NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Advanced Crash Test Dummy Research

Why Advanced Crash Test Dummies?

- **Field Data**: Significant number of injuries/fatalities still occur despite current regulations/consumer metric programs
- **How to address?**
  1. Crash Tests: Evaluate test conditions not currently in regulation/consumer metric programs that are prevalent in the field data
  2. **Dummies: Develop/document new ATDs that are more human-like and have enhanced instrumentation**
  3. Injury Criteria: Given 1 and/or 2, develop and apply new injury measures that could be used to design improved safety countermeasures

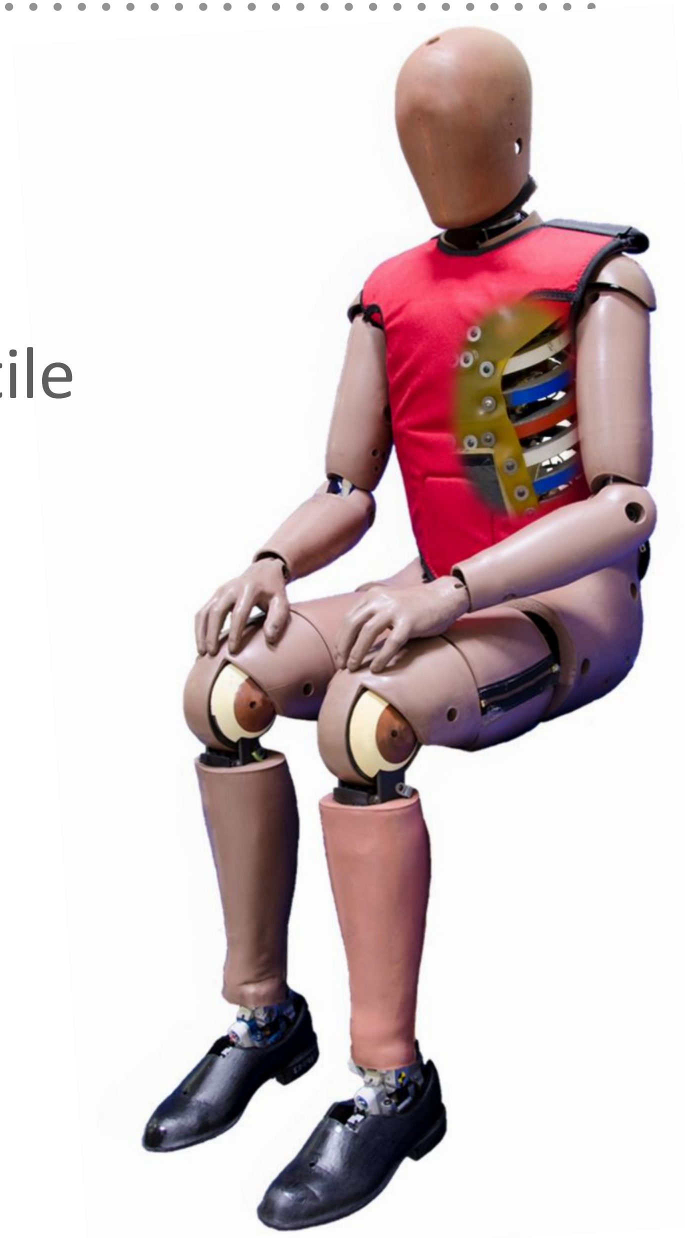
1. THOR 50th Male – Extended Overview
2. THOR 5th Female
3. LODC 10 year old
4. WorldSID 50th Male
5. WorldSID 5th Female
6. BioRID

THOR-50M

Dan Parent

THOR-50M Overview

- THOR = Test Device for Human Occupant Restraint
  - Anthropomorphic Test Device (ATD)
  - 50th percentile male (“THOR-50M”)
- Provides improvements over the Hybrid III 50th percentile male ATD
  - More biofidelic (human-like)
  - Enhanced instrumentation
  - Increased injury prediction capability
- Used in NHTSA research projects dating back to 1999
  - ~175 tests in Vehicle Database
  - ~1400 tests in Biomechanics Database
- Funded by NHTSA throughout development



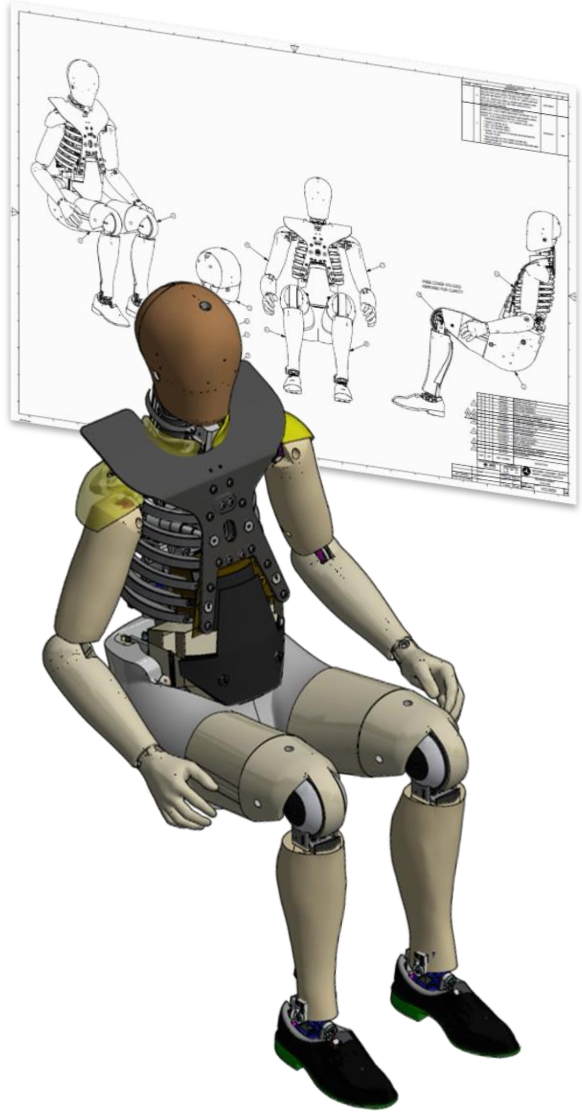
THOR-50M Documentation

Title	Description
Drawing Package	Engineering drawings describing detailed design, 2D and 3D database
Qualification	Procedures and response specifications in component and fully body impact tests
Durability	Elevated-energy qualification tests to ensure sufficient durability in repeated use
R&R (THOR Qualification)	Repeated qualification tests to evaluate repeatability and reproducibility of results
R&R (Oblique w/ THOR)	Repeated Oblique crash tests to ensure repeatability and reproducibility of crash test results
Biofidelity	Quantitative biofidelity assessment and comparison to Hybrid III
PADI	Procedures for assembly, disassembly, inspection; serves as user's manual for a dummy
Seating Procedure	Step-by-step positioning procedure in the driver or right front passenger seat for a crash test
Injury Criteria	Describes development of injury risk functions and their application to THOR

THOR-50M Drawing Package

- August 2018 version
  - 2D Drawings: PDF, AutoCAD
  - 3D Parametric Database: Autodesk Inventor, STEP
  - Drawing revisions since August 2016 release
  - Parts list

- Updates since August 2016 release
  - External dimensions (per procedure in PADI)
  - Body segment mass & C.G. location
  - Design updates to improve usability, durability, accuracy
  - Drawing updates to improve manufacturability



THOR-50M Qualification Manual

- September 2018 version
  - Step-by-step procedures for qualification testing
  - Performance specifications
    - At least one specification for each measurement used in Injury Criteria
  - Includes comparison to August 2016 specifications

- Updates since August 2016 release
  - Standardized specification corridor width (±10%)
  - Ensure that face response meets biofidelity corridor
  - Reduced total number of specifications
    - Removed redundant measurements in neck tests
    - Use peak resultant deflection in thorax tests

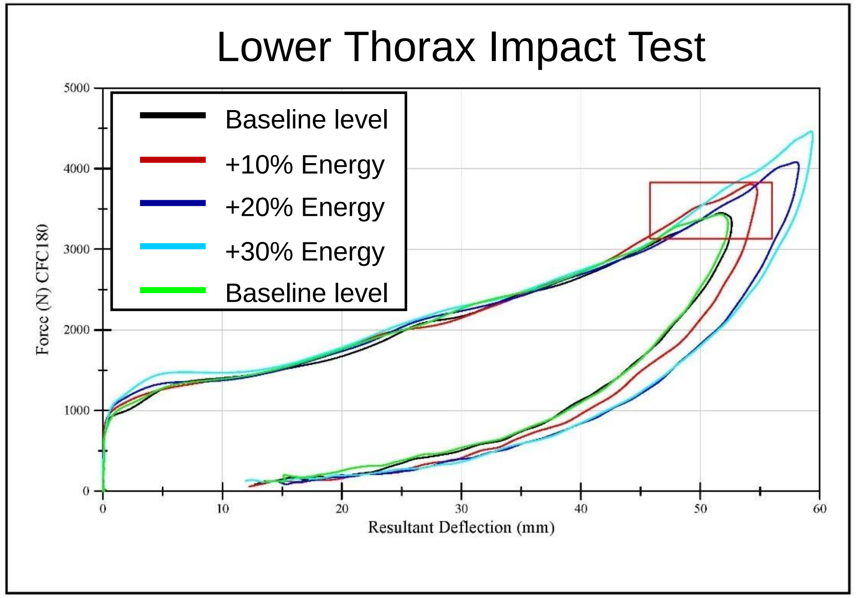
THOR-50M Durability

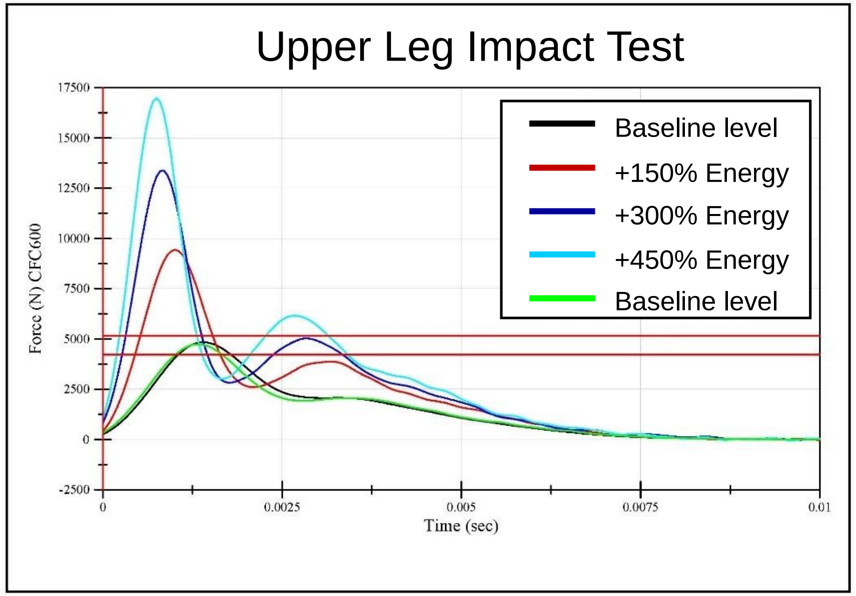
- Durability in Qualification Procedures
  - 5 tests in each qualification test mode
    1) Baseline level
    2) +10% Energy
    3) +20% Energy
    4) +30% Energy
    5) Baseline level

  Response > Mean + S.D. from crash tests

  - NHTSA BioDB (TSTNOs 12085-12159)

- Durability in Crash Tests
  - 150+ vehicle crash tests
  - 300+ sled tests
  - 1000+ component tests





THOR-50M R&R (Qualification)

- Repeatability
  - Similarity of responses from repeated tests on same THOR
- Reproducibility
  - Similarity of responses from different THORs
  - Similarity of responses from the same THOR at different labs
- Quantify results using Coefficient of Variation

$$CV = \frac{\sigma}{\mu} \times 100\%$$

- Results used to define qualification specifications
- NHTSA BioDB (TSTNOs 12285-12794)

24 Test Modes

×

5 Tests per ATD

×

5 ATDs
3 ATDs at VRTC
1 ATD at 2 other labs

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600 Qualification Tests

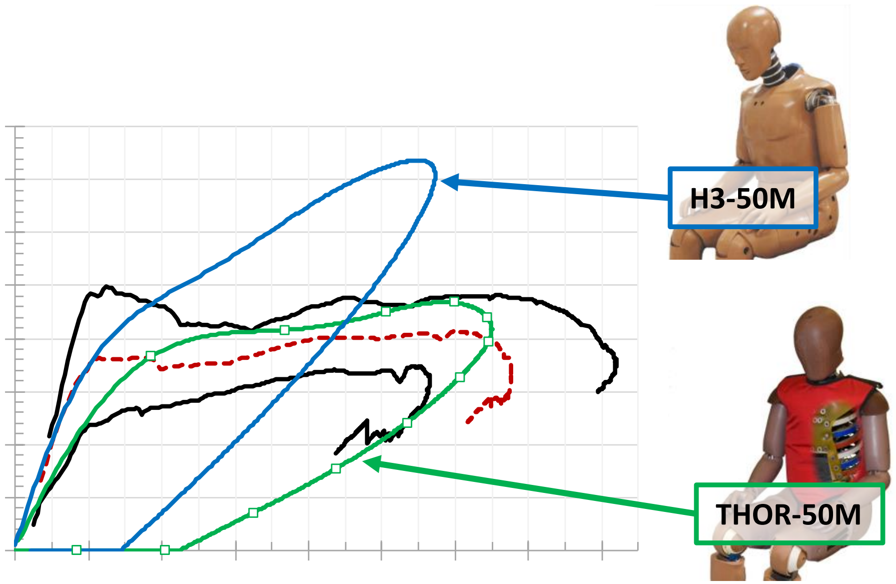
THOR-50M R&R (Oblique w/ THOR)

- Repeatability
  - Similarity of responses from repeated tests on same vehicle and same THOR
- Reproducibility
  - Similarity of responses from repeated tests on same vehicle and same THOR at different lab
- Result
  - R&R metrics same or better than frontal rigid barrier test mode with Hybrid III 50th
  - Recommended improvements to seating procedure
- Source
  - Saunders et al., "*Repeatability and Reproducibility of Oblique Moving Deformable Barrier Test Procedure,*" 2018 SAE World Congress
  - NHTSA VehDB (see paper for TSTNOs)

THOR-50M Biofidelity

- Biofidelity
  - Describes the similarity of a surrogate (ATD, human body model) to a human
  - Response corridors are developed from post-mortem human surrogates (PMHS, or cadaver)
  - Surrogate response compared to corridor, quantified using BioRank
  - THOR-50M demonstrates improved biofidelity compared to Hybrid III 50th

