

# **The New Member of World SID Family**

## **5 Percentile WSID: FE Model Development and Validation**

Y. Liu, F. Zhu, J. Rasico, M. van Ratingen

FTSS, Inc.

# **A new member of World SID family – 5<sup>th</sup> percentile female: FE model development and validation**

*Presented by Fuchun Zhu*

*First Technology Safety Systems, Inc.*

# Contents

---

- Introduction
- World SID 5<sup>th</sup> Key Design Features
- Finite Element Model Development
  - Materials Development
  - Component validation
  - Full Dummy Pendulum validation
- Next Step: Sled and Vehicle Tests
- Summary and Conclusions



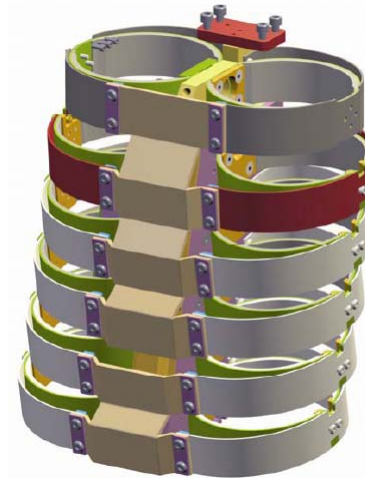
# Introduction

---

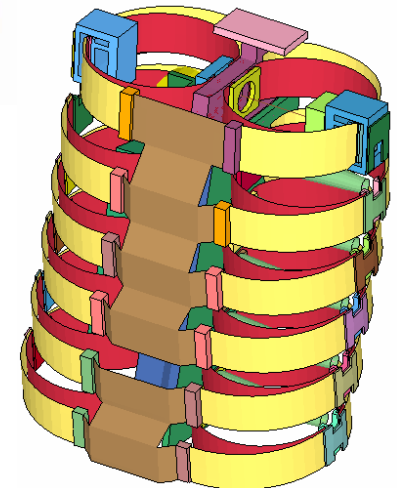
- World SID 5<sup>th</sup> percentile female dummy is a new member to the World SID family after 50<sup>th</sup> male dummy.
- The design work was carried out under the directions of the WorldSID Task Group and IHRA (ISO TC22/SC12/WG5), to deliver a highly biofidelic small size side impact dummy since 2003.
- The World SID 5<sup>th</sup> uses a scaled down design concept from the World SID 50<sup>th</sup> aiming to achieve a good Biofidelity rating (WSID 50<sup>th</sup>: 7.6 on a scale of 10 according to ISO TR9790).
- This dummy has been evaluated by the APROSYS members and the Transport Canada at prototype release since early 2006.
- The World SID 5<sup>th</sup> FE model is being developed by FTSS.

# World SID 5<sup>th</sup> Key Design Features

- Similar design structure as in 50<sup>th</sup> dummy
- 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



World SID 5<sup>th</sup>  
thorax assembly

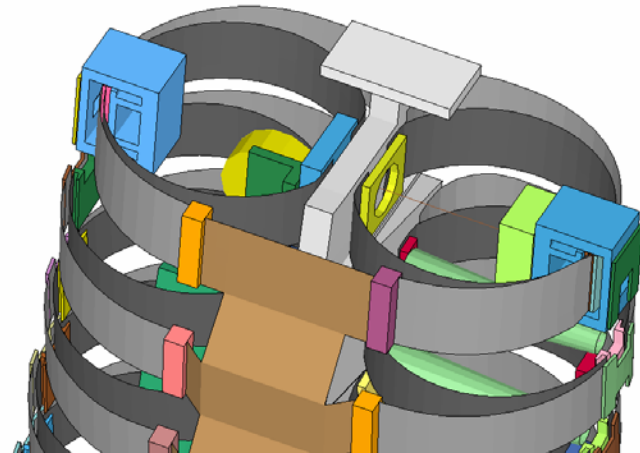


FE Model

# World SID 5<sup>th</sup> Key Design Features

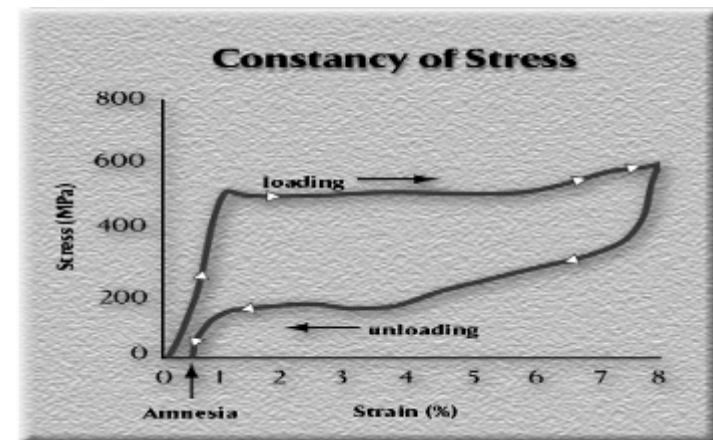
## Upper torso ribs

- Outer band – Nitinol
- Inner band – Nitinol
- Damping material removed (latest development)
- 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

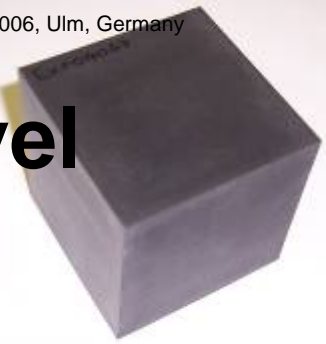


# FEM Development: Material Level

---

- Unique Materials
  - Nitinol (Nickel Titanium super-elastic alloy)
  - Hyperlast Polyurethane Elastomer
- Material modeling technology developed

