ATD Technical Advisory Meeting on Dummy Design
Thursday, December 4, 2014
7:00 am – 9:00 am EST
Humanetics Headquarters in Plymouth, MI
and via WebEx
Agenda

• Petition Update
  o Auto Alliance petition / NHTSA
    ‣ Small Female Jacket
    ‣ Eurosid Abdomen

• ATD Component Updates
  o Small Female Skull Cap
  o Hybrid III Lumbar
  o Hybrid III Ankle J2949
  o FMVSS 226 Head form
  o IRTACC

• Harmonization Update
  o H Standard Update

• Regulation Dummy Update
  o Small Female Worldsid
  o Small Female THOR

• Future Dummy Update
  o Obese
  o Abdominal Upgrade
Auto Alliance Petition

NHTSA responded to Auto Alliance Petition

- Update drawing package for both the jacket and spine box updates
- Reviewed NHTSA comments and questions
- Discussed with Peter Martin the answer to overall NHTSA questions, and will provide follow up answers in writing with more data from different alliance members
- Next Auto Alliance meeting December 5, 2014
H head skin and cap skin
In Process

• The Production aluminum mold drawings for the HIII-5F Cap Skin are in the review state in the Vault.
Update on Lumbar testing at Humanetics on first lumbar J3074 for SAE DTEC H3-50th Lumbar Flexion Task Group

November 4, 2014
John Below, Michael S. Beebe, Mark Brown, Humanetics Innovative Solutions, Inc.
Testing Completed on both FT and Harmonized Lumbar

- Spine Box without pot bracket to interfere with lumbar
- Spine Box with Spacer behind pot bracket to cause interference with lumbar
- Initial Angle Differences.
Nominal Seating Posture in Vehicle

- Head Level
- Spine Box at 12.1 Degree rearward
- Pelvic Angle of 22.5 Degree
Nov 4, 2014; Conclusions for FT vs Harmonized Lumbar

• **Pot bracket contact with lumbar will increase force (small at 20) at 30 degrees**
  - The greater the starting angle, the higher the force at 30 degrees
  - Harmonized generally lower force at 30 degrees with no contact
  - FT generally lower force at 30 with no contact

• **Recommendation for procedure**
  - Spine without pot bracket, requires a new insert
  - Start of 0 degrees Seating or 12.1 degree +/- 2 degrees, back of spine box instrument cavity opening (same as Hybrid III family, standard seating posture)
  - Harmonized generally lower, to out of, force corridor at 30 degrees at starting angle of 12.1 degrees.
  - FT generally lower force to out of force corridor at 30 degrees at starting angle of 12.1 degrees.

• **Recommendation for Corridor**
  - Adjust 30 degrees based upon population testing from SAE round robin
  - Humanetics supply spine box and neck bracket
HHH50 Lumbar Data Summary

FT & Harmonized Lumbars

Higher Starting angles

Lower Starting angles
No contact with Pot Bracket
<table>
<thead>
<tr>
<th>Lumbar</th>
<th>Start Angle</th>
<th>Spacer</th>
</tr>
</thead>
<tbody>
<tr>
<td>HARMONIZED</td>
<td>12.1 DEG</td>
<td>WITH SPACER</td>
</tr>
<tr>
<td>OLD FT</td>
<td>15.7 DEG</td>
<td>NO SPACER</td>
</tr>
<tr>
<td></td>
<td>20.1 DEG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO SPACER</td>
<td></td>
</tr>
</tbody>
</table>

Mean of Force at 30 deg Corrected for R:

- Lumbar: 320
- Start Angle: 330
- Spacer: 410

Force at 30 degrees

Fitted Means

20.1 DEG (8 DEG)
Draft Outline Test Procedure

• Equipment
  o Spine Box replacement (w/ Hybrid II type neck bracket replacement)
  o Torso Flexion machine
  o 95th pelvic adaptor

1. Pre Flex lumbar (3X)
   o Pull forward to 35 degrees
   o Hold at initial position (12.1 degrees back of spine box) for 30 minutes