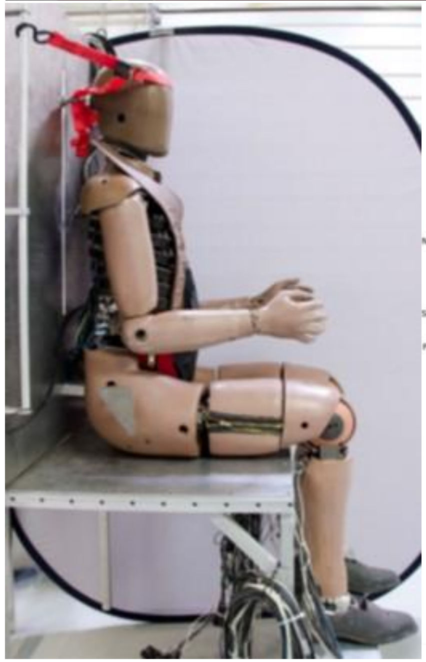
- Source
  - Data in NHTSA BioDB (see paper for TSTNOs)
  - Parent et al., "*Biofidelity Evaluation of the THOR and Hybrid III 50th Percentile Male Frontal Impact Anthropomorphic Test Devices,*" 2017 Stapp Conference

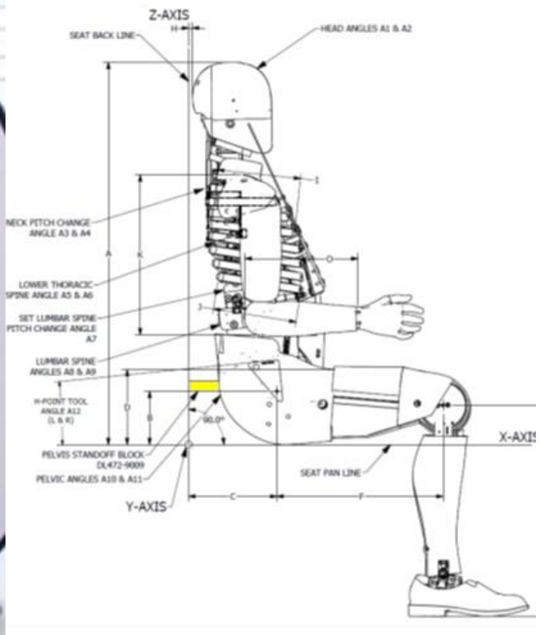


Body Region	THOR-50M	H3-50M
Head	Excellent	Poor
Neck	Good	Poor
Thorax	Excellent	Good
Abdomen	Marginal	Marginal
Knee/Thigh/Hip	Good	Poor
Lower Extremity	Good	N/A
Whole-body	Good	Good

THOR-50M PADI

- Procedures for Assembly, Disassembly, and Inspection
- Also describes
    - Handling and storage
    - H-point tool assembly and use
    - Posture adjustments
    - Instrumentation cable routing and grounding
    - Instrumentation polarity check
    - Thorax/abdomen instrumentation calibration and post-processing
    - External dimension measurement procedure





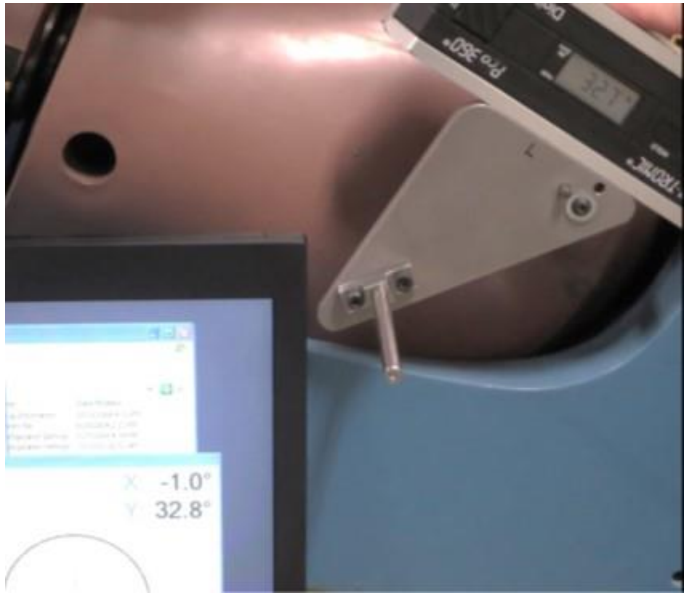
THOR-50M Seating Procedure

- Describes procedure for positioning THOR-50M in vehicle for crash testing
  - Driver
  - Right Front Passenger

- Changes from previous publication (NHTSA-2015-0119-0009, NHTSA-2015-0119-0022)
  - Driver heel point accounts for both suspended and floor-mounted accelerator pedals
  - Wider tolerances on H-point target location
  - Additional seat position fore/aft adjustment to avoid leg contact
  - Head angle about the Y-axis set to 0 degrees (± 1 degree), but may deviate after all other steps are conducted

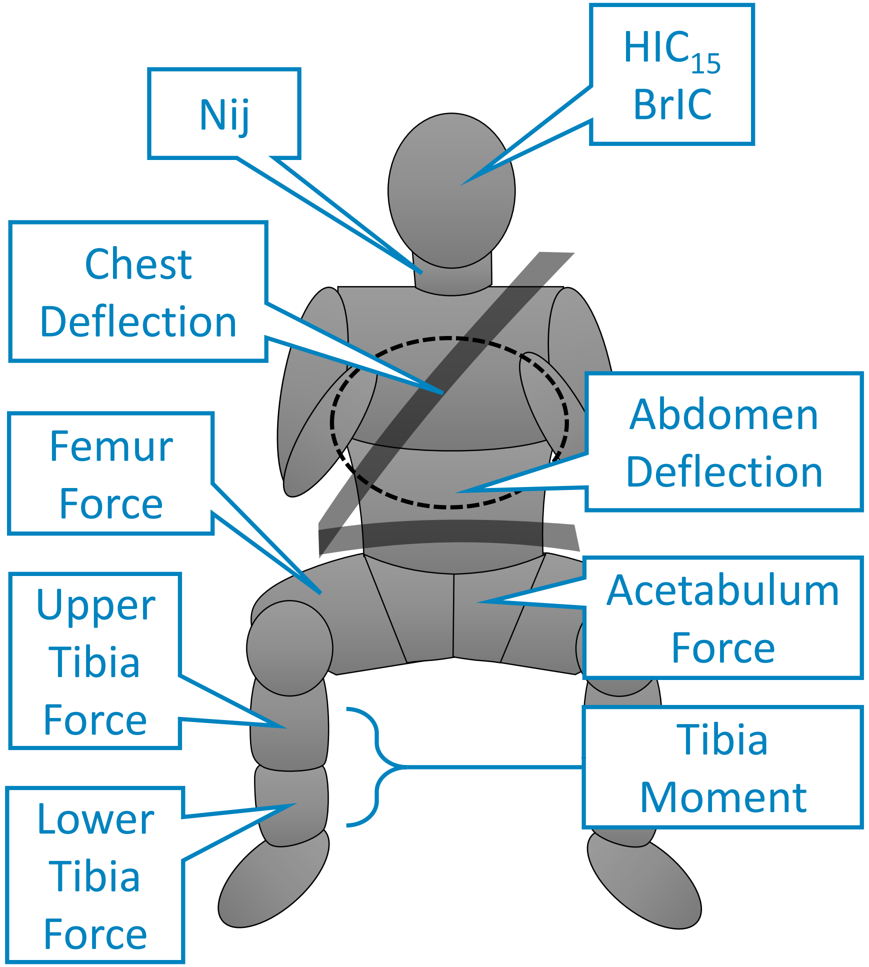
- Published in NTL (https://rosap.ntl.bts.gov/view/dot/40786)





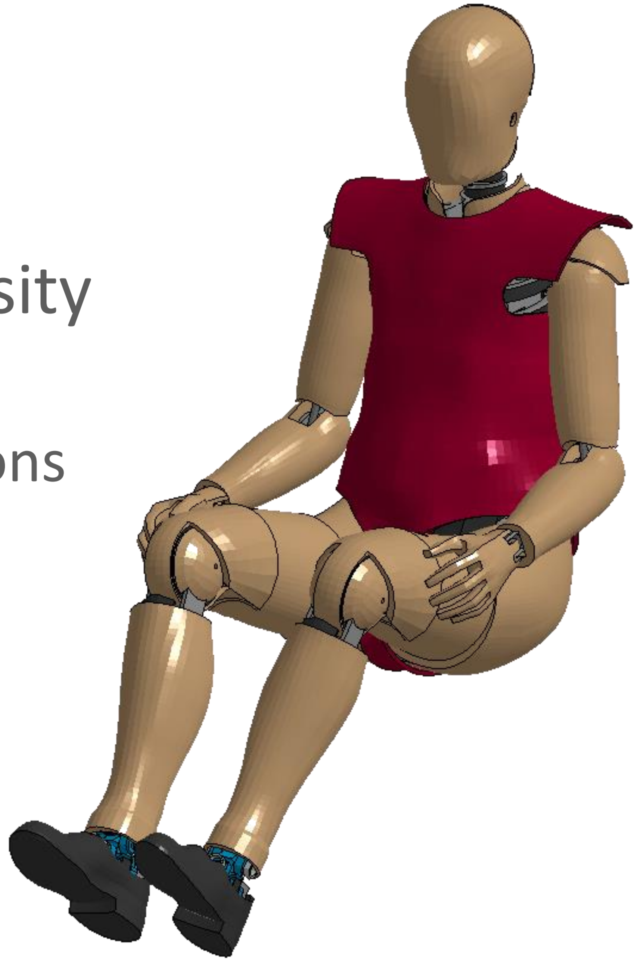
THOR-50M Injury Criteria

- For each body region:
  - Field and Historical Fleet Data
  - Literature Review
  - Design & Instrumentation
  - Biofidelity
  - Review of Available Data
  - Injury Risk Function Formulation
  - Application of Risk Function to THOR-50M
  - Fleet Test Data
  - Limitations
- Peer-reviewed
  - Reviewer comments and responses to be published



THOR-50M Finite Element Model

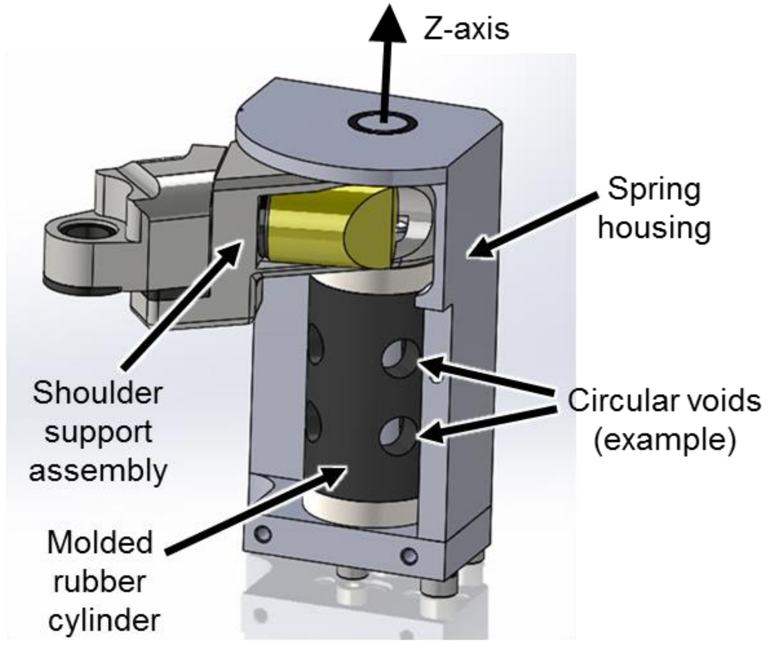
- Allows virtual crash tests, parametric analyses
- Developed by NHTSA with support from academic and industry partners
- Recent updates carried out under contract with University of Virginia Center for Applied Biomechanics
    - Updated to meet drawing package, qualification specifications
    - Experimental characterization of neck, thorax
    - Key improvements to torso, pelvis flesh, molded shoes
    - New jacket model to improve robustness
    - Stability checks in increased-energy simulations
    - Decreased simulation times by ~75%

