FAT Dummy Modells

News and Update

June 28,2007

DYNAmore GmbH, Stuttgart, Germany

FAT Dummy Models: News and Update

- SID and RID Models:

  - BioRID2 v2.0 latest changes to the model

  - USSID v5.0 latest changes in the model

  - ES2, ES2 re v4.0 latest changes to the model

  - ES2, ES2 re news for the following release

  - Further developments for all DYNAmore dummy models

DYNA
MORE

FAT Dummy Models: News and Update

- SID and RID Models:

  - BioRID II v2.0 latest changes to the model

  - USSID v5.0 latest changes in the model

  - ES-2, ES-2 re v4.0 latest changes to the model

  - ES-2, ES-2 re news for the following release

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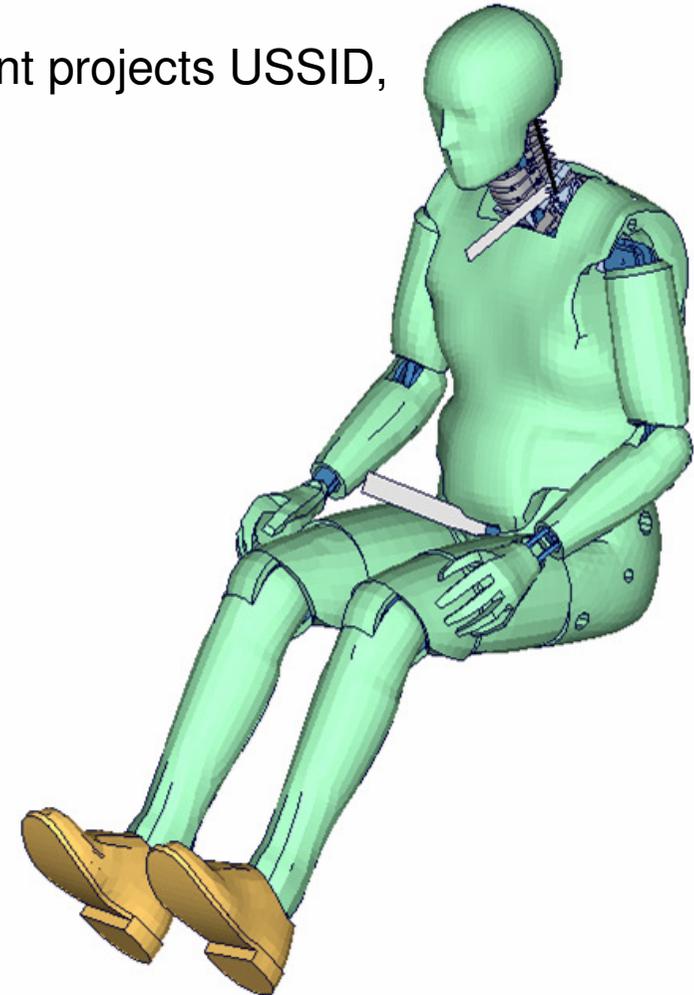# BioRID II v2.0 latest changes to the model

- Project launched by the FAT to develop BioRID II Model

- FAT = German Research Organization for Automotive Industry

- Project similar to former dummy model development projects USSID, SID-HIII, Eurosid-1, ES-2, ES-2re

- Participating companies in this project:

OEMs:
- Audi
- BMW
- DaimlerChrysler
- Opel
- Porsche
- Volkswagen
- Karman

Seat manufacturer:
- CR Hammerstein
- Johnson Controls
- Keiper Recaro

- C1 – C7 are connected by beams

- Rubber bumpers are insert between the vertebras

- On the right hand side two cables slip through the vertebras. They connect preloaded springs in piston guides with the OC-plate.

- At the left hand side one cable slips through the vertebras around a rotational damper

→ Parallel spring and damper unit for the OC-plate
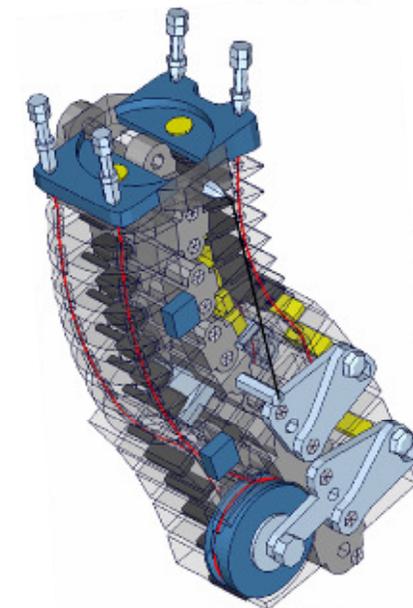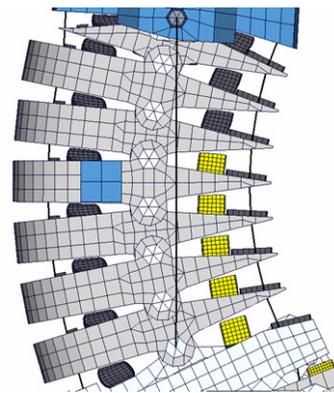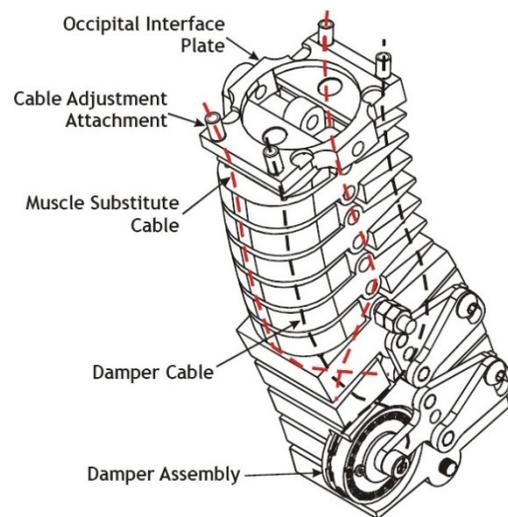
- *INITIAL_FOAM_REFERENCE_GEOEMTRY for Bumpers

- Torsional beam:
  *CONSTRAINED_JOINT_STIFFNESS_GENERALIZED

Preloaded Spring - rear -

Preloaded Spring - front -

OC 29.5°

T2 37.0°

Gravity
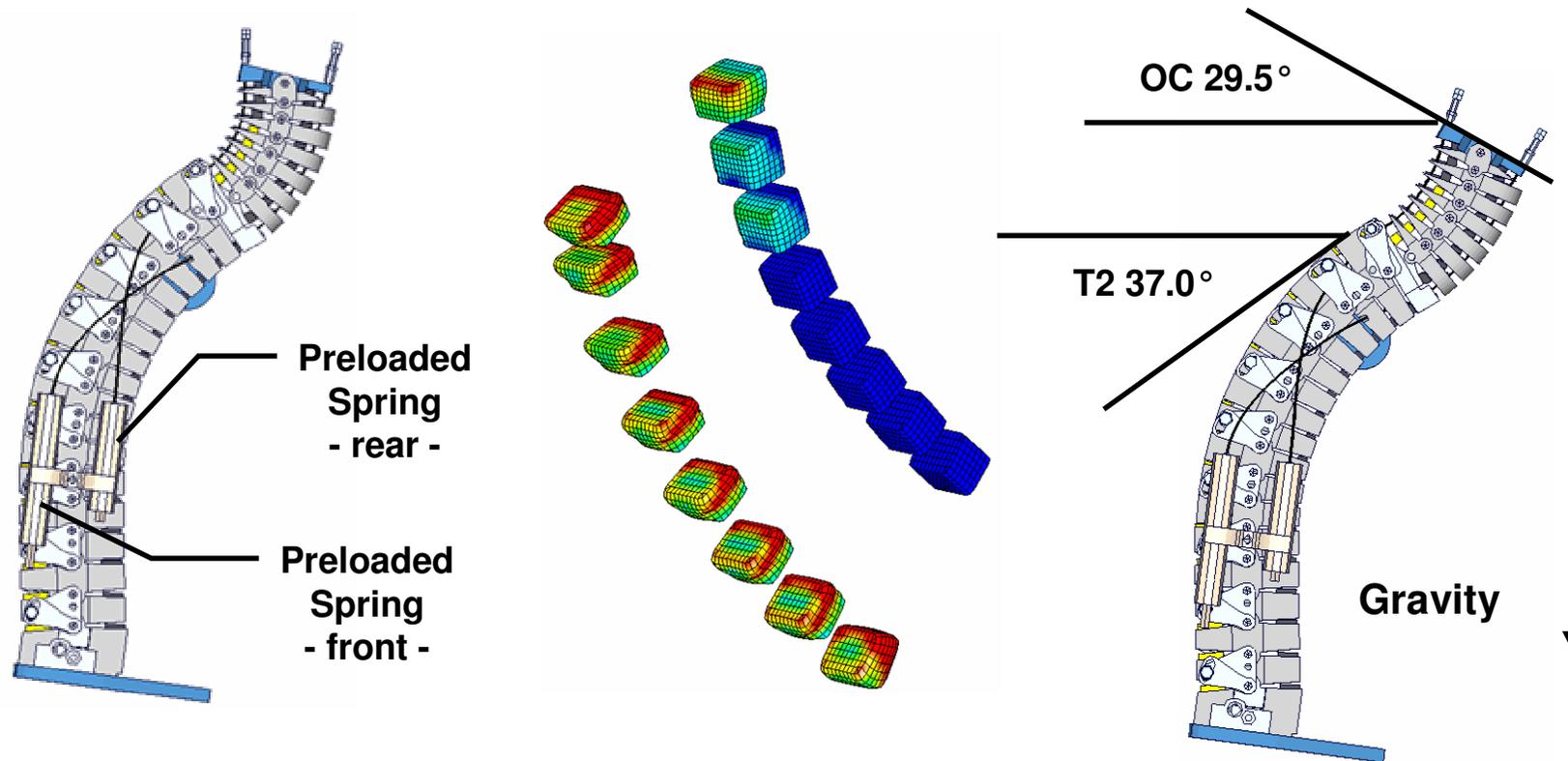
BioRID II v2.0 latest changes to the model

- The Model is based on CAD data of BioRID II build level C.

- A water cavity is in the stomach area (*MAT_NULL)

- Model details:

- nodes: 148,000

- hex: 88,000

- tets: 22,000

- shells : 72,000

- beams : 4,000

water cavity
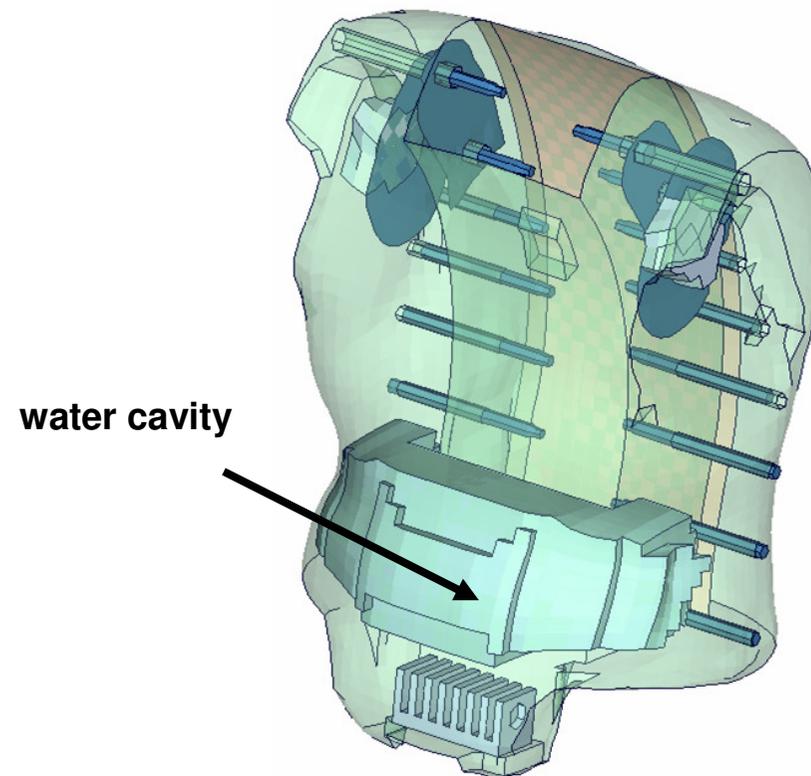
- Geometry of T1 vertebra is generated more accurate to the CAD Data

- The rubber bumpers are meshed in a small pit. This disables the lateral strain of the rubber bumpers and changes the stiffness of the neck

- The silicon filling material is modeled piecewise at important areas

- The material model of the rubber bumpers is switched to MAT_SIMPLYFIED_RUBBER (MAT_181)

- The KEYWORD *INITIAL_FOAM_REFERENCE_GEOMETRY is implemented for the MAT_181 in LS-DYNA 971

