NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

# Automated Driving Systems Research

# Overview of Automated Driving System Research

- Support Updating and Modernizing Regulations
  (removing assumption of a driver from current regs)
- System Safety Performance
  (tests, test methods, safety performance metrics)
- Human Factors
  (signaling, telltales, disabled user needs)
- Occupant Protection
  (alternative cabin configurations)
- Functional Safety, ADS Subsystems, Cybersecurity
  (covered in previous session)

## 1 Support Updating and Modernizing Regulations

- FMVSS Considerations for Vehicles with ADS

## 2 System Safety Performance

- Test Methodology for Test Track Testing
- Development of Simulation Methods
- Testing & Evaluation of Low Speed L4 Shuttles
- Research on Candidate ADS Performance Measures
- ADS Safety Assessment Metrics
- ADS Testable Cases & Scenarios
- On-Road Assessment Methods

## 3 Human Factors

- Vulnerable and Disabled Road Users Research

## 4 Occupant Protection – Alternative Cabin Configurations

- Rear-facing Occupant Kinematics
- Forward-facing Reclined Seating
- Rear seat safety for ADS occupants

# FMVSS Considerations for Vehicles with ADS

*Ellen Lee*

# FMVSS Considerations for Vehicles with ADS

- Identify unnecessary/unintended regulatory barriers to self-certification and compliance verification of innovative vehicle designs with Automated Driving Systems (ADS)
- Provide technical translation options of FMVSS and related compliance test procedures for ADS-equipped vehicles
- Focus is on ADS-Dedicated Vehicles (ADS-DVs) that lack manually operated driving controls (e.g. steering wheel, brake pedal)

# FMVSS Considerations for Vehicles with ADS

- Phase 1 FMVSS of focus

| Crash Avoidance | | | Crashworthiness & Occupant Protection | | |
|---|---|---|---|---|---|
| **101** Controls and displays | **110** Tire selection and rims and motor home/recreation vehicle trailer load carrying capacity information | **124** Accelerator control systems | **201** Occupant protection in interior impact | **206** Door locks and door retention components | **216a** Roof crush resistance |
| **102** Transmission shift position sequence, starter interlock, and transmission braking effect | **111** Rear visibility | **125** Warning devices | **202a** Head restraints | **207** Seating systems | **219** Windshield zone intrusion |
| **103** Windshield defrosting and defogging systems | **113** Hood latch system | **126** Electronic stability control systems for light vehicles | **203** Impact protection for the driver from the steering control system | **208** Occupant crash protection | **222** School bus passenger seating and crash protection |
| **104** Windshield wiping and washing systems | **114** Theft protection and rollaway prevention | **138** Tire pressure monitoring systems | **204** Steering control rearward displacement | **210** Seat belt assembly anchorages | **225** Child restraint anchorage systems |
| **108** Lamps, reflective devices, and associated equipment | **118** Power-operated window, partition, and roof panel systems | **141** Minimum Sound Requirements for Hybrid and Electric Vehicles | **205** Glazing materials | **214** Side impact protection | **226** Ejection Mitigation |

- Detailed evaluation performed on both FMVSS regulatory text and compliance test procedures

- Test Methods: Crash Avoidance
  - Investigate the equipment, methods, and/or procedures to perform compliance testing
  - Evaluate functionalities required to execute compliance test procedures using several potential test methods
- Phase 2 Focus:
  - Technical translations for FMVSS not covered in Phase 1
  - Refinement of crash avoidance test methods
  - Additional research that stemmed from Phase 1

# Test Methodology for Test Track Testing ADS

*Tim Johnson*

# Testing Methodology for Test Track Testing ADS

## Motivation

- Test track work that will simulate multi-vehicle test scenarios (from any direction)
  - E.g. Intersection Crash Avoidance

- Test infrastructure and scalable actors (targets) necessary to stress an ADS
  - Varying complexity
  - Density (multi-vehicle)
  - Specialized instrumentation

- ADS system performance research considers tests inclusive of track and simulation assessments
  - Practical, minimum
  - Complex variable or randomized methods

# Guided Soft Targets

- 2 ABD low profile robotic platforms
- 1 DRI robotic platform (with heavy vehicle capacity)
- 2 Global Vehicle Targets (GVT rev f)
- Multiple misc. soft cars




# Throttle/Brake/Steering Controllers

- 4 complete ABD "drop-in" systems
- 2 combined Brake and Accelerator Robots (CBAR)
- 2 steering robots

# Soft Pedestrian System

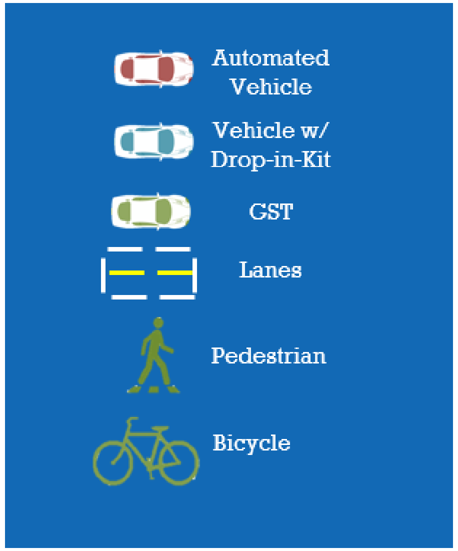
- System consists of:
  - ABD (SR60-based steering robot)
  - Support vehicle retrofitted with steering robot controlle
  - Multiple 4a mannequins
  - 4a bicycle and rider

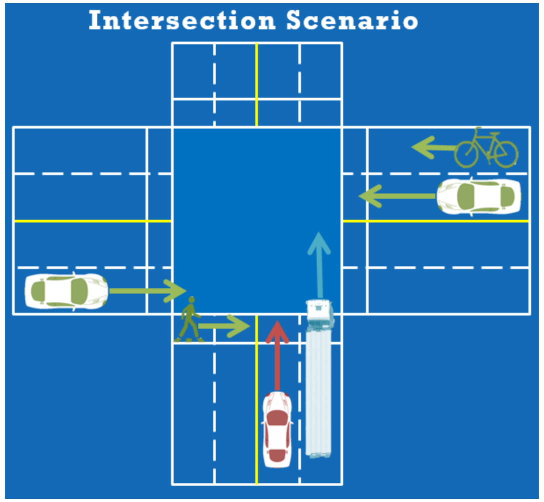




# Multi-Actor Testing and Support

- 2 support vehicles retrofitted with base station hardware
- Current software supports choreography of up to 5 actors
- Real-time data telemetry
- Remote control for manual driving
- Safety (system override)





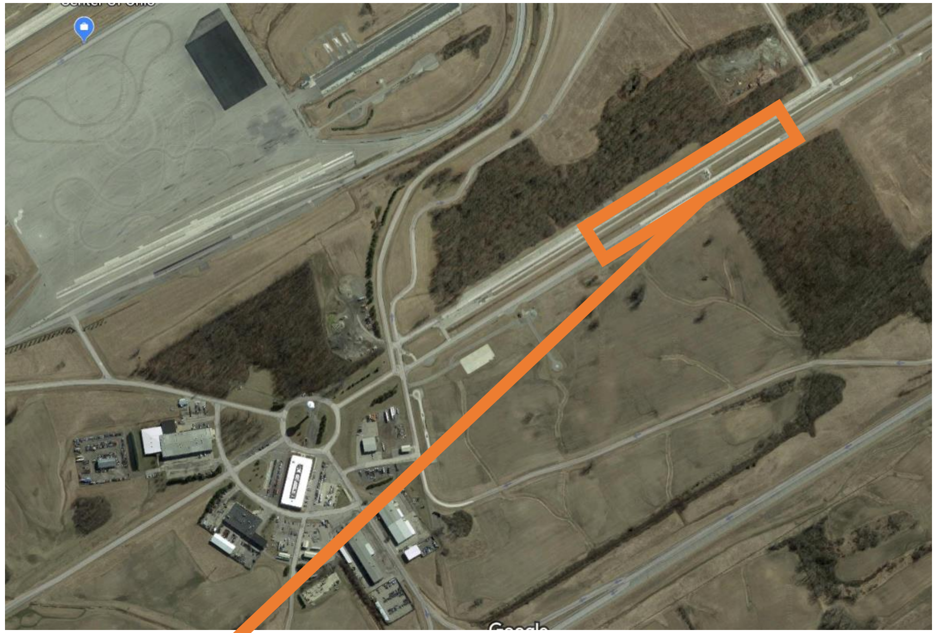
# Multi Actor Example

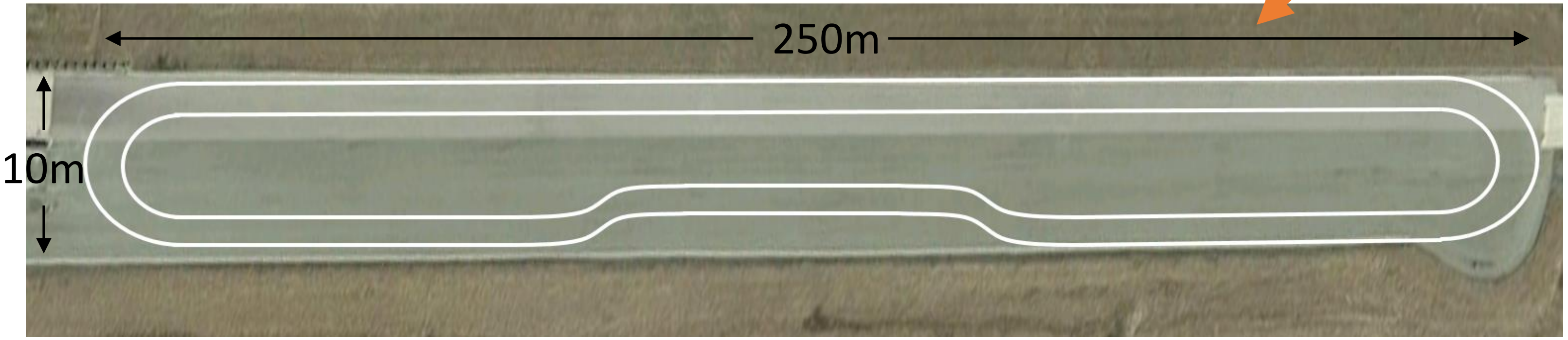
# ADS Testing and Evaluation of Low Speed L4 Shuttles

