NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Rear-Facing Reclined Testing

Sled Buck Design & ATD Tests

Alena Hagedorn, TRC Inc.

Automated Vehicle Occupant Safety Workshop

11. 27. 2018

AGENDA

11. 27. 2018

1. Sled Buck Design Evolution
2. Sled Tests with Instrumented ATDs
3. Plans for PMHS Sled Tests

Sled Buck Design Evolution

A rear impact sled buck design was fabricated and tested for durability and feasibility using ballast dummies

Sled Buck Design

- 2 occupant design
- Adjustable configurations
  - Recline angles
  - Seatback rotation limits
  - Loading directions
  - Various seats
  - Integrated or standard belts

Seat Selection

Honda Odyssey

- Integrated seatbelt
- 2nd row seating
- Readily available
- Used throughout test series

Seatback Support Bracket

- Intended to create “fixed” scenario and/or limit seatback rotation
- Adjustable to align with seatback angle

Sled Buck Shakedown Tests

Ballast dummies used to check durability and feasibility of sled buck

25°/ 45° recline free back
25°/ 45° recline fixed back
25°/ 45° recline with 20° allowable rotation

Test Pulses

- **24 kph**
  - **Consistent with previous low/moderate speed rear impact testing**
- **56 kph avg. NCAP pulse**

Sled Buck Issues
Solution

- Eliminate free back configuration from future tests for better repeatability

Sled Buck Issues

- Seatback support bracket height allows seatback bending
- Rotation of the bracket during seatback contact

25 Deg Recline with 20 Deg Allowable Seatback Rotation

45 Deg Recline with No Allowable Seatback Rotation

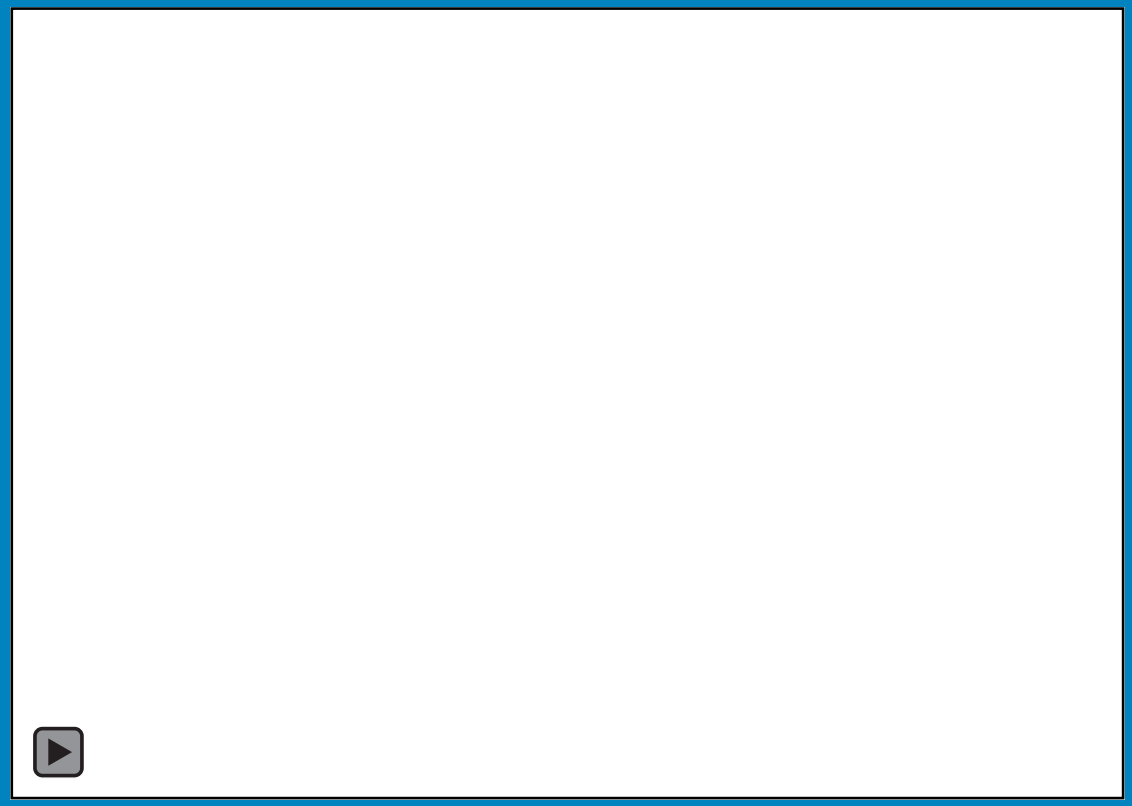
Sled Buck Issues - Solutions

- Extended seatback support bracket height to encompass seatback
- Additional reinforcement to center to prevent bracket rotation

Sled Buck Issues
- Solutions

- Increase height of seatback support bracket to cover entire seatback frame

25 Deg Recline with 20 Deg Allowable Seatback Rotation



45 Deg Recline with No Allowable Seatback Rotation

Sled Tests with Instrumented ATDs

Two sled test series with THOR-50M and HIII-50th performed at 24 kph and 56 kph

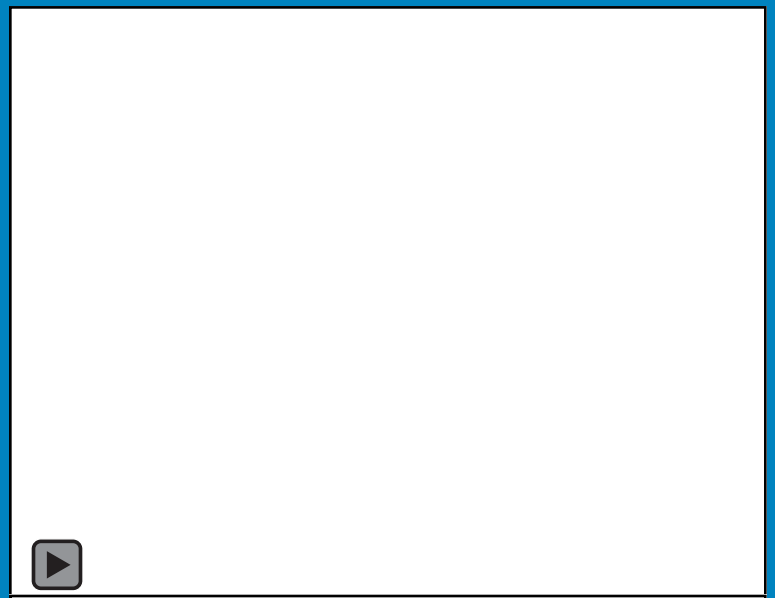
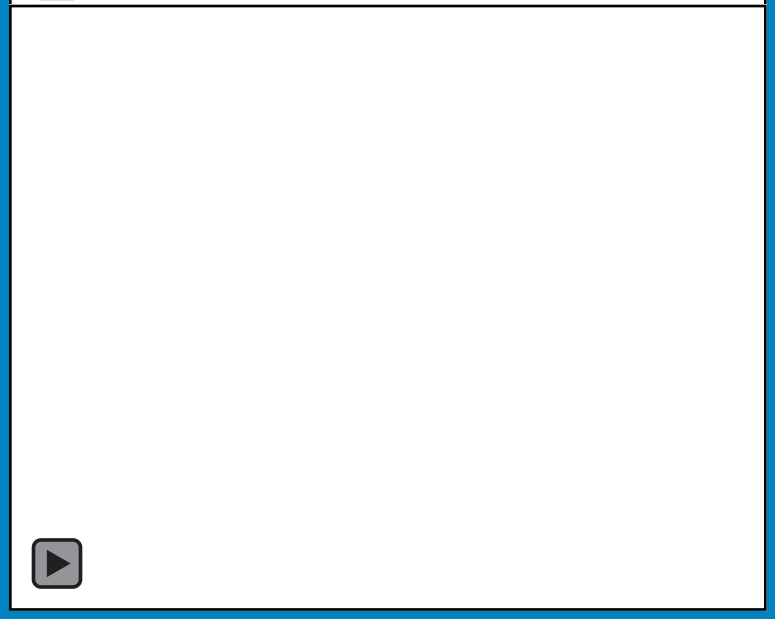
Instrumented ATD Sled Tests

25°/ 45° recline fixed back
25°/ 45° recline with 20° allowable rotation

Addition of Seat Anchor Load Cells

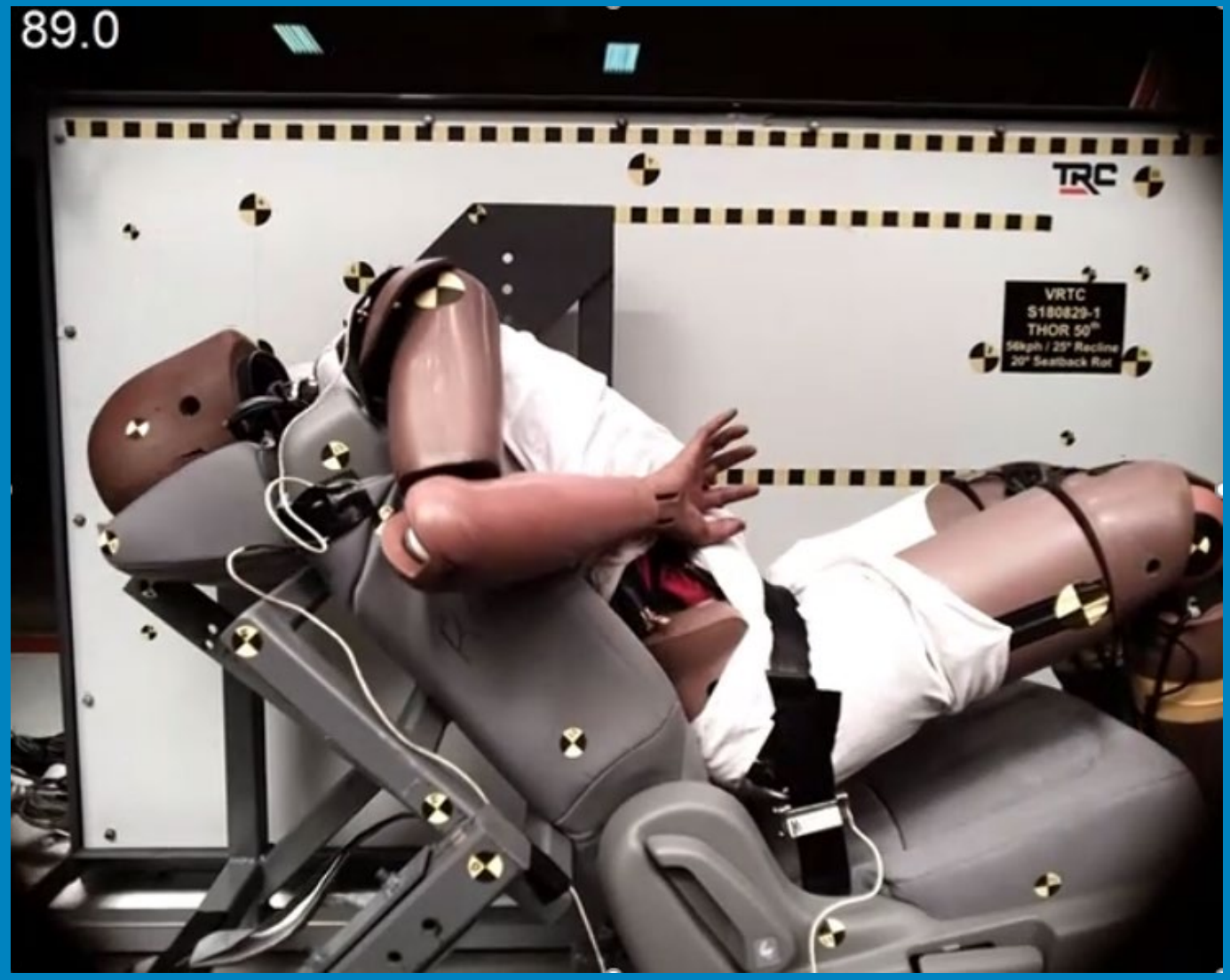
- Load cells added to the anchor points to measure reaction forces
  - For model validation

56 kph Tests: THOR-50M

	25 Deg Recline	45 Deg Recline
Fixed Seatback		
Seatback Allowed to Rotate 20 Deg		This test not conducted due to ATD instrumentation issues