Silicon filling material

Rubber bumper in a pit
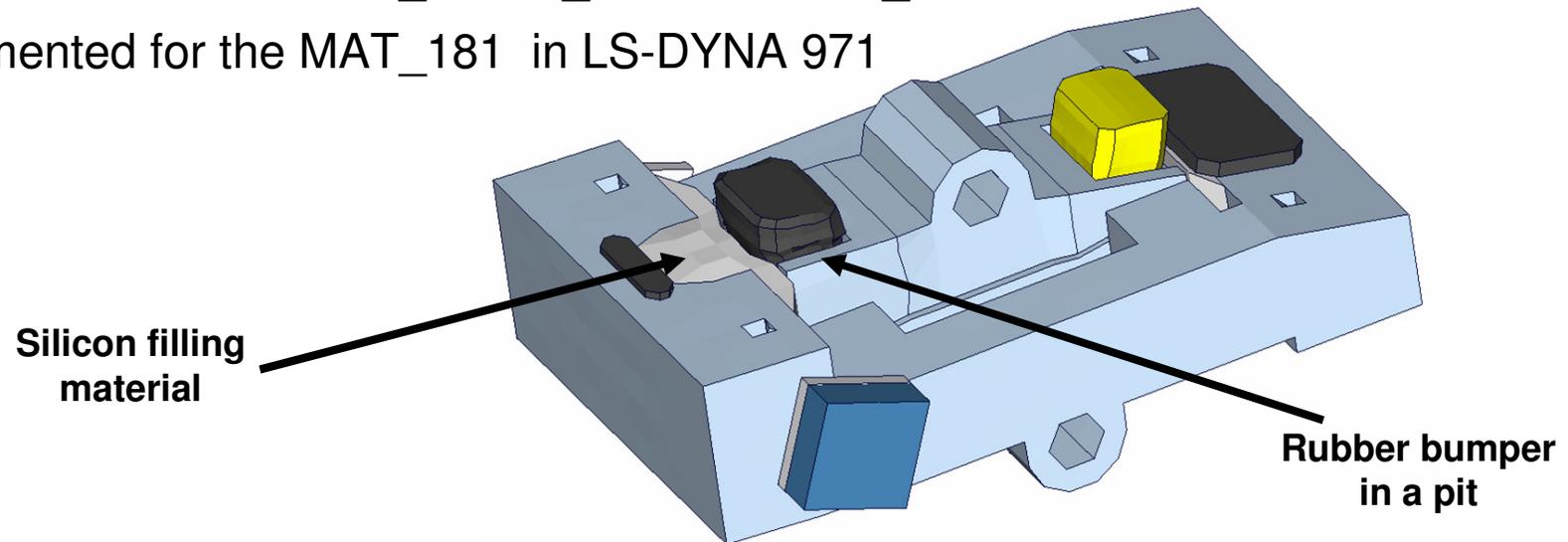
- At the back, the torso flesh is opened

- The Teflon plate in the back of the torso flesh is modeled on contact. It is only plugged in beadings on both sides in the torso flesh

Gap in the torso flesh

beads in the torso with plugged Teflon plate
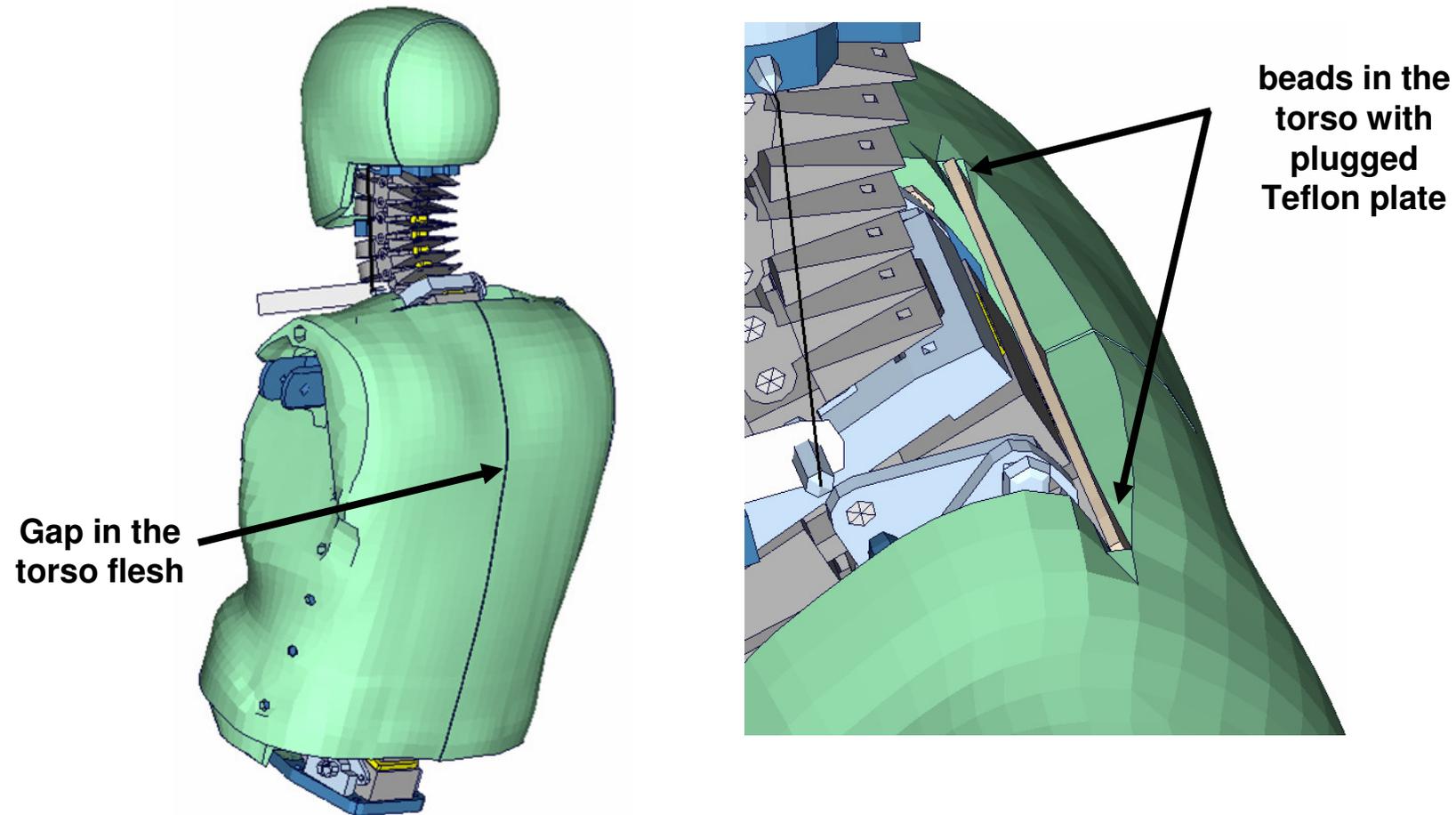
- Repairing Seatbelt Elements

  - It is distributed a program (repair_seatbelt_elements) for different platforms to repair the seatbelt elements after a positioning simulation

  - As input only the dummy model with the slipped seatbelt elements is used

  - If the user renumbered the model an nodal offset can be input (default 0)

  - The nodes of the seatbelt elements are therefore in the node ID range of 11000-11500

  - The program moves the nodes of the seatbelt elements to the needed slip ring node

  - The nodes between the slip rings are moved linear between the slip ring nodes

- Static tension and compression tests for vinyl, silicon, and foam parts

- Dynamic tension and compression tests with strain rates of 0.001, 0.1, 10, 100, 500 [1/s]

- Static tension tests

SILICON

VINYL
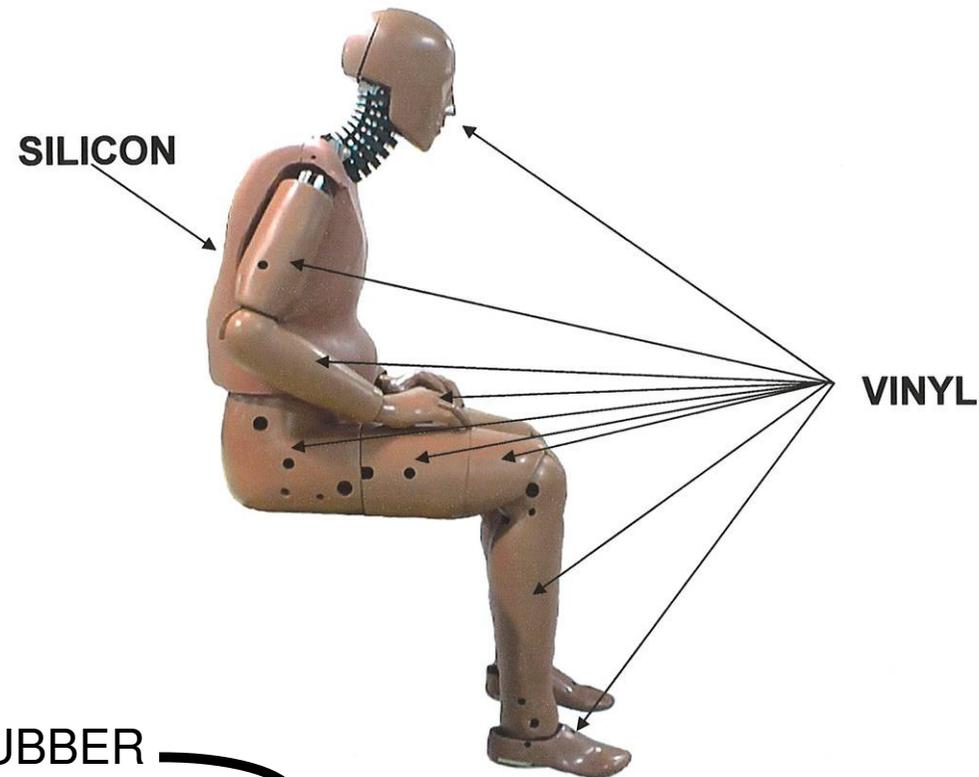
- *MAT_FU_CHANG_FOAM

- *MAT_MOONEY-RIVLIN_RUBBER

- *MAT_SIMPLIFIED_RUBBER

rubber bumper material
for the next release

- Fore many different material combinations are done static and dynamic friction tests.

- Material combinations tested are

    - Bumper to vertebrae

    - Steel cable to vertebrae

    - Fabric (cloths of BioRID II) to vinyl and different seat covers

    - Silicon fabric

    - And other combinations which are important for the full assembled test with the BioRID II
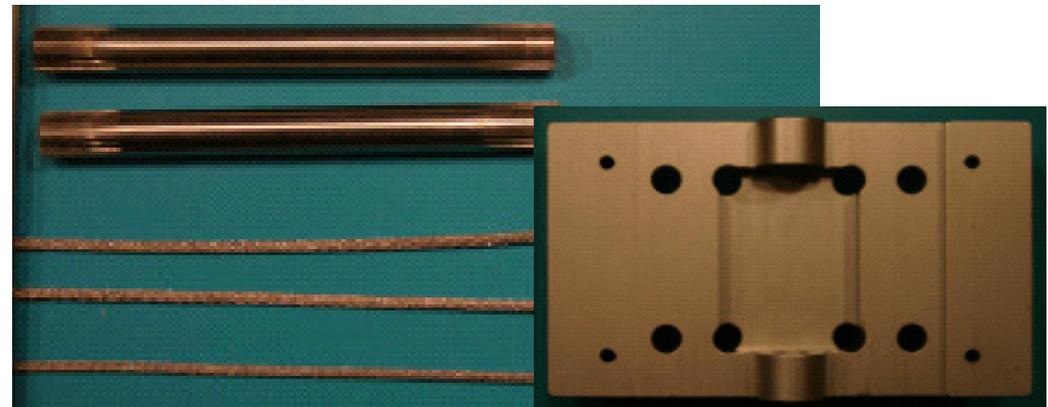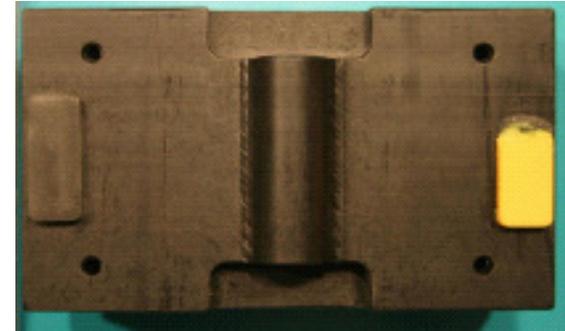
- Calibration test:

  - The calibration test is performed is use of the information from the BioRID II manual