2. Remove any load from pull device

3. Record initial position after 2 minutes (<5 degrees from nominal)

4. Pull forward to 45 degrees at one degree per second and hold for 10 seconds

5. Release
   o Record final angle after 3 minutes?

6. Plot absolute angles and compare to force specification at 10, 20, and 30 degrees.
   o Force Specifications need to be verified by test program.
Conclusion

• Humanetics to draft Lumbar test for SAE and will send out for vote
Will re-issue SAE J2949 Document

Second ballot did receive enough votes - Approved with Comments
Document has been updated with comments and sent back to SAE
Ejection Head Form

- Mold insert is done, its in the check phase.
- First trials with mold early December
- Available for customer trials first Quarter 2015
This presentation will cover the latest significant improvements:

1. **Absolute Length Calibration**
   - For all 2D IR-TRACC WorldSID and Q10 applications

2. **Enhanced IR-TRACC Tubes In-Out Calibration**
   - All IR-TRACCs
   - Including component improvements
   - Includes additional measurements taken with telescoping tubes in the full-in and full-out positions
1. 2D IR-TRACC Absolute Length Calibration

- Additional calibration step providing absolute length and reference angle
  - Required for Euro NCAP
  - Lateral chest deflection calculation

- Procedure applicable for WorldSID 50th, 5th and Q10

- Fixture and procedure fully developed and validated
  - Internally vetted during past three months
  - Will be made commercially available

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1. 2D IR-TRACC Absolute Length Calibration

- Formal implementation is in process
  - Technical service bulletin describing procedure published 31 October
  - Euro NCAP makes reference to service bulletin
  - Procedure is implemented at Humanetics Europe

- Manuals in process (nearing completion)
  - User Instruction of absolute calibration
  - Calibration Software for data collection
  - Dummy manuals (WS50, WS5F, Q10) for use of calibration parameters, polarity checks, data processing formulae

- Next steps
  - Define ISO standard for 2D IR-TRACC Absolute Lenght Calibration
  - Define ISO MME coding for 2D IR-TRACC signals
  - Humanetics working with AK3 members
2. Tubes In-Out IR-TRACC Calibration Procedure

- Updated procedure according to findings previously reported at WorldSID UM, ISO WG3 June& November 2014, WorldSID TEG, AK3 / AK5
  - Includes tubes-in & tubes-out position analysis
- Narrower tolerance based on span of in-out error
- Internal validation over past several months showed good results
  - In-out calibration began with all new IR-TRACC production on 1 September
  - Yield is extremely high (>95%) and any IR-TRACC not passing the enhanced procedure has not been approved for use
- Technical service bulletin release is imminent
2. Tubes In-Out IR-TRACC Calibration Procedure

- Existing IR-TRACCs **possibly** do not pass narrow tolerance of new procedure
- Upgrade of existing IR-TRACCs to improve accuracy
  - New components: higher grade photo transistor and guide tube, implemented in production since January 2014
  - Re-adjustment & Re-calibration tubes In-Out
- In-Dummy - single point- quick check for Existing IR-TRACCs included in service bulletin
  - Users are recommended to check their IR-TRACCs
  - If quick-check passes LIKELY to pass Tubes In-Out
  - If quick-check fails you can decide to keep IR-TRACC in service
  - Or contact Humanetics sales representative for upgrade
Next Steps

► Continuing to study ways to develop and implement additional improvements
► Development of a calibration standard for 2D IR-TRACC in cooperation with the working groups
  ► Already started
► Any other items?
Humanetics has developed an absolute length calibration procedure for the 2D IR-TRACC assembly (Infra-Red Telescoping Rod for the Assessment of Chest Compression). The 2D IR-TRACC millimeter (mm) output will now be expressed in absolute length with respect to the rotation centre. In this procedure a Reference Angle is obtained as well. Absolute Length and Reference Angle are relevant to the WorldSID 50th, but applicable to additional ATDs in the near future. The absolute length calibration procedure is developed in parallel with the standard length calibration procedure which should precede the absolute length calibration step. The absolute length calibration is available as a service from Humanetics Europe GmbH, our facility in Heidelberg, Germany, and will be implemented in other Humanetics facilities in the future.