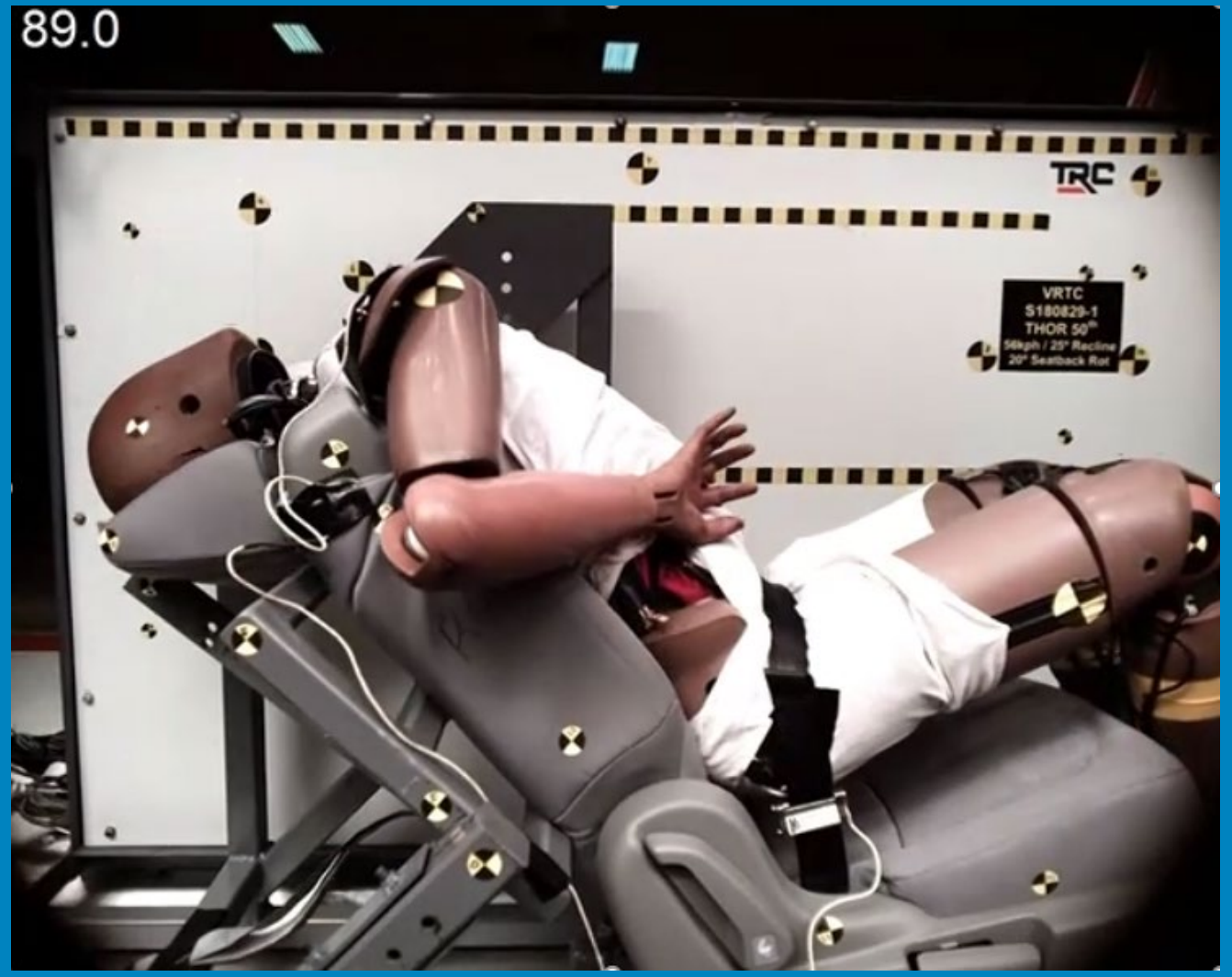
Sled Buck Issues

- Head restraint bent, broke, or pulled out due to head interaction
- Undesirable for repeatability & model validation
- **SOLUTION: Fix both head restraint and seatback**



ATD Issues

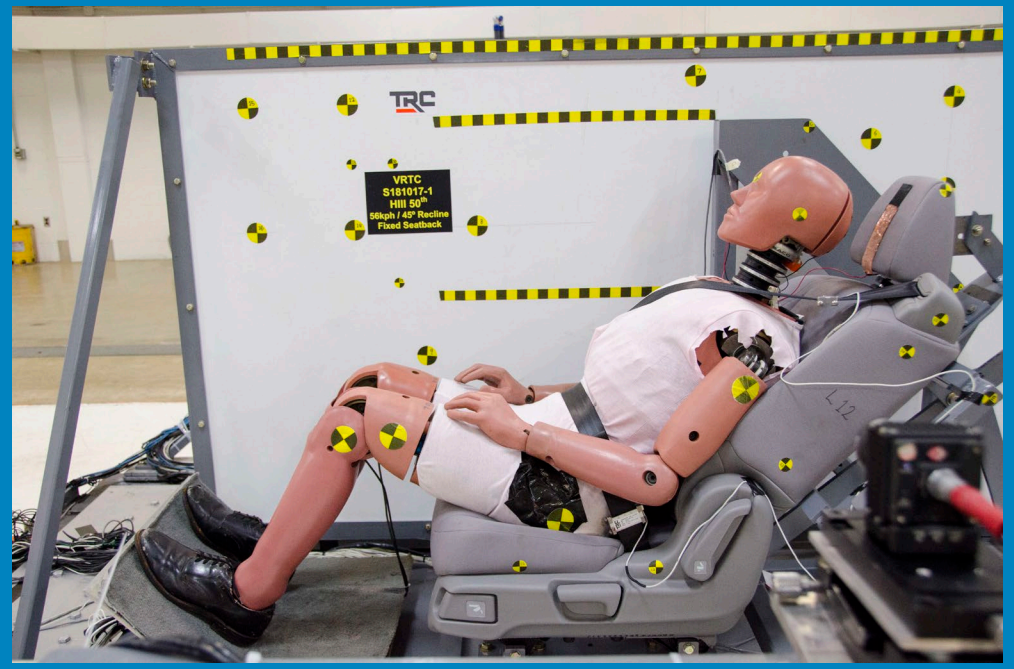
- Pinched cables, data channel loss
- Associated with cable bundle interacting with seatback
- **SOLUTION: Reroute cables for next series**

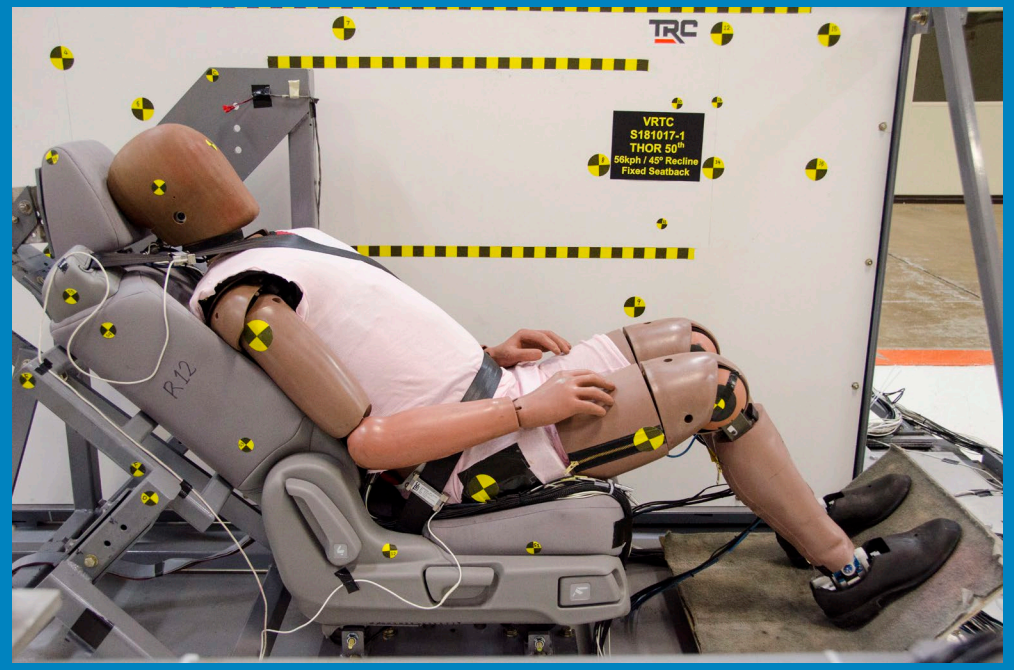


ATD Issues

- HYIII head far from head restraint in 45° recline

- THOR lumbar spine set to erect to better fit 45° recline





Instrumented ATD Series: Findings

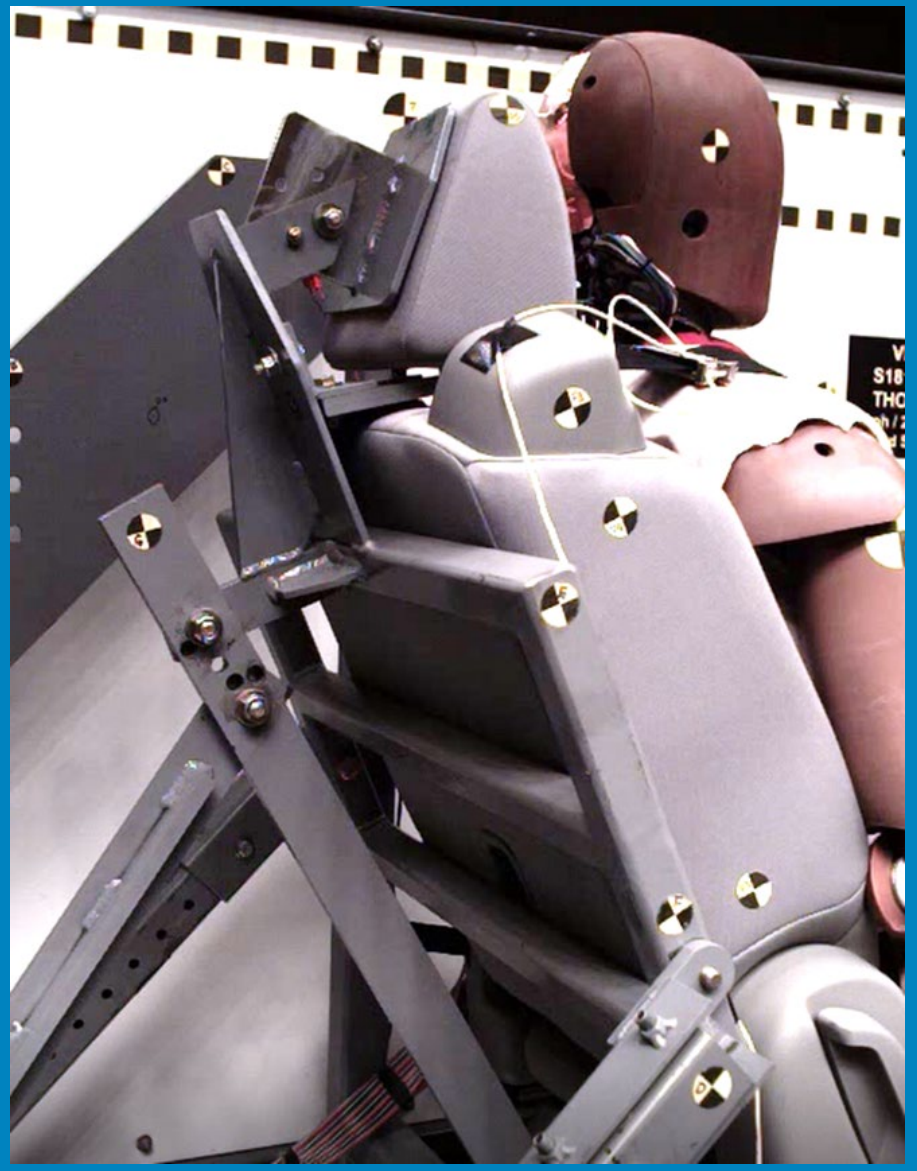
- Fix all seatbacks for next series
  - No allowable seatback rotation
  - Pulse, recline angle, and ATD only variables for repeatability
- Cable rerouting needed to limit cable bundle interacting with seatback
- Head restraint needs to be supported

Instrumented ATD Sled Tests – Round 2

25°/ 45° recline fixed back

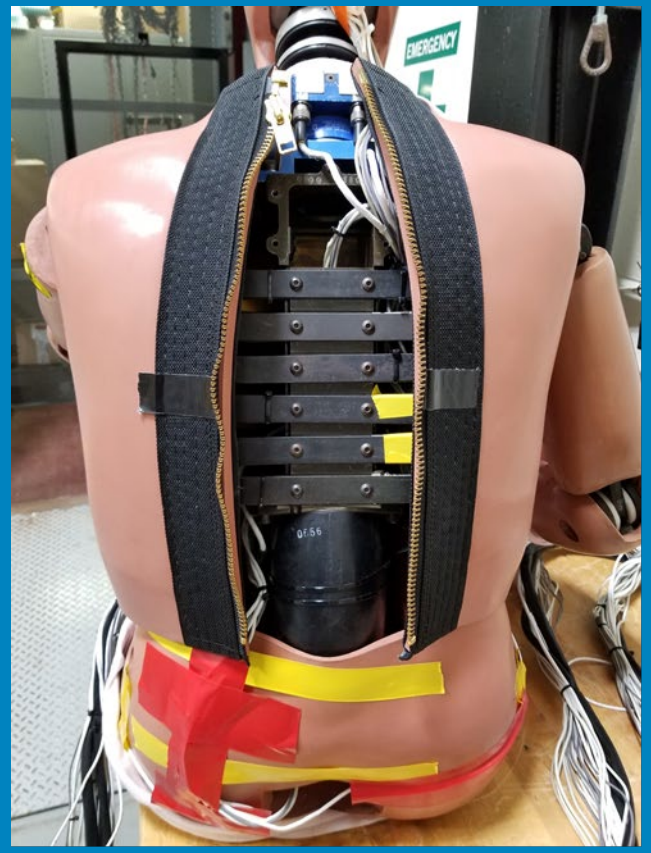
New Head Restraint Support

- Fully supports head restraint
- Posts have set screw “clamps” to keep headrest from being pulled out