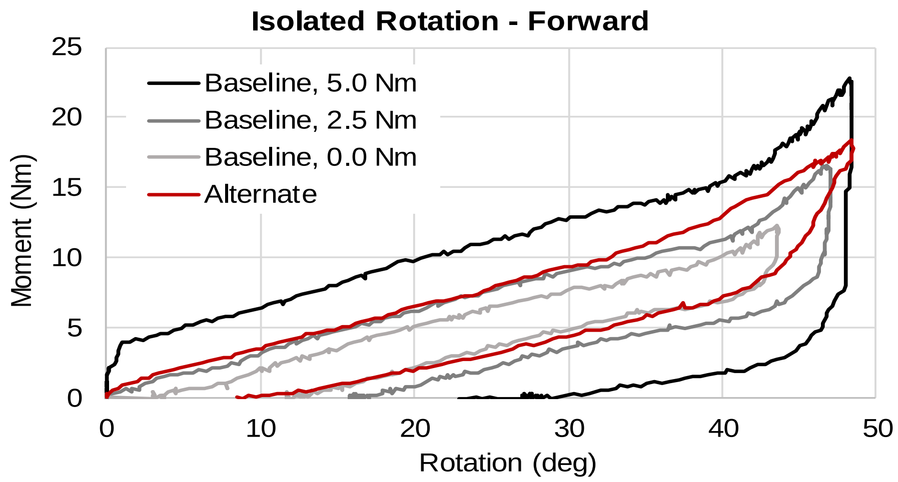


THOR-50M FE Model Version 2.7

THOR-50M Alternate Configurations – Shoulder

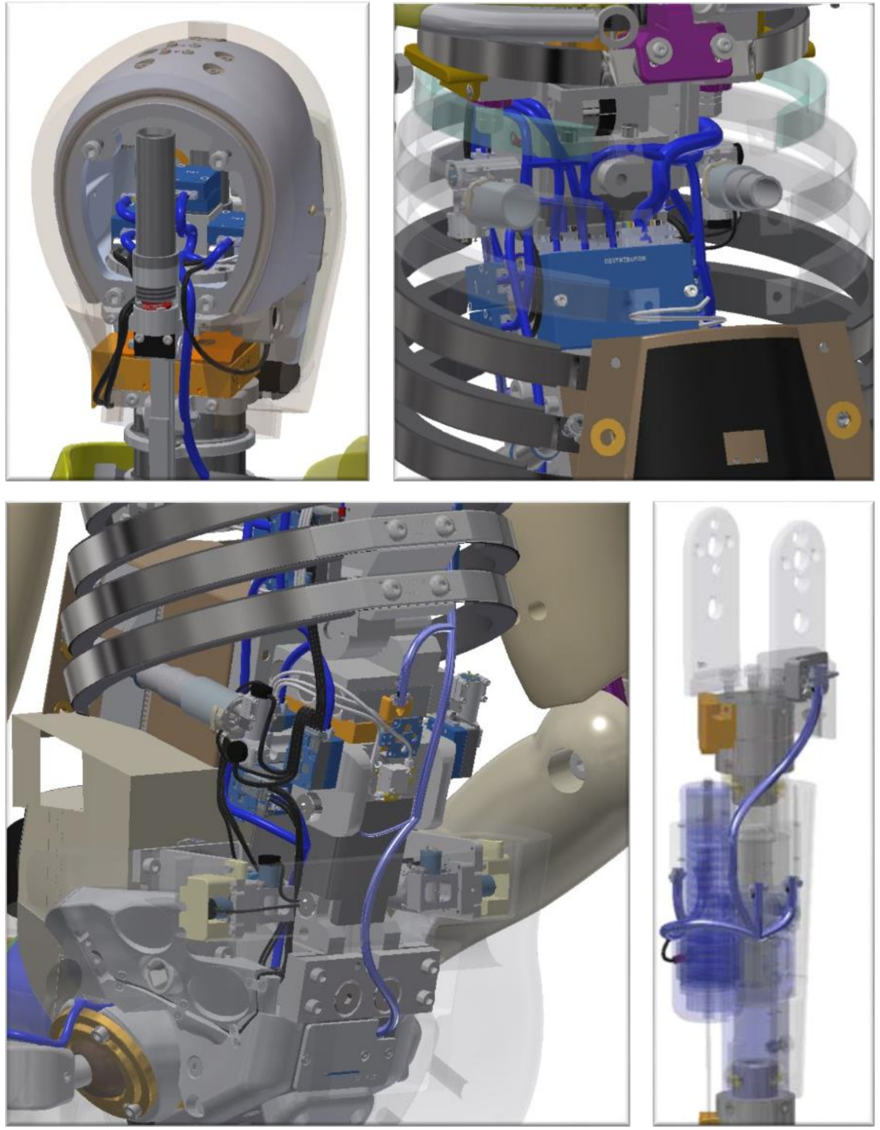
- Contract awarded to TRC
  - Design, build, and evaluate two shoulder prototypes
- Evaluate alternate design vs. baseline
  - Quasi-static rotation
  - Fit check in THOR-50M
  - Quasi-static biofidelity (Tornvall et al., 2005)
  - Qualification test (upper thorax)
- Selected one design to move forward
- Next steps
  - Evaluation in sled and/or vehicle testing
  - Complete drawings/specifications





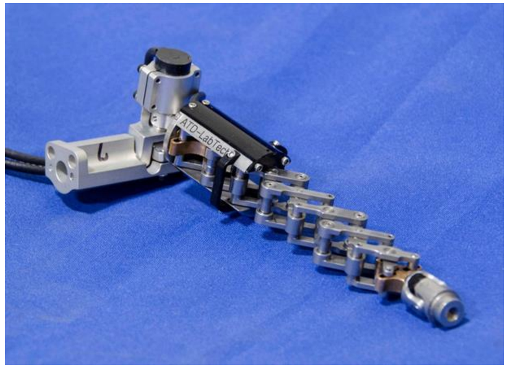
THOR-50M Alternate Configurations – In-dummy DAS

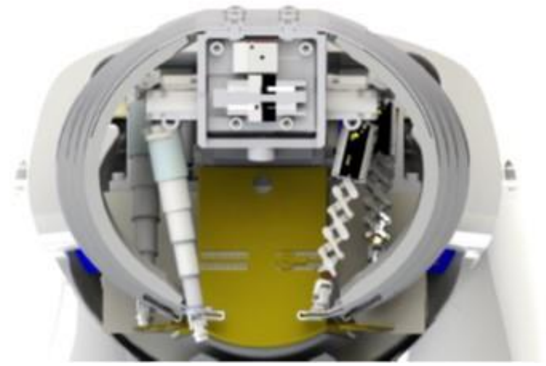
- Contract awarded to DTS
  - Design and install in-dummy data acquisition system (DAS) in THOR-50M
- Evaluate alternate design vs. baseline (umbilical)
  - Compare mass and C.G. locations of body segments
  - Fit check in THOR-50M
  - Compare full set of qualification tests
- Next steps
  - Compare vehicle crash test results

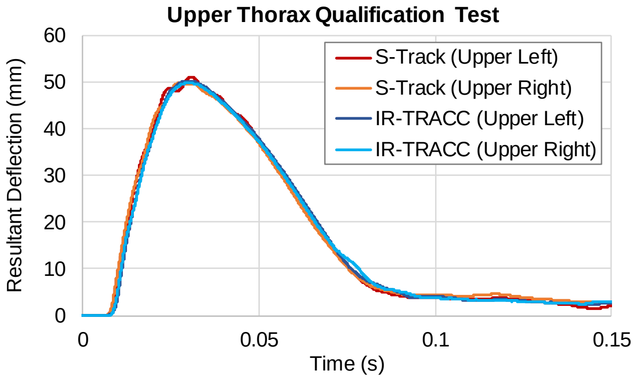


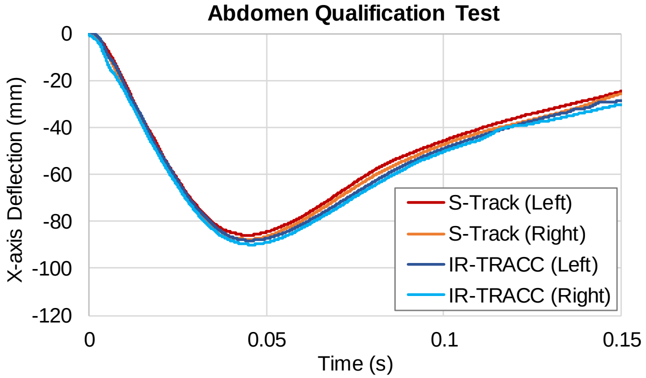
THOR-50M Alternate Configurations – IR-TRACC

- Contract awarded to ATD-LabTech
  - Commercially-available thoracic and abdominal 3D deflection instrumentation
- Evaluate alternate design vs. baseline
  - Calibration
  - Fit check in THOR-50M
  - Qualification tests
  - Sled tests (near-side frontal oblique)
- Next steps
  - Develop framework for evaluating alternate designs









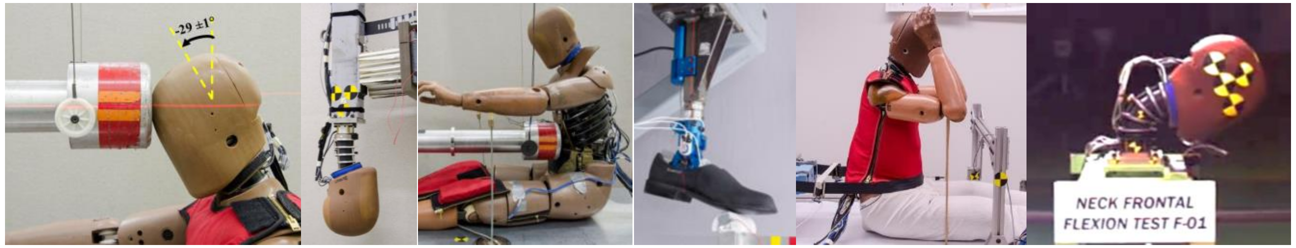
Use in NHTSA Research Projects

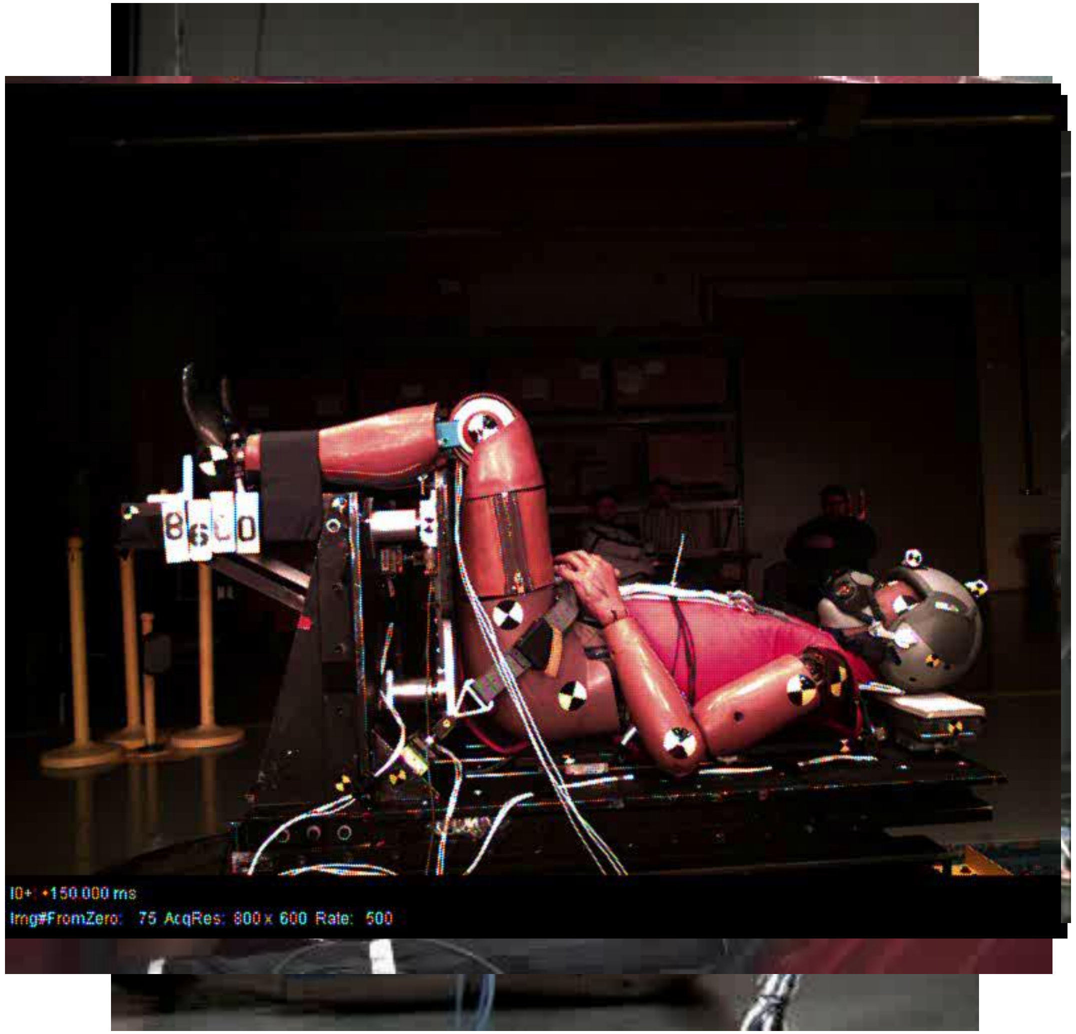
8 THOR-50M ATDs owned by NHTSA

164 Vehicle Crash Tests

348 Crash Simulation Sled Tests

1013 Dynamic Component Tests





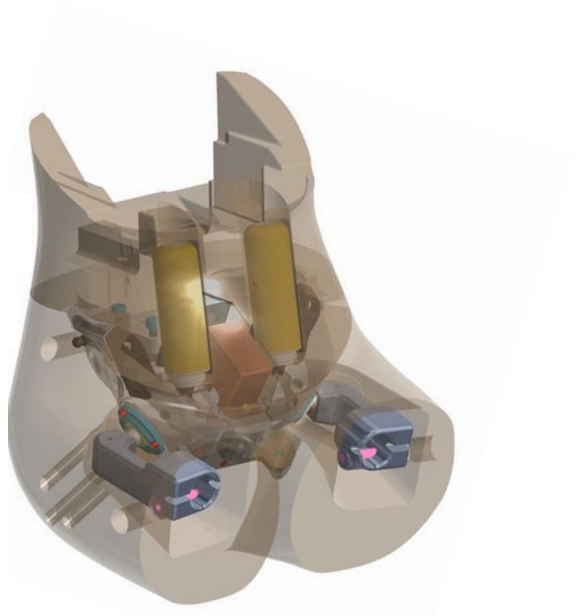
THOR 50th Questions?

THOR 5th Percentile Female ATD

Ellen Lee

THOR-05F: 5th Percentile Female ATD

- Incorporates key improvements from THOR-50M
- Human-like characteristics that mimics human seat belt interaction
- Designed to match small female-specific anthropometry and mass properties
- State-of-the-art measurement capabilities, including built-in capacity for on-board DAS
- Improved injury prediction capabilities, e.g. abdominal pressure sensors

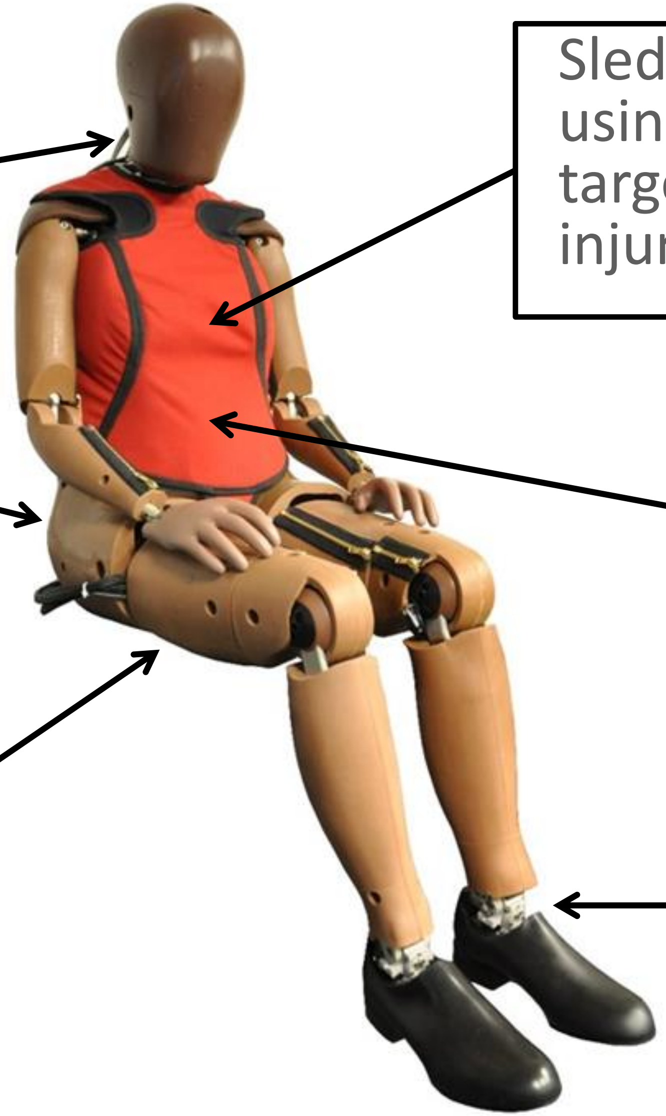


Female-specific Design and Data Collection

Existing female cervical spine data considered as part of injury criterion development