Background

Euro NCAP will implement the WorldSID dummy with 2D-IR-TRACCS in their side impact protocols starting 2015. The injury parameters will be based on the lateral compression of the ribs. This requires calculation of the rib position in the spine box co-ordinate system. Absolute Length Calibration facilitates this calculation.

Absolute Length Calibration

The new procedure is carried out in three steps. In the first step, length calibration is carried out according to the standard IR-TRACC calibration procedure (reference Service Bulletin “IR-TRACC Harmonized Certification,” publication date February, 2014.) The angle sensor needs to be calibrated according to the existing procedure.

In the next step the 2D-IR-TRACC assembly is mounted on Reference Fixture part # 11220 in an accurately defined reference position. This allows finding the ‘Absolute intercept’ and the ‘Reference Angle’. These parameters are required for calculating the position in x- and y-co-ordinates.

The third and final step is to validate the calibration results. The data obtained in position 1 and 2 on the reference fixture are used to check polarity of the angle sensor and to check if the calculated x- and y-co-ordinates (and also angle and length) correspond to the predefined known positions on the fixture. This last step confirms that the calibration has been executed correctly. In case of a non-correspondence, all previous steps need to be re-examined and corrected until the results are corresponding to the expected values.

Implementation of Service

The new procedure is currently offered as an additional service to customers effective immediately from Humanetics Europe GmbH and will follow in other Humanetics facilities in the near future.

Implementation into standard IR-TRACC production will be forthcoming in early 2015 and the tools needed to do this calibration will be made commercially available.

Scope of Absolute Length Calibration: only 2D-IR-TRACCS, IF-367 and IF-368 for WorldSID 50M; IF-371 for WorldSID 5th Female; IF-372 for Q10.

Equipment: Reference Fixture part # 11220

Documentation: The user manuals of WorldSID 50M, 5F and Q10 provide details and instructions on implementation of the calibration parameters in the data acquisition system, formulas to obtain results in the dummy spine co-ordinate system and how to check sensor polarities.
DRAFT H STANDARD
READY FOR DISTRIBUTION
H Standard

Humanetics

H Standard

for ATD Certification Laboratories
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3.2 Potentiometers
3.2.1 Displacement Transducer Calibration Standards

Humanetics Innovative Solutions, Inc. calibration standard for Rotary Potentiometers: Fixture # 6790 (Figure 1).

Humanetics Innovative Solutions, Inc. calibration standard for Linear Potentiometers: Fixture # 5245 (Figure 2) with appropriate adapters where needed.

![Figure 1- 6790 Rotary Potentiometer Calibrator](image1)

Calibrated Voltmeter with adequate precision: Agilent 34401A or equivalent

Precision Power Supply: 10.00 VDC stable with zero drift.

The calibration of the potentiometer must indicate the accuracy over the calibration range of the device.
3.2.5 **H 211 Linear Displacement Transducers Specifications**

**Calibration Range** – Entire mechanical travel (minus 1-2mm from the ends of mechanical travel) with center of electrical travel set to 0mm. The endpoints of the electrical travel are sometimes at the end of mechanical travel and should not be used in the error calculations.

**% Independent Non-Linearity** – the largest acceptable error in terms of percent of calibration range when comparing actual value to best fit line over the calibration range shall be less than 0.25% over the calibration range.

**Error** – The maximum acceptable error must be less than 0.0025 times the calibration range for a given linear potentiometer.

**Minimum Number of Calibration Points** – To have an adequate representation of the electrical characteristics of the potentiometer, a minimum of (11) eleven calibration points should be taken.

**Hysteresis** – At this time there are no requirements for hysteresis, however all data must be taken in same direction. Reversing direction or hunting for a point will introduce some hysteresis error and should be avoided.