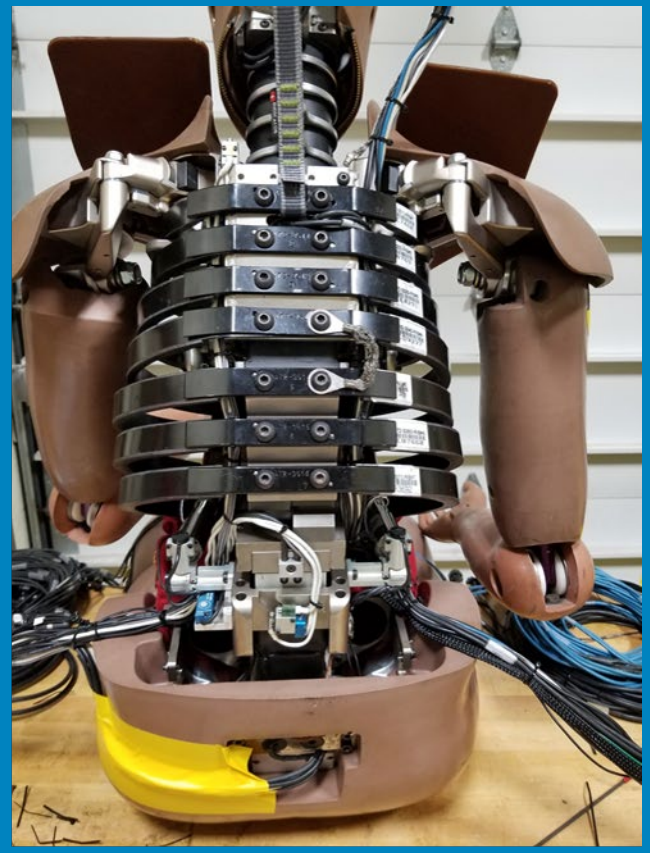


Reroute Cables

- Reconfigured to prevent compression of cables on the back

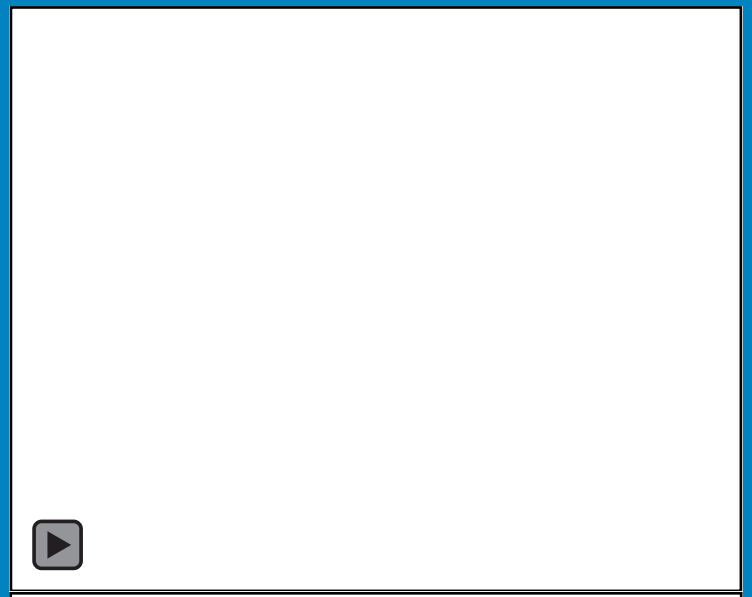
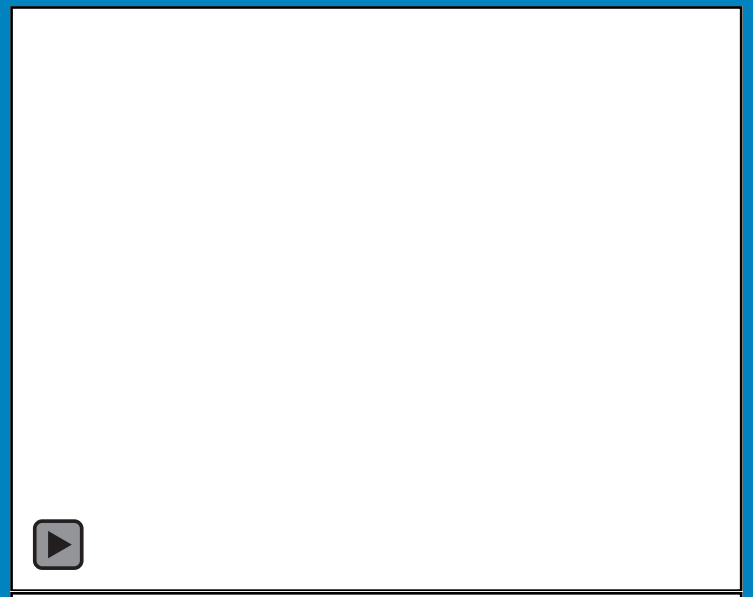
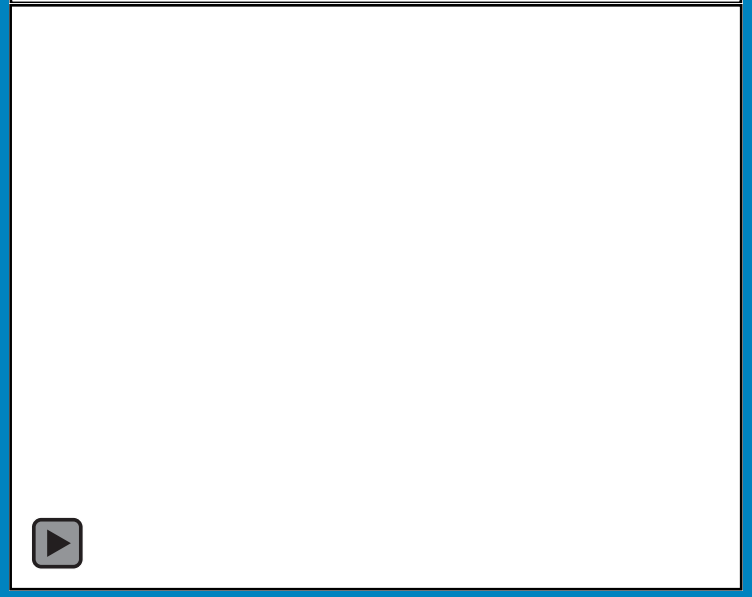
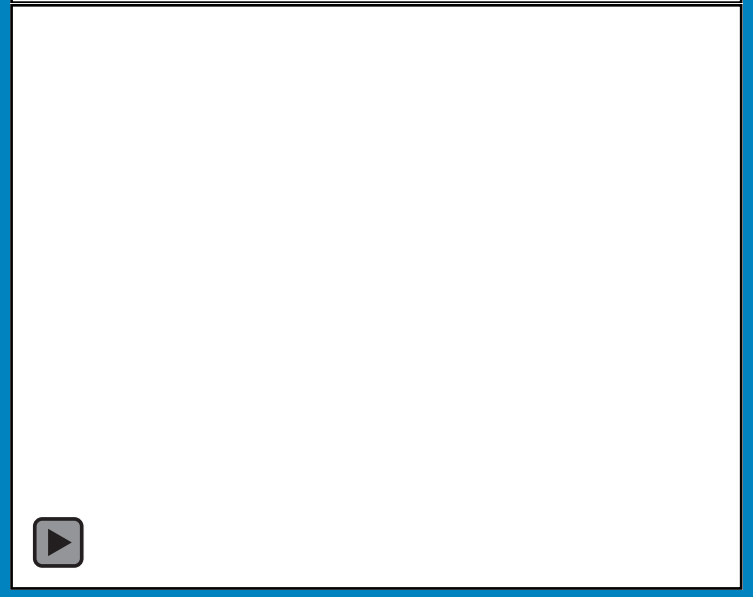


HIII-50th



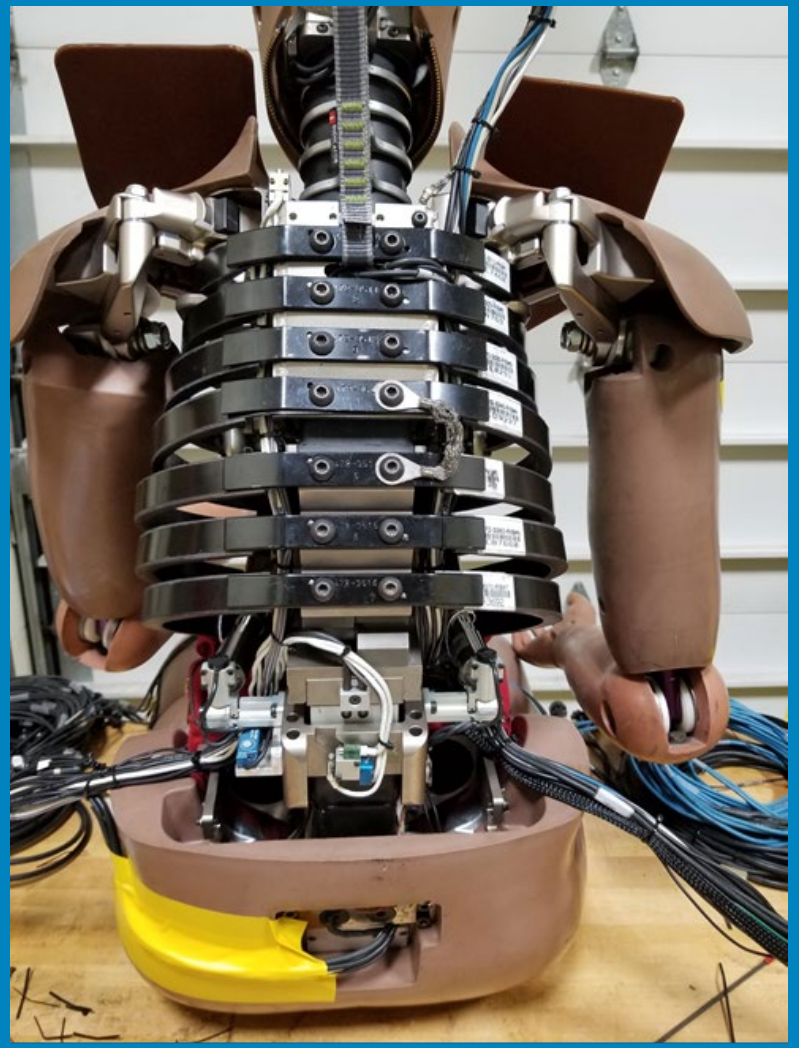
THOR-50M

56 kph: THOR-50M & HIII-50th

	25 Deg Recline	45 Deg Recline
HIII-50th		
THOR-50M		

Instrumented ATD Tests Round 2: Findings

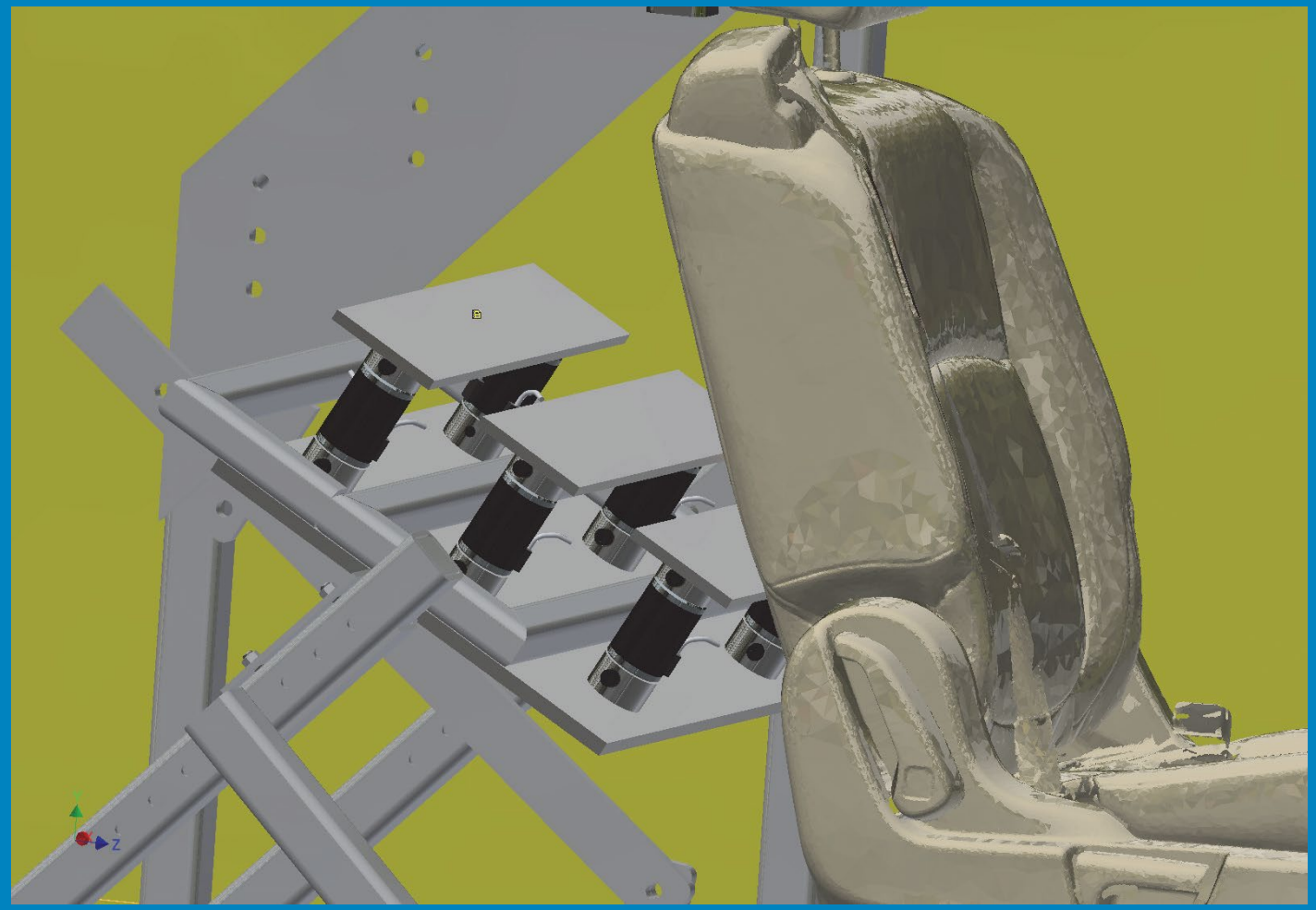
- Rerouting instrumentation cables was effective
- Fixed seatback + fixed head restraint appears to exhibit a repeatable configuration
  - Allows for PMHS vs. ATD comparison of seatback/head restraint interaction