Pelvis geometry derived from female data

Existing female knee-thigh-hip data considered as part of injury criterion development



Sled tests in multiple configurations using small female specimens, targeting female-specific thoracic injury criterion development

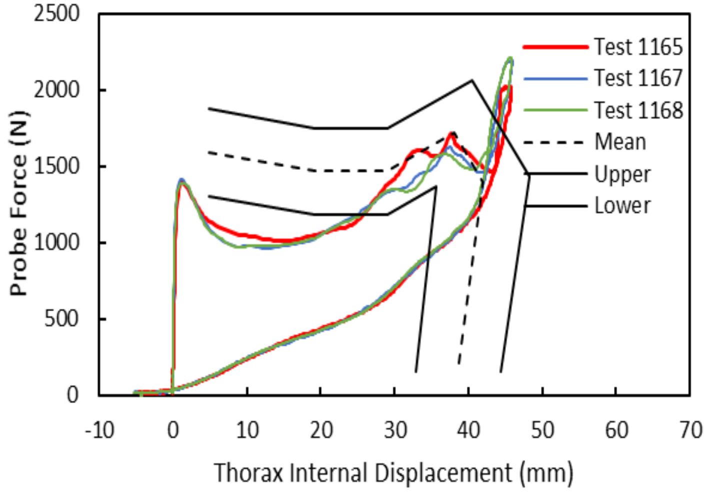
Abdomen injury data collected on small female specimens

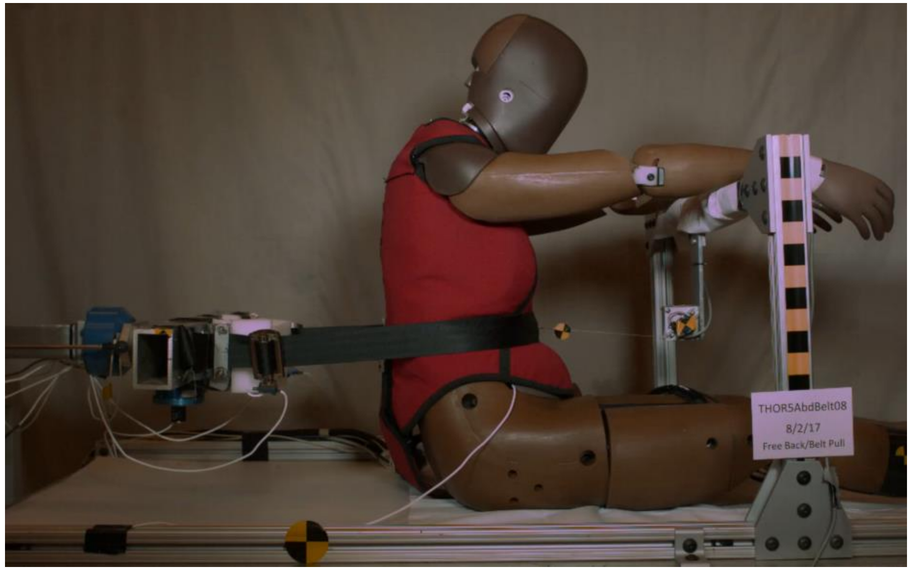
Small female data collected for heel impact, ankle dorsiflexion and ankle inversion/eversion

THOR-05F Biofidelity

- Biofidelity
  - Describes the similarity of a surrogate (ATD, human body model) to a human
  - Response corridors are developed from post-mortem human surrogates (PMHS, or cadaver)
  - Surrogate response compared to corridor, quantified using BioRank

Body Region	Biofidelity
Head	Good
Neck	Marginal
Shoulder	Excellent
Thorax	Good
Abdomen	Marginal
Knee-Thigh-Hip	Good
Lower Extremity	Good
Overall	Good

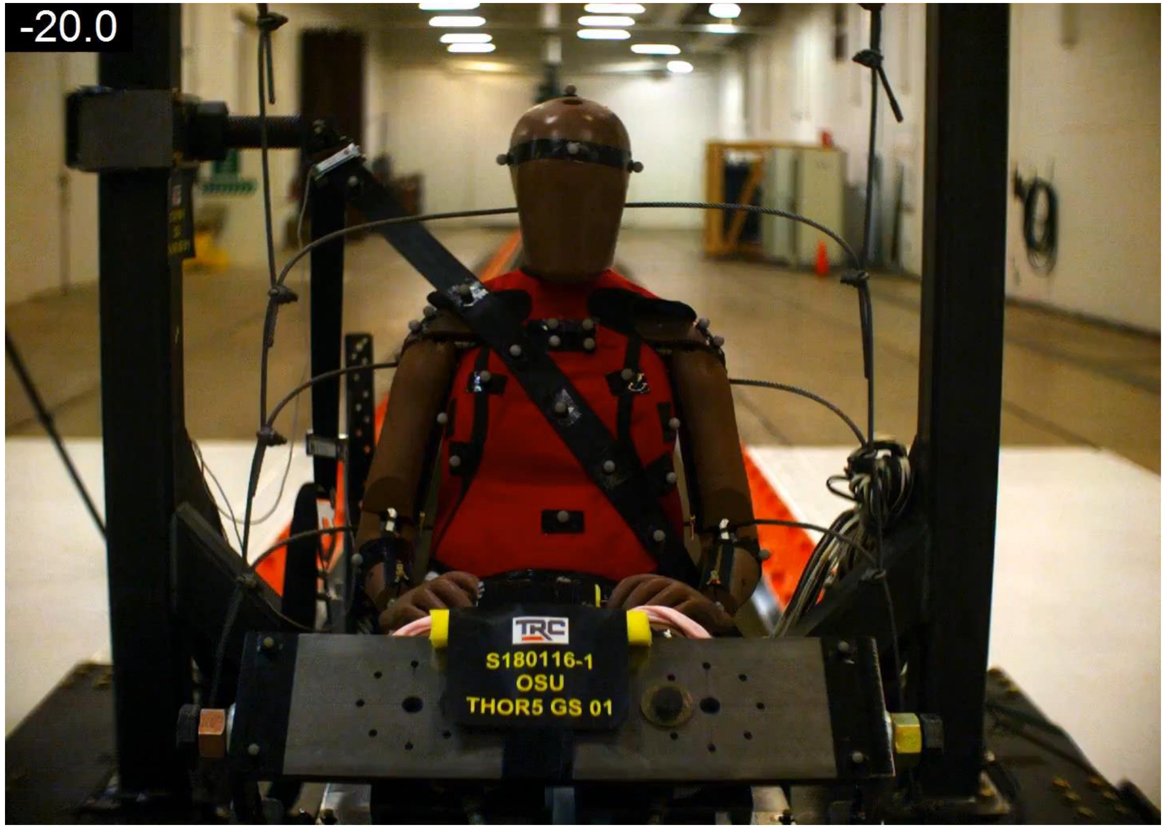




Current Research

- Evaluating 3 prototype ATDs
  - Repeatability, durability
  - Sled testing in rear and front seat configurations
- Developing Injury Risk Curves
  - Collecting biomechanical data (PMHS) and conducting matched pair ATD tests
- Developing technical reports & documentation:

Biofidelity Requirements Manual	**R&R and Durability Reports**
Biofidelity Report	**PADI**
Drawing Package	**Injury Criteria Report**



For more information, see Docket ID NHTSA-2019-0107 NHTSA Crashworthiness Research – THOR-05F Documentation

Large Omnidirectional Child (LODC) ATD

Jason Stammen, Ph.D.

Head has inertial/mass properties matching pediatric data

Source: Loyd (Duke)

Shoulders and thorax reflect pediatric anatomy and mimic pediatric response

Sources: Kent/Parent (UVA), Maltese (CHOP), Agnew/Bolte (OSU)

Biofidelic, instrumented abdomen to measure belt-induced loading

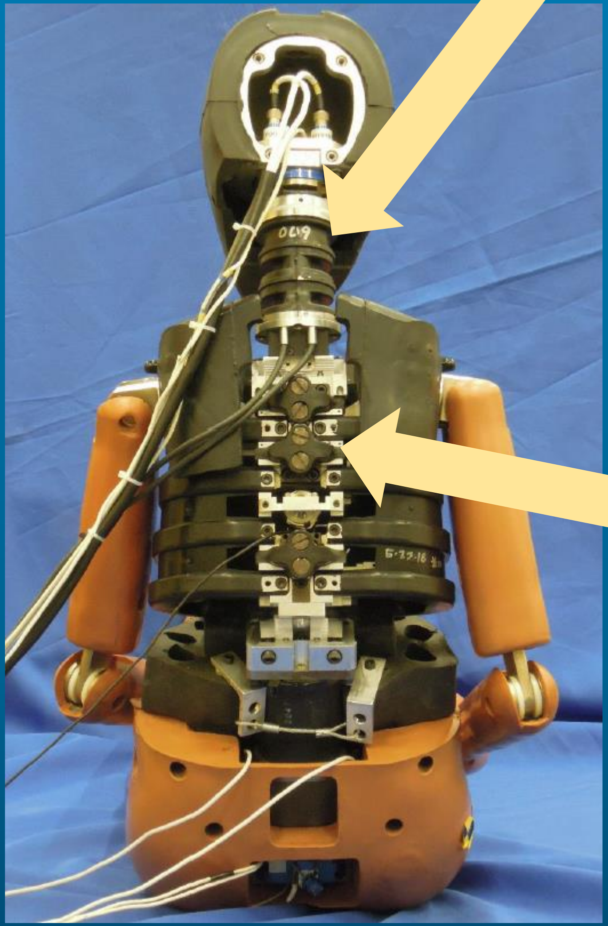
Sources: Kent (UVA), Beillas (IFSTTAR) Ramachandra (OSU), Hardy (Wayne State)

Anthropometry matches actual seated child data

Source: Reed (UMTRI)

Neck can elongate and allows for free Z axis rotation; response matching pediatric data

Sources: Dibb/Luck/Myers (Duke), Thunnissen 1995



Flexible cervicothoracic & thoracic spine for more biofidelic head trajectory and neck loads

Sources: Kang (OSU), Lopez-Valdes/Ash (UVA), Arbogast (CHOP), Pintar/Yoganandan (MCW)

LODC History

2005 - 2009: Testing of Hybrid III 10YO establishes the need for improvements in biofidelity; pediatric biomechanical studies

Stammen et al. (2012) ABME

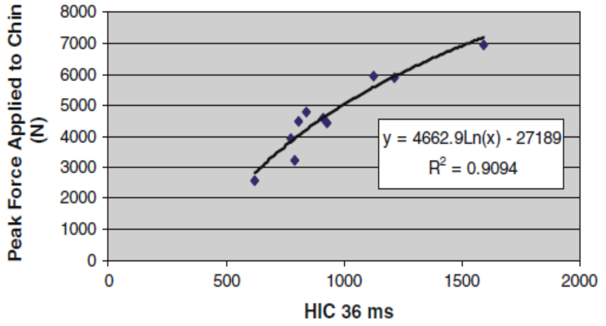
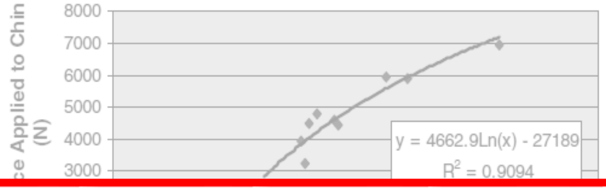


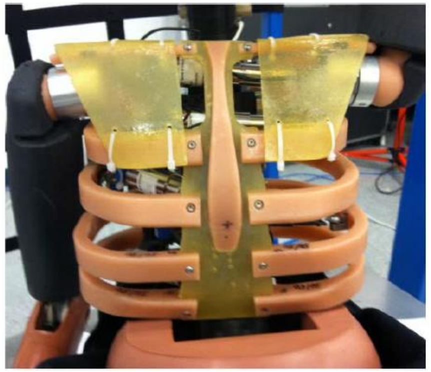
FIGURE 11. Applied chin force correlates strongly to the HIC outcome in sled testing (data from Stammen and Sullivan[16]).

