the UCRS is designed to cover.
- NHTSA tested each UCRS using those situations identified.

## Tests for Potential Real-World Scenarios

- NHTSA Special Crash Investigation (SCI) Review of 2019 PVH fatality cases
  - Identified real-world situations encountered in 2019
- NHTSA tested each UCRS using scenarios from each of the broad categories:
  - Forgotten
  - Caregiver confusion
  - Gained access

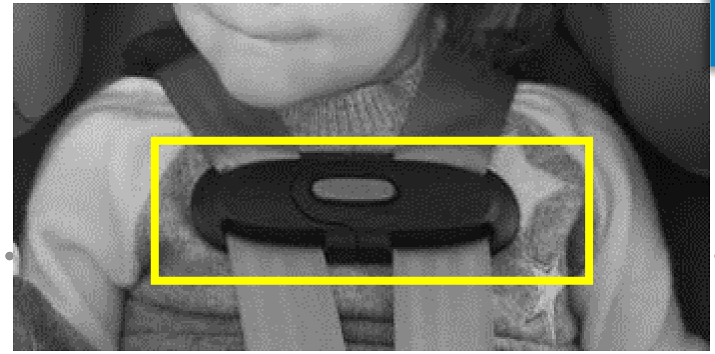
# Observations:

- Each test scenario was repeated three times.
- All the systems worked as designed by the manufacturer to alert the caregiver when a child is left unattended in the vehicle.
- Observations:
  - For all systems using Bluetooth, keeping in range was necessary; poor signal strength at times delayed alerts.
  - CRS Chest Clip: Temperature was also monitored, and an alarm would alert (within Bluetooth range) if reached a preset temperature set by the system.
  - GPS Phone Application: A visual warning would appear on the phone's screen. Alert may not appear if the system did not identify that the destination was reached.
  - Temperature Monitor: Option is available to dismiss the alert or continue to monitor (if within Bluetooth range).
  - Smartphone applications must be running for the alert to occur.
  - Radar-based system could detect small breathing movements in all rows.

# Observations (Continued):

- Ultrasonic sensor could detect arm movements but not small breathing movements.
- All doors must be locked to activate the ultrasonic system sensor.
- Rear door logic systems infer the possibility of an occupant in the rear seat from the sequence of door openings, and as currently implemented, will not provide warnings to the driver in certain scenarios where an occupant may still be in the vehicle at the end of a trip.
- For the rear door logic systems to arm, the rear door needs to be opened and shut within a specified time the ignition is turned on or the front door is opened and closed.
- The vehicle must achieve a 5 mph or higher speed for one of the rear door logic systems and the CRS clip system to start monitoring.
- Countermeasures monitoring only the rear seats may not address situations where the child is in the front seats.

# Summary



## *UCRS Systems Tested*

9 Different UCRS and Technologies

- Rear Door Logic (3)
- Combination Rear Door Logic and Ultrasonic
- Radar-Based System
- GPS Phone Application
- Pressure and Seat Belt Sensors
- Temperature Monitor
- CRS Chest Clip


Systems were tested for situations described in each user manual and for real-world situations.

## ***Conclusion***

- Based on the observations made from this testing, all the systems worked as designed to alert the caregiver when a child is left unattended in the vehicle.
- Some systems were more capable than others in addressing the variety of real-world situations. No single system could address all situations leading to unattended children.
- None of the systems as tested addressed the "gained access" situation.

