EVALUATION OF THE NHTSA THOR FINITE ELEMENT MODEL

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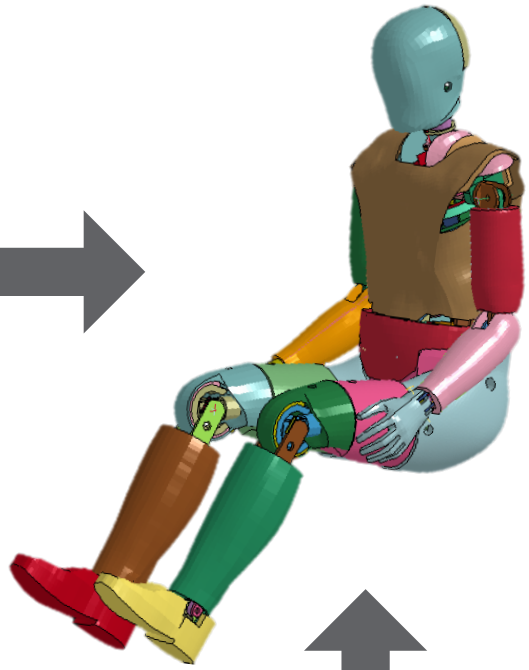
NHTSA THOR finite element model overview

User Groups

- Academic researchers
- Restraint manufacturers
- Vehicle manufacturers
- Government researchers



Application

- Parametric analysis
- Restraint optimization
- Crashworthiness evaluation
- Safety design
- Crash reconstruction

Advantages

- Computational methods are cheaper and faster than full testing
- No licensing costs, available to everyone

NHTSA THOR finite element model overview

THOR FE model development has paralleled the dummy development

- Multiple groups working/developing the model over the year

UVA oversight of the latest revision of the model

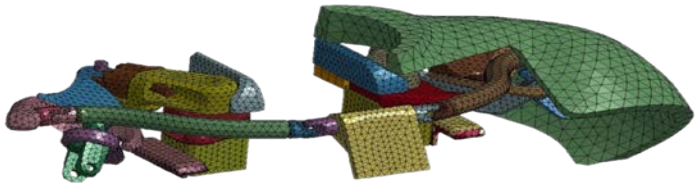
- Implementation of the latest design alterations
- Simplification and streamlining the model
- Improvement of model stability

NHTSA THOR finite element model overview

Current model features

Mod-Kit/Metric design build

SD3 shoulder and arm



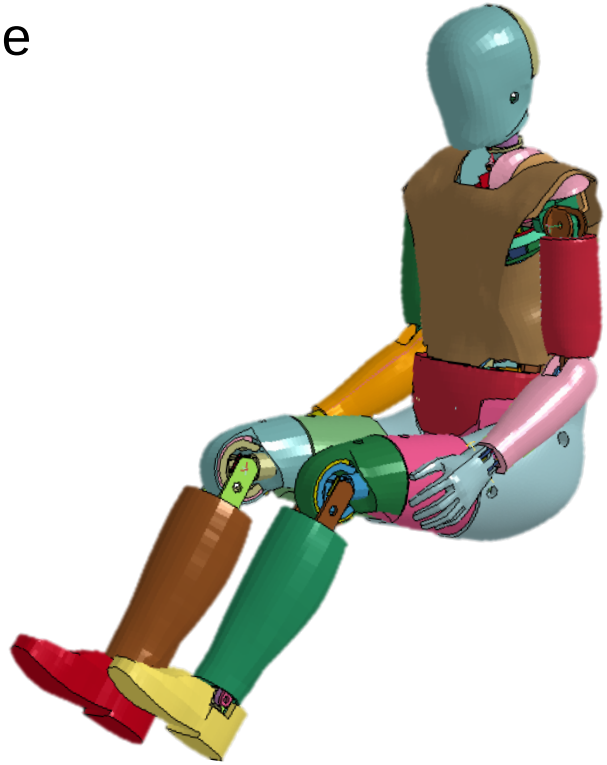
Full instrumentation

Interactive occupant positioning tree

Certification suite

Modular design with controlled IDs

- Head
- Neck
- Thorax
- Arm
- Pelvis
- Leg
- Shoe



NHTSA THOR finite element model overview

Instrumentation outputs

Locations and orientations consistent with physical dummy

4 accelerometers

- Output in NODOUT files (local)

21 load cells

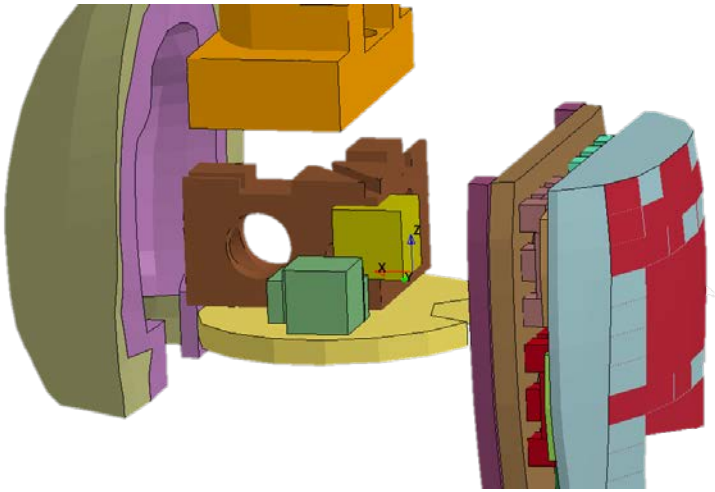
- Output in ELOUT files (local)

5 potentiometers

- Output in NODOUT files (local)

6 IR-TRACCs

- Output in NODOUT files (local)
- IR-TRACC output already in transformed state



Evaluation procedures

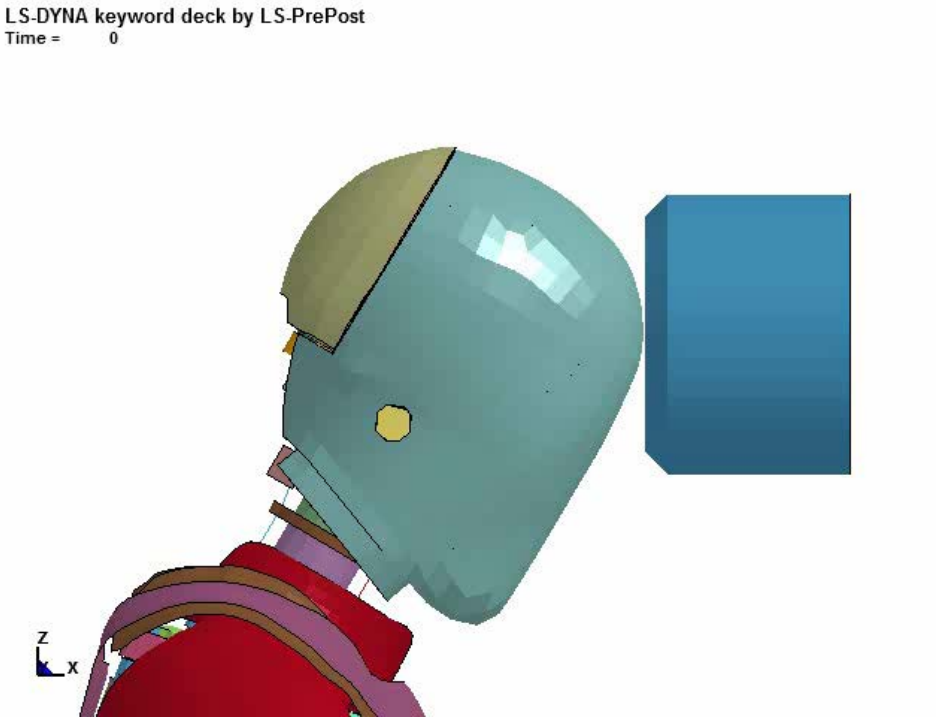
Current THOR Certification tests

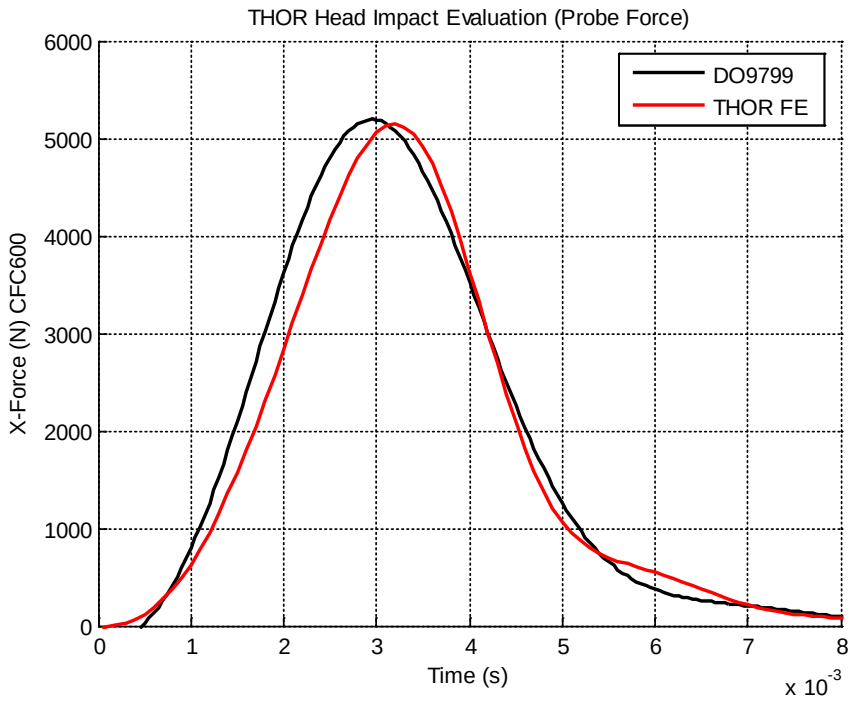
Gold Standard 1 frontal sled test

Head impact evaluation

Simulation parameters:

- Impactor mass: 23.4 kg
- Impactor velocity: 2.0 m/s

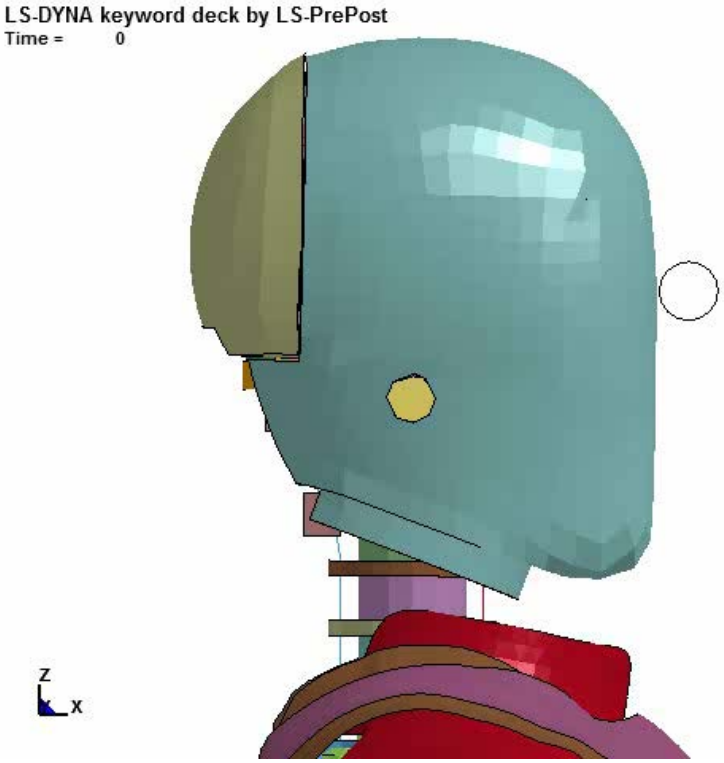


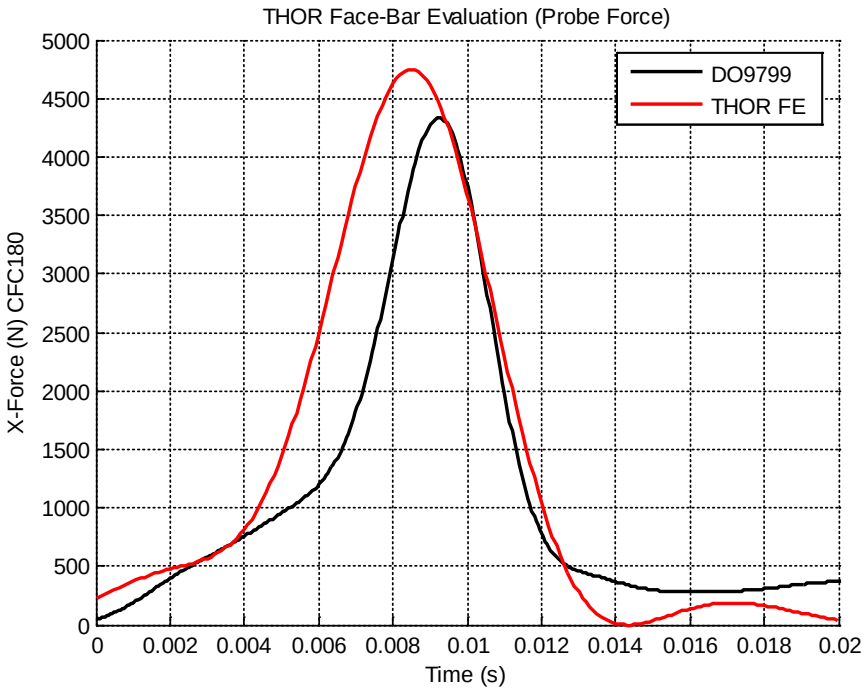


Face impact (bar) evaluation

Simulation parameters:

- Impactor mass: 32 kg
- Impactor velocity: 3.6 m/s

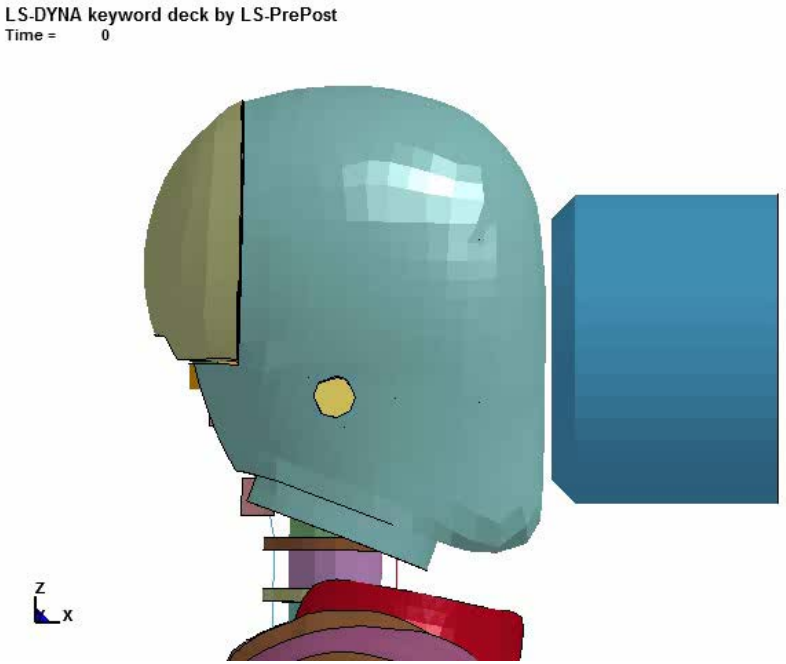


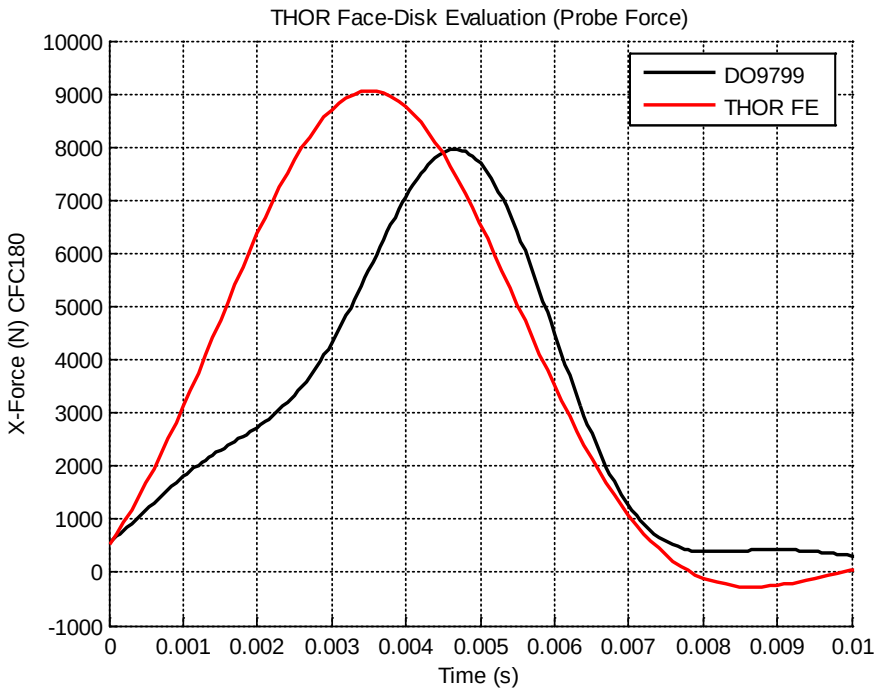


Face impact (disc) evaluation

Simulation parameters:

- Impactor mass: 13 kg
- Impactor velocity: 6.7 m/s

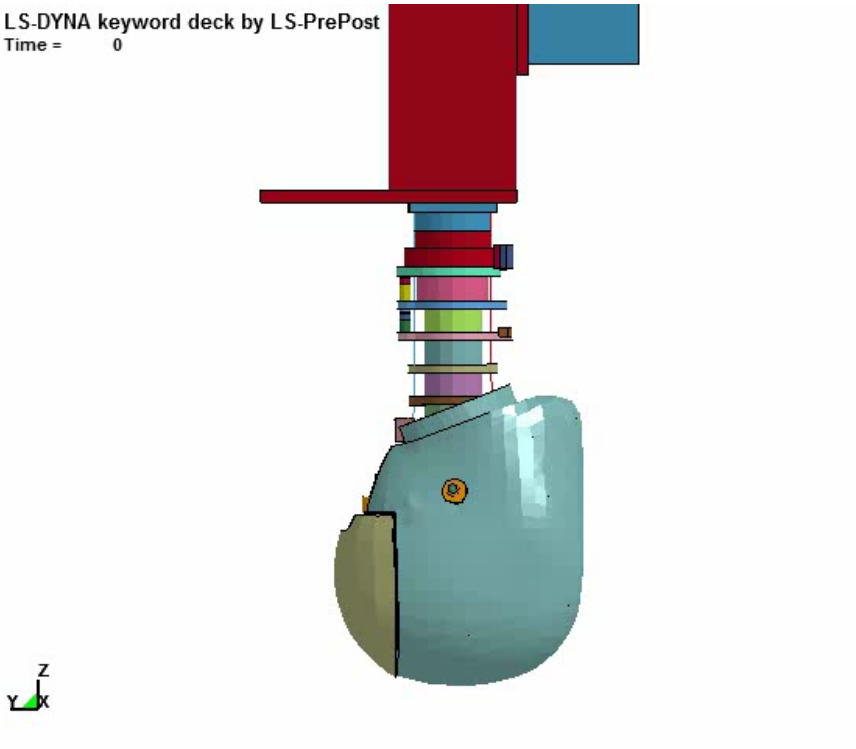


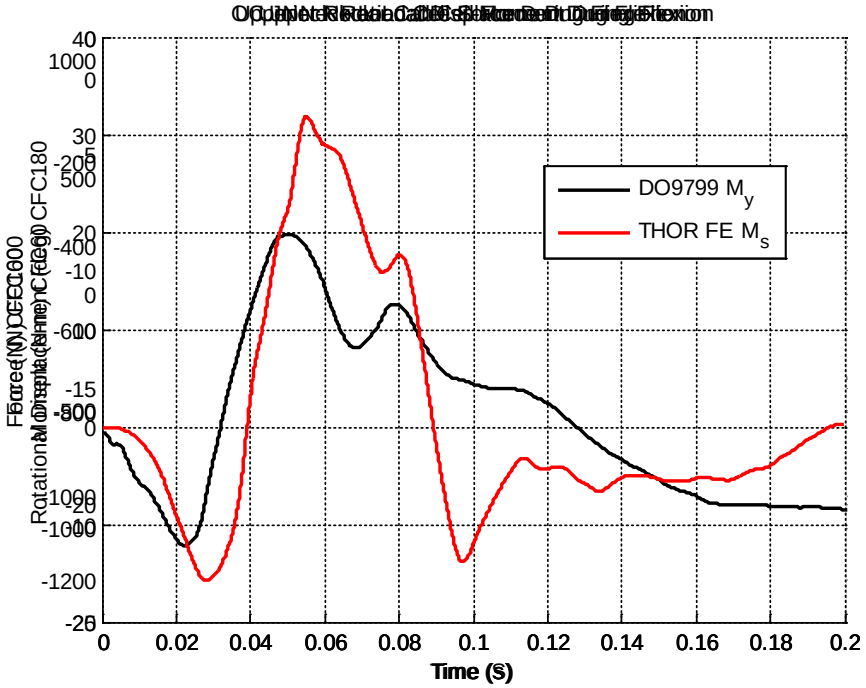


Dynamic neck flexion (pendulum) evaluation

Simulation parameters:

- Dynamic pendulum test
- Test velocity: 3.8 m/s

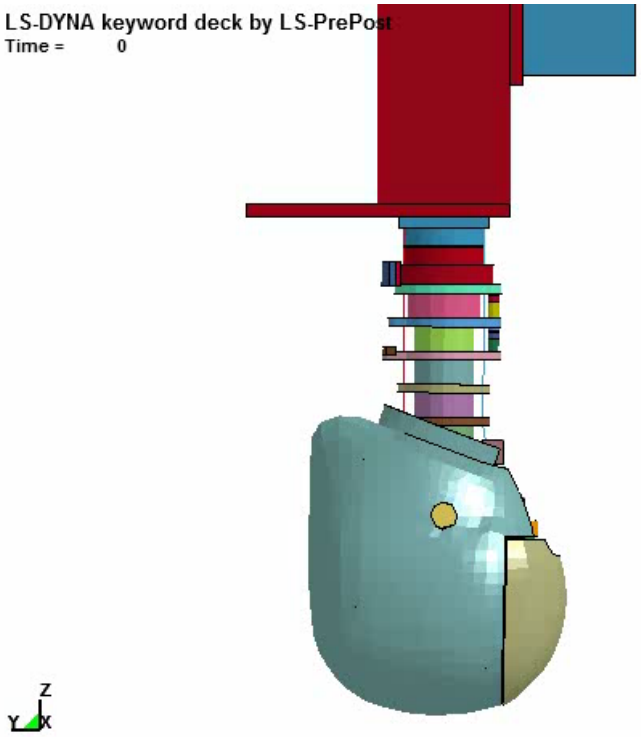


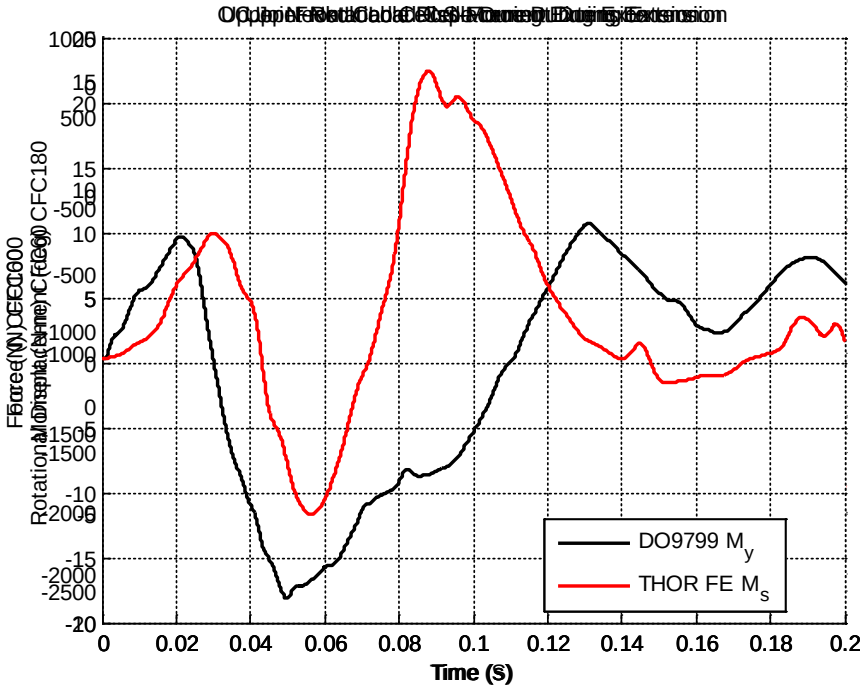


Dynamic neck extension (pendulum) evaluation

Simulation parameters:

- Dynamic pendulum test
- Test velocity: 3.7 m/s

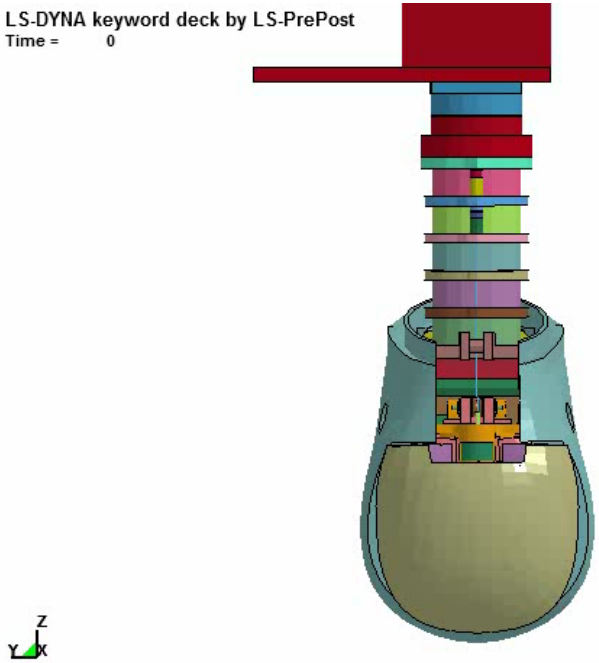


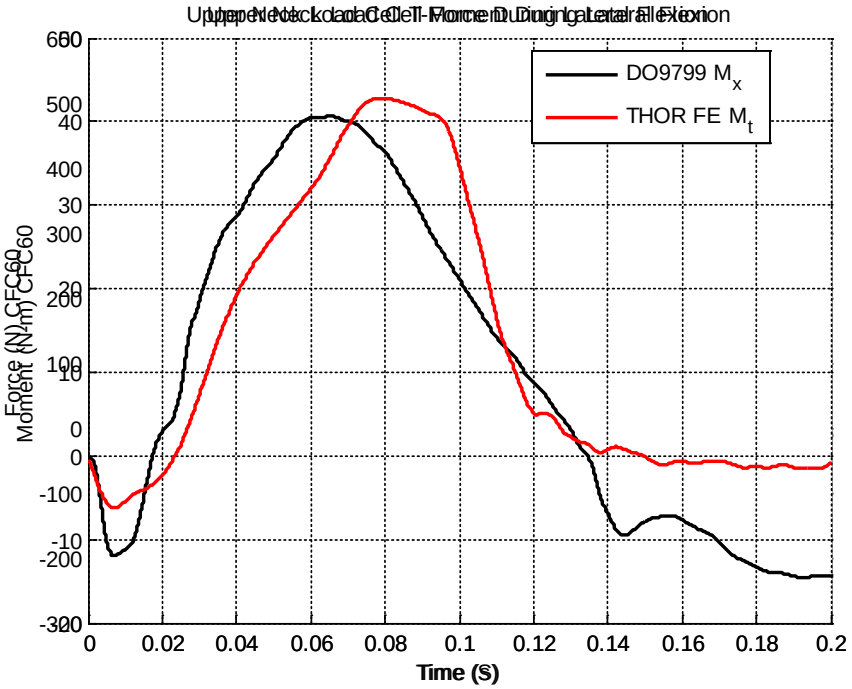


Dynamic neck lateral bending (pendulum) evaluation

Simulation parameters:

- Dynamic pendulum test
- Test velocity: 2.9 m/s

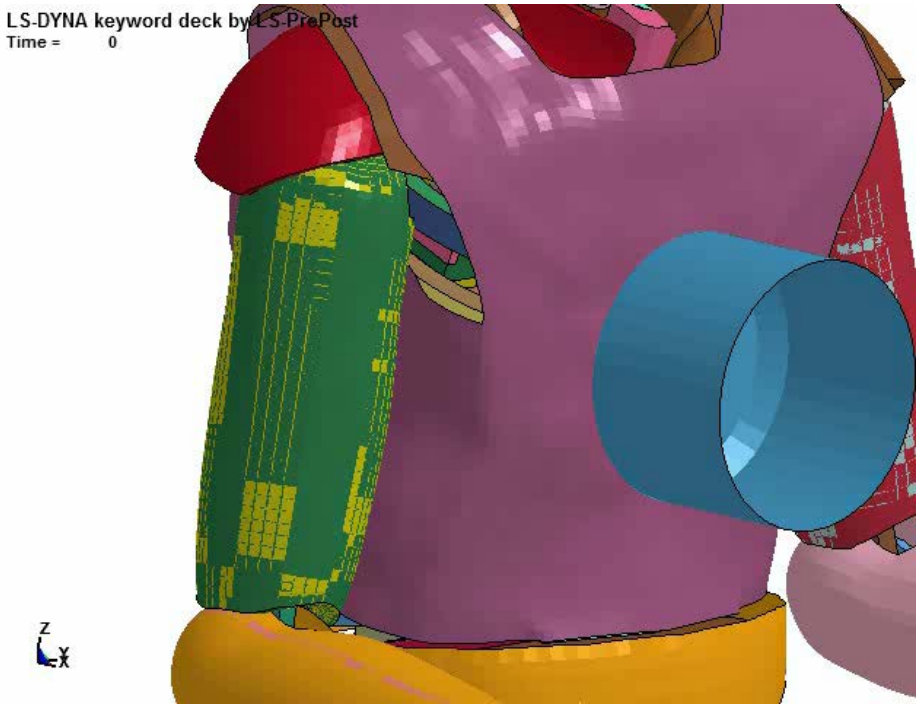


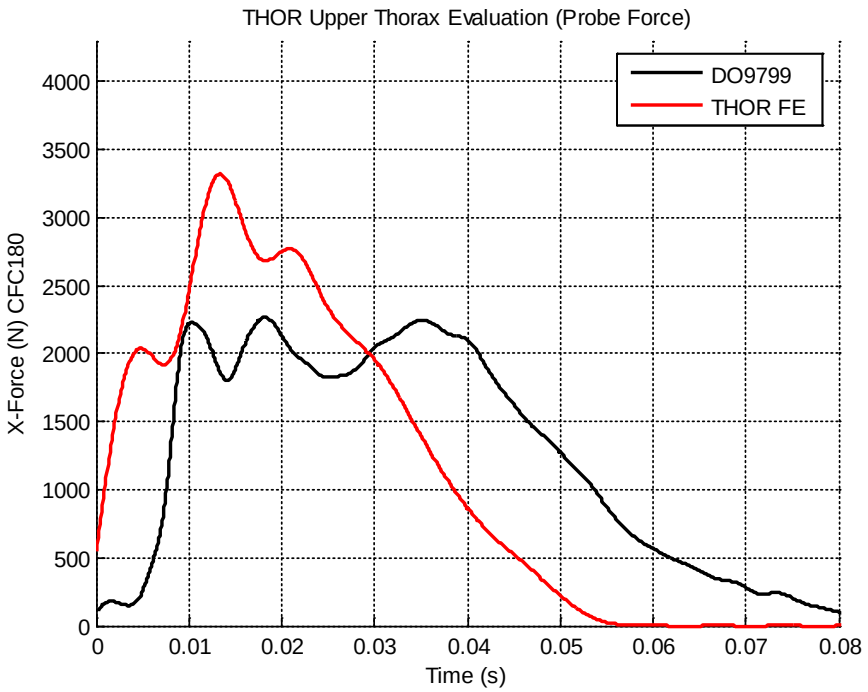


Chest impact (upper) evaluation

Simulation parameters:

- Impactor mass: 23.4
- Impactor velocity: 4.3 m/s

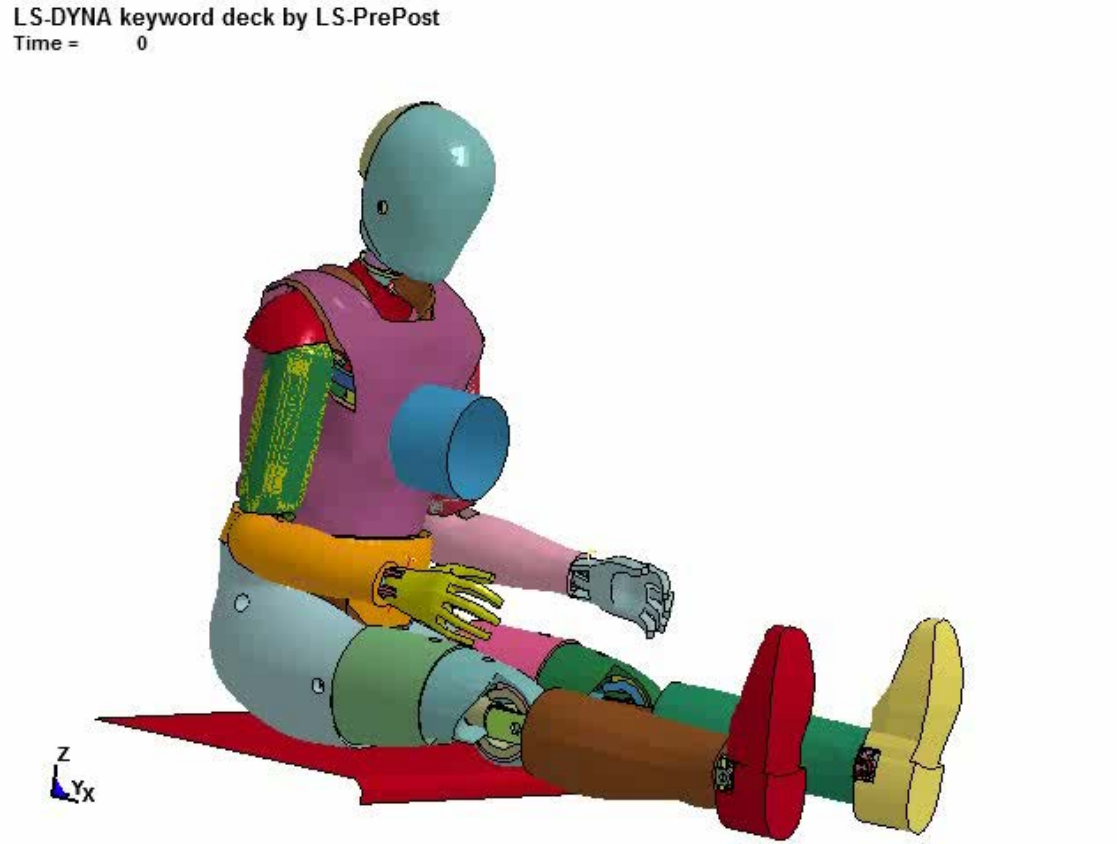




Chest impact (upper) stability assessment

Simulation parameters:

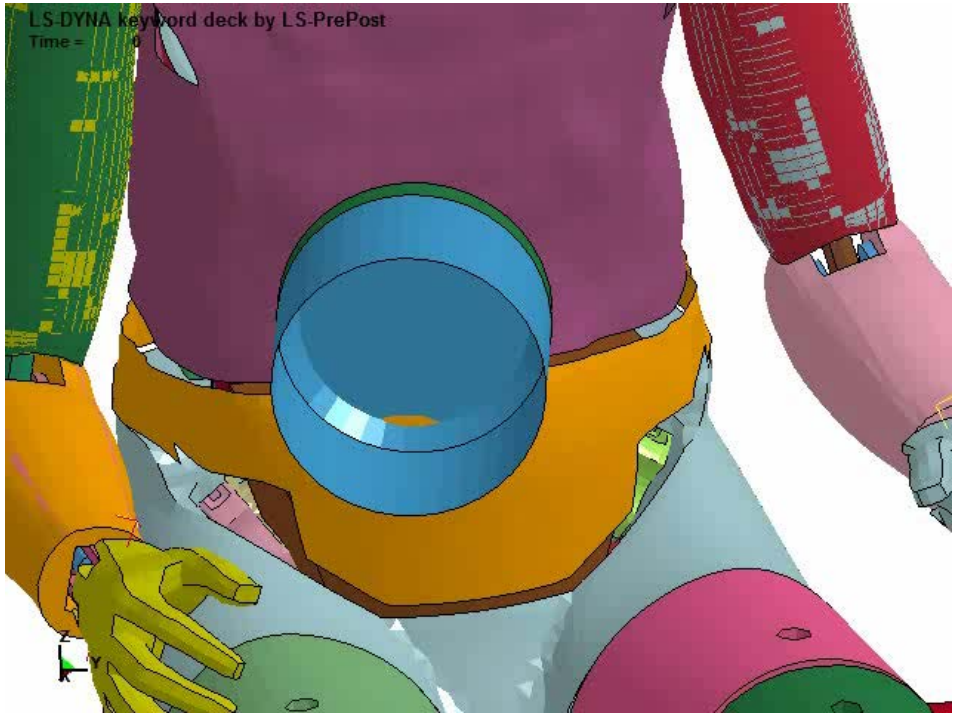
- Impactor mass: 23.4
- Impactor velocity: 6.7 m/s

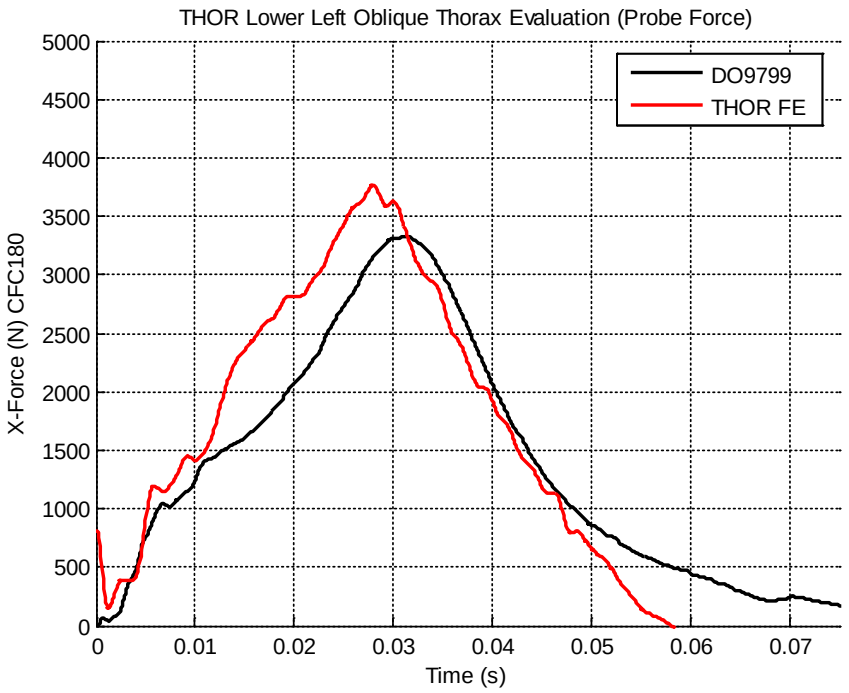


Chest impact (lower oblique) evaluation

Simulation parameters:

- Impactor mass: 23.4 kg
- Impactor velocity: 6.7 m/s

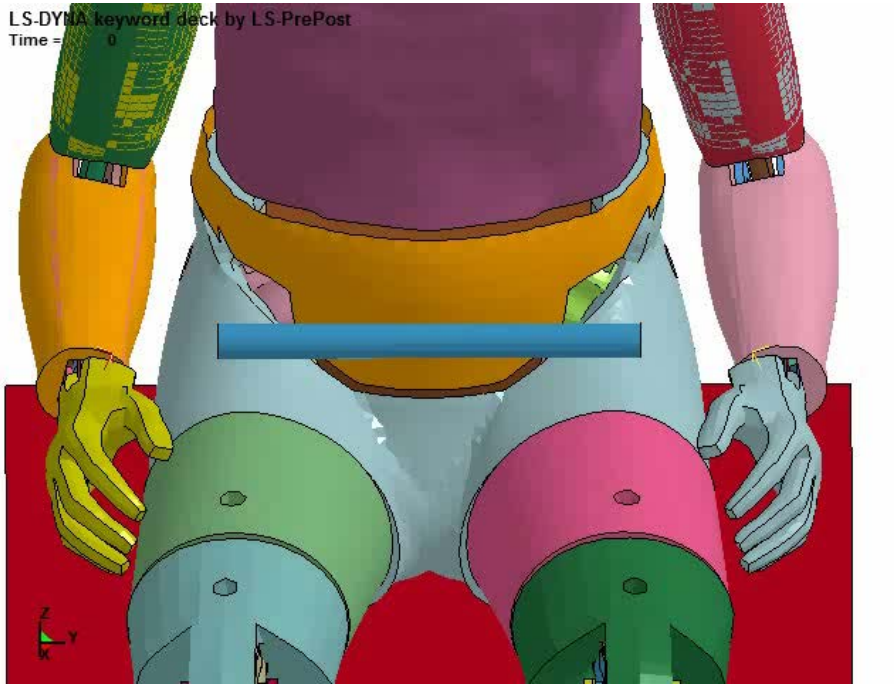


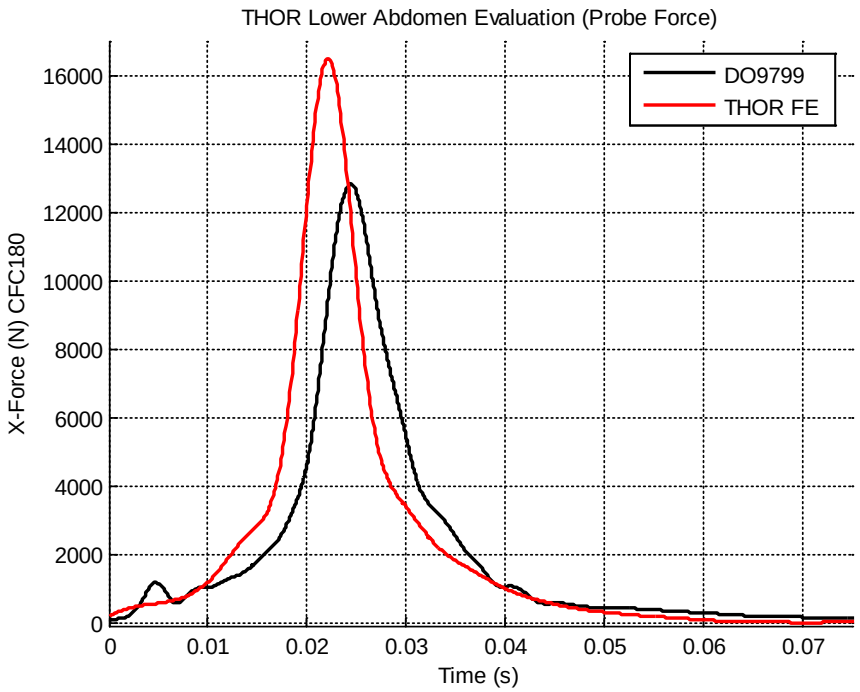


Abdomen impact (lower) evaluation

Simulation parameters:

- Impactor mass: 32 kg
- Impactor velocity: 6.1 m/s

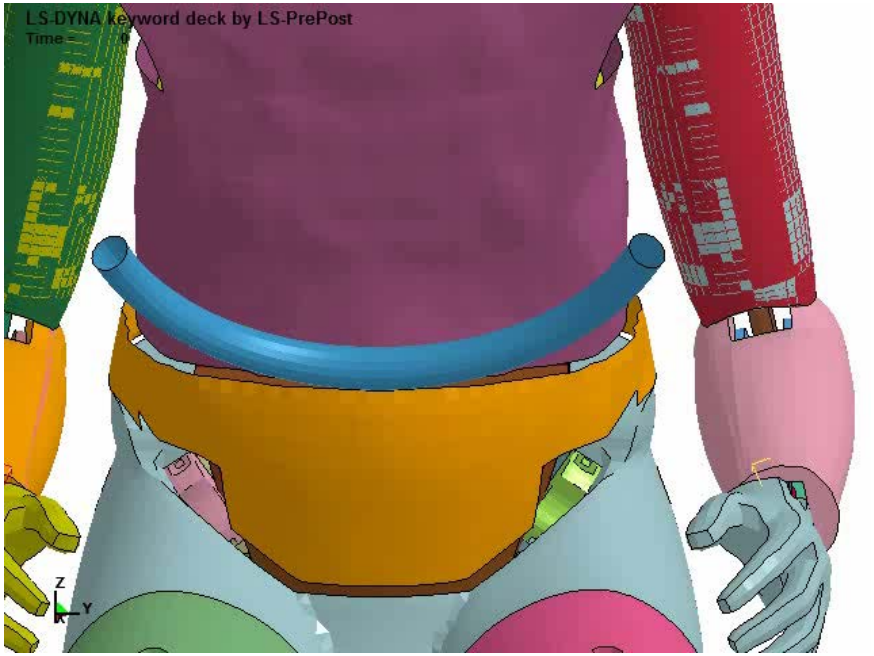


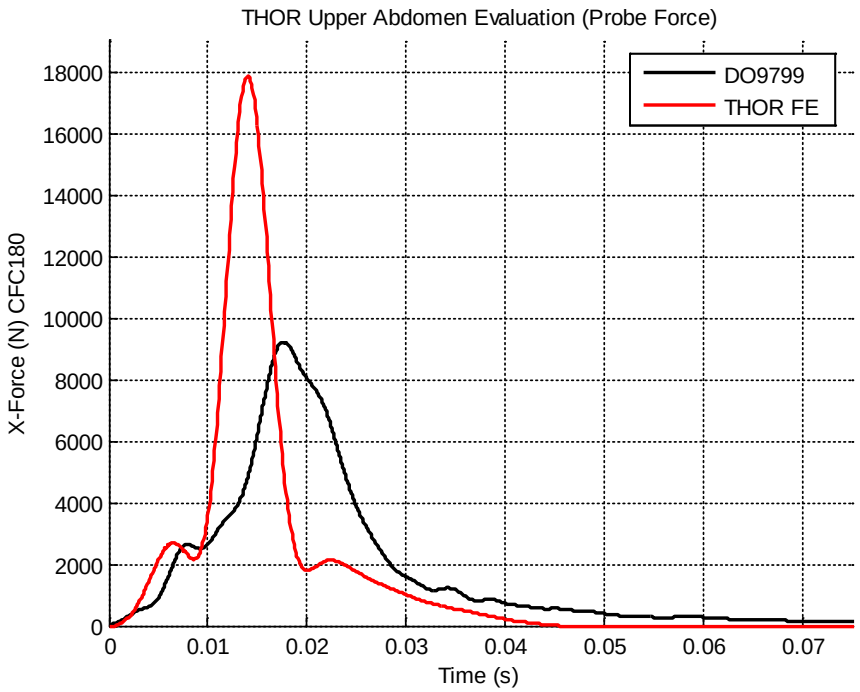


Abdomen impact (upper) evaluation

Simulation parameters:

- Impactor mass: 18 kg
- Impactor velocity: 8.0 m/s

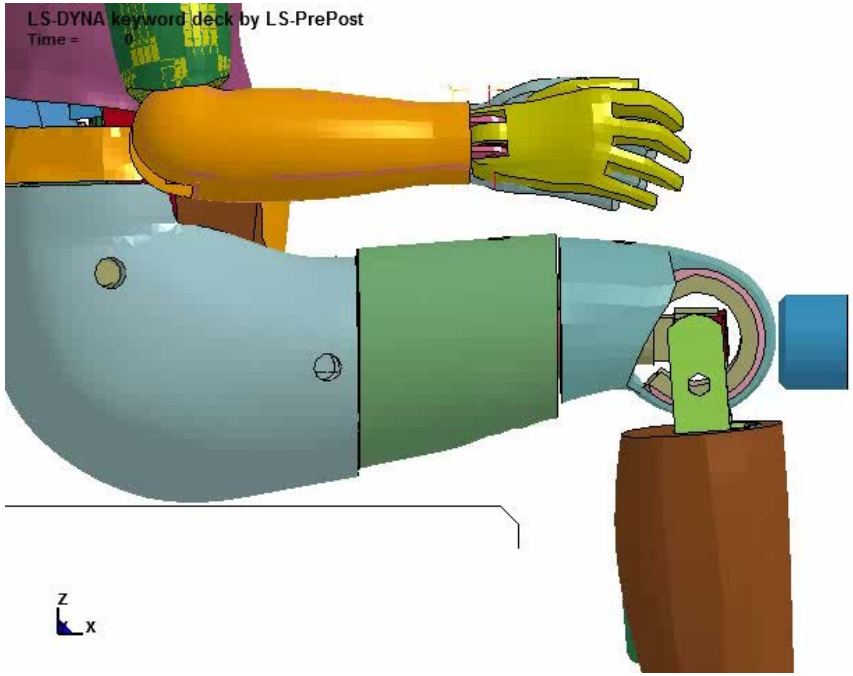


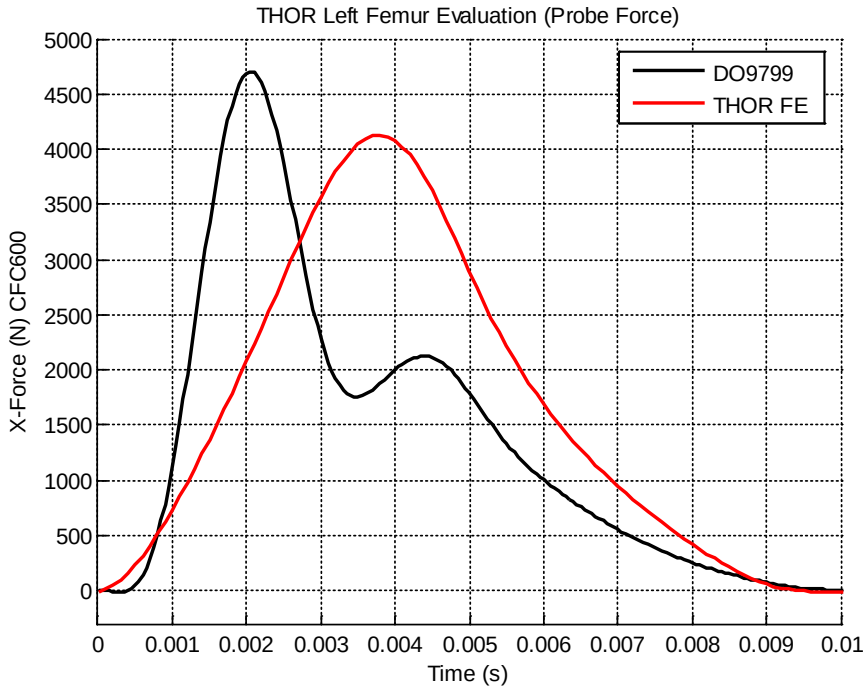


Femur impact evaluation

Simulation parameters:

- Impactor mass: 5.0 kg
- Impactor velocity: 2.6 m/s

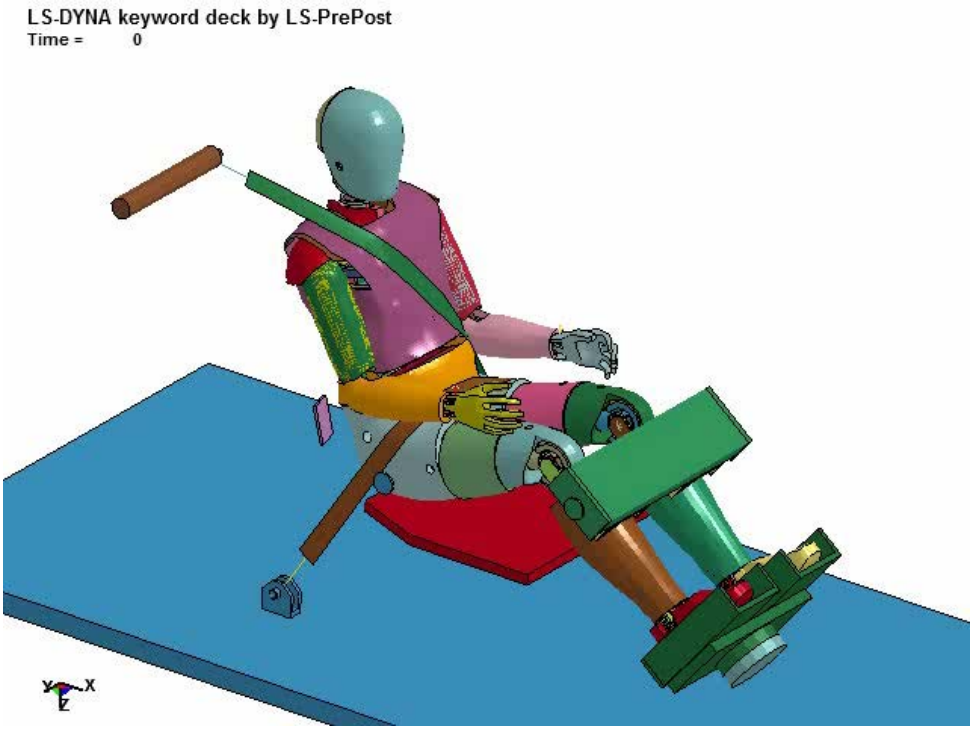


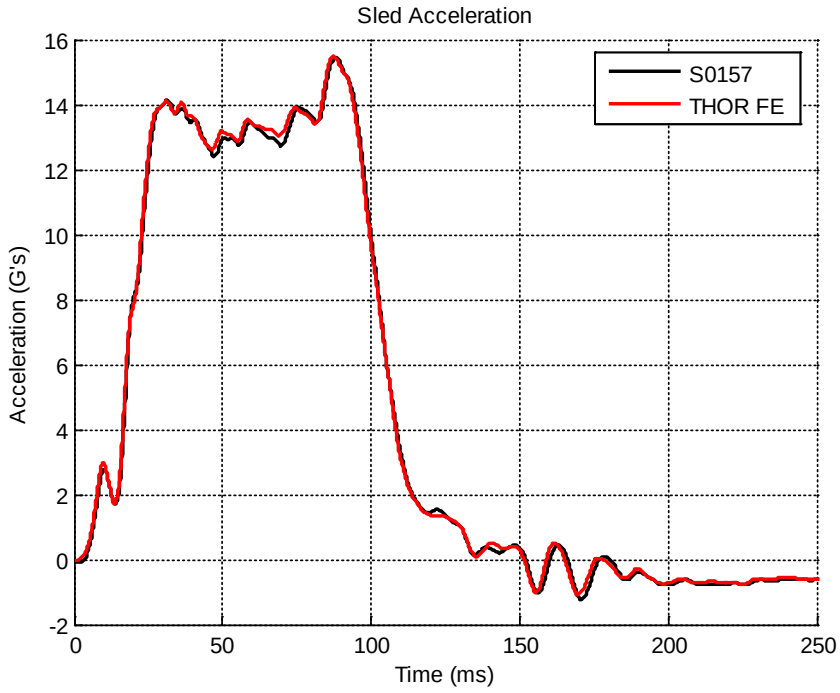


Gold Standard 1 Evaluation

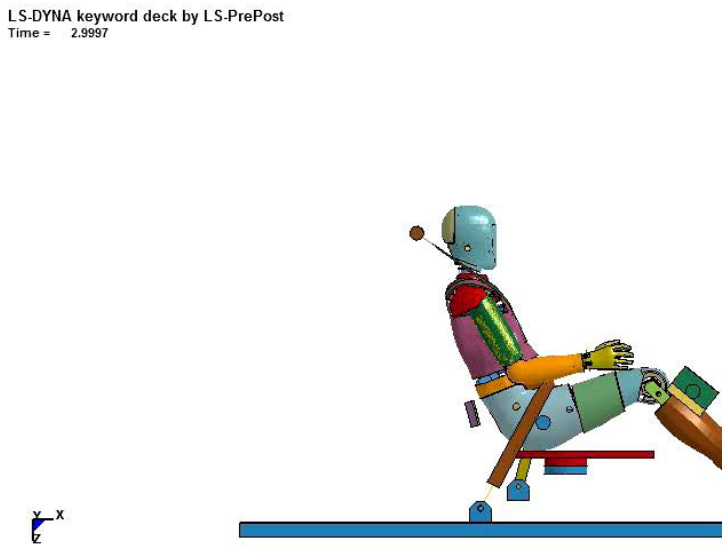
Simulation parameters:

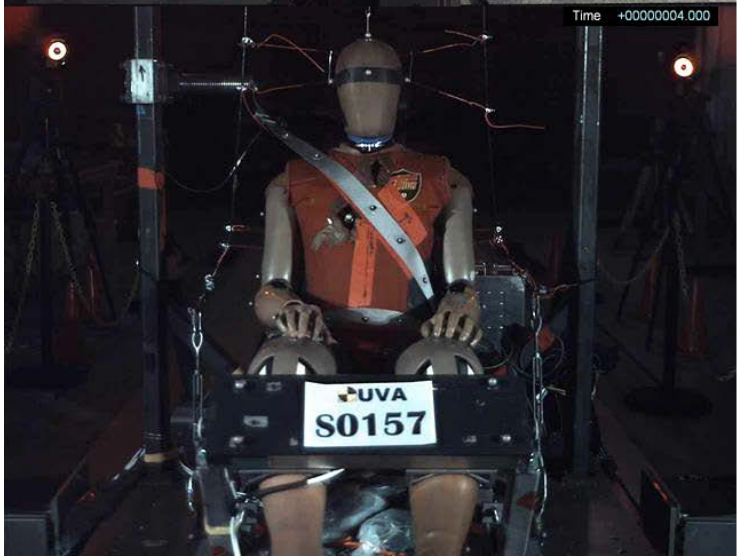
- Subject restrained by a standard three-point shoulder/lap belt
- Lower extremity restrained by knee bolster and foot rest
- THOR Metric dummy with SD3 shoulder test S0157 performed at the UVA (05/2013)