  - For sled load a acceleration pulse of the sled from a test is used

  - In the simulation the BioRID II is positioned under gravity on the sled
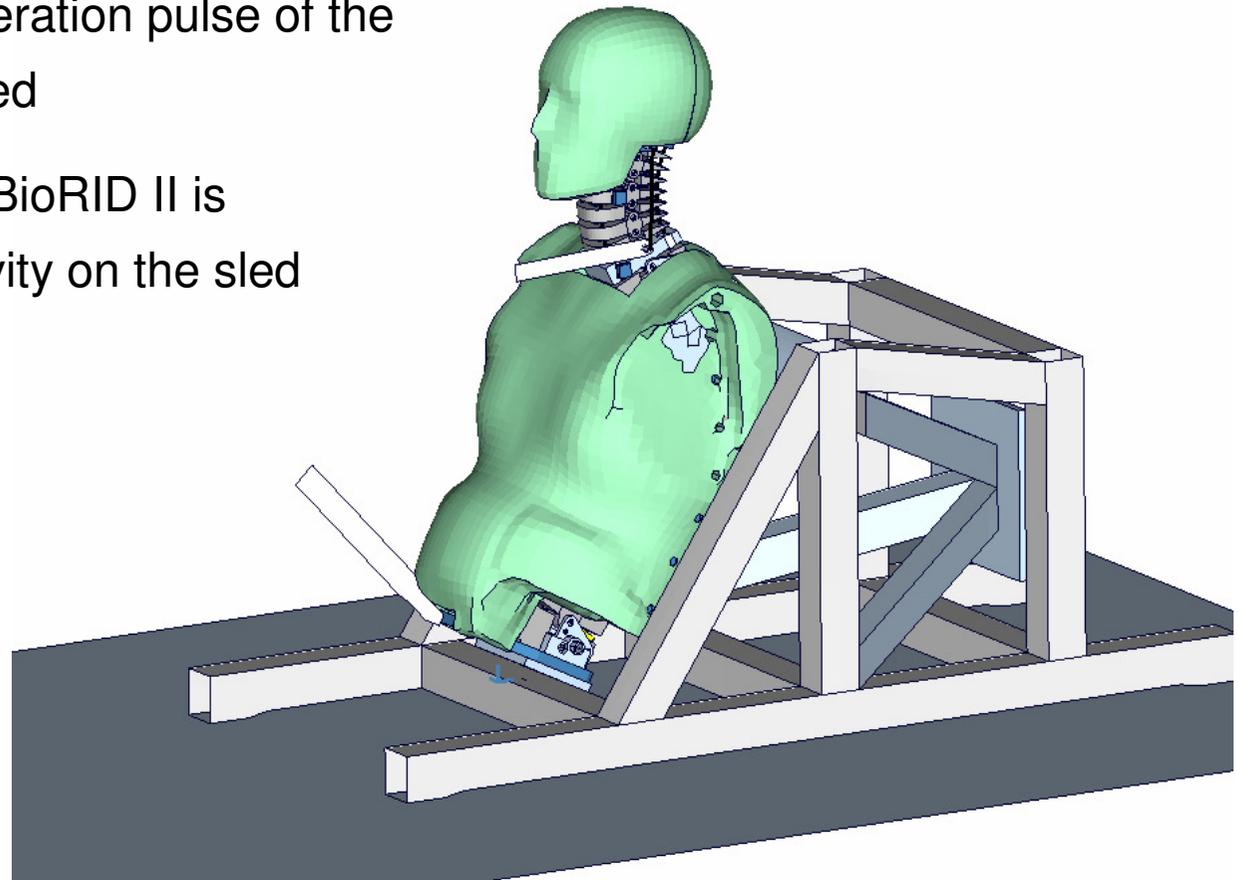
- Calibration Test:
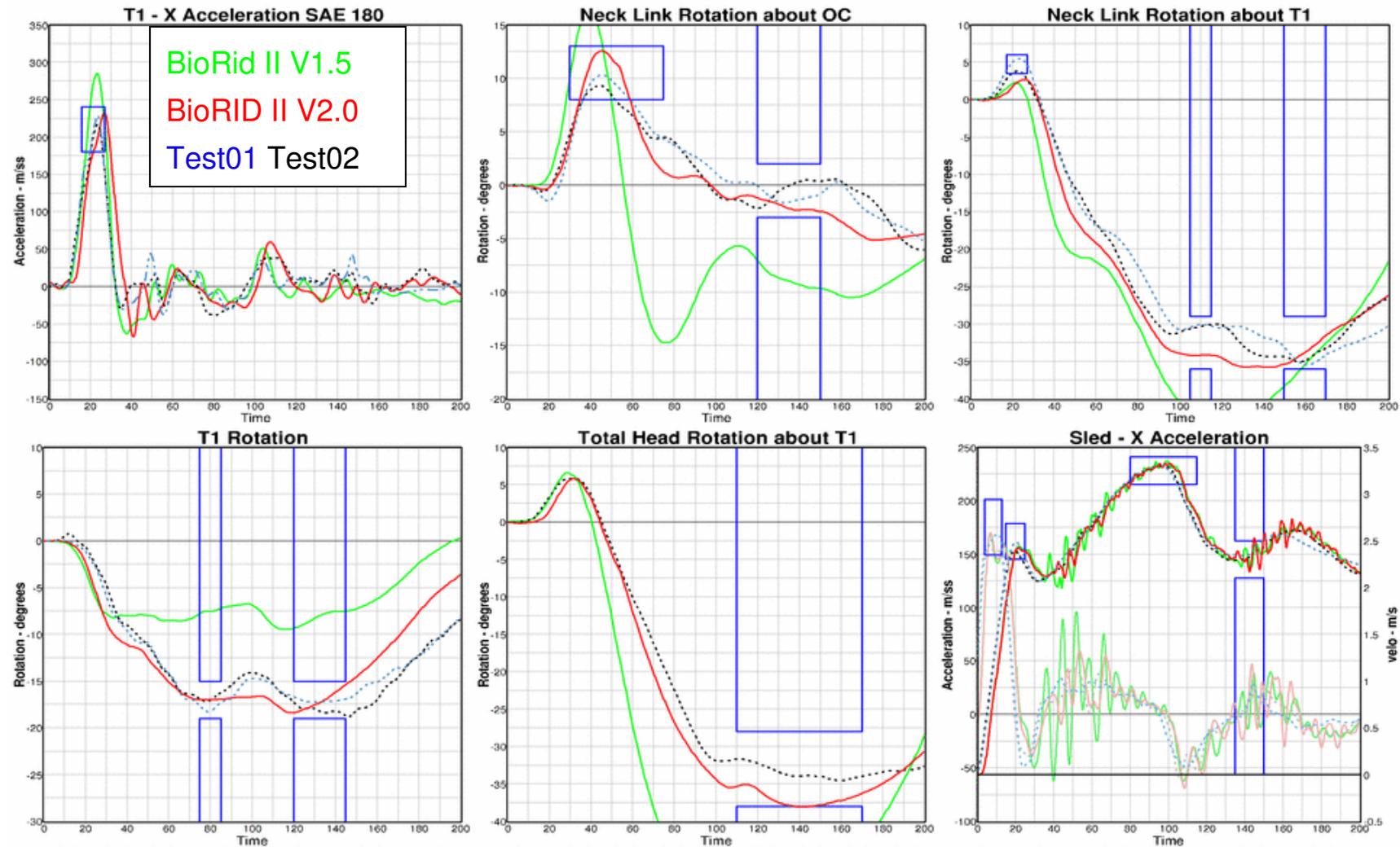
- Main focus on the behavior of the spine and neck

- Spine could be coupled piecewise with the sled

- Spine is tested full assembled, without damper, without damper and springs

- Additional test with the torso flesh similar to the calibration test
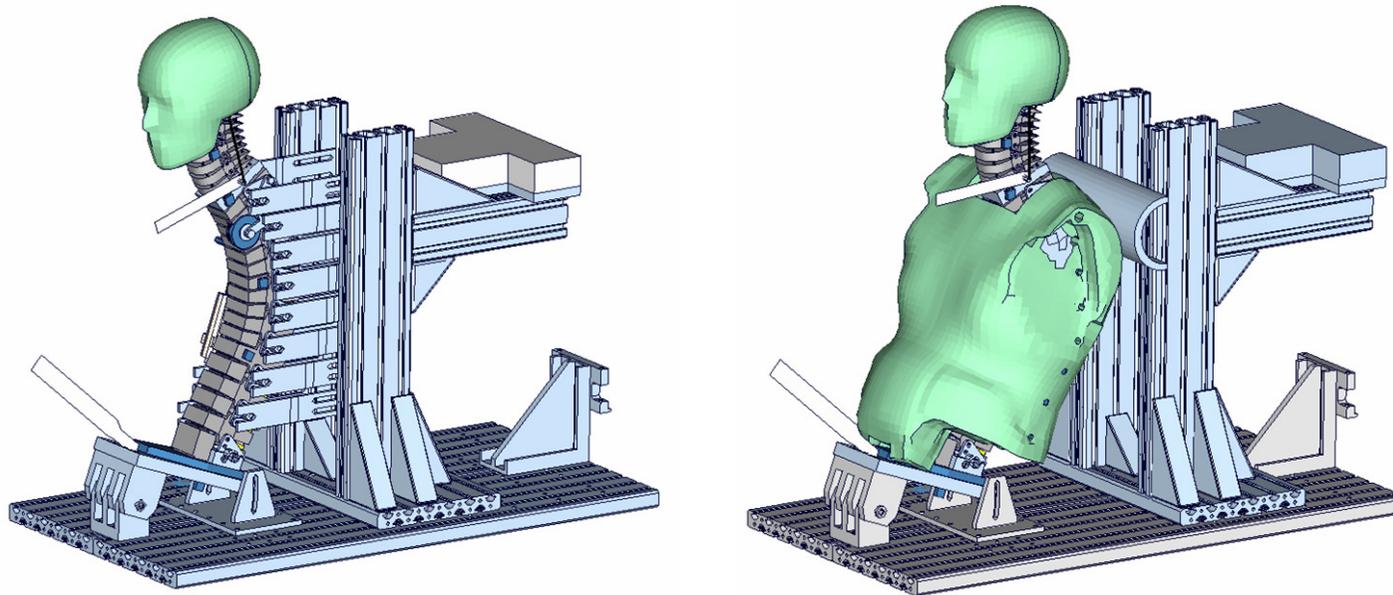
- Spine is equipped with head, damper and springs and is supported from the spine mounting plate up to T1