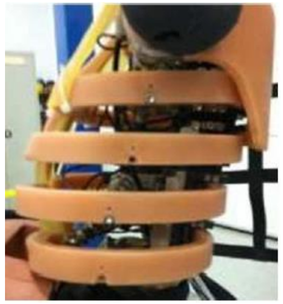
LODC History

2005 - 2009: Testing of Hybrid III 10YO establishes the need for imp
biofid
biome



2010 – 2012: Design and construction of initial LODC prototype thorax; NHTSA decides to leave HIC requirement out of FMVSS 213 due to issues with Hybrid III 10YO chin-chest





Stammen et al. (2014) Advances in Child Injury Prevention

LODC History

2005 - 2009: Testing of Hybrid III 10YO establishes the need for imp
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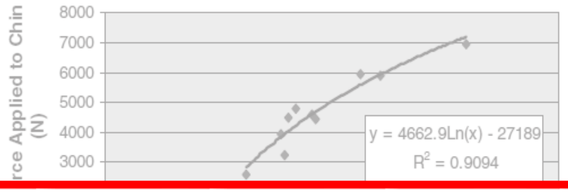

2010 – 2012: Design and construction of initial LODC prototype thorax; NHTSA decides
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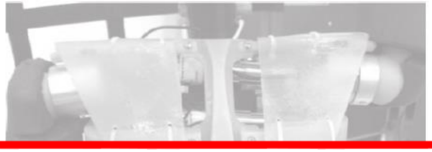
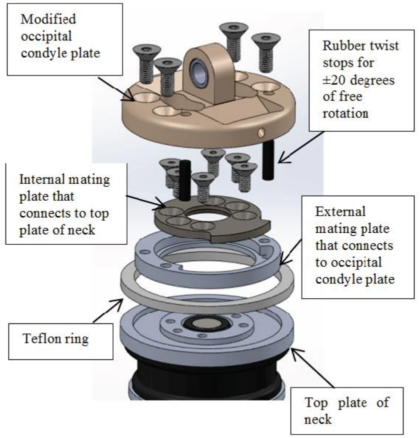
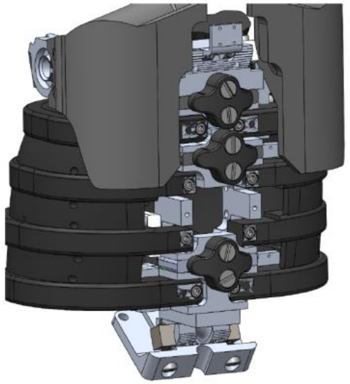


2013 - 2014: Initiate internal dummy prototyping effort using lessons learned from Hybrid III 10YO testing; build first in-house prototype for evaluation





Stammen et al. (2014) IRCOBI

LODC History

2005 - 2009: Testing of Hybrid III 10YO establishes the need for imp
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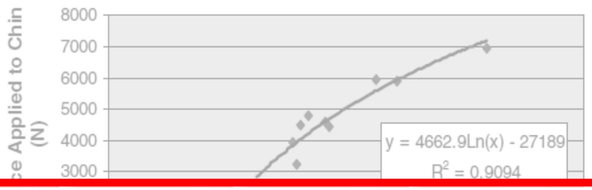

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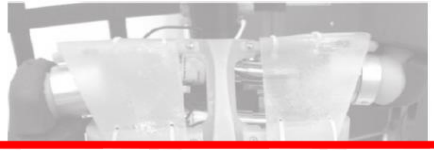

2013 - 2014: Initiate internal dummy prototyping effort using lessons learned from Hy
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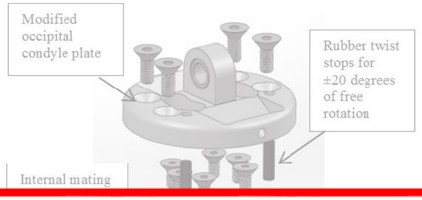
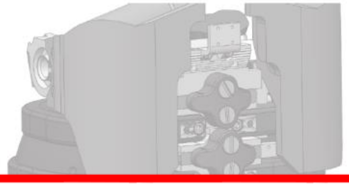
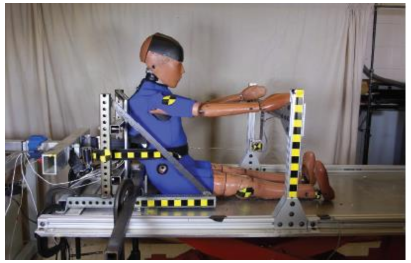
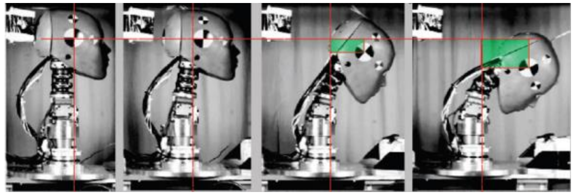




2015 - 2017: Establish that the LODC has improved biofidelity over HIII-10YO, is durable, and is repeatable tool



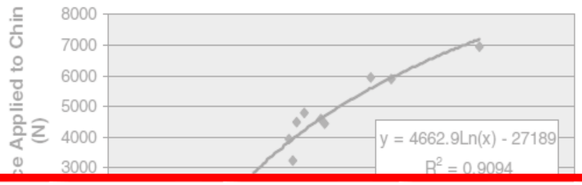


Body Region	LODC	HIII-10C
Head	0.79	1.81
Neck	1.37	2.73
Thoracic Spine	1.35	1.83
Thorax	0.79	5.50
Abdomen	0.78	1.61
OVERALL ATD	**1.02**	**2.70**

Stammen et al. (2016) Stapp

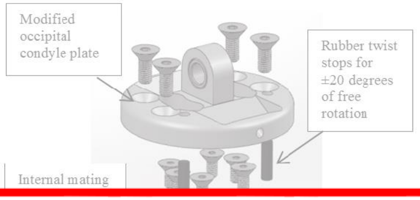
LODC History

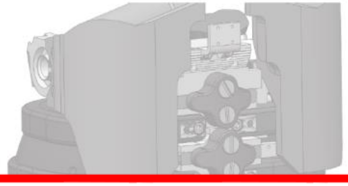
2005 - 2009: Testing of Hybrid III 10YO establishes the need for imp biofid biome



2010 – 2012: Design and construction of initial LODC prototype thorax; NHTSA decides requir due to 10YO

2013 - 2014: Initiate internal dummy prototyping effort using lessons learned from Hy testing; prototy





2015 - 2017: Establish that the LODC has improved biofidelity over H3 durable, repeatab

Body Region	LODC	HIII-10C
Head	0.79	1.81
Neck	1.37	2.73

2018 – Present: Evaluate upgraded LODC's both internally and externally

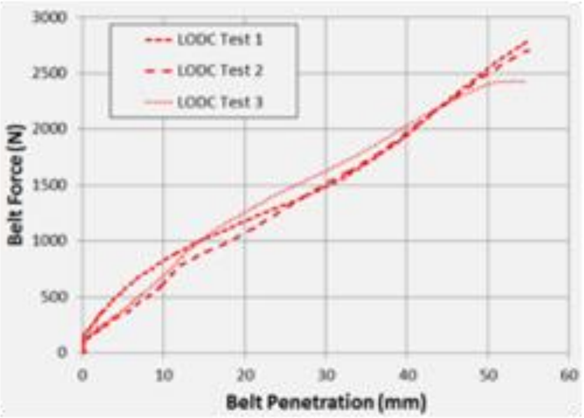
From: Seacrist et al. (2019) Stapp

Suntay et al. (2019) DOT HS

Recent Upgrades

Recent Work

- Usability improvements with slight improvement in biofidelity
- Evaluated R&R
- Shoulder/thorax biofidelity improved by including additional biofidelity test condition



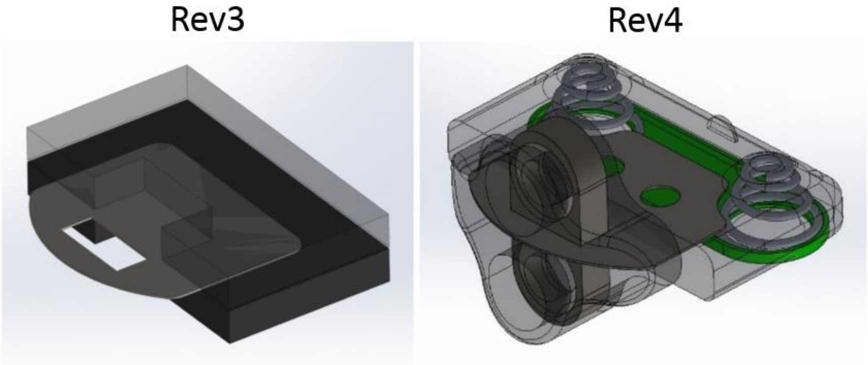
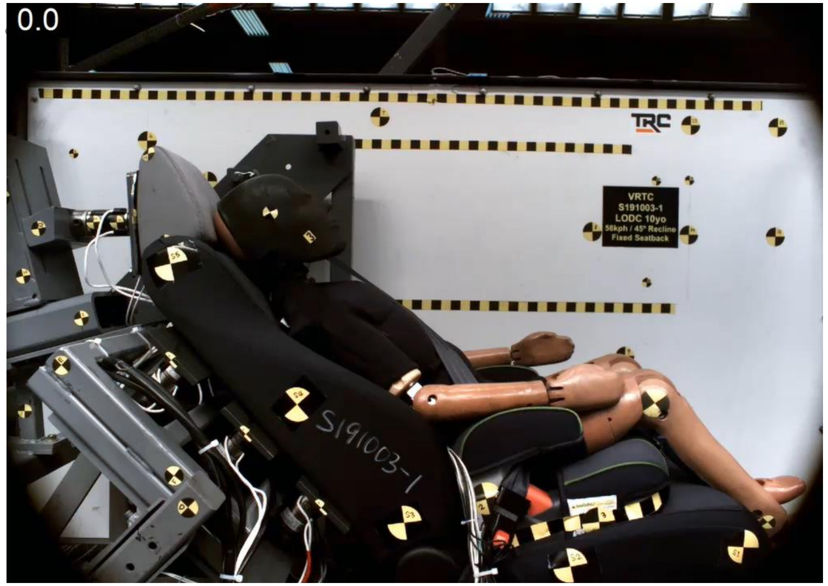


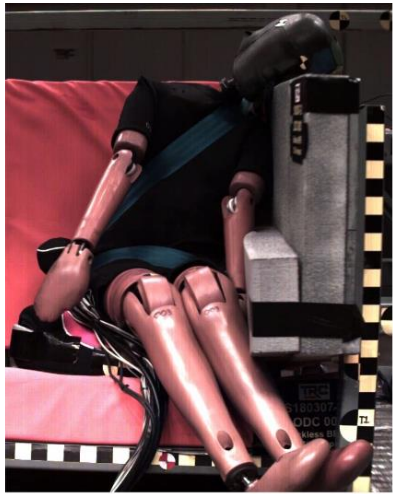
Figure 6. Updated flexible spine element

Suntay & Stammen "Evaluation of the Large Omnidirectional Child (LODC) ATD" DOT HS 812 755. https://rosap.ntl.bts.gov/view/dot/41843

Recent Work

- Feasible to use ATD in non-frontal conditions
- Tested in vehicle rear seat, aircraft seat, lateral, oblique, and rear impact

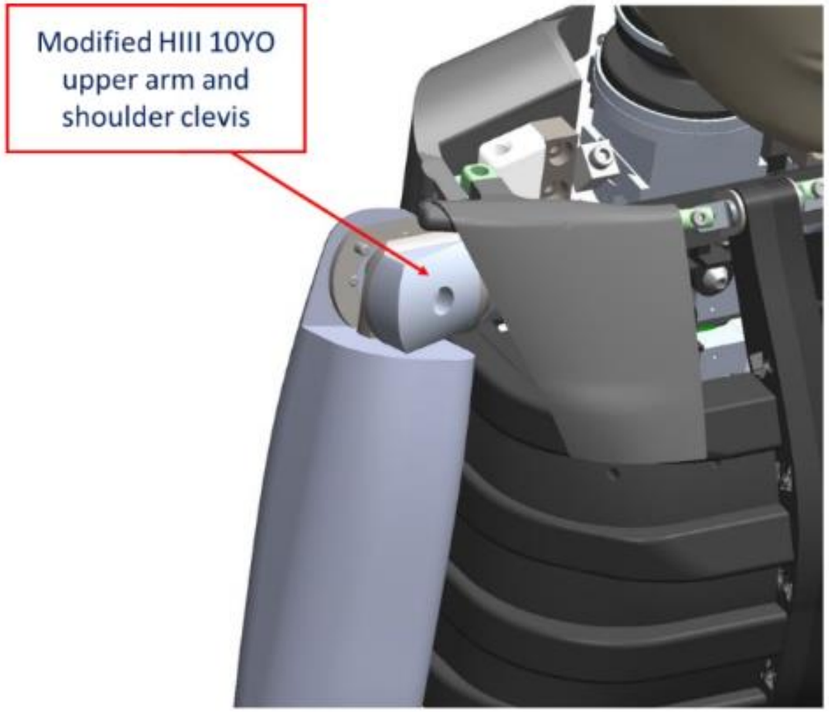




Suntay & Stammen "Evaluation of the Large Omnidirectional Child (LODC) ATD" DOT HS 812 755. [*https://rosap.ntl.bts.gov/view/dot/41843*](https://rosap.ntl.bts.gov/view/dot/41843)

Recent Work

- Upper arm/shoulder and belt engagement improved; prevent artificial belt folding

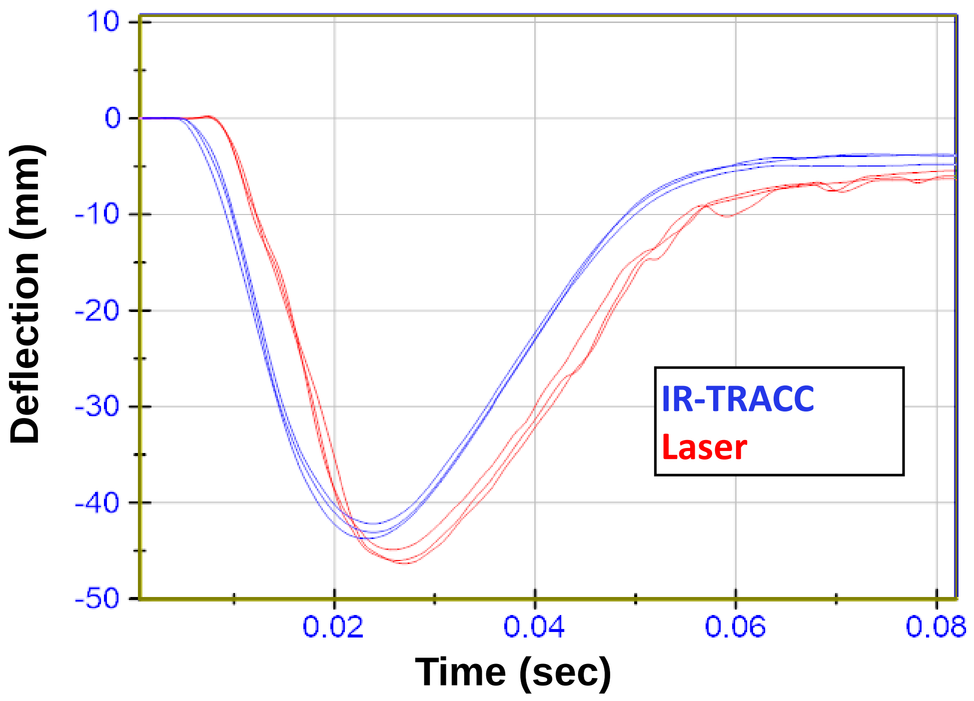


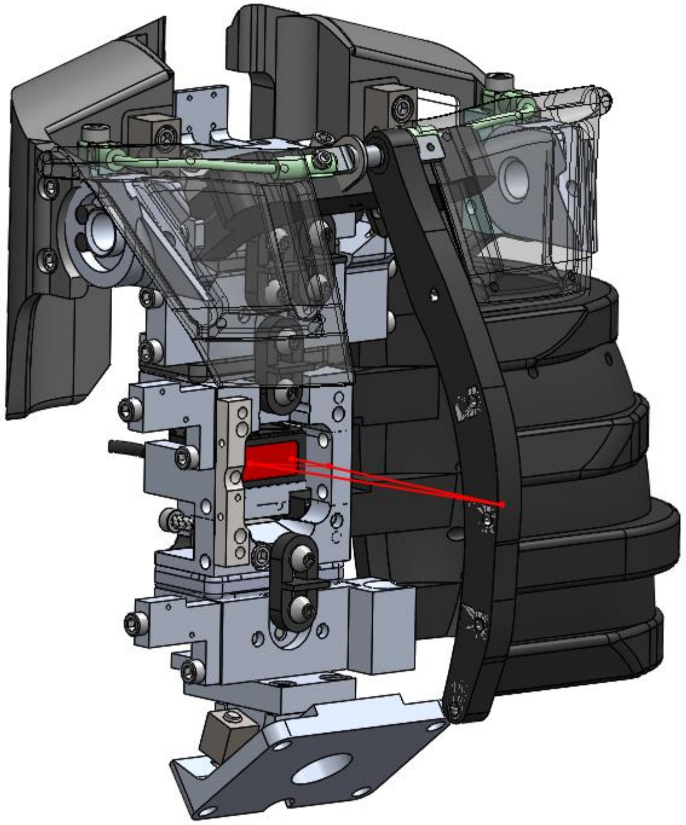
Suntay & Stammen "Evaluation of the Large Omnidirectional Child (LODC) ATD" DOT HS 812 755.
https://rosap.ntl.bts.gov/view/dot/41843