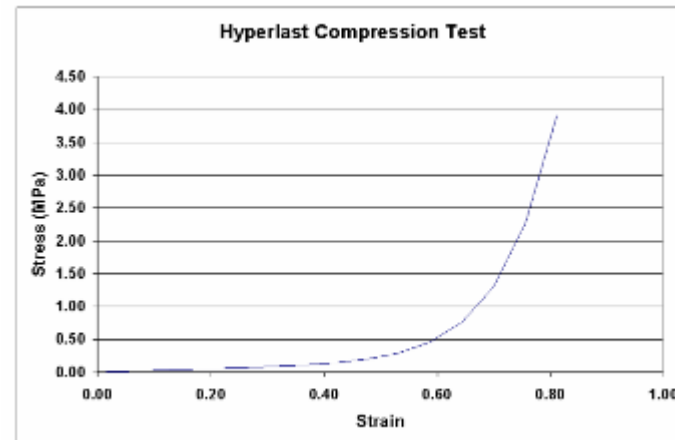
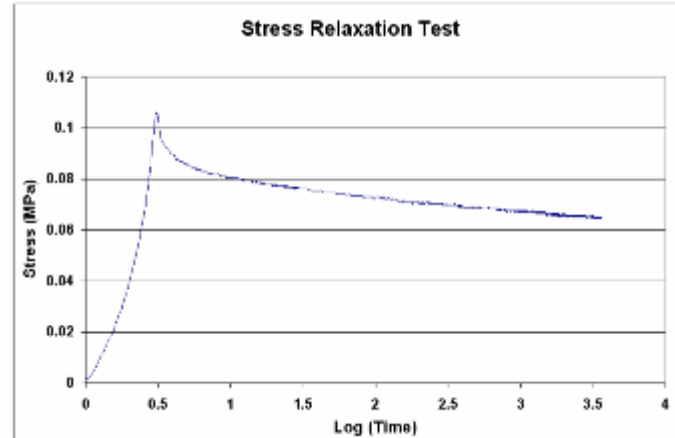
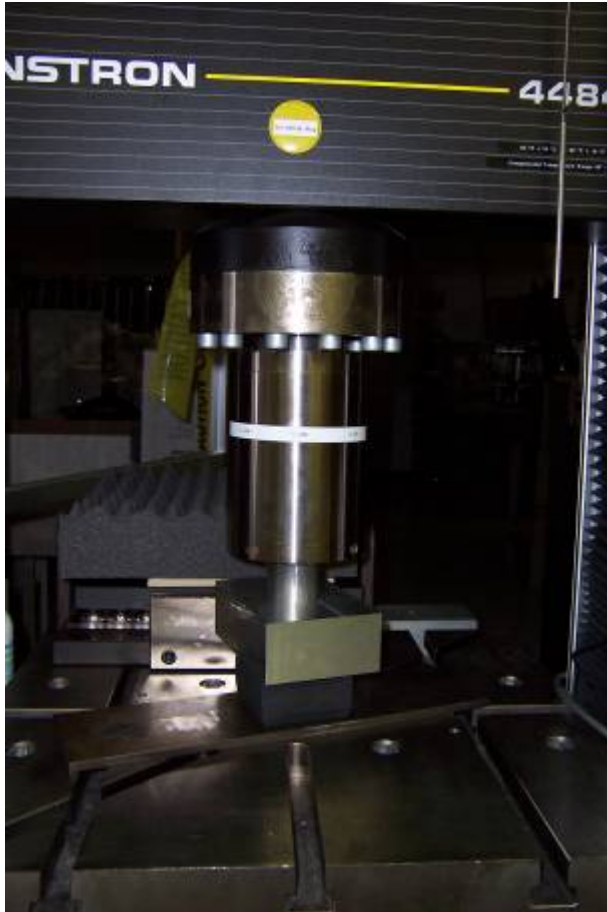




# FEM Development: Material Level

## Stress Relaxation & Compression Tests

Test sample: Hyperlast cube (3" each side)

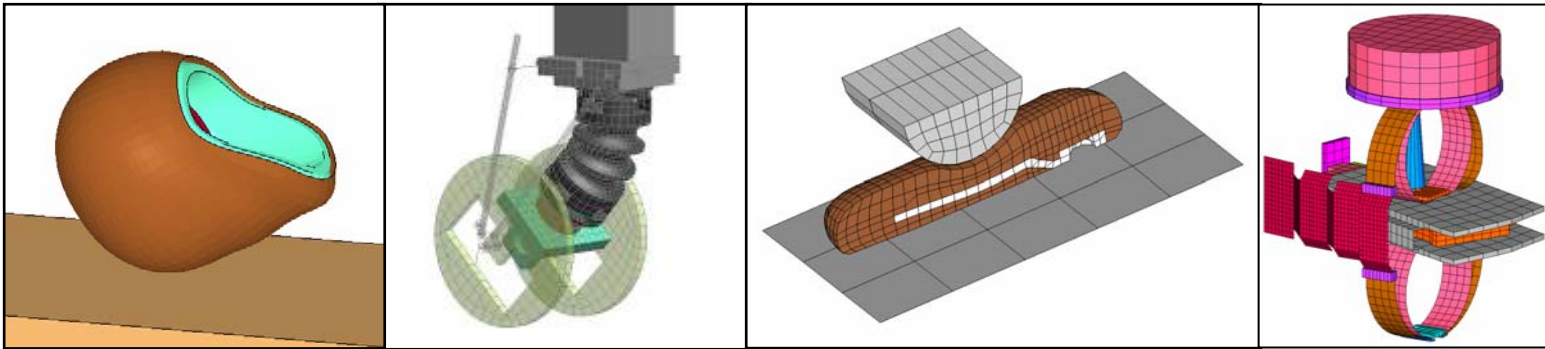




# FEM Development: Component Level

---

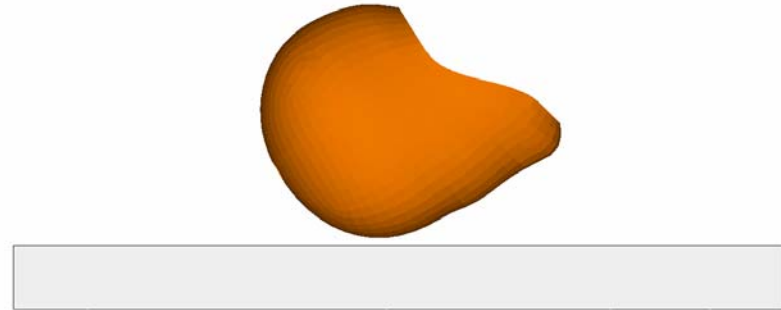
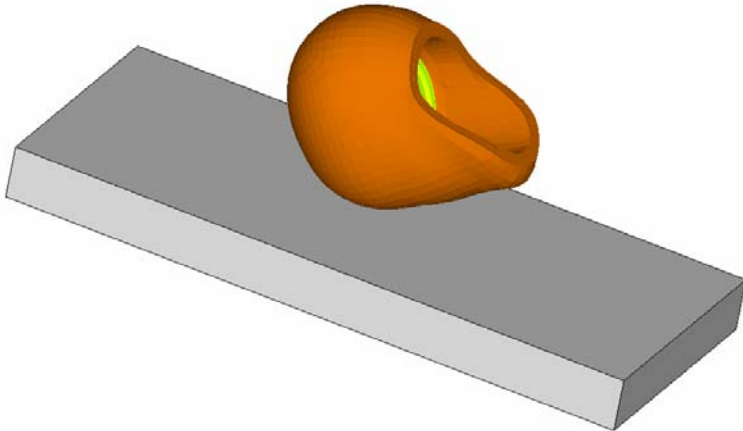
- The following component level validation tests were conducted with multiple impact speeds:
  - Head dynamic drop
  - Neck pendulum
  - Arm dynamic drop
  - Rib dynamic drop



