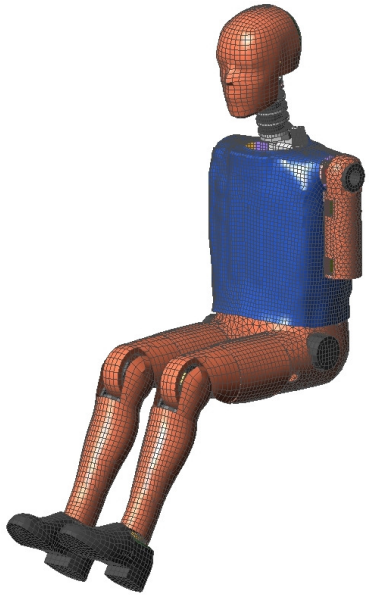


Side Impact Dummy Models

Yi Liu, Robert Kant, Jim Rasico, Fuchun Zhu

First Technology Safety Systems, Inc.

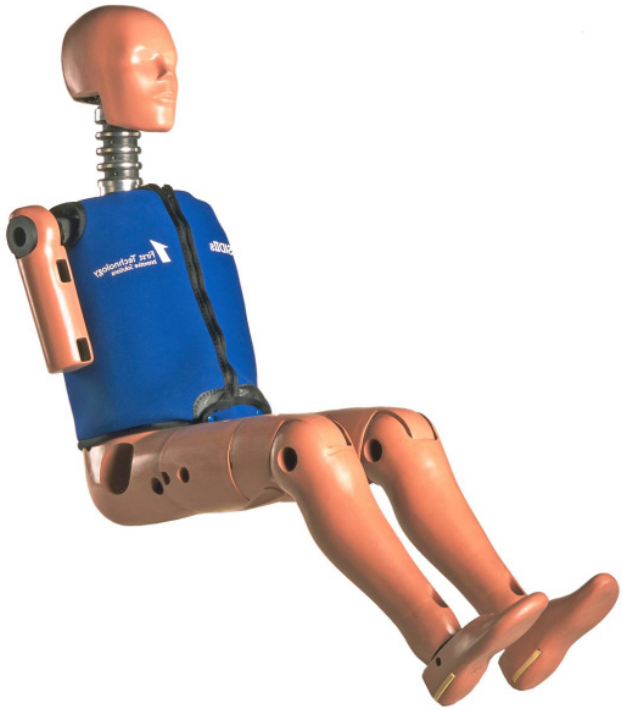
Contents

- SID-IIs
- WorldSID
- Q3s

Introduction

	SID-IIs hardware	SID-IIs model
1994	Development	
1995	“Alpha prototype”	
1998	“Beta+ prototype”	
2000	“Production level”	
2001		Development started
2002	SBL C specified in IIHS test	SBL C v1.0
2003		SBL C v1.1
2004	FRG NPRM	SBL C v1.2 / FRG v 1.3
2005		SBL C v1.6
2006	SBL D Final Rule issue	SBL D v2.0 (beta)
2007	SBL D to replace SBL C in IIHS?	

Introduction



SID-IIs SBL C

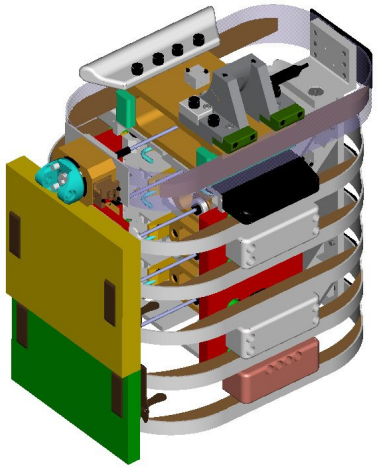
- IIHS SUV barrier test procedure
  - Movable deformable SUV type barrier test

SID-IIs SBL D

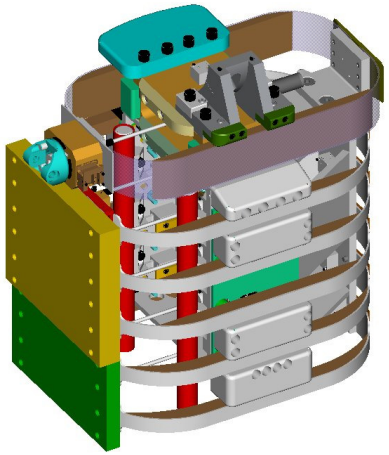
- Considered for FMVSS 214 final rule
  - NHTSA Oblique Pole Test
    - 75 degree oblique angle
    - Up to 32 km/h (20 mph) impact speed
  - Moving Deformable Barrier Test
    - Simulate vehicle-to-vehicle “T-bone” intersection crash
    - 33.5 mph impact speed

Main differences SID-IIs SBL D and C

- Standard Build Level D
  - *Address the durability issues related to Level C dummies*
    - Thinner and taller damping material for shoulder rib
    - Extended shoulder frontal rib guides
    - Rounded shoulder rear rib guides
    - Rigid thorax/abdomen ribs stops
    - New spine box to ballast weight
    - Rib pads tied around each rib with plastic tie wrap
    - ½" diameter linear potentiometers



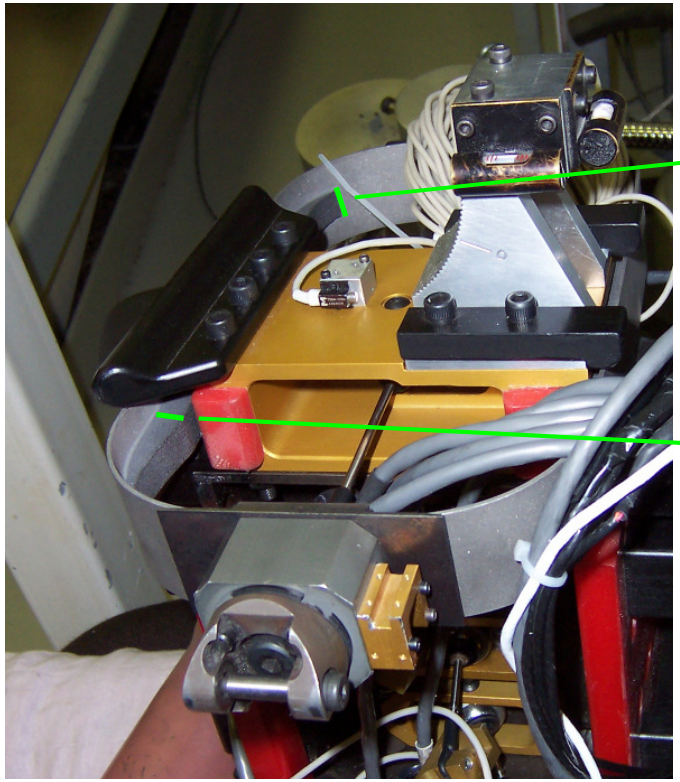
SBL C



SBL D

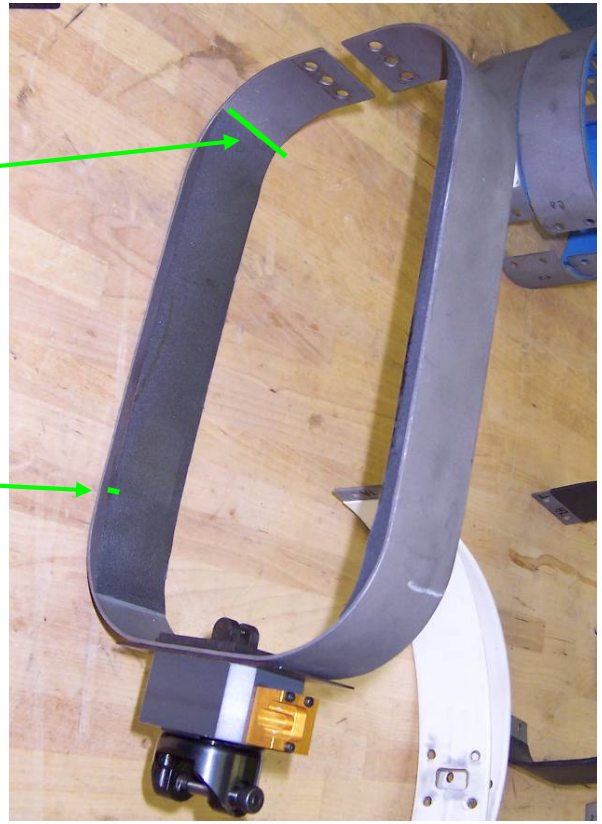
Shoulder Rib

- Width of damping material increased
- Depth of damping material reduced to attain similar performance



Width

Depth

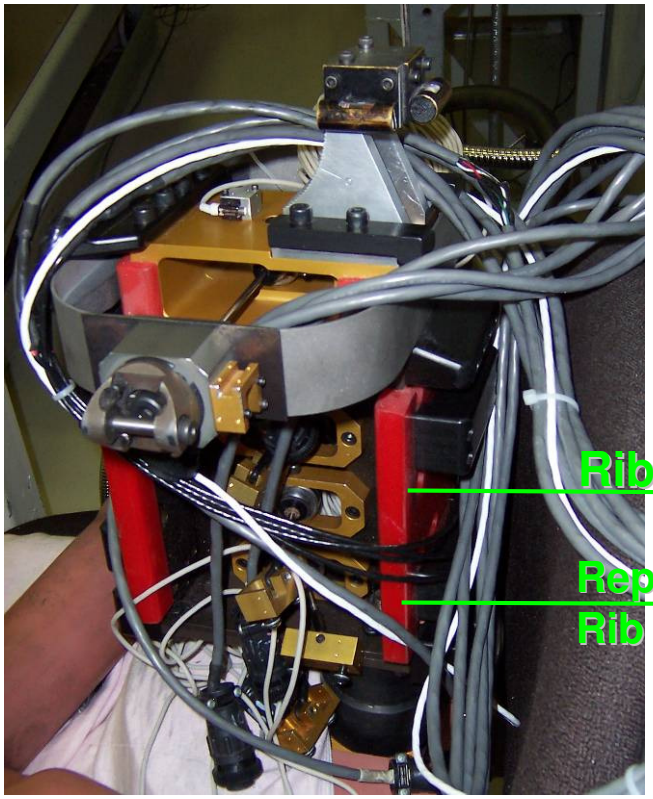


Level “C”

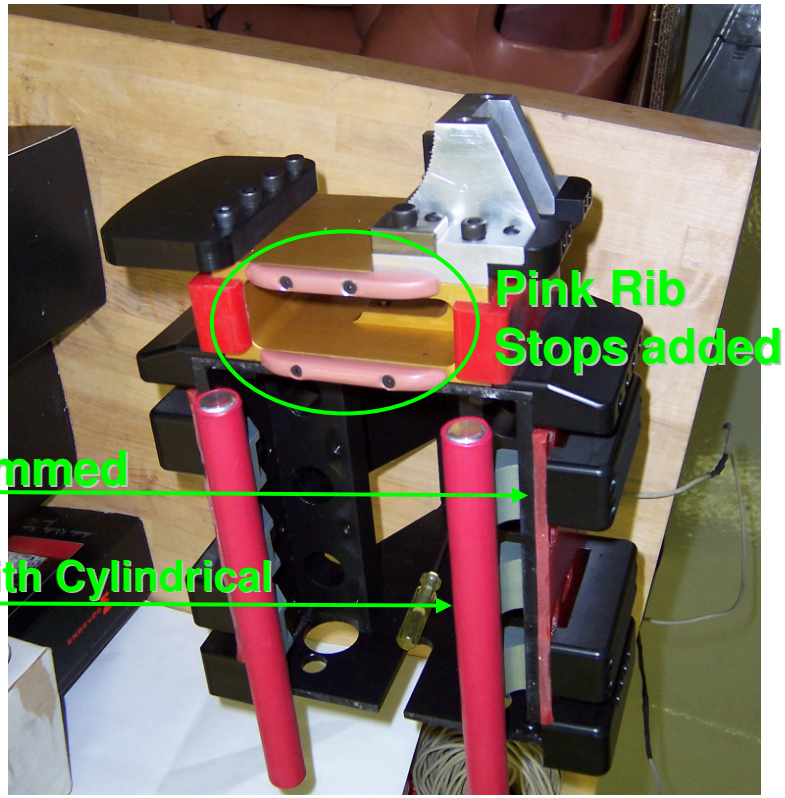
Level “D”

Rib Stops

- Rib pads trimmed
- Rib pad ends replaced with padded cylindrical rib stops
- Pink shoulder rib stops added.