*Tim Johnson*

# ADS Testing and Evaluation of Low Speed L4 Shuttles

- Testing two Low Speed Automated Driving Shuttles (LSADS)
  - Navya
  - Ridecell
    - Based on Dataspeed Vehicle (Ford Fusion)
- Shuttles are operating in SAE Level 4
  - Run on pre-defined path
  - 12 mph or less





# Objectives

- Understand how to test low speed L4 vehicles.
  - Understand current state of the art performance
  - Understand limitations of the tests
- Perform ADAS tests
  - AEB, PAEB, BSI, etc.
  - Recognize areas needed to perform additional research for testing.
- Systems Testing
  - Low speed challenges
  - Sensor Failure
    - Blocking a laser, blocking a RADAR, etc.
  - General performance when localization degrades
  - Operation Robustness (how many bugs, glitches, problems do we find over time)

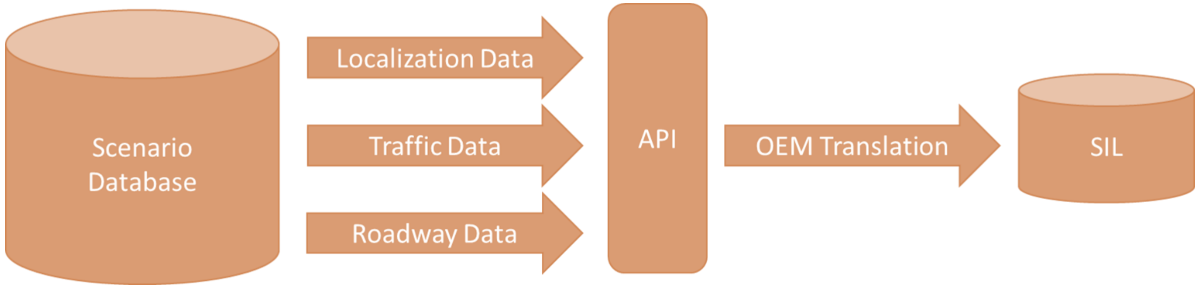
# Test Examples

# Development of Simulation Methods

*Tim Johnson*

# Development of Simulation Methodologies

- Background
  - Objective methods and a open simulation framework could benefit the process of validating performance of Automated Driving Systems in scenarios encountered in the United States
- Motivation and Project Focus
  - Such a framework could enable scenario exchanges among stakeholders and facilitate more rapid development of a knowledge base around safety relevant scenarios
  - Performing research on elements needed to describe a driving scenario in a simulation environment and open file formats
    - Drafting a paper that covers scenario elements to describe 5 sample scenarios



# Simulation Example

# Automated Driving System Metrics

*Tim Johnson*

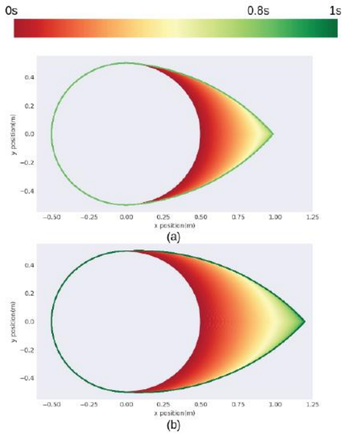
*Alrik Svenson*

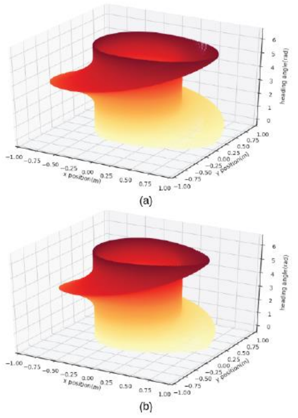
# Automated Driving Systems Safety Assessment Metrics

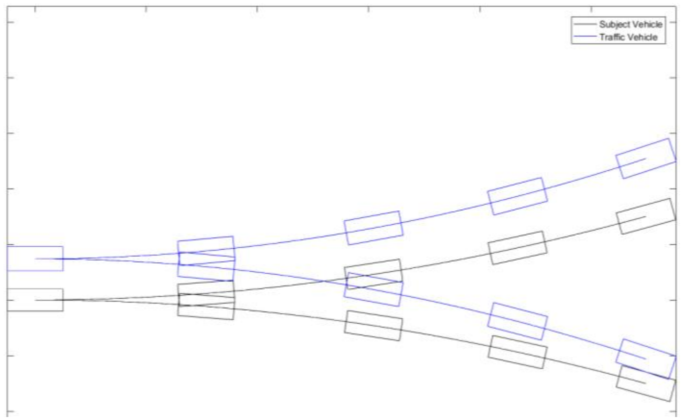
- Background
  - Innovative driving  performance assessment models have been proposed by industry  that could potentially serve a role in understanding the safety performance of an ADS equipped vehicles
  - Various “leading indicators” of safety performance have also been studied.
- Approach
  - Review candidate safety assessment models
  - Synthesize and review potential leading indicators of safe driving behavior.
  - Catalogue data needs and sources used for assessing safety
  - Assess strengths and weaknesses of identified approaches through both analysis and stakeholder outreach efforts.
- Expected Results
  - Better understanding of currently proposed safety assessment models.
  - Potential data needs for assessing the safety of an ADS.
  - Project initiated in October 2019.

# Applied Research on Candidate ADS Performance Measures for Utility Assessment

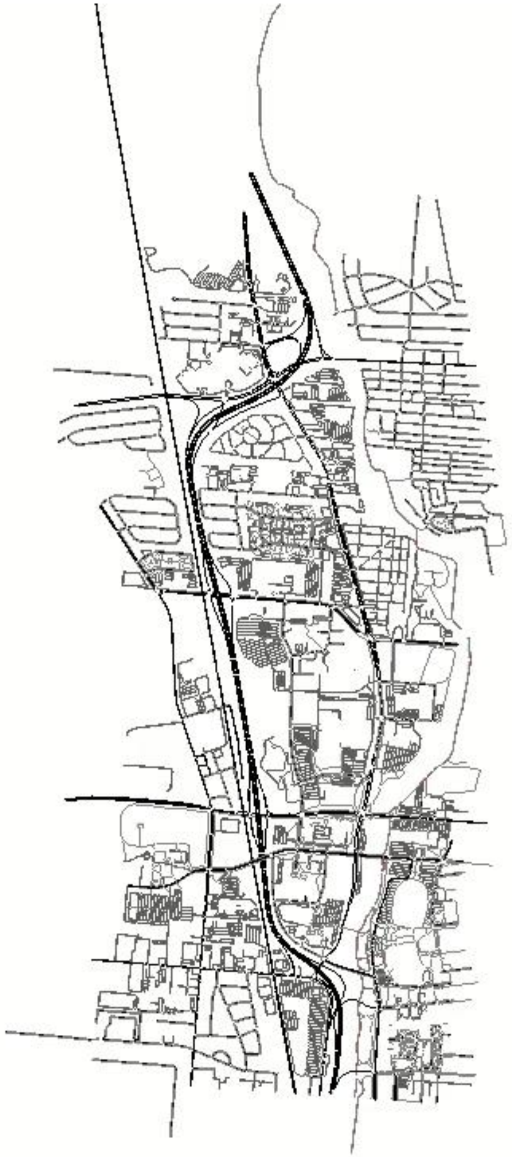
- Research to evaluate various safety measures that have been identified to date (e.g. ISM, DIST, RSS, RII) to characterize the safety performance of Automated Driving Systems (ADS).
- These measures will be applied to both real world data and simulated data. Safety margins will be observed as well as sensitivity to crashes, false positives, and other outcomes that are indicative of performance.
- The results of this research will contribute to better understanding these measures and how they can be applied assess the safety performance of ADS.



# Metric Development



# ADS Testable Cases and Scenarios

*Paul Rau*

# ADS Testable Cases and Scenarios Framework

## OBJECTIVES:

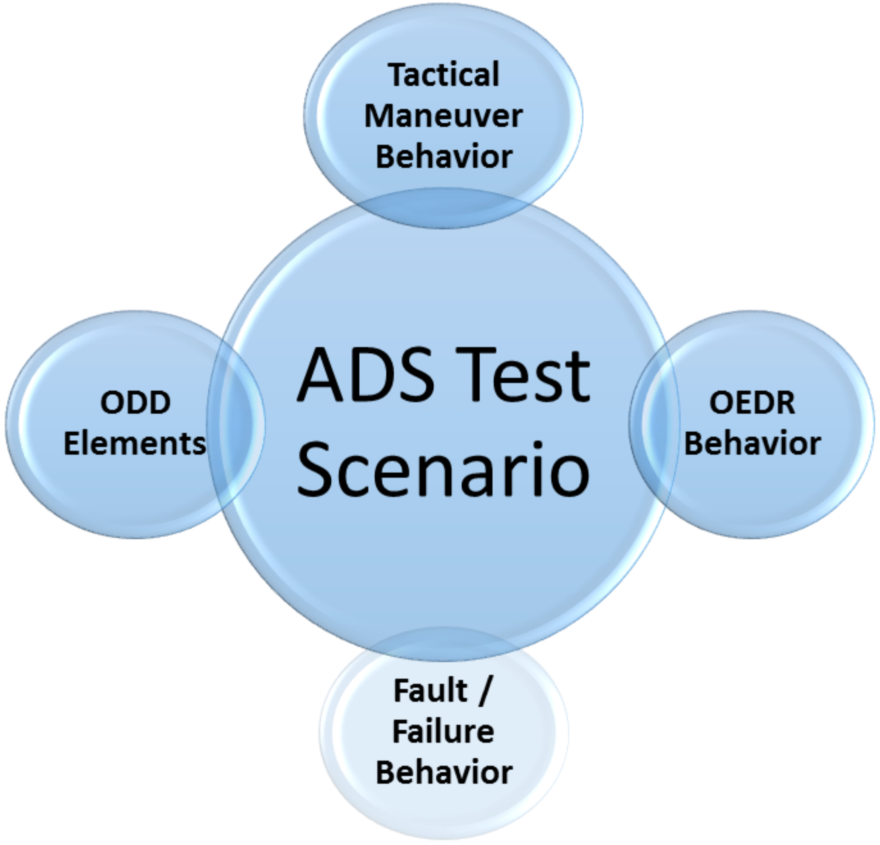
- Develop a preliminary objective testing and assessment approach, which may contribute to industry approaches to understand ADS safety performance.
- Take the first steps of partitioning the ADS performance space as a test framework of independent factors.