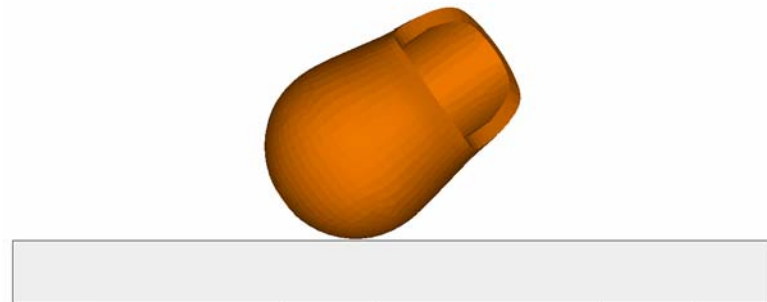
# Component Level: Head Drop

---

Frontal: drop height 200mm and 376mm

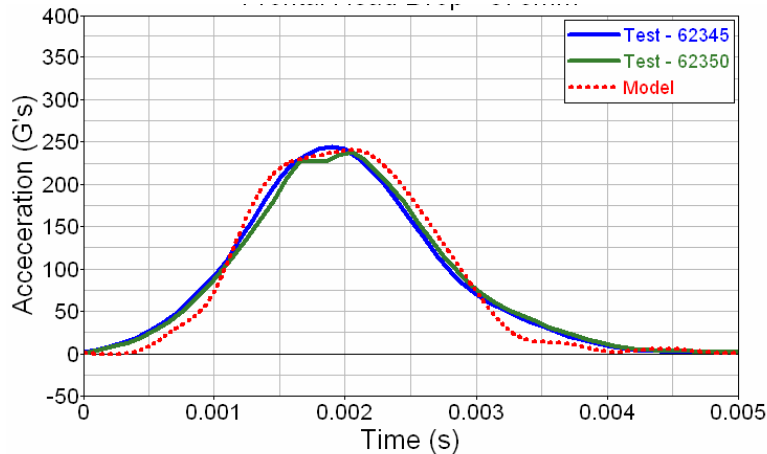


Lateral: drop height 200mm and 376mm

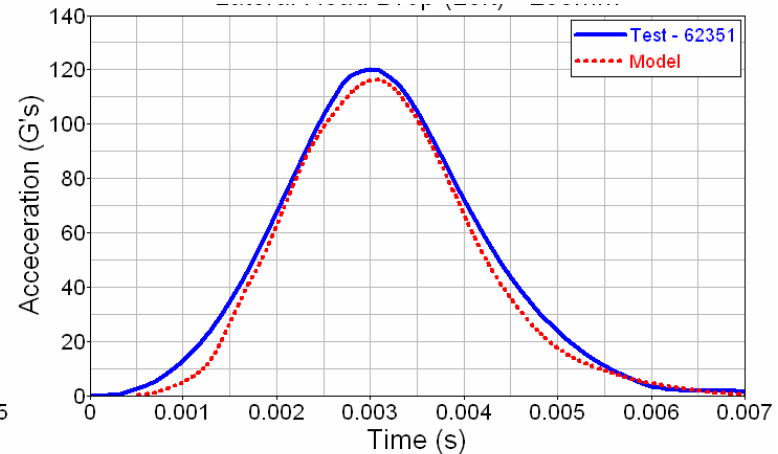


# Head drop (Resultant acceleration)

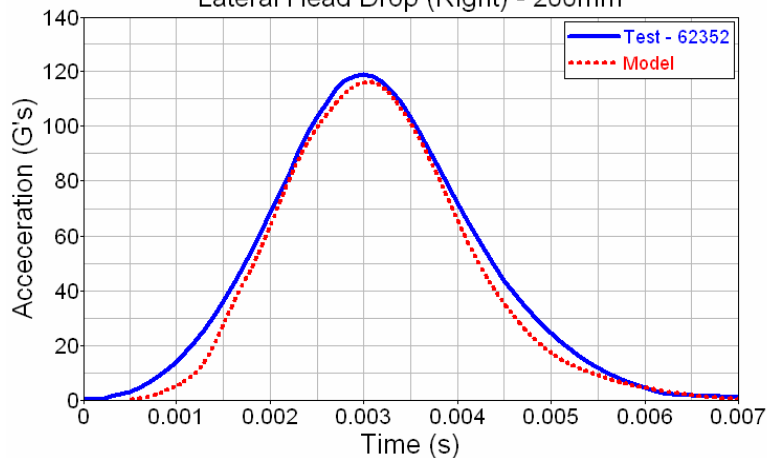
### Frontal Head Drop (200mm)



