

Introduction of a New Thorax for a Large Child ATD



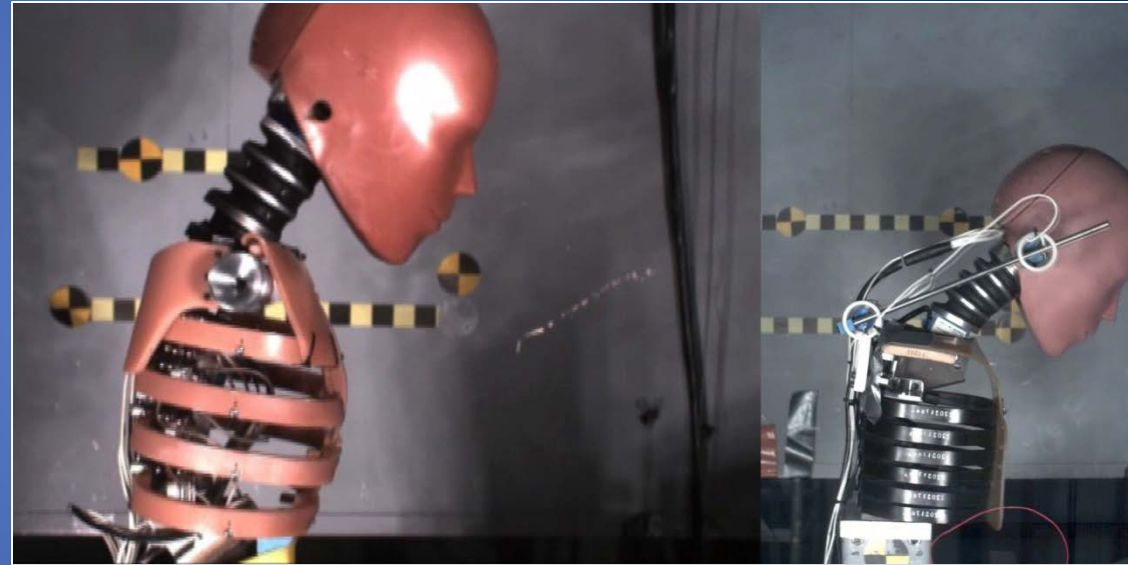
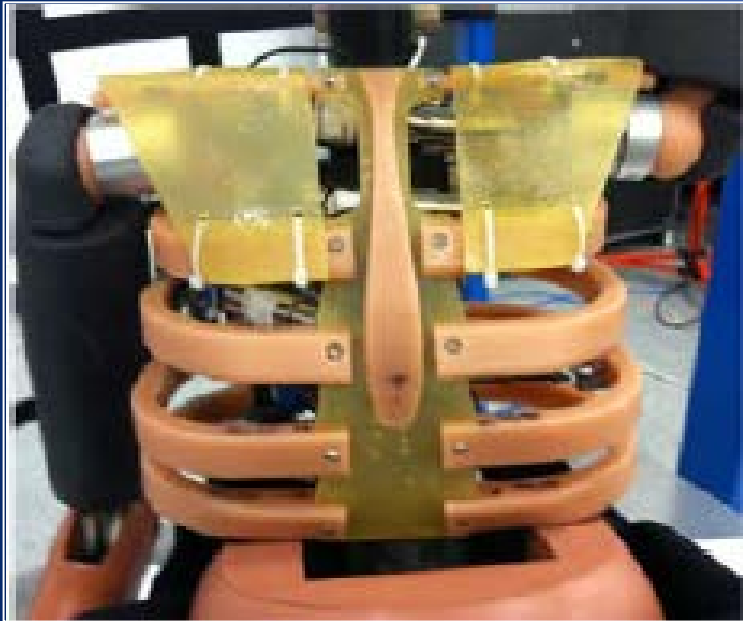
Jason Stammen
NHTSA Vehicle Research & Test Center

Advances in Child Injury Prevention
May 29, 2014

Motivation

- **NHTSA stated in FMVSS No. 213 Final Rule (2012) that research will continue to enhance Hybrid III 6/10YO ATDs**
 - Develop head and abdomen injury criteria
 - Chin-chest contact due to rigid thoracic spine
 - Lack of instrumented abdomen
- **Pediatric biomechanical studies initiated and ATD prototype hardware developed**
 - 6YO size: abdomen/pelvis (DAPRR)
 - 10YO size: thorax (LODC)

Large Omnidirectional Child (LODC)



Large Omni-Directional Child (LODC) Thorax

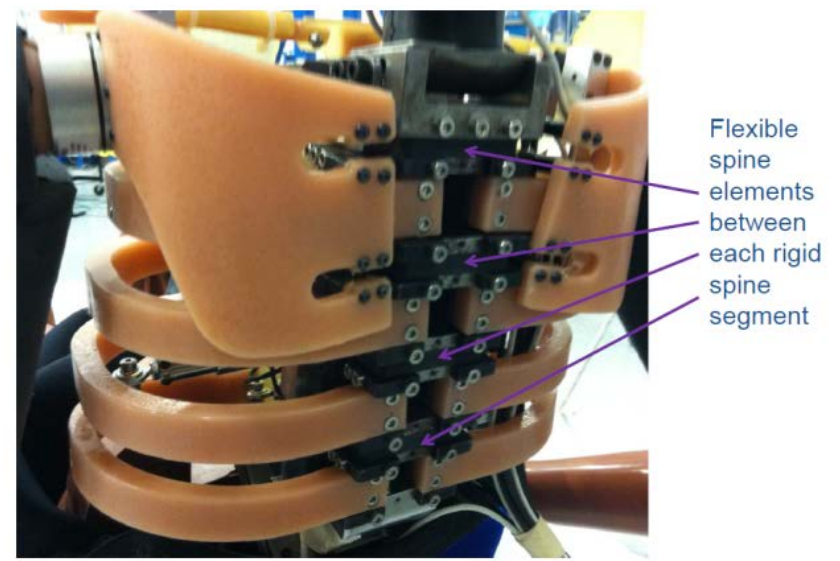
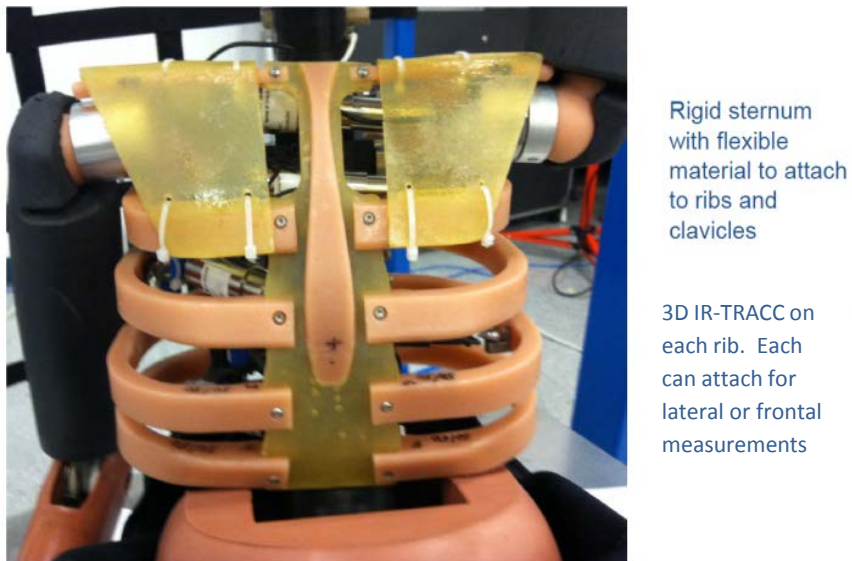
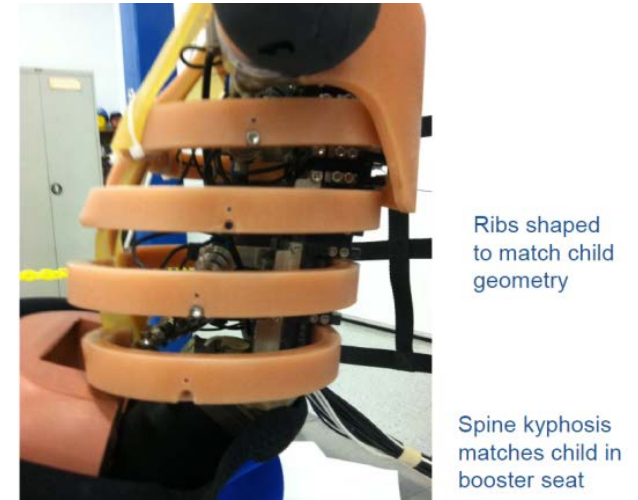
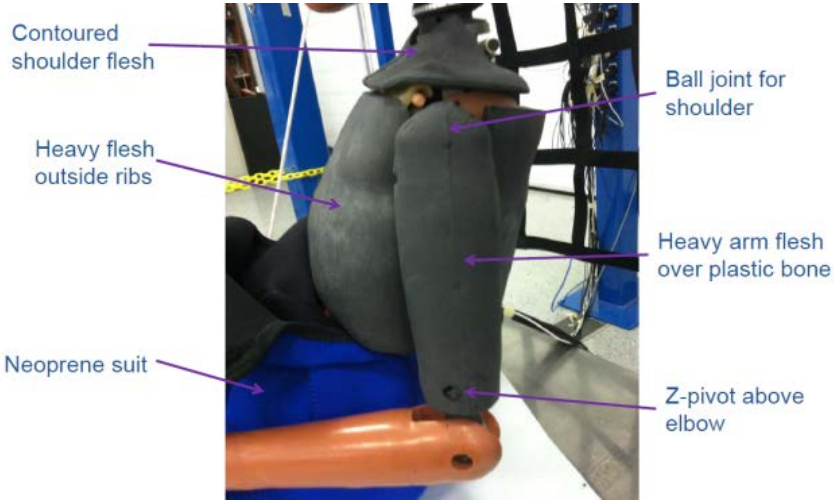
- Flexible spine (tunable)
- Anthropometry
 - Shoulder
 - Forward pelvis & inclined lumbar
 - Ribcage
- Multi-point thoracic deflection