## OUTCOMES:

- Identify sample list of candidate maneuver/competency behaviors from various sources.
- Identify factors that define the ADS Operational Design Domains (ODD)
- Develop a Model Framework of Assessment Factors

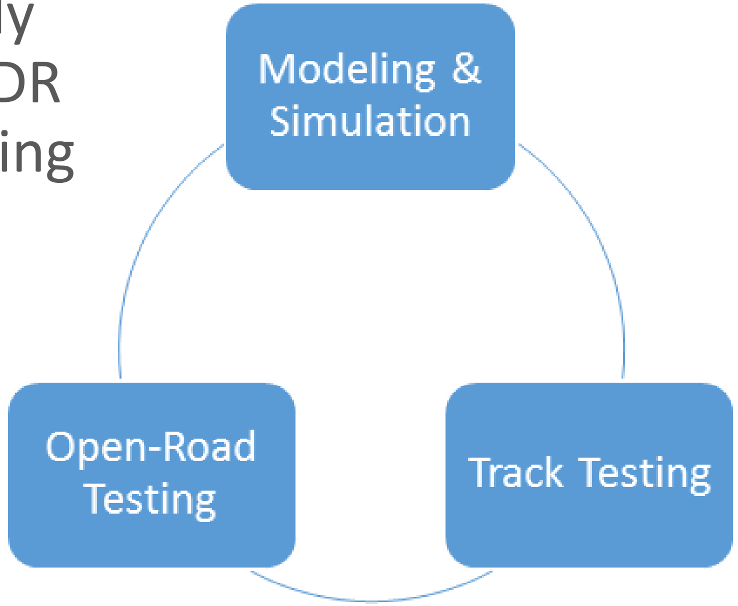
# Test Scenarios and Test Procedures

- Define key elements of a scenario (e.g., maneuver behaviors, ODD, OEDR)
- Develop candidate scenario tests for specific competencies
- Operational scenarios can be composed of multiple behavioral competency tests
- Can add fault/failure behaviors to scenario tests



# Testing Framework

- Modeling & Simulation
  - Controlled, predictable, repeatable
  - Opportunity to run large number of simulations very quickly
  - Opportunity to perform sensitivity analysis of ODD and OEDR variability, and identify candidate scenarios for further testing
- Closed-Track Testing
  - Controlled, predictable, repeatable
  - Opportunity to assess full system performance
- Open-Road Testing
  - Uncontrolled, unpredictable
  - Exposure to variety of environmental conditions (e.g., weather) and other ODD elements (e.g., local traffic patterns and infrastructure conditions)
  - Exposure to variety of real-world scenarios that may be difficult to replicate on a test track or simulator

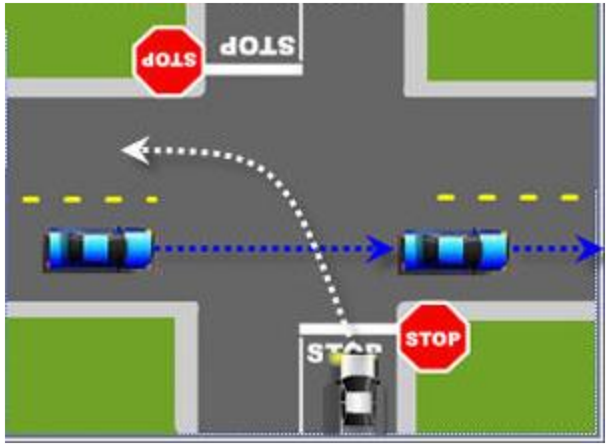


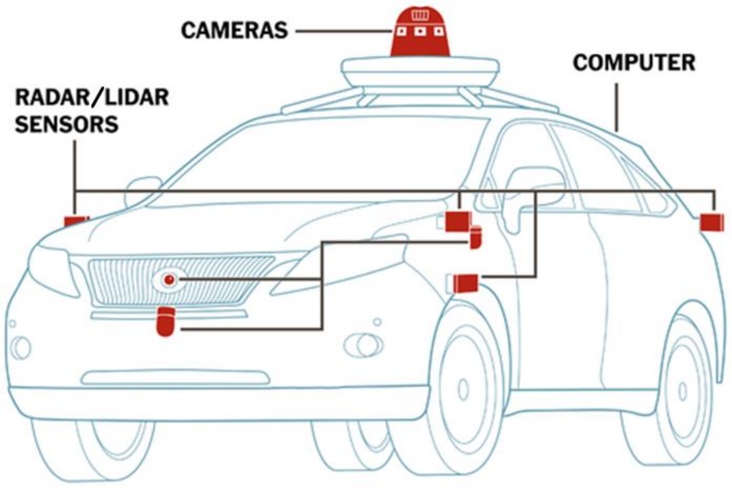
# Development of Tools & Methods to Record ADS Data During On-Road Testing

*Sebastian Silvani*

# Development of Tools & Methods to record ADS data during On-Road Testing

- Background
  - Collection of data during “normal” and “challenging” on-road operations is fundamental to assessing driving performance
- Approach
  - Identify sample (concept) driving scenarios
  - Determine data needed for assessing performance
  - Develop a prototype Ground Truth Trip Recorder (GTTR) that will not interfere with vehicle sensor systems.
  - Test and refinement of: data needs; GTTR; and, analysis methods
- Expected Results
  - Sample scenarios and metrics
  - GTTR prototype
  - Concept of operations
  - Feasibility and practicality assessment



# Vulnerable and Disabled Road Users: Considerations Inside and Outside the ADS Vehicle


*Eric Traube*

*Presented by Dee Williams*


# Population Addressed in this Study

- Disabled Road Users (DRUs)
  - 18.5 million with mobility disabilities
  - 19 million with vision or hearing disabilities
  - 28 million with cognitive or psychiatric disabilities (e.g., autism, intellectual, learning, and mental health disabilities, traumatic brain injuries)
- Vulnerable Road Users (VRUs)
  - Pedestrians
  - 47.5 million bicyclists
  - 8.4 million motorcyclists

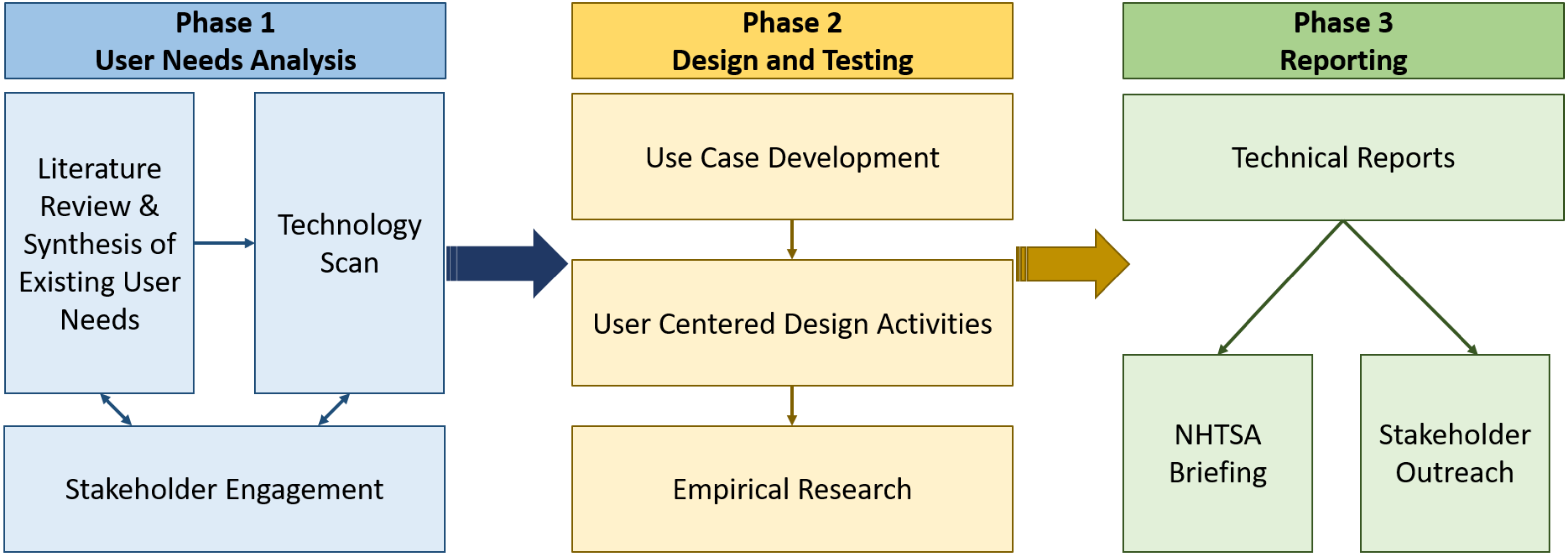
# Project Objectives

- Identify vehicle-side needs for ADSs to interact with
  - Disabled Road Users.
  - Vulnerable Road Users.
- Prioritize the most pressing needs and identify possible interaction techniques and communication strategies that could facilitate trust, efficiency, and safety.
- Assess a subset of possible solutions with end-users in an experimental setting.

# Research Questions

- What are the travel needs of DRUs?
- What information do DRUs require to maximize confidence, trust, efficiency, and safety?
- What are effective display/communication options for users within each category of disability?
- What feedback is desirable, including when the route or destination is unavailable at different points in the trip?
- What other concerns may need to be addressed to ensure a satisfactory end-to-end user experience for all levels and types of disabilities?
- What are the information needs and expectations of VRUs?
- What are the best ways to communicate this information to VRUs?