### Frontal Head Drop (376mm)

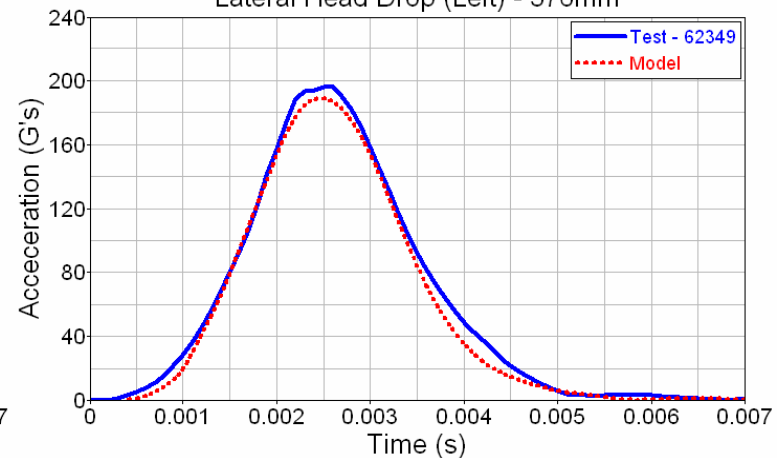


### Lateral Head Drop (Right) - 200mm



### Right Side Head Drop

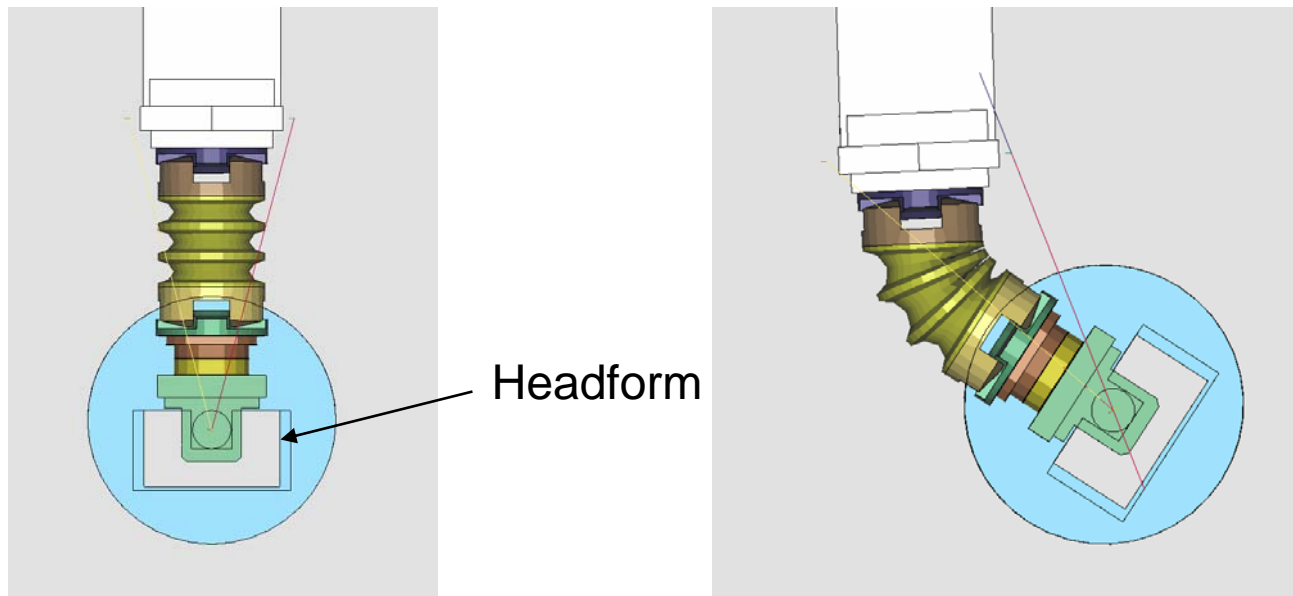
### Lateral Head Drop (Left) - 376mm



### Left Side Head Drop

# Component Level: Neck Pendulum

---

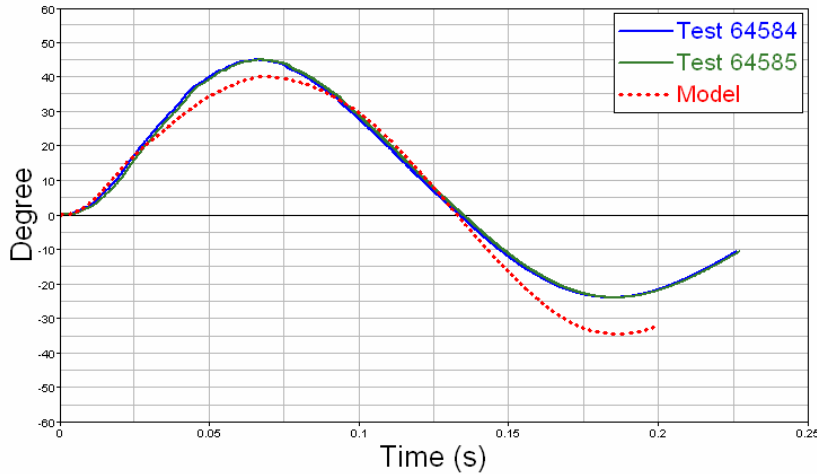