THOR-50M

Seatback/Head Restraint Loads

- 8 load cells per seatback:
  - 1 on head restraint
  - 1 to measure head restraint post load
  - 6 to measure seatback loads (in groups of 2)



Rear-Facing Reclined Testing
PMHS Instrumentation Plan

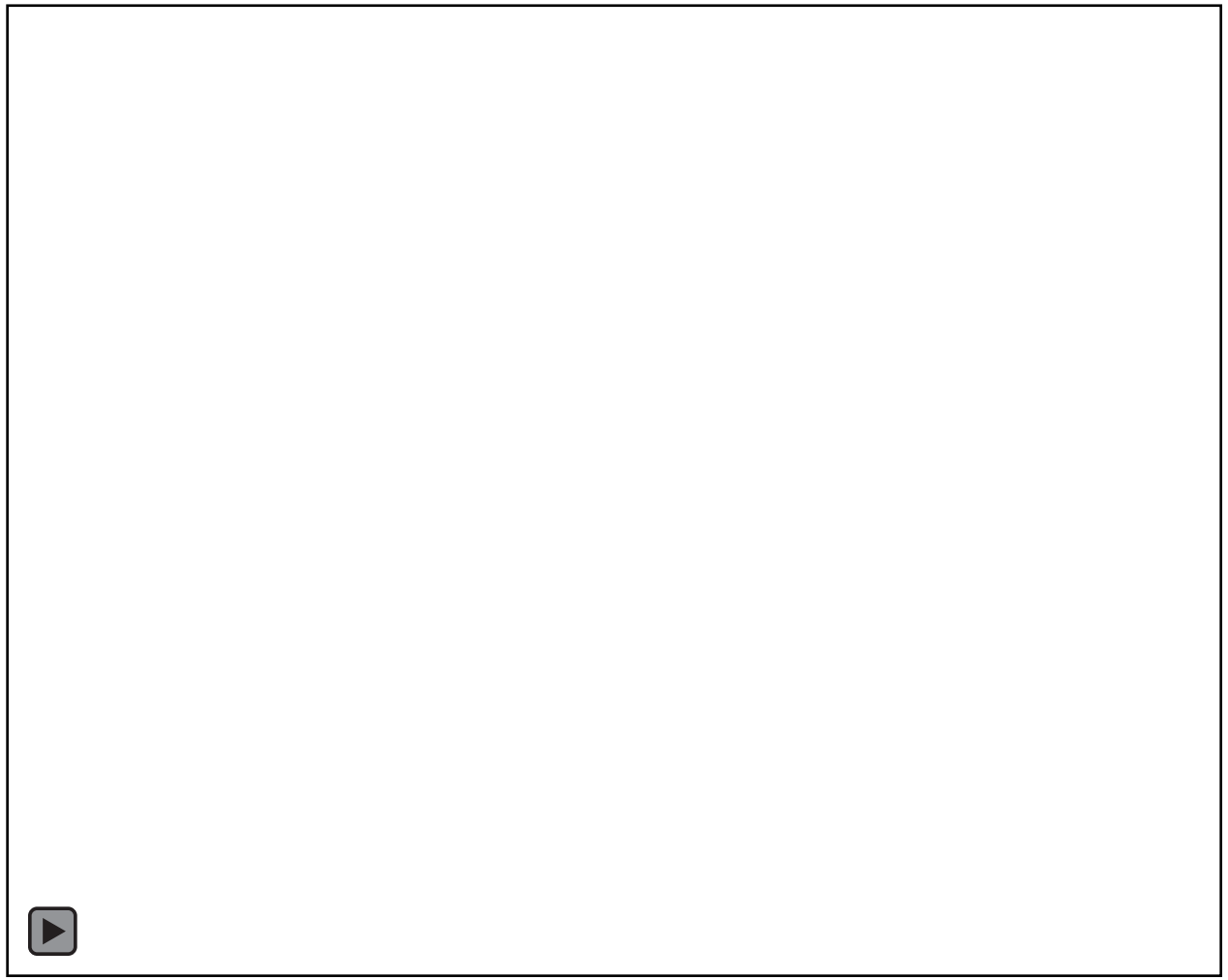
Yun-Seok Kang, PhD

Automated Vehicle Occupant Safety Workshop
11.27.2018

INJURY BIOMECHANICS RESEARCH CENTER
THE OHIO STATE UNIVERSITY

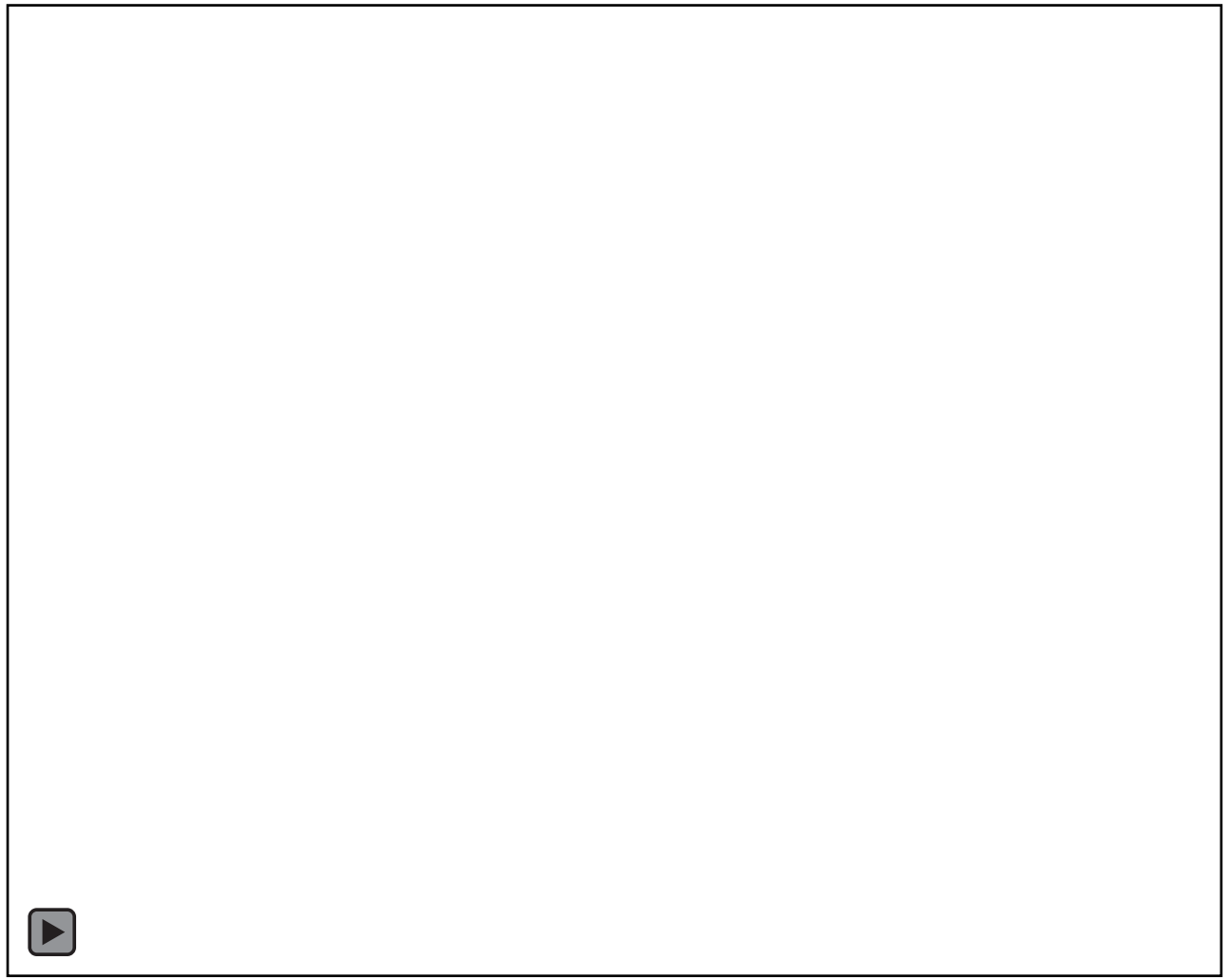
THOR-50M Qualitative Analysis

25° Recline

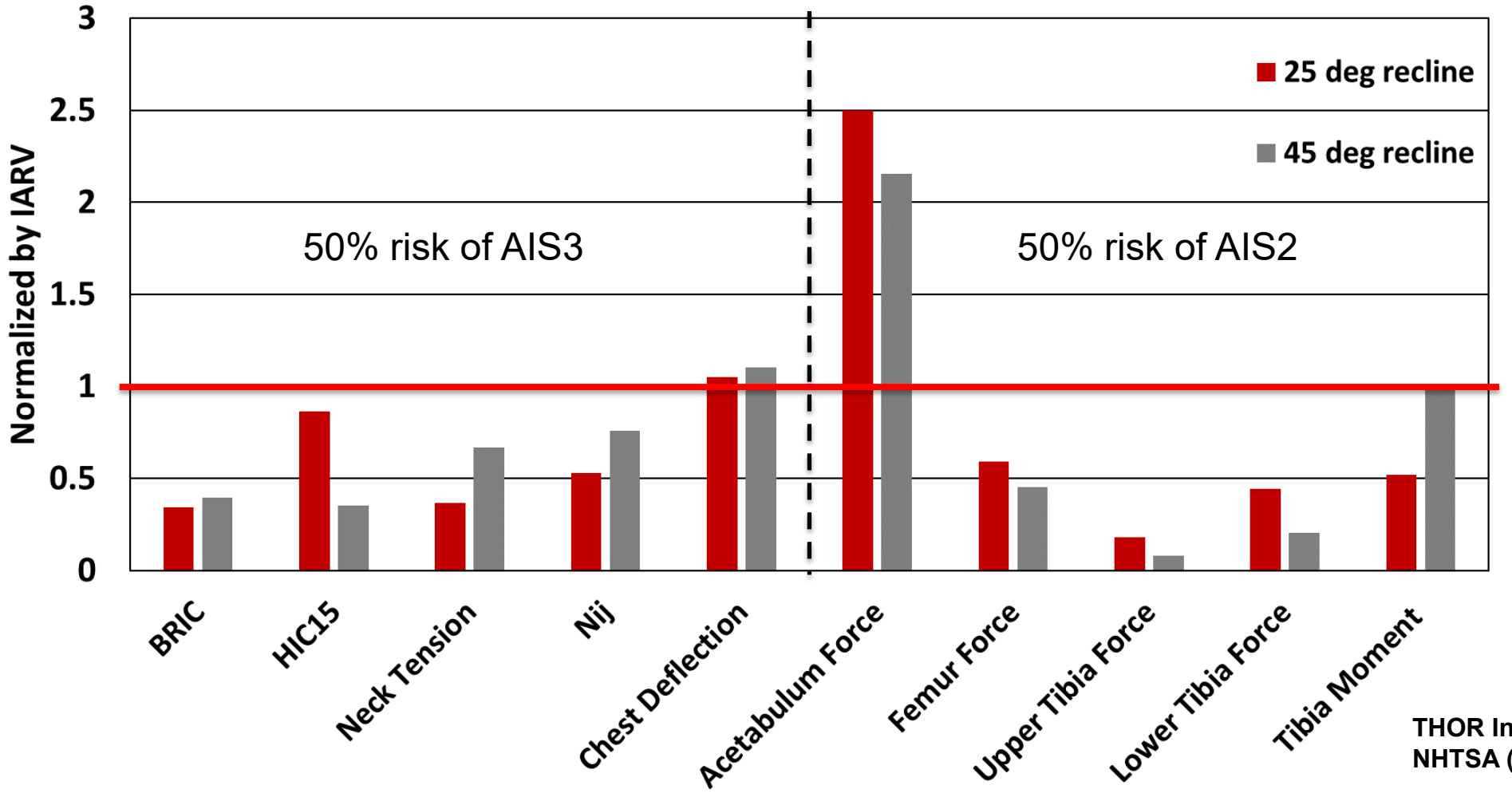


THOR-50M Qualitative Analysis

45° Recline



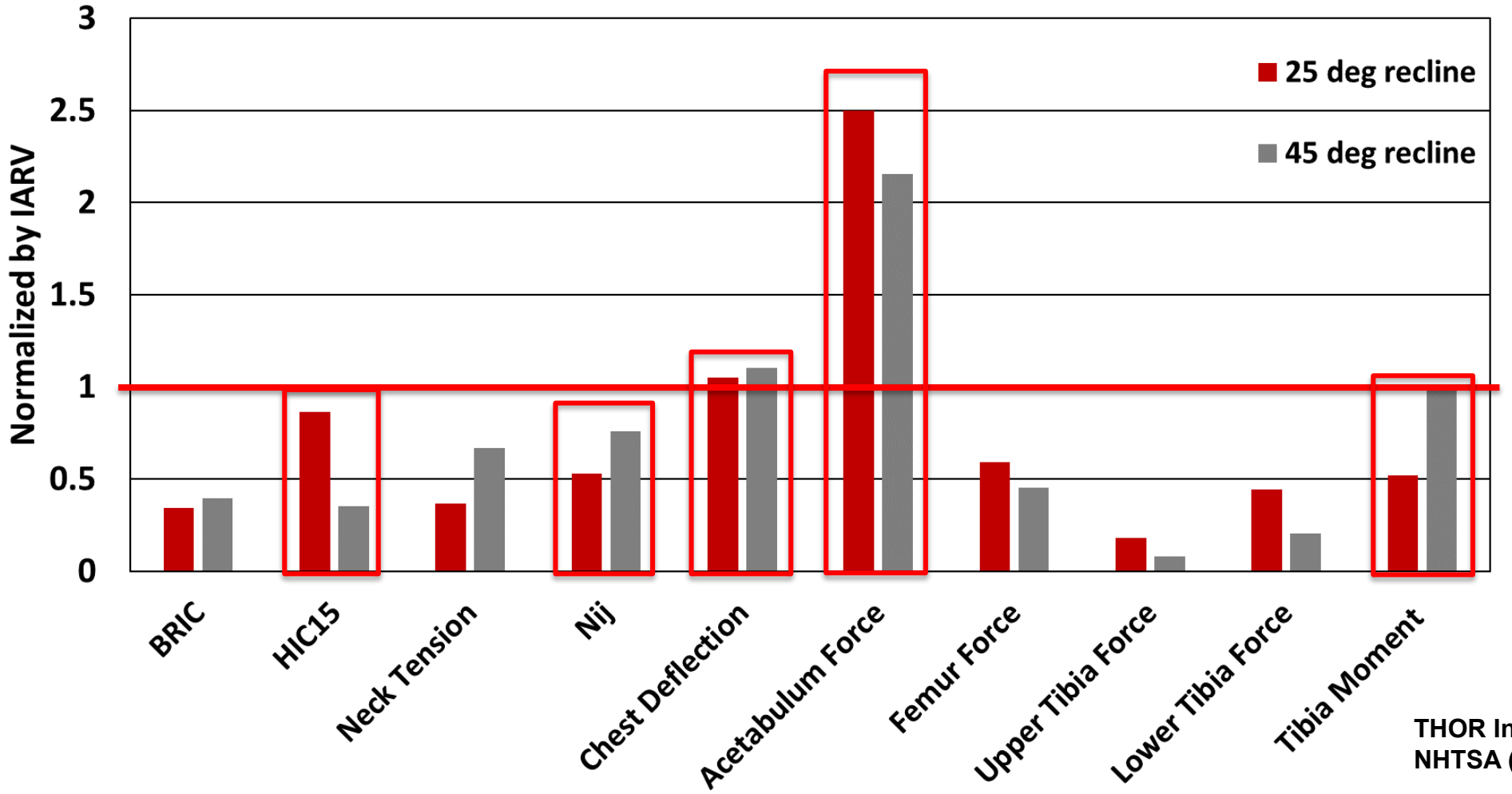
Preliminary Results
THOR-50M 56kph



THOR Injury Criteria Report
NHTSA (unpublished)

This chart is NOT intended to assess injury but to use as a guide for PMHS instrumentation

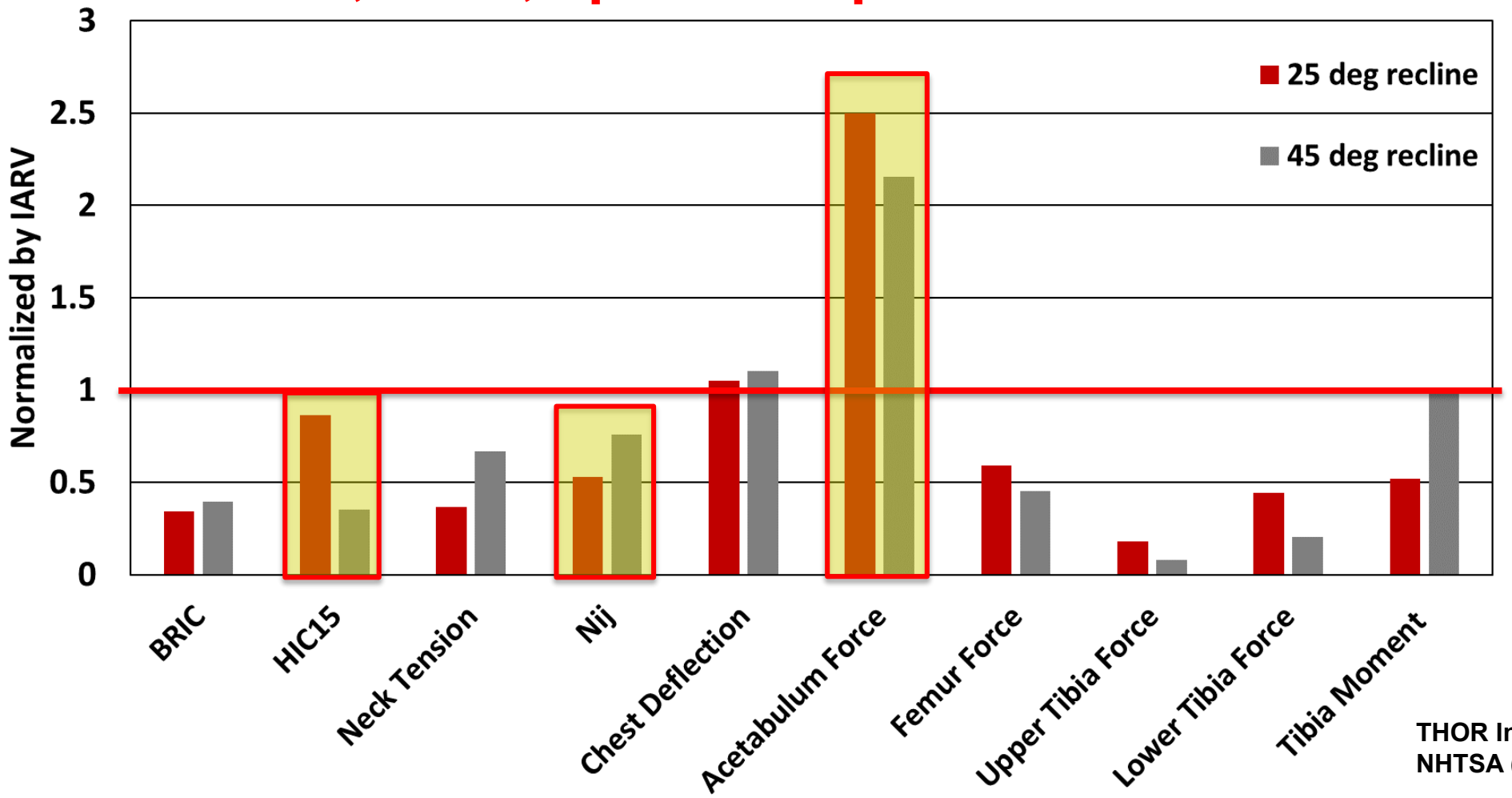
Preliminary Results
THOR-50M 56kph



THOR Injury Criteria Report
NHTSA (unpublished)

