WorldSID 50th
The Next Generation Side Impact Dummy

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Introduction

- Side impact collisions account for almost 43% of all vehicle occupant deaths in Europe.
- Despite an increase in regulation/rating programs and the introduction of innovative active and passive vehicle restraint systems, there is no evidence of a reduction in car crash deaths.
- Further research is required into side impact configurations and ATD's to develop a useful specification for inclusion into regulation.
- Government, industry and research have been working together under the WorldSID Task Group and IHRA (ISO TC22/SC12/WG5), focused on delivering a highly biofidelic side impact dummy since 1997, the WorldSID 50th ATD.
- The WorldSID 50th prototype dummy has been undergoing evaluated in North America, Europe and Asia since July 2003.
- A production version of the dummy was released in March 2004.

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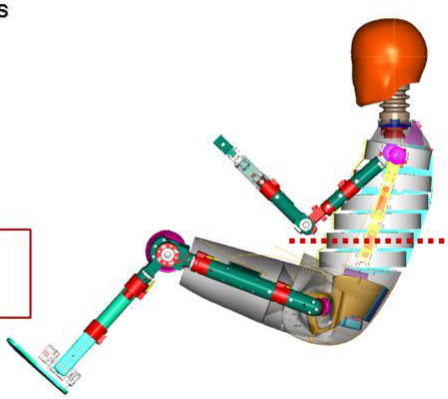
WorldSID 50th Key Design Features

- Horizontal orientation of ribs in seated position
- 6 Upper Torso Ribs
  - 1 shoulder rib
  - 3 Thorax ribs
  - 2 Abdomen ribs
- Instrumentation
  - IR-TRACC Rib Deflection
  - Rib accelerometers



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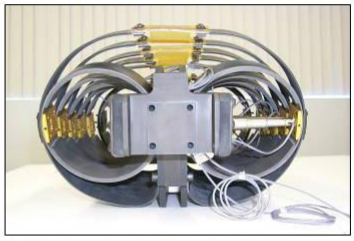
WorldSID 50th Key Design Features

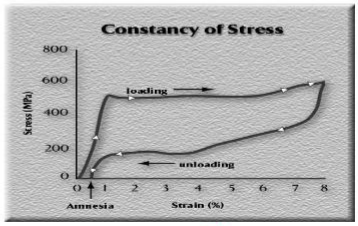
Upper torso ribs

- Outer band – Nitinol
- Inner band – Nitinol with rib damping material
- Oblique loading considered
- FEA used for rib development



Nitinol

- Nickel Titanium shape memory alloy
- Super-elastic
- Transformation change
  - Austenite to Martensite
- Capable of 6-8% strain



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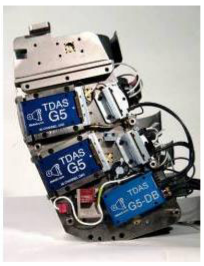
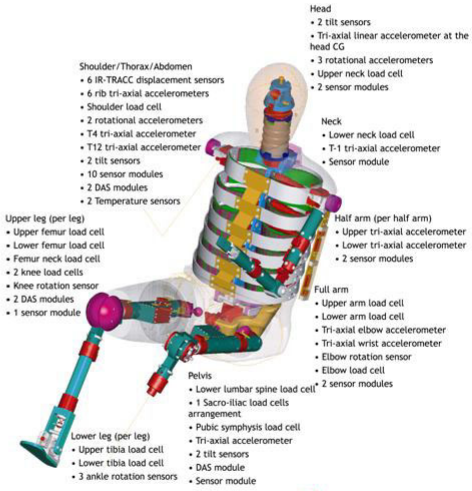
WorldSID 50th Key Design Features

- 160 Data Channels
- Instrumentation
  - Accelerometers
  - Load cells
  - IR-TRACC displacement sensors
  - Tilt positioning sensors
  - Rotational Accelerometers
- Onboard In-Dummy DAS





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Side Impact Biofidelity Comparison