# Crashworthiness Research - Special Safety Investigations

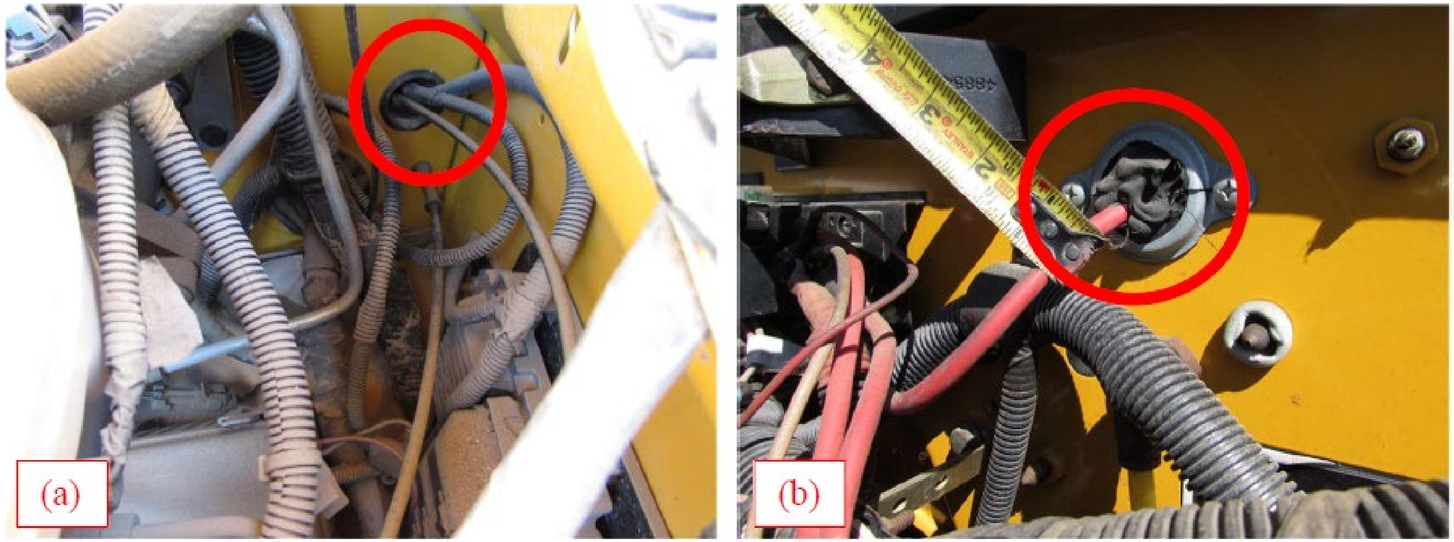
*Peter Martin*

# Special Safety Investigations

1. **School bus firewall assessment**
2. **FMVSS No. 204, Steering control rearward displacement**
3. **FMVSS No. 214, Side impact protection**

# School bus firewall assessment

Safety Concern:  In engine fires, hazardous gases and flames can pass through the firewall into the passenger compartment.




*Open firewall penetration with grommet (a) and sealed penetration (b)*

**Research objective**:  Assess school bus firewall designs against existing safety benchmarks.

# School bus firewall assessment

Firewall Safety Benchmarks - Typical School bus vs. Motorcoach

| **Desirable attribute** | **School bus** | **Motorcoach** |
|---|---|---|
| Hose and wire openings sealed with fire-resistant gromments | Not in all cases | Yes |
| Firewall coated with thermal insulation | Not insulated | Not insulated |
| Metal ducts with dampers, thermosealed | Plastic HVAC thru firewall | No ducts, only wires and hoses |
| Engine location - isolated | Front | Rear |
| Total no. of firewall protrusions minimal | 34 | 6 |

# School bus firewall assessment

Firewall penetration measurements for school buses

| School Bus Model | Length | Engine Position | Firewall Area (sq in) | No. of Penetrations | Total Penetration Area (sq in) | Total Penetration Fraction (%) |
|---|---|---|---|---|---|---|
| 2021 IC (full) | Full | Front | 1733 | 62 | 127 | 7.4 |
| 2017 Lion 360 | Full | Front | 1244 | 15 | 56 | 4.5 |
| 2004 IC (long) | Full | Front | 1467 | 34 | 155 | 10.6 |
| 2016 Van-Con Type B wheelchair | Medium | Front | 906 | 5 | 56 | 6.2 |
| 2016 Microbird MB-11 | Medium | Front | 756 | 7 | 30 | 4 |
| 2006 IC (short) | Reduced | Front | 1479 | 33 | 110 | 7.5 |

# School bus firewall assessment

Report (in review):