# Research Phases

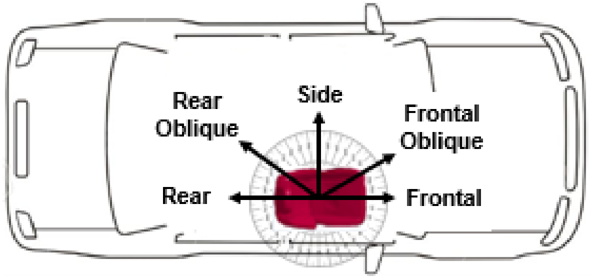


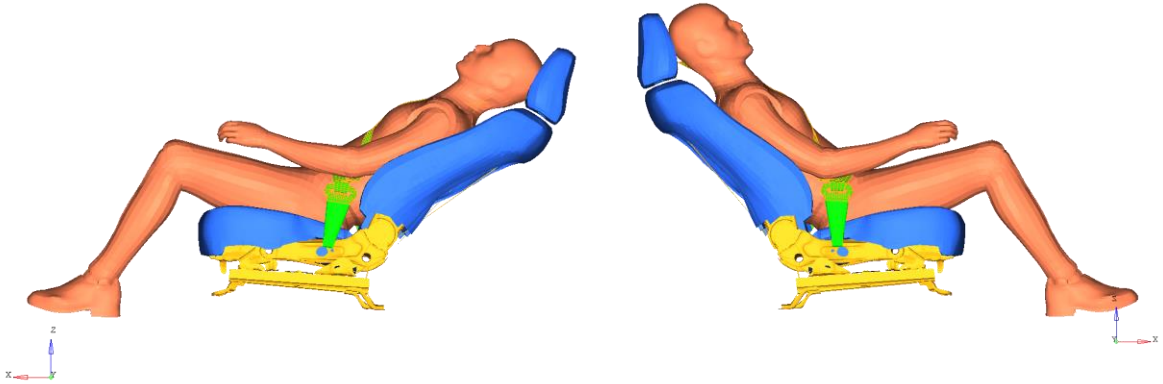
# ADS-Equipped Vehicle Occupant Kinematics: Rear-facing Reclined

*Jason Stammen*

# Motivation

- NHTSA is investigating existing computational models and crash test dummies in the most likely scenarios in Automated Driving Systems (ADS)-equipped vehicles reclined seating for both forward and rear-facing occupants for different impact severities
- Biofidelity of tools to be modified as needed to provide optimal injury risk assessment given new post-mortem human surrogate (PMHS)-based biomechanical data
- NHTSA is sponsoring three research projects to generate new biomechanical data: (1) rear-facing, (2) forward-facing, (3) forward-facing for occupants vulnerable to submarining/abdominal injury



# Test Setup: Rear-facing

- Repeatability: rigidized support to prevent seatback rotation – eliminates variation due to rotational stiffness when testing different seats
- Instrumentation: load cells to measure forces & moments at head restraint, seatback, and seat anchor points to floor
- Adjustability: can accommodate various recline angles, seats, PDOF, and speeds

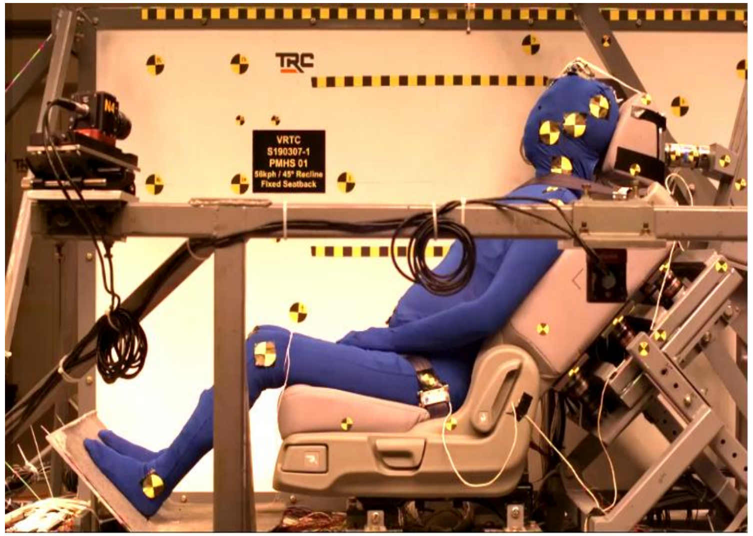

**2018 Honda Odyssey 2nd Row Seat**
- ABTS: most likely for reclined ADS
- Availability

# Test Matrix: PHMS

- Subject selection: anthropometry close to 50th male ATD, no physical issues preventing sensor installation
- Positioning: approximate volunteer postures from UMTRI study[1]
- Head restraint location: follow FMVSS 202a backset for standard seatback angle; maintain HR position relative to seatback when reclined

PMHS, 25° Seatback

PMHS, 45° Seatback



| # of Tests | Seat | Delta V (kph) | Seat Back Angle |
|---|---|---|---|
| 3 | 2018 Honda Odyssey, 2nd Row (w/ABTS) | 56 | 25 |
| 3 | | 56 | 45 |
| 1 | | 24 | 25 |
| 1 | | 24 | 45 |
| 7 | TBD | | |

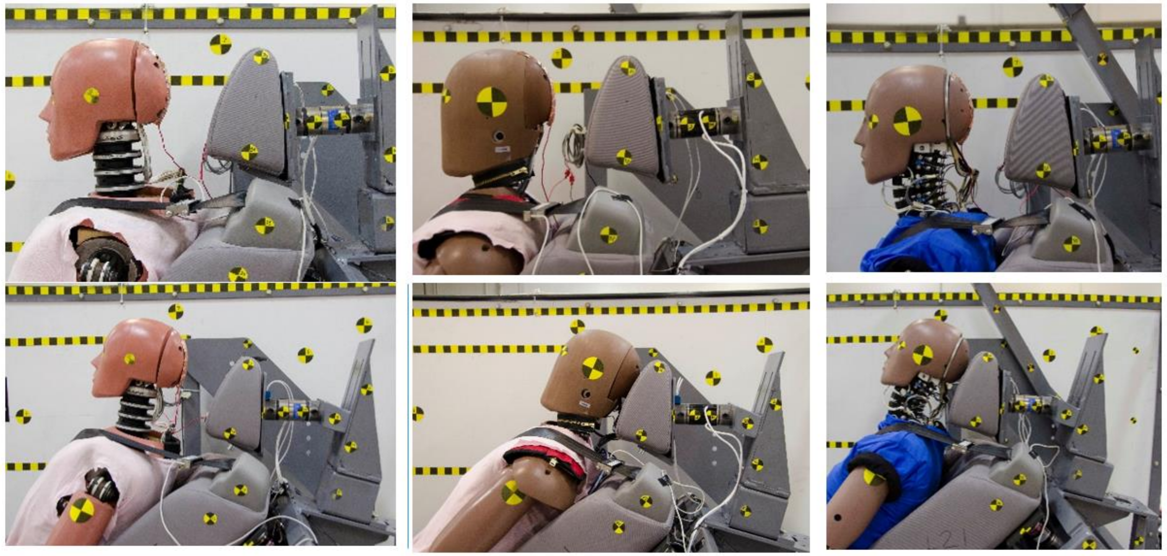
# Test Matrix: ATD

- Positioning: approximate volunteer postures from UMTRI study[1] (when possible)
- Head restraint location: same as PMHS, with some adjustment to accommodate ATD posture limitations when reclined

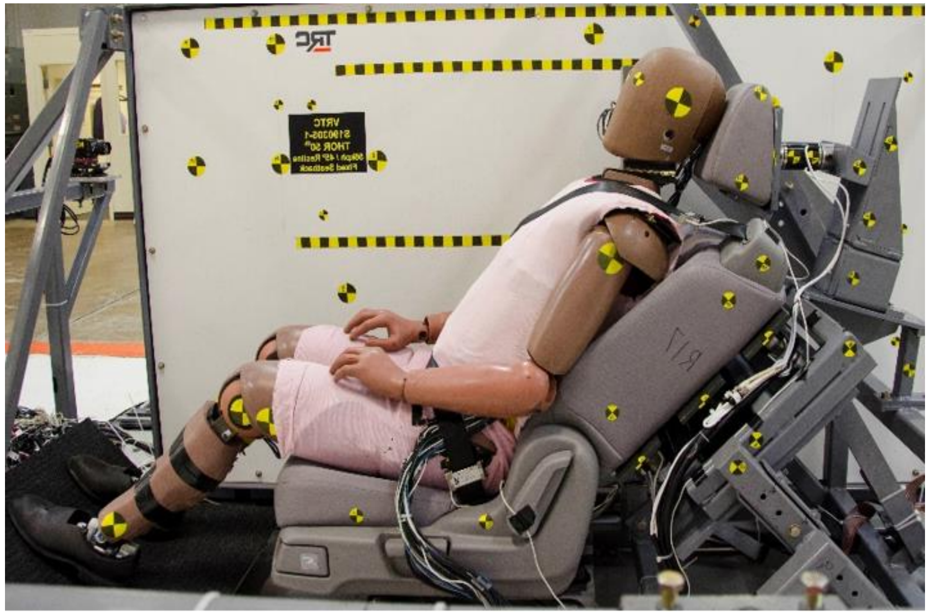
| Seats | ATDs | Delta V (kph) | Seat Back Angle |
|---|---|---|---|
| (1) 2018 Honda Odyssey, 2nd Row (w/ABTS) | THOR-50M, Hybrid III 50th | 56 | 25 |
| | | 56 | 45 |
| (2) 2018 Honda Accord, 1st Row (standard belt) | THOR-50M, Hybrid III 50th, BioRID | 24 | 25 |
| | | 24 | 45 |