Body Region	SID	ES-2	ES-2re	WorldSID
Head	0	5	5	10
Neck	2.5	4.4	4.2	5.6
Shoulder	0	5.3	4.5	7.1
Thorax	3.1	5.8	4.0	8.4
Abdomen	4.4	2.7	4.1	7.8
Pelvis	2.5	5.2	3.2	6.1
Overall	2.3	4.7	4.2	7.6 → "GOOD"

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Courtesy of www.worldsid.org

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Finite Element Model Development

- Unique Materials
  - Nitinol (Nickel Titanium super-elastic alloy)
  - Hyperlast Polyurethane Elastomer
- Material modelling technology needed to be developed

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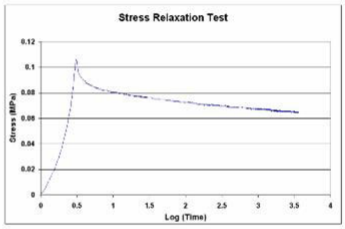
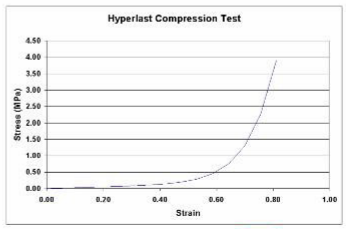
Elastomer Material Testing

Stress Relaxation & Compression Tests
Test sample: Hyperlast cube (3" each side)





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*MAT_OGDEN_RUBBER Material Characterisation

Ogden rubber material characteristic is implemented in LS-Dyna as:

$$\lambda_2 = \lambda_3 = \lambda_1^{-1/2}, \sigma_1 = \frac{1}{\lambda_2 \lambda_3}\frac{\partial W}{\partial \lambda_1} = \sum_{i=1}^{n} \mu_i (\lambda_1^{\alpha_i} - \lambda_1^{-\alpha_i/2})$$

Where λ_i is the stretch and μ_i and α_i are material constants such that

The material constants μ_i and λ_i can be obtained by fitting a curve to the above equation and applying the compression data from the hyperlast test.

μ_i	0.001	0.0710	-0.001
α_i	1.3	4.85	-2

For the strain rate properties, the Maxwell constants G_i and β_i can be obtained by fitting the stress-relaxation test data to the equation below:

$$G(t) = \sum_{i=1}^{n} G_i e^{-\beta_i t}$$ six terms from the Prony series

Maxwell material constants developed for Hyperlast are:

β_i	0.00164	0.04439	0.8544	9.9921	100.0	1000.0
G_i	0.00810	0.00895	0.0144	0.0183	0.2450	-0.5866

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WorldSID 50th Arm Drop Validation

A component drop test was used to validate the material properties derived from the material tests. The impactor is positioned at centre of the arm. Tests were carried out at 4.4 m/s and 6.3 m/s.

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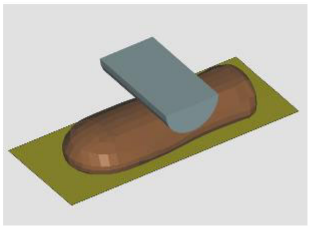
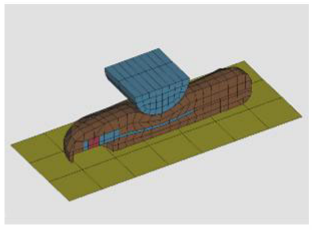
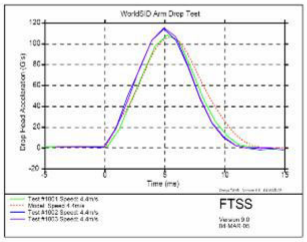
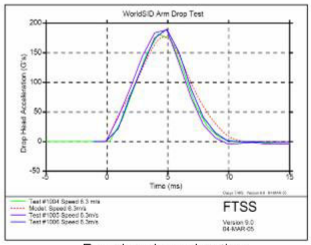
WorldSID 50th Arm Drop Correlation







Drop head acceleration
(Impact speed: 4.4m/s)



Drop head acceleration
(Impact speed: 6.3m/s)