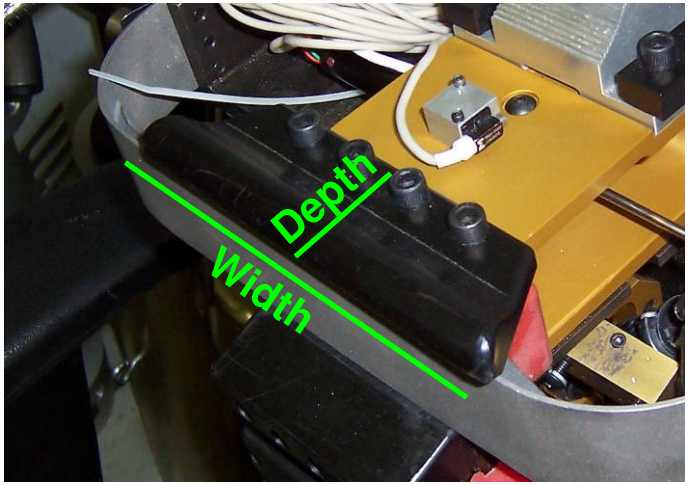
Level "C"



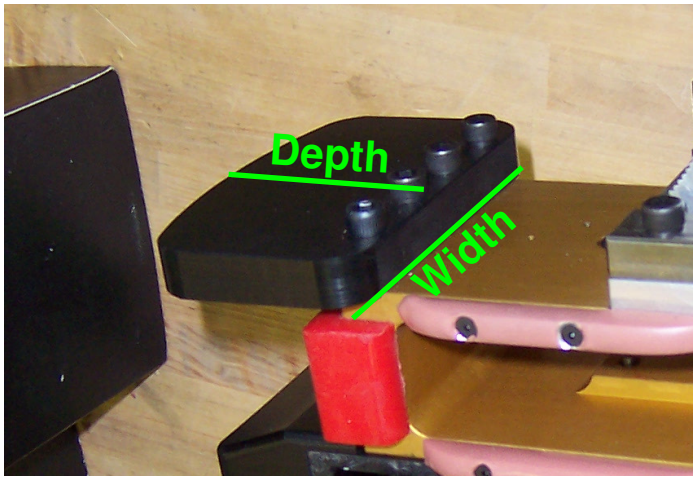
Level "D"

Shoulder Rib Guide Top

- Width reduced
- Depth increased
- Radii modified



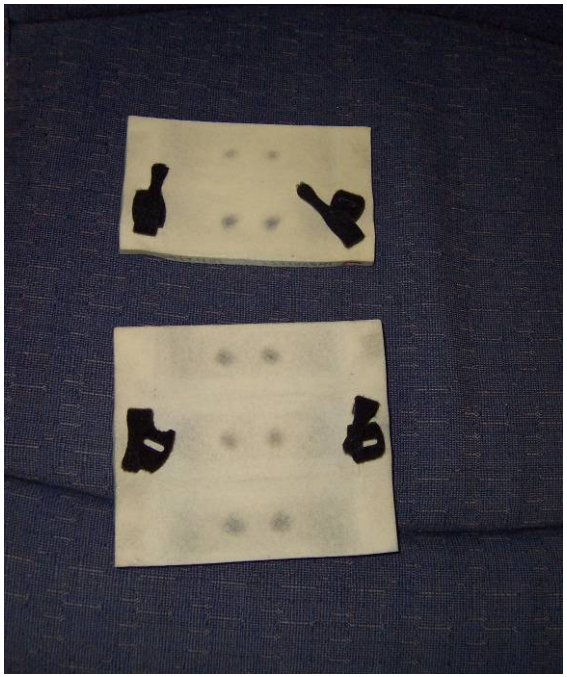
Level “C”



Level “D”

Ensolite Foam Pads

- Space between the Ensolite pieces is shortened
- 1 set of plastic ties per rib instead of 1 set of straps per pad

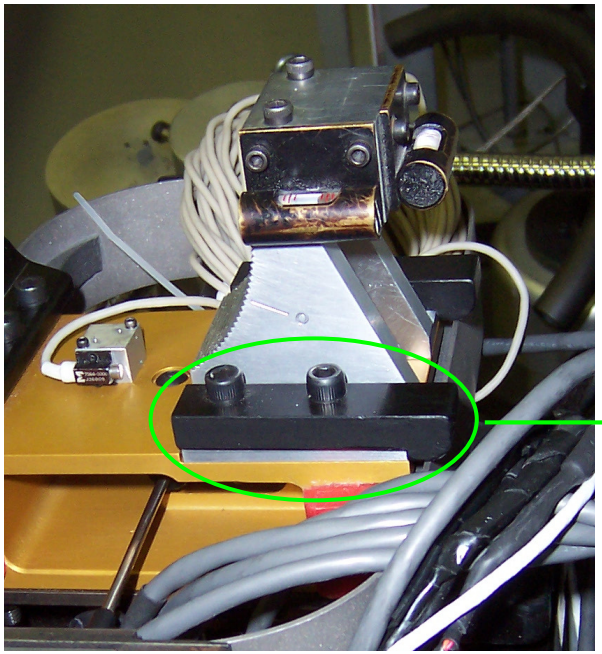


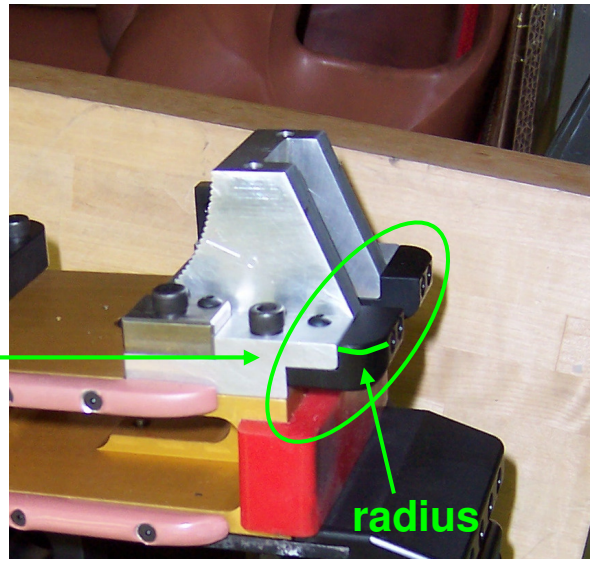
Level “C”

Level “D”

Lower Neck Bracket

- Rib Guide Attachment position and geometry modified
- Rib Guide radius increased





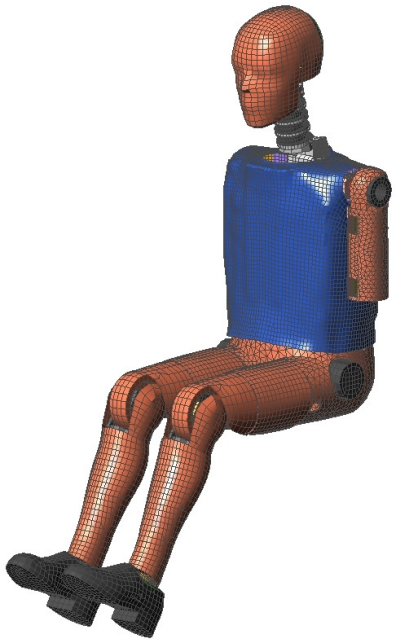
Level “C”

Level “D”

SID-IIs Models

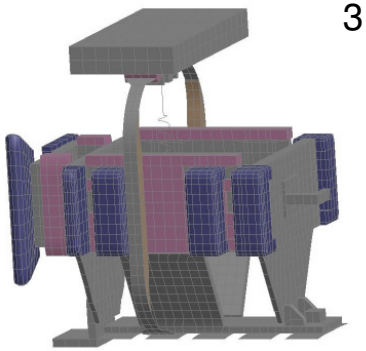
SID-IIs SBL D version 2.0

Item	Total Number
Part, section & material	345
Nodes	68174
Elements	116416
Beam	322
Shell	48383
Solid	67615
Discrete	7
Accelerometer	16
Joint	13
Masses	22
Rigid Links	38
Contact surface	2
Coordinate systems	42
Curves & Table	21