25° Recline

45° Recline



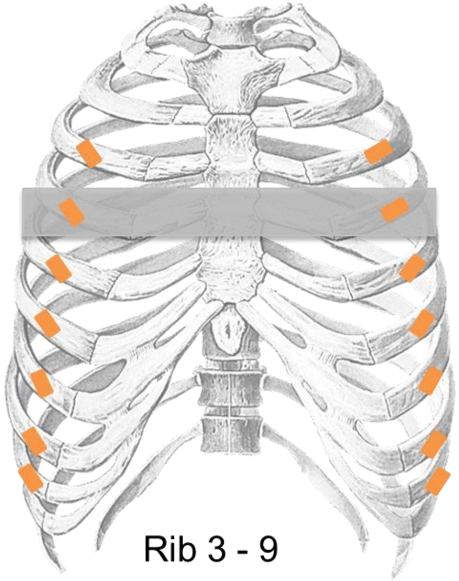
THOR-50M, 45° Seatback

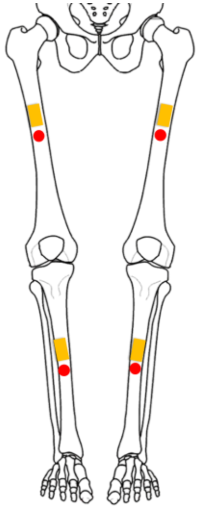


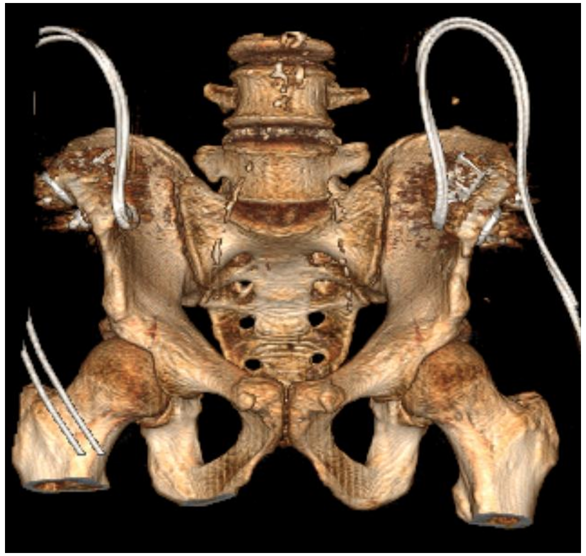
# Instrumentation

- Kinematics: head, spine, pelvis, legs
- Forces & Moments: seat, seatbelt, legs
- Strains (PMHS only): ribs, pelvis, legs
- Deflections: ribcage

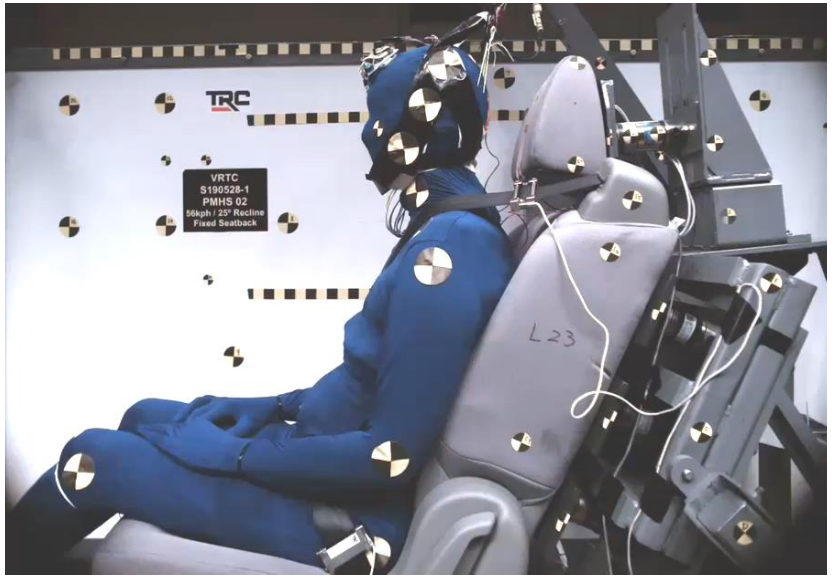
| ATD/PMHS/Seat | # of Channels |
|---|---|
| Seat (11 Load Cells) | 52 |
| Belt Load Cells | 2 |
| PMHS | 186 |
| THOR-50M | 104 |
| Hybrid III 50$^{th}$ Male | 81 |
| BioRID-II | 89 |



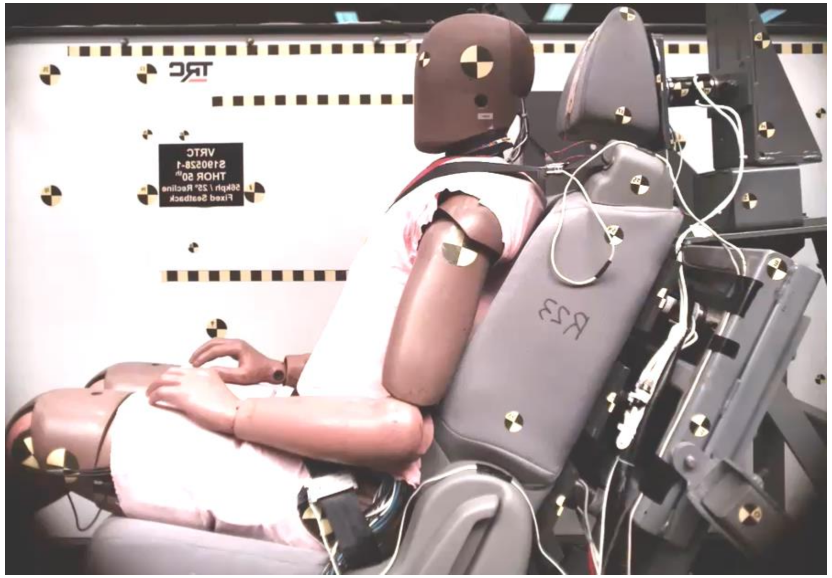





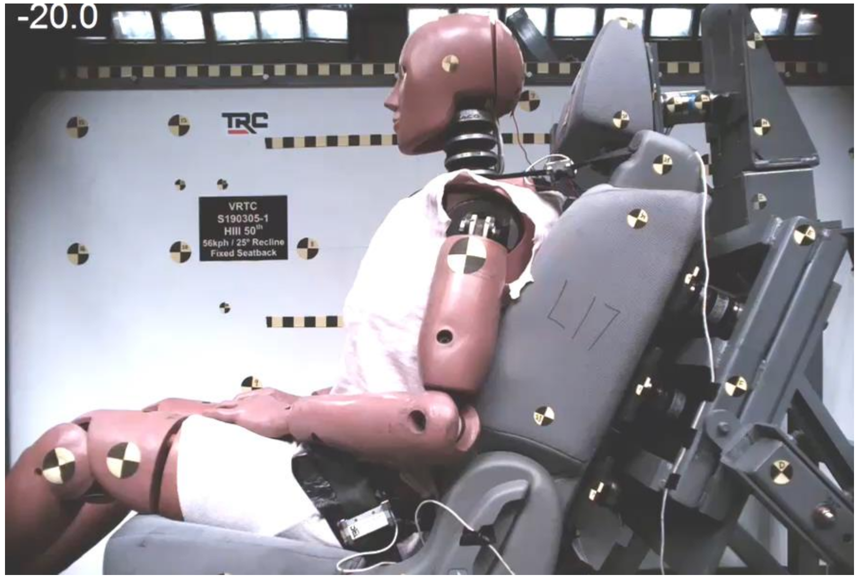
# Results: 25 deg, 56 kph




PMHS[1]



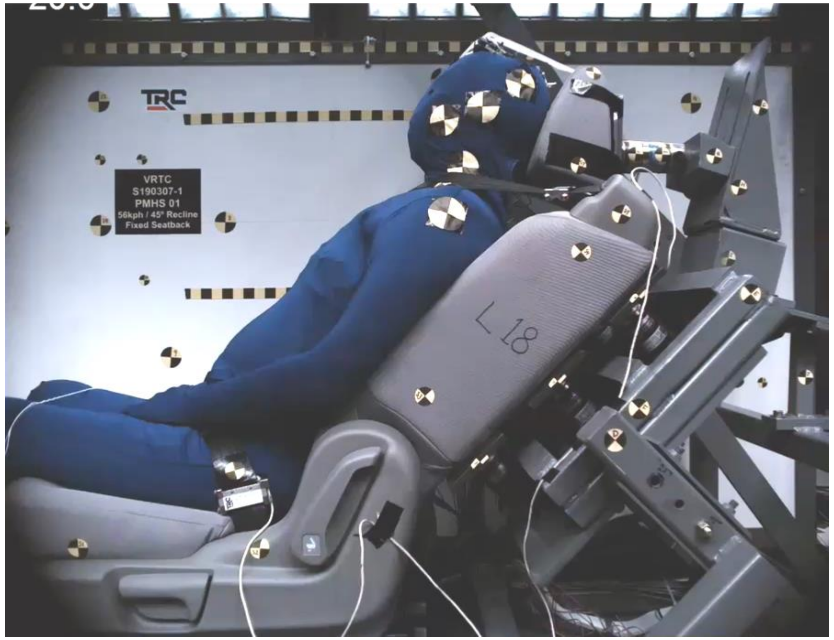
THOR $50^{th}$ Male



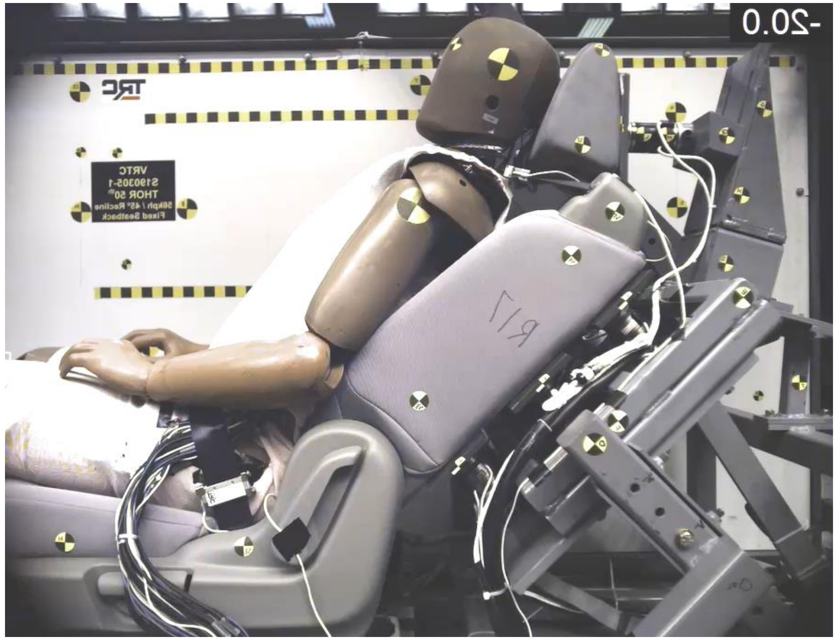

Hybrid III $50^{th}$ Male

[1]*Kang Y. "Biomechanical Responses and Injury Assessment of PMHS in Rear-facing Seating Configurations" SAE Govt/Industry 2019*