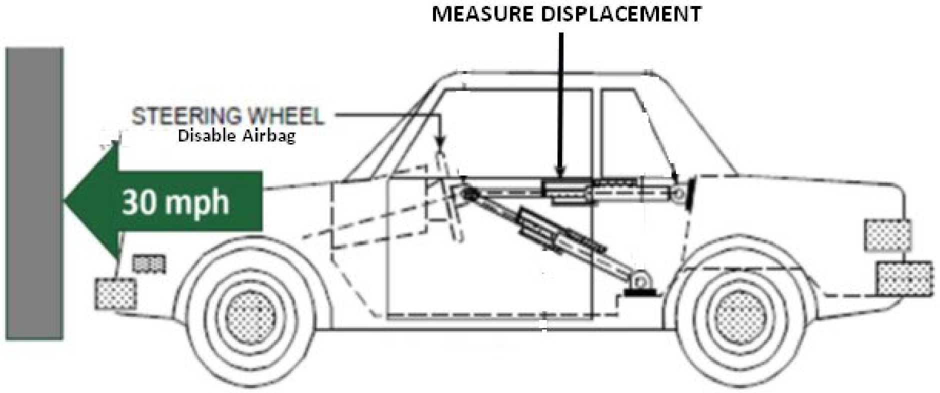
Firewall Design in Buses to Mitigate the Propagation of Engine Fires, DOT Report No. HS xxx xxx, [date].

[Report no. and date will be assigned upon publication in NTL.]

# FMVSS No. 204, Steering control rearward displacement

**FMVSS 204**

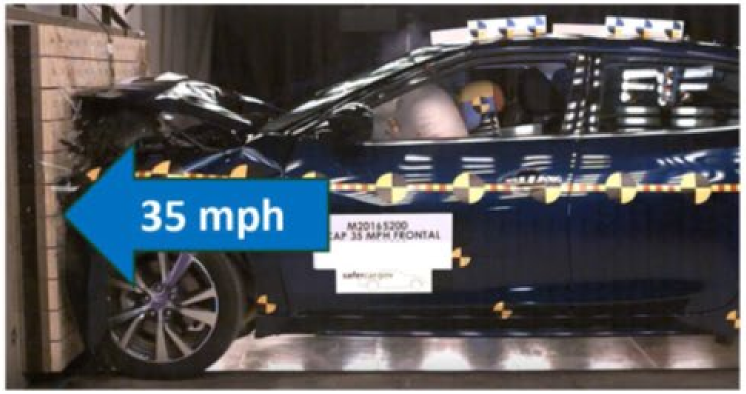
No occupants / No airbags




127 mm limit on rearward displacement of steering column.

**FMVSS 208**

With occupants / With airbags




PASS/FAIL limits based on ATD measurements.

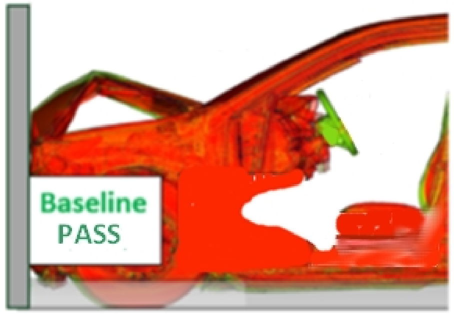
**Research objectives:**

1. Assess whether steering column displacement in FMVSS No. 208 tests can be used as indicants for FMVSS No. 204 displacement.
2. Devise a way to measure dynamic steering column motion in an FMVSS No. 208 frontal rigid-barrier test.

# FMVSS No. 204, Steering control rearward displacement

| Actual FMVSS No. 204 (ref 127 mm) | FMVSS No. 208 (inc. dummy, airbag) | Predicted FMVSS No. 204 (from 208 data) |
|---|---|---|

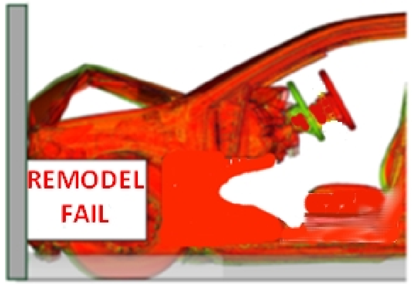
**Baseline: 9 mm**




| Impact Velocity | SW Column (mm) | HIC15 (ref 700) | Chest Defl, mm (ref 63 mm) |
|---|---|---|---|
| 30 mph | -83 | 189 | 29 |
| 35 mph | -65 | 325 | 33 |