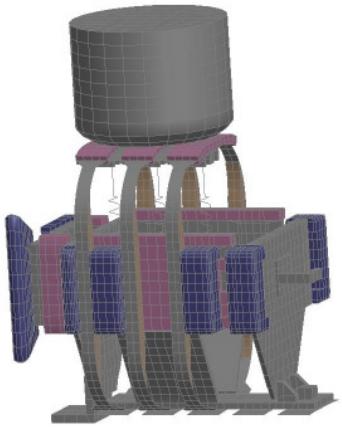


- SID-IIs SBL C version 1.6
- SID-IIs SBL D Beta version 2.0

Rib Component



3.3 Kg

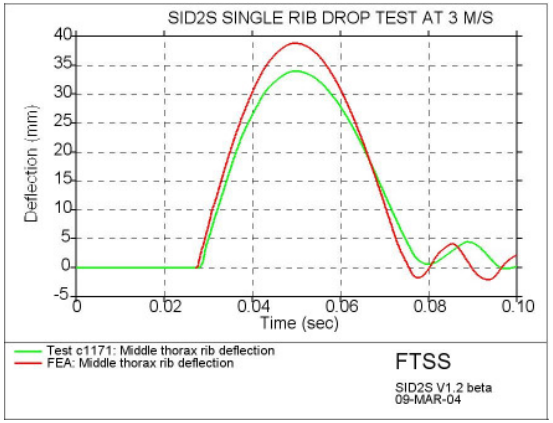


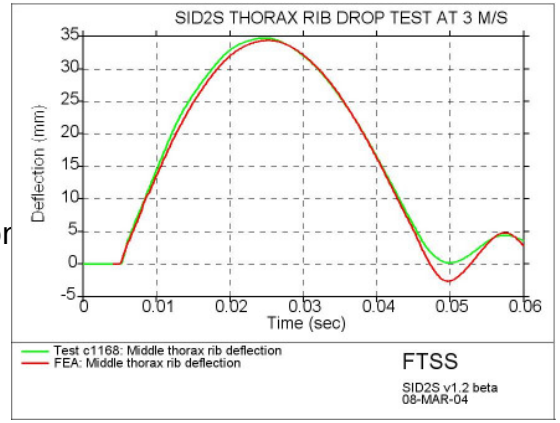
8.3 Kg

Test

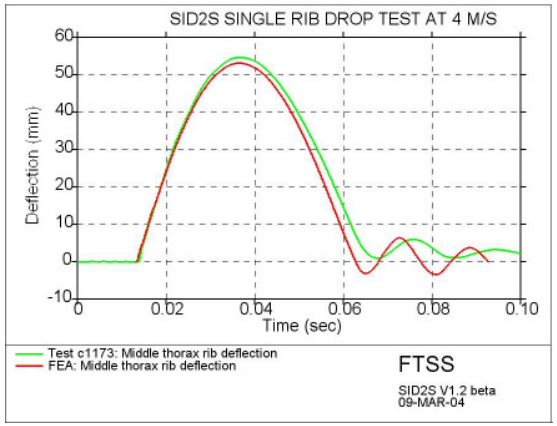
Simulation

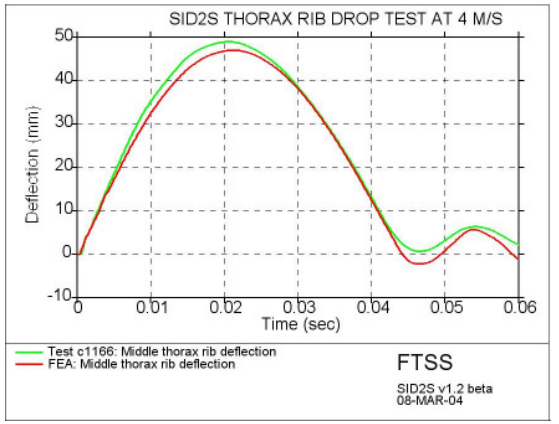
3 m/s





4 m/s





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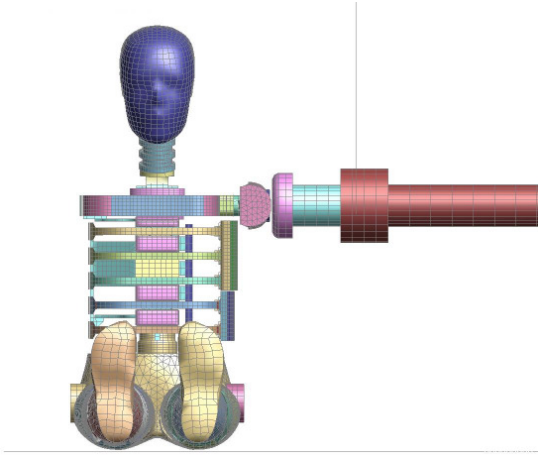
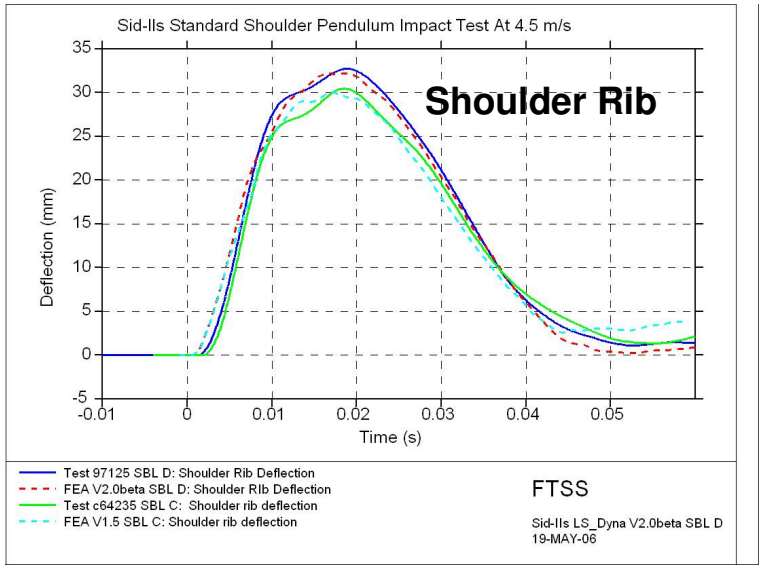
Innovative Solutions