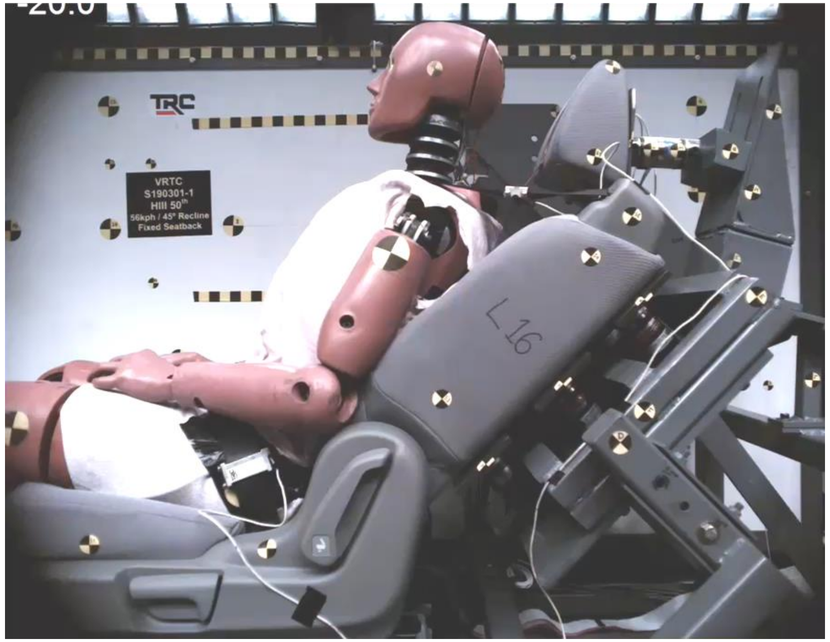
# Results: 45 deg, 56 kph




PMHS[1]



THOR 50th Male




Hybrid III 50th Male

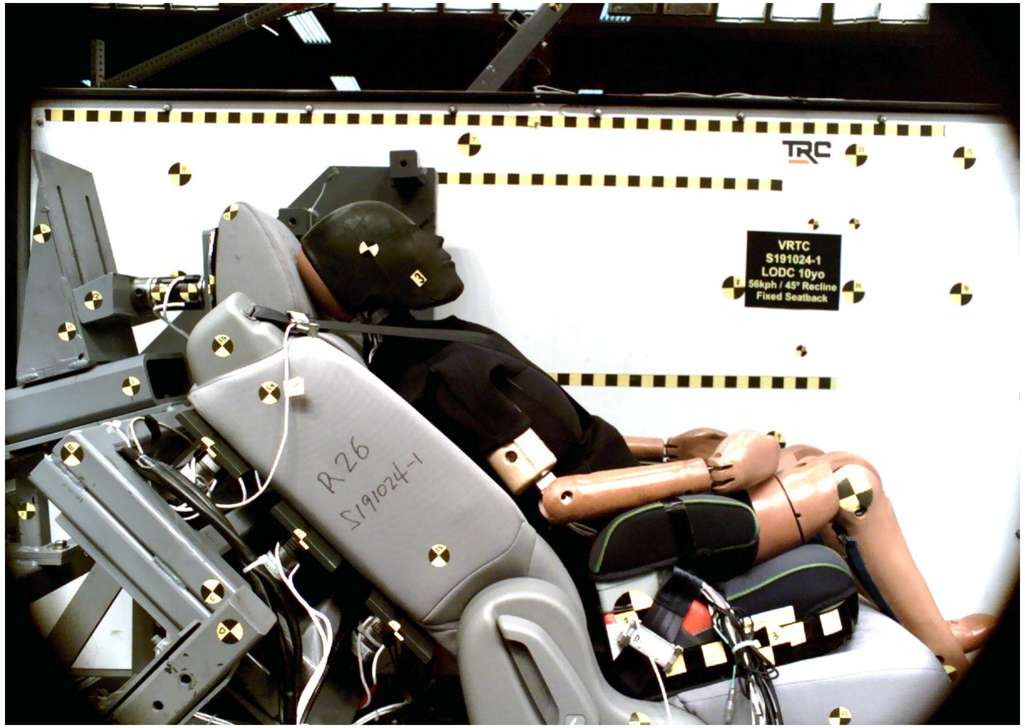
[1]*Kang Y. "Biomechanical Responses and Injury Assessment of PMHS in Rear-facing Seating Configurations" SAE Govt/Industry 2019*

# Results: Findings to Date

- Cable routing changes are needed for the frontal ATDs due to posterior interaction with the seatback
- Difficulties encountered getting ATDs into reclined posture
- ATD chest deflections higher with upright than reclined seatback
- Extensive PMHS injuries in high speed testing: fractures observed in posterior ribs, thoracic/lumbar spine, pelvis, scapula, tibia
    - Combination of rigid seatback and localized structures needed for ABTS

# Current Work

- SAE Gov't/Industry 2020
- Derive Biomechanical Targets and Assess ATD Biofidelity
- Injury Mechanisms for Various Body Regions
- Test Other Seats
- Evaluate LODC



# Summary

- NHTSA is generating biomechanical data in high and low speed rear-facing, reclined seating scenarios so that ATDs and models can be evaluated and refined
- Results indicate potential for injuries to posterior ribcage, lower spine, pelvis, and lower extremities
- ATDs will need to be revised for reclined seating and protection of rear-mounted instrumentation
- More details on our testing so far will be presented at SAE G/I 2020

For more information see Docket ID NHTSA-2019-0123 NHTSA Crashworthiness Research – Occupant Protection for ADS-Equipped Vehicles Documentation

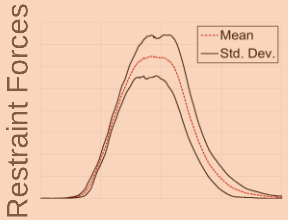
# ADS-Equipped Vehicle Occupant Kinematics

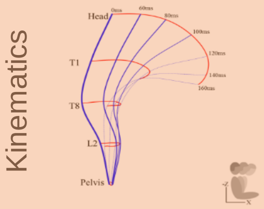
# Forward-facing Reclined

*Dan Parent*

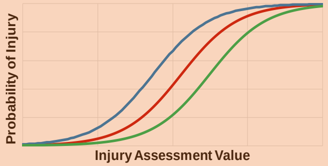
# ADS-Equipped Vehicle Occupant Kinematics Overview

PMHS Testing

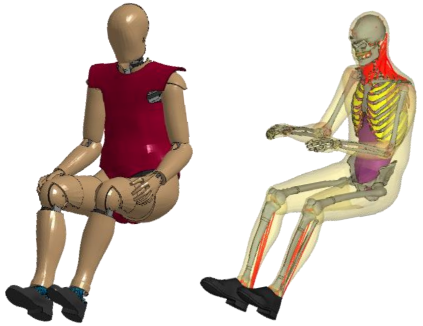


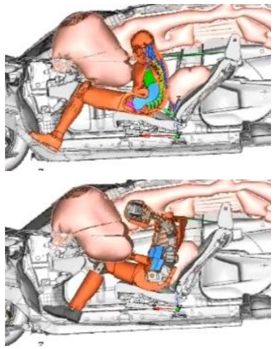

Response Targets




Injury Mechanisms and Criteria



Evaluation, Improvement of Tools



Application of Improved Tools to Assess, Improve Safety


rosap

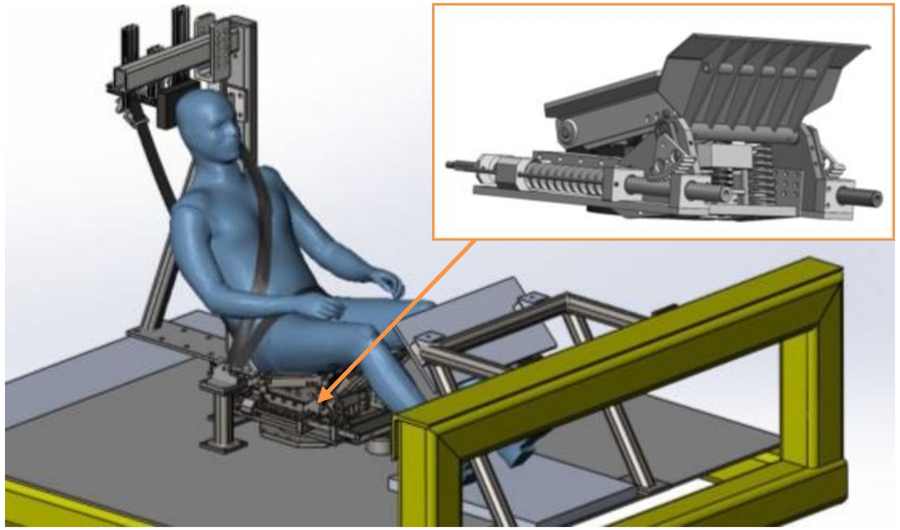
Public Availability of Data, Tools, Reports

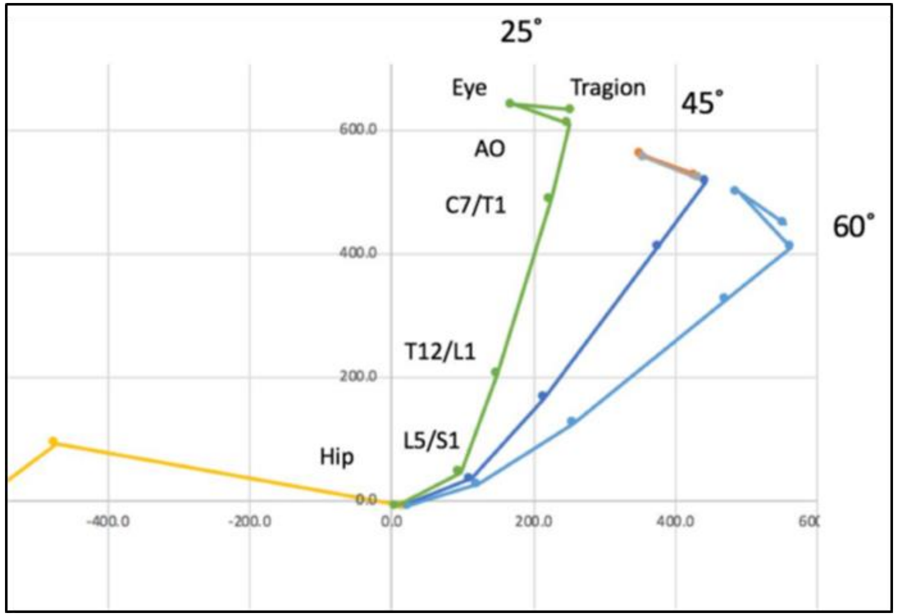
**Phase I:** 50th Percentile Male Occupants

