WS-1-7

EEVC WG12 WorldSID presentation

Washington, November 5-6, 2009

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Chairman EEVC WG12

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- WorldSID 50th percentile EEVC review
- WorldSID 5th percentile (small female)


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Activities EEVC WG 12

- Frontal dummies (THOR)
- Side Impact dummies (WorldSID)
- Whiplash dummies (BioRID and RID3d)
- Advanced child dummies (Q family)
- Injury criteria

Side Impact dummies

- WorldSID 50th percentile male dummy: EEVC WG 12 status report (2009).
- WorldSID 5th female developed within Aprosys: status report in preparation

Some history 50th percentile male side impact dummies

- ECE Regulation 95 in 1995 with EuroSID-1 dummy (ES 1)
- Same time period DOT-SID in FMVSS 214
- 1997: Start of 50th percentile WorldSID
- ES-2 in 2003 in ECE 1995 (intended as interim harmonized dummy)
- ES-2 re (re=rib extension) introduced in 2007 in FMVSS 214

Conclusions from EEVC WorldSID 50th percentile status report (2009)

- Biofidelity of the WorldSID is better than ES-2 and ES-2re.
- Other design requirements (repeatability etc..) of the WorldSID are in general well fulfilled
- Still concern on thorax deflection measurement method
- WorldSID is smaller than ES-2 dependent on seating position

Future activities EEVC concerning 50th percentile WorldSID

- Detailed analysis of the NHTSA (and other) test results as soon as available (including thorax deflection measurements)
- Analysis of injury risk functions under development by ISO WG6 and WorldSID positioning procedures
- Set-up of possible EEVC test program dependent on above findings

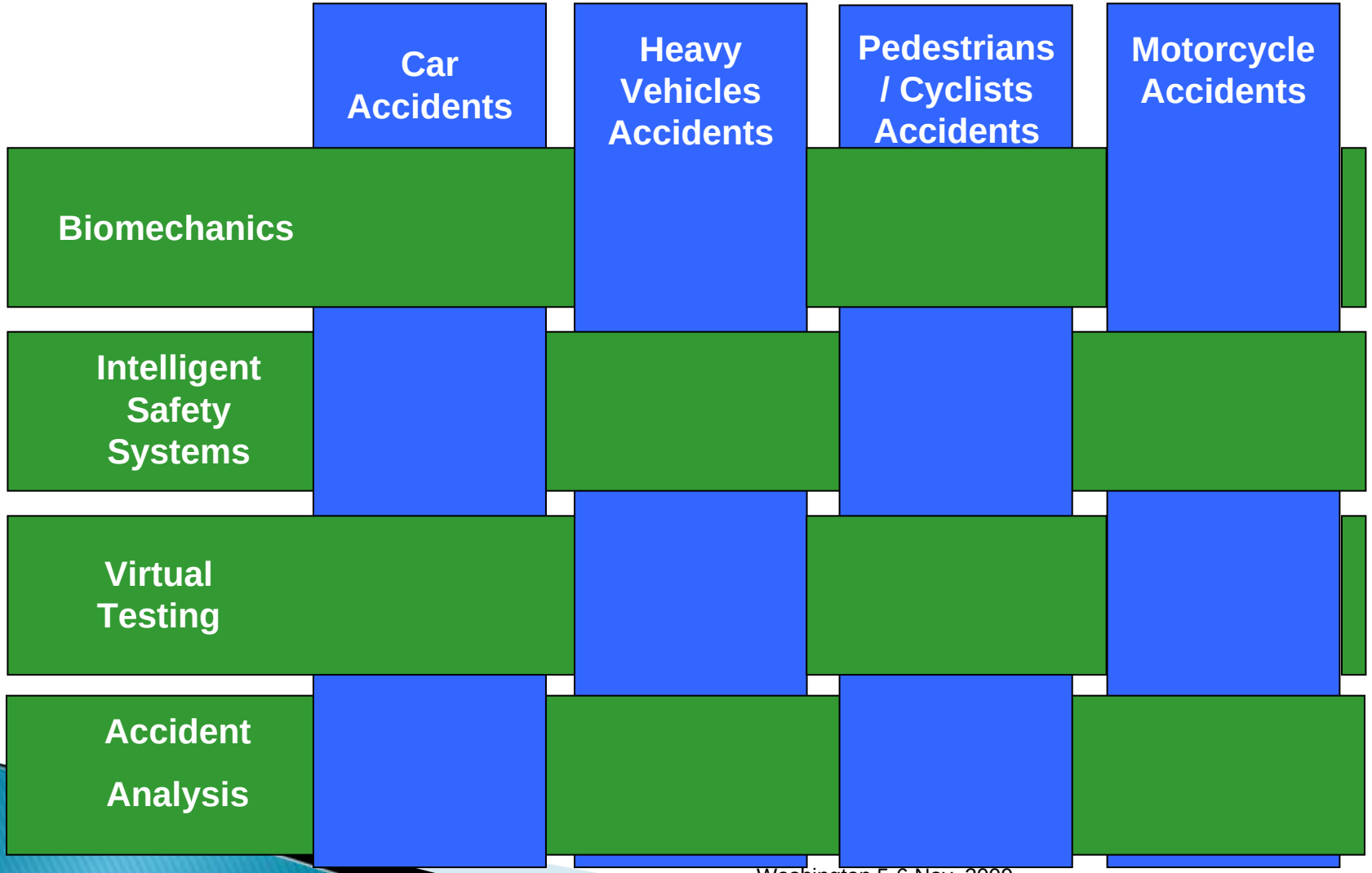
APROSYS

WorldSID Small Female Side Impact Dummy

APROSYS Overview

Project name:	Advanced Protection Systems - APROSYS
Coordinator:	TNO
Consortium:	51 partners (OEM, Suppliers, RTDs, Universities)
Core group members & sub project leaders:	Daimler, Renault, FIAT, VDO Automotive, TNO, CIDAUT, TRL, TUG, INRETS, Altair, Volkswagen, CIC
Starting Date:	01 April 2004
Ending Date:	30 March 2009
Budget Total / Funding:	32 MEURO / 18 MEURO