LODC Thorax

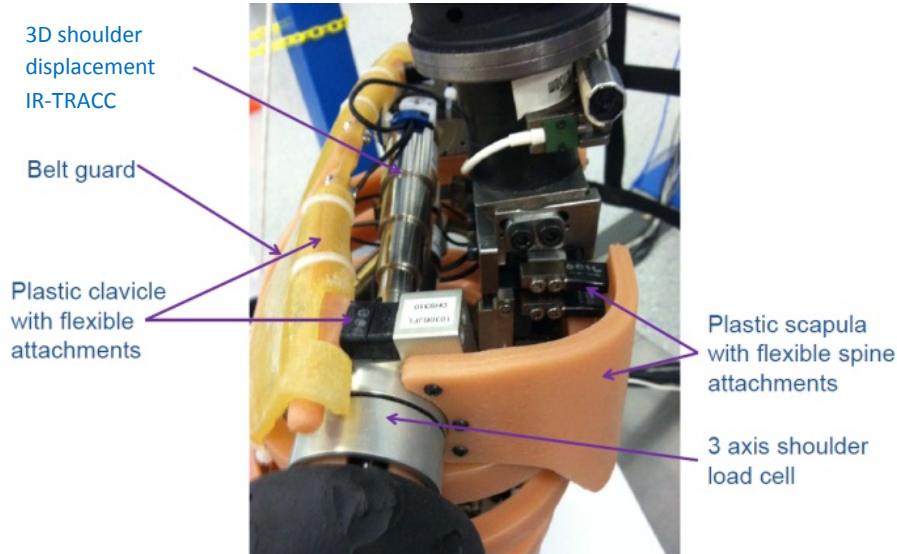
Hybrid III Thorax

Goal: Improved head kinematics & belt interaction

LODC Features – Thorax

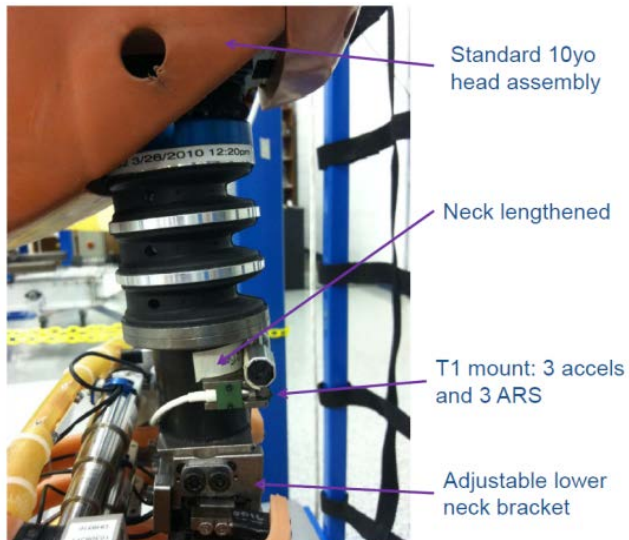
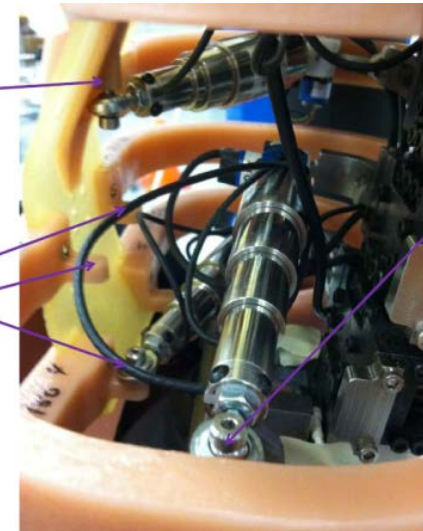


LODC Features – Shoulder & Instrumentation

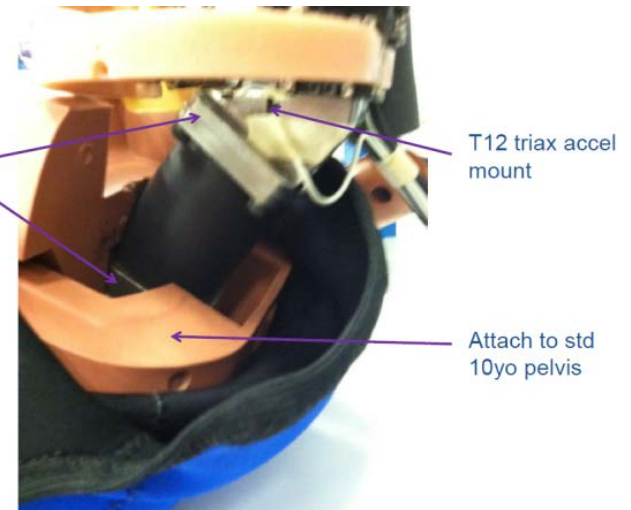


IR-TRACCs on ribs 1 & 2 can attach to sternum for frontal measurement

IR-TRACCs on ribs 3 & 4 can be attached to rib on either side of sternum



Adapters to use std 10yo lumbar but adjust orientation for correct positioning of pelvis to match child seated in a booster seat.