- Neck and head movement during the component test at 0, 45,125 ms
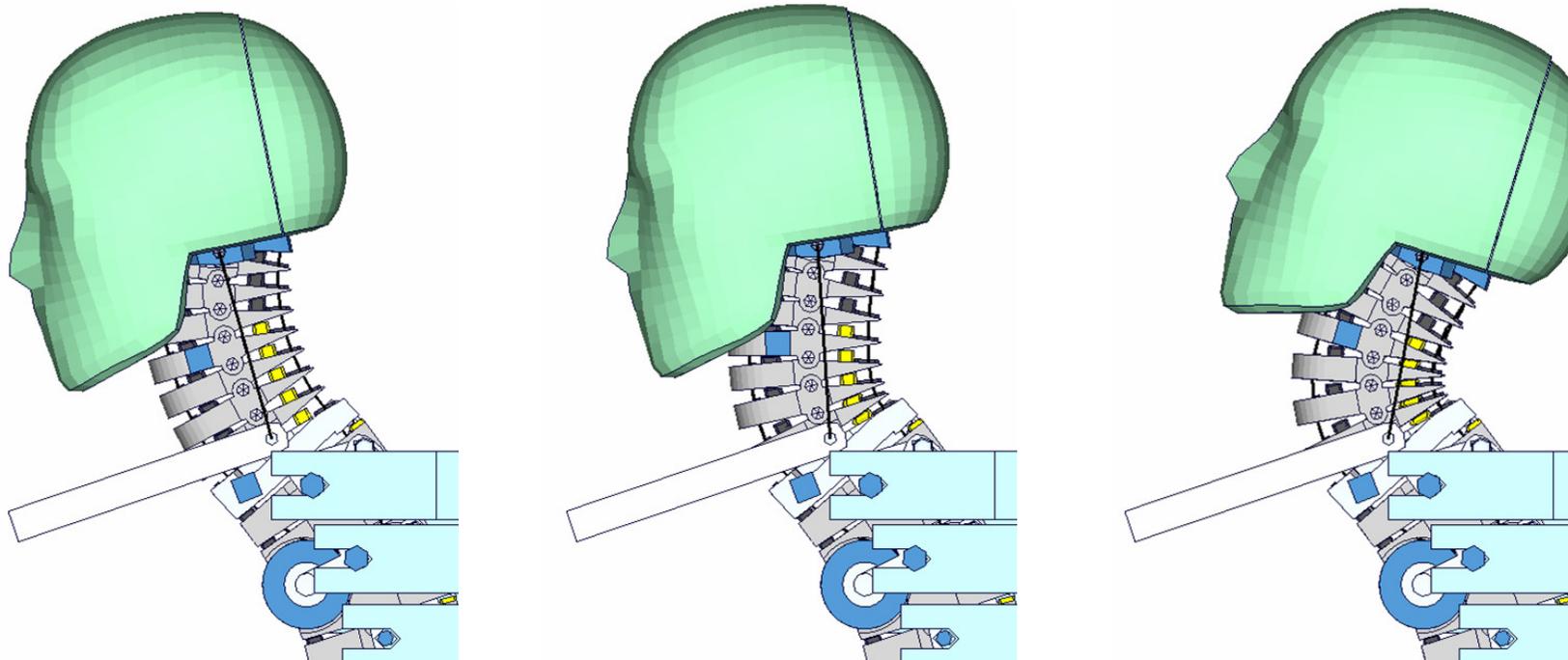
- Results component test
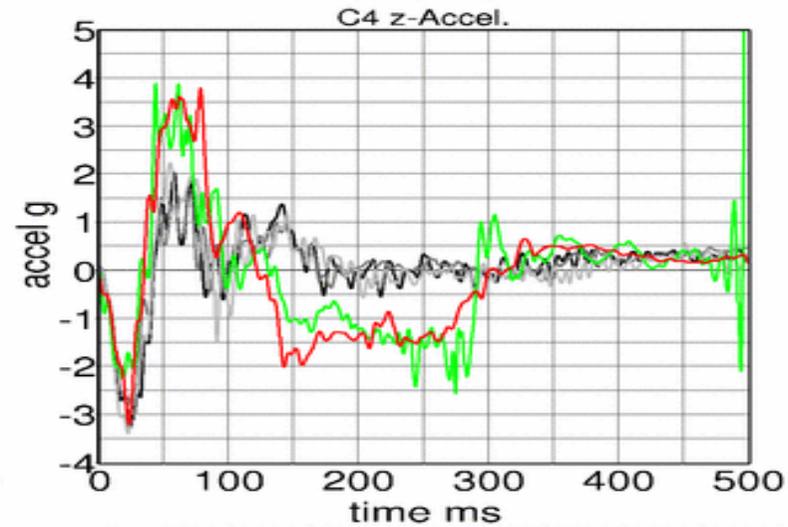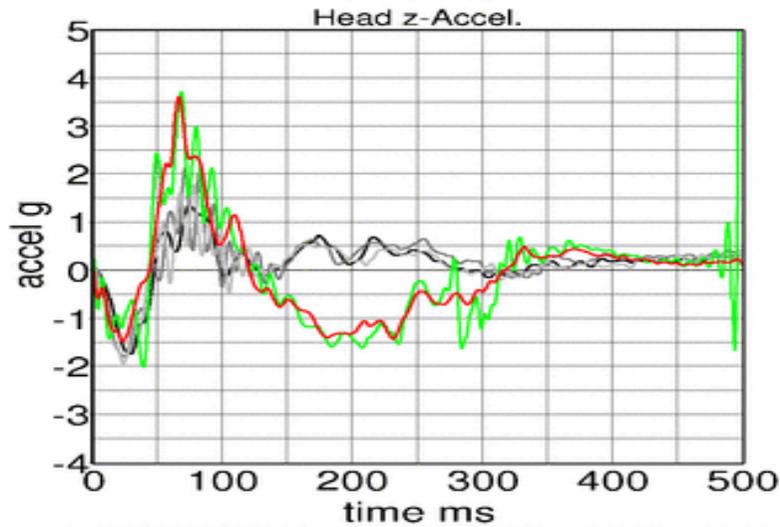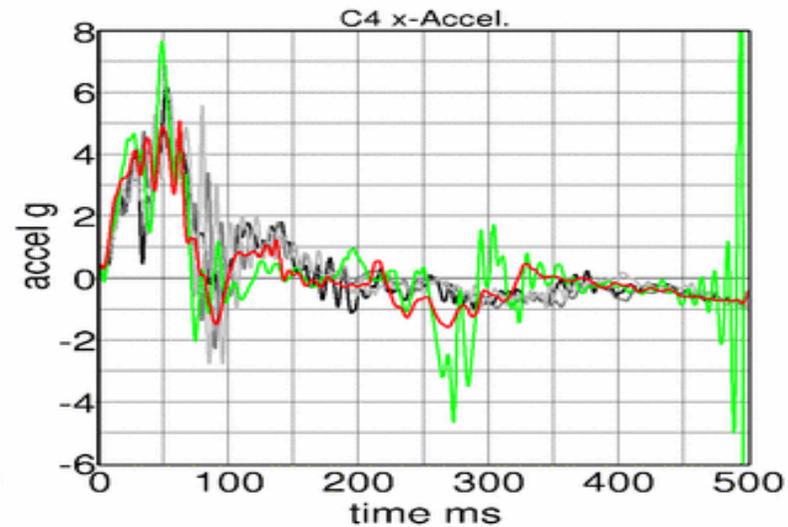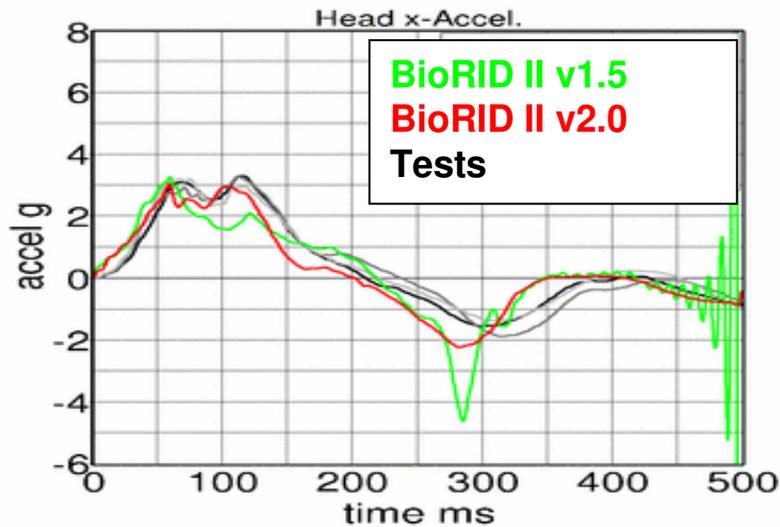
- **Results component test**
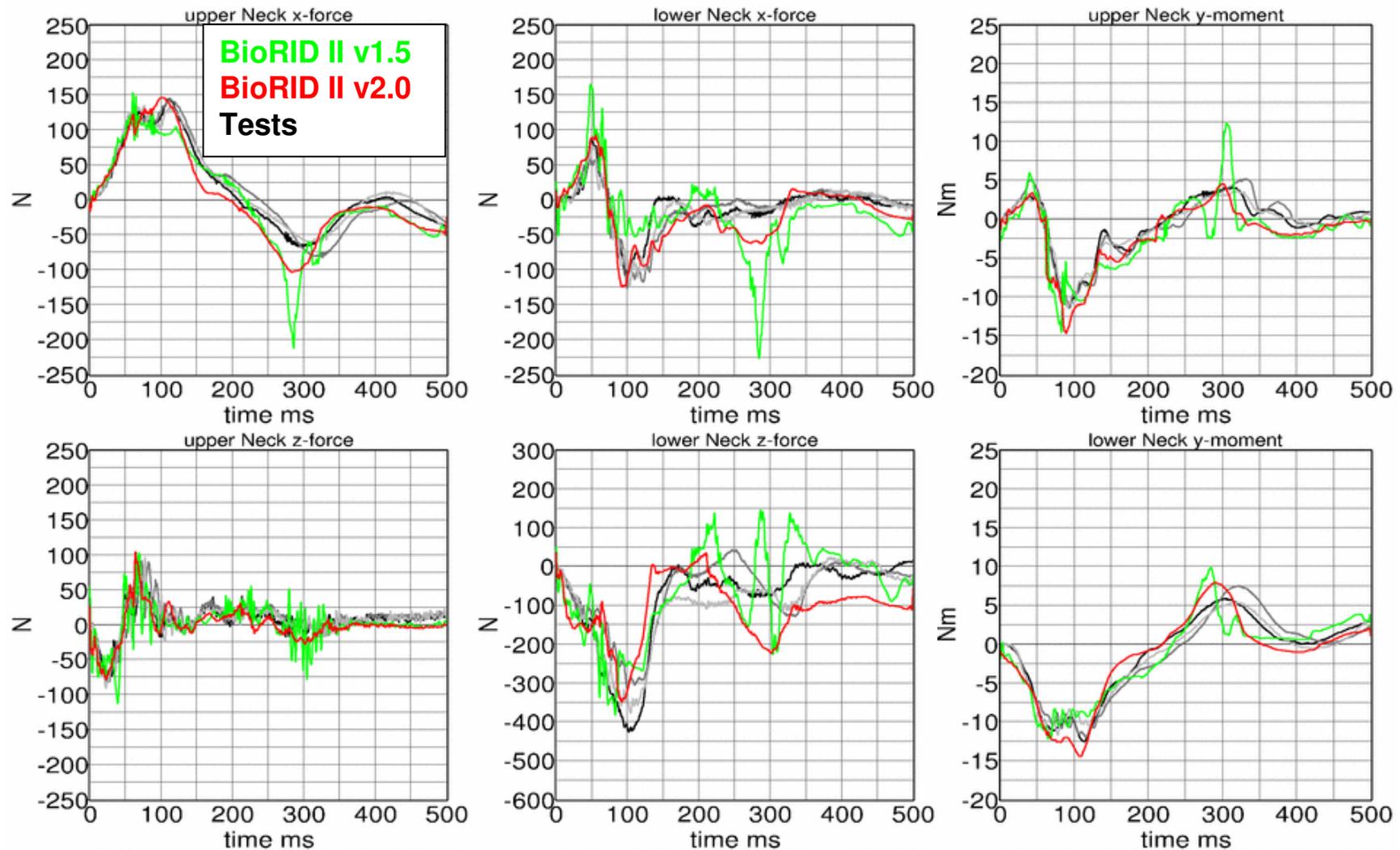
- Oscillation problem is decreased a lot

- Example therefore is the component test and th
  spine is supported from the bottom up to T8

T1 x-acceleration

BioRID II v1.5
BioRID II v2.0
Tests
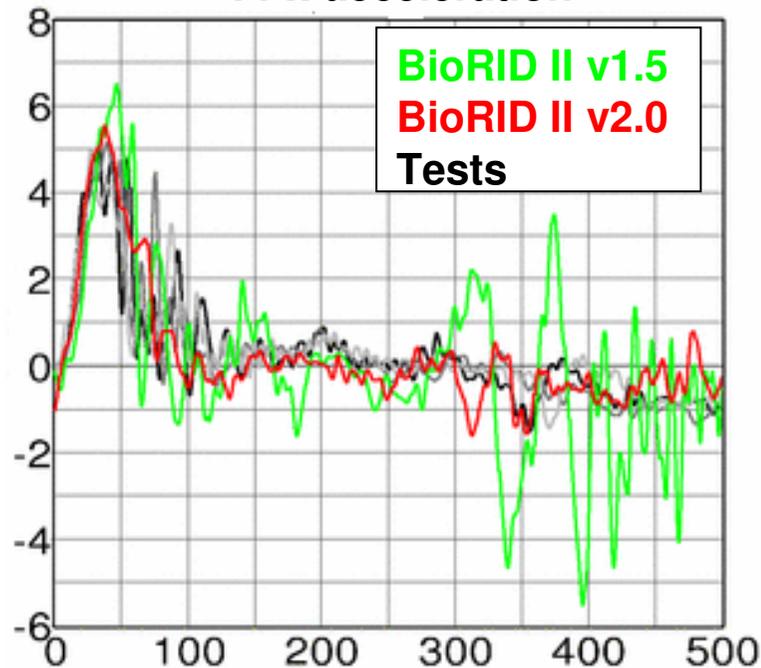
T1 z-acceleration

BioRID II v2.0 latest changes to the model

- Simplified seat system is used to validate the dummy model

- Seat is modified seat originally used at Chalmers University to develop the BioRID dummy

- The seat was loaded with three different pulses

- 10g triangular pulse and 5g/7g trapezoid pulse
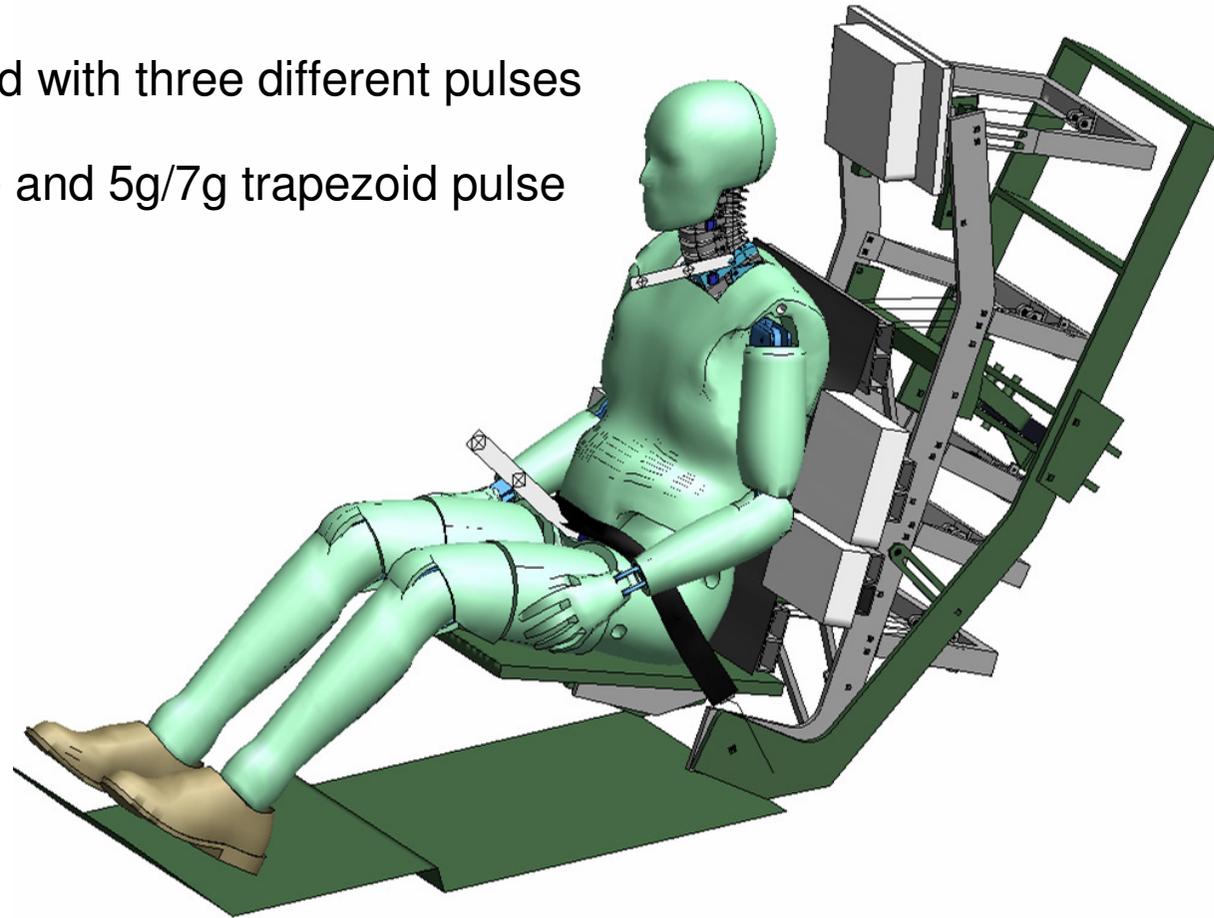
- Seat provides four panels, which can move separately. The resistance is adapted to behave similarly the local stiffness of the back rest.

- The frame of the pads rotates about a pivot center. It is resisted by a break system which presents the stiffness of the back frame against rotation.

- The seat is partially equipped with foam pads to provide soft contact conditions comparable to a vehicle seat.