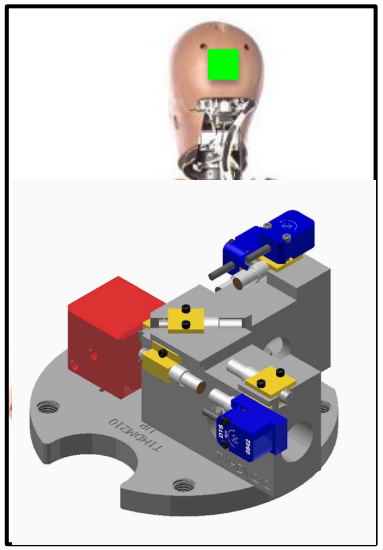
Instrumentation Plan

Head, neck, spine and pelvis kinematics

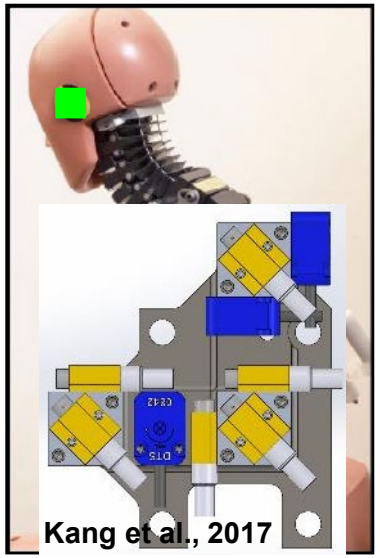


THOR Injury Criteria Report
NHTSA (unpublished)

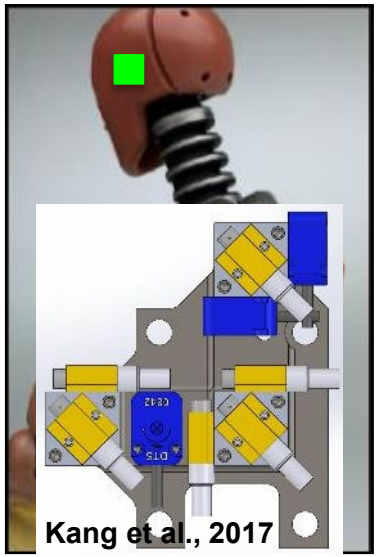
Head, Neck, Spine, and Pelvis
ATD vs. PMHS



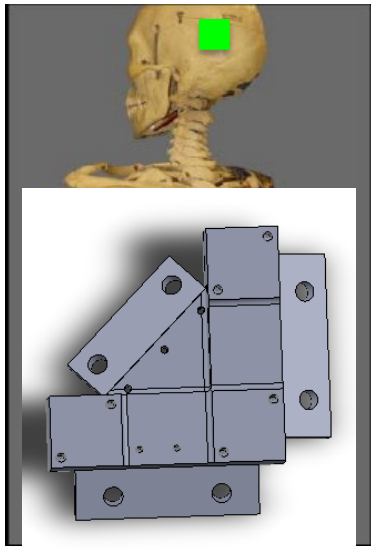
<THOR-50M>



<BioRID II>



<HIII-50th>

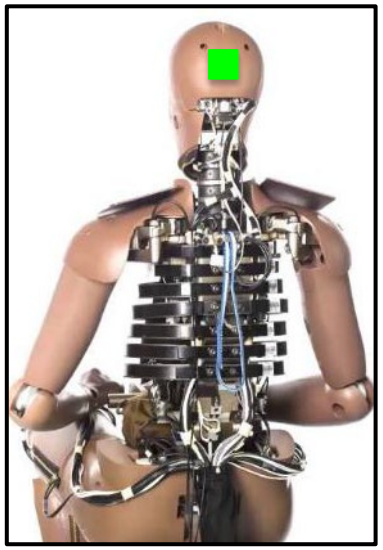


<PMHS>

Coplanar 6aω

	THOR-50M	BioRID II	HIII-50th	PMHS
Head	■	■	■	■
C2/4/6	N/A	●	N/A	●
T1	●	●	N/A	●
T4	N/A	N/A	●	●
T8	N/A	●	N/A	●
T12	●	N/A	N/A	●
L1	N/A	●	N/A	N/A
Pelvis	●	●	●	● ● ●

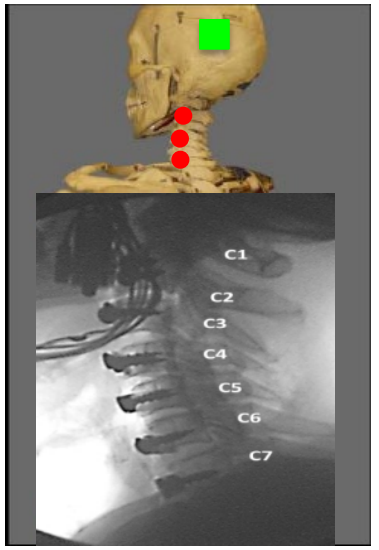
Head, Neck, Spine, and Pelvis
ATD vs. PMHS



<THOR-50M>

<BioRID II>

<HIII-50th>



<PMHS>

Coplanar 6aω

3aω

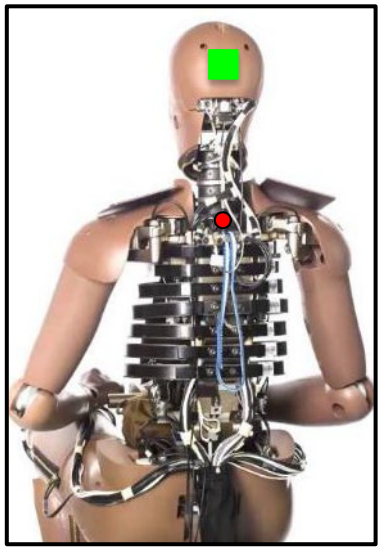
ARS

	THOR-50M	BioRID II	HIII-50th	PMHS
Head	■	■	■	■
C2/4/6	N/A	●	N/A	●
T1	●	●	N/A	●
T4	N/A	N/A	●	●
T8	N/A	●	N/A	●
T12	●	N/A	N/A	●
L1	N/A	●	N/A	N/A
Pelvis	●	●	●	● ● ●