Pendulum Impact - Shoulder

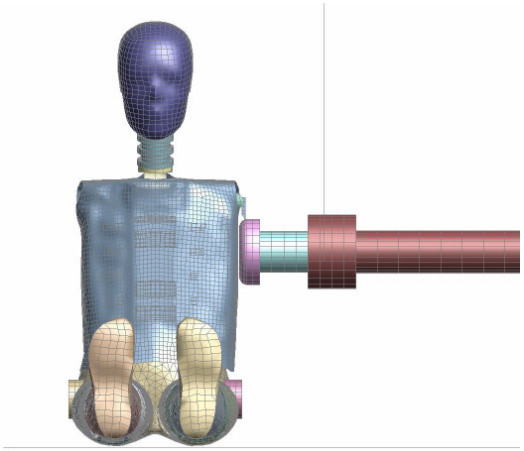


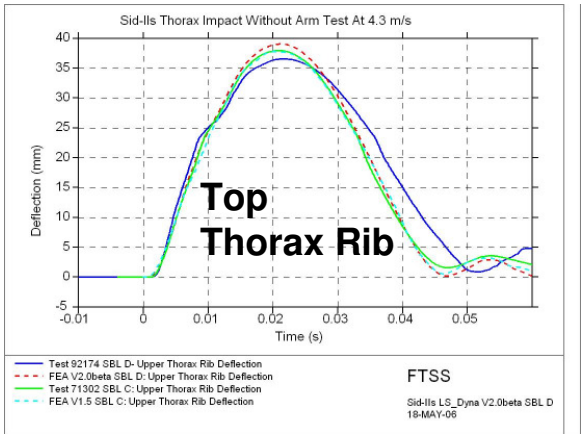


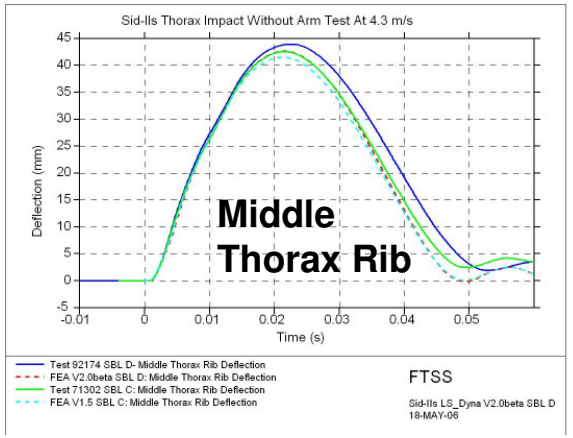
Test

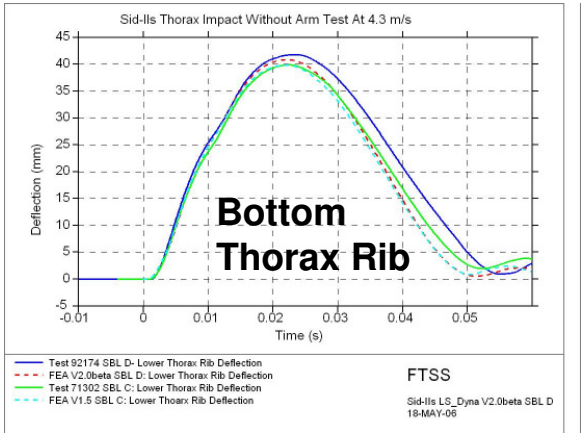
Simulation

Pendulum Impact – Thorax No Arm





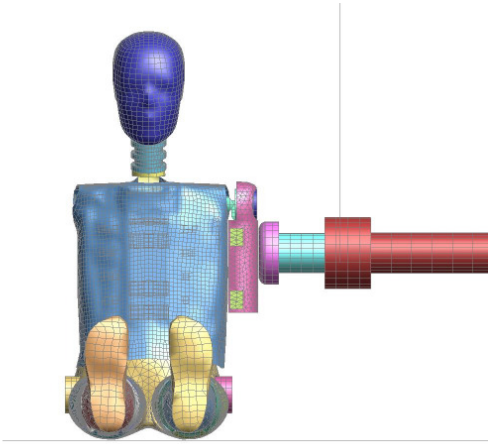


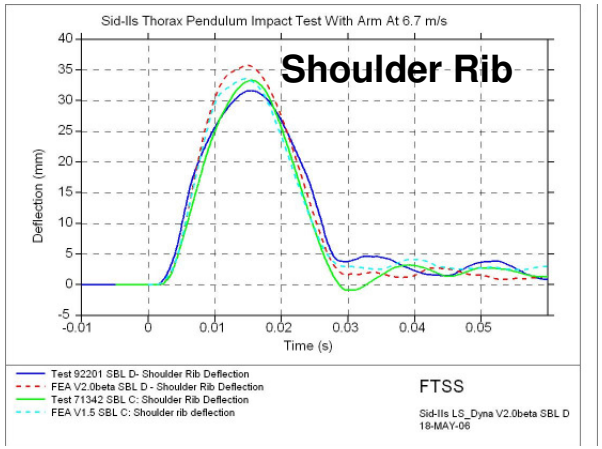


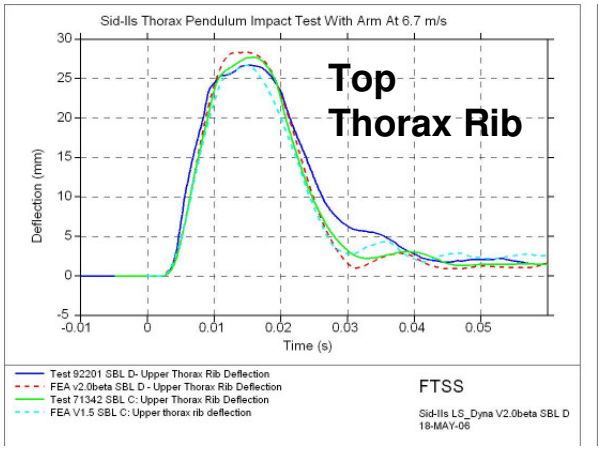
Test
Simulation

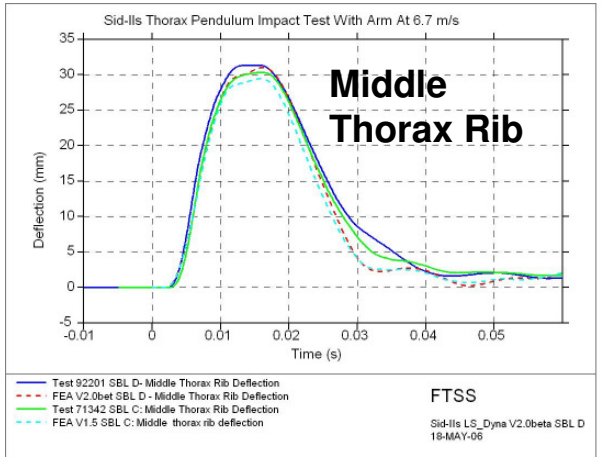
First Technology
Innovative Solutions

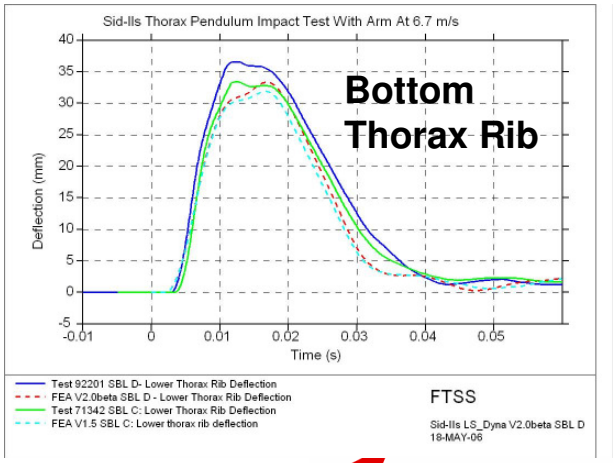
Pendulum Impact – Thorax With Arm







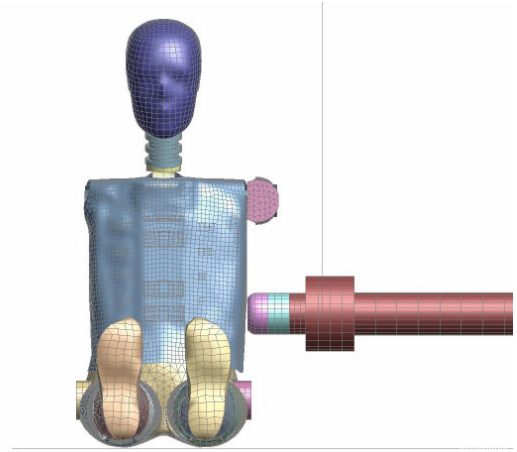


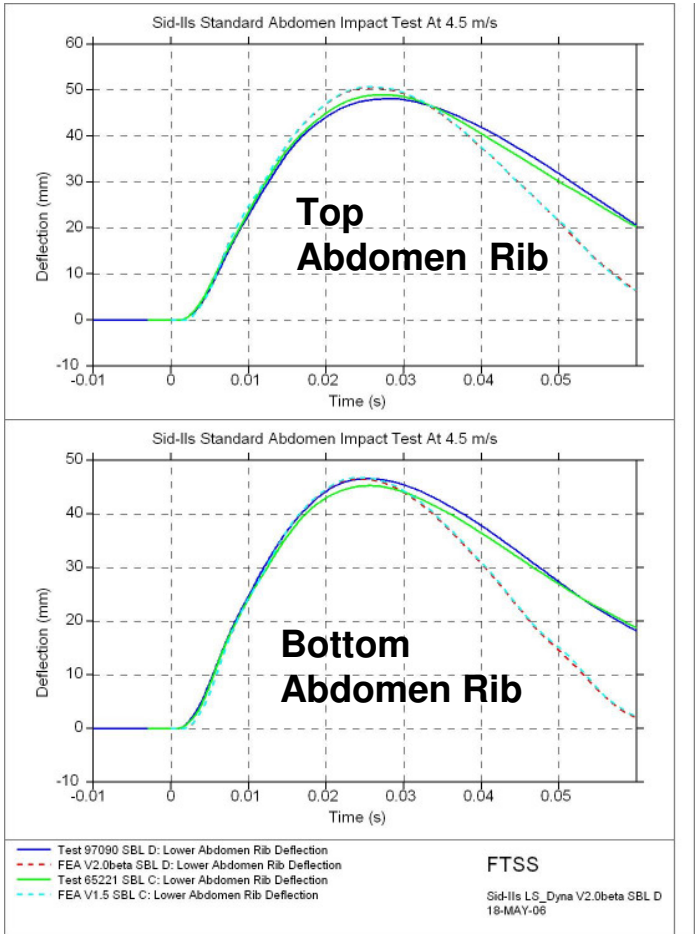


Test
Simulation

First Technology
Innovative Solutions

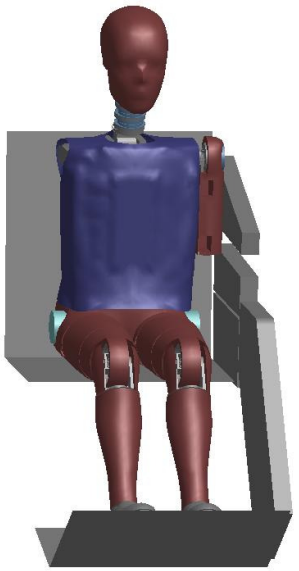
Pendulum Impact - Abdomen



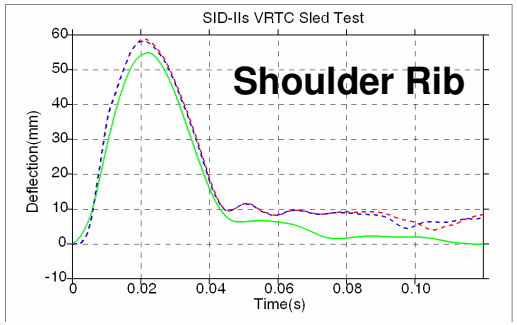


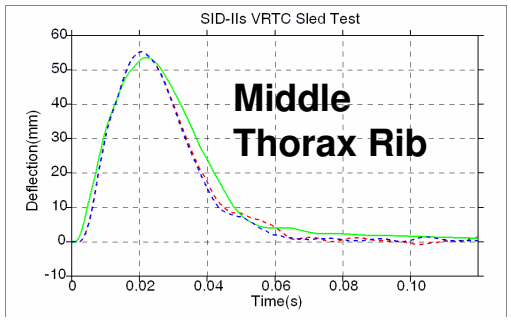
Test
Simulation

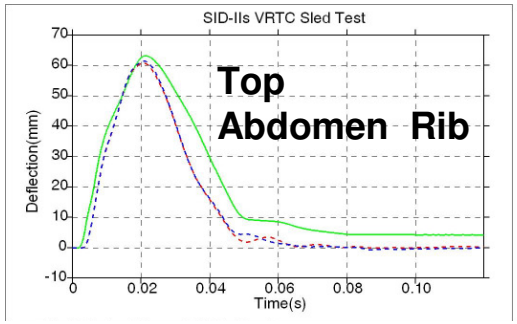
NHTSA VRTC Sled Test

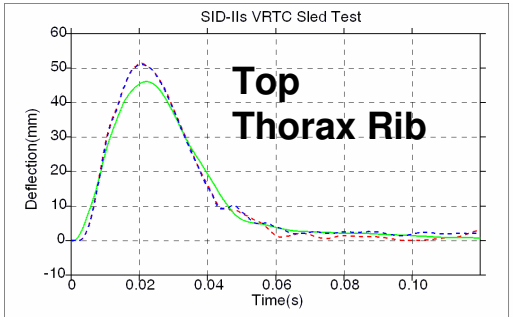


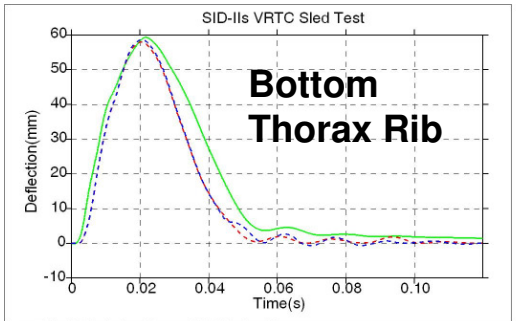
SBL C

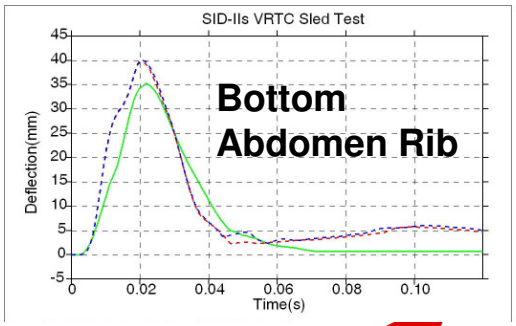






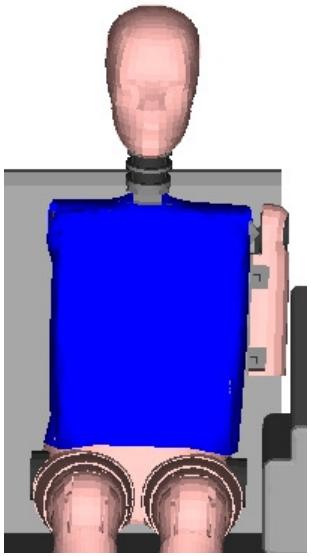




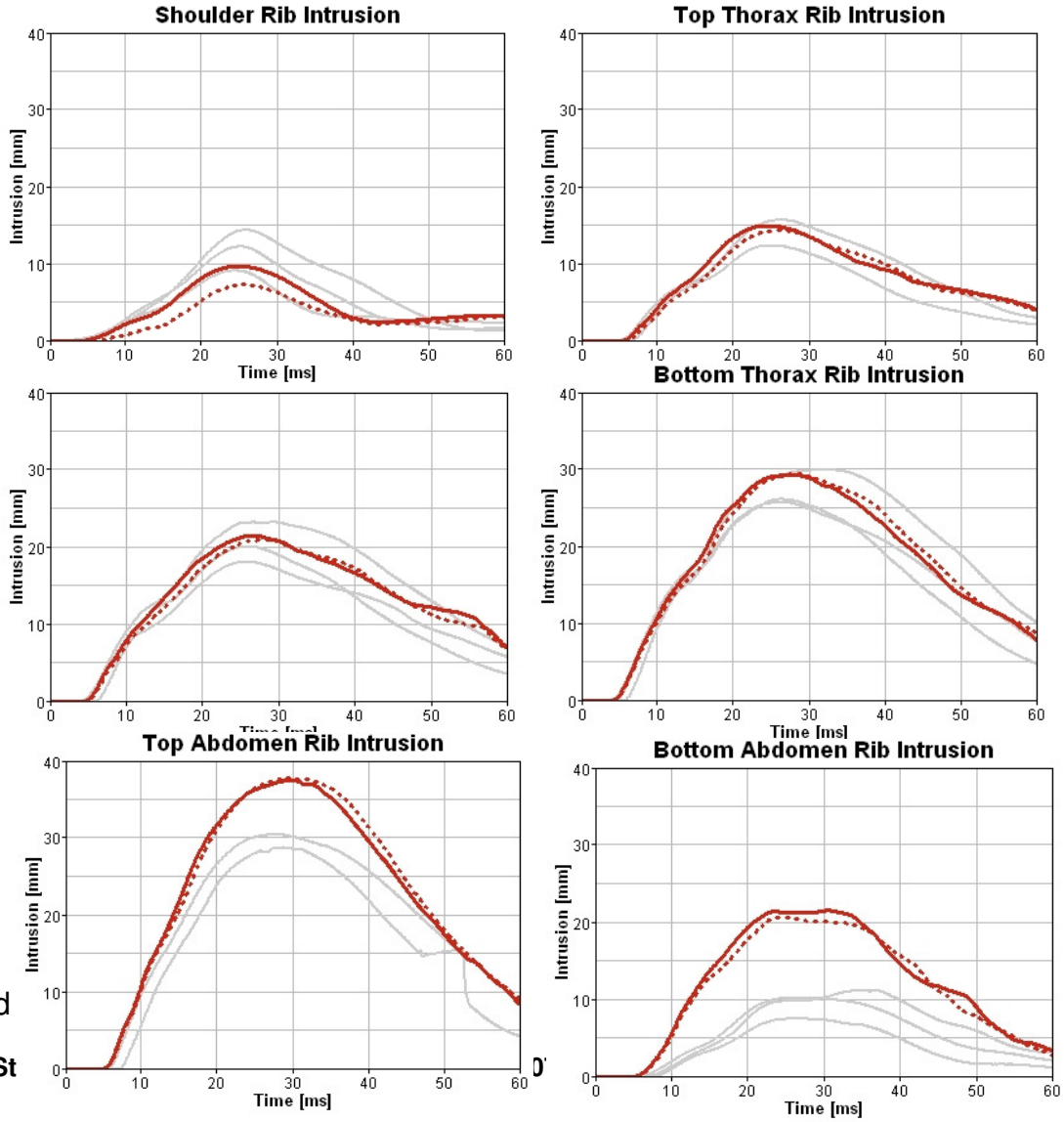


Test
V1.6
V1.5

PDB barrier Sled test



rotated 2 degrees.



SBL C models

- User feedback:
  - Still a relatively low confidence in the arm kinematics
  - Thorax and abdomen rib deflection not always accurate: (under-predicted)
  - Pelvis pubic load is often over-predicted

- A project has been kicked-off in May to improve the arm, rib and pelvis for SBL C and D

Material model and Geometry updates

Geometry

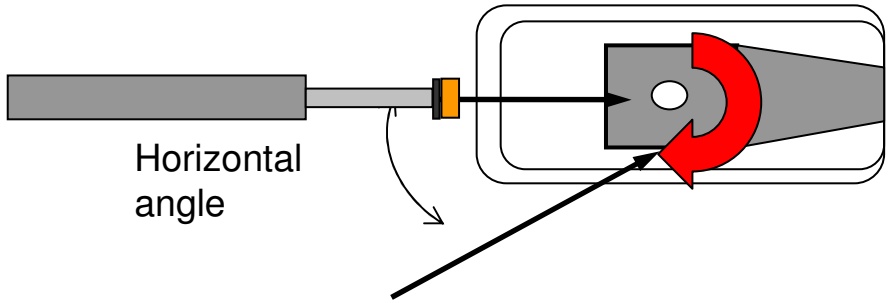
- Arm and pelvis: Vinyl/foam separation
- Arm/shoulder/joint
- Symmetric pelvis foam
- Torso and leg geometry

Material

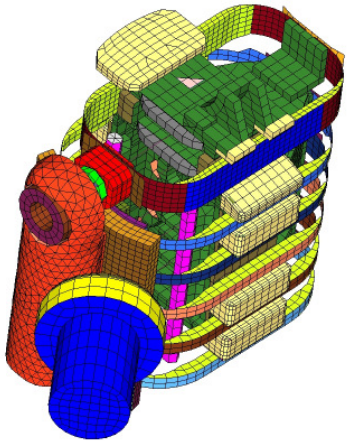
- Arm skin Vinyl (C=D)
- Arm foam (C=D)
- Rib damping material (C=D)
- Thorax/Abdomen pad Ensolite foam (C=D)
- Shoulder rubber plug (C=D)
- Iliac wing material (#2 for D, #3 for C)
- Pelvis plug foam (C=D)