- Simplified seat results

Head x-acceleration
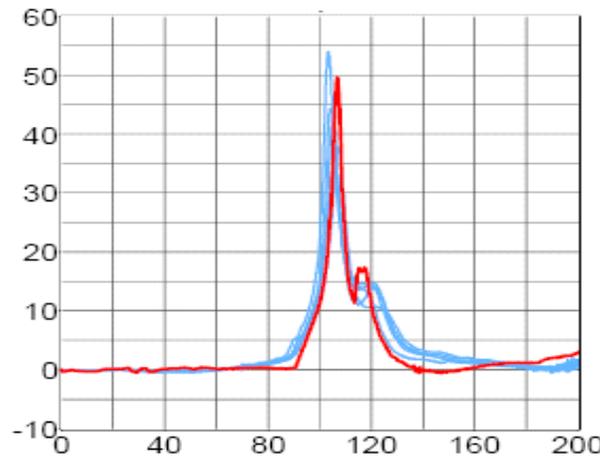
C4 x-acceleration
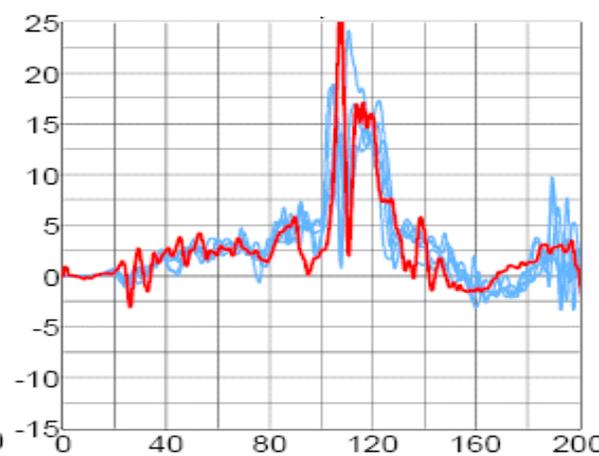
T1 x-acceleration
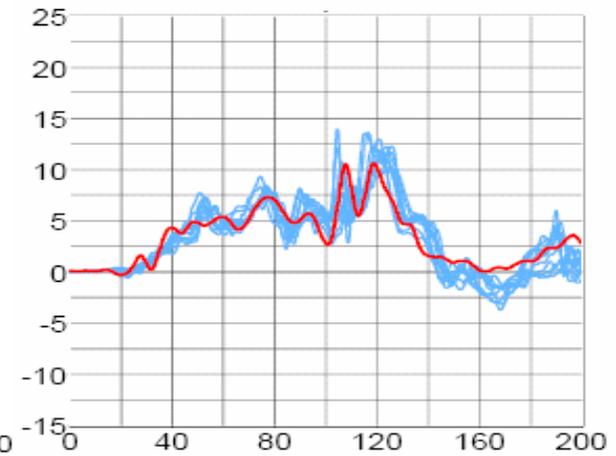
Head z-acceleration
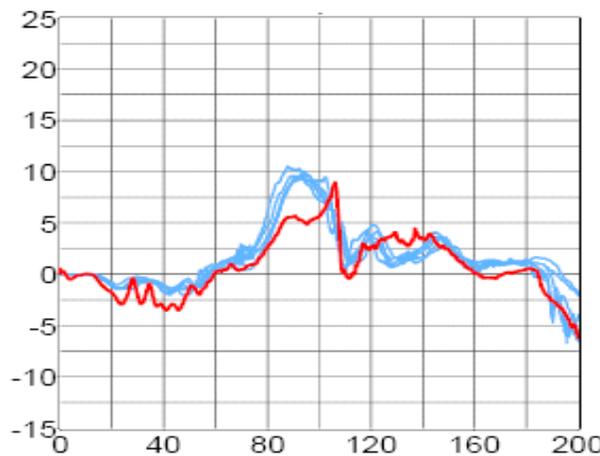
C4 z-acceleration

T1 z-acceleration

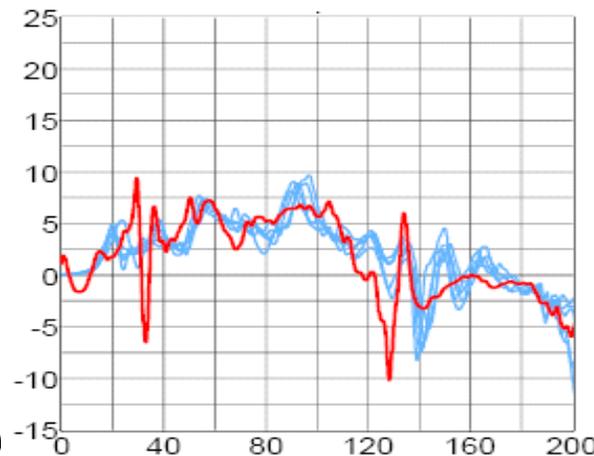# BioRID II v2.0 latest changes to the model
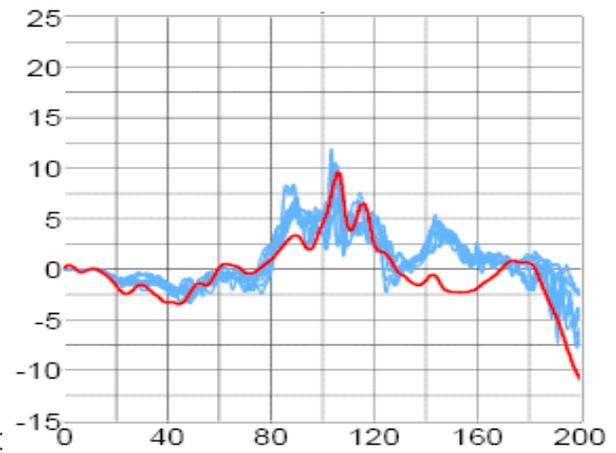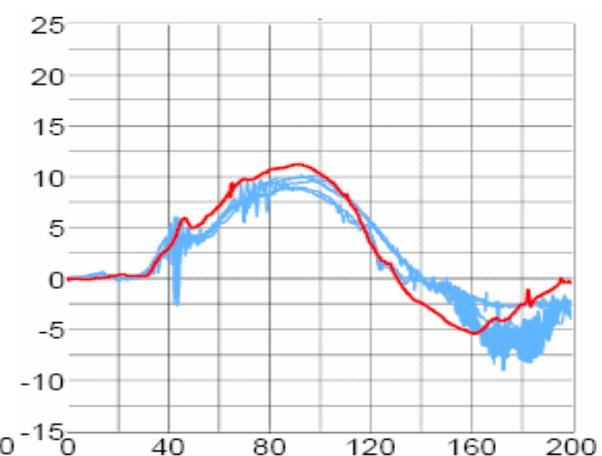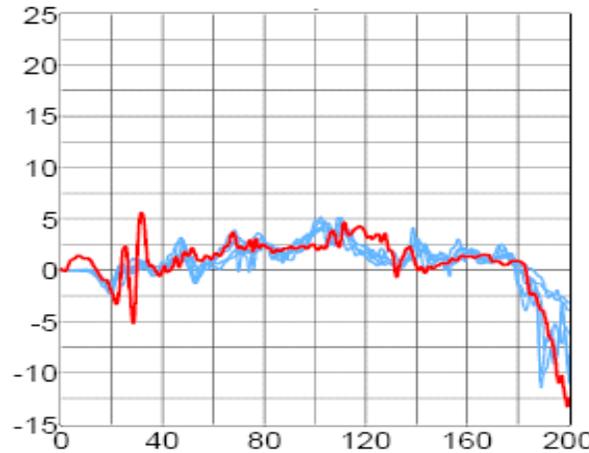
- Simplified seat results
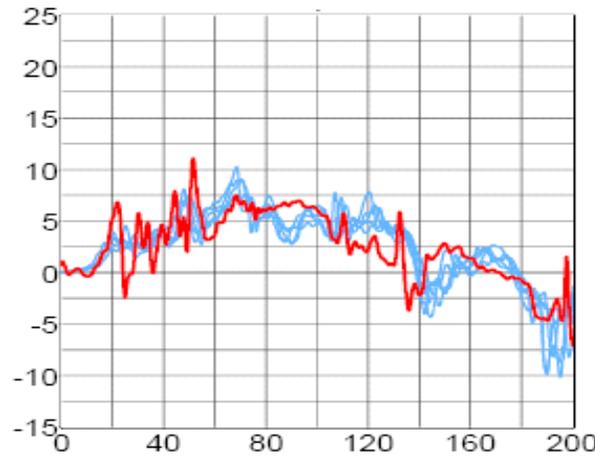
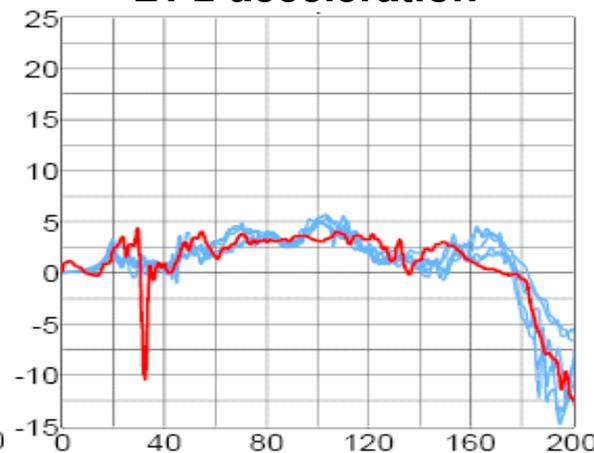### T8 x-acceleration
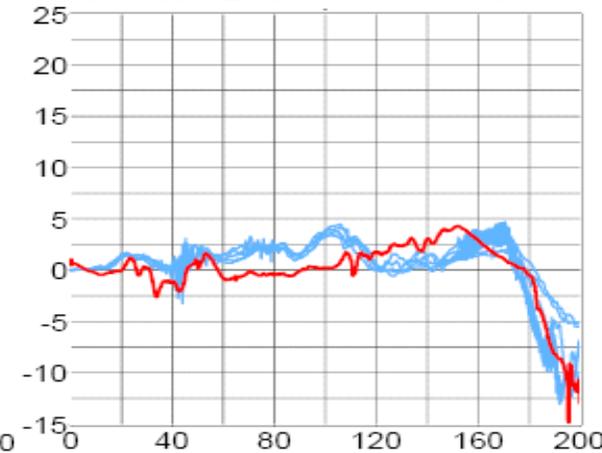### L1 x-acceleration
Pelvis x-acceleration

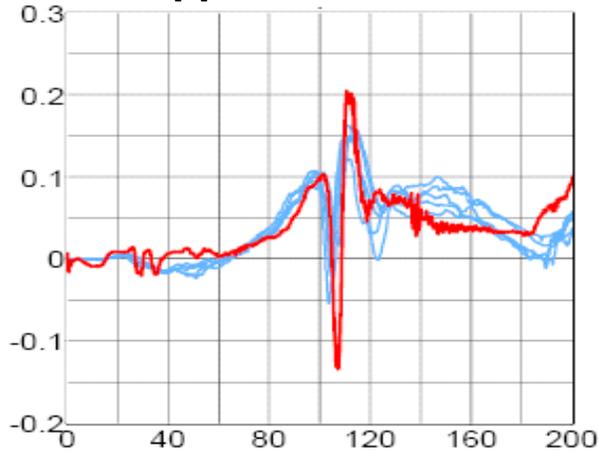### T8 z-acceleration
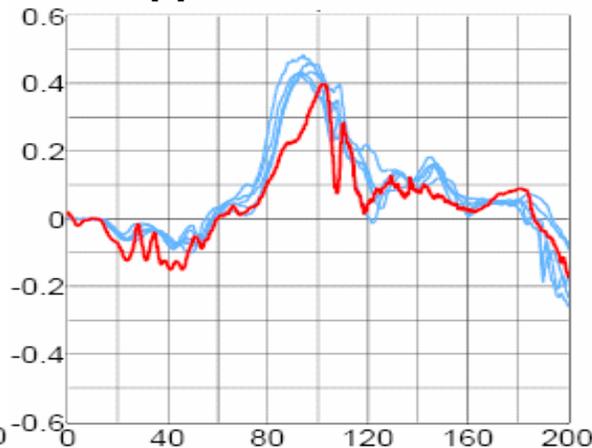### L1 z-acceleration
Pelvis z-acceleration
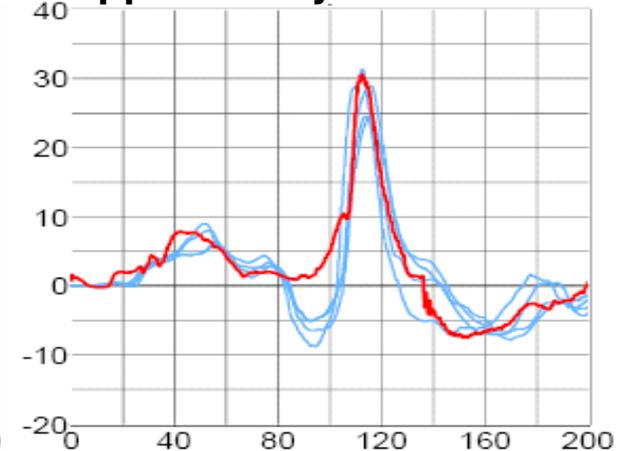
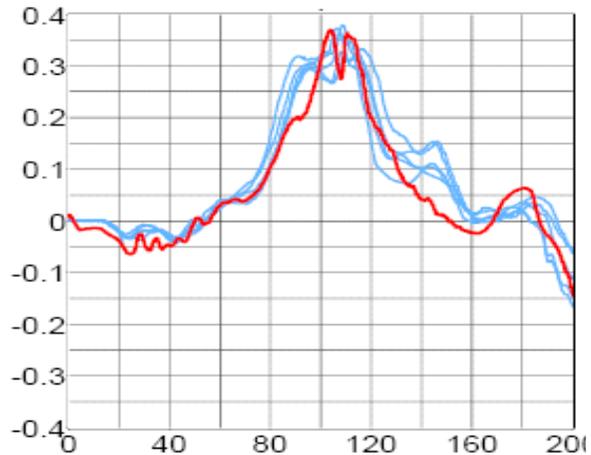- Simplified seat results
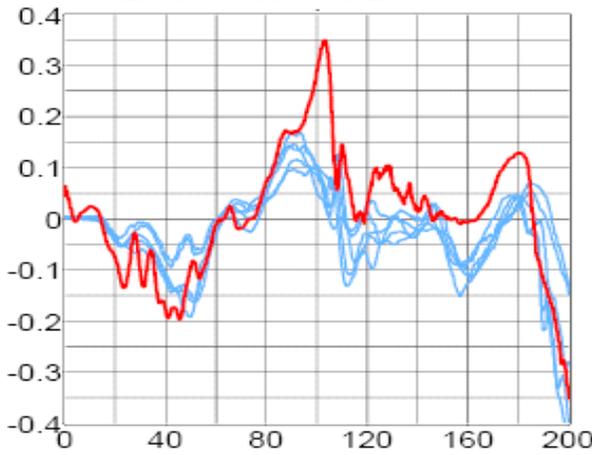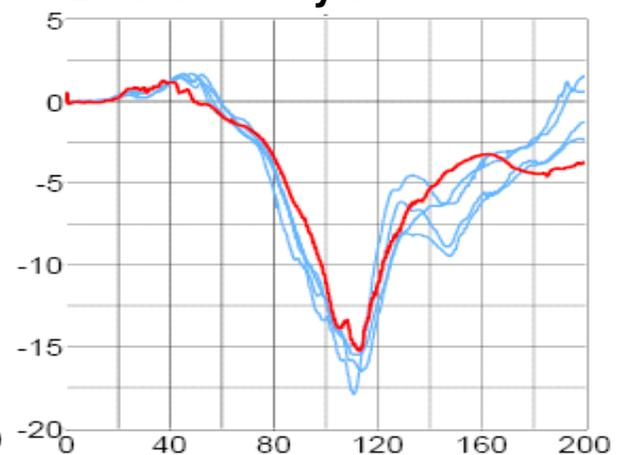
Upper neck x-force