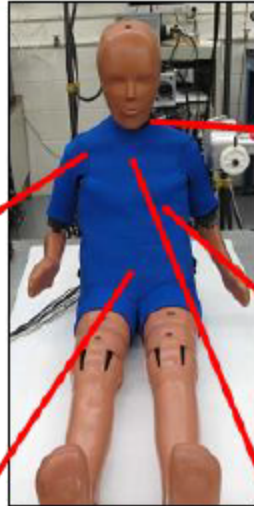
Project Approach

1. Develop concept thorax with flexible characteristics & improved anthropometry
2. Evaluate biofidelity, durability, and repeatability of LODC thorax in component and sled conditions
3. Optimize the response & durability of LODC based on step 2 evaluation results
4. Conduct LODCrev1 tests and compare with Hybrid III and Q-series ATDs
5. Initiate round robin evaluation of evolved prototype ATD with interested parties
 - Combine best attributes into a harmonized child ATD

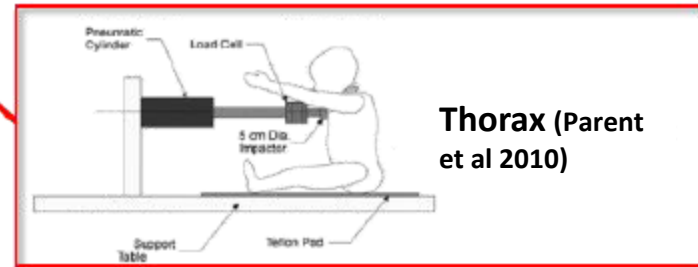
Biofidelity Evaluation



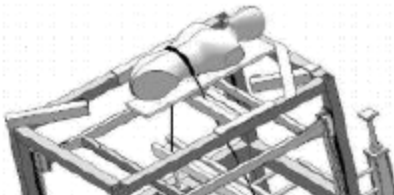
Shoulder
(Suntay et al 2011)



Neck (Dibb et al 2013)



Thorax (Parent et al 2010)



Abdomen (Kent et al 2006, 2008, 2011; Hardy et al 2001; Rouhana et al 2001)



Thoracic Spine (Lopez-Valdes et al 2010, 2011; Stammen et al 2012)



Full body kinematics
(Arbogast et al 2009; Ash et al 2009; Dibb et al 2013)

Observations: Biofidelity

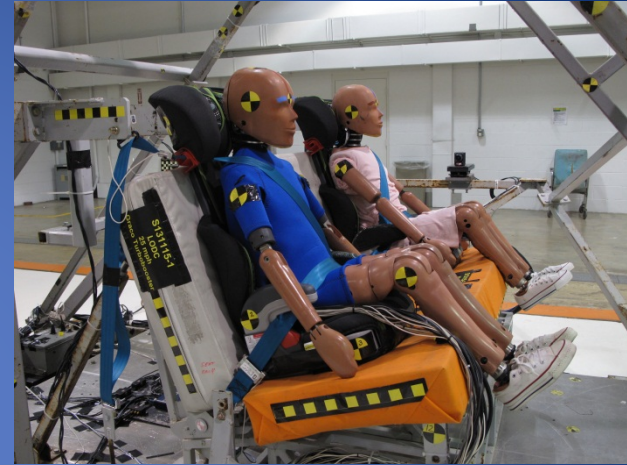
Test condition	Observation
Frontal thorax	Met 6YO based corridor
Lateral thorax & shoulder	Met scaled corridors
Quasi-static oblique shoulder	Stiffer than pediatric volunteers (but it is not dynamic)
Neck flexion	Moment consistent with Duke model at peak rotation
Thoracic Spine	Softer than scaled adult PMHS response
Abdomen	Met UVA corridor
Low speed sled (bumper car)	Greater downward & less forward head motion than pediatric volunteers
Medium/high speed sled	Similar head kinematics as NBDL volunteers & 13YO PMHS

*All test modes showed good/excellent repeatability

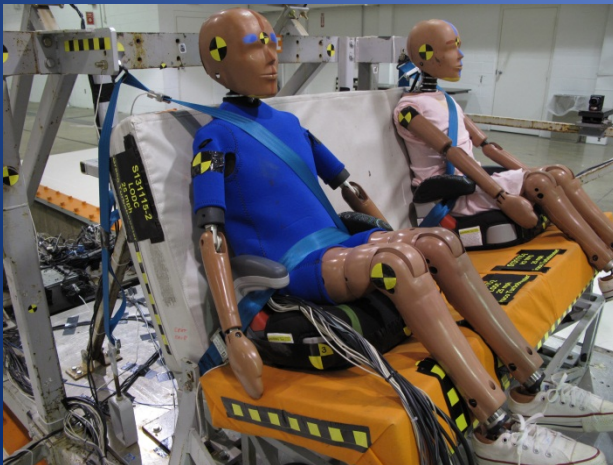
Sled Testing



5 point harness CRS



Highback BPB

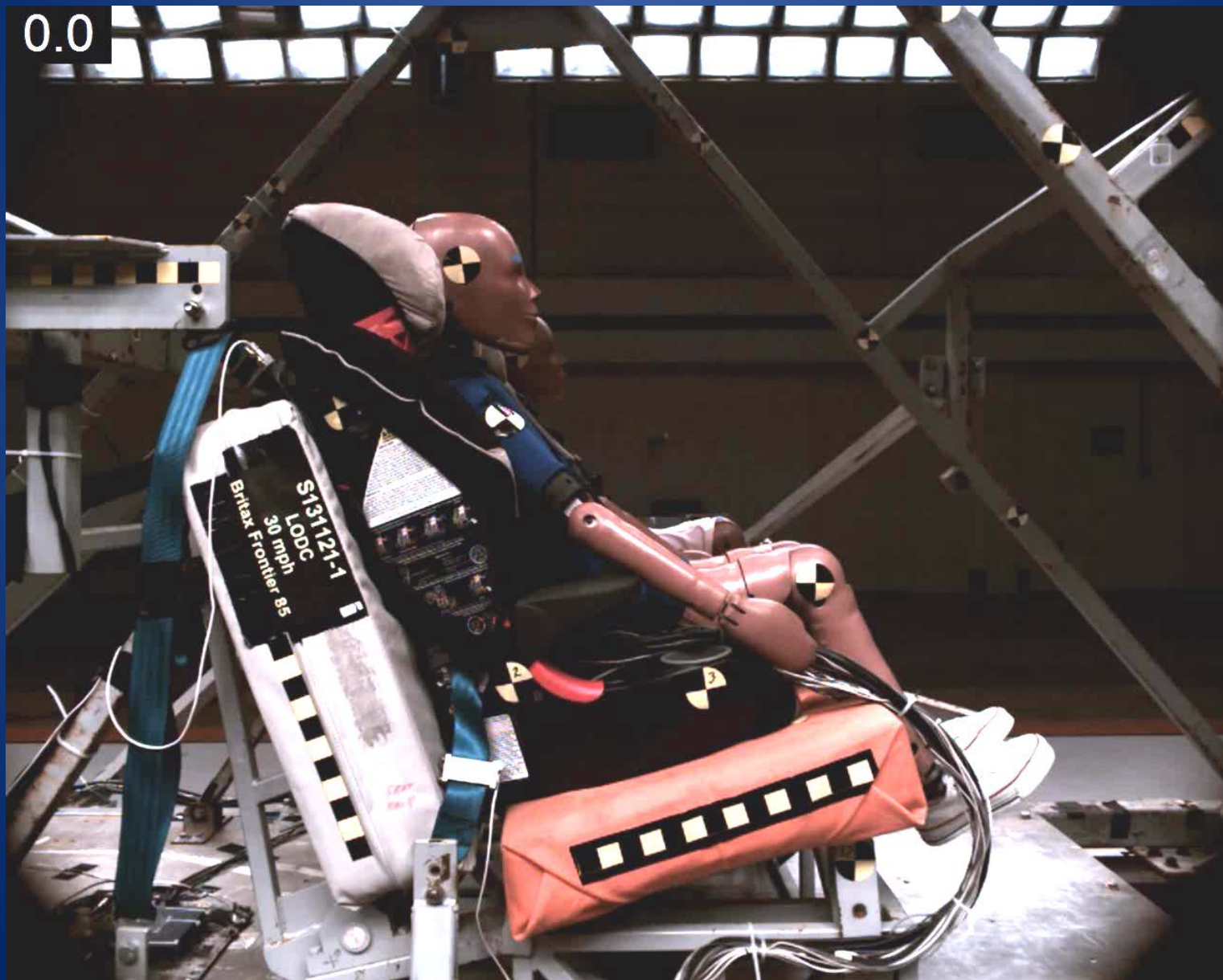


Backless BPB

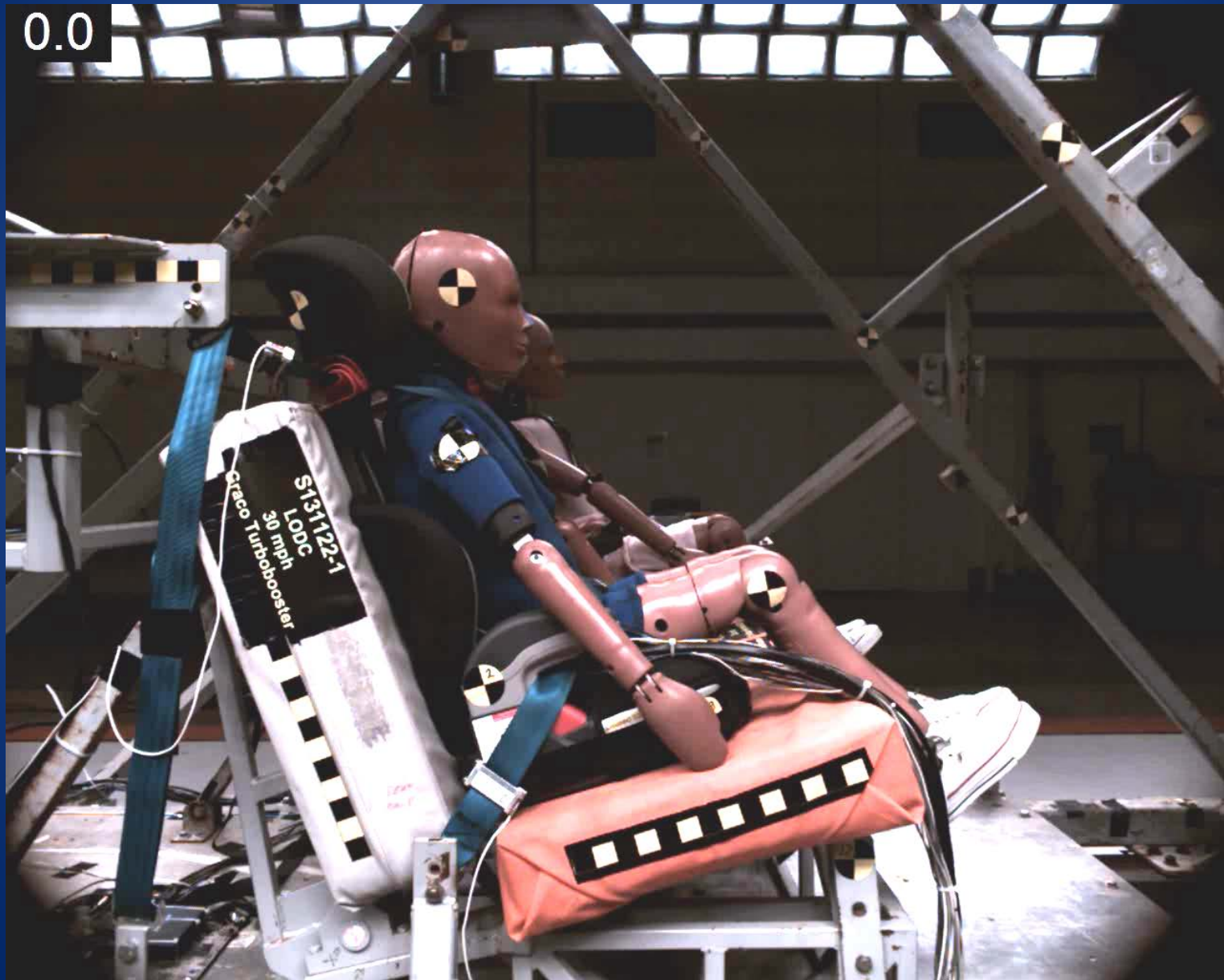


No CRS

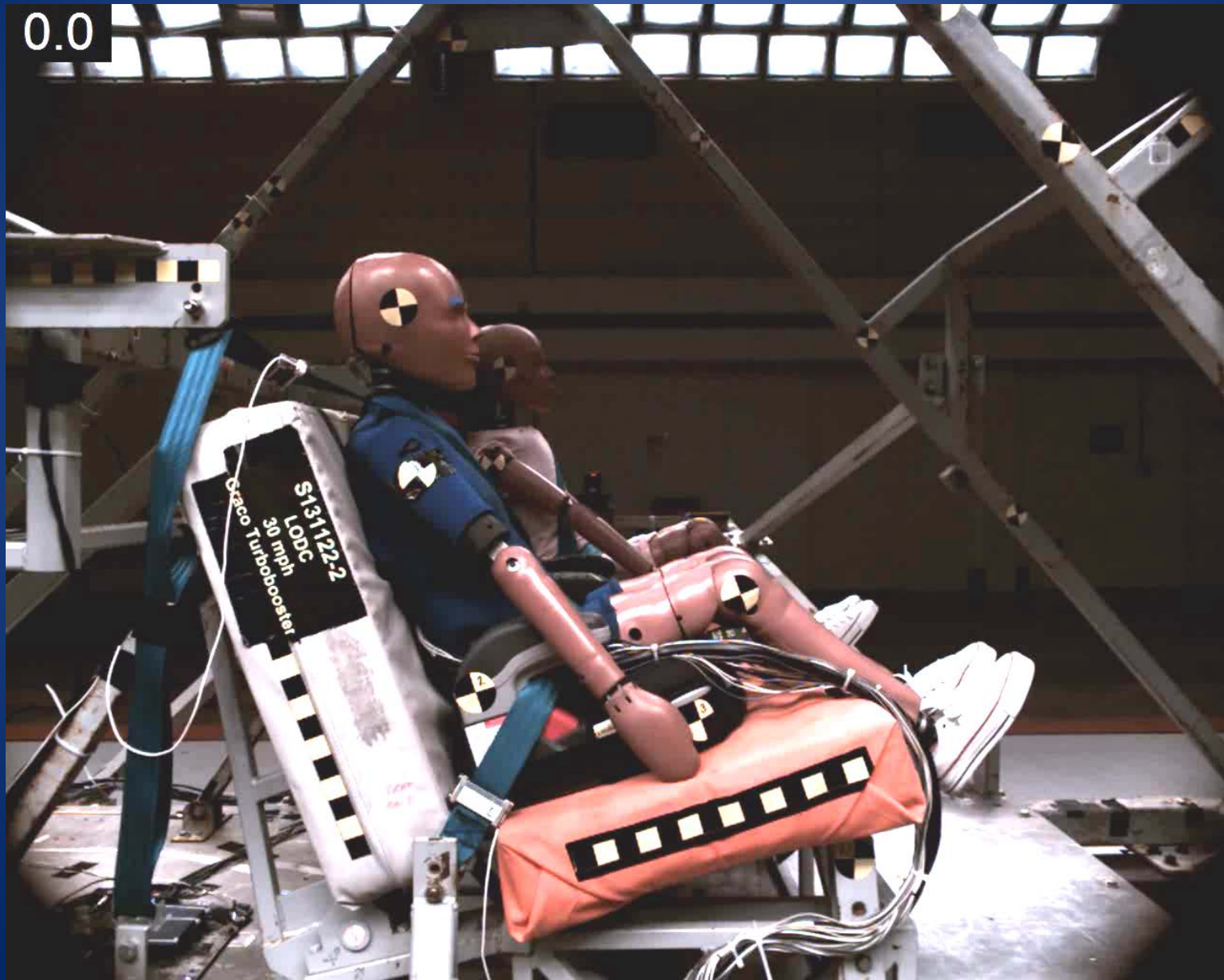
5 Point Harness (213 Pulse)



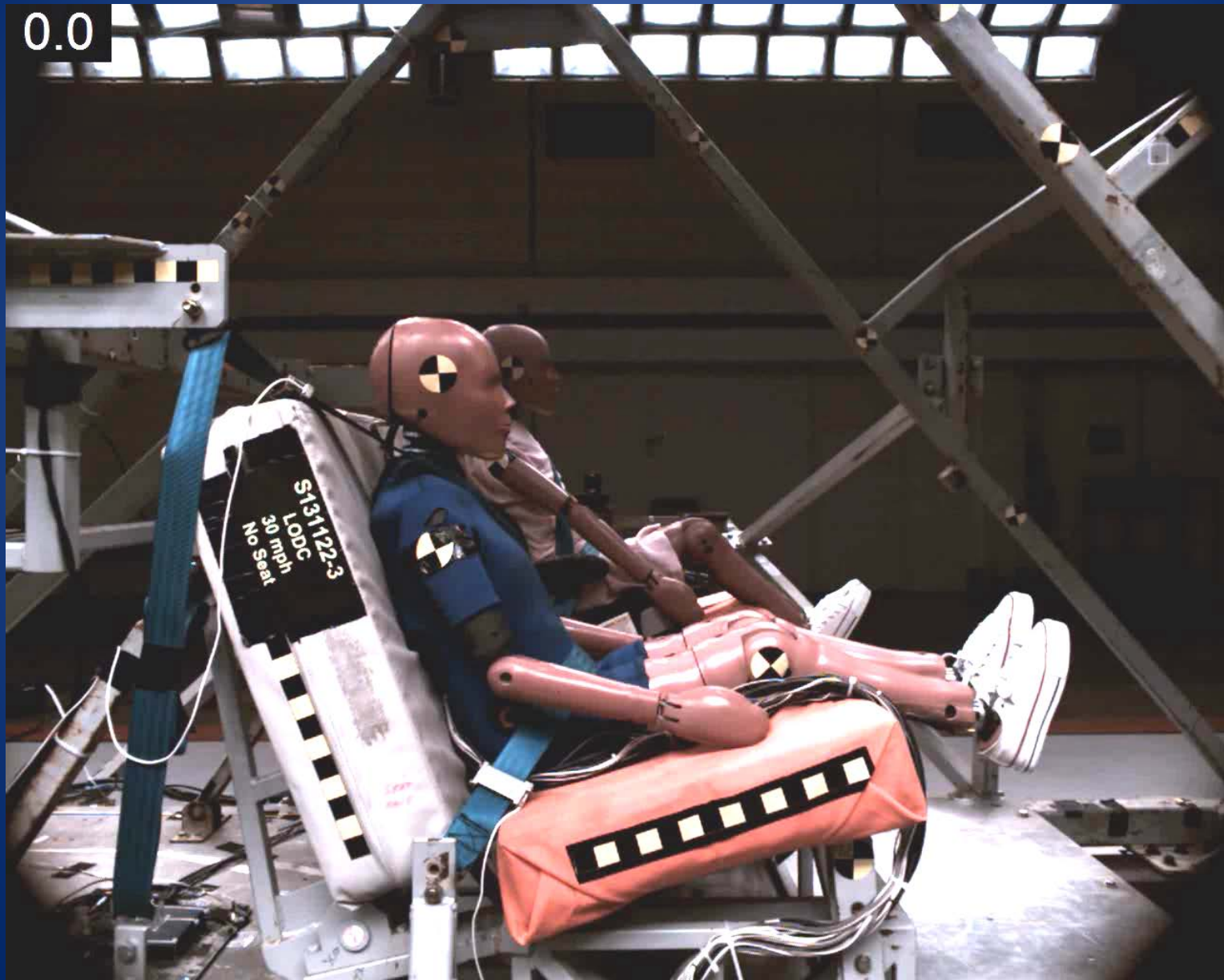
Highback BPB (213 Pulse)



Backless BPB (213 Pulse)



No CRS (213 Pulse)



Observations: Sled Tests

5 point harness CRS

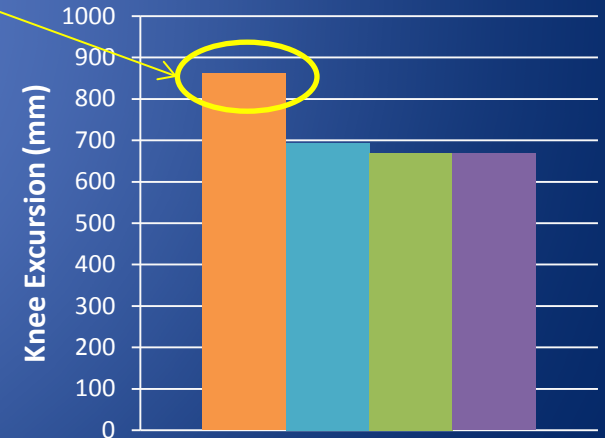
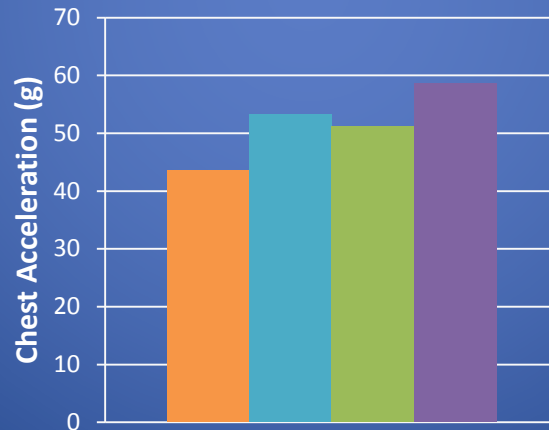
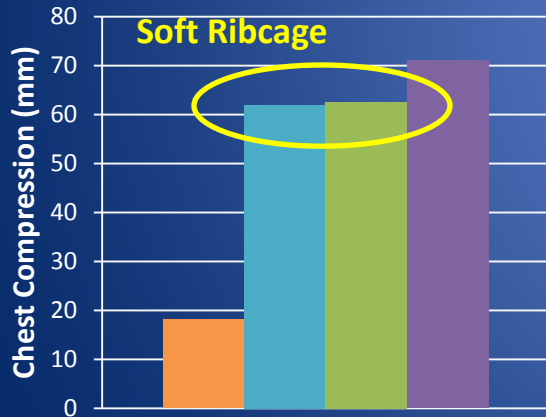
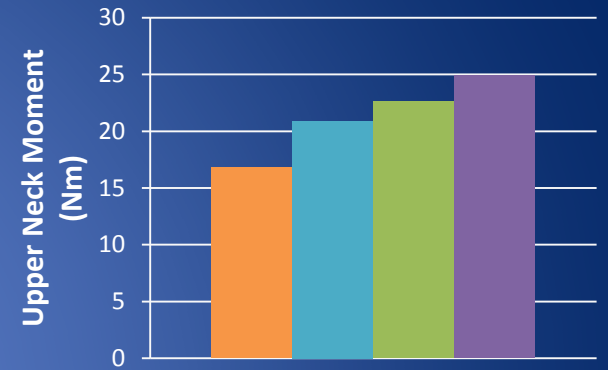
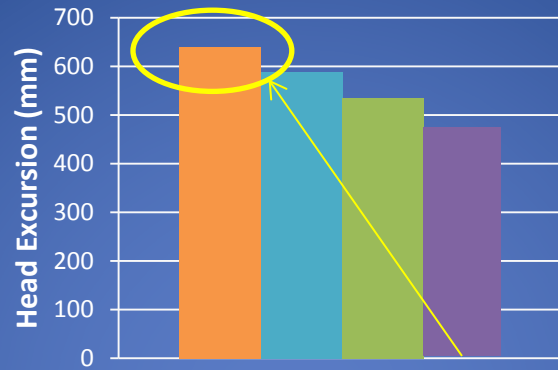
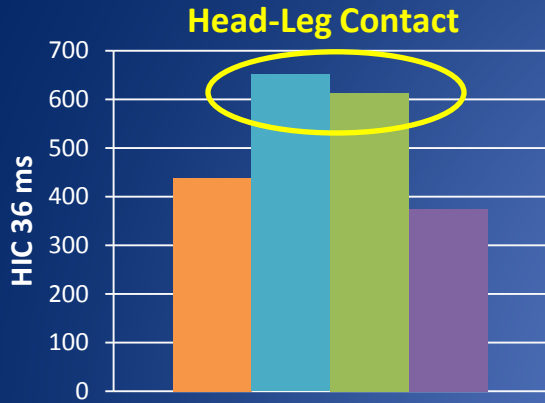
Highback BPB

Backless BPB

No CRS



Observations: Sled Tests

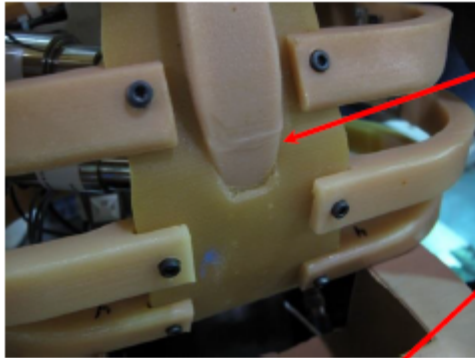


5-Point Harness High Back Booster

Backless Booster **No CRS**

Confounded by right shoulder separation

Durability - Sternum

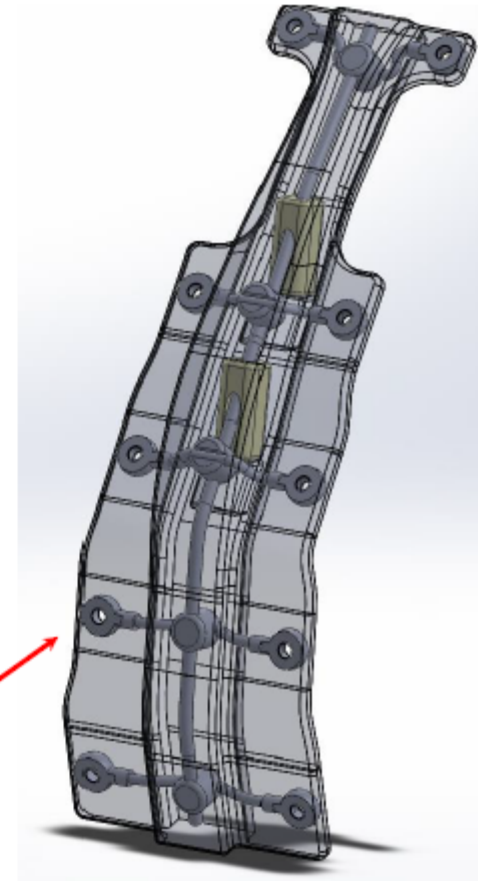
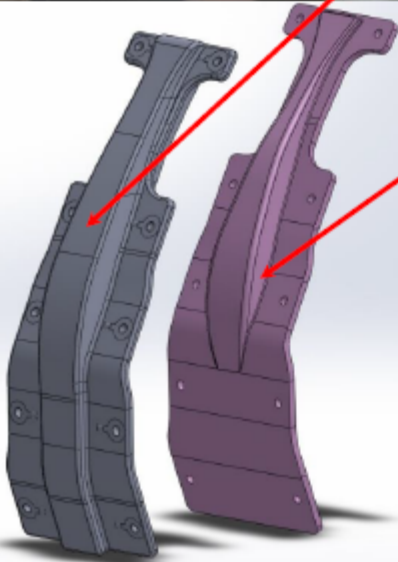


2 piece construction
delaminated

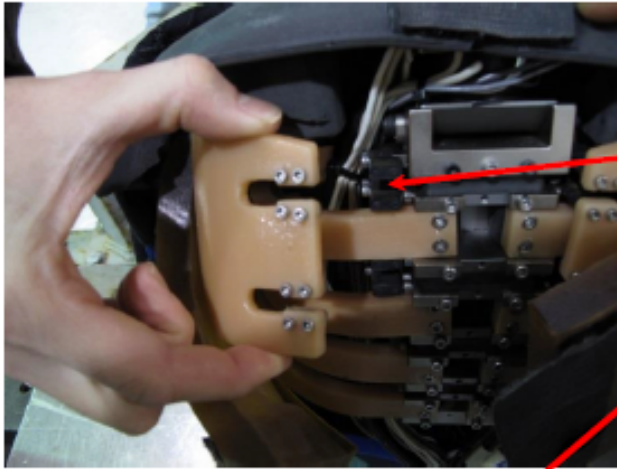
Mold as single rubber
part with reinforced rib
and clavicle
attachments

Existing Sternum shape
is maintained.
Compatible with
existing ribs and
IRTRACC attachments

Steel cables and
fittings link the
sternum attachment
points

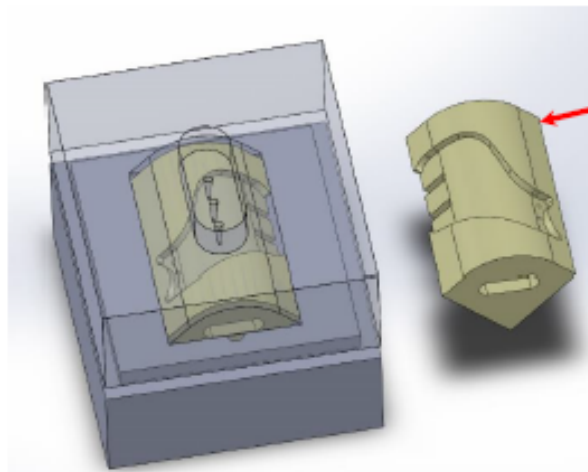
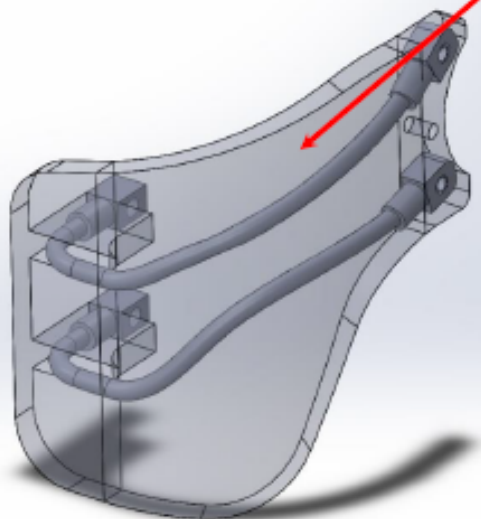


Durability - Scapula



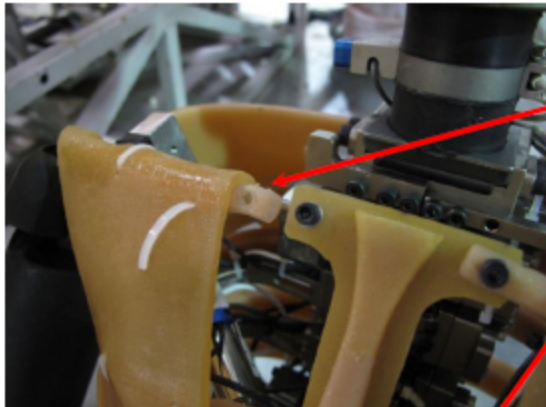
Scapula attachments bridge across vertebrae, restraining motion
Rubber mounts sheared off

Cable reinforced
molded rubber part



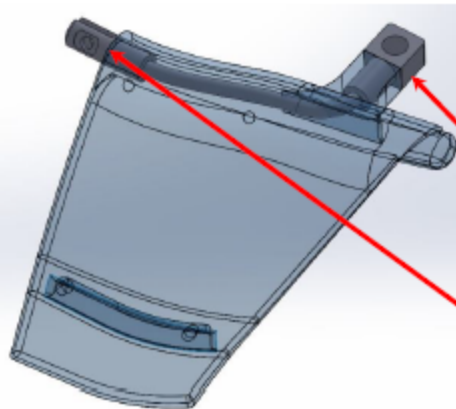
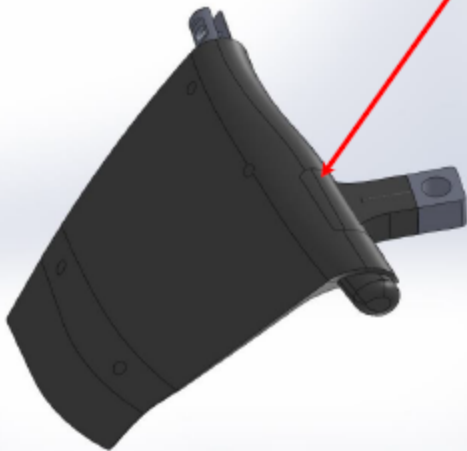
Mold with left and right side inserts

Durability – Clavicle



Clavicle failed at the sternum attachment point

Mold as single rubber part with internal steel cable



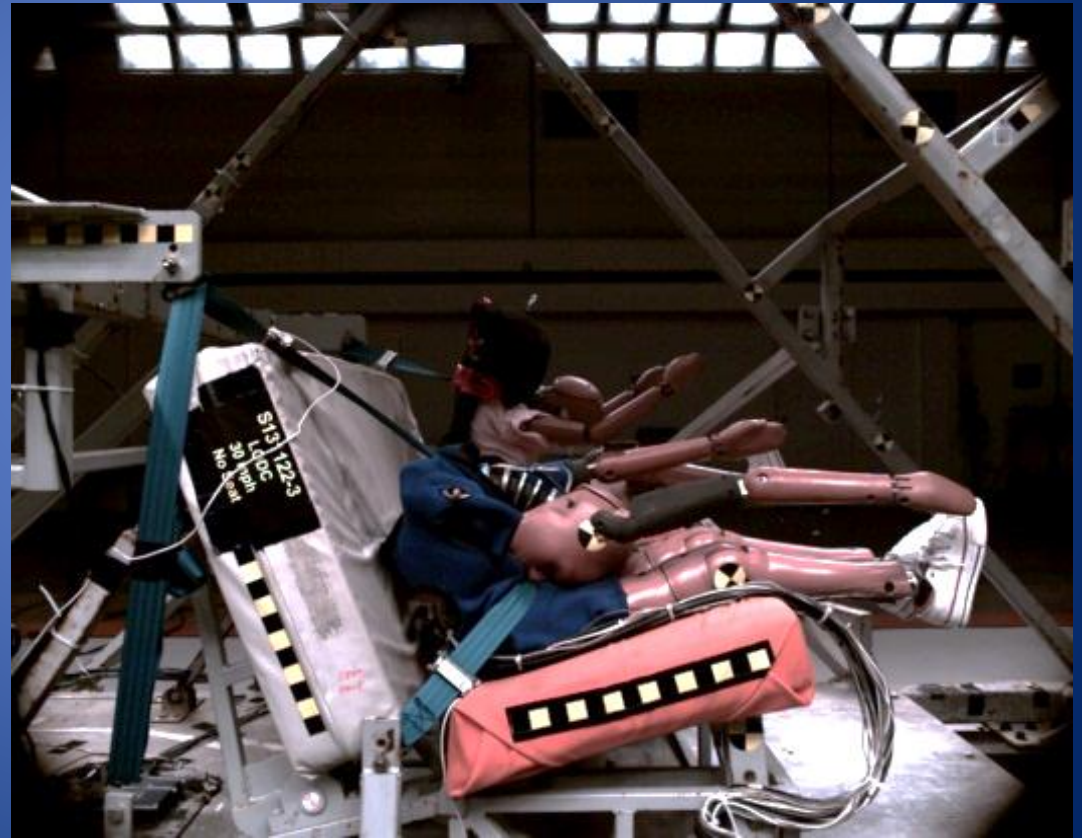
Shoulder attach point

Sternum attach point

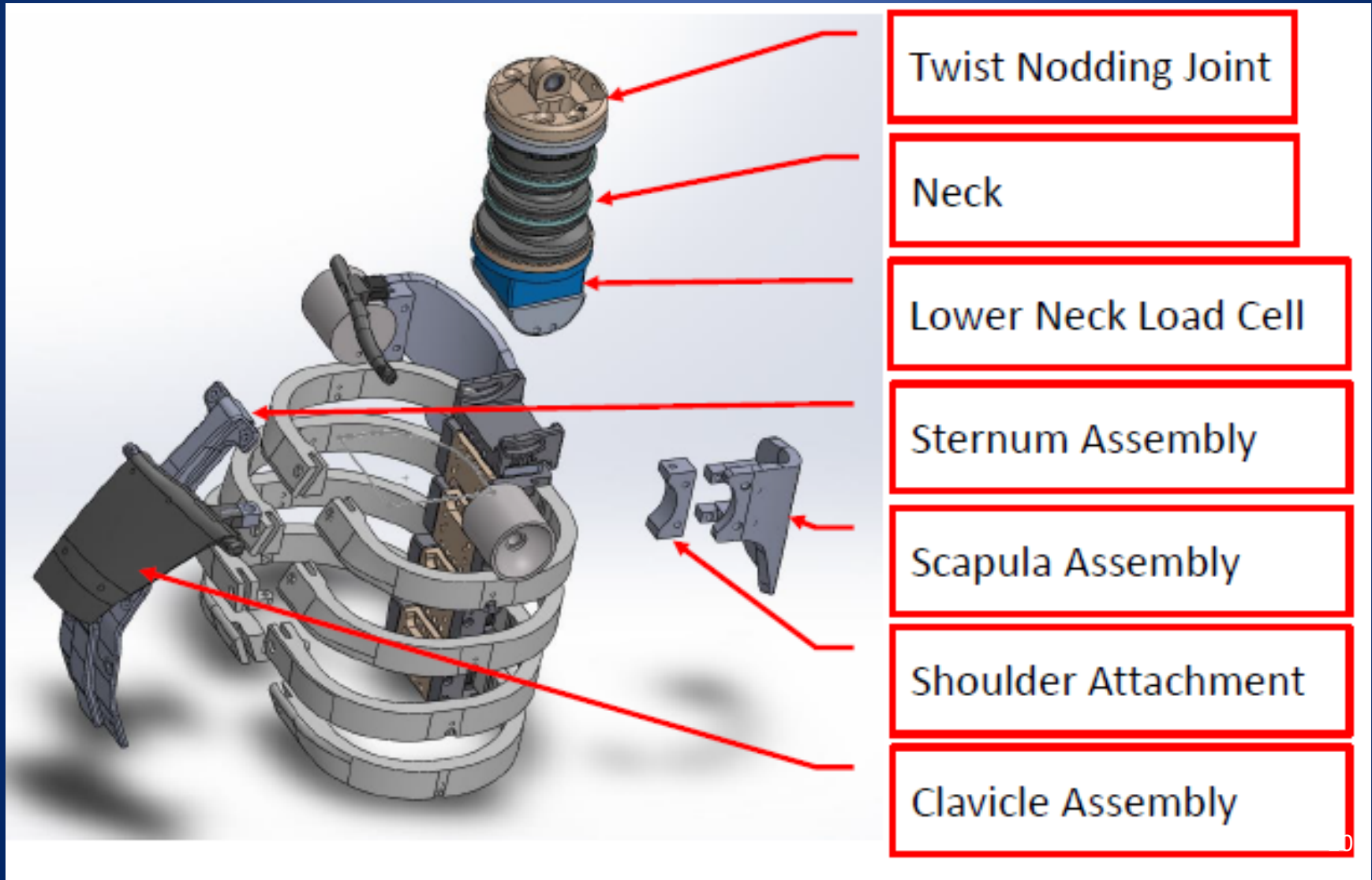
Durability – Upper Arm



- Scapula and clavicle improvements should prevent this complete separation of the arm!
- Increasing screw size to make sure

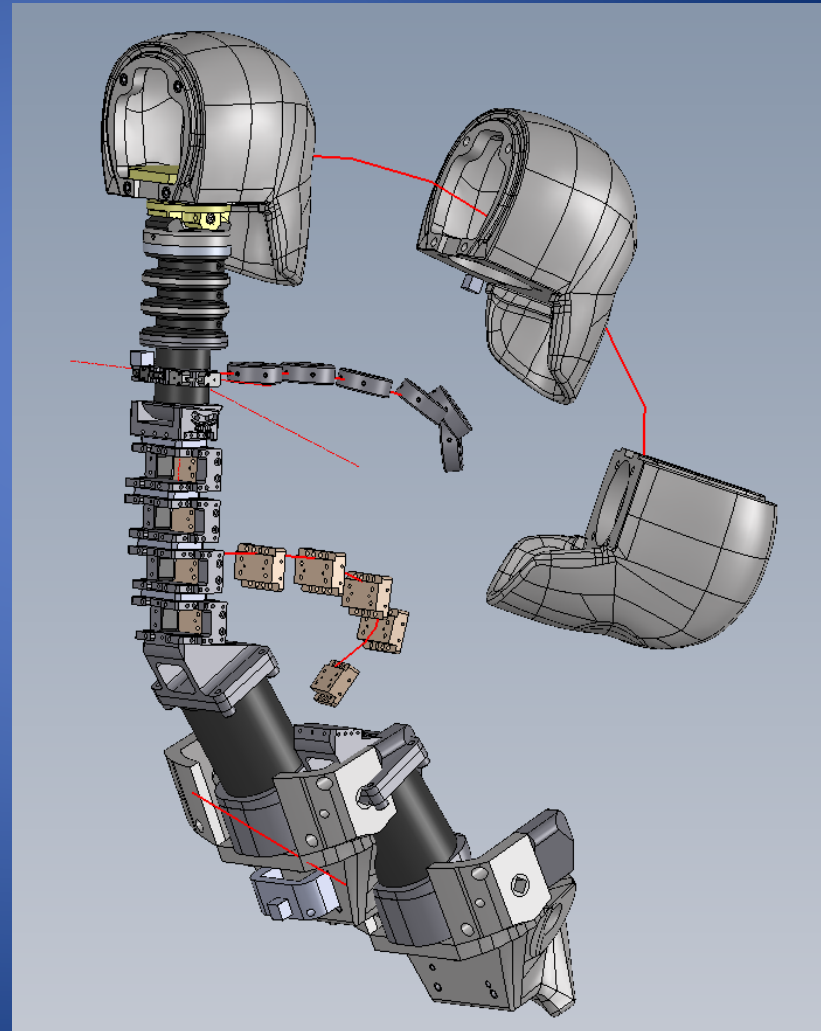


LODC Updates



Design Optimization

- Implement LODC sled test trajectories to visualize spine kinematics
 - Primary focus on stiffened T1 joint
- Biomechanics study to evaluate new LODC neck with tuned T1
- Evaluate LODC spine vs. human trajectories from literature



Upcoming Work

Task	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Publish work with original LODC (vs. HIII-10c)	█	█	█					
LODC revisions & assembly	█	█						
LODCrev1 component tests			█					
LODCrev1 tests at CHOP				█				
LODCrev1 vs. Q10 tests				█	█			
Revise LODCrev1 (as needed)						█	█	█

Summary

- NHTSA is developing a prototype LODC thorax that could potentially enhance the Hybrid III 10 year old ATD
 - As noted in 2012 FR research plan
- Evaluation of the initial LODC prototype identified:
 - Component-level biofidelity
 - Sensitivity to restraint condition in FMVSS No. 213 sled conditions
 - Areas in need of improvement (durability/biofidelity)
 - Shoulder-thorax attachment
 - Stiffer thorax/T1 joint & softer shoulder
- LODC is currently being revised as technical papers are being generated to present work conducted so far
 - Thoracic spine biofidelity target development
 - Comparison with HIII-10YO & Q10
 - LODCrev1 testing expected to resume this summer

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