*Figure 6- Linear Potentiometers*
### Table 1 - Linear Potentiometer Calibration Points

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Potentiometer Calibration Points (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-0121</td>
<td>Knee String Potentiometer</td>
<td>-18, -15, -12, -9, -6, -3, 0, 3, 6, 9, 12, 15, 18</td>
</tr>
<tr>
<td>79051-29</td>
<td>Knee Potentiometer</td>
<td>-10, -8, -6, -4, -2, 0, 2, 4, 6, 8, 10</td>
</tr>
<tr>
<td>9000851</td>
<td>ES-II Thorax Potentiometer</td>
<td>-30, -25, -20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30</td>
</tr>
<tr>
<td>880105-516</td>
<td>Knee Potentiometer – H-III5F</td>
<td>-8, -6, -4, -2, 0, 2, 4, 6, 8</td>
</tr>
<tr>
<td>960715-387</td>
<td>ES-1 Thorax Potentiometer</td>
<td>-30, -25, -20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30</td>
</tr>
<tr>
<td>160-0321L</td>
<td>H-II50th Thorax String Pot</td>
<td>-40, -35, -30, -25, -20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30</td>
</tr>
<tr>
<td>SID-089</td>
<td>SID Dummy Thorax Pot</td>
<td>-30, -25, -20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30</td>
</tr>
<tr>
<td>SA572-S61</td>
<td>SID-lls Thorax Pot</td>
<td>-30, -25, -20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30</td>
</tr>
</tbody>
</table>

- Recheck the excitation voltage ensure no change has taken place. The voltage should not have changed more than +/-0.001V.
- Calculate the slope using a linear regression analysis between the actual displacement and millivolts of output per volts of excitation (mm/mV/V_{excitation}).
- Calculate the error in millimeters between the calculated displacement and actual displacement for each calibration position.
- Determine potentiometer acceptability by comparing the error to the specifications in section 3.2.4.
4.2 Positioning Devices

Setting up the dummy or dummy component is important. Humanetics utilizes a variety of devices to aid in test setups.

The following devices are used for angular setups
- Levels
- Angle Indicators (non-digital) – protractors
- Digital Angle Indicators
- Alignment Attachment Fixtures

4.2.1 Levels

A variety of levels, ranging from vials, line levels and small precision levels are used in the Humanetics Test Lab. Each starting off with one important step... Verification.

4.2.1.1 Level Specifications

Level verification is completed by comparing the “Zero” angle (level) to a calibrated Starret Machinist Level Model 98-6 with an accuracy of 0.005”/12” (80-90 seconds). Each level is compared on the CFR 49 Part 572 Head Drop Fixture Plate (this is a precision ground surface with roughness specifications) which is level in each axis’. Each level is then checked to confirm the “Zero” angle is level. Devices are discarded which do not meet this criteria.

Line levels are used to position the dummies prior to the impact tests.
Line levels and Vials are also used to level Head Assemblies prior to drop tests.
Precision Pocket Levels (Starrett Model 135A) are used to level probes, fixtures, dummies, and components during test setups. Level are used in conjunction with linear scales to accurately level rib assemblies prior to testing.

4.2.2 Angle Indicators (non-digital) - Protractors

Humanetics uses non-digital angle indicators to measure reference angle for resetting the dummy after setting the pelvis angle and leveling the ribs. The reference angles are first taken (on the neck) and on the H-point tool once the ribs are level. This allows for the technician to reset the dummy's position once the jacket and clothing is replaced.

4.2.2.1 Angle Indicators (non-digital) - Protractors Specifications

Humanetics uses many different manufactures of protractors. An excellent example is the Empire Level 36 Protractor. All protractors have a 1 degree increments and a pointer to indicate position.

All protractors are verified using the 6790 potentiometer calibration fixture and checked through +/−90 degrees. The accuracy of these devices are better than +/−2 degrees. If any device is greater than +/−2 degrees then it is discarded.
4.3 Head Drop Plate
A head drop plate conforming to CFR 49 Part 572 Subpart E requirements is used with the Starrett 98-6 Machinist Level as the standard surface for verification of instruments which require the precise absolute 0 angle (level). The drop plate measurement tolerances follow the SAE J2856 recommended practices.