New component and sled validation

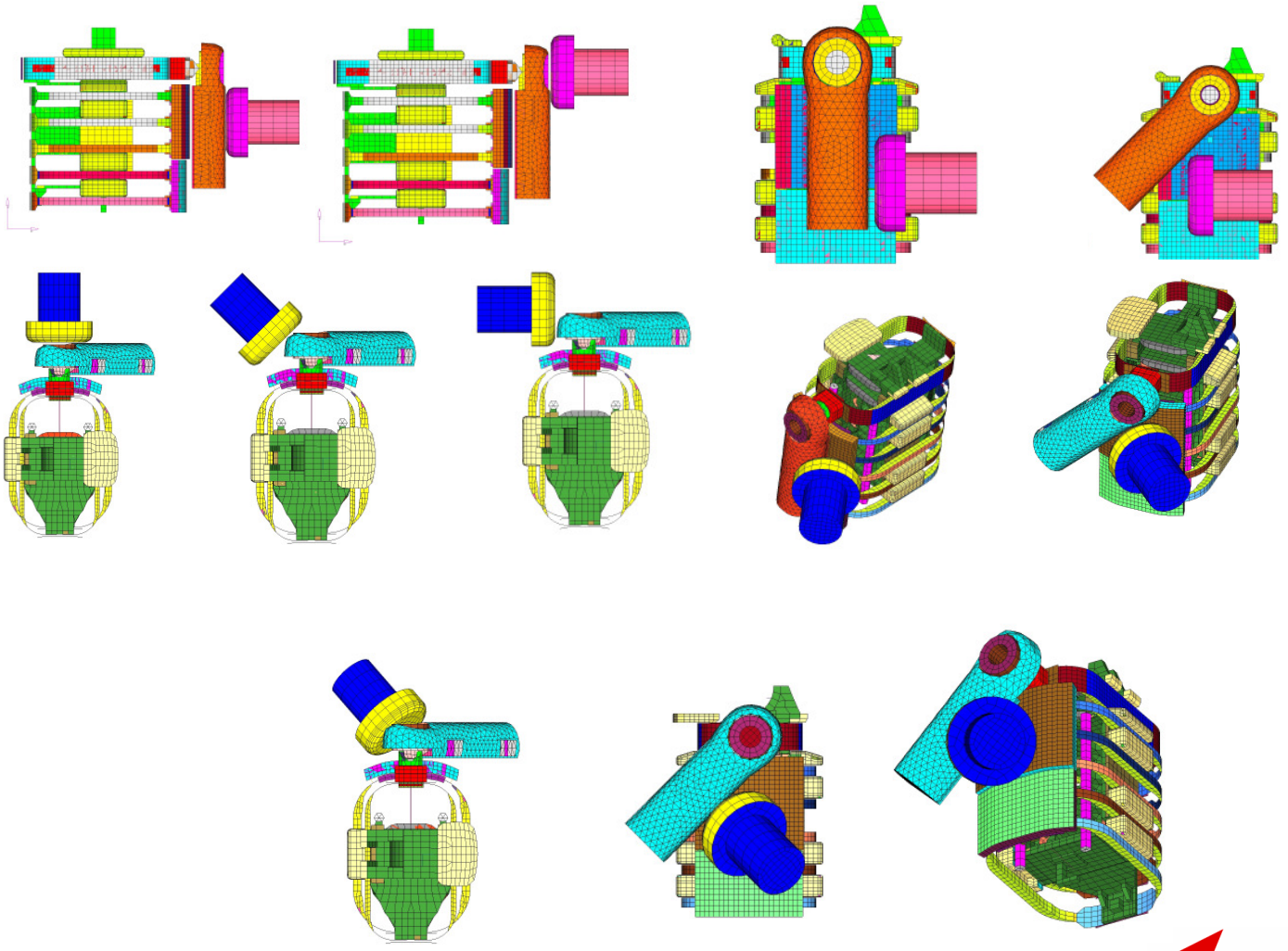
- Rib component (SBL C)
  - Impacts on the ribs under (vertical and horizontal) angles (15...30 load cases)
  - Source: Autoliv NA



- Arm-Rib interaction with (SBL D)
  - Pendulum impact on different locations and under different angles

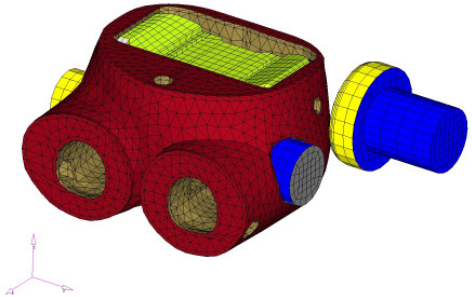


Arm-Rib Interaction loadcases

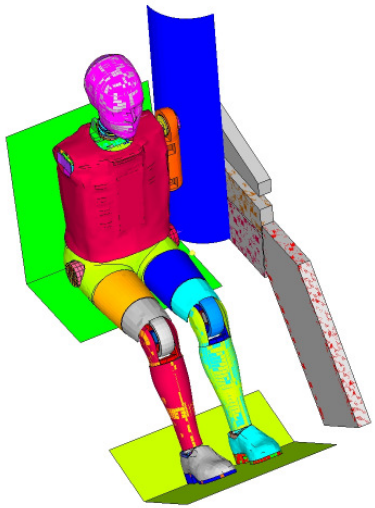


New component and sled validation

- Pelvis component impact (SBL D)
  - 3 load cases



- Rigid wall sled tests with (SBL D)
  - Different impact shapes to vary loading on:
    shoulder, thorax, abdomen and pelvis
  - # load cases



Summary

- SID-IIs models are available representing the different Standard Build Levels C and D (and FRG)
- A serious upgrade project has been kicked-off in May to address the arm, rib and pelvis issues for the SBL C and D models

WorldSID 50th

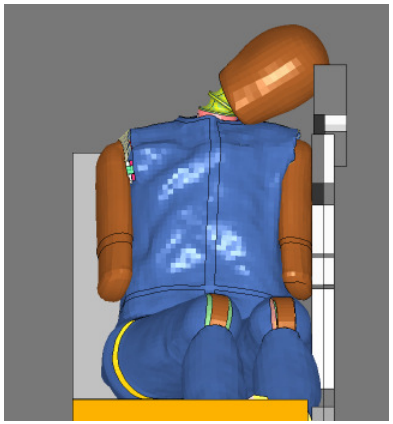
WorldSID 50th

The WorldSID 50th hardware

- Production Revision 1 was released in 2005 and NHTSA is evaluating the dummy for future potential regulations

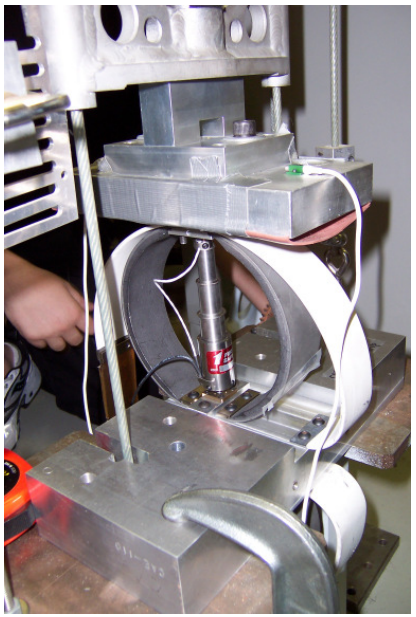
The FTSS WorldSID 50th model

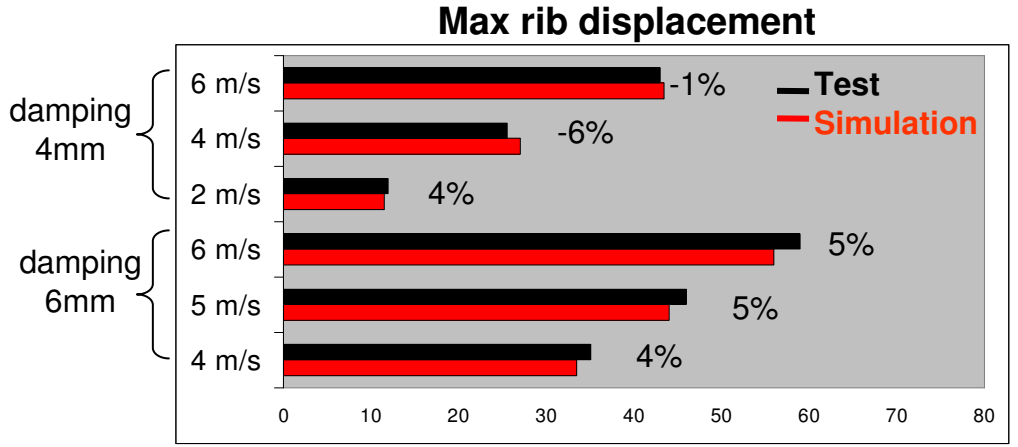
- Available since 2005
- *Recently explored by Autoliv Sweden*