Integrated Approach



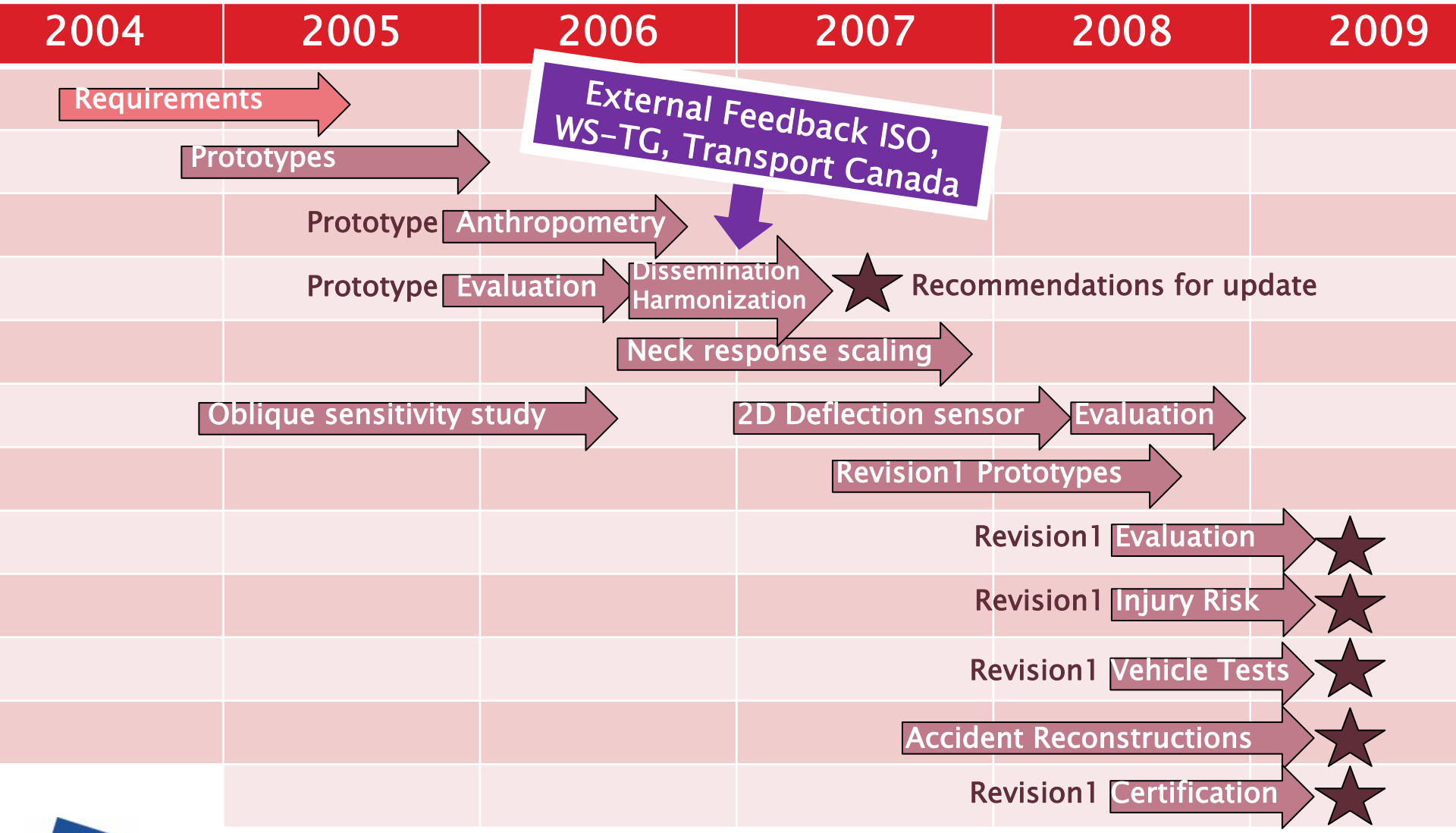
Specific Project Objectives

1. New injury criteria and injury tolerances
2. New mathematical models of the human body
3. New world-wide harmonized crash dummy
4. New knowledge and tools for intelligent safety systems
5. Enhancement of virtual testing technology
6. New test methods (for advanced safety systems)
7. Advanced protection systems for injury reduction in most relevant accident types

Why a small female side impact dummy?

- 30% of vehicle occupant deaths and serious injuries are attributed to side collisions
- Small females constitute an important share in vehicle to vehicle lateral collisions

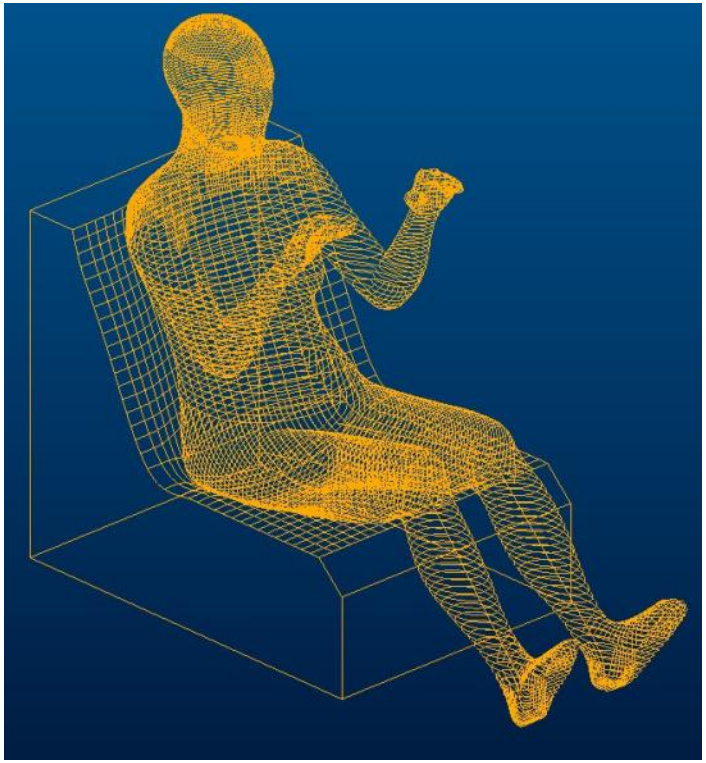
Overview of WorldSID Small Female Development