Model: Initial set-up

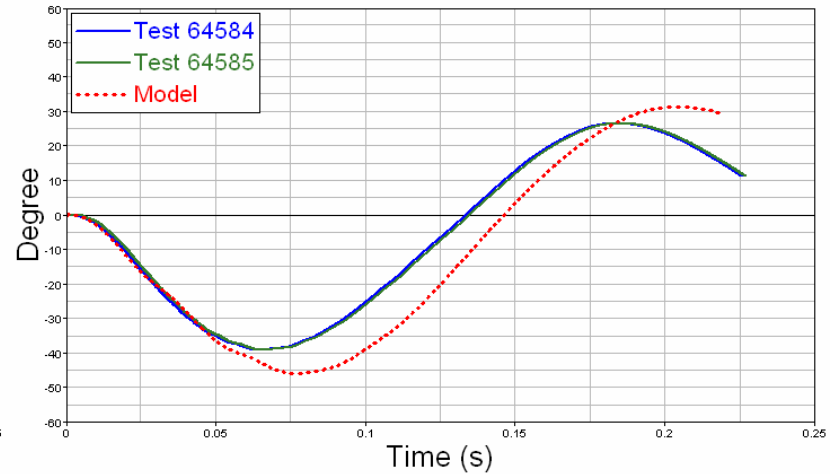
Model: Impact at 0.06s

# Neck Pendulum Impact

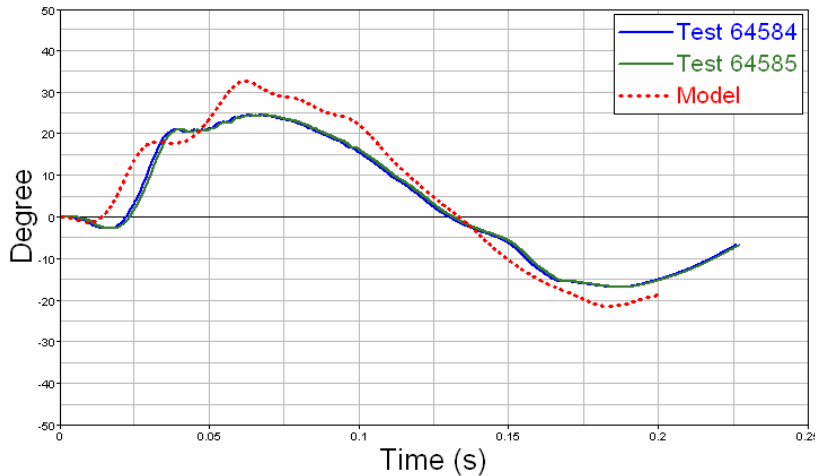
Front Pot Rotation



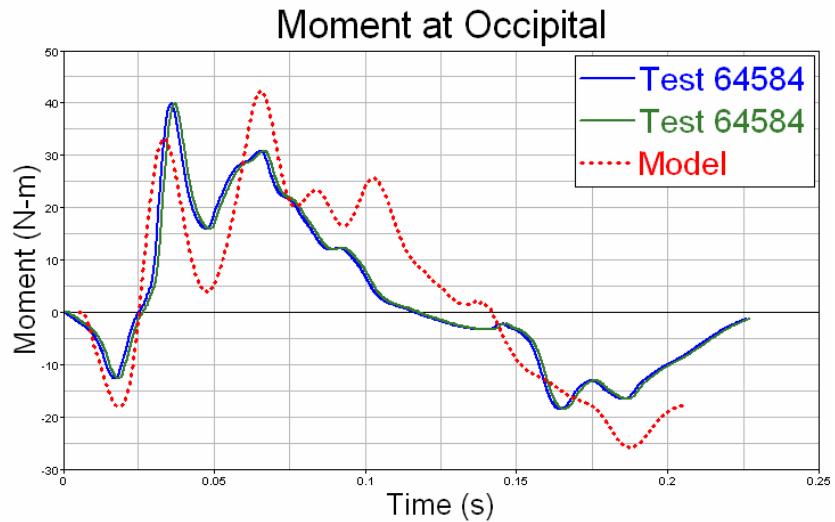
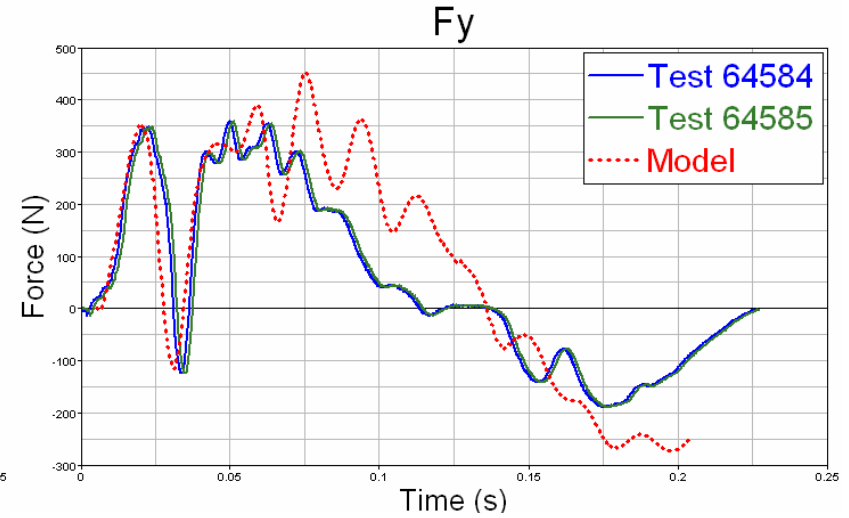
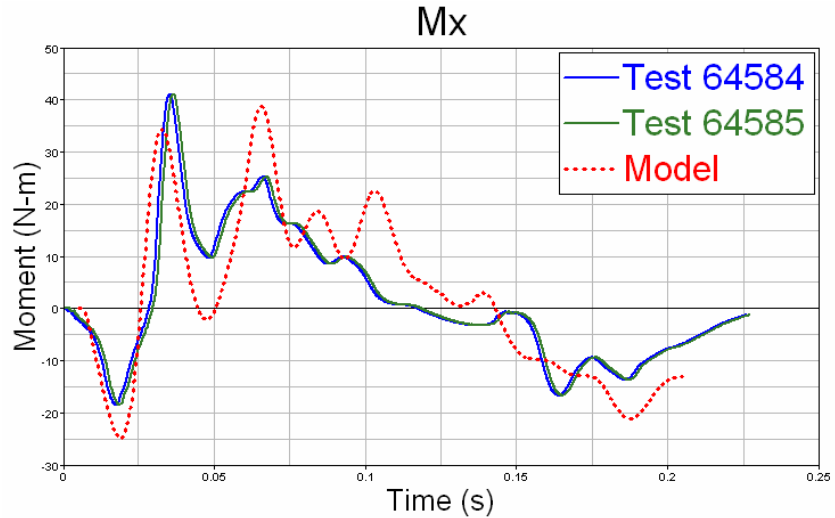
Rear Pot Rotation