**Phase II:** Vulnerable Occupants

# Test Setup: Forward-facing Reclined

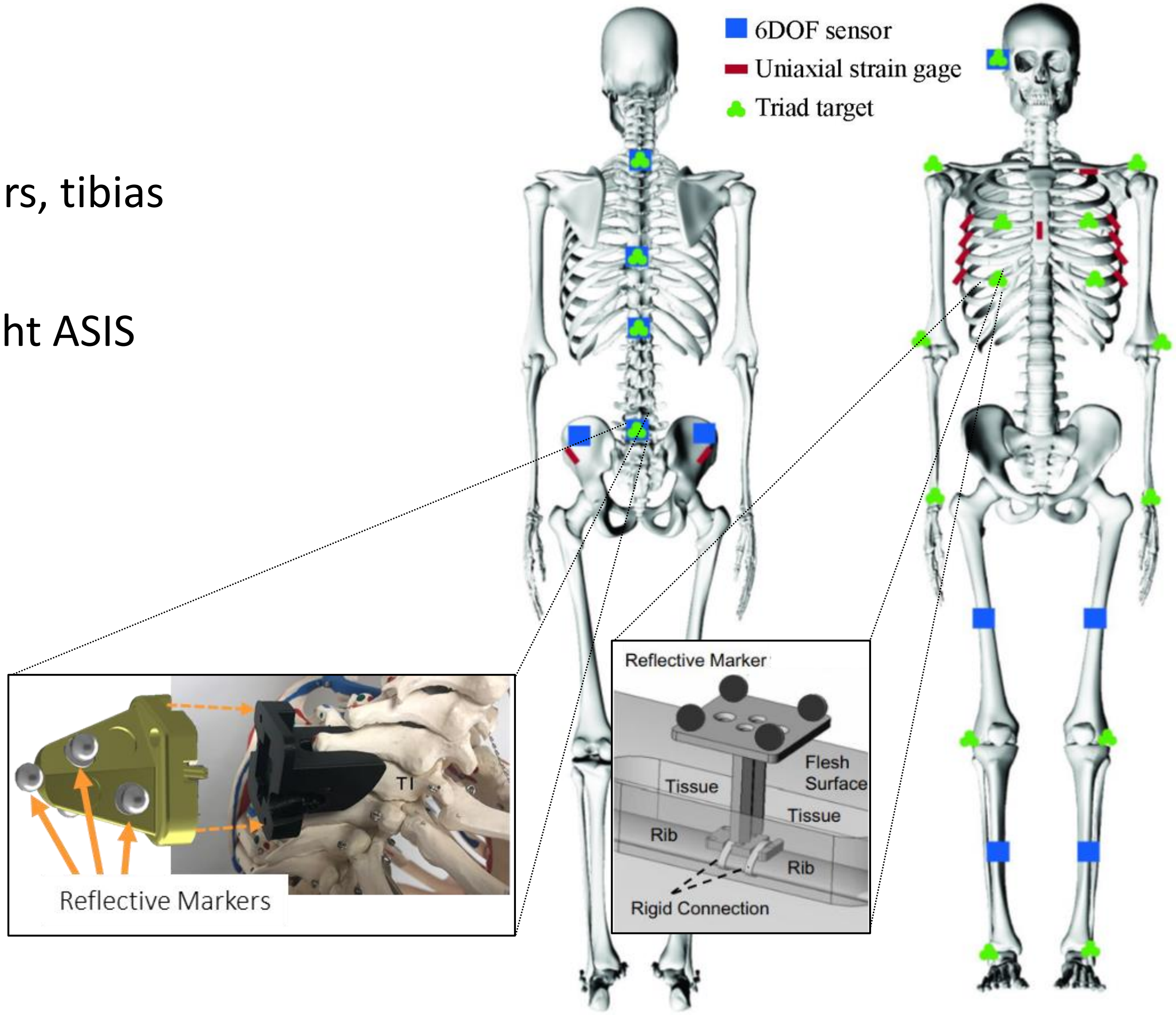
- Test Apparatus
  - Spring-controlled seat (Uriot et al., 2015)
  - Adjustable, open seatback
  - Adjustable, padded knee bolster
- Crash Pulse
  - Representative of vehicle pulse in frontal rigid barrier crash test
  - High-speed: 56 kph
  - Low-speed: 15 kph or 32 kph (scaled)
- Subject positioning
  - Target volunteer postures (Reed et al., 2018)
    - 25, 45, 60 degree posture predictions





# Instrumentation: Forward-facing Reclined

- PMHS Instrumentation
  - 6DOF sensors
    - head, T1, T8, T12, L4/L5, iliac wings, femurs, tibias
  - Uniaxial strain gages
    - left clavicle, sternum, ribs 4-7, left and right ASIS
  - 3D triad targets (TEMA or VICON)
    - All 6DOF sensors
    - skeletal landmarks
    - 4 locations on anterior ribcage



# Test Matrix: Forward-facing Reclined

## Phase I: 50th Male

- Subject Inclusion Criteria
  - Age ≥ 18 years
  - 170 ≤ Height ≤ 181 cm
  - 18.5 ≤ BMI ≤ 30 kg/$m^2$
  - qCT BMD ≥ 80 mg/cc
- 24 PMHS tests (+12 optional)

| # of Tests | Delta V (kph) | Seat Back Angle | Restraints |
|---|---|---|---|
| 3 | 32 | 25° | force-limited belt<br>knee bolster initially out of contact |
| 3 | 56 | 25° | |
| 3 | 32 | 45° | |
| 3 | 56 | 45° | |
| 12 | TBD | | |

## Phase II: Vulnerable Occupant

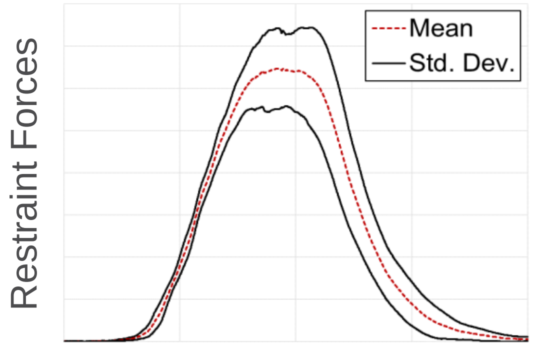
- Obese Occupants
  - Male or female
  - BMI ≥ 30 kg/m2
- Small Female Occupants
  - 143 ≤ Height ≤ 157 cm
  - 38 ≤ Weight ≤ 62 kg
- 24 PMHS tests (+12 optional)

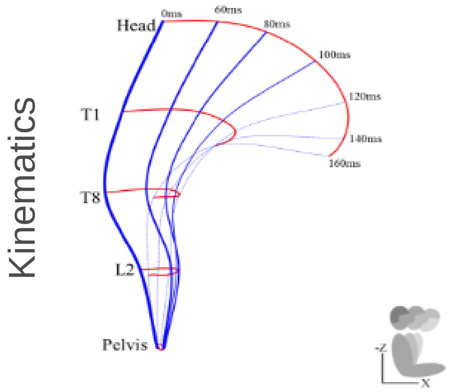
| # of Tests | Occupant | Delta V (kph) | Seat Back Angle | Restraints |
|---|---|---|---|---|
| 3 | Obese | 1) 15 km/h<br>2) if no injury, 56 km/h | 25° | force-limited belt<br>knee bolster initially out of contact |
| 3 | | | 45° | |
| 3 | Small Female | | 25° | |
| 3 | | | 45° | |
| 12 | TBD | | | |

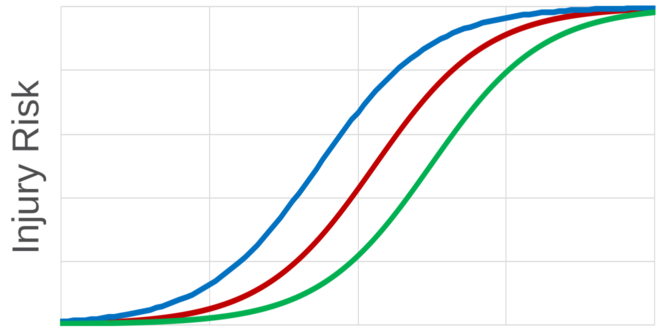
Detailed Task Implementation Plans: http://mreed.umtri.umich.edu/AV_Safety_TIP/

# ADS-Equipped Vehicle Occupant Kinematics

- Additional Tasks
  - Biofidelity Corridor Creation
  - ATD Matched Pair Tests
  - Human Body Model Evaluation/Improvement
  - Injury Criteria Development
- Status/Schedule
  - Work underway since September 2018
  - Sled bucks complete, PMHS testing ongoing
  - PMHS data due to NHTSA 30 days after each test
    - Targeting posting to NHTSA Biomechanics Database within 10 days of delivery
    - Processed data, reports added on rolling basis