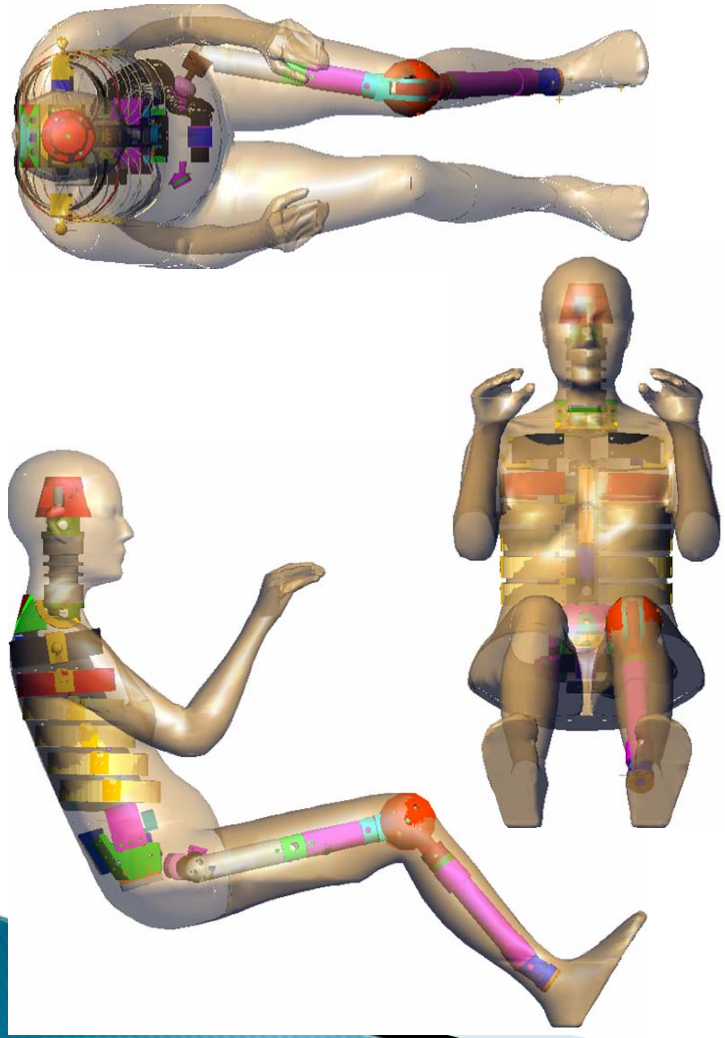
Anthropometry Requirements

- Schneider L.W., Robbins D.H., Pflüg M.A., Snyder R.G. (1983), 'Anthropometry of Motor Vehicle Occupants', Final Report DOT-HS-806-715 NHTSA (UMTRI)

- Reynolds, Snow, Young, (1981), 'Spatial Geometry of the Human Pelvis', Federal Aviation Administration, Memorandum Report No. AAC-119-81-5



Summary Anthropometry



Body segment [kg]	Target (UMTRI)	WorldSID 5F Rev1
Head	3.70	3.66
Neck	0.60	0.54
Thorax including half arms and 2D IR-tracc's	15.23	15.81
Abdomen	1.61	1.33
Pelvis	6.98	6.98
Upper legs	11.83	11.83
Lower legs, feet & shoes	6.00	6.61
Total	45.94	46.75
Suit	1.52	1.52
Pair of shoes	0.64	-
Total	**48.1**	**48.3**

Biofidelity Requirements

- Irwin A.L., Mertz H.J., Ali M. Elhagediab A.M., Moss S. (2002), 'Guidelines for Assessing the Biofidelity of Side Impact Dummies of Various Sizes and Ages, 46th STAPP Car Crash Conference *(based on ISO/TC22/SC12/WG5, Road Vehicles – Mid size male side impact dummy – Lateral impact response requirements to assess the biofidelity, TR 9790, 1997)*

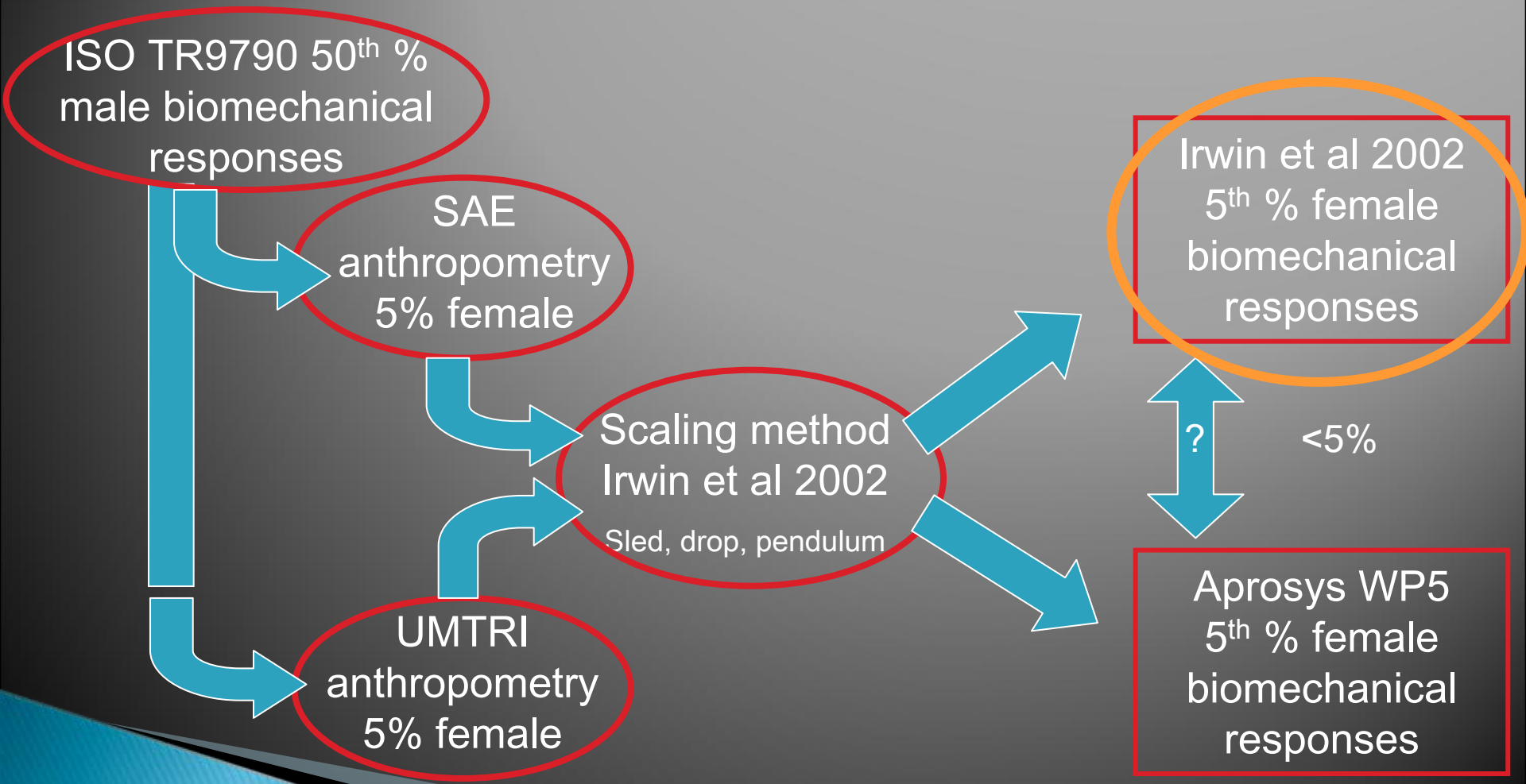
- Yoganandan & Pintar, 'Deflection, Acceleration, and Force Corridors for Small Females in Side Impacts', Traffic Injury Prevention, 6:379–386, 2005

Specific biofidelity Requirements

- ***Upper extremity***: Kemper, Stitzel, Duma, Matsuoka, Masuda, 'Biofidelity of the SID-IIs and a Modified SID-IIs Upper Extremity: Biomechanical Properties of the Human Humerus', ESV Paper Number 05-0123