Upper neck z-force

Upper neck y-moment
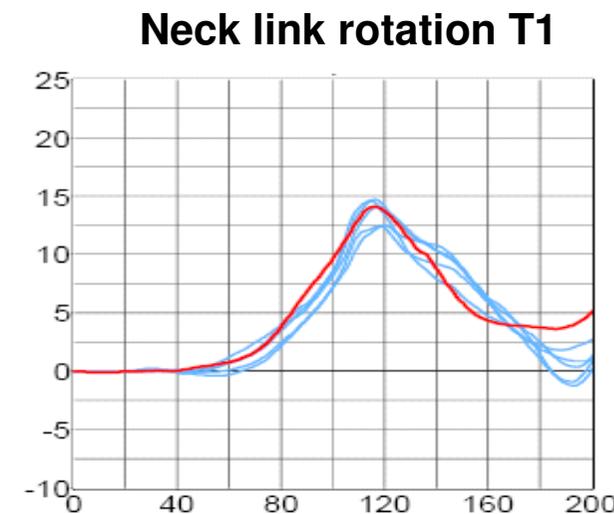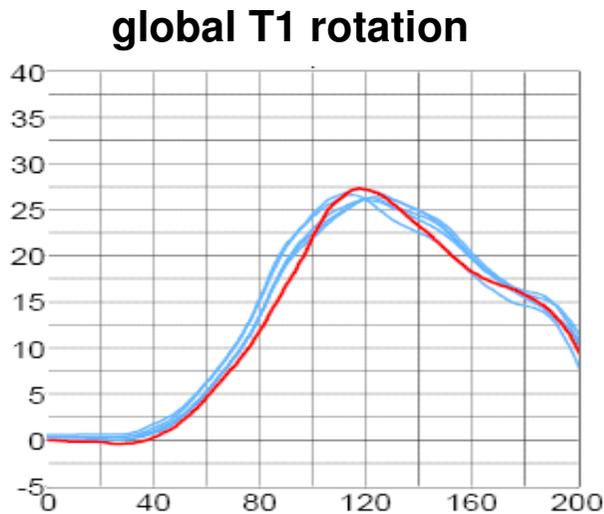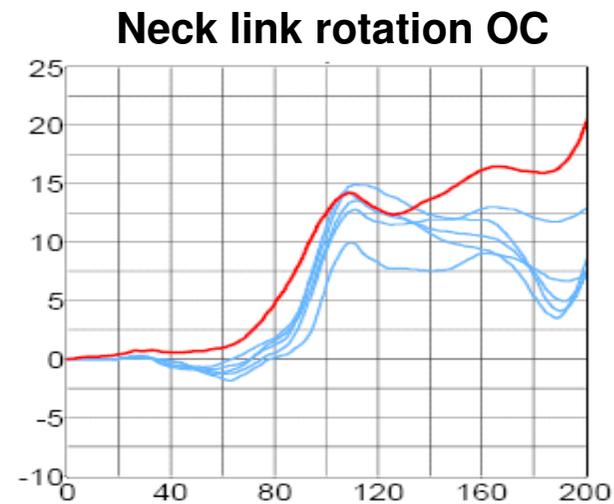
Lower neck x-force

Lower neck z-force

Lower neck y-moment

- Simplified seat results
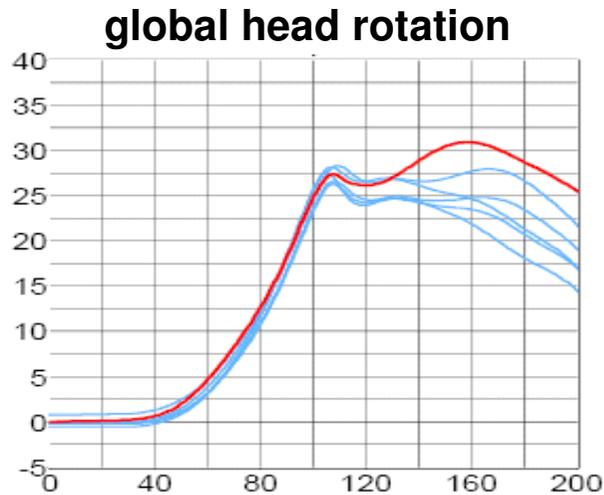
global head rotation

Neck link rotation OC

global T1 rotation

Neck link rotation T1

FAT Dummy Models: Update and News

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    - BioRID II v2.0 latest changes to the model

    - USSID v5.0 latest changes in the model

    - ES-2, ES-2re v4.0 latest changes to the model

    - ES-2, ES-2re news for the following release

    - Further developments for all DYNAmore dummy models

FAT USSID v5.0

- FAT USSID v5.0:

    - Used in the US NCAP Test

    - Finite element models have been developed by FAT

    - FAT: German Association for Automotive Research

    - Members of the FAT:

    Audi   Autoliv   BMW

    Ford   Karmann   KeiperRecaro

    Mercedes   Opel   Porsche

    TRW   Volkswagen
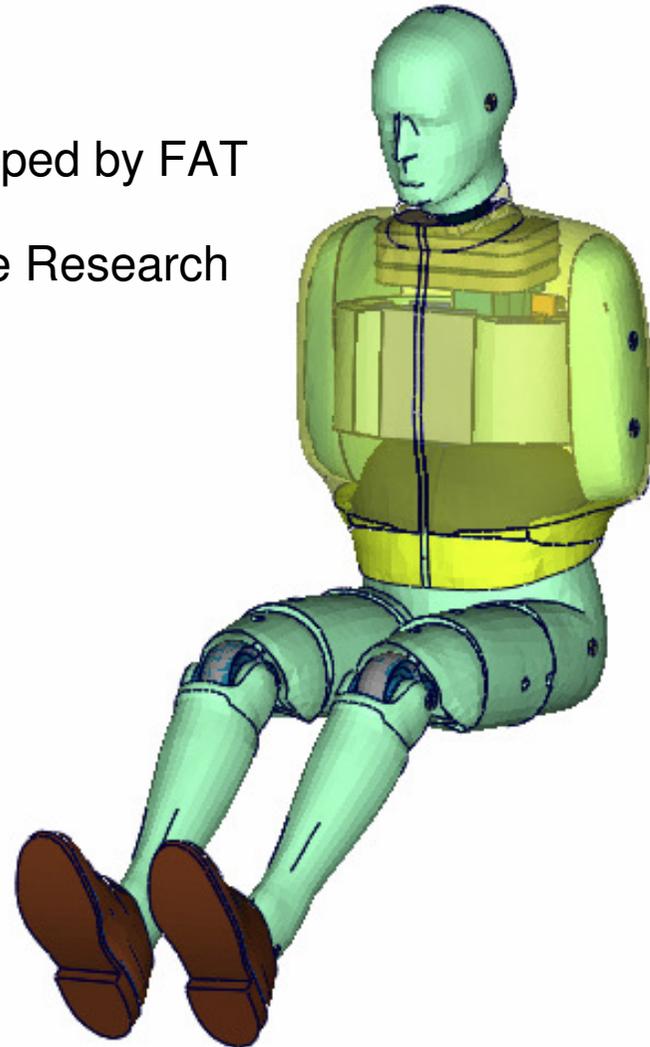
FAT USSID v5.0

- FAT USSID v5.0:

  - Lower legs has been remodeled more accurate to the physical dummy.

  - There through the stability of the knee pads is increased o lot.

  - The shoes are modeled to locate the heel point in the full car crash.

 - Material properties of jacket has been changed (improving rib intrusions).
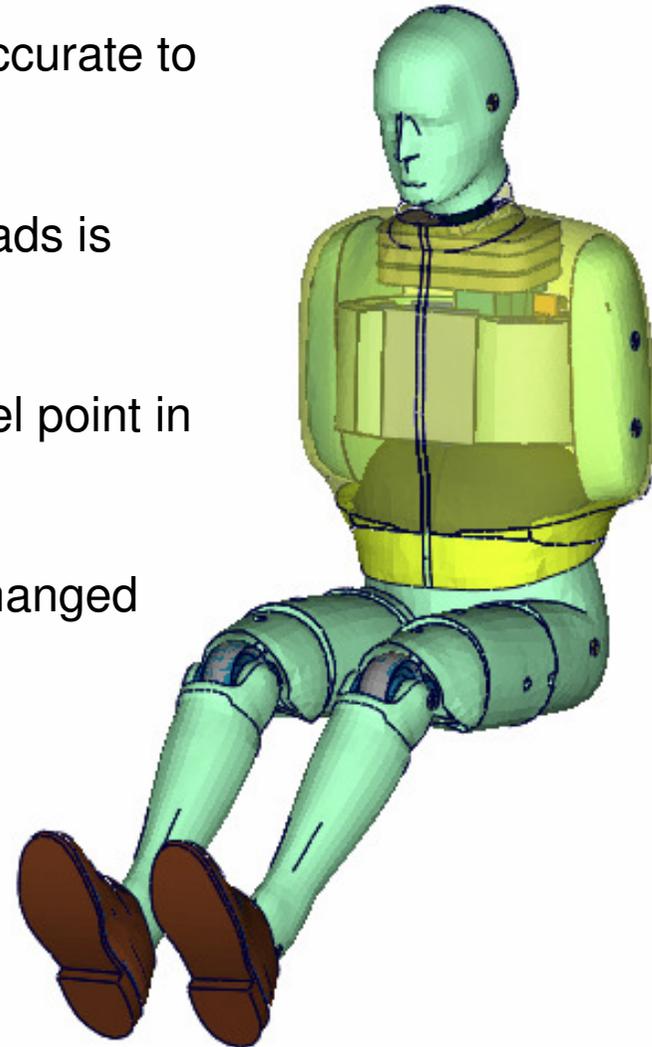
- New property sets :

- 1500: shell face of the dummy used for contact to environment.

- 1501: all dummy properties this set can be used to exclude the dummy out of an Global Single Surface Contact in the Vehicle.
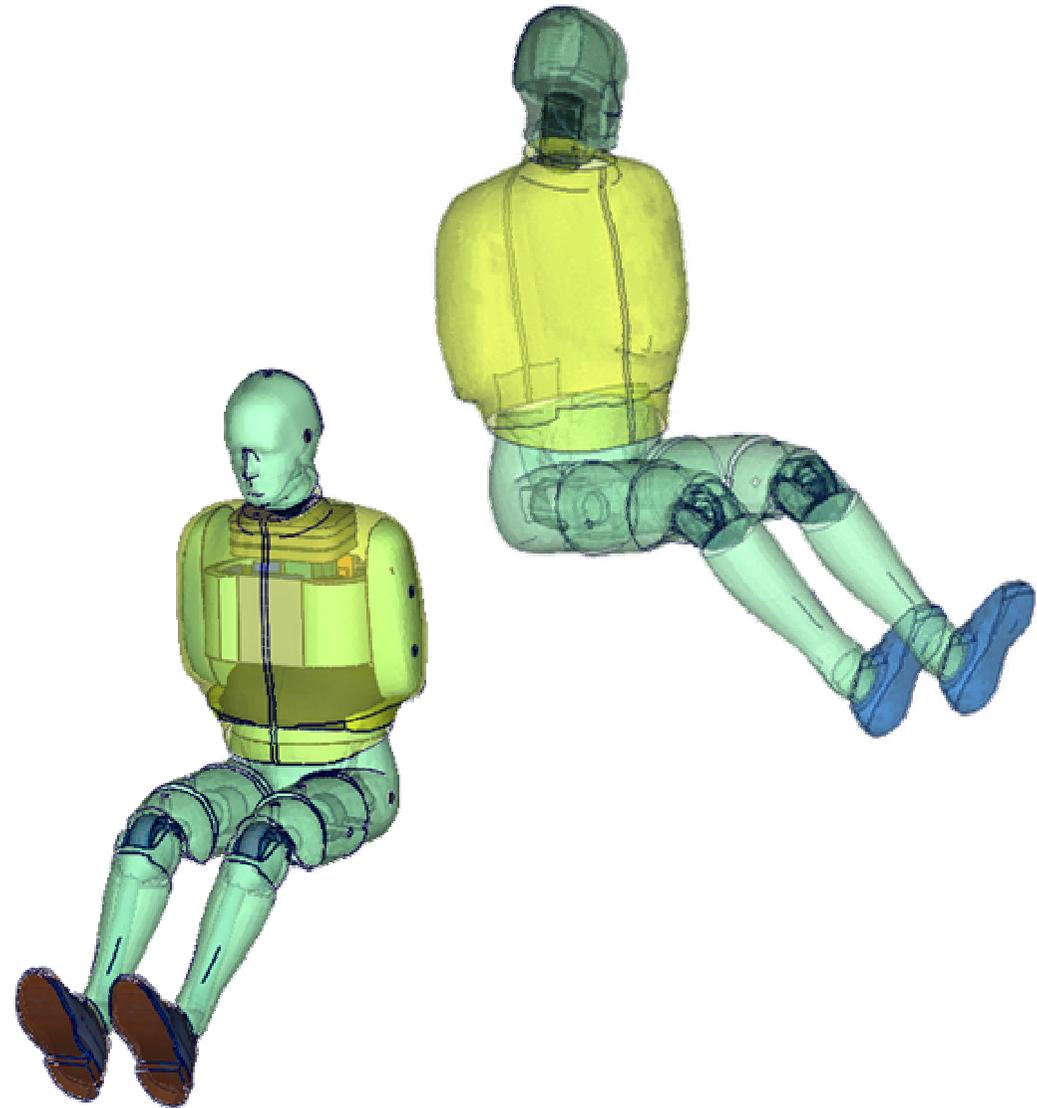
- Primer tree-file has been modified:

    - red: global coordinate system

    - blue: local coordinate system

    - The coordinate systems are located in the
      H-Point and they are connected by an
      spherical joint.