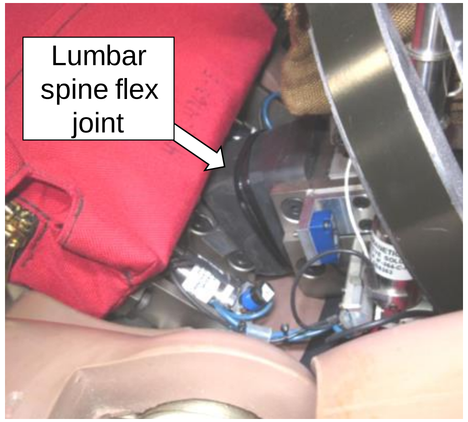
# ATD Seating in Highly Reclined Seats

- Objective
  - Examine the range of positions that the ATD could assume in a current production seat
- Test Apparatus
  - 2018 Honda Odyssey driver seat
  - Reclined from standard up to 75° in 5° increments
- ATDs Evaluated
  - H-III 50th M, H-III 5th F, THOR-50M, THOR-05F, WSID 50th M, WSID 5th F, BioRID 50th M, LODC 10 YO
- Observations
  - Current ATDs exhibit limitations when positioned in reclined seats
    - Gaps between head, headrest
    - Gaps between pelvis, abdomen, thorax
    - Excessive extension of flexible spine elements
- More information
  - Prasad, 2019 SAE Government-Industry Meeting
  - [https://www.nhtsa.gov/es/document/atd-seating-highly-reclined-seats](https://www.nhtsa.gov/es/document/atd-seating-highly-reclined-seats)

NHTSA VRTC
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Hybrid III 50th

THOR-50M



# THOR-50M Modifications for Reclined Seating

- Objective
  - Design and fabricate modified parts to address limitations in THOR-50M static positioning in reclined seats
- Tasks
  - Baseline static positioning assessment in 3 seats
    - 2 production, 1 generic
    - Follow procedure from VRTC study
  - Design and fabricate prototype parts
  - Incorporate design in THOR-50M FE model
  - Repeat baseline positioning assessment with modified THOR-50M
  - (Optional) Fabricate 3 additional sets of parts
- Key Outputs
  - 3D CAD package for modified parts
  - Static positioning assessment data
  - Updated THOR-50M FE model

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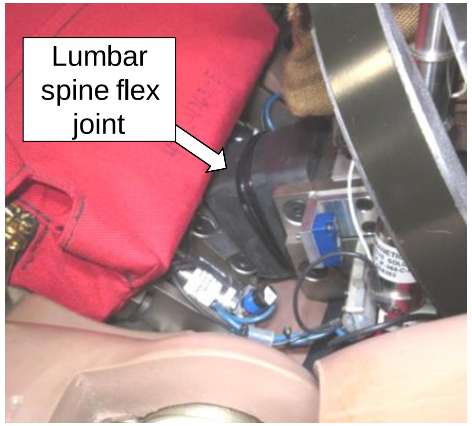
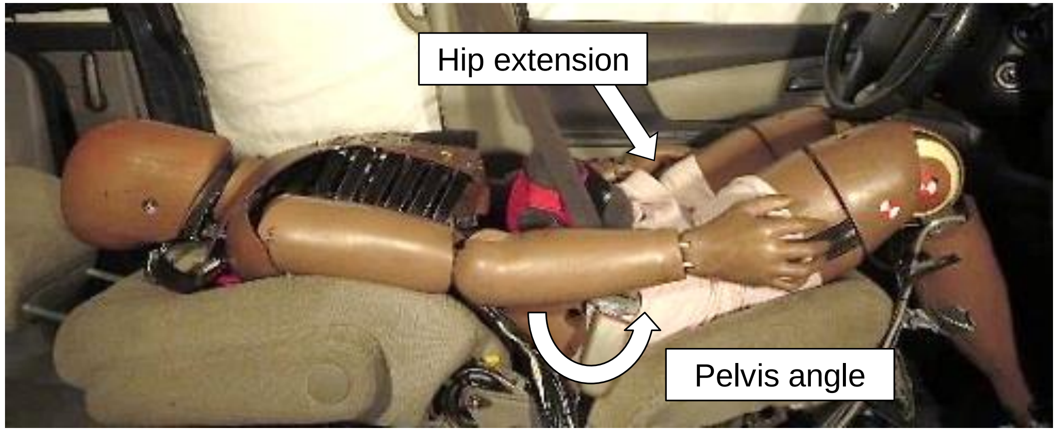
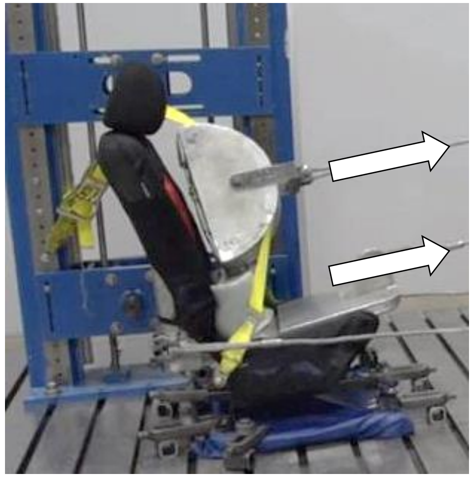
CELLBOND

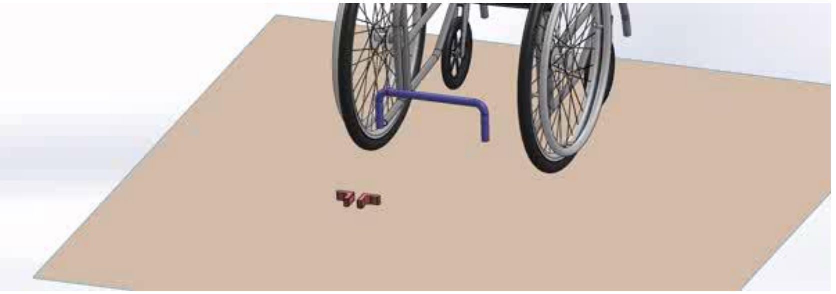
# Integrated Seat Modeling

- Objective
  - Develop and validate model of seat with integrated seat belt system
- Tasks
  - Seat selection (‘18-’19 Honda Odyssey 2nd row)
  - Seat tear-down, scanning, model development & validation
  - Destructive quasi-static testing (forward, rearward)
  - Frontal impact sled test with THOR-50M
  - Rear impact sled test with BioRID
  - (Optional) Additional sled tests with reclined seatback
- Key Outputs
  - Seat validation data (quasi-static, sled test)
  - Finite element model of integrated seat



# Automated Wheelchair Securement System

- Objective
  - To develop a prototype automated wheelchair tiedown and occupant restraint system (AWTORS) that can be used without assistance in an ADS-equipped vehicle by a person traveling in a wheelchair
- AWTORS Design Concept
  - Incorporate Universal Docking Interface Geometry (UDIG)
  - Automated seat belt donning system
  - Consider advanced belt features that could improve fit, ease of use, and occupant protection (e.g. Active Buckle Lifter)
  - Include airbag restraints as part of occupant protection system (e.g. Self Conforming Rearseat Air Bag – SCaRAB)
- Key Outputs
  - Volunteer usability testing data
  - Design demonstration

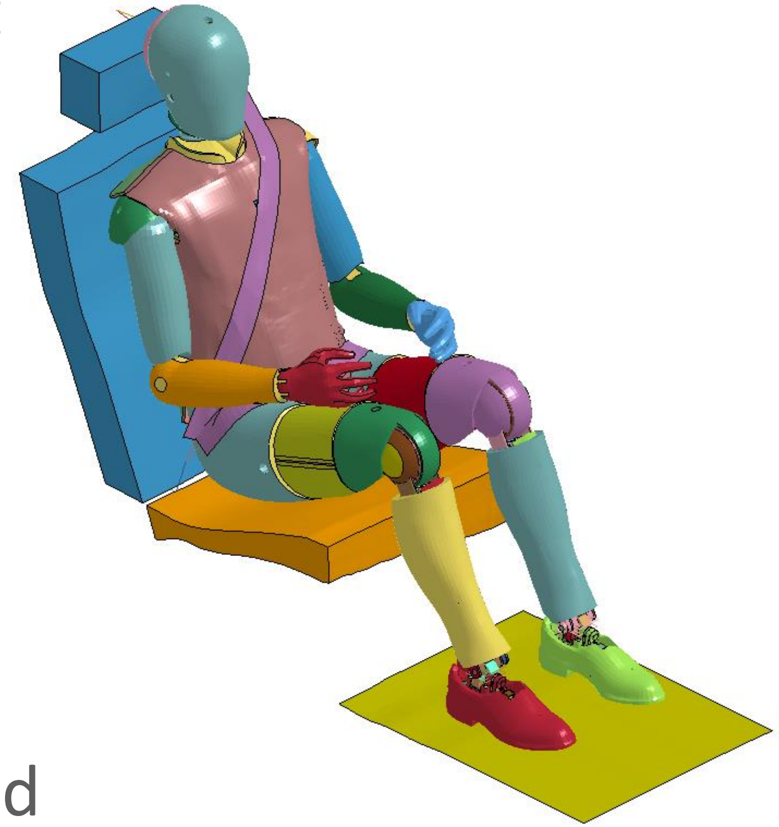


# Rear Seat Occupant Protection

*Ellen Lee*

# Motivation and Project Overview

- Current emphasis of frontal crash tests is on the front seats.
- Expectation is that Automated Driving Systems-Dedicated Vehicles (ADS-DV) occupants may be more likely to self-select a rear seat.
- Initial focus of research effort was to evaluate rear seat occupant crash protection for conventional seating.
- A range of rear seats were evaluated using finite element (FE) modeling and ATD sled tests (both Hybrid III and THOR-50M)



# Project Overview

**1. REAL-WORLD PROBLEM SCOPING**

- Estimate the extent to which individuals will self-select the rear seat in ADS-DVS
- Estimate injury risk in rear seat

**2. FE MODELING, VEHICLE SELECTION**

- Simulate NCAP tests using ATD models to assess the related safety performance
- Select a range of late model vehicles for physical testing

**3. TEST BUCK PREPARATION**

**4. ATD SLED TESTING**

- Conduct ATD sled tests using THOR-50M and Hybrid III
- Assess submarining and injury risk in the rear seats

**5. ANALYSIS AND NEXT STEPS**

- PMHS testing
- Finite element (FE) modeling
- Parametric analysis to determine key vehicle design parameters that affect safety

# Discussion and Next Steps

- To date, submarining and injury risks in head, neck, chest, femur and abdomen have been documented in five vehicles
- PMHS testing will be used to corroborate ATD results and to determine the efficacy of the ATDs for assessing rear seat safety
- Future analysis will seek to define some key vehicle design parameters (e.g. pretensioner/load limiter, seat pan geometry, anti-submarining ramp, seat cushion stiffness) that could improve rear seat passenger safety

# Clarification or Questions?