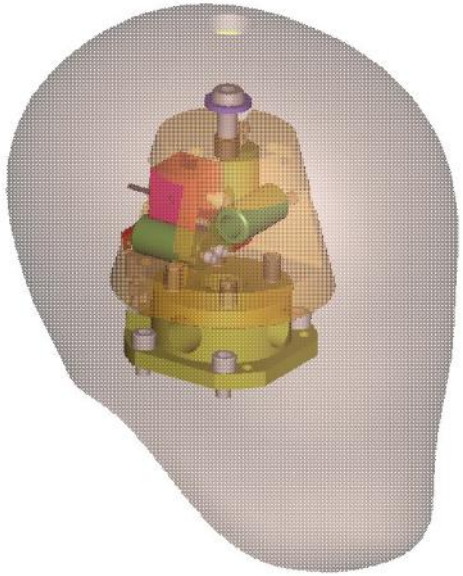
- ***Neck***: Meijer, R, Wisgerhof R., Wismans J., Been B., 'Scaling Head-neck Response Data And Derivation Of 5th Percentile Female Side-impact Dummy Head-neck Response Requirements In NBDL Test Conditions' International Journal of Crashworthiness, Volume 14 Issue 3 2009.

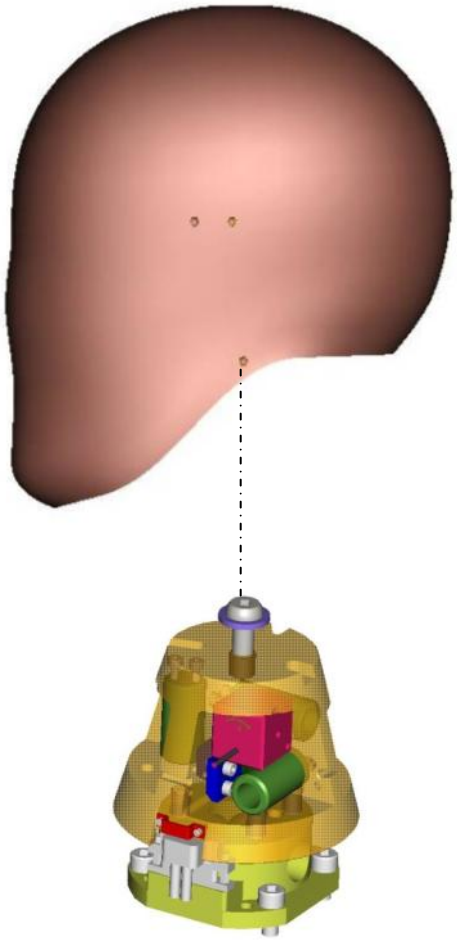
Biomechanical response scaling method



Head

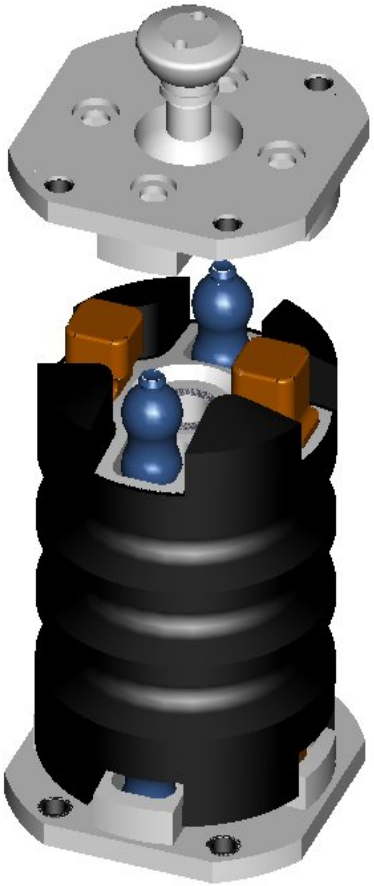
- Molded one piece polymer skull and skin
- Instrumented core
- Easy access to instrumentation