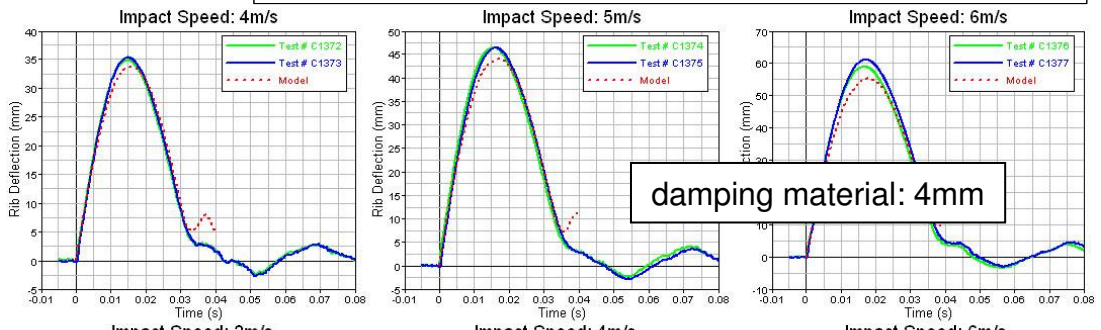


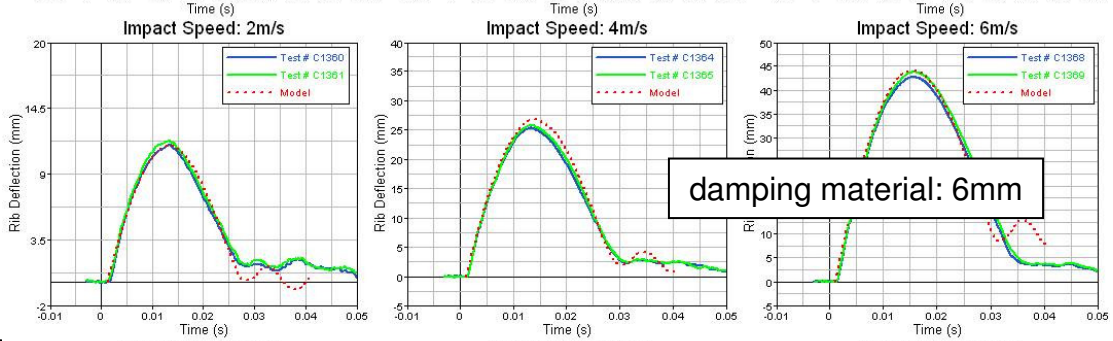
WorldSID 50th

Rib component test









Test 1
Test 2
Simulation

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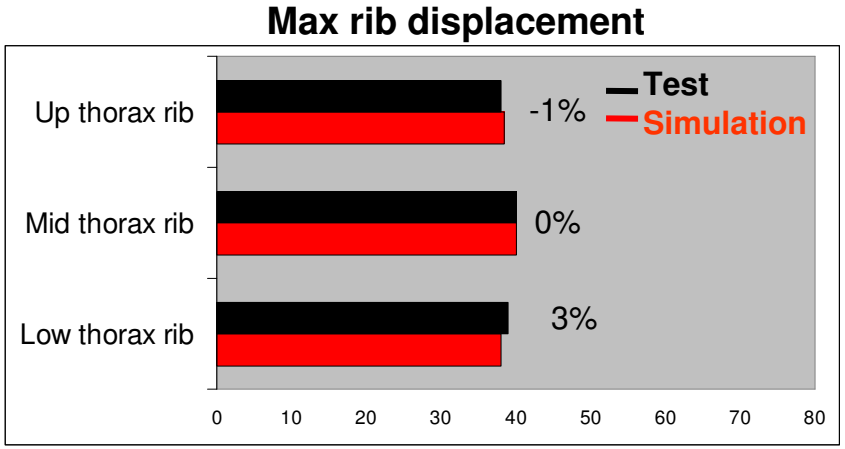
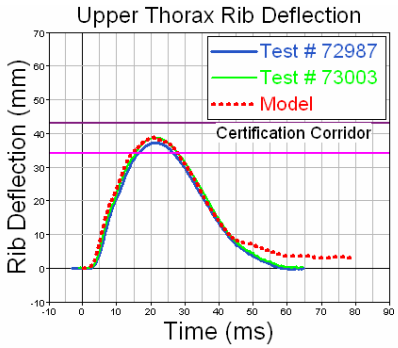
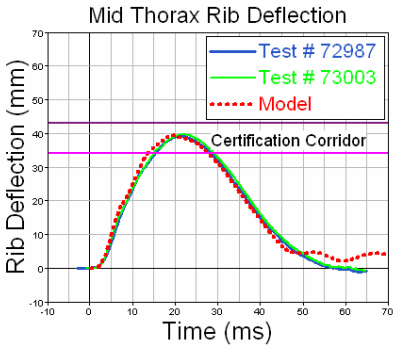
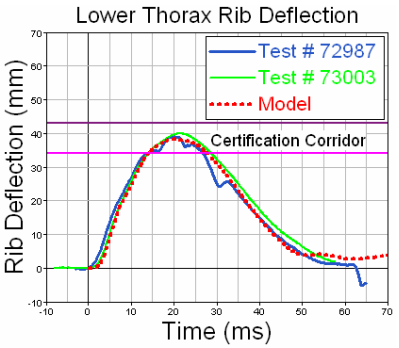
Thorax certification test

Test 1
Test 2
Simulation









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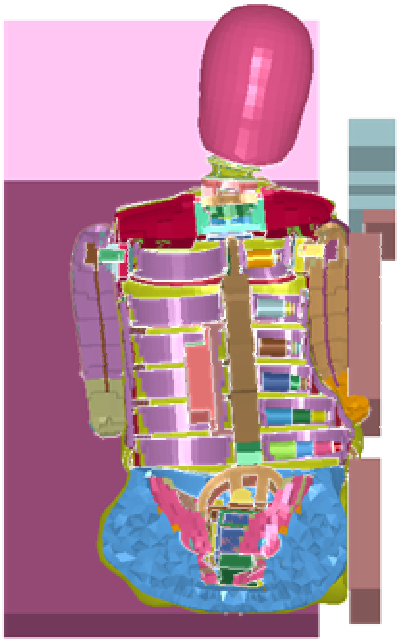
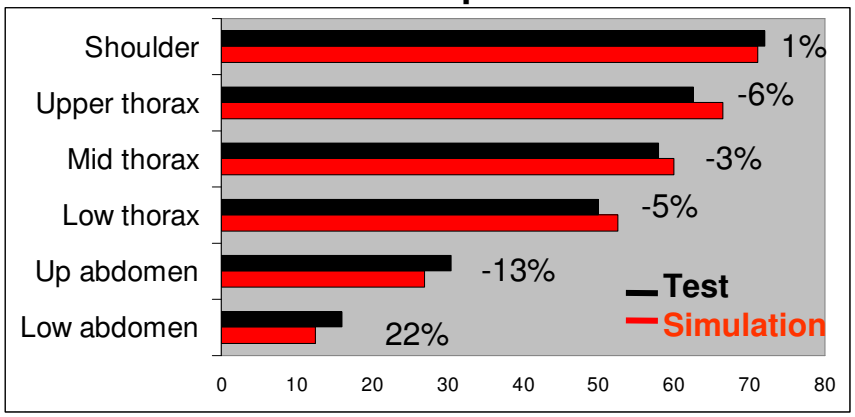
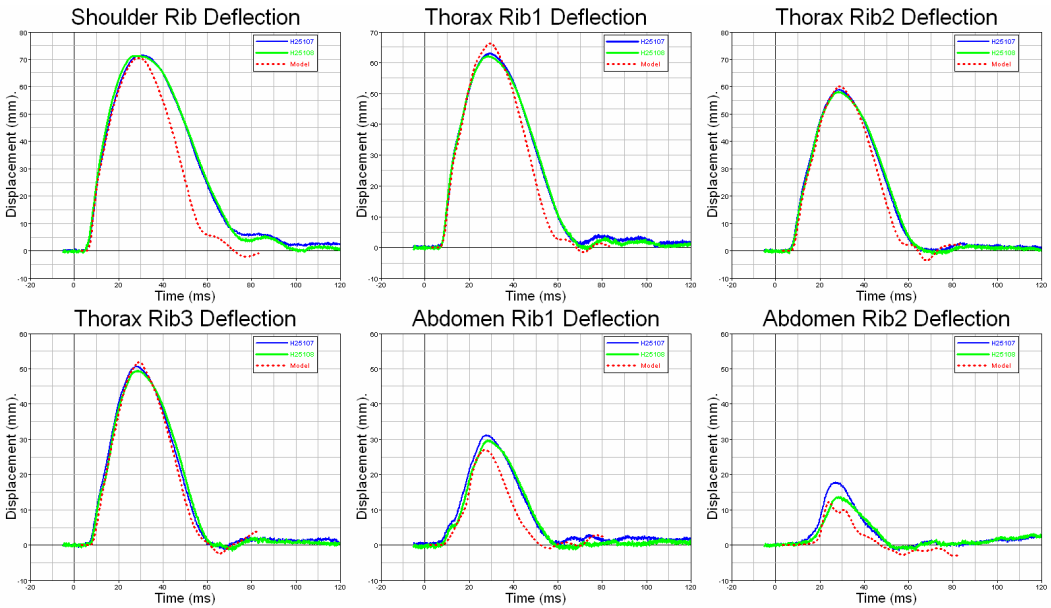
Sled test “Heidelberg 6.7 m/s”



Test 1
Test 2
Simulation

Max rib displacement





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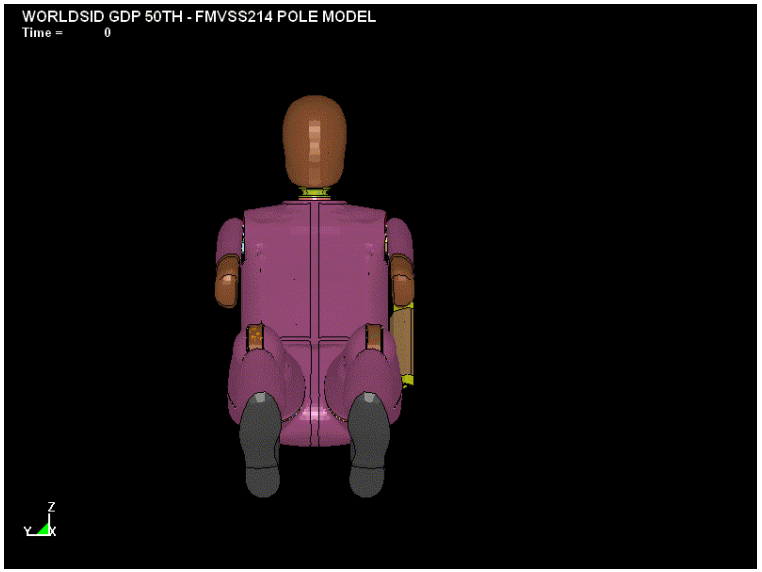
Autoliv Sweden – FTSS project



- Autoliv objectives
  - Understand physical performance of the dummy
  - Learn how to guide customers and advise product requirements
  - Examine model performance and establish confidence in the model.
  - Increase dummy model quality (FTSS)

- Study is based on 33.5MpH MDB and 32KpH 285° Pole FMVSS214 load cases

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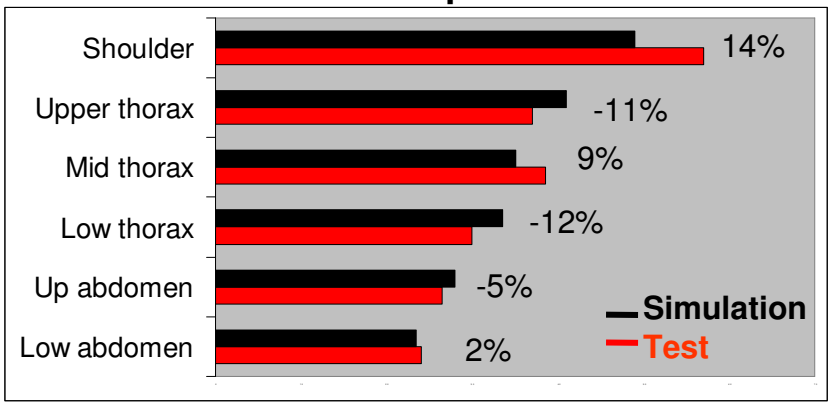
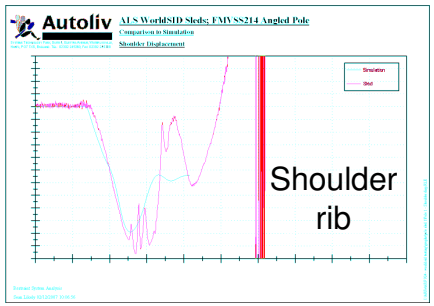
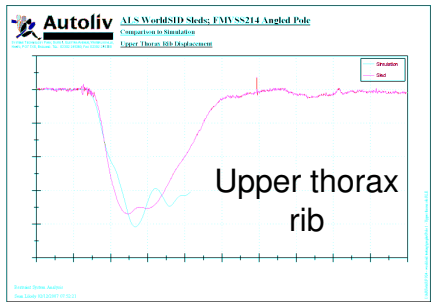
Autoliv Sweden – FTSS project

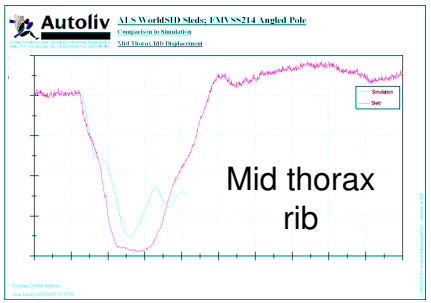
Simulation results were generated before test

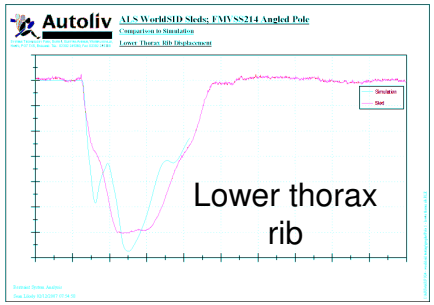
Max rib displacement

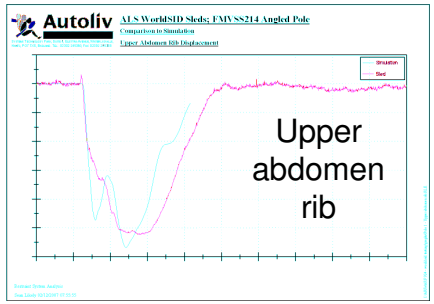


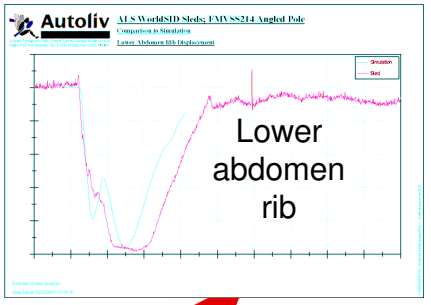












Simulation
Test

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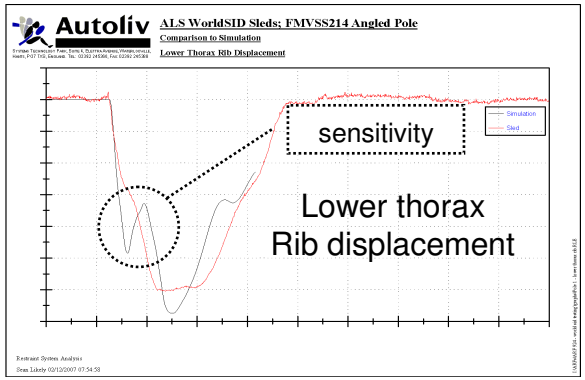
Autoliv Sweden – FTSS project