4.4 Impact Probes
Humanetics uses many different impact probes for the large variety of products that are tested. Humanetics follows the CFR 49 Part 572 regulation for masses and incorporates tolerances specified in the corresponding SAE manual for a particular dummy. More explanation on test probes are explained in the H572—Dummy Certification Requirement.

4.4.1 Impact Probe Suspension Cables
Humanetics hangs all impact probes on a 6 wire suspension cable set with turn buckles near the top of the test fixture for minute changes. That is there are a total of four cables equally spaced dropped from the top of the test fixture to each of the four pulleys. These four cables align the probe with the direction of impact and allow for the probe to be level while free hanging. A set of two cross over cables are attached to rear pulleys away from the probe impact face. These two cross over cables cross from one side of the test fixture to the opposite side of the probe. This stabilizes the probe and keep the flight true prior to impacting the dummy. More specifics regarding suspension cable size is explained in the H572—Dummy Certification Requirement.

4.4.2 Suspension Cable Hanging Procedure
Probes suspension cables are first attached to a pair of angle plates previously machined with a hole pattern that matches the distance between the pulleys on the test probe. The cables are left to hang loose while the impact probe is centered.
WORLDSID 5TH DESIGN UPDATES PRESENTED TO GTR TEG

prepared by: Paul Depinet & Ashwin Mathews
Small Female World-SID

Durability Testing results

- Pelvis- Consensus was that minimum contact above the desired test speed of 8.9 m/s was acceptable performance

- Neck/shoulder- To eliminate contact between the shoulder load cell and IRTRACC, a chamfer will be added along the bottom of the load cell, along with a plastic guard on the medial surface of the rib.
Small Female World-SID Seating Workshop

• The recommendation of the Seating Workshop group was to modify the spine to lumbar connection plate by a four degree wedge to change the hip to head angle to about 15 degrees when seated, i.e., rotate the torso forward resulting in a rib angle of approximately six degrees from horizontal. The head to upper neck connection plate would then be modified with a new plate that rotates the head rearward to make the head level to the ground. VRTC is investigating this change in head to neck angle and will provide data to the Seating Workshop group in order to facilitate the development of a seating procedure.
Small Female World-SID
Schedule for Evaluation Testing

<table>
<thead>
<tr>
<th>Lab</th>
<th>Duration</th>
<th>Tentative Date</th>
<th>Description of testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRTC</td>
<td>1 week</td>
<td>1st week December</td>
<td>Shoulder testing</td>
</tr>
<tr>
<td>OSRP GM/ Ford/WSU or TC</td>
<td>10 weeks</td>
<td>December 2014, January 2015, February 2015</td>
<td>Biofidelity pendulum &amp; sled testing; drop testing</td>
</tr>
<tr>
<td>PDB</td>
<td>8 weeks</td>
<td>March 2015, April 2015</td>
<td>TBD</td>
</tr>
<tr>
<td>Toyota/JAMA</td>
<td>8 weeks</td>
<td>May 2015, June 2015</td>
<td>TBD</td>
</tr>
<tr>
<td>Autoliv</td>
<td>8 weeks</td>
<td>July 2015, August 2015</td>
<td>TBD</td>
</tr>
</tbody>
</table>
SMALL FEMALE THOR
NHTSA Small Female THOR

- NHTSA RFQ has been release for Quote, due January 2015
- NHTSA provides scaled models to build from.
THOR ATD

HUMANETICS INNOVATIVE SOLUTIONS, INC.
THOR-M

• THOR-M dummy is configured with SD3 shoulder and THOR-LX legs

• Typical order includes 136 channels of instrumentation

• Options available for ARS sensors mounts in Head, Chest, and Pelvis

• Currently building over 14 dummies
THOR iliac

- Pelvic bone failures reported during THORAX test program, NHTSA UVA test program

- Coordinated with NHTSA to develop load limit requirements for analysis

- Speculations: thin area around the h-point hole boss caused the failure
THOR iliac wing

- Recent activity involves fabrication of sample wings and creating fixtures to perform destructive testing
- Estimate months of effort to perform evaluation and complete the redesign
Background of Current Prototype Obese ATD
Presentation at the Human Biomechanics Workshop November 9, 2014

Authors

Breanna Beahlen, Mike Beebe
Humanetics Innovative Solutions, Inc.