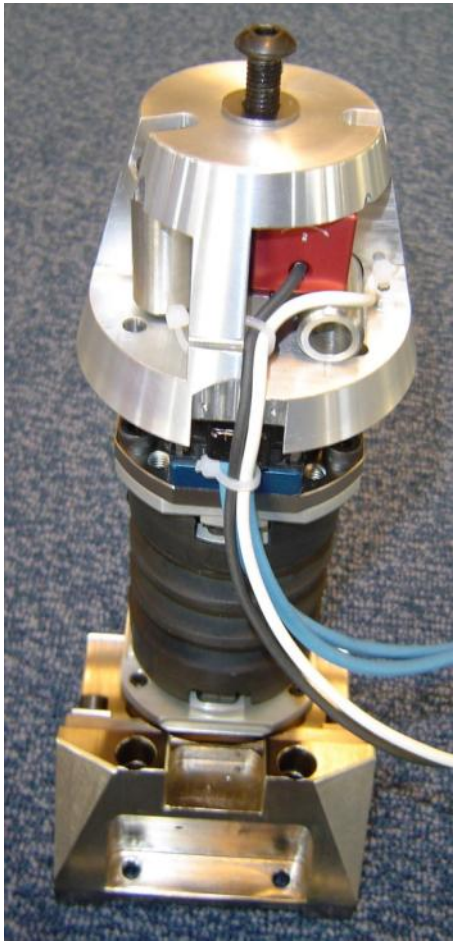




Neck

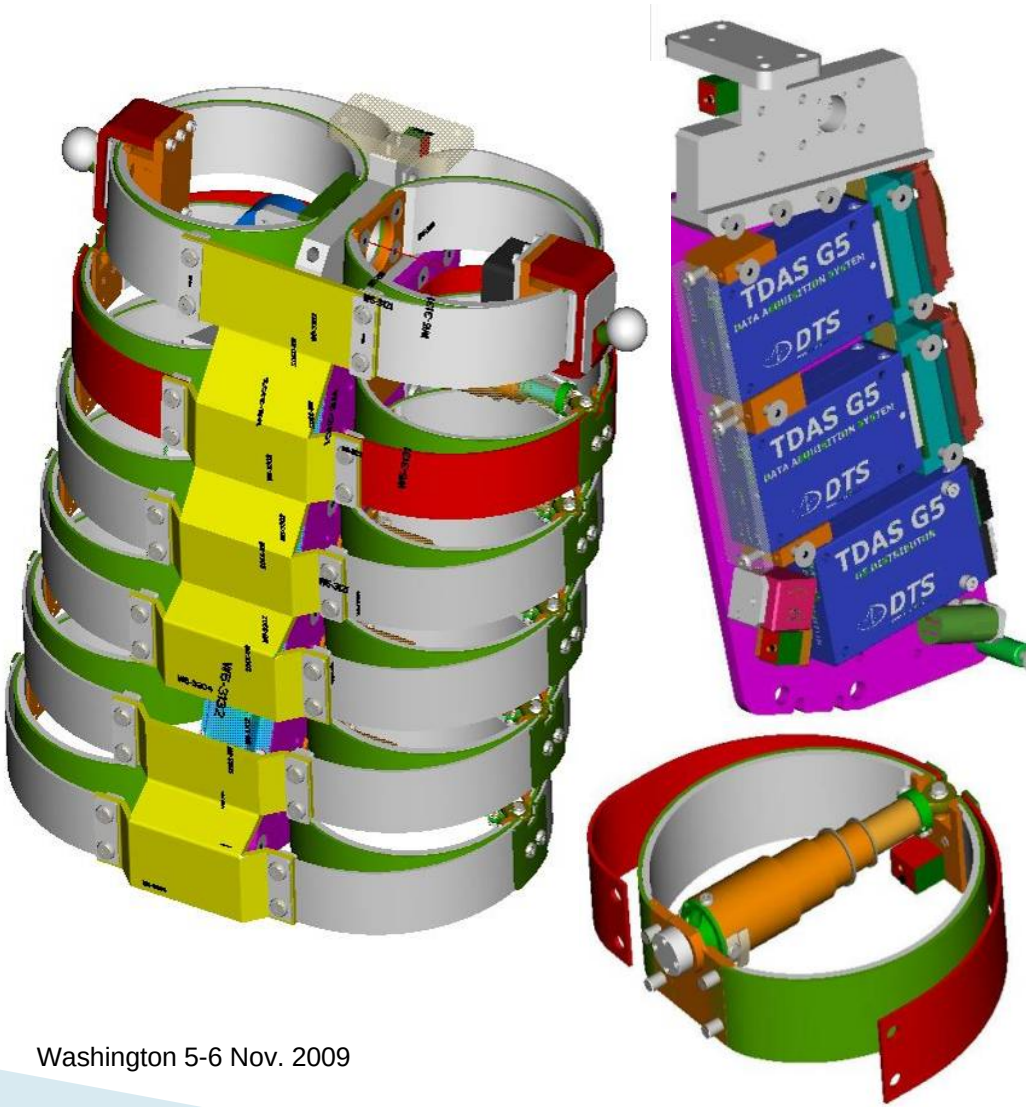
- Scaled down WSID 50th neck design
- Neck angle adjustment from front





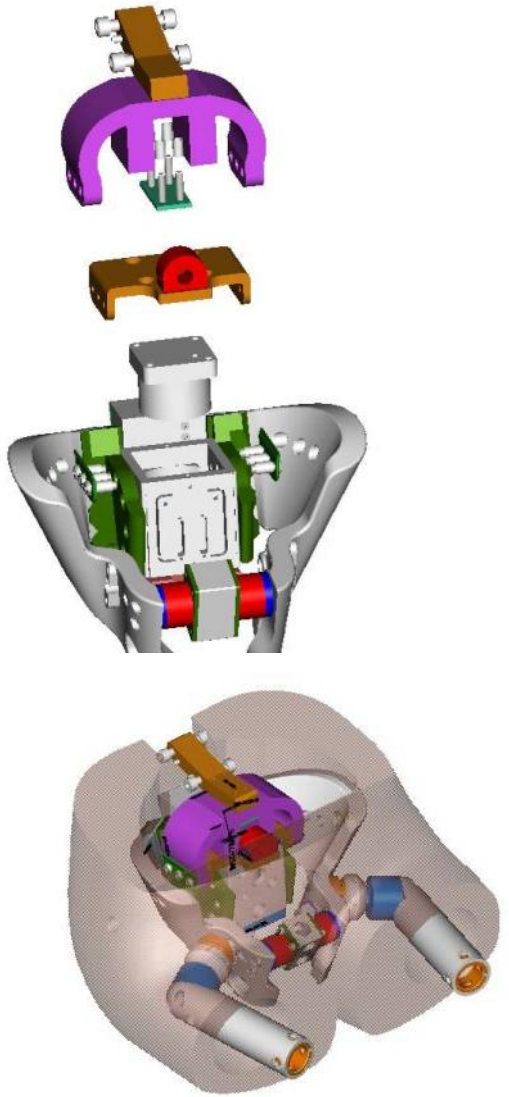
Shoulder/Thorax/Abdomen

- Scaled WorldSID 50th male concept
- L+R symmetric double band rib design
- Nickel Titanium super elastic alloy ribs
- Polymer sternum
- Mid saggital spine box packaging DAQ systems
- Shoulder joint 3DOF ball joint
- Deflection: IR-Tracc