Head Pot Rotation



# Neck Pendulum Impact

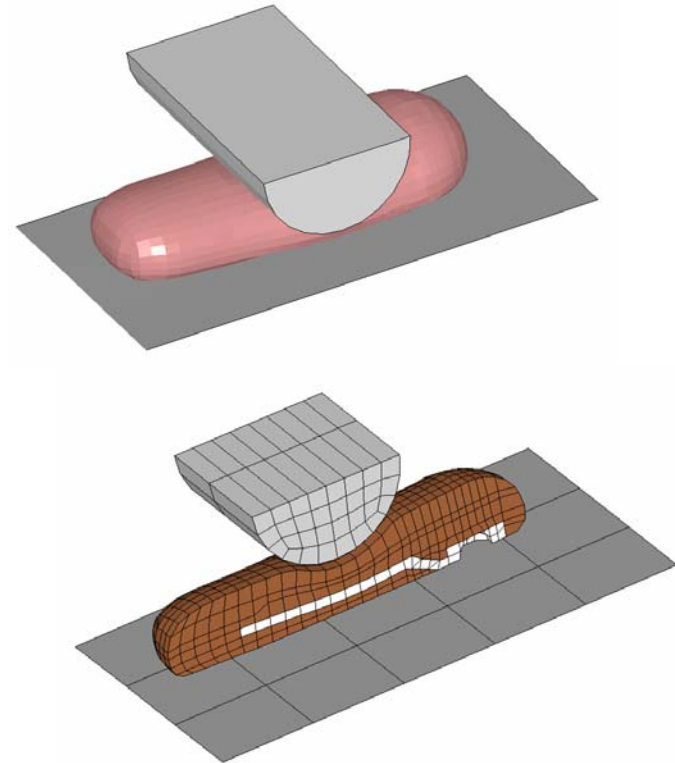


# Component Level: Arm Drop

---



Arm drop test set-up

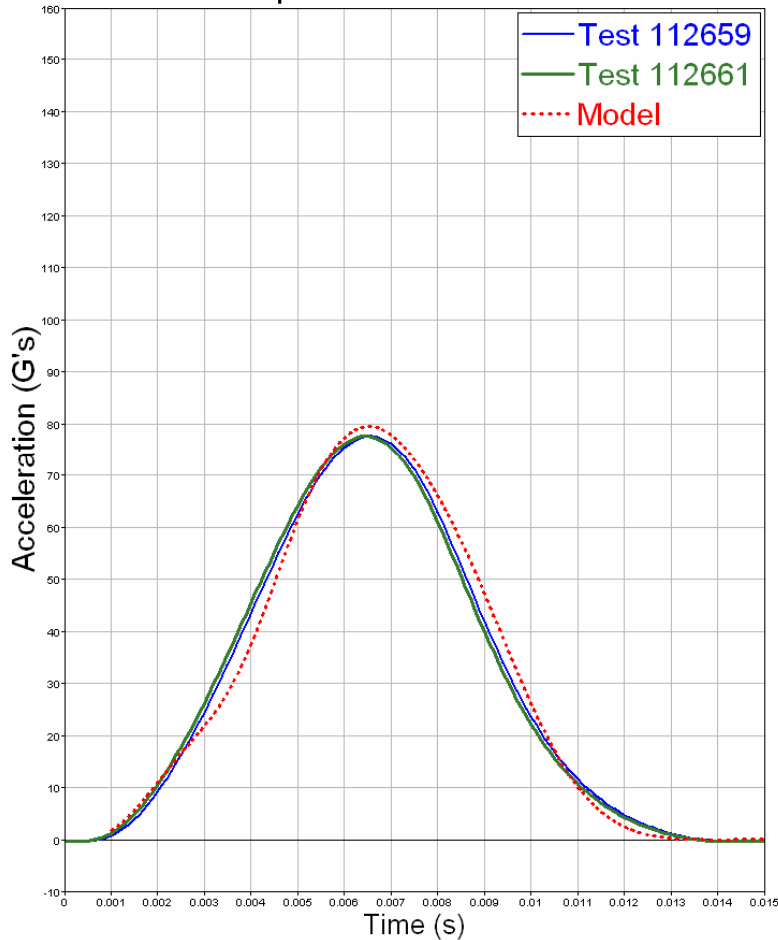


FE Model

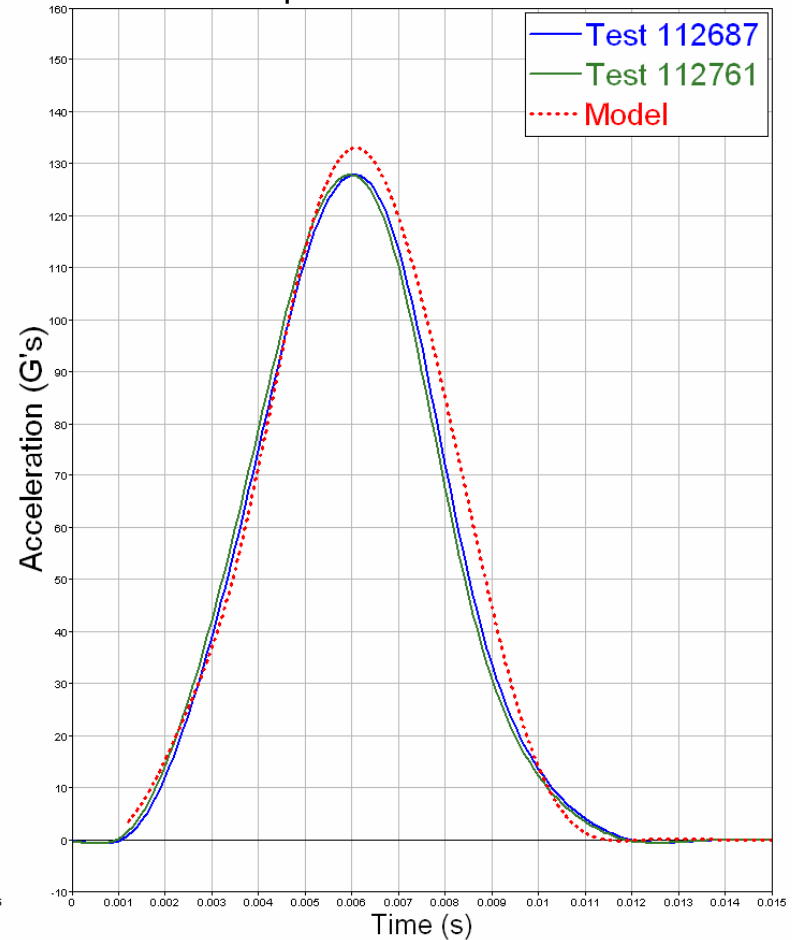
# Component Level: Arm Drop

## Drop head de-acceleration

Arm Drop - Mid Location - 3.13m/s



Arm Drop - Mid Location - 4.24m/s





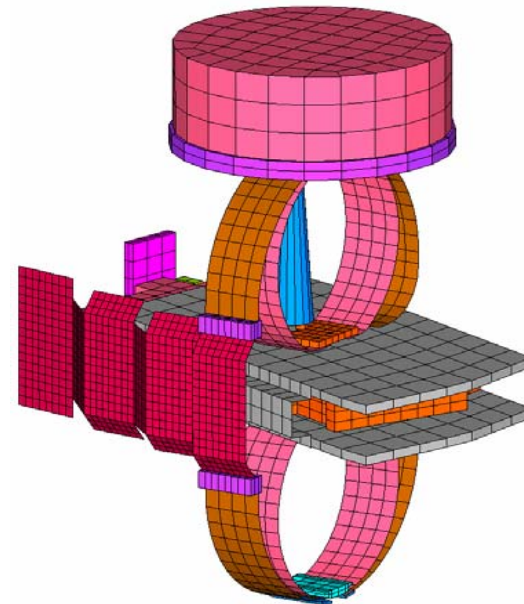
# Component Level: Single Rib Drop

---



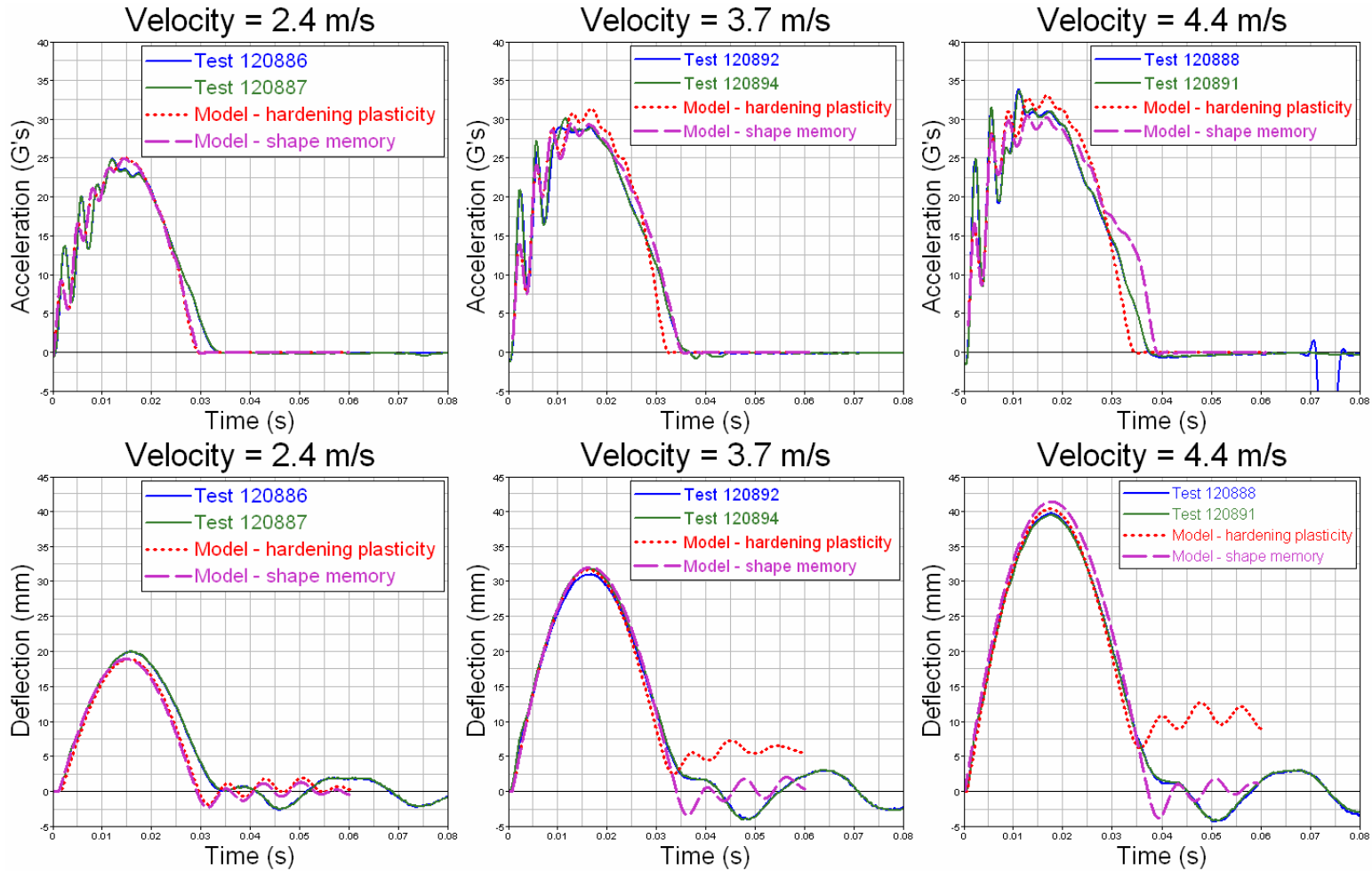
World SID 5<sup>th</sup> rib drop test set-up