Intermediate observations and results

- Good initial correlation between simulation and test but further verifications/improvements is being looked at

- Focus points for model development
  - Verify the arm kinematics
  - Understand initial sensitivity of rib displacements



Simulation
Test

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Q3s

Child Crash Dummy Development

P-dummies

- Developed in early ‘70
- Limited:
  - impact biofidelity
  - injury assessment capabilities
  - measurement capabilities
- Size: 0, 3/4, 1½, 3, 6 and 10

Q-dummies

- Developed mid-1990s (CHILD program)
- Improved/extended:
  - biofidelity (frontal & side)
  - anthropometry (world)
  - measurement capabilities (up to 33 channels)
  - “easy-to-use” design
- Size: 0, 1, 1½, 3, 6, *(10)*

HIII child dummies

- Development started in 1987
- Specified by SAE
- Not developed for side impact
- Size:
  6, 12 & 18m (CRABI);
  3, 6 & 10yr (HIII)

Current Child Safety Test Protocols

P-dummies

- ECE-R44 for CRS in frontal and rear impact
- EuroNCAP (P1.5 & P3)

Q-dummies

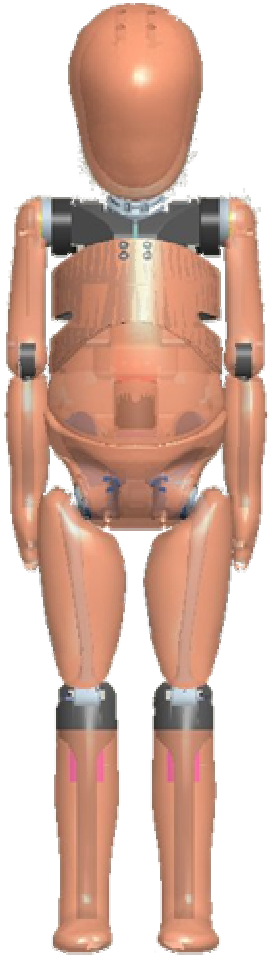
- New Program for the Assessment of Child Seats (NPACS)
- Proposed replacement for P-dummies in ECE-R44
- EuroNCAP Q1.5 and Q3 under consideration

HIII child dummies

- Part 571.213 Child Restraint Systems
- Part 571.208 Advanced Airbag Rule

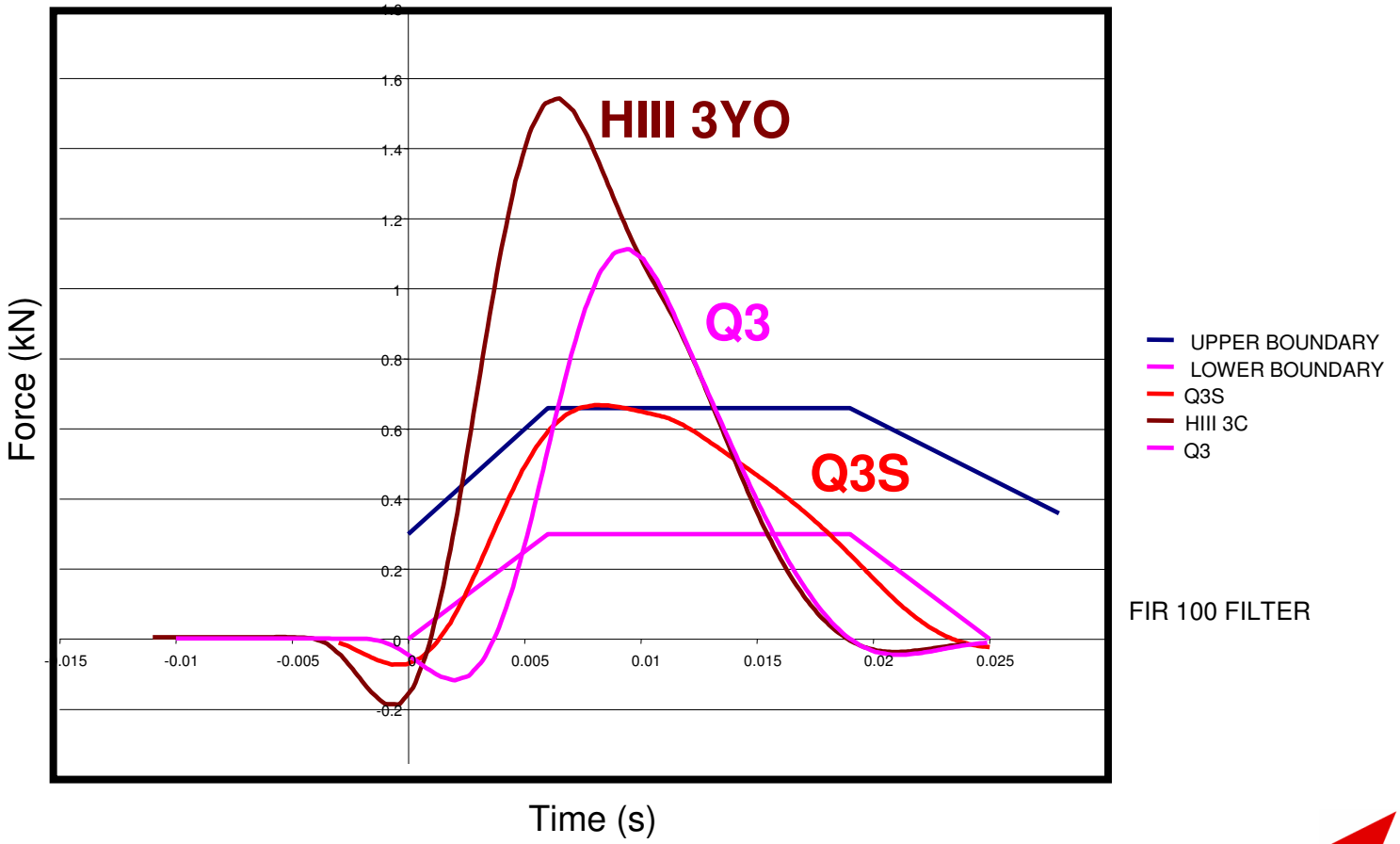
Q3s – Side Impact 3YO Child Dummy

- Special side impact version which compliments the HIII 3YO for lateral impact
- Developed in cooperation with NHTSA, OSRP and TC
  - Q3s has superior lateral biofidelity
- NHTSA is fast-tracking Q3s to support child side impact regulation
- Requirements:
  - Current Part 572 Subpart P (HIII 3YO) head-neck frontal requirements
  - ISO 9790 lateral biofidelity corridors scaled for children by Irwin et al (STAPP 2002)



Lateral Biofidelity Improvements

- Chest Pendulum Impact (4.3 m/s, 1.7 kg)



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Design Features of Q3s

Fiberglass Skull to eliminate “ringing”
Q3 head anthropometry and impact biofidelity

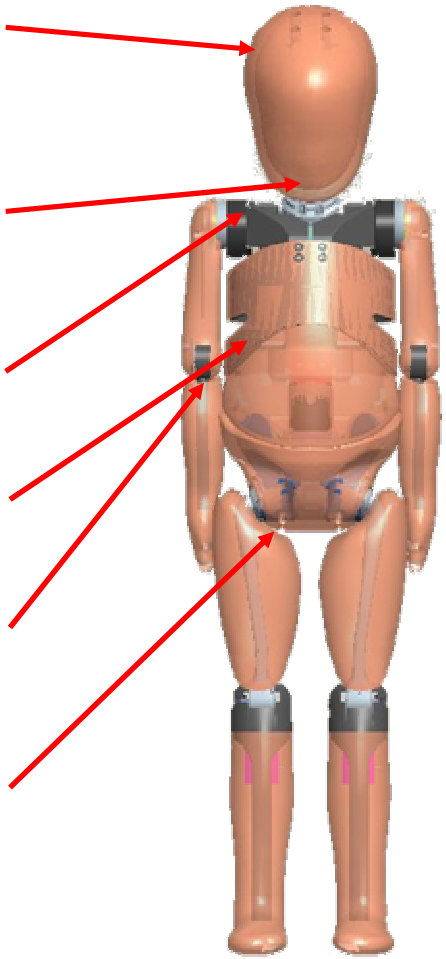
Neck has improved biofidelity for frontal (oblique)

Shoulder has enhanced lateral flexibility

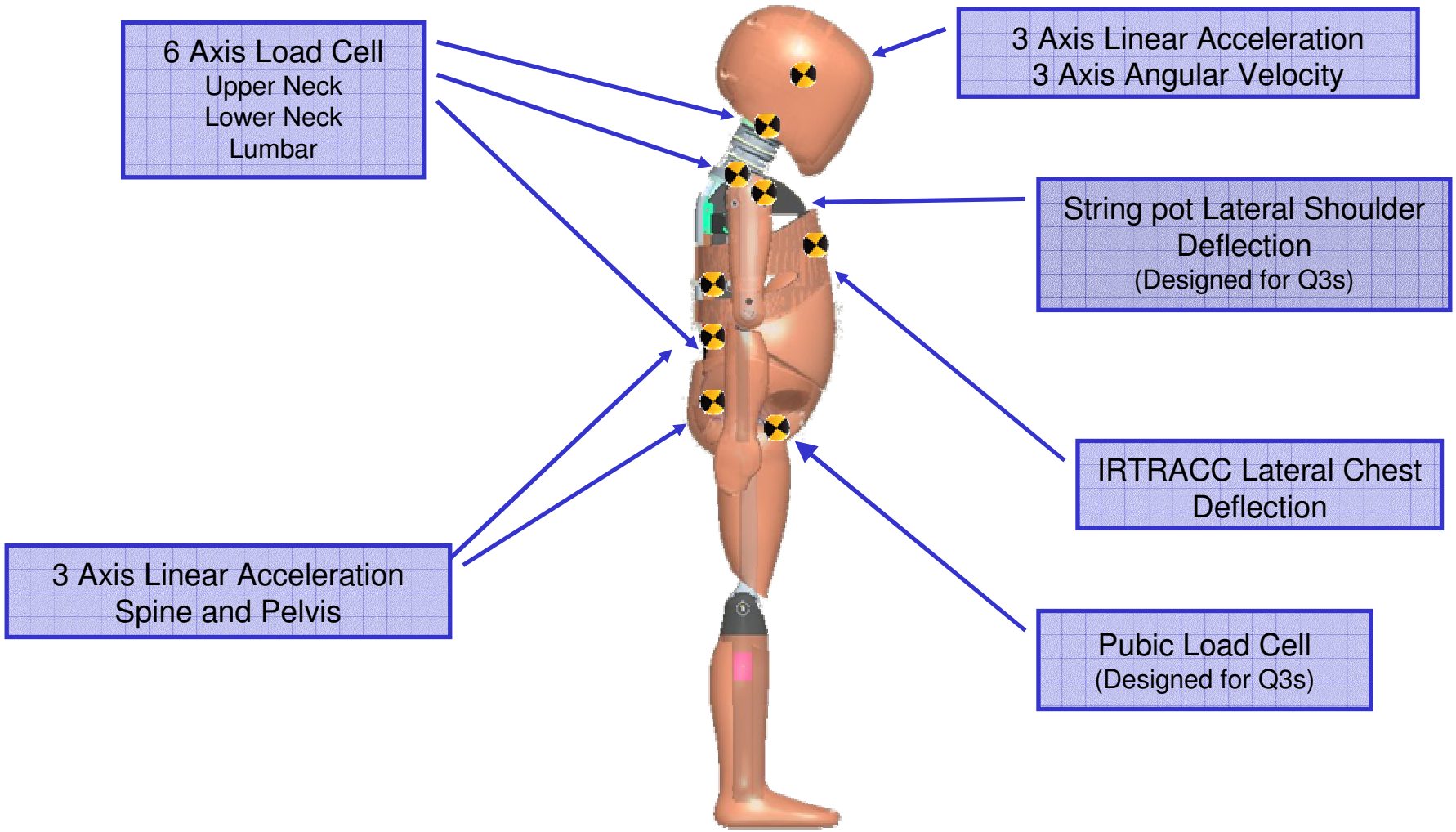
Chest has enhanced lateral biofidelity

Arm flesh covers entire upper arm (improved biofidelity)