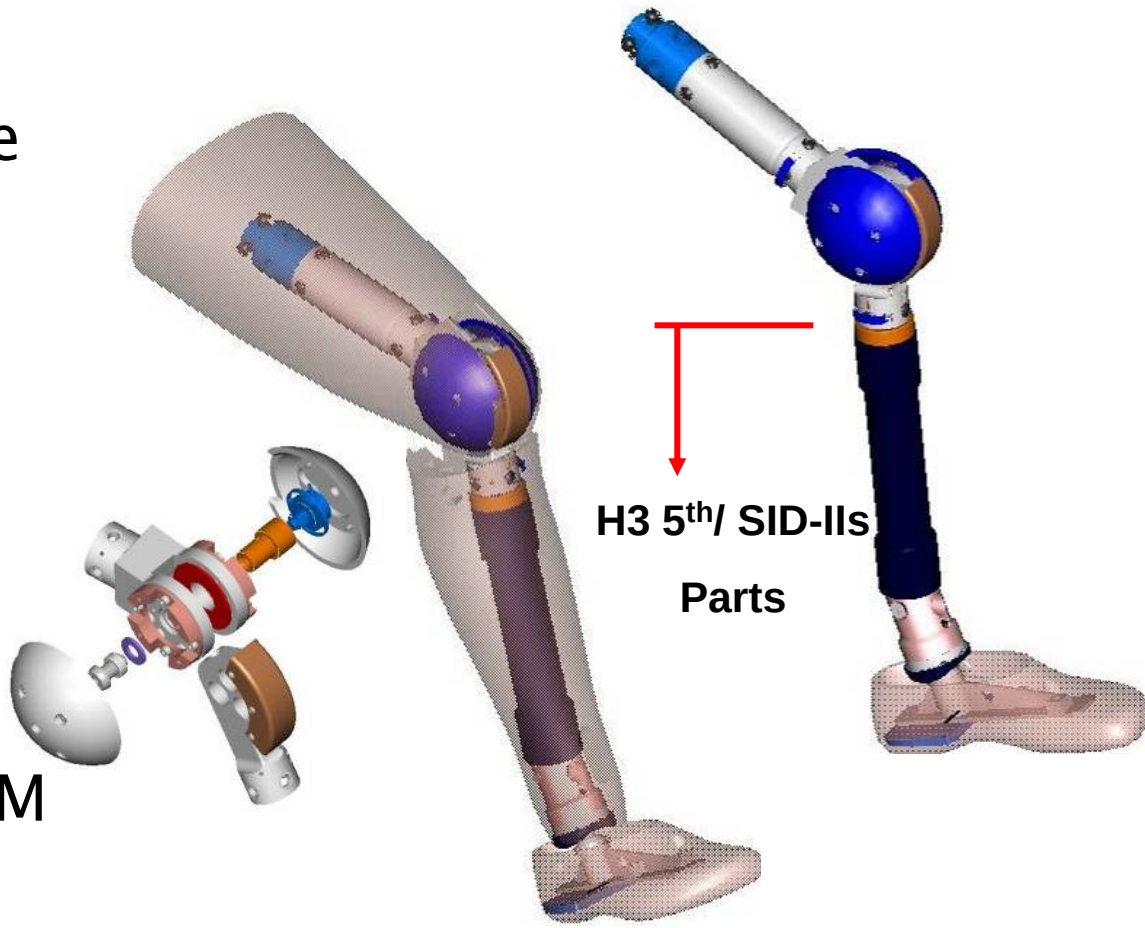
Pelvis

- Lumbar spine design to simulate upper and lower torso shear motion
- Detachable PVC/foam flesh
- Polymer flexible bone
- Throchanter representation
  - According new UMTRI data

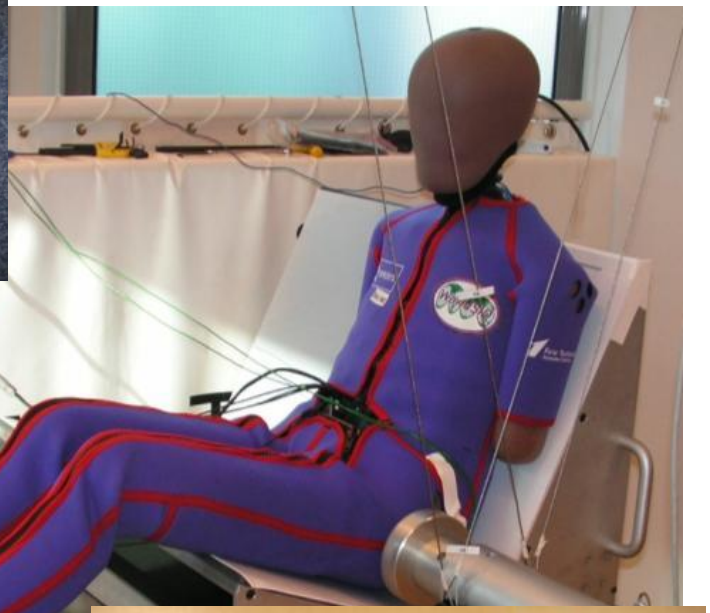


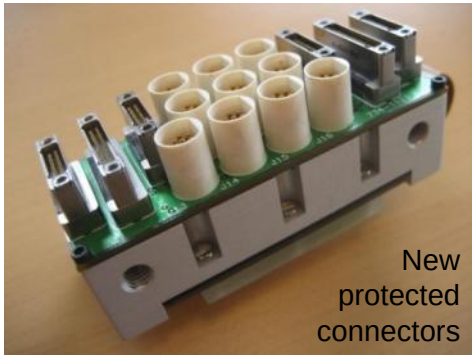
Leg/foot

- Upper leg
  - New flesh and bone design
- Lower leg and foot
  - H3 5th/SID-IIs
  - Modified lower leg flesh
  - Light weight aluminum bone
- Knee modified WS50M