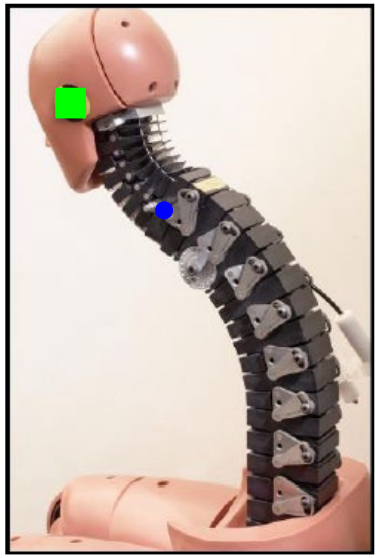
3aω

ARS

Head, Neck, Spine, and Pelvis
ATD vs. PMHS

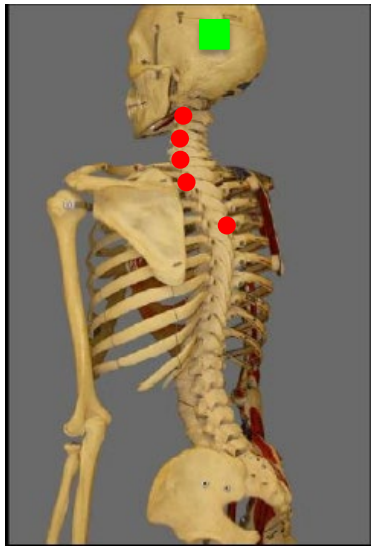


<THOR-50M>



<BioRID II>

<HIII-50th>

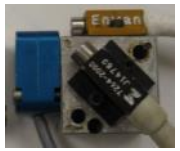


<PMHS>

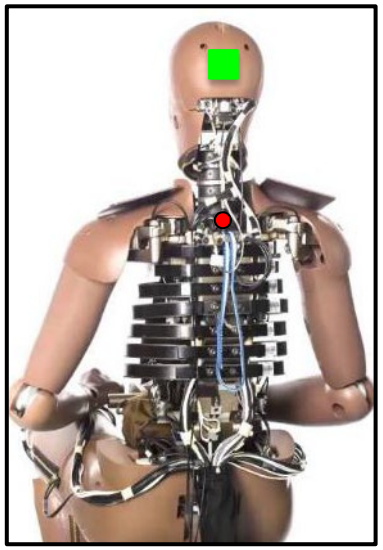
- Coplanar 6aω
- 3aω
- ARS
- Biaxial accelerometers (x, z) and one ARS (y)

	THOR-50M	BioRID II	HIII-50th	PMHS
Head	■	■	■	■
C2/4/6	N/A	●	N/A	●
T1	●	●	N/A	●
T4	N/A	N/A	●	●
T8	N/A	●	N/A	●
T12	●	N/A	N/A	●
L1	N/A	●	N/A	N/A
Pelvis	●	●	●	● ● ●

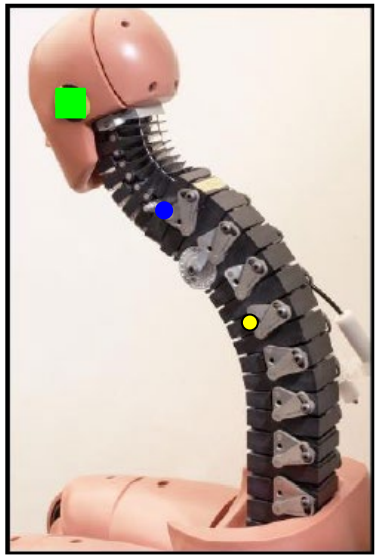
- Biaxial accelerometers (x, z) and one ARS (y)



Head, Neck, Spine, and Pelvis
ATD vs. PMHS

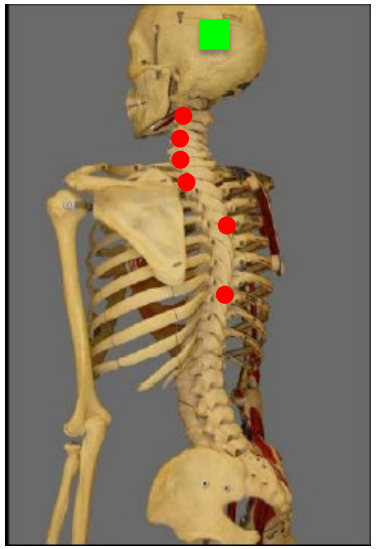


<THOR-50M>



<BioRID II>

<HIII-50th>



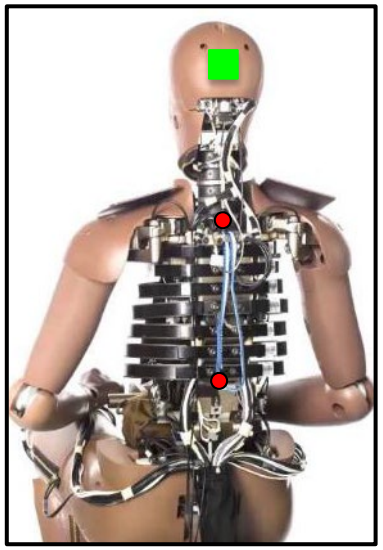
<PMHS>

- Coplanar 6aω
- 3aω
- ARS
- Biaxial accelerometers (x, z) and one ARS (y)
- Biaxial accelerometers (x, z)

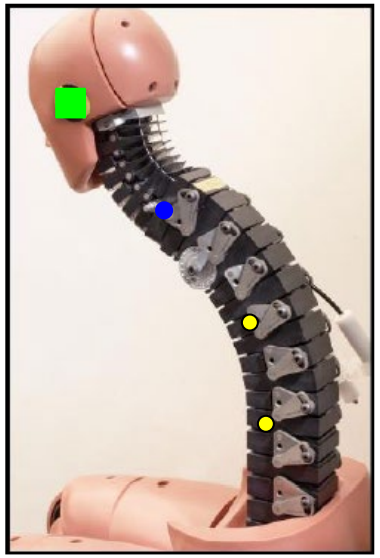
	THOR-50M	BioRID II	HIII-50th	PMHS
Head	■	■	■	■
C2/4/6	N/A	●	N/A	●
T1	●	●	N/A	●
T4	N/A	N/A	●	●
T8	N/A	●	N/A	●
T12	●	N/A	N/A	●
L1	N/A	●	N/A	N/A
Pelvis	●	●	●	● ● ●

- Biaxial accelerometers (x, z)

Head, Neck, Spine, and Pelvis
ATD vs. PMHS

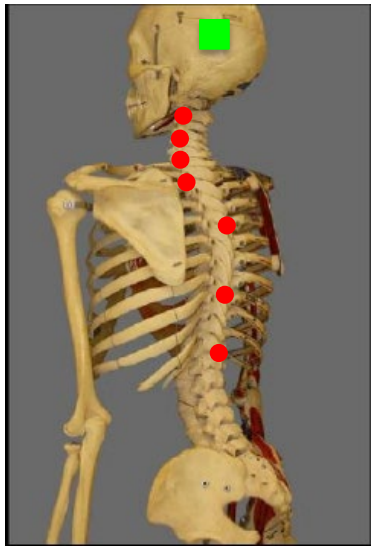


<THOR-50M>



<BioRID II>

<HIII-50th>

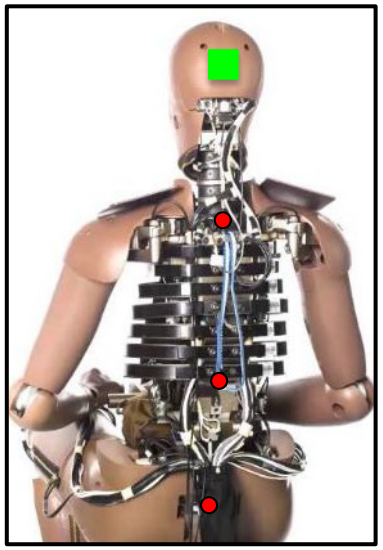


<PMHS>

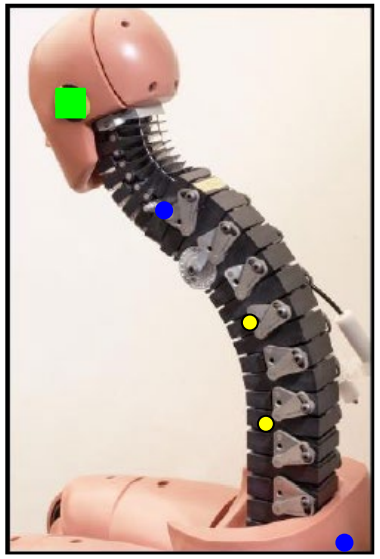
- Coplanar 6aω
- 3aω
- ARS
- Biaxial accelerometers (x, z) and one ARS (y)
- Biaxial accelerometers (x, z)

	THOR-50M	BioRID II	HIII-50th	PMHS
Head	■	■	■	■
C2/4/6	N/A	●	N/A	●
T1	●	●	N/A	●
T4	N/A	N/A	●	●
T8	N/A	●	N/A	●
T12	●	N/A	N/A	●
L1	N/A	●	N/A	N/A
Pelvis	●	●	●	● ● ●

Head, Neck, Spine, and Pelvis
ATD vs. PMHS

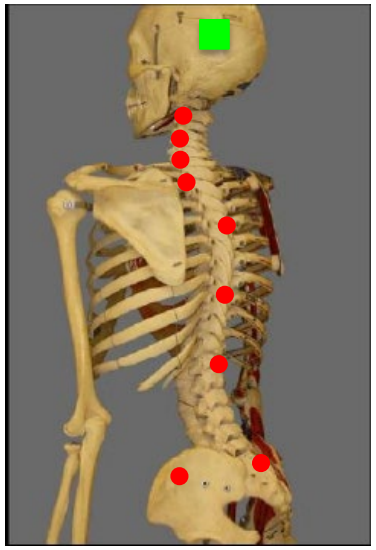


<THOR-50M>



<BioRID II>

<HIII-50th>



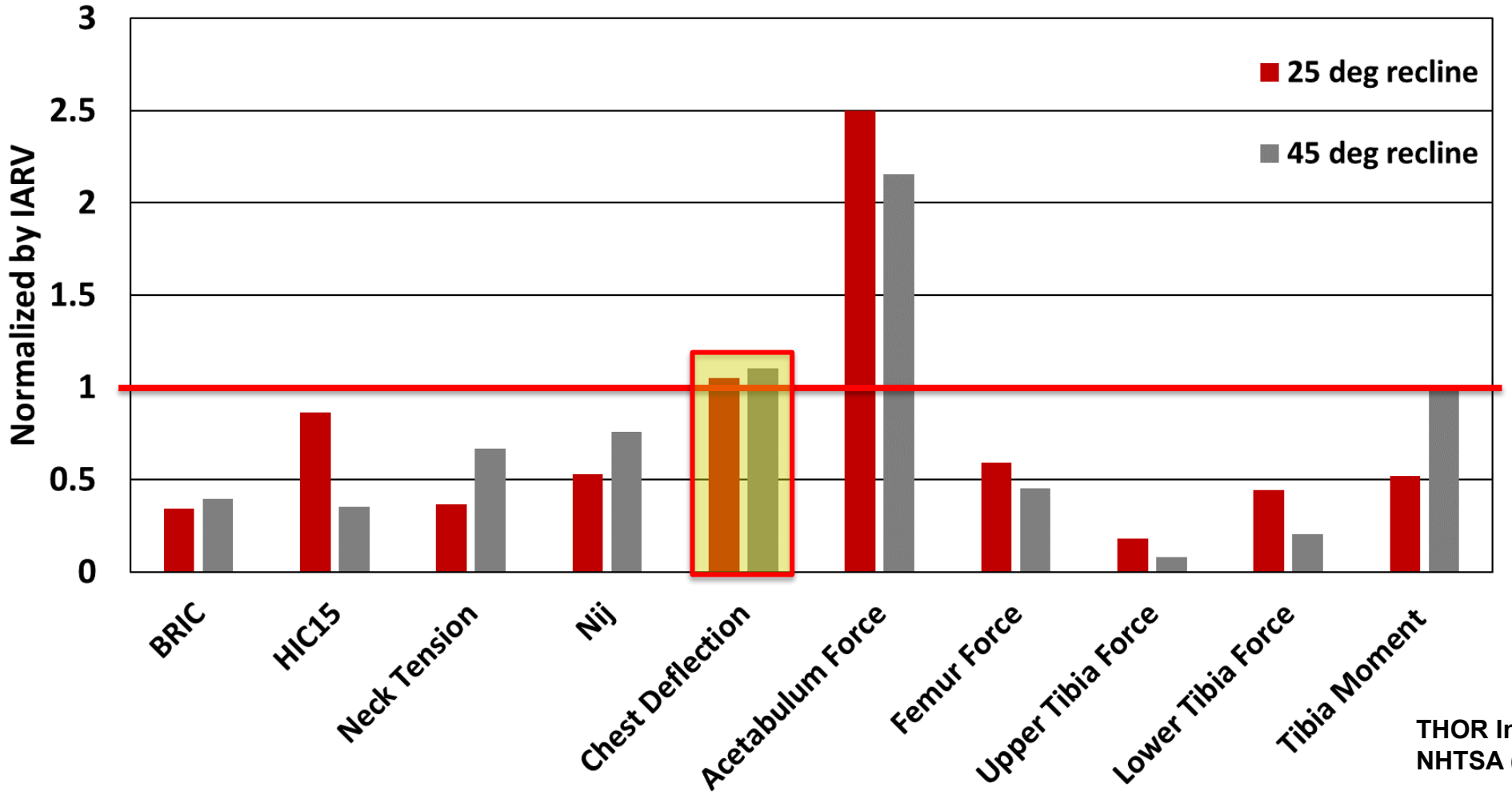
<PMHS>

- Coplanar 6aω
- 3aω
- ARS
- Biaxial accelerometers (x, z) and one ARS (y)
- Biaxial accelerometers (x, z)