Jason Forman, Hamed Joodaki, Ali Forghani, Jeff Crandall
University of Virginia, Center for Applied Biomechanics

First Generation Obese ATD
Prototype Design Targets

• Weight: 35 BMI

• External Dimensions: 35 BMI

• Response: Match Kinematic results from UVa Sled testing.
35 BMI Weight Target

Body Mass Index: \( BMI = \frac{Mass \ (kg)}{(Height \ (m))^2} \)

- Risk of death and serious injury tends to increase \( \sim \) BMI 35**
- Mean BMI of obese people treated for automobile collision injuries \( \sim 35 \) (Neville et al. 2004)
  - “Choban et al. 1991 – “… in order to survive severely overweight [MI>31] patients can have no more than trivial injuries.”

- Design goal: Increase segment weights and size of torso, pelvis, upper legs- goal 273 lbs, \( 35 \frac{kg}{m^2} \) BMI

** Mock et al. 2002; Zhu et al. 2006; Jehle et al. 2012
## Weight Targets

<table>
<thead>
<tr>
<th>Segment</th>
<th>Hybrid III (lbs)</th>
<th>THOR (lbs)</th>
<th>Obese (lbs) Design Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>10 (5.8%)</td>
<td>10.2 (6.1%)</td>
<td>10.2</td>
</tr>
<tr>
<td>Neck</td>
<td>3.4 (1.9%)</td>
<td>3.64 (2.2%)</td>
<td>3.64</td>
</tr>
<tr>
<td>Upper Torso</td>
<td>37.9 (22.1%)</td>
<td>29.59 (17.9%)</td>
<td>49</td>
</tr>
<tr>
<td>Lower Torso</td>
<td>50.8 (29.7%)</td>
<td>62.3 (37.7%)</td>
<td>112</td>
</tr>
<tr>
<td>Upper Arm (each)</td>
<td>4.4 (5.1%)</td>
<td>4.4 (5.3%)</td>
<td>7.25</td>
</tr>
<tr>
<td>Lower Arm + Hand (each)</td>
<td>5 (5.8%)</td>
<td>5 (6.05%)</td>
<td>8.25</td>
</tr>
<tr>
<td>Upper leg (each)</td>
<td>13.2 (15.4%)</td>
<td>9.81 (11.9%)</td>
<td>16.2</td>
</tr>
<tr>
<td>Lower leg + feet (each)</td>
<td>12 (14%)</td>
<td>10.47 (12.7%)</td>
<td>17.4</td>
</tr>
<tr>
<td><strong>Total Weight</strong></td>
<td><strong>171.3</strong></td>
<td><strong>165.15</strong></td>
<td><strong>273</strong></td>
</tr>
</tbody>
</table>
35 BMI External Measurements Targets

<table>
<thead>
<tr>
<th>Location</th>
<th>ATD measurement(s) (cm)</th>
<th>PMHS measurement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Breadth - 4th Rib</td>
<td>42</td>
<td>40</td>
</tr>
<tr>
<td>Chest Breadth - 8th Rib</td>
<td>41</td>
<td>36</td>
</tr>
<tr>
<td>Chest Depth - 4th Rib</td>
<td>29</td>
<td>23.5</td>
</tr>
<tr>
<td>Chest Depth - 8th Rib</td>
<td>30</td>
<td>25.5</td>
</tr>
<tr>
<td>Hip Breadth</td>
<td>44.5</td>
<td>39.1</td>
</tr>
<tr>
<td>Chest Circumference - 4th Rib</td>
<td>130</td>
<td>110.7</td>
</tr>
<tr>
<td>Chest Circumference - 8th Rib</td>
<td>119</td>
<td>114.3</td>
</tr>
<tr>
<td>Waist Circumference - At Umbilicus</td>
<td>123.5</td>
<td>120</td>
</tr>
<tr>
<td>Waist Circumference - 8cm above Umbilicus</td>
<td>120</td>
<td>119.7</td>
</tr>
<tr>
<td>Waist Circumference - 8cm below Umbilicus</td>
<td>126</td>
<td>116.9</td>
</tr>
<tr>
<td>Thigh Circumference</td>
<td>65</td>
<td>68.6</td>
</tr>
<tr>
<td>Shoulder Breadth (Biacromial)</td>
<td>49</td>
<td>43</td>
</tr>
<tr>
<td>Seated Height</td>
<td>139</td>
<td>139.2</td>
</tr>
<tr>
<td>Seated Head to Buttock</td>
<td>93.5</td>
<td>98</td>
</tr>
</tbody>
</table>
Kinematics