WorldSID 5th Female rev1 update



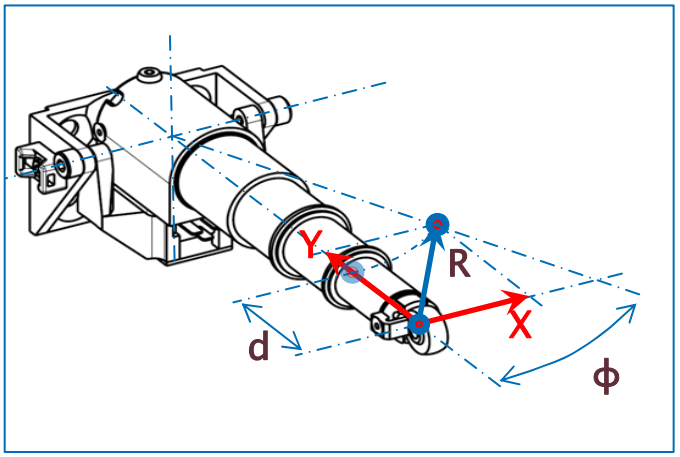


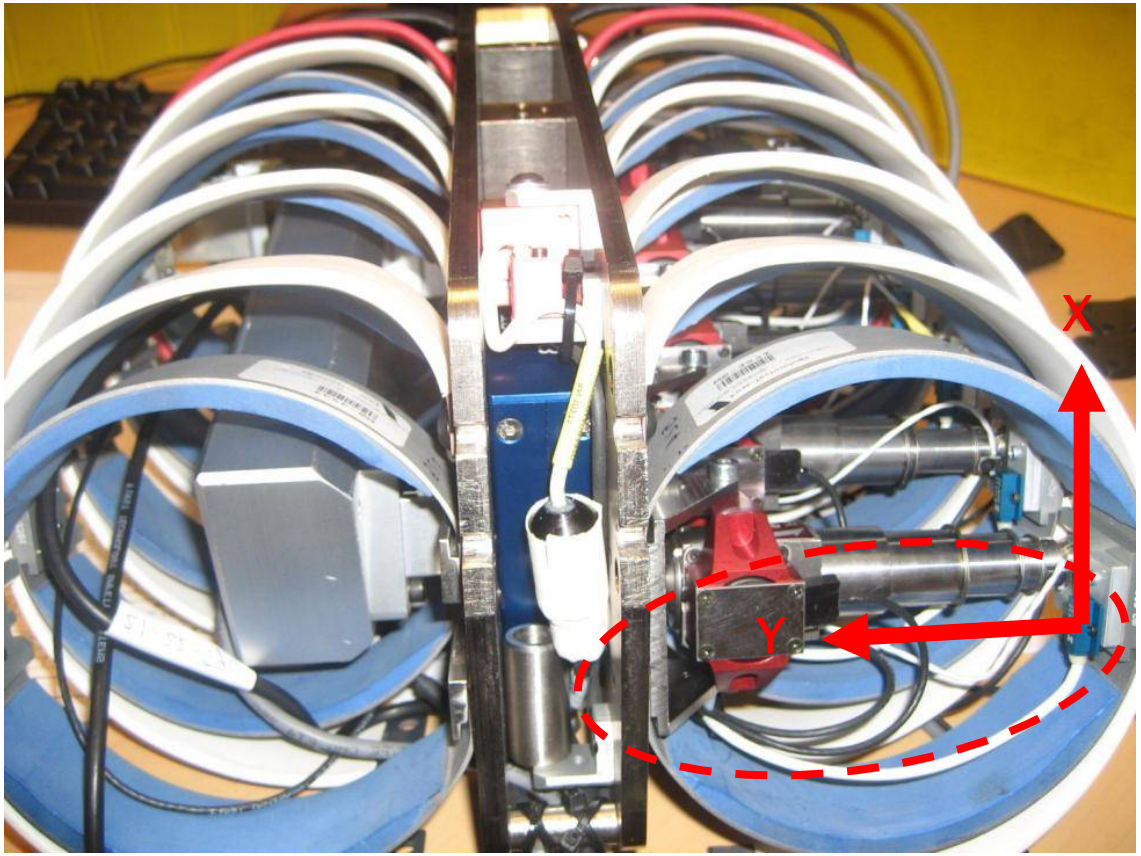
Instrumentation

Location	Description	Ch.	Sub
Head	Linear Acceleration (Ax, Ay, Az)	3	3
	Rotational Acceleration (Ax, Ay, Az)	3	3
Neck	Upper Neck Load Cell (Fx, Fy, Fz, Mx, My, Mz)	6	6
	Lower Neck Load Cell (Fx, Fy, Fz, Mx, My, Mz)	6	6
Shoulder	Shoulder: Load Cell (Fx, Fy, Fz)	2*3	6
	Deflection (δy)	1	1
	Linear Acceleration (Ax, Ay, Az)	2*3	6
	Linear Acceleration (Ax) mounted on part W5-3156	2*1	2
Thorax	T1 Linear Acceleration (Ax, Ay, Az)	3	3
	T4 Linear Acceleration (Ax, Ay, Az)	3	3
	T12 Linear Acceleration (Ax, Ay, Az)	3	3
	T12 Rotational Acceleration (Ax)	1	1
	5x Rib Deflection (δy) (alternative)	5	5
	5x 2D Rib Deflection & Rotation (δy, φz)	10	10
	5x Rib Acceleration (Ay) mounted on part W5-4040	5	5
	5x Rib Acceleration (Ax Ay, Az)	15	15

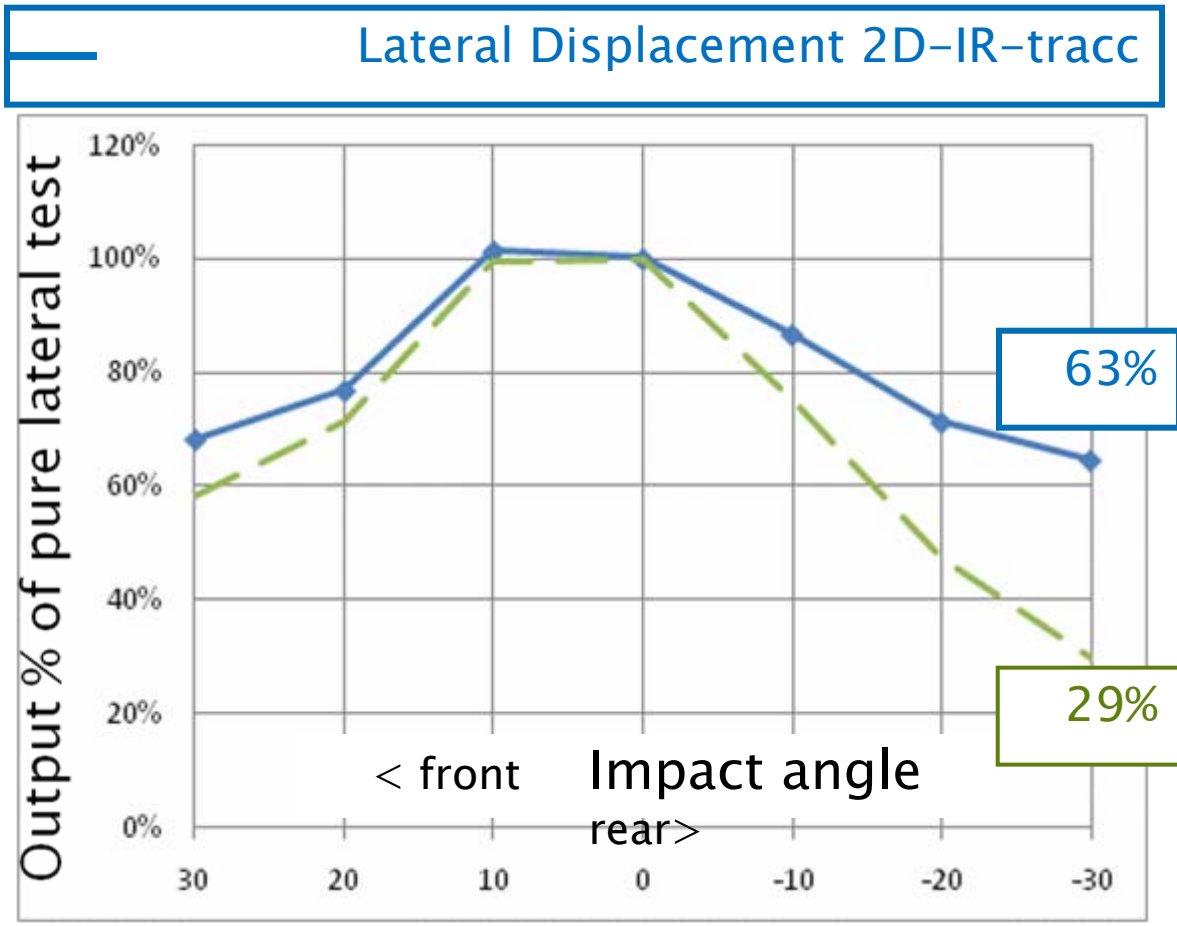
Location	Description	Ch	Sub
Lumbar Spine	Load Cell (Fx, Fy, Fz, Mx, My, Mz)	6	6
Pelvis	Sacro-iliac Load Cell (Fx, Fy, Fz, Mx, My, Mz)	12	12
	Linear Acceleration (Ax, Ay, Az)	3	3
	Pubic Load Cell (Fy)	1	1
	Rotational Acceleration (Ax)	1	1
Upper Leg: (Left/Right)	Femoral Neck Load Cell (Fx, Fy, Fz)	2*3	6
	Femur Load Cell (Fx, Fy, Fz, Mx, My, Mz)	2*6	12
	Knee Load Cell inboard/outboard (Fy)	4*1	4
Lower Leg (Left/Right)	Upper Tibia Load Cell (Fx, Fy, Fz, Mx, My, Mz)	2*6	12
	Lower Tibia Load Cell (Fx, Fy, Fz, Mx, My, Mz)	2*6	12
Static	Static: Temperature Sensor Thorax	1	
	3x 2-axis Tilt Sensors (θx,y)	3*2	
Maximum channels			**137 ***