Impact speed: 2.4, 3.7, 4.4 m/s



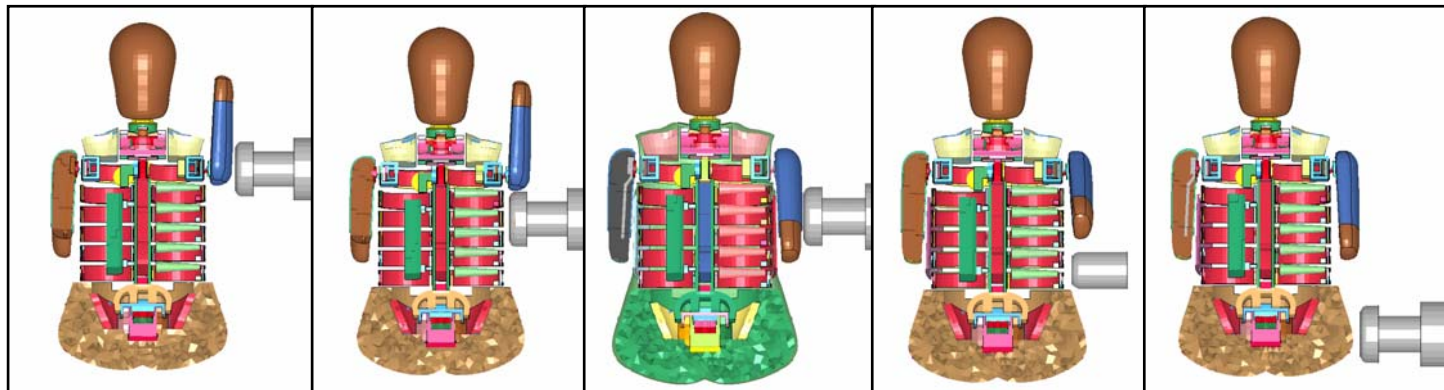
World SID 5<sup>th</sup> rib drop FE model test set-up

# Component Level: Single Rib Drop



# Full Dummy Pendulum Validation

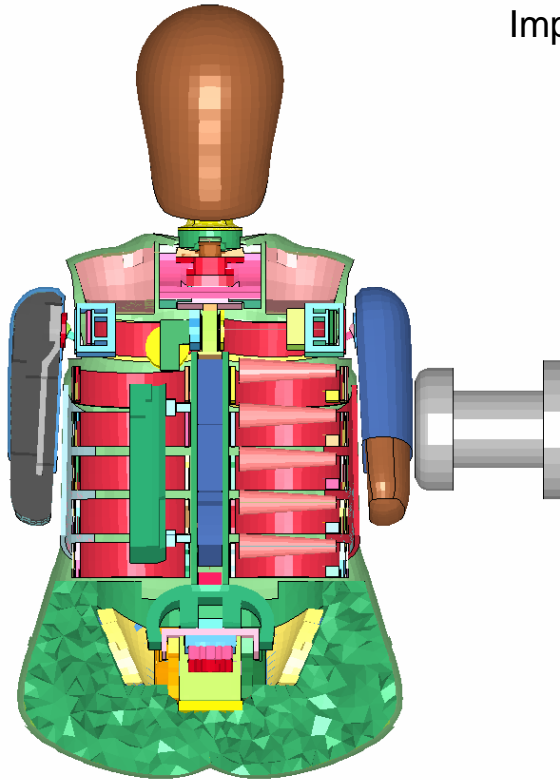
- The following full dummy pendulum validation tests were conducted:
  - Shoulder impact
  - Thorax impact with arm up
  - Thorax impact with arm down
  - Abdomen impact
  - Pelvis impact



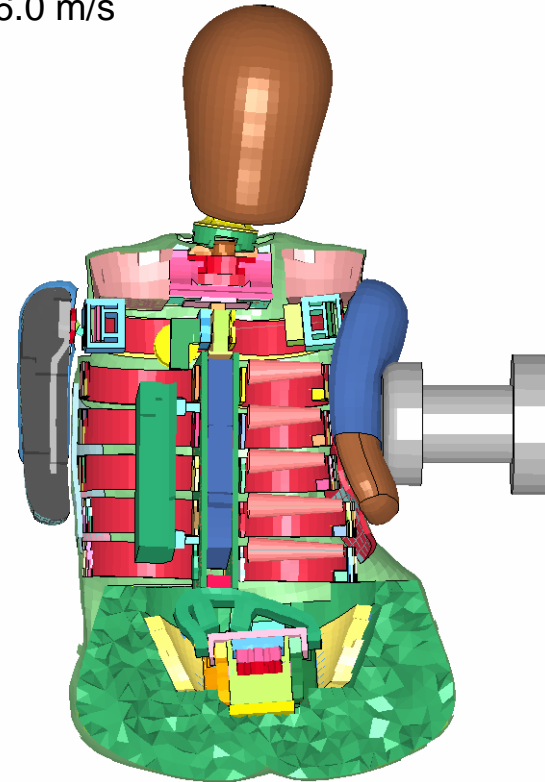
Dummy Pendulum tests: 14kg, Impact speed: 4.5 m/s - 6.7m/s