	THOR-50M	BioRID II	HIII-50th	PMHS
Head	■	■	■	■
C2/4/6	N/A	●	N/A	●
T1	●	●	N/A	●
T4	N/A	N/A	●	●
T8	N/A	●	N/A	●
T12	●	N/A	N/A	●
L1	N/A	●	N/A	N/A
Pelvis	●	●	●	● ● ●

Instrumentation Plan

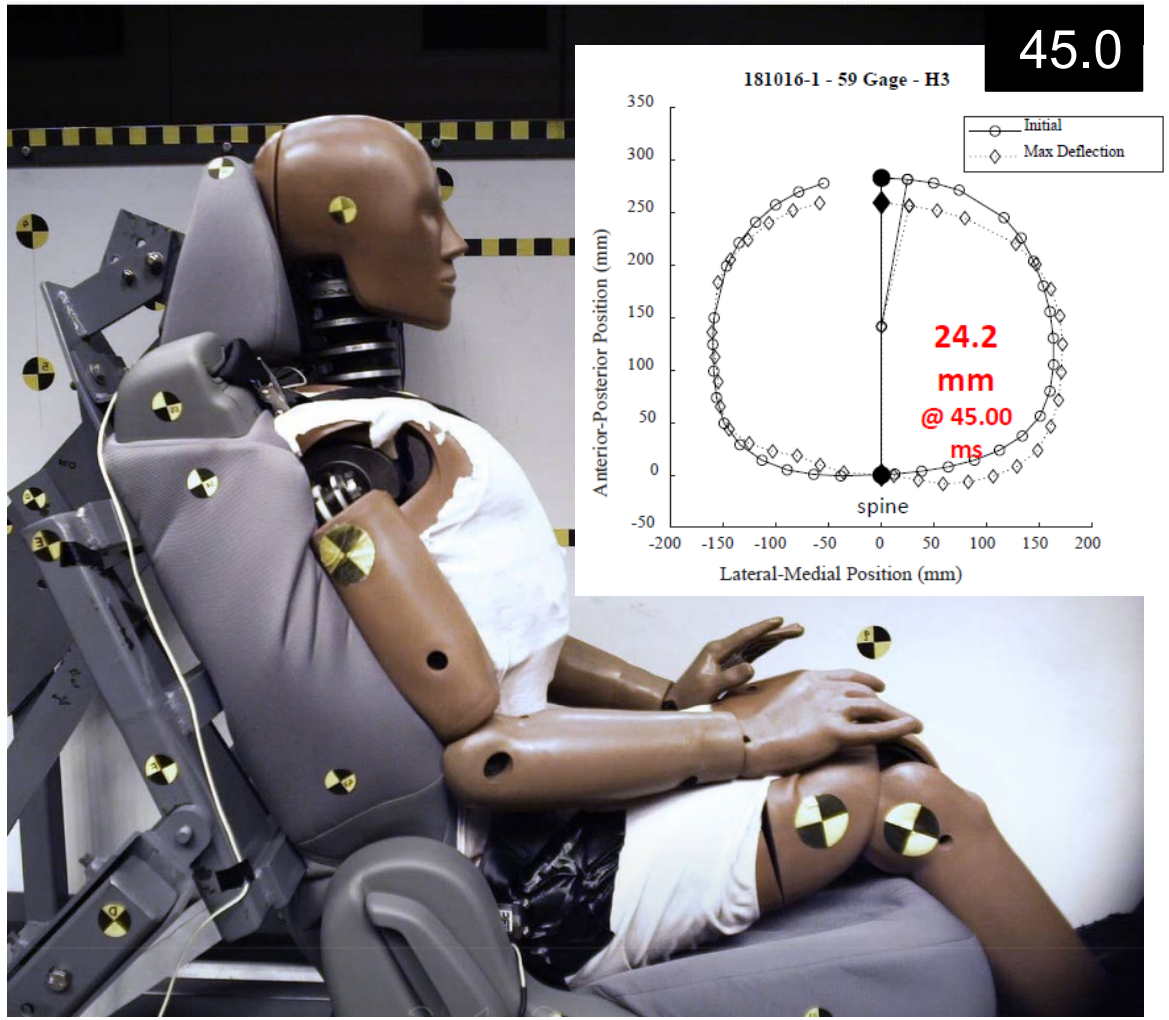
Chest deflection



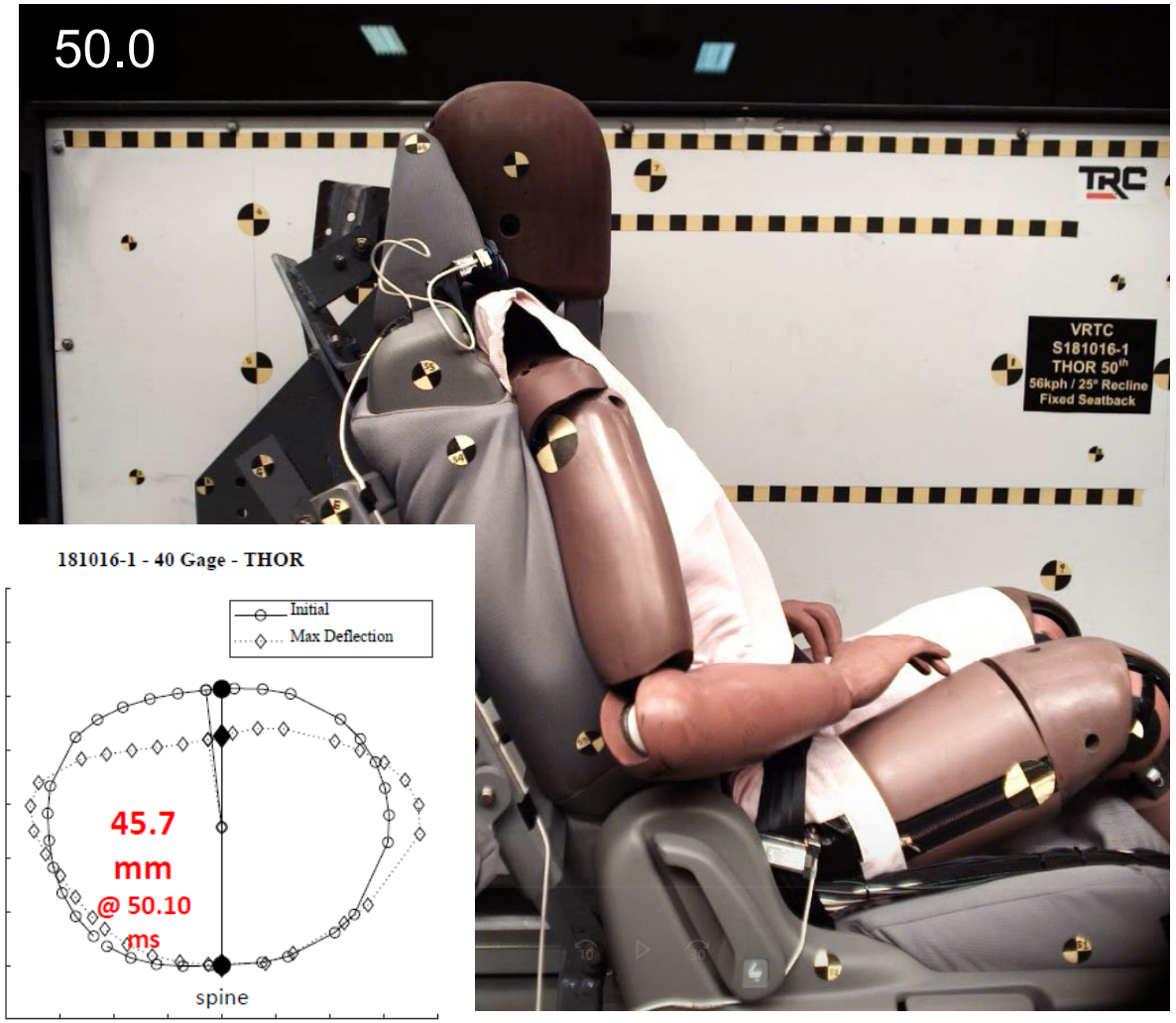
THOR Injury Criteria Report
NHTSA (unpublished)