2D rib deflection sensors





Oblique sensitivity Rib Unit Drop Tests



Biofidelity tests

- Pendulum tests: neck, shoulder, abdomen, thorax and pelvis
- Head drop and component tests
- Prioritized High weighted ISO TR9790 sled tests:
  - WSU, Heidelberg
  - Rigid and padded
  - 6.7 & 8.9 m/s
- NHTSA-MCW sled
  - Rigid & Padded
  - Flat wall
  - Pelvis Offset wall
  - 6.7m/s

Biofidelity Rating according ISO TR9790

ISO TR9790 Biofidelity Rating			
	WorldSID		
	Mid size male	*Small female Rev1	SID-IIs
Head	10	10	7.5
Neck	5.3	6.2	5.1
Shoulder	10	7.4	5.8
Thorax	8.2	6.9	6.6
Abdomen	9.3	8.5	7.7
Pelvis	5.1	6.5	4.3
Overall rating	8.0	7.5	6.2

*Based on:

- Prioritized test matrix (high weighted conditions)
- NBDL Prototype neck tests and Meijer corridors

Biofidelity Classification	BR (Calculated Biofidelity Rating)
Excellent	$8.6 \leq B < 10$
Good	$6.5 \leq B < 8.6$
Fair	$4.4 \leq B < 6.5$
Marginal	$2.6 \leq B < 4.4$
Unacceptable	$0.0 \leq B < 2.6$

'Biofidelity Of The WorldSID Small Female Revision1 Dummy', Eggers, Schnottale, Been, Waagmeester, Hynd, Carroll, Martínez, ESV Paper Number 09-0420

Repeatability and Reproducibility

- Repeatability
  - Pendulum and drop tests
    - 52 tests, 19 parameters, 6 test conditions
    - Average CV=1.8%
  - Sled tests repeated 3-5 times
    - Average repeatability of all sled test CV=3.7%
- Reproducibility
  - Certification tests, 3 dummies
  - Average CV=6.3%

Preliminary Injury Risk Functions

- Initial Risk functions developed for Thorax, Abdomen and Pelvis
  - Based on scaling WS50M and
  - Based on Aprosys injurious and non-injurious biomechanical tests
- General conclusions
  - Test data base small, wide confidence limits, especially for more severe injury
  - Injury values from different methods are generally close enough to be used as preliminary indicators of injuries

Accident Reconstructions

- Objective: Evaluate the injury prediction capability of the dummy
- Case selection:
  - Two accidents with injured small female occupant
  - One low injury case (MAIS1): VW Polo vs. tree
  - One high injury case (MAIS5): Nissan Micra vs. Tree

Accident Reconstruction Results

High severity Nissan Micra

Body Region	Injury Value	WS5F Measured Value*	Predicted Injury Risk	Injury in sustained
Head	HIC36	6883	>70% AIS4+	AIS 5
Neck	Peak axial force (upper neck)	+1.77 kN	0.9% AIS3+	AIS 1
Thorax	Peak lateral thoracic rib displacement	47.6 mm	69% AIS3+	AIS 4
Abdomen	Peak lateral abdomen rib displacement	58.8 mm	78% AIS2+ 43% AIS3+	AIS 2
Pelvis	Peak pubic symphysis force	891 kN	2.0% AIS 2+	AIS 1
	Peak lateral pelvis acceleration	134 g	>50% AIS2+ (108g)	

Low severity Volkswagen Polo

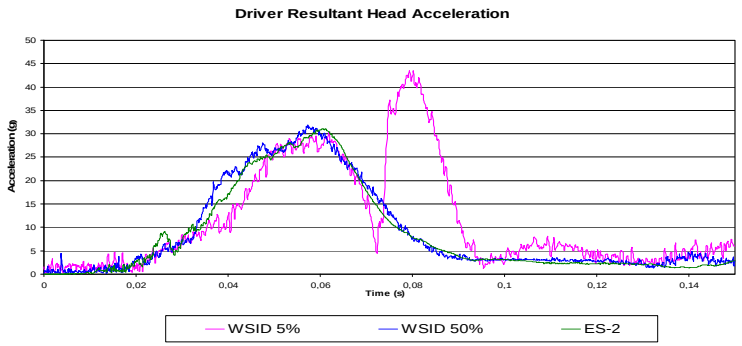
Body Region	Injury Value	WS5F Measured Value*	Predicted Injury Risk	Injury sustained
Head	HIC36	144	<1% AIS2+	AIS 1
Neck	Peak axial force (upper neck)	+1.18 kN	<0.1% AIS3+	AIS 0
Thorax	Peak lateral thoracic rib displacement	7.6 mm	2% AIS3+	AIS 0
Abdomen	Peak lateral abdomen rib displacement	2.5 mm	0.6% AIS2+ 1.8% AIS3+	AIS 0
Pelvis	Peak pubic symphysis force	202 kN	0.02% AIS 2+	AIS 0

Vehicle Tests

- Assessment of dummy in vehicle crash environment
  - IIHS 1500kg 50km/h 90° MDB test
  - Advanced European MDB 1500kg 50km/h
  - 75° Pole test 20MPH (32km/h)
  - Driver and passenger dummies
- Comparison WorldSID5th and 50th and SID-IIs dummies
  - Injury parameters, seating position

Example of vehicle test results

- Airbag problem identified with small female dummy
  - Head slipped under the airbag
  - Contact on door trim panel
  - Causing a second higher acceleration peak on the head
- Problem not found in identical test with WorldSID 50M
  - The mid male WorldSID head was well protected by the curtain airbag.



Vehicle Tests Results

- Only one mechanical failure was observed during the vehicle tests indicating that the dummy is durable enough;
- Easy to position, is well build, generally user friendly, human like seating posture;
- At IDIADA and TNO measurements with the in-dummy data acquisition systems have been carried out successfully
- In the PDB test series a complete loss of data was experienced from of one of the two dummies; also IR-Tracc failures were observed

Conclusions

- WorldSID 5th percentile meets anthropometry targets of UMTRI very well
- Biofidelity Rating ISO 7.5, similar to WorldSID Mid size male and better than SID-IIs
- With CV=3.7% exceeds repeatability targets of CV< 7%
- Dummy is generally robust: durable in severe pole tests, little damage sustained
- Improved oblique impact thorax sensitivity with 2D-IR-Tracc
- Draft certification corridors developed based on 3 dummies

Conclusions (cont.)

- Preliminary Injury Assessment Reference values available: Good prediction of injury in reconstructed crashes
- EEVC status report in preparation (expected end of 2009)
- Dummy is ready now for a well-coordinated worldwide evaluation program addressing also jointly further open issues

Acknowledgments

Transport Canada

DAIMLER

DTS
www.dtsweb.com

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