• Trajectories $20 \frac{kg}{m^2}$ BMI vs $35 \frac{kg}{m^2}$ BMI, 48 km/h

Forman et al. 2009 AAAM
Additional Design Considerations

• THOR M models for pelvis, upper leg and Biorid jacket were reengineered to roughly 1.24x their original designs

• Place on the THOR Skeleton

• Chose materials to conform to seats
  o Materials with similar human flesh properties

• Use ballasts to increase weight of arms and lower legs
Obese Test Plan
Testing completed at UVa Sept, 29 2014

• Ran 4 tests, 2 @ 29km/h and 2 @ 48 km/h
  o Match the test conditions that were performed on the UVA obese cadaver
• Data measured from the following:
  o 2 Abdomen IRTRACCS
  o Upper neck load cell
  o 9 accelerometers
    ▸ 3 – head
    ▸ 3 – thorax
    ▸ 3 – pelvis
  o 6 Angular Rate Sensors
    ▸ 3 – head
    ▸ 3 – T1
• Test completed in a 2004 mid-sized sedan rear seat buck (Forman et al. 2009)
• Compare kinematics to 35 BMI PMHS data
Photos – Before & After 29 km/h Test
Photos – Before & After 48 km/h Test
Test Results and Discussion
Trajectories - 48 km/h

(from Forman et al. 2009)
New Pelvis & Thigh Flesh Material

• Pelvic flesh spread out 50mm in seating position in a soft seat to better simulate human flesh in seats
2015 Obese Draft Plan for Introduction
Next Steps - 1st Quarter 2015

Prototype ATD

• Complete data analysis from sled tests
• Provide to others that want to perform sled testing.

Plan for Commercialization of ATD

• Improve Arm Anthropometry
• Permanent Mold for Jacket
• Permanent Molds for Pelvis, Arm, & Thigh Flesh
• Improve lower leg ballast design
• Determine additional instrumentation which may be needed.
Next Steps - 2nd Quarter 2015

Prototype ATD

- Remold ATD as necessary
- Perform lab impact testing, as needed.

Plan for Commercialization of ATD

- Build new Obese ATD based on current THOR M 50th, with new arms and legs with permanent ballasts.
- Review and/or scale existing THOR M Certification test responses
Next Steps - 3rd Quarter 2015

**Prototype ATD**
- No Further work needed

**Plan for Commercialization of ATD**
- Perform all THOR M certification tests and check to draft corridors.
- Preform sled tests at UVa for final check on Kinematics
- Release First Version of Obese ATD
Next Steps - 4th Quarter 2015

Prototype ATD

- No Further work needed

Plan for Commercialization of ATD

- Review all customer testing feedback.
The ability to have the correct regional abdominal stiffness, intrusion measurement of the abdominal organs, and loading patterns in the thorax in motor vehicle crash conditions is important for assessing head-neck loads, brain, thorax, and abdominal injuries. Current ATD’s do not have all the components necessary to measure regional abdominal organ loadings necessary in new types of crash test procedures such as offsets. A proper thorax regional stiffness using the proper shaped and stiffness organs in the abdominal cavity covered with a muscle and fat layer are the items described in this presentation. As part of the development for these new platforms, the development of new biofidelity corridors and injury criterion will be completed.
PMHS Tests – Pressurization

Measure change of pressure in spleen

Pressure Sensor
— Catheter
Figure 2: (Left) FBL08-O sensor placement, as planned with sensors in hepatic veins and IVC; (Right) FBL06-O sensor placement, sensor placed extremely deep in hepatic vessel.