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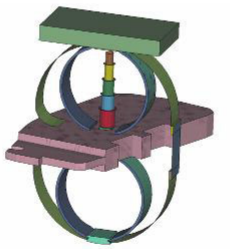
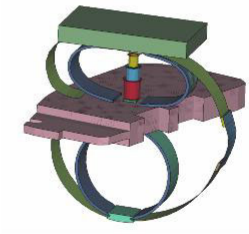
WorldSID 50th Rib Material Development

- Development of the rib material using drop tower type single rib tests.
- Impact speeds: 4, 5, and 6 m/s and the shoulder at a further 7 m/s.
- Uses MAT_24, *MAT_PLASTIC_KINEMATIC for the time being
- LSTC supporting FTSS with development of MAT_30, *MAT_SHAPE_MEMORY for shell elements in next release of LS-Dyna

Test set-up



Model – initial set-up



Model – maximum rib deflection at 15ms

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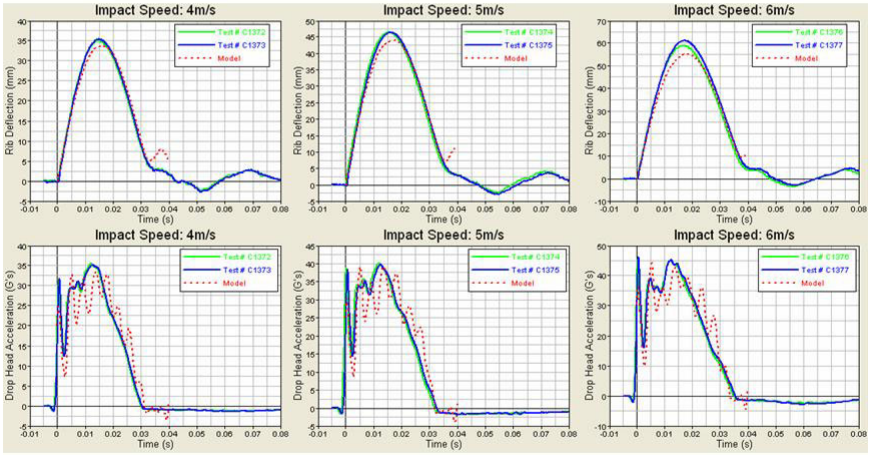
WorldSID 50th Rib Material Development

Thorax single rib drop test – Rib deflection & Drop head acceleration correlation



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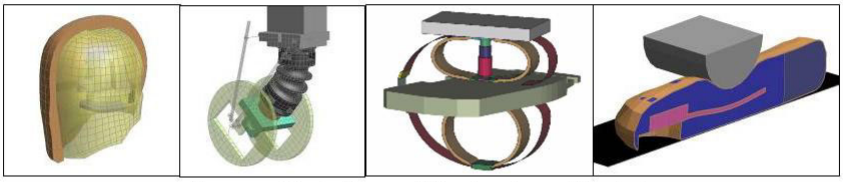
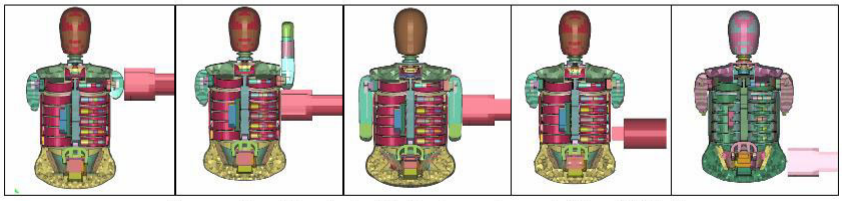
WorldSID-50th Model Development