**3 mm**

**Worst case: 143 mm**

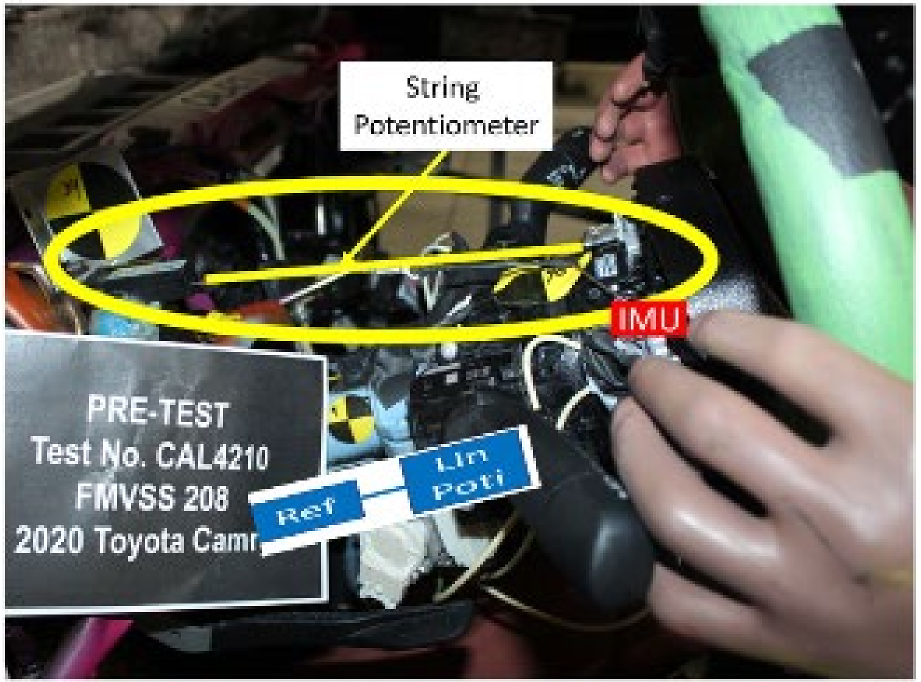


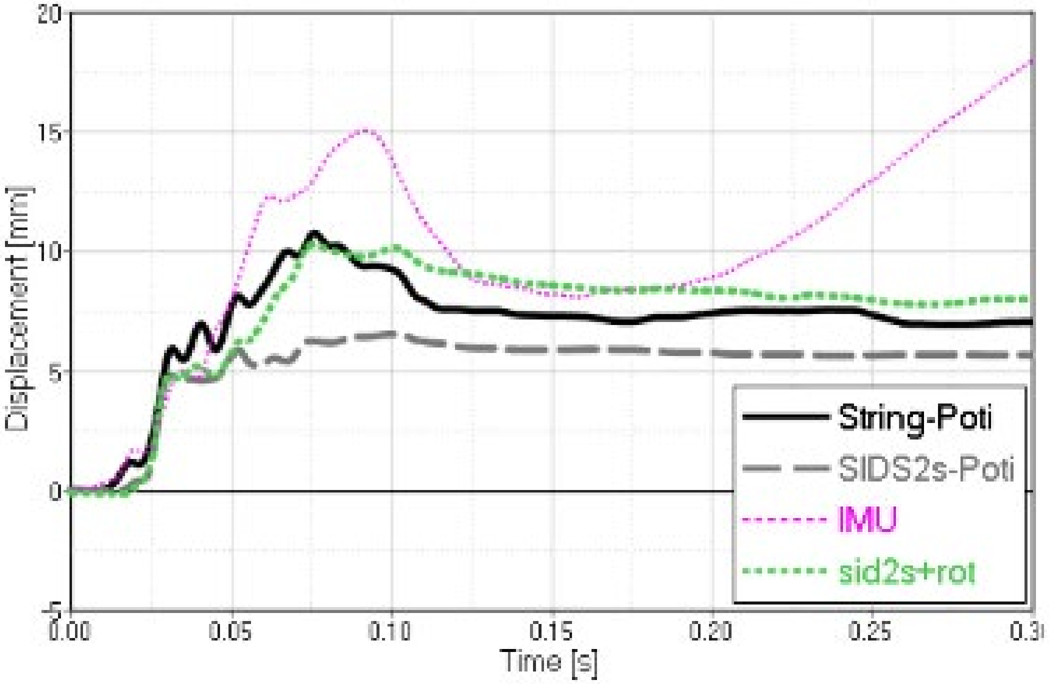

| Impact Velocity | SW Column (mm) | HIC15 (ref 700) | Chest Defl, mm (ref 63 mm) |
|---|---|---|---|
| 30 mph | 116 | 371 | 79 |
| 35 mph | 167 | 516 | 83 |