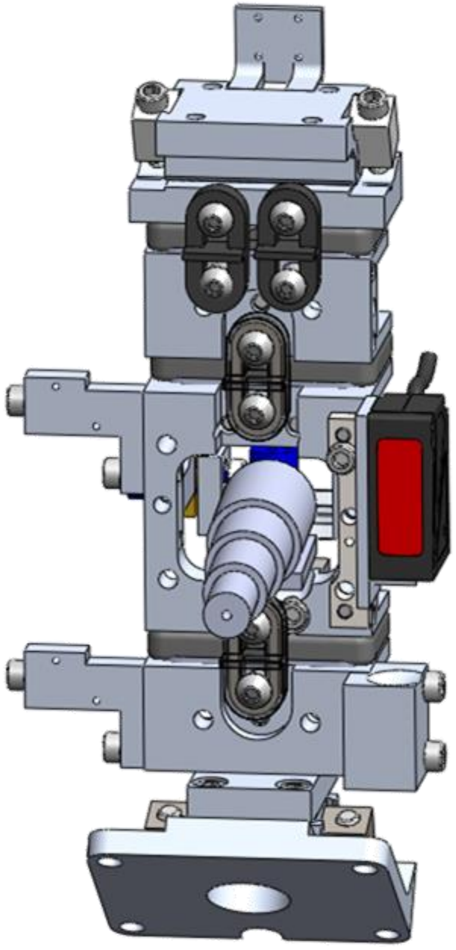
Current Activities

Current Activities

- Developing new chest deflection system
- Can be used instead of or in tandem with IR-TRACC
- More details at SAE Government/Industry

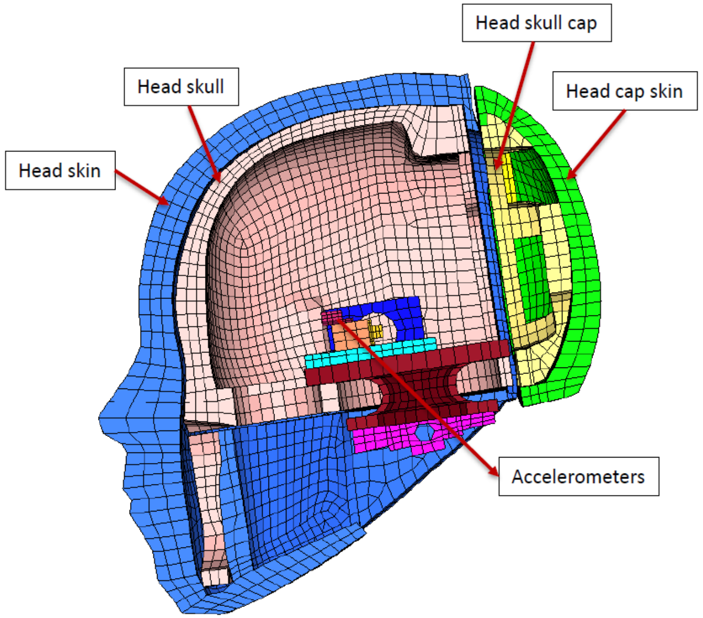


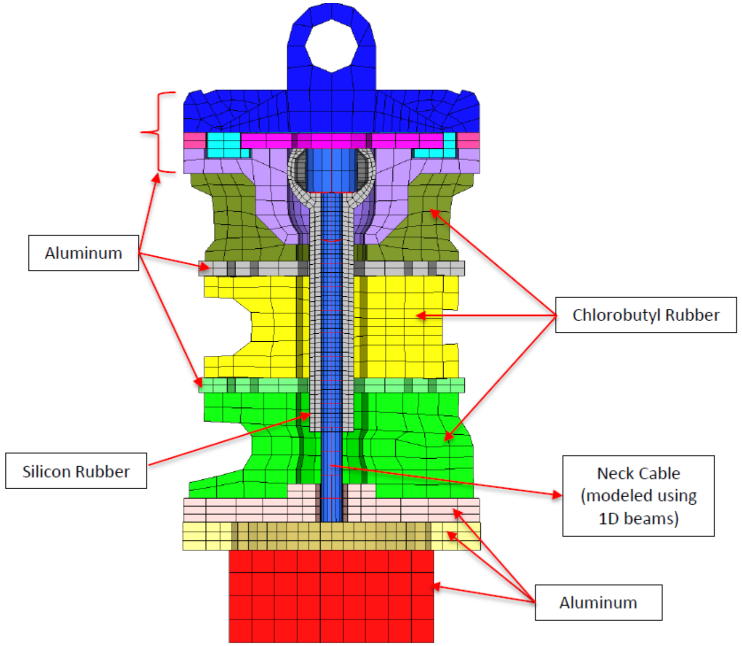


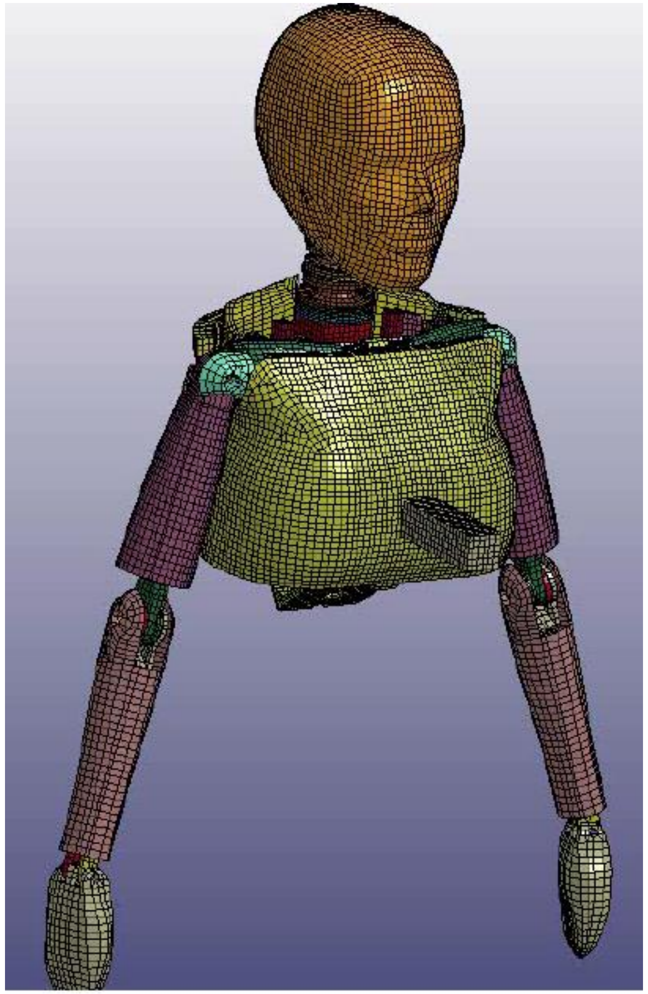


Current Activities

- Developing FE model
- Meshing almost complete
- Material property analysis & experimental validation underway

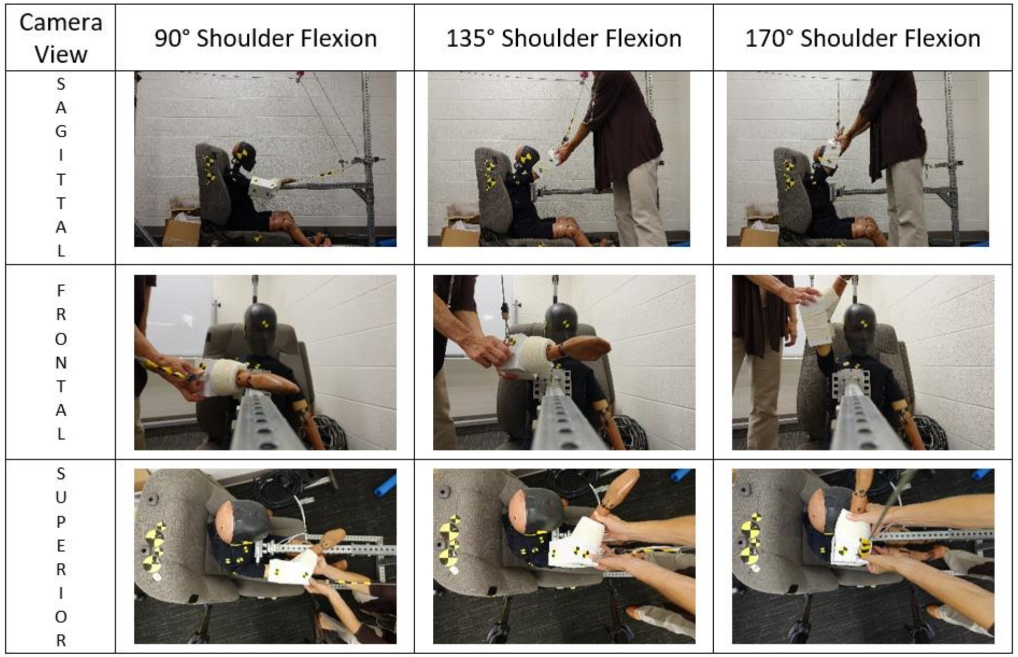




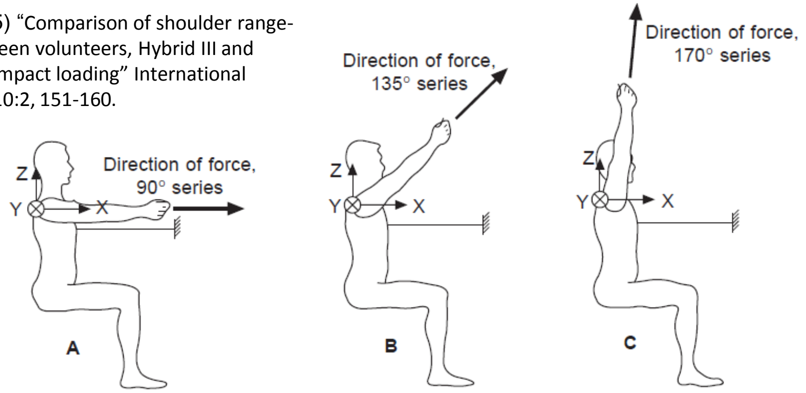


Current Activities

- Initiating a study at Ohio State to evaluate the frontal shoulder range of motion & stiffness in pediatric volunteers
- Trial testing with LODC to refine experimental details
- Volunteer testing starting in 2020
- Real-time biofidelity assessment of LODC

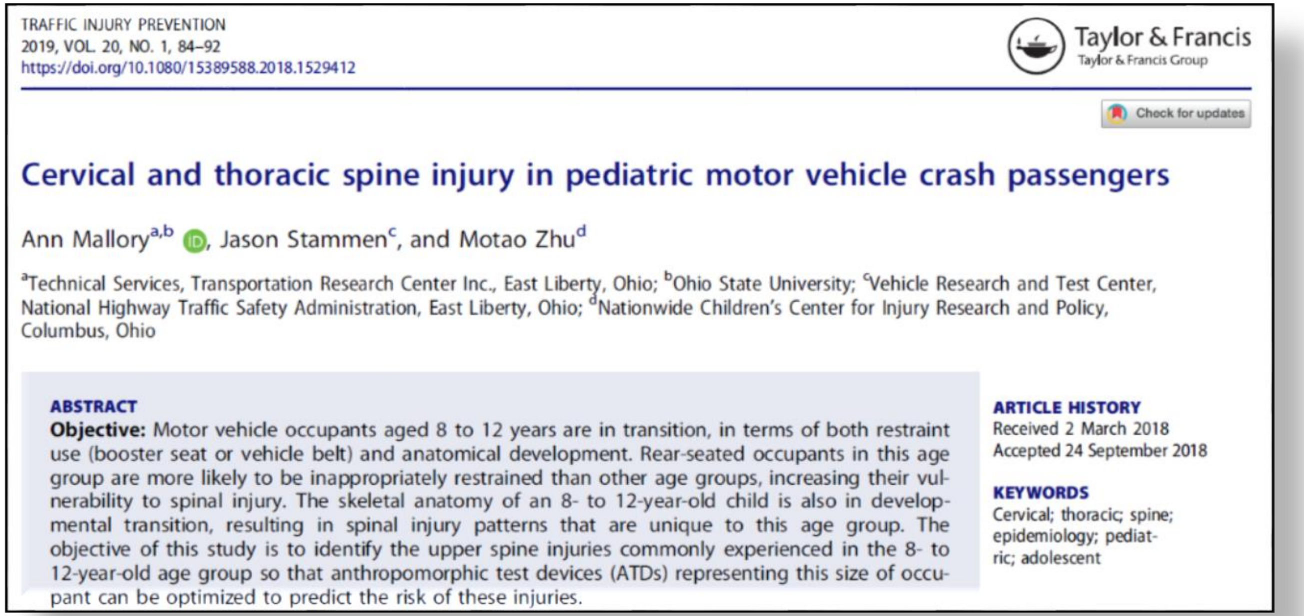


From: Tornvall, et al. (2005) "Comparison of shoulder range-of-motion and stiffness between volunteers, Hybrid III and THOR Alpha in static frontal impact loading" International Journal of Crashworthiness, 10:2, 151-160.