- Component validation and Pendulum verification completed



Component tests: Drop weight and neck pendulum tests



Dummy Pendulum tests: 23.4kg, Impact speed: 4.3 m/s/6.7m/s

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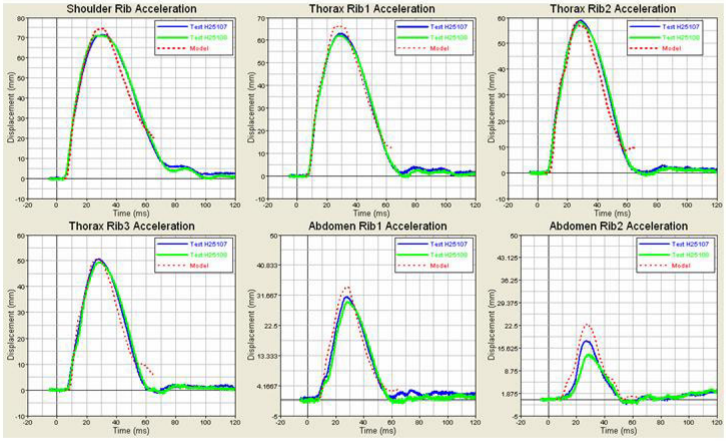
WorldSID 50th Sled Test Verification



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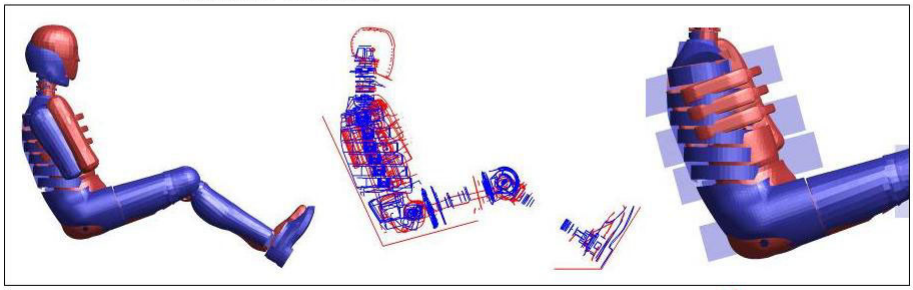
WorldSID 50th Compared to ES-2re

- ES-2re (RED) and W50 (BLUE) overlaid with the same H-point and back angle
- Key differences:
  - Seating height
  - Arm position
  - Thorax rib orientation



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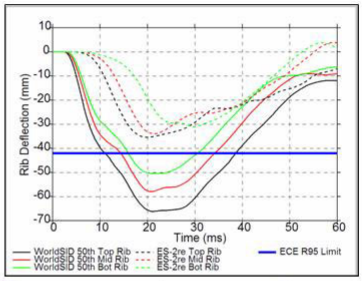
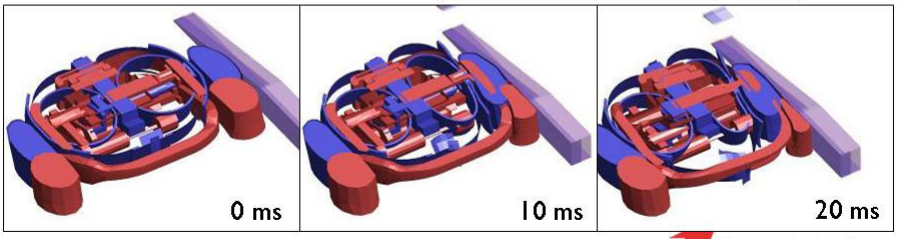
WorldSID 50th Compared to ES-2re

- WSU sled test configuration
- Test speed 6.35 m/s
- WorldSID 50th shows about twice the thorax rib deflection compared to ES-2re
- The WorldSID 50th rib results are higher than the current ECE R95 ES-2 injury limits





Summary and Conclusions

- WorldSID 50th has the highest ISO TR9790 biofidelity rating of any side impact ATD
- The injury criteria for the WorldSID 50th is yet to be developed through ISO TC22/SC12/WG5
- Could have a large influence on vehicle design compared to existing ATD's due to the improved biofidelity and ability to capture oblique loading conditions
  - A comparison in the WSU sled test configuration shows the WorldSID 50th reports about twice as much thorax rib deflection compared to ES-2re
  - The WorldSID 50th captures the shoulder load path via rib
  - Arm position differences could results in differing kinematics
- FTSS have developed and released a validated finite element model of the WorldSID 50th