    - The initial pelvis angle is shown in the
   PRIMER
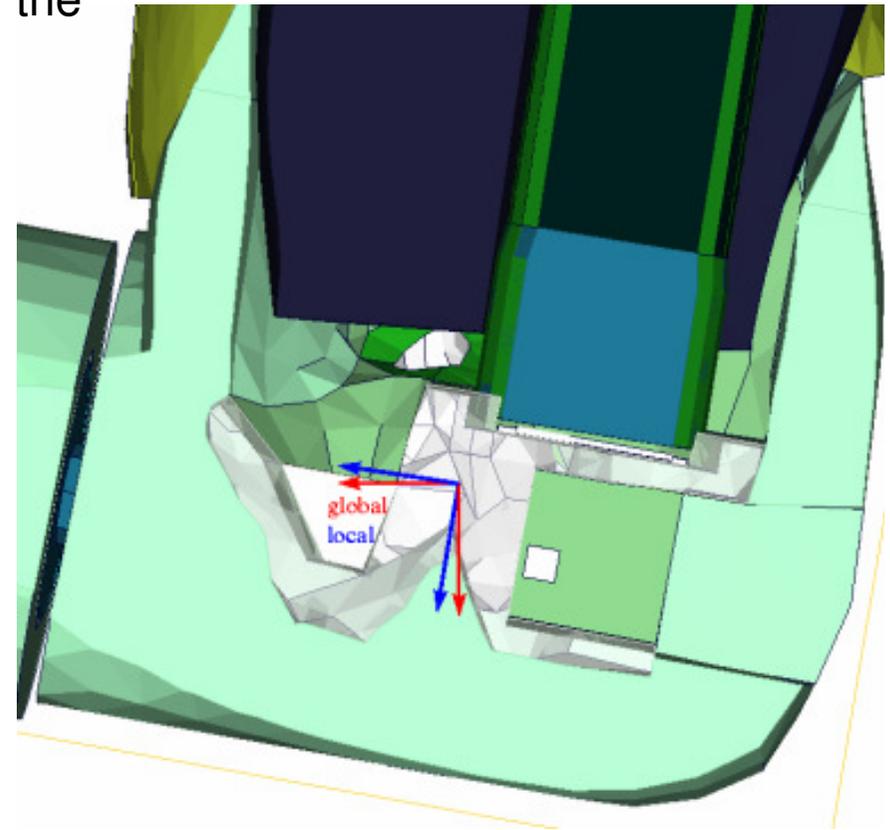
- A separate file including null shell elements to close gaps in the model.

- The user can feel free if he wants to use this Include file ore not.
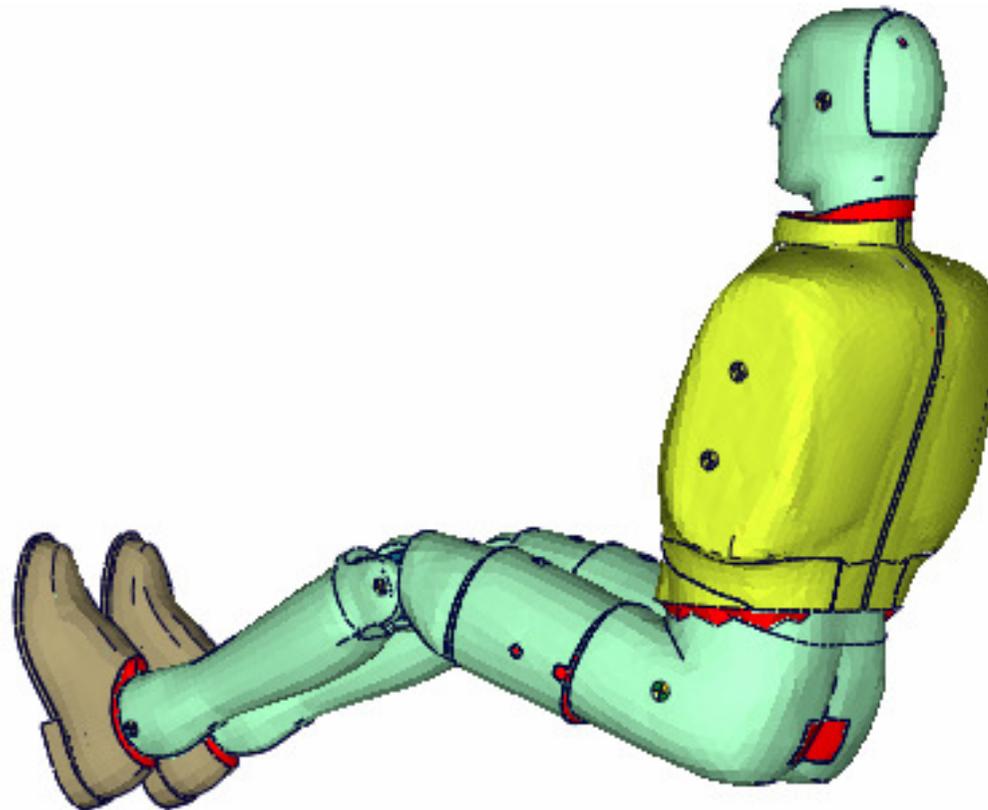
- FAT SID-H3 v5.0:

- After finishing a release of USSID, we build a SID-H3 model based on the new USSID.

- SID-H3 v5.0 based on USSID v5.0 with all news and changes. Only the head and neck model are changed.