# Pendulum Impact – Thorax With Arm

Pendulum mass: 14kg  
Impact speed: 6.0 m/s



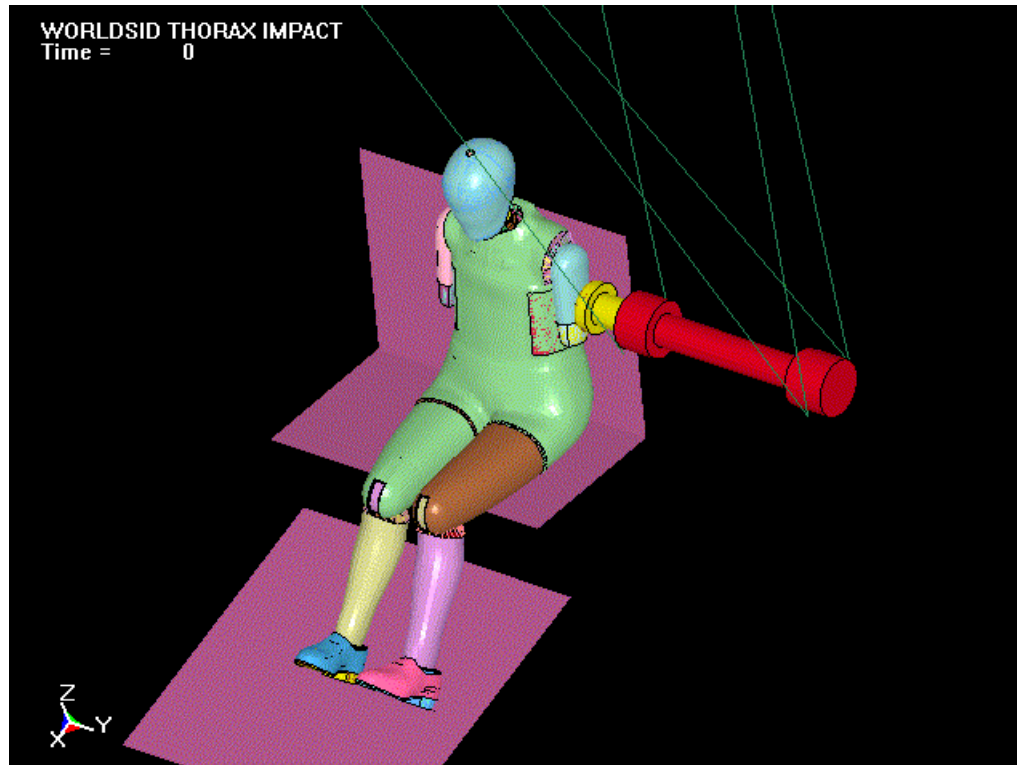
Initial set-up



Maximum rib deflection at 20ms

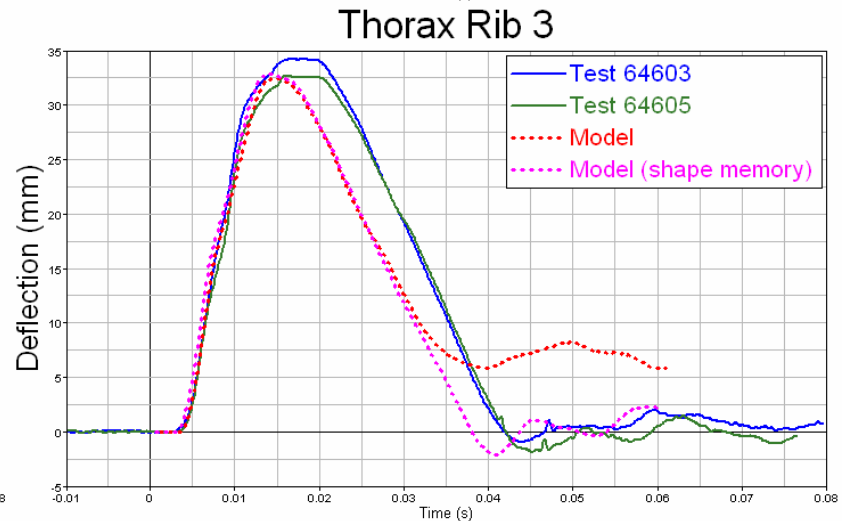
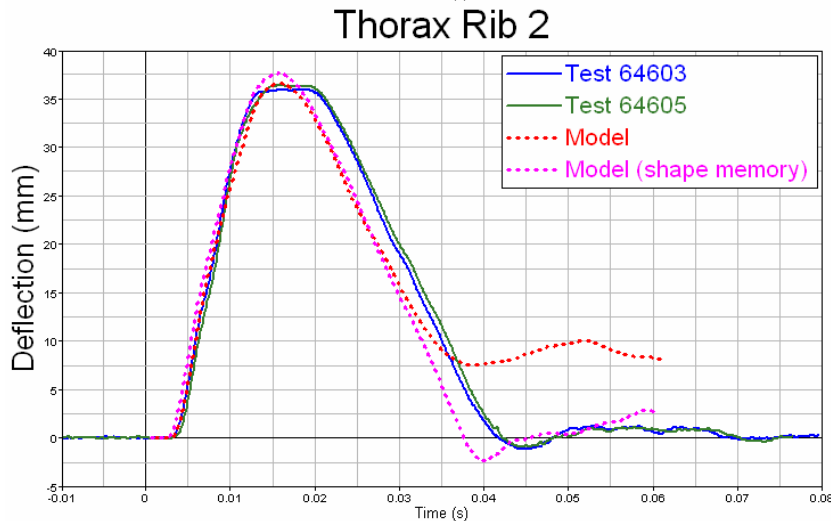
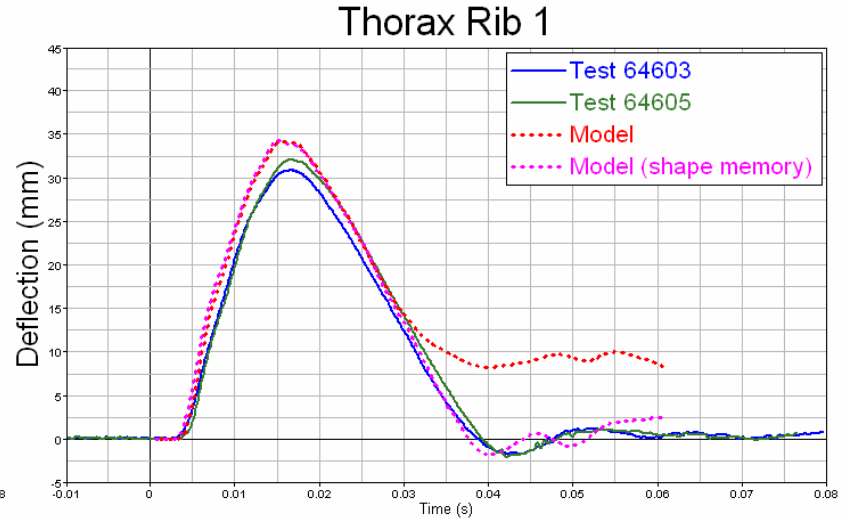
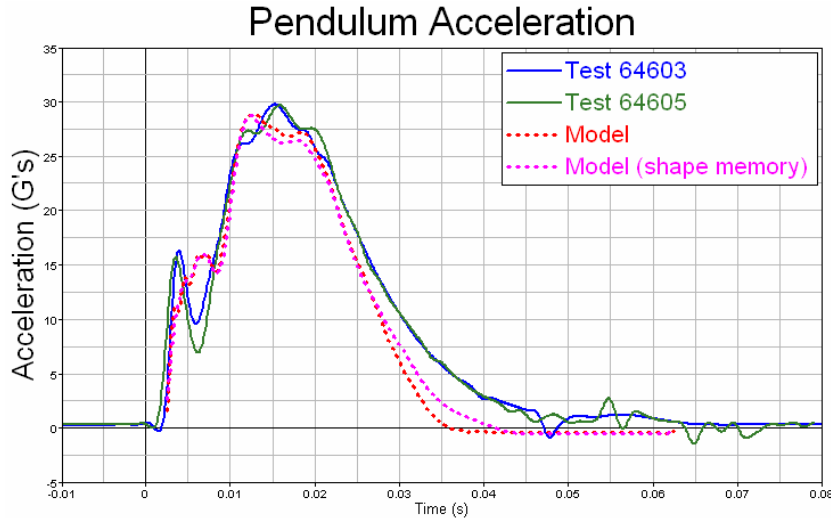
# Pendulum Impact – Thorax With Arm

---



Pendulum mass: 14kg  
Impact speed: 6.0 m/s

# Pendulum Impact – Thorax With Arm



# Next Step: Sled Tests

---

- Sled configuration: test data available
- FTSS is validating/verifying the test data against FE model.
- A v1.0 production model release by the end year 2006



# Next Step: Pole Impact Tests

---

- FTSS is looking for industrial cooperation for the vehicle sub-system test data to further verify FE dummy model.





# Next Step: MDB Impact Tests

---

- FTSS is looking for industrial cooperation for the vehicle or sub-system test data to further verify FE dummy model.



# Summary and Conclusions

---

- The World SID 5<sup>th</sup> is a scaled down dummy from World SID 50<sup>th</sup> that has a good Biofidelity rating (7.6 out of 10).
- The injury criteria for the WorldSID 5<sup>th</sup> is yet to be developed through ISO TC22/SC12/WG5.
- It 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.
- FTSS will release a production version 1.0 WSID 5<sup>th</sup> FE dummy model with sled test data correlation by the end of 2006.

# Thank You!

---