Thorax
Chest Deflection

45.0

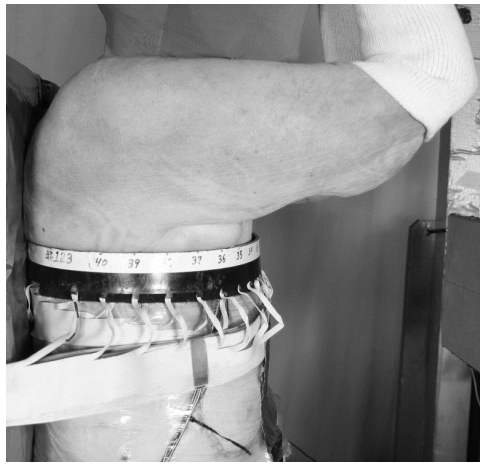


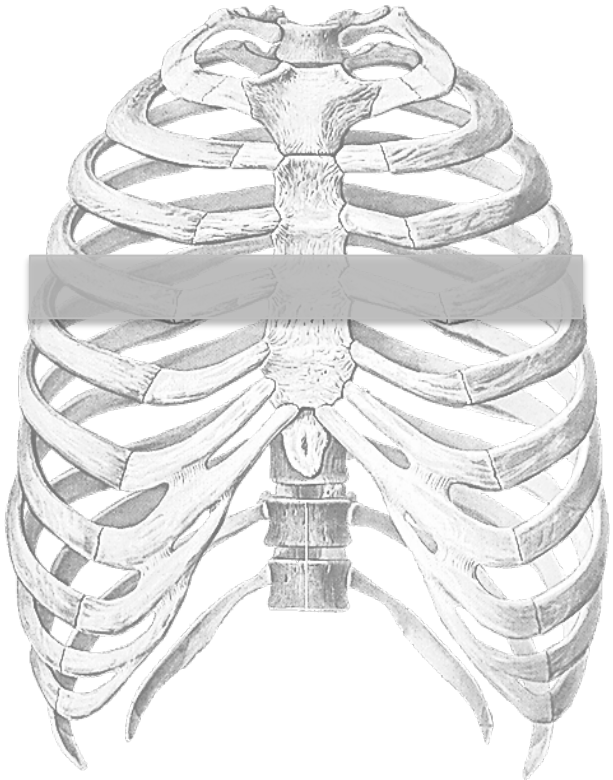
50.0

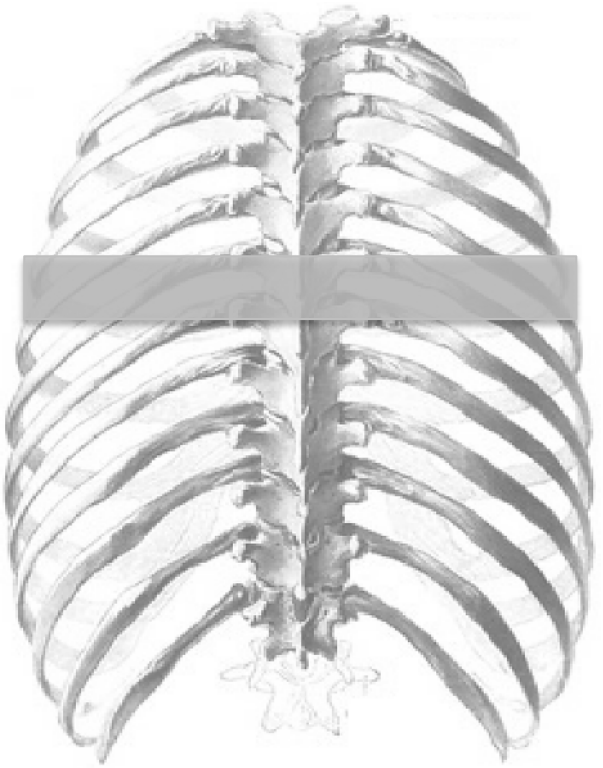


Thorax
Instrumentation

: Chest band



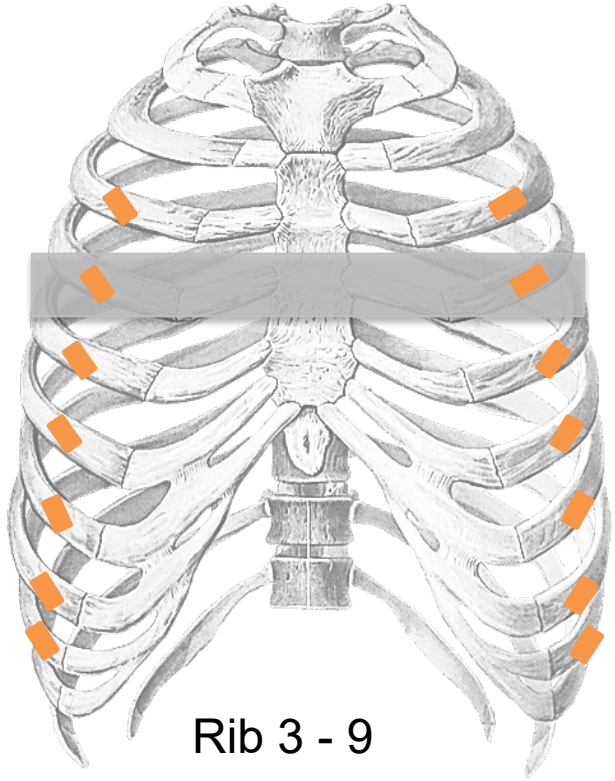




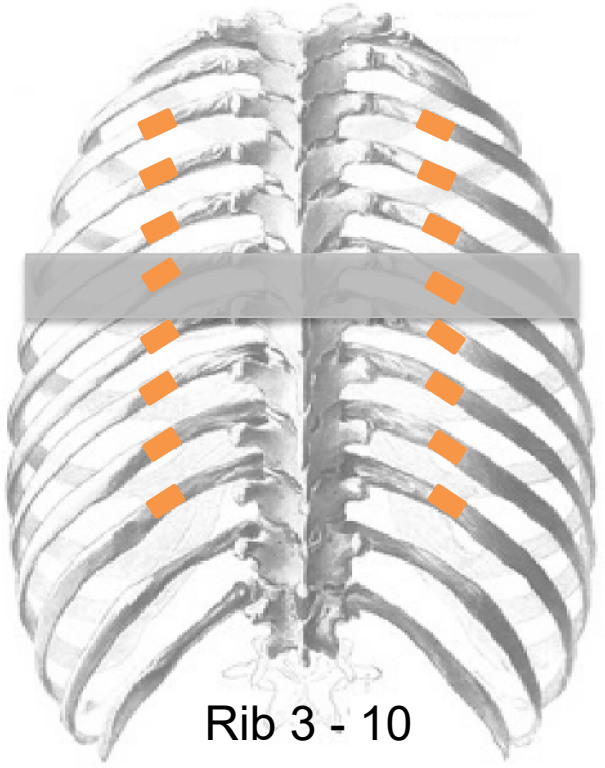
Thorax
Instrumentation

: Chest band

: Strain Gage



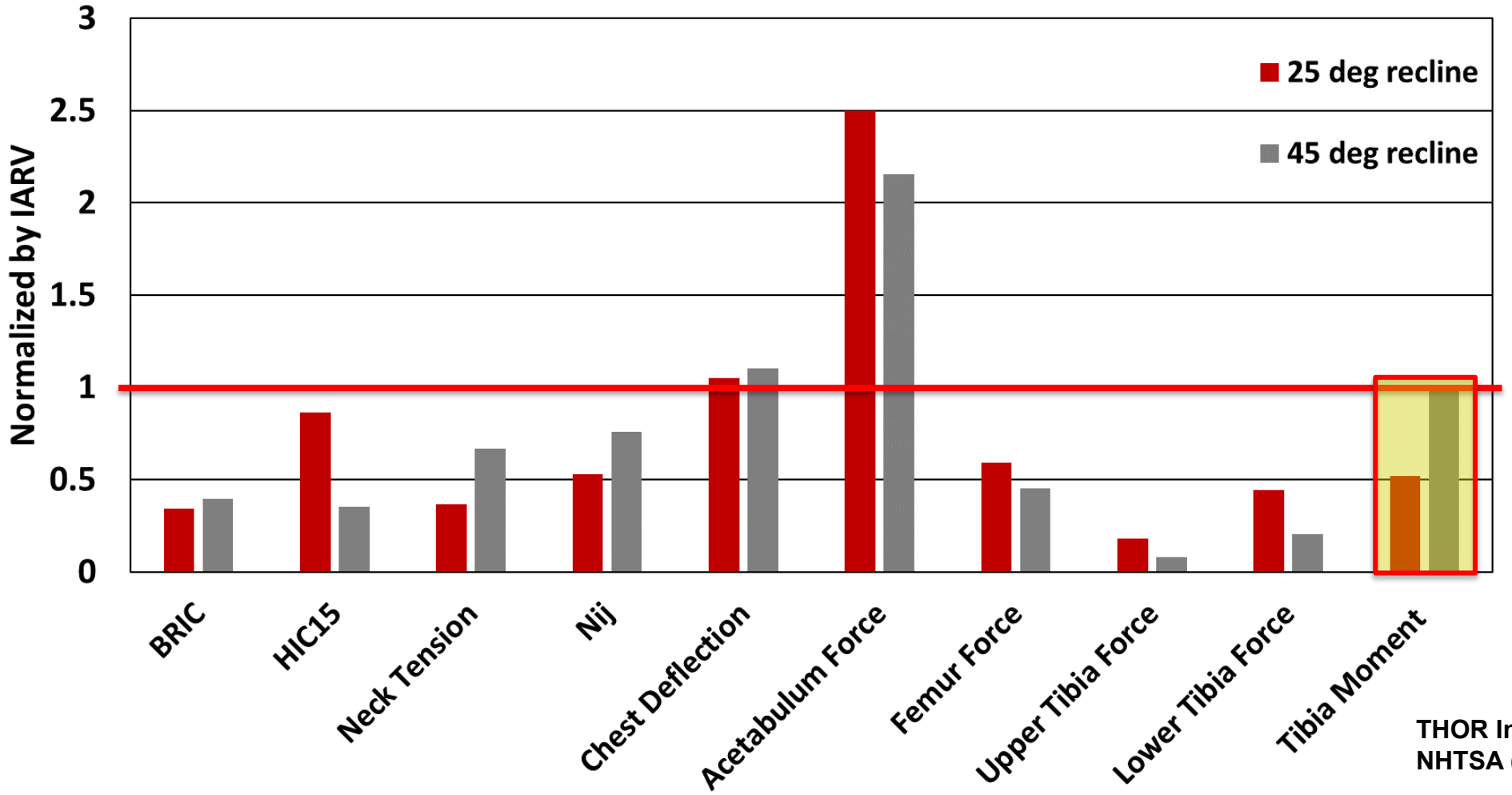
Rib 3 - 9



Rib 3 - 10

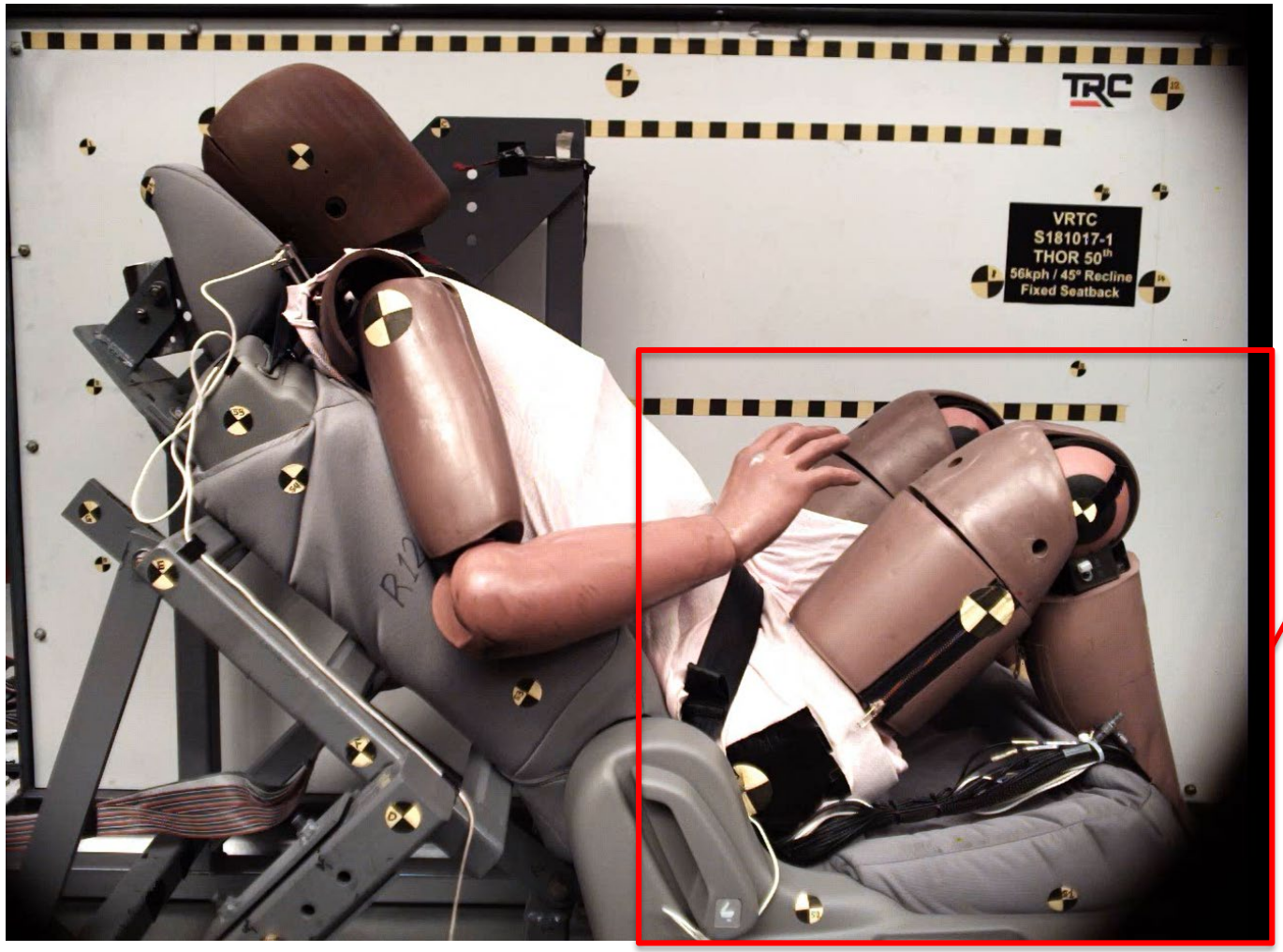
Instrumentation Plan

Femur and tibia

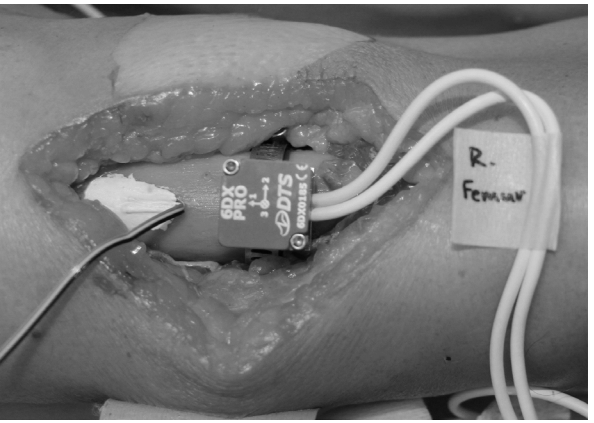


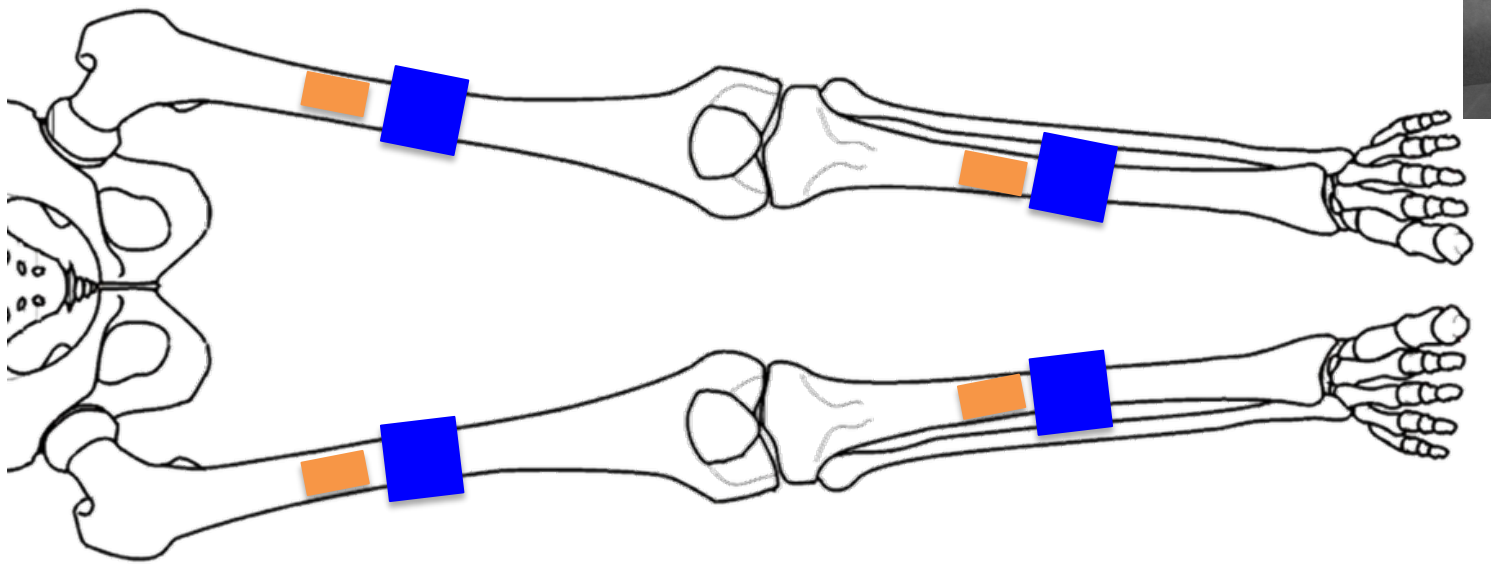
THOR Injury Criteria Report
NHTSA (unpublished)

Seat Pan Interaction with Tibia



Femur and Tibia
Instrumentation





3aω

Strain Gage