Current Activities

- Leveraging pediatric biomechanical data, developmental transfer functions, CIREN cases, NTDB injury data, and ATD tests to derive injury risk functions
- Initial focus is on abdomen – thorax, head, and spine to follow



TRAFFIC INJURY PREVENTION
2019, VOL. 20, NO. 1, 84–92
https://doi.org/10.1080/15389588.2018.1529412

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Check for updates

Cervical and thoracic spine injury in pediatric motor vehicle crash passengers

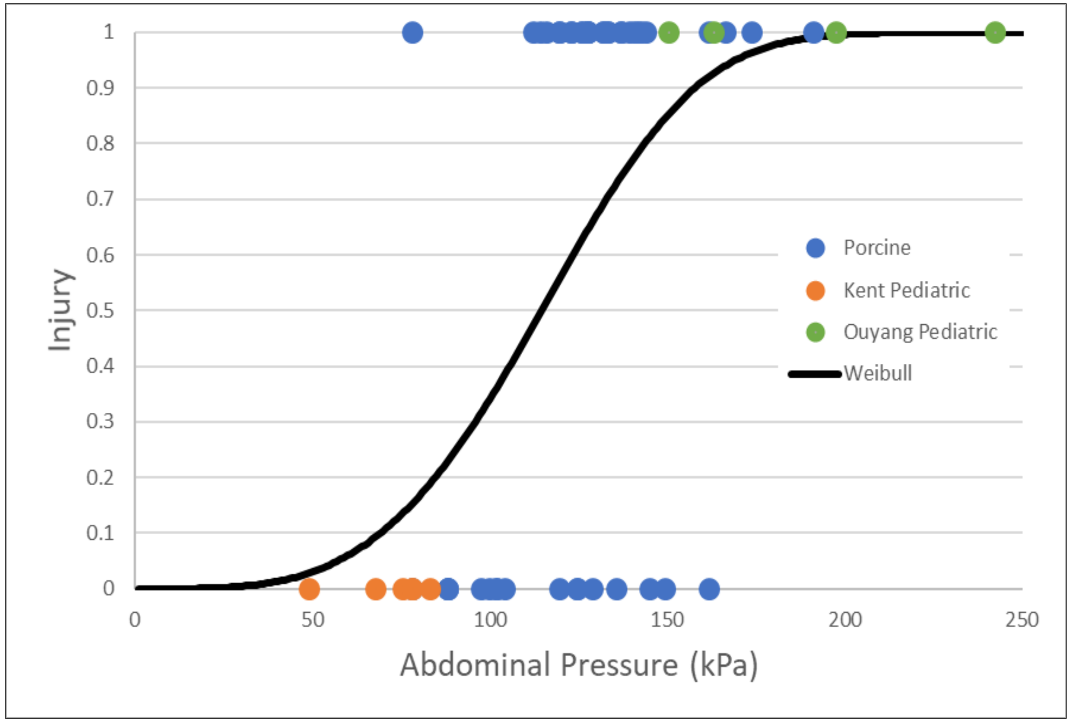
Ann Mallory[a,b], Jason Stammen[c], and Motao Zhu[d]

[a]Technical Services, Transportation Research Center Inc., East Liberty, Ohio; [b]Ohio State University; [c]Vehicle Research and Test Center, National Highway Traffic Safety Administration, East Liberty, Ohio; [d]Nationwide Children's Center for Injury Research and Policy, Columbus, Ohio

ABSTRACT
Objective: Motor vehicle occupants aged 8 to 12 years are in transition, in terms of both restraint use (booster seat or vehicle belt) and anatomical development. Rear-seated occupants in this age group are more likely to be inappropriately restrained than other age groups, increasing their vulnerability to spinal injury. The skeletal anatomy of an 8- to 12-year-old child is also in developmental transition, resulting in spinal injury patterns that are unique to this age group. The objective of this study is to identify the upper spine injuries commonly experienced in the 8- to 12-year-old age group so that anthropomorphic test devices (ATDs) representing this size of occupant can be optimized to predict the risk of these injuries.

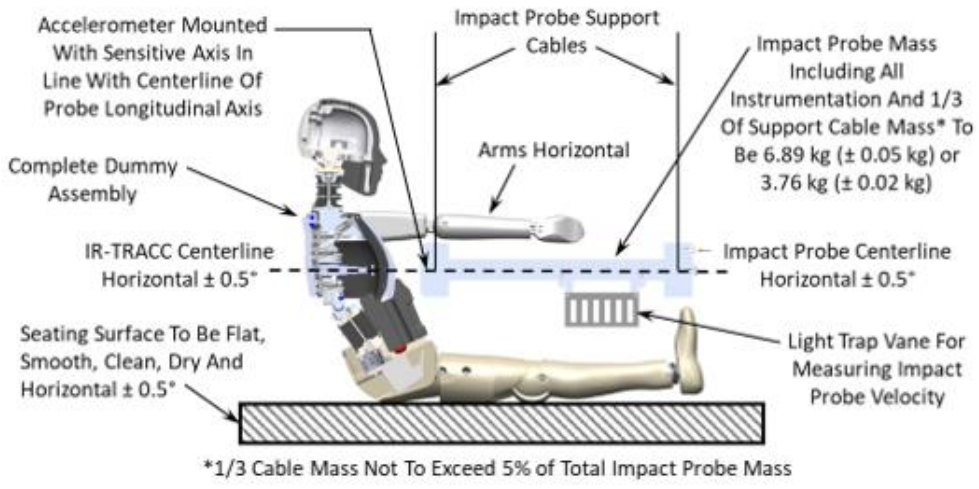
ARTICLE HISTORY
Received 2 March 2018
Accepted 24 September 2018

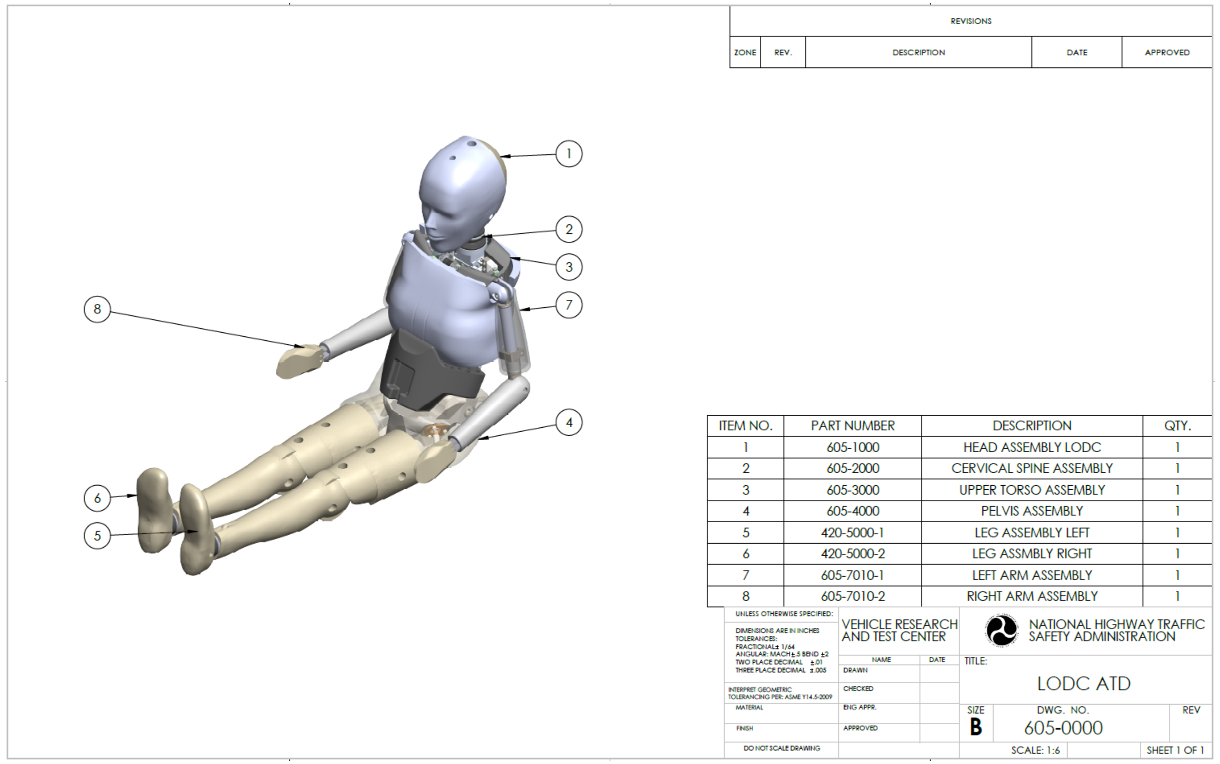
KEYWORDS
Cervical; thoracic; spine; epidemiology; pediatric; adolescent



Current Activities

- Generating documentation needed for Part 572: drawing package, parts list, user’s manual, and qualification procedures
- Open source ATD: will include material properties, tooling, and other manufacturing details





Summary

- NHTSA initiated work on the LODC to address limitations with Hybrid III 10YO
- Recent pediatric biomechanical research has provided the data needed to make the LODC biofidelic
- Recent work has focused on improving repeatability, usability, and widening its application bandwidth
- Current activities are focused on completing the LODC design, building a computational model, injury risk functions, and Part 572 documentation

RESEARCH DOCKET ENTRIES

1. *Stammen et al.”Biomechanical Response of the Human Chin and Manubrium” Annals of Biomedical Engineering (2012).*
2. *Stammen ”Introduction of a New Thorax for a Large Child ATD” Advances in Child Injury Prevention (2014).*
3. *Stammen et al. ”Dynamic Response Criteria for a Large Child ATD Thoracic Spine” IRCOBI (2014).*
4. *Suntay & Stammen “Comparative Biofidelity Assessment of the Large Omnidirectional Child Prototype and Hybrid III 10-Year-Old ATD” DOT HS Report (2014).*
5. *Stammen et al. ”Development of the Large Omnidirectional Child (LODC) ATD” SAE Govt/Industry (2016).*
6. *Stammen et al. ”The Large Omnidirectional Child (LODC) ATD: Biofidelity Comparison with the Hybrid III 10-Year-Old” Stapp Car Crash Conference (2016).*
7. *Ramachandra et al. ”Abdominal Biofidelity Assessment of 50th Percentile Male and 10-Year-Old ATD Responses Relative to a Recently Developed Belt-Loading Corridor” IRCOBI (2017).*
8. *Mallory, Stammen, & Zhu “Cervical and Thoracic Spine Injury in Pediatric Motor Vehicle Crash Passengers” Traffic Injury Prevention 20:1, 84-92 (2019).*
9. *Suntay & Stammen “Evaluation of the Large Omnidirectional Child (LODC) ATD” DOT HS 812 755 (2019). https://rosap.ntl.bts.gov/view/dot/41843*

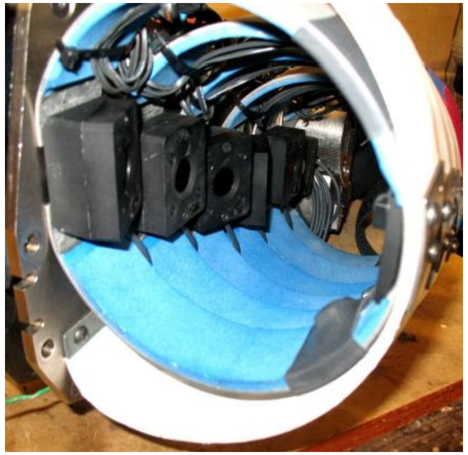
WorldSID 50th Percentile Male ATD

Kevin Moorhouse, Ph.D.

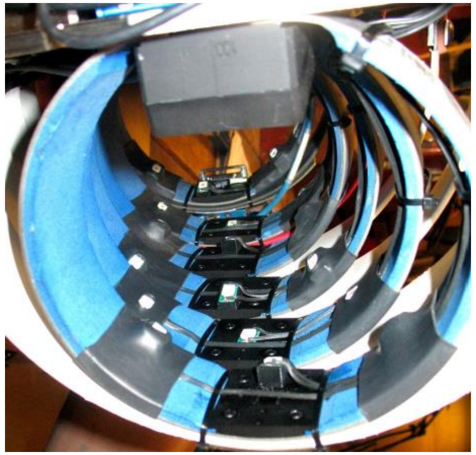
WSID-50M: 50th Percentile Male ATD

- Features include: six independent ribs tuned for humanlike response, RibEye measurement system capable of measuring lateral and oblique rib displacements, and on-board DAS
- Anthropometry derived from UMTRI AMVO data set
- Biofidelity quantitatively evaluated using Biofidelity Ranking System (BioRank); demonstrated improvement compared to ES-2re

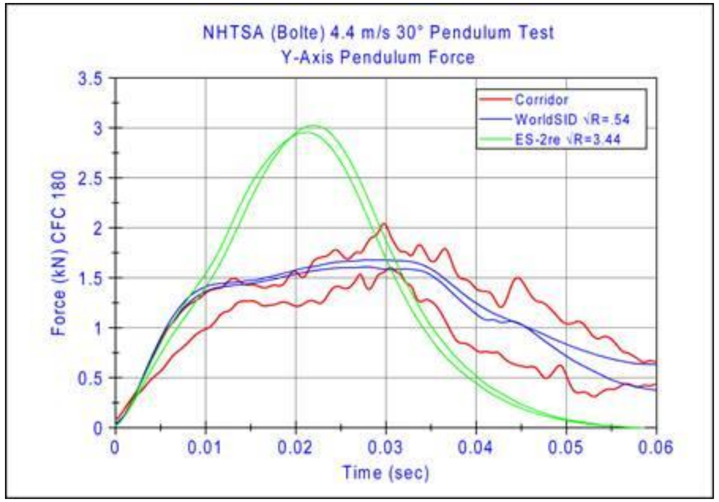
RibEye Sensors



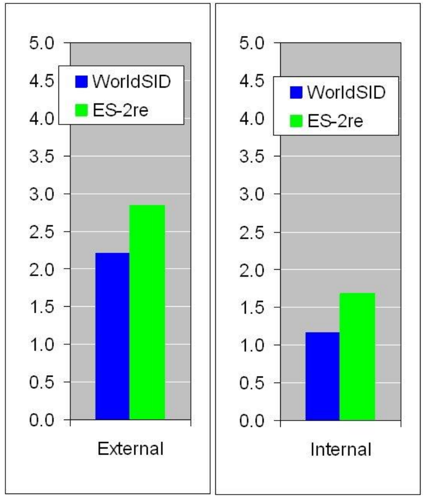
RibEye LEDs



Shoulder Biofidelity

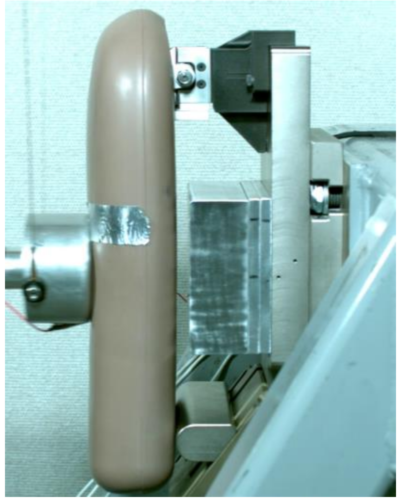


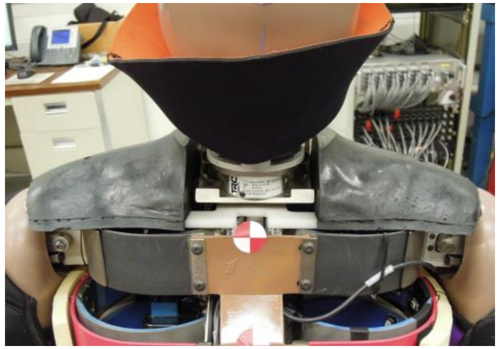
Overall Biofidelity



Current Research

- Developing single-arm qualification test
- Design improvements:
  - Shoulder pad
  - Split thorax pads
  - Sleeveless suit