Figure 4: Schematic of external instrumentation
### Ex Vivo Liver Tests

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Units</th>
<th>50% Risk Value (Survival)</th>
<th>50% Risk Value (Logistic)</th>
<th>Log Likelihood</th>
<th>P-value</th>
<th>Goodman-Kruskal Gamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tissue $\dot{P}_{\text{max}}$</td>
<td>kPa/ms</td>
<td>8.97</td>
<td>8.69</td>
<td>-2.235</td>
<td>0.005</td>
<td>0.80</td>
</tr>
<tr>
<td>AIC ($V_{\text{max}} \cdot C_{\text{max}}$)</td>
<td>m/s</td>
<td>0.81</td>
<td>0.82</td>
<td>-6.110</td>
<td>0.009</td>
<td>0.79</td>
</tr>
<tr>
<td>Vascular $\dot{P}_{\text{max}}$</td>
<td>kPa/ms</td>
<td>10.4</td>
<td>10.6</td>
<td>-5.098</td>
<td>0.013</td>
<td>0.77</td>
</tr>
<tr>
<td>Tissue $P_{\text{max}}$</td>
<td>kPa</td>
<td>55.3</td>
<td>56.3</td>
<td>-3.584</td>
<td>0.023</td>
<td>0.70</td>
</tr>
<tr>
<td>Compression</td>
<td>%</td>
<td>30.2</td>
<td>29.9</td>
<td>-7.303</td>
<td>0.034</td>
<td>0.58</td>
</tr>
</tbody>
</table>

**Figure 9:** Injury risk vs. tissue $P_{\text{max}}$ for ex vivo liver tests.
• OSU radiology department provided direction for size and placement of organs
• Reviewing data to compare auto seated to standing or lying posture
• Used CAD Model from Zygote:

Solid Model of 50th Percentile Male (U.S. by height 68-70 inches and weight 184-196 lbs) Skin from Medical Scan Data
Measurement Goals for Thorax/Abdomen

- 3D IRTRACCs
- Strain Gages on Ribs
- Pressure measurements
- Chest Bands
Next Step

• OSU PMHS testing, measure liver, spleen, etc.
  Pressure, review injury

• Final Development of abdomen sac for ATD
Existing Hardware

• Lower Torso and legs from THOR
• Arms from Hybrid III
• Head from THOR

New Hardware

• Flexible Spine Shape from AVEO 50
• Floating Shoulder
• Thorax Ribs
  o adjusted to 7 degrees upward (elderly)
  o Adjusted to required position for Obese
• Organ design concept based on OSU data
  o locations from radiology
  o Organ Sac to hold organs in place
  o Muscle layer to hold organ sac in place
  o Fat Layer over entire torso
  o Fat layer covered with neoprene jacket
New Hardware

- **Flexible Spine Shape using AVEO Study (UMTRI)**
- Floating Shoulder
- Thorax Ribs
  - adjusted to 7 degrees upward (elderly)
  - Adjusted to required position for Obese
- Organ design concept based on OSU data
  - locations from radiology
  - Organ Sac to hold organs in place
  - Muscle layer to hold organ sac in place
  - Fat Layer over entire torso
  - Fat layer covered with neoprene jacket
New Hardware

- Flexible Spine Shape using AVEO Study (UMTRI)
- **Floating Shoulder**
  - Clavicle
  - Scapula
  - Ball joint for arm attachment
- Thorax Ribs
  - adjusted to 7 degrees upward (elderly)
  - Adjusted to required position for Obese
- Organ design concept based on OSU data
  - locations from radiology
  - Organ Sac to hold organs in place
  - Muscle layer to hold organ sac in place
  - Fat Layer over entire torso
  - Fat layer covered with neoprene jacket
Thank You for your attention