**153 mm**

# FMVSS No. 204, Steering control rearward displacement

## Measuring Steering Hub Displacement in an FMVSS No. 208 test



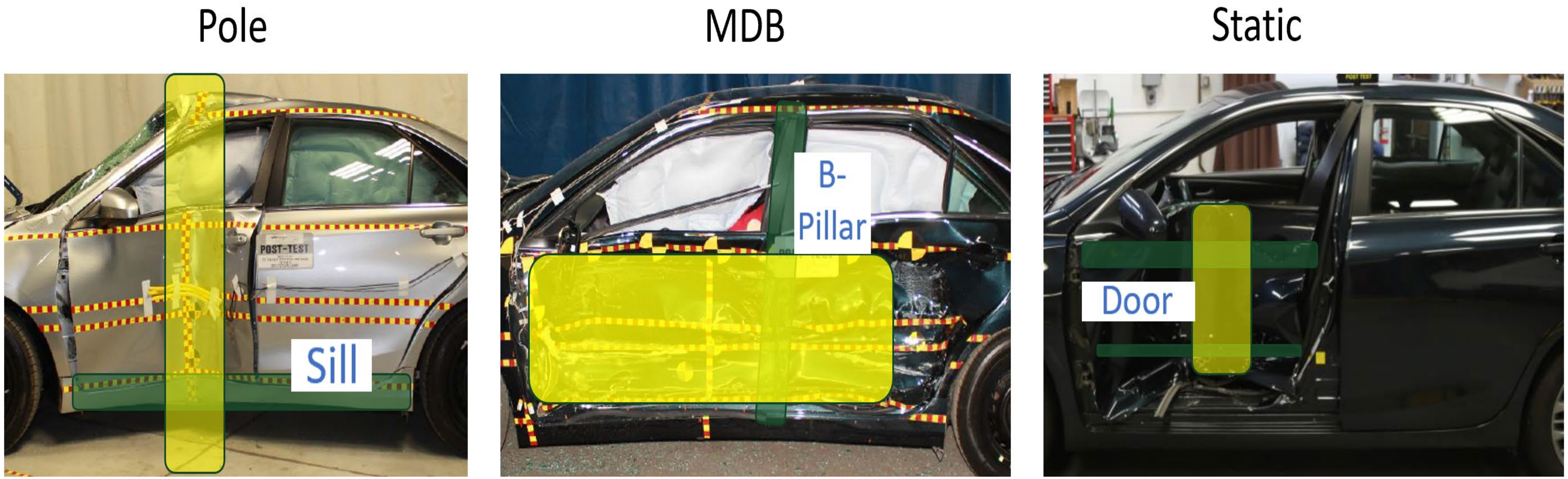
# FMVSS No. 204, Steering control rearward displacement

Report (published):

Measuring Steering Column Motion in Frontal Rigid-Barrier Test, DOT Report No. HS 813 094, July 1, 2021.