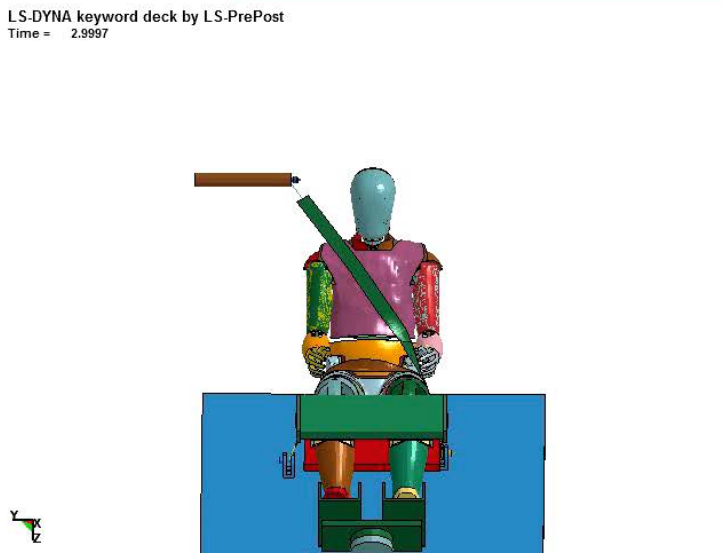




Gold Standard 1 Evaluation

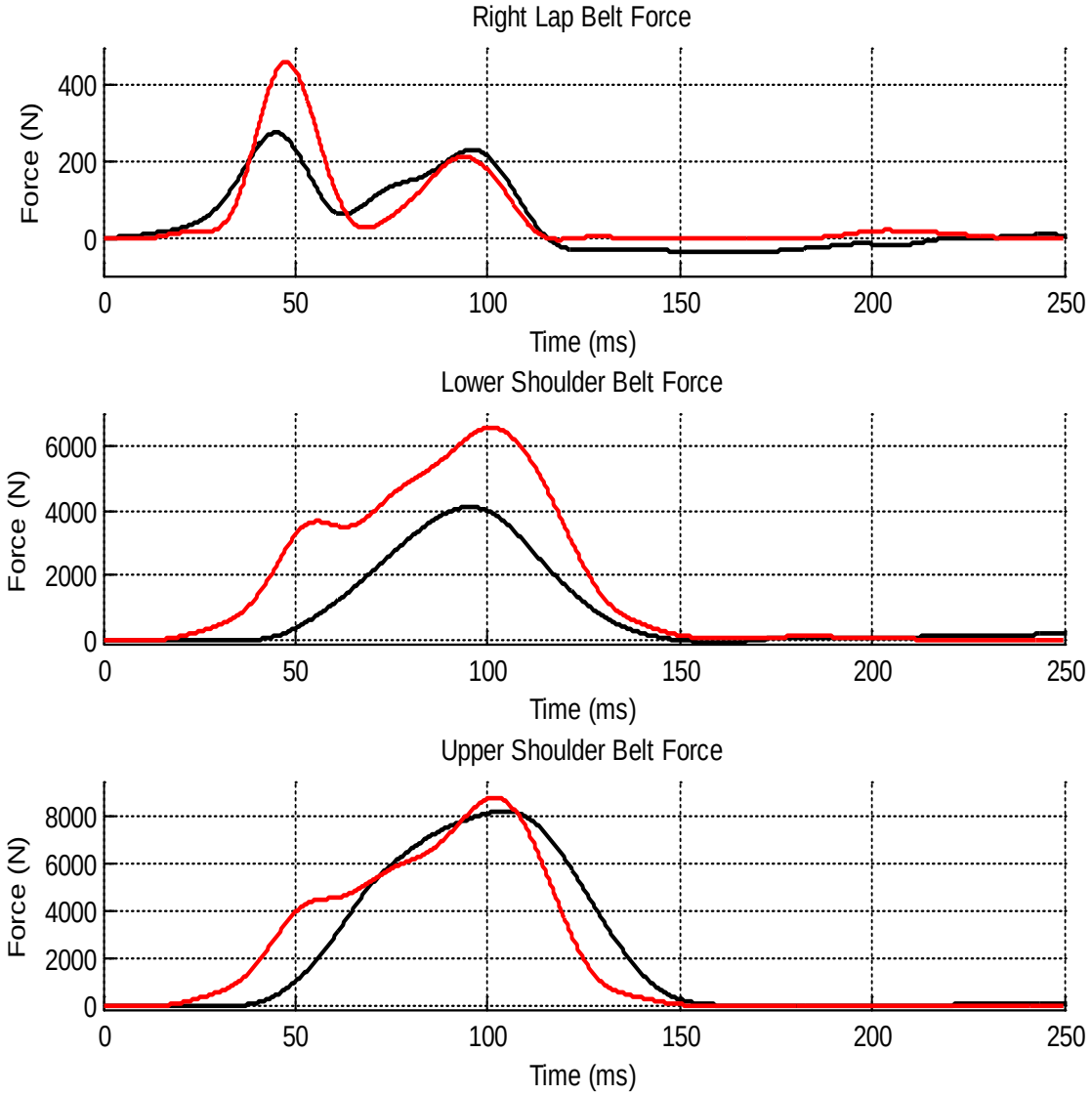




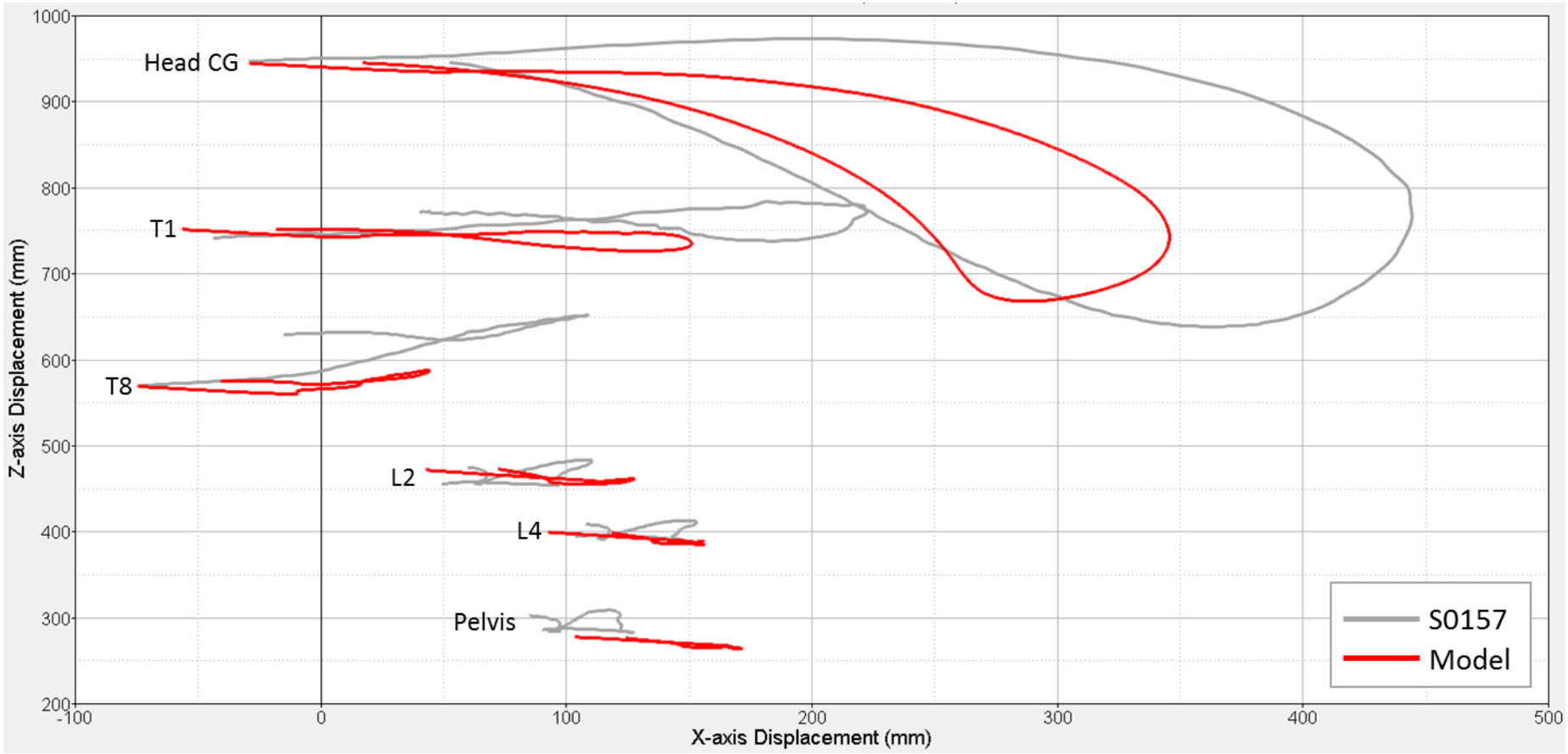


Gold Standard 1 Evaluation

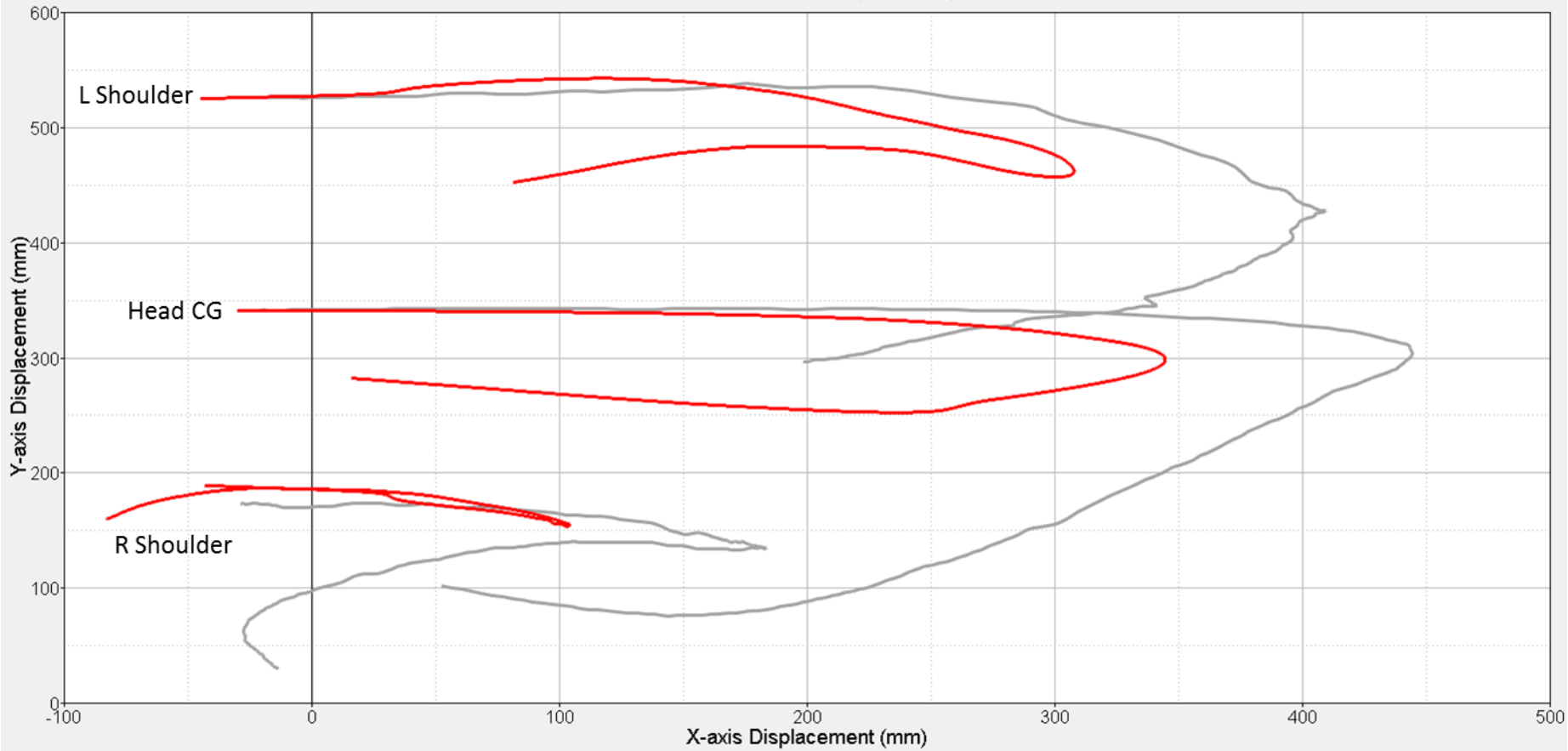
Belt force



Full body kinematic traces



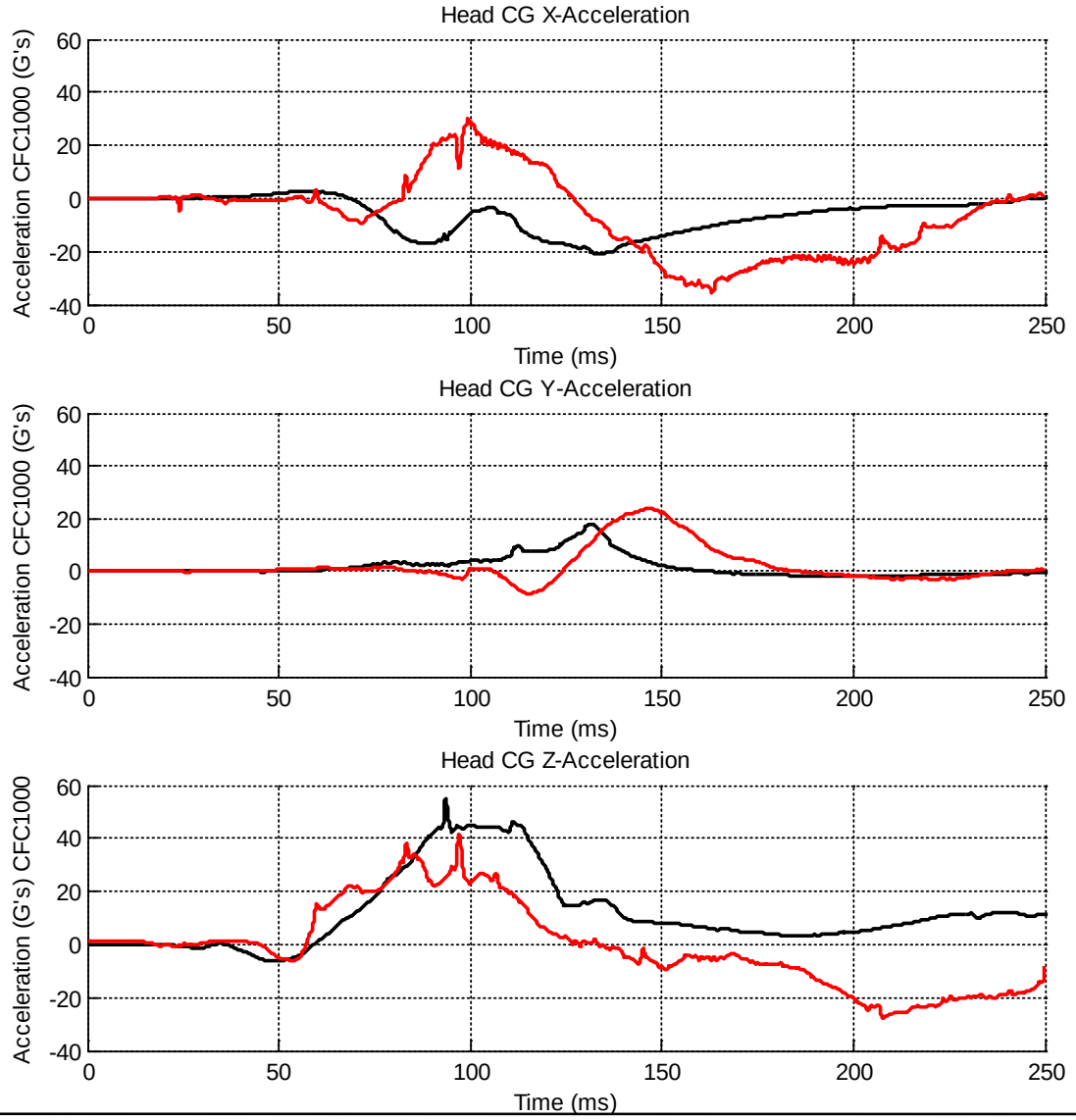
Full body kinematic traces



Gold Standard 1 Evaluation

Head CG

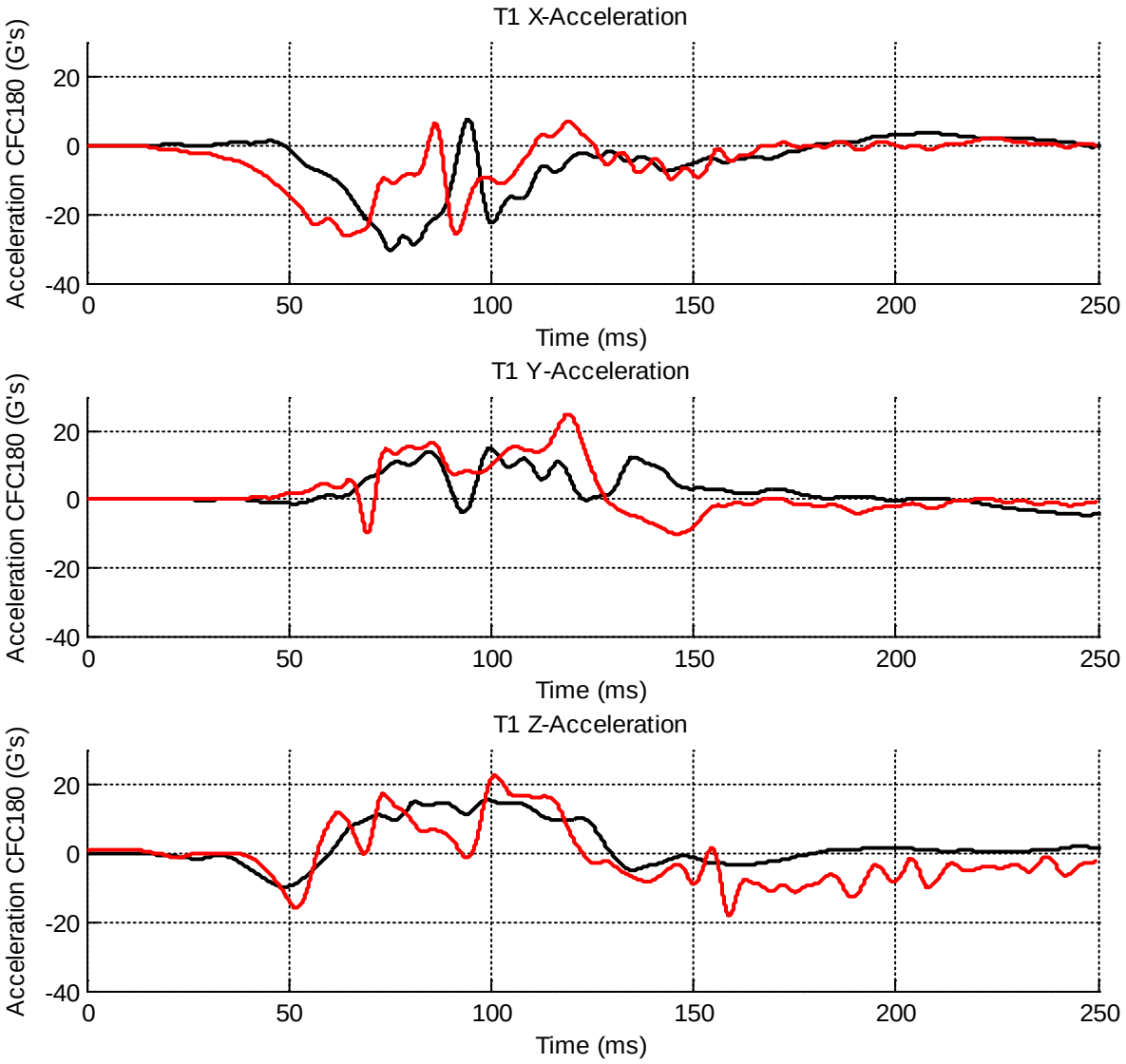
S0157
Model



Gold Standard 1 Evaluation

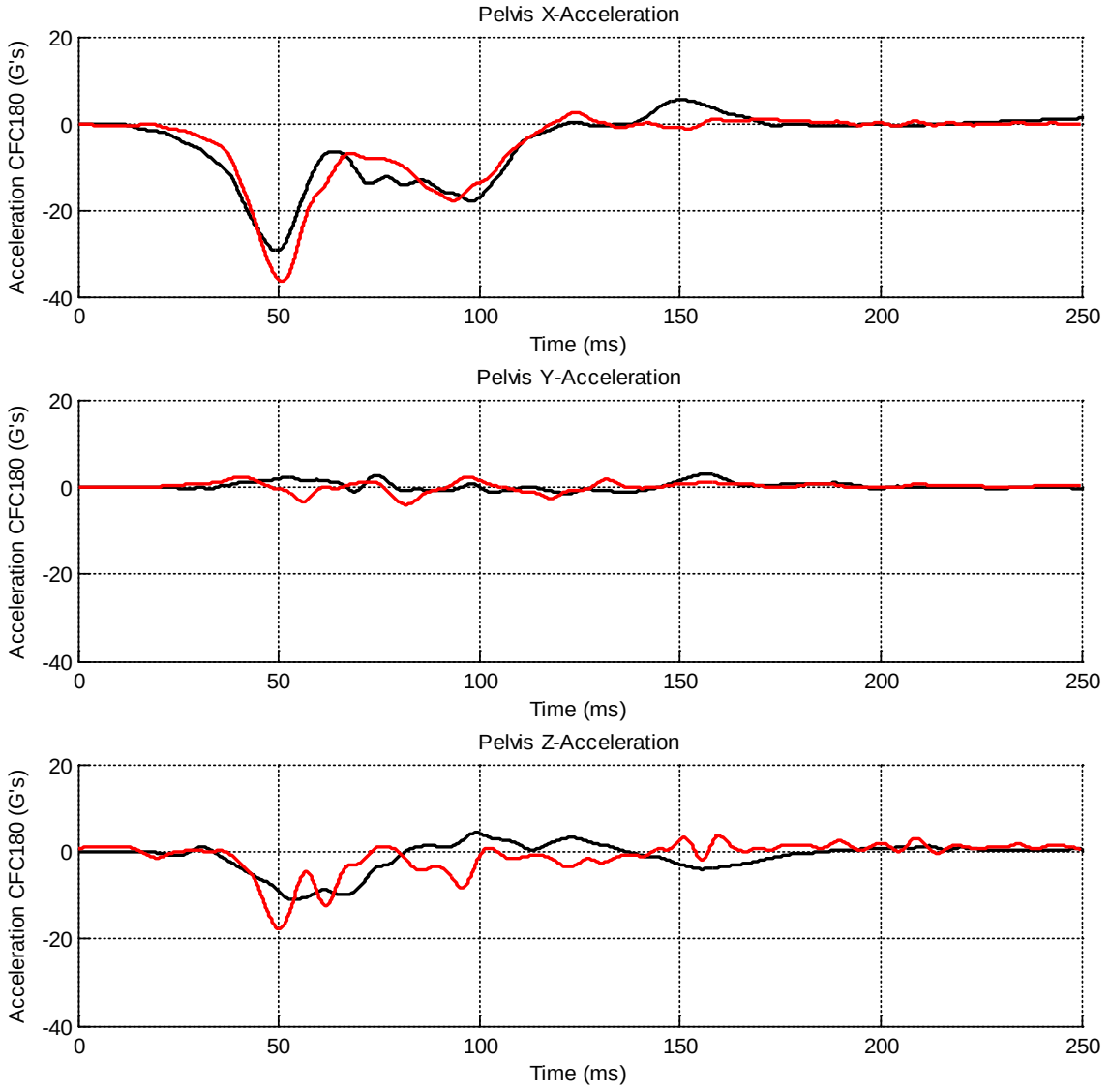
T1

S0157
Model



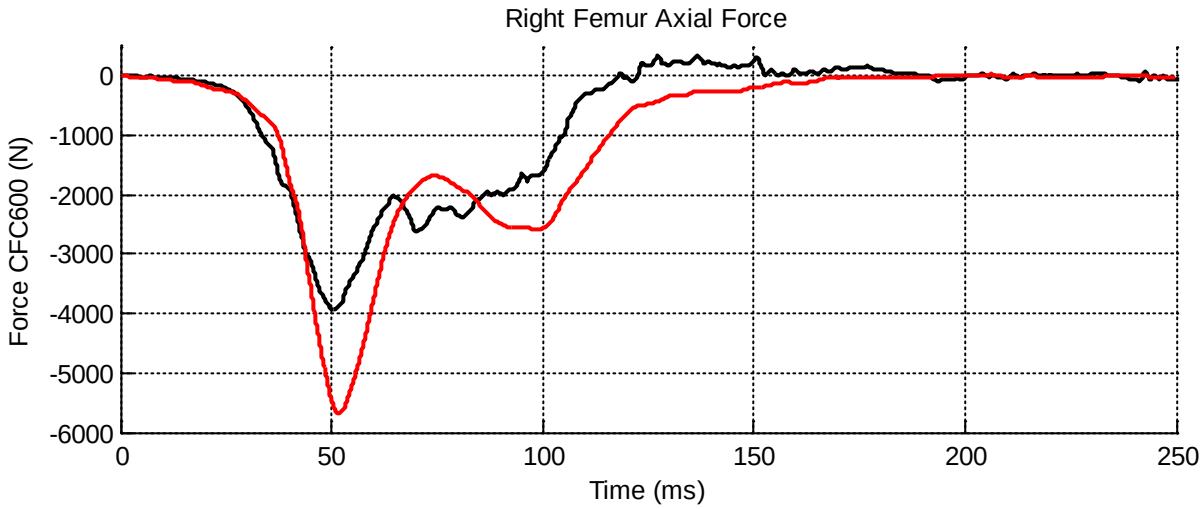
Gold Standard 1 Evaluation

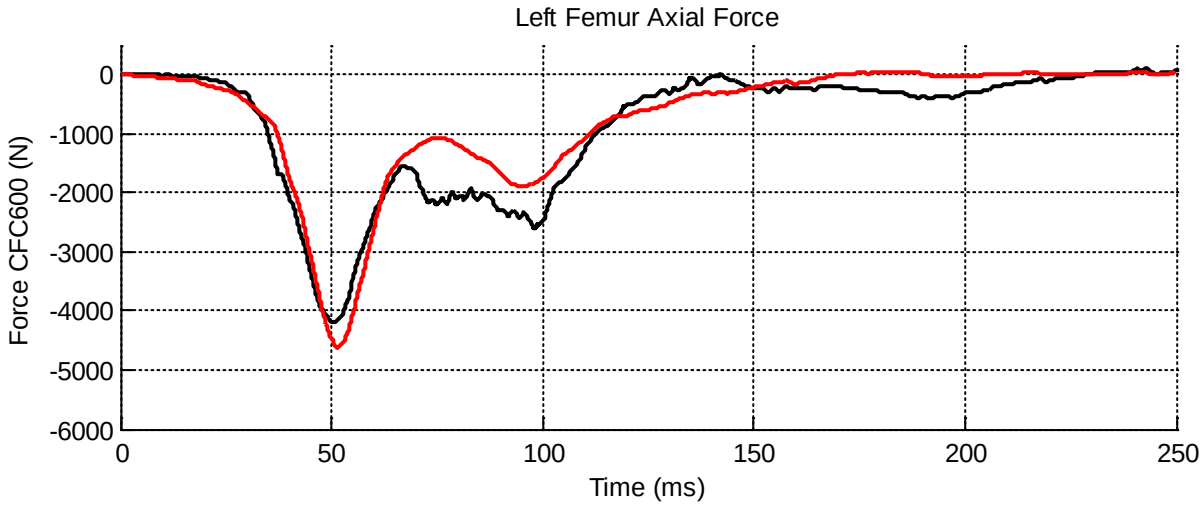
Pelvis



Gold Standard 1 Evaluation

Femur





Summary of current model

Model stability

- Top priority focus
- No issues in all “certification” and Gold Standard 1 simulations
- Stability in vehicle crash simulation needs assessment

Model fidelity

- Secondary priority focus
- Response is generally good (average CORA score 0.75)
- Neck extension needs most improvement (average CORA is 0.57)
- Some materials are stiffer for stability; materials not tuned
- Gold Standard 1 belt model may be too restricting

Summary of current model

Current version of THOR FE model (v2.1) will be hosted on NHTSA website for public download, and will include:

- User manual
- Certification suite model files
- Gold Standard 1 model files

Target release date: Jan 30, 2015

Acknowledgements

NHTSA

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Chalmers University of Technology (SD3 Shoulder)

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Virginia Tech (Head & Neck)

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Livermore Software Technology Corp

Christoph Maurath

Dilip Bhalsod

And many of the THOR FE model users who provided feedback!

Thank you…

Questions?

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