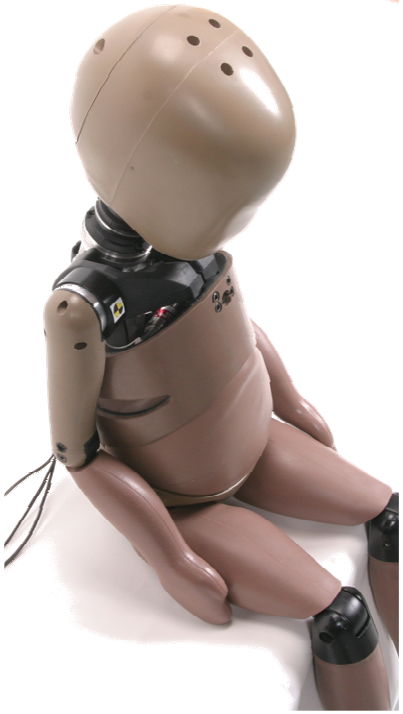
Pelvis flesh more compliant for improved lateral biofidelity
Floating hip cups, spring loaded for lateral impact
Softer thigh flesh (more humanlike) for improved biofidelity



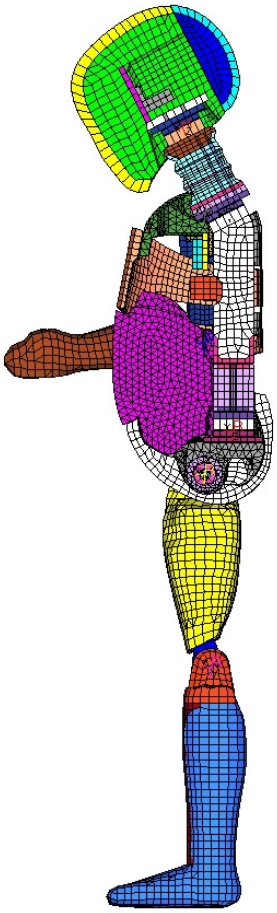
Instrumentation of Q3s (35 channels)



Q3s Finite Element Model



- Finite element model of Q3s has been developed
  - Beta version is available since Q1 2007
- The model is being used to support Q3s developments



Q3s FE Model Test Matrix

Model calibration & validation

Material level

Dynamic relaxation: Head skin, neck rubber, shoulder, rib wrap, pelvis skin, arm flesh, leg flesh

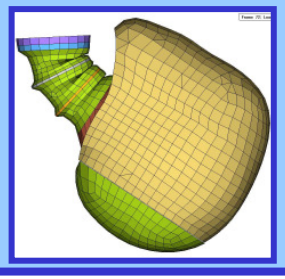
Quasi-static compression: Head skin, head skull, neck rubber, shoulder, rib cage, rib wrap, pelvis skin, arm flesh, leg flesh, abdomen foam

Dynamic drop: abdomen foam

Component level

speed in m/s

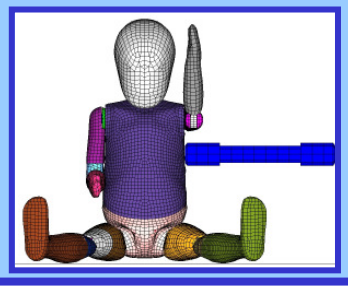
Head drop – frontal (1.6 m/s)
Head drop – frontal (2.71 m/s)
Head drop – lateral (1.6 m/s)
Head drop – lateral (2.0 m/s)
Neck pend impact – front (3.9 m/s)
Neck pend impact – lateral (3.5 m/s)
Lumbar spine pend – frontal (4.4 m/s)
Lumbar spine pend – lateral (4.4 m/s)



Whole dummy level

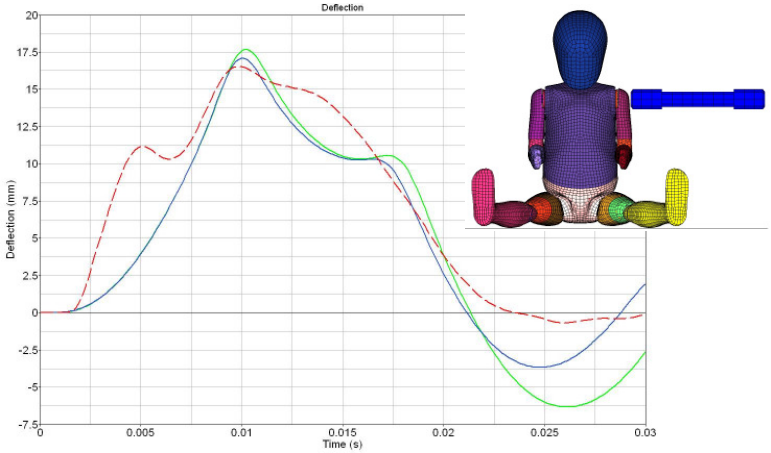
mass in kg / speed in m/s

Shoulder pend impact (1.7kg / 4.5 m/s)
Thorax pend impact (1.7kg / 4.3 m/s)
Abdomen pend impact (3.8 kg / 4.8 m/s)
Abdomen pend impact (3.8 kg / 6.8 m/s)
Pelvis pend impact (2.27 kg / 4.5 m/s)

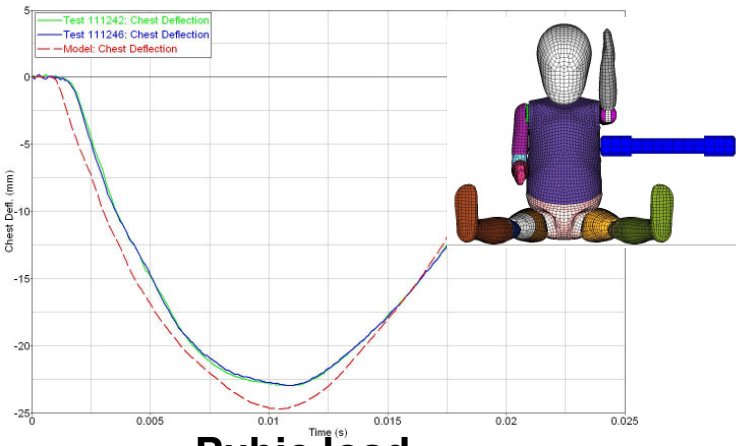


Q3s

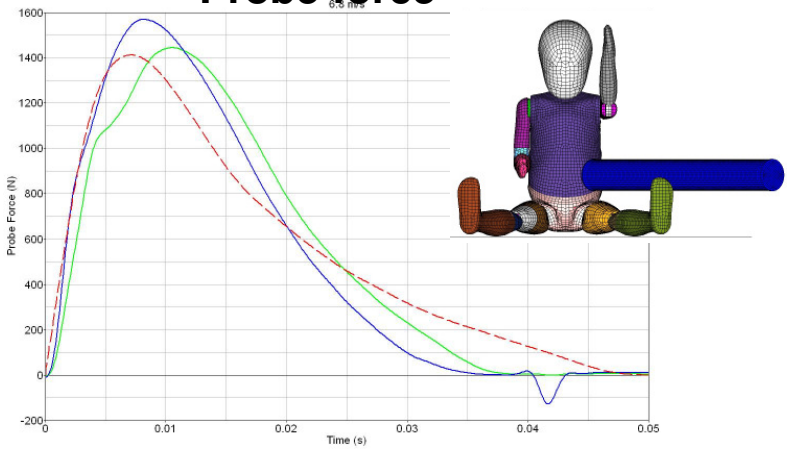
Shoulder deflection



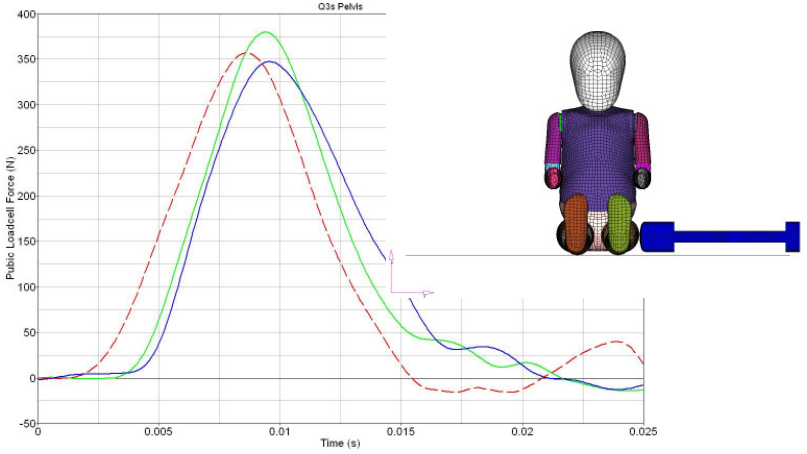
Chest deflection



Probe force



Pubic load



Test 1
Test 2
simulation

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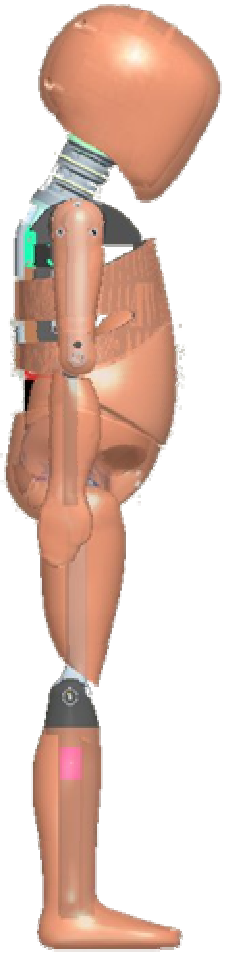
Conclusion Q3s hardware

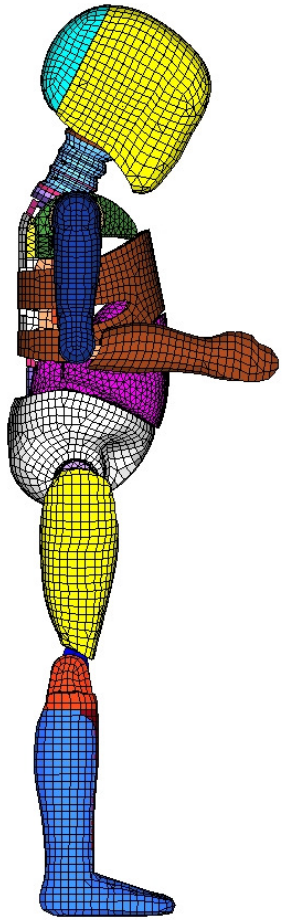


- Q3s improvements over standard Q3 in lateral performance
- New instrumentation in shoulder and pelvis
- Biofidelity in lateral impact superior to H-III3YO and standard Q3

Further Work

- Prototype review by the OSRP Q3s Task Force & NHTSA
- Recommendations will lead to production release
- Development of Q6s and Q1.5s

Q3s model



- The model is ready to be explored and used for child restraint system analysis

Thank you for your attention