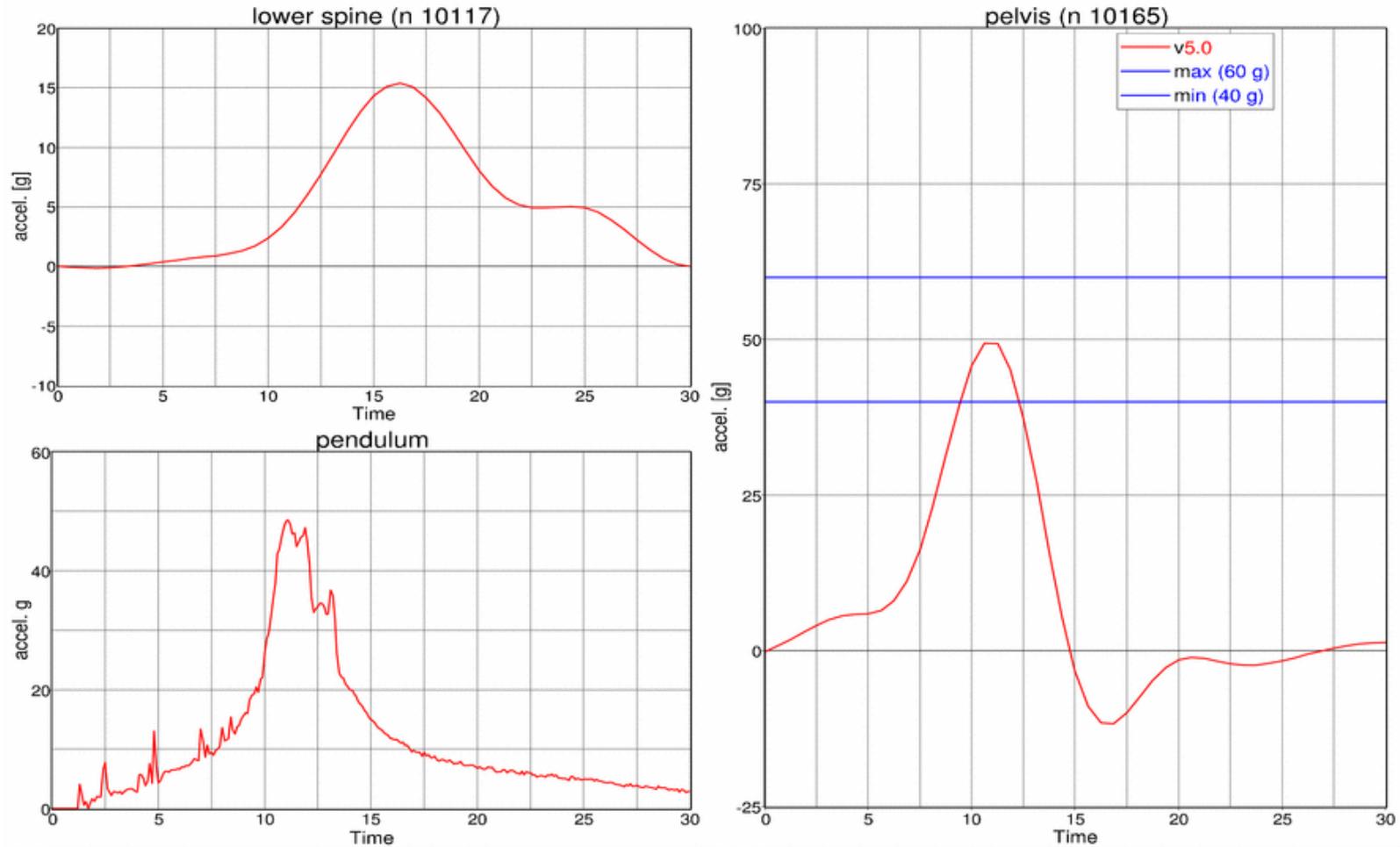- For the head and neck model the parts of the Hybrid III dummy model from FTSS are used (H350 v5.0a).
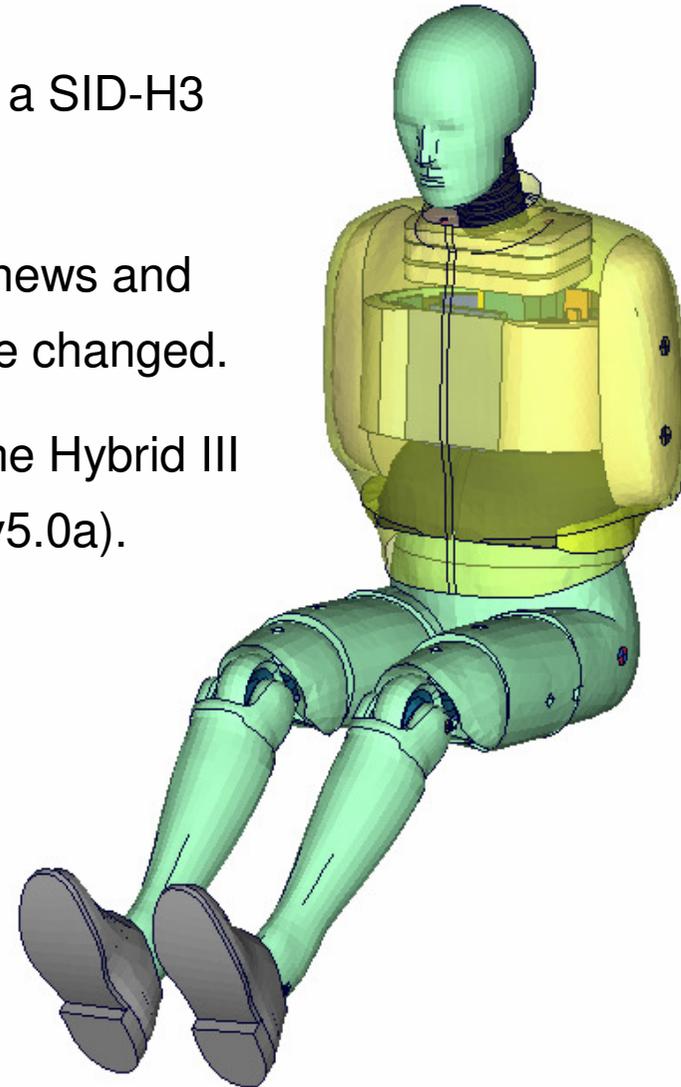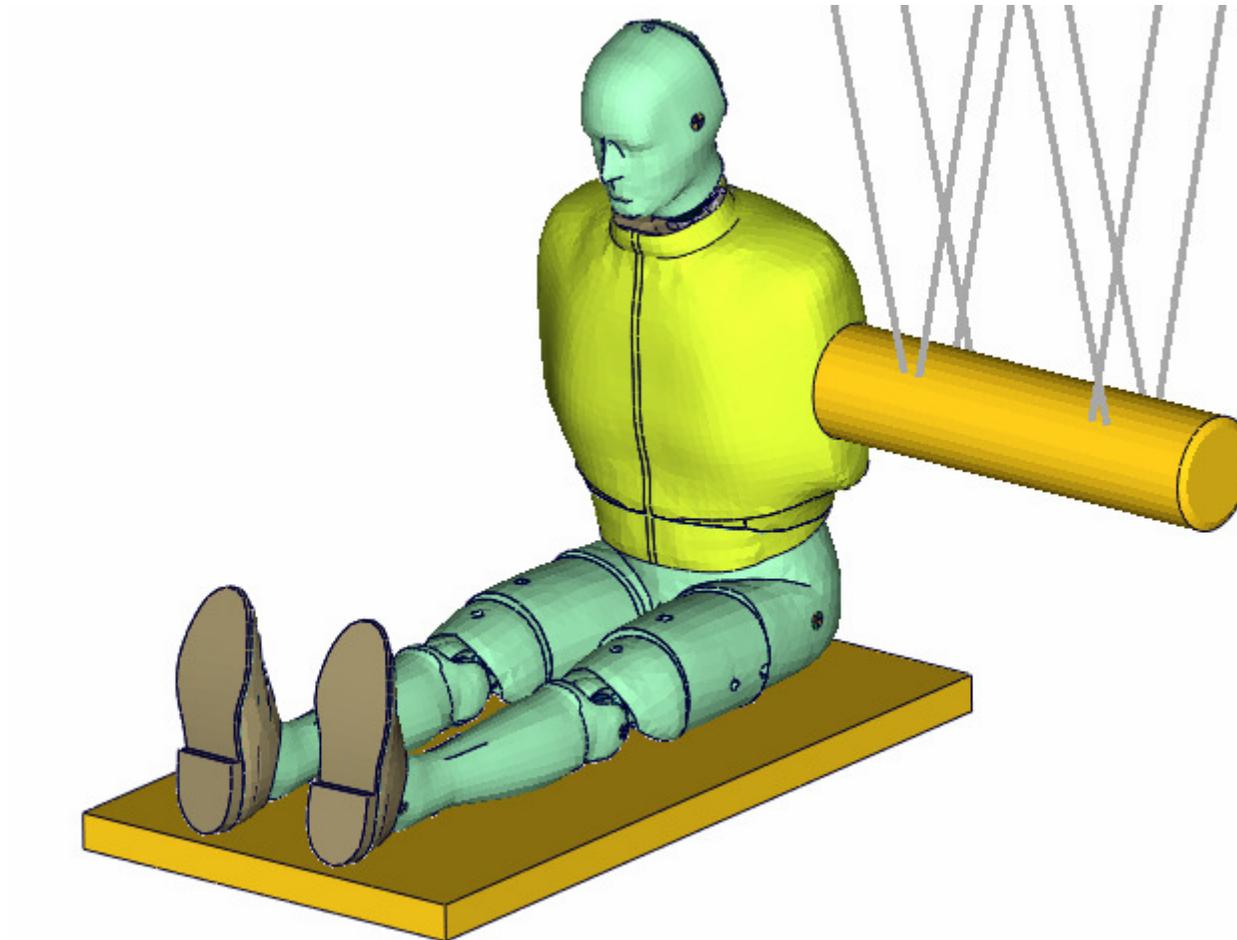
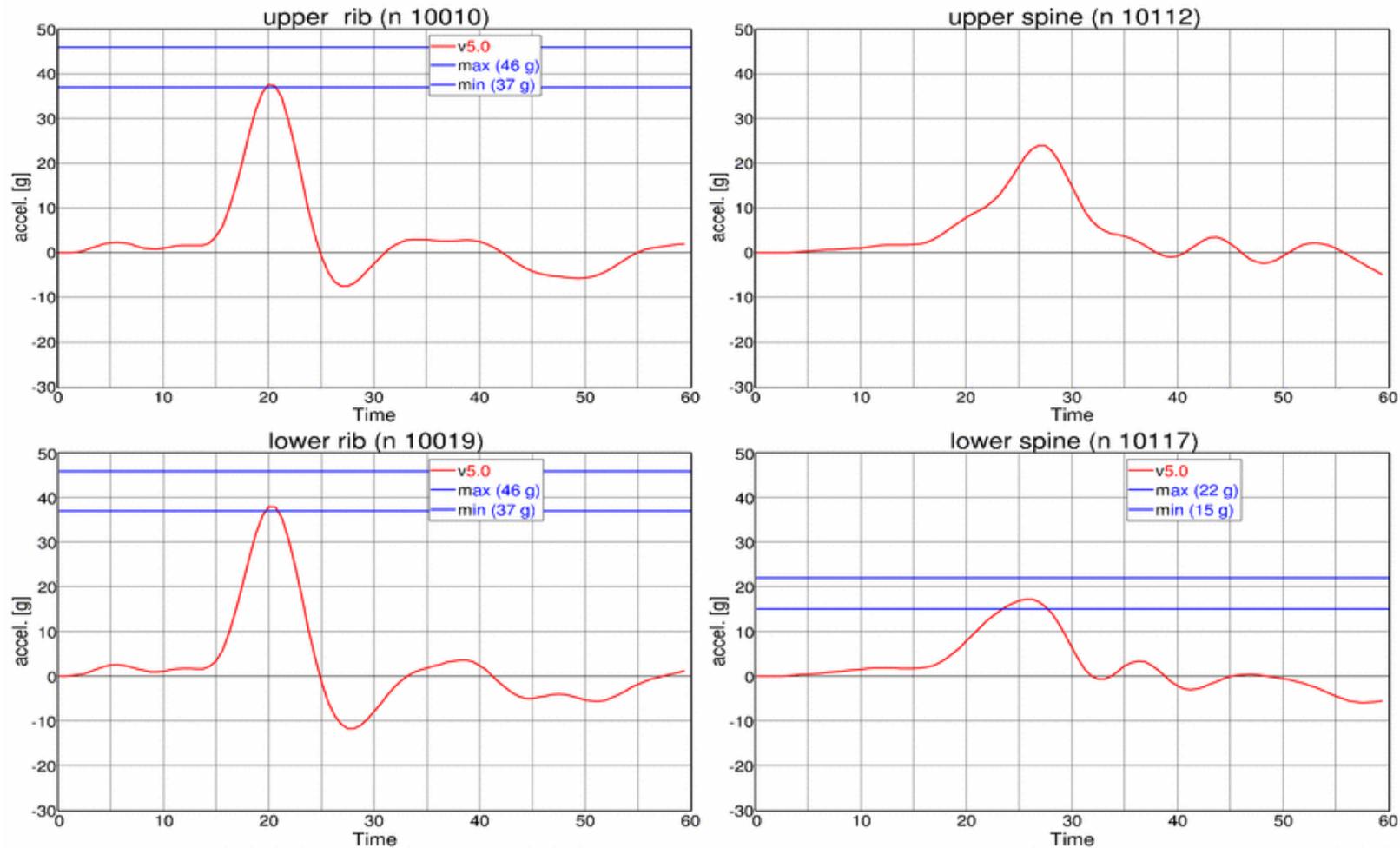- Pelvis calibration test
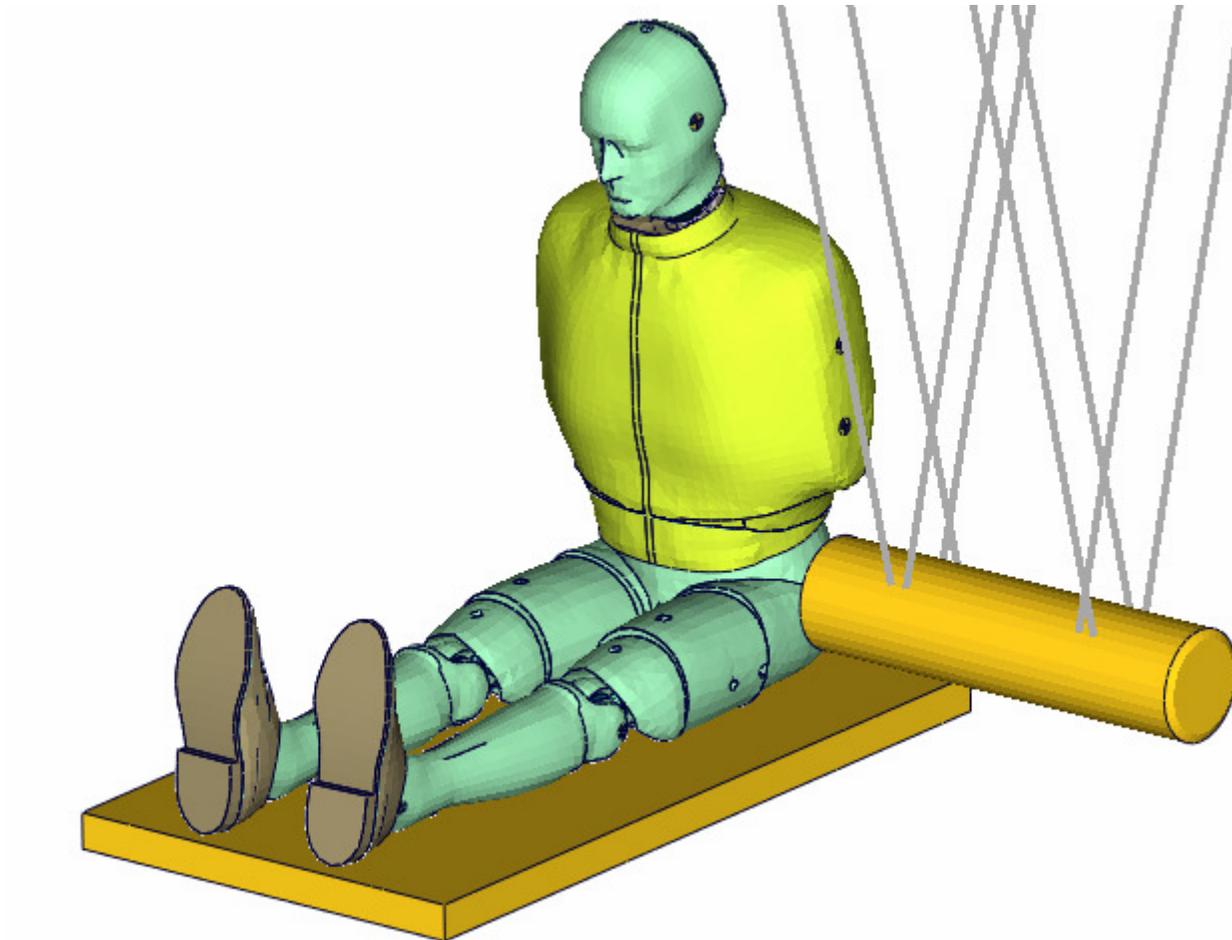
- Pelvis calibration test
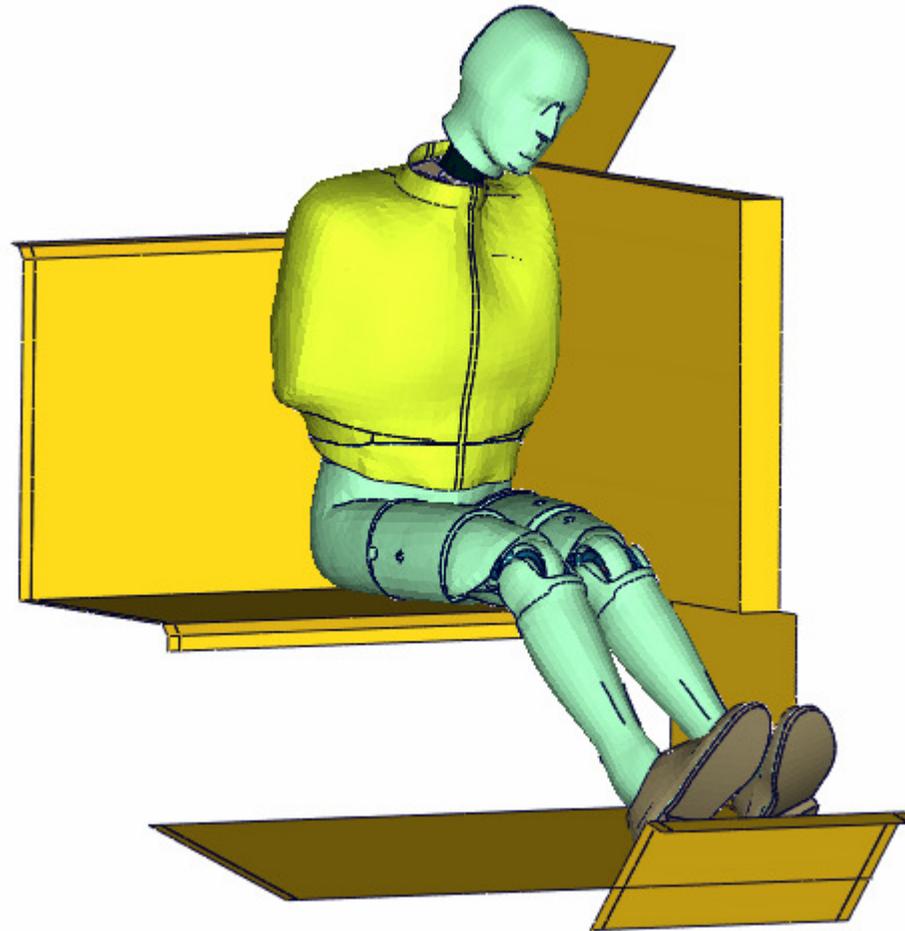
- Thorax calibration test