https://rosap.ntl.bts.gov/view/dot/56576

# FMVSS No. 214, Side impact protection

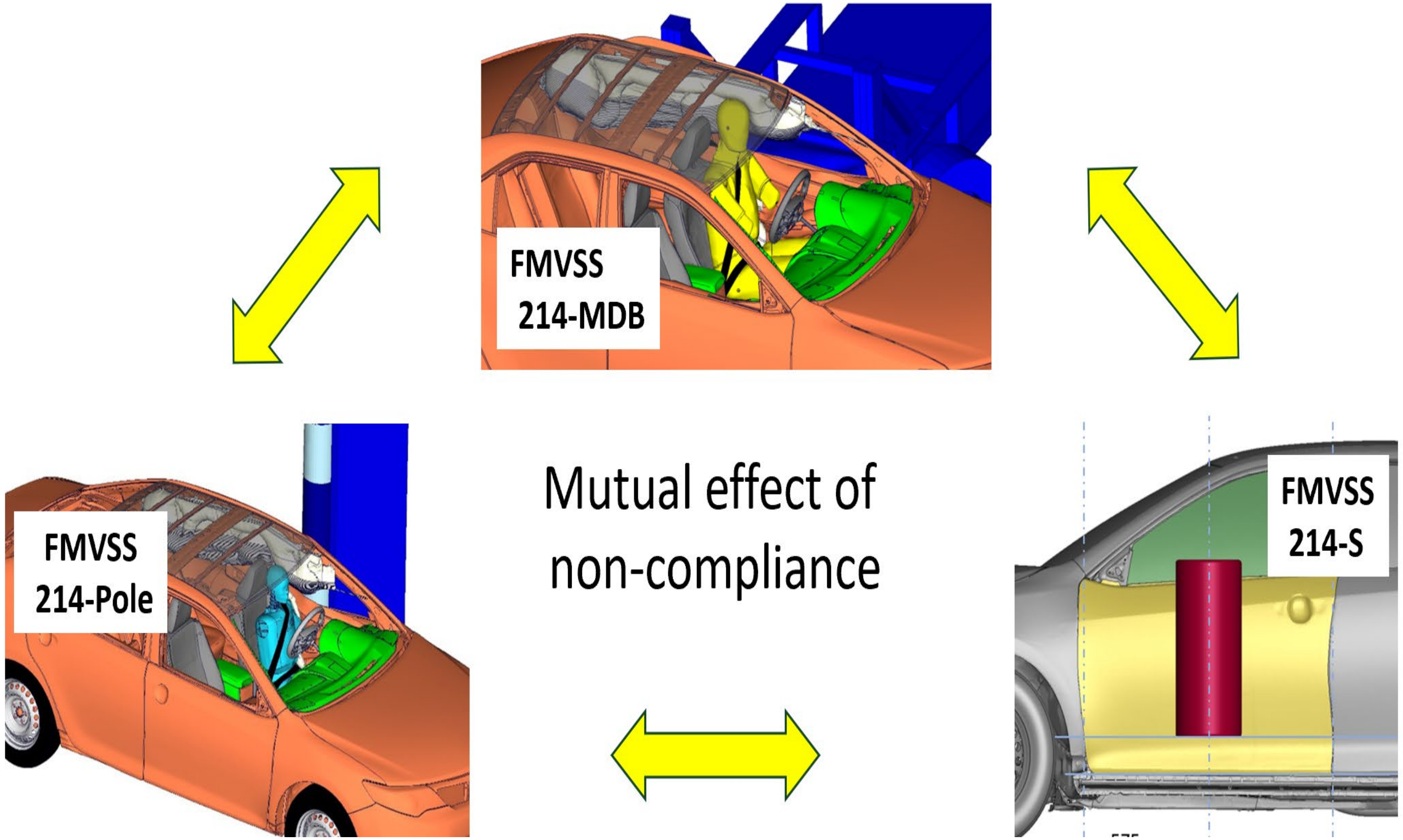



Main Load Paths during FMVSS No 214 (a) Pole; (b) MDB; and (c) Static Door Crush

**Research objective**: Investigate use of a dynamic performance measurement as a surrogate for the static test.

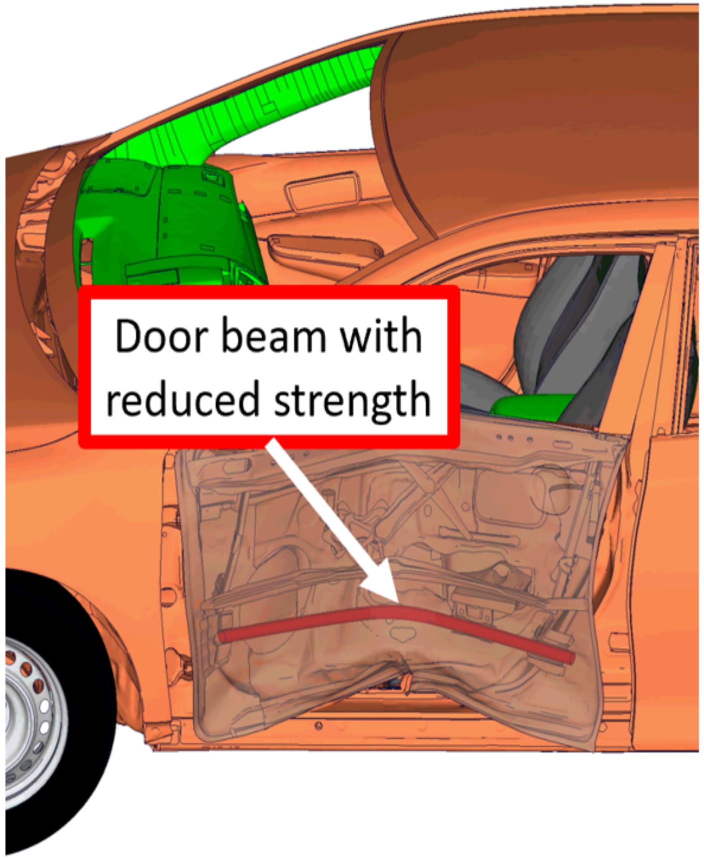
# FMVSS No. 214, Side impact protection

Process to study Effect of Mutual Non-Compliance



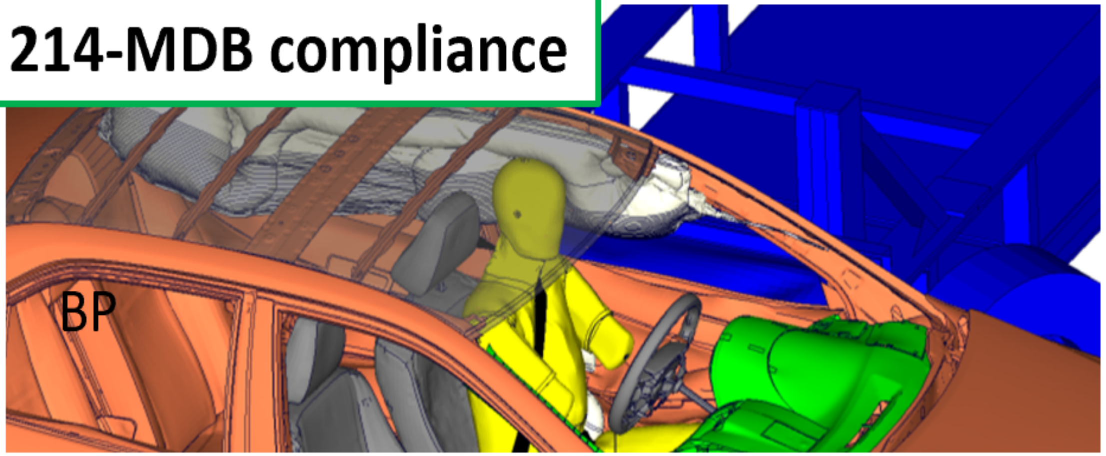
# FMVSS No. 214, Side impact protection

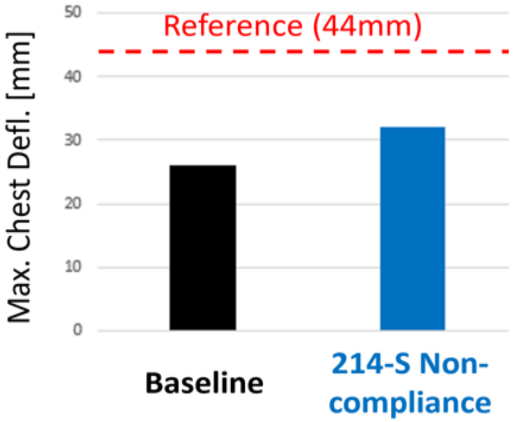
**214-S non-compliance**




resulted in

**214-MDB compliance**




| | Velocity [m/s] | |
|---|---|---|
| | B-Pillar | Door |
| Baseline | 8.5 | 10.1 |
| 214-S non-compliance | 8.8 | 10.2 |

# FMVSS No. 214, Side impact protection

Report (in review):

Crash Simulation of FMVSS No. 214 Safety Performance, DOT Report No. HS xxx xxx, [date].

[Report no. and date will be assigned upon publication in NTL.]

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Computational model:

2020 Nissan Rogue FE model. Download from George Mason University website: https://www.ccsa.gmu.edu/models/

# Thank you for your time and attention


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