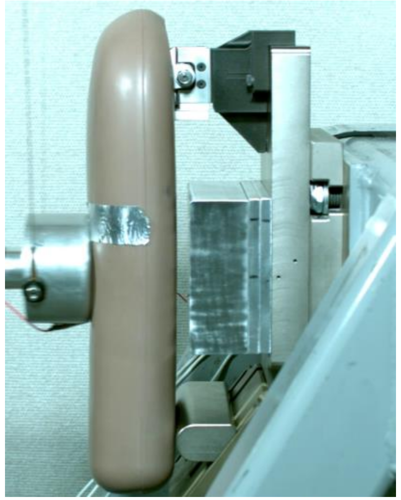
- Developing technical reports & documentation

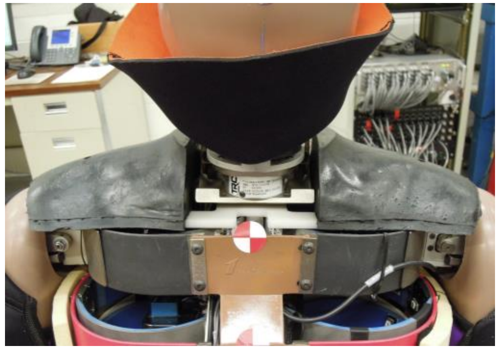
  Available (see Docket):
  - Biofidelity Evaluation (ESV 2009)
  - Dummy Seating Procedure: DOT HS 812 729 https://rosap.ntl.bts.gov/view/dot/41900
  - Optimal RibEye LED Locations: DOT HS 812 758 https://rosap.ntl.bts.gov/view/dot/41937

For more information, see Docket ID NHTSA-2019-0108 NHTSA Crashworthiness Research – WorldSID-50M Documentation

Current Research

- Developing single-arm qualification test
- Design improvements:
  - Shoulder pad
  - Split thorax pads
  - Sleeveless suit





- Developing technical reports & documentation

  Future Reports:
  - RibEye Implementation/Evaluation Report
  - R&R, Durability Report
  - PADI, Qualification Procedures
  - Injury Criteria, Drawing Package

For more information, see Docket ID NHTSA-2019-0108 NHTSA Crashworthiness Research – WorldSID-50M Documentation

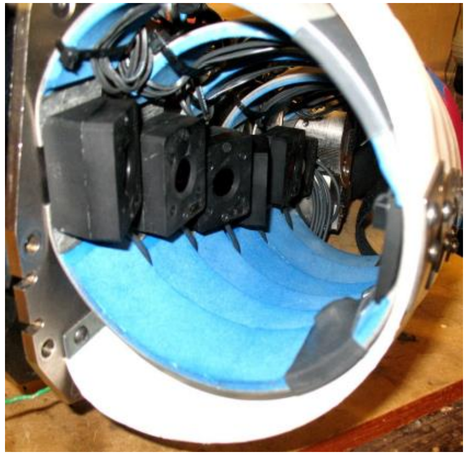
WorldSID 5th Percentile Female ATD

Kevin Moorhouse, Ph.D.

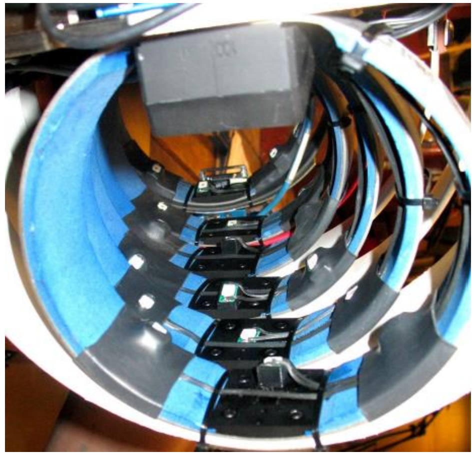
WSID-05F: 5th Percentile Female ATD

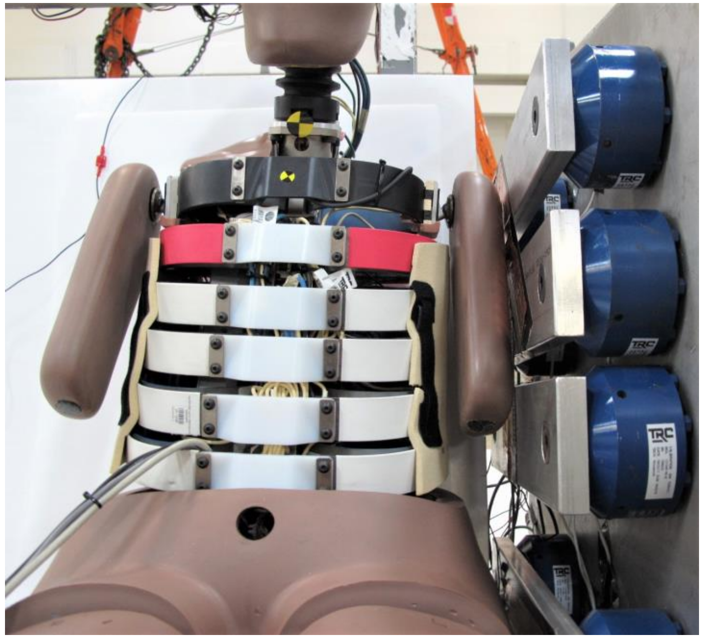
- Represents small-size adult female and adolescent
- Features include: six independent ribs tuned for humanlike response, RibEye measurement system capable of measuring lateral and oblique rib displacements, and on-board DAS
- Anthropometry derived from UMTRI AMVO data set

RibEye Sensors



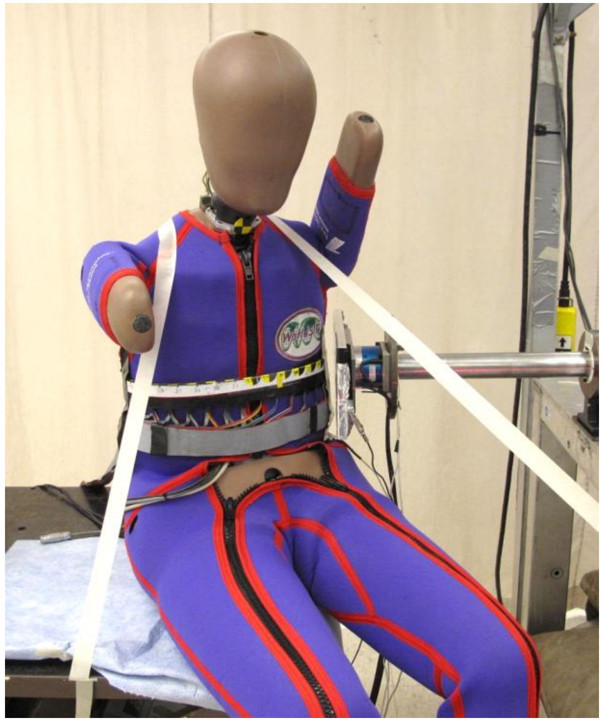
RibEye LEDs

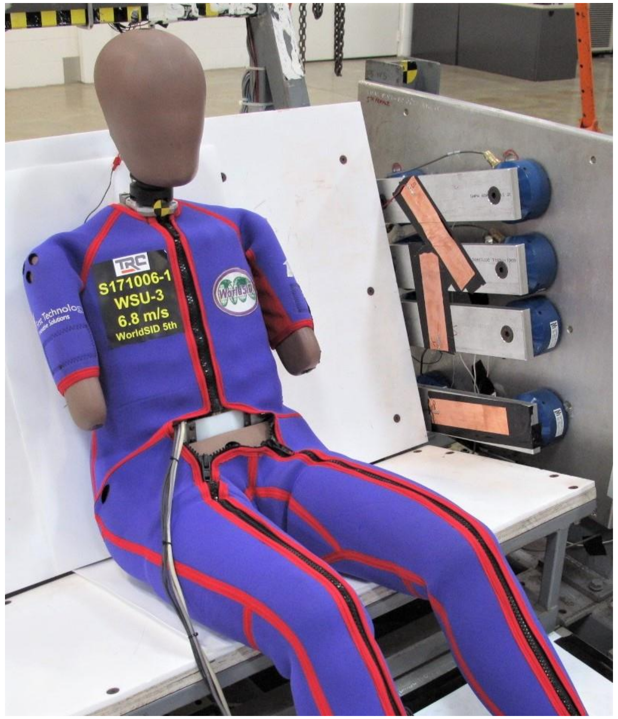




Current Research

- Evaluating Biofidelity
  - Dummy tests complete
  - Developing new response targets
  - Refining BioRank system
  - Comparing to SID-IIs
- Measuring Mass Properties
- Developing Seating Procedure
- Future Work
  - Dummy Upgrades
    - Pelvis, shoulder, and neck bracket
  - RibEye Implementation/Evaluation
  - R&R Evaluation
  - Injury Risk Curve Development





- Durability Evaluation
- Qualification Procedures Development
- PADI
- Drawing Package

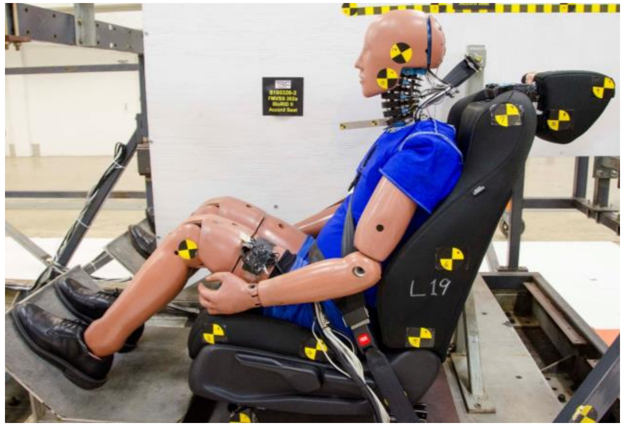
For more information, see Docket ID NHTSA-2019-0109 NHTSA Crashworthiness Research – WorldSID-05F Documentation

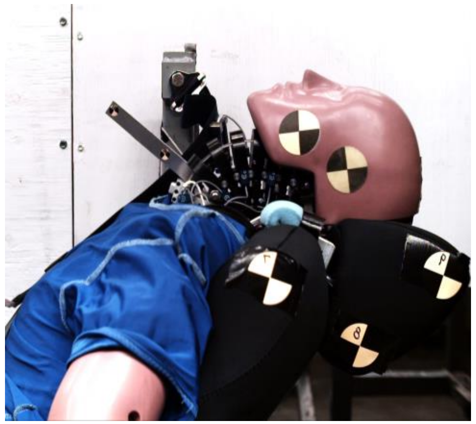
BioRID-II 50th Percentile Male ATD

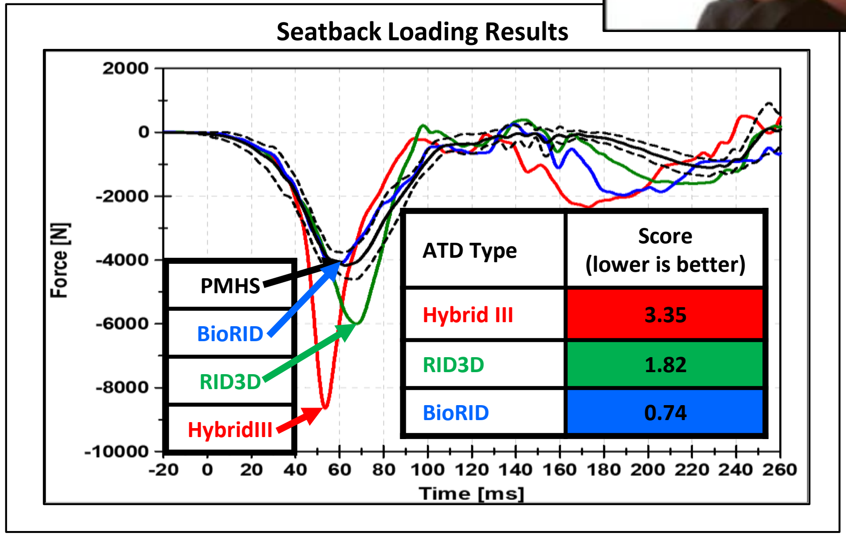
Kevin Moorhouse, Ph.D.

BioRID-II: 50th Percentile Male ATD

- Offers human-like characteristics, such as a fully articulated spine that contains elastomeric elements that represents muscles and discs.
- The unique design of the BioRID-II allows it to move like a human while promoting realistic seat back interaction
- Includes state-of-the-art measurement capabilities that can detect whiplash injuries







Current Research

- Developing Extension-Based Injury Criteria
  - Collecting biomechanical data (PMHS) and conducting matched pair ATD tests
- Installation of qualification sled
- Evaluation of qualification tests

- Developing technical reports & documentation

Available (see Docket):

- Biofidelity Evaluation (Stapp 2012)
- Various other Stapp/IRCOBI/ESV/TIP publications

Future work:

- R&R, Durability, Drawing Package, PADI
- Qualification Procedures, Seating Procedure
- Injury Criteria, Injury Risk Curves

For more information, see Docket ID NHTSA-2019-0111 NHTSA Crashworthiness Research – BioRID-II Documentation

Summary of NHTSA ATD Research Dockets

ATD	Docket Number - Title
THOR-50M	**NHTSA-2019-0106** - NHTSA Crashworthiness Research – THOR-50M Documentation
THOR-05F	**NHTSA-2019-0107** - NHTSA Crashworthiness Research – THOR-05F Documentation
LODC	**NHTSA-2019-0110** - NHTSA Crashworthiness Research – LODC Documentation
WorldSID-50M	**NHTSA-2019-0108** - NHTSA Crashworthiness Research – WorldSID-50M Documentation
WorldSID-05F	**NHTSA-2019-0109** - NHTSA Crashworthiness Research – WorldSID-05F Documentation
Bio-RID II	**NHTSA-2019-0111** - NHTSA Crashworthiness Research – BioRID II Documentation

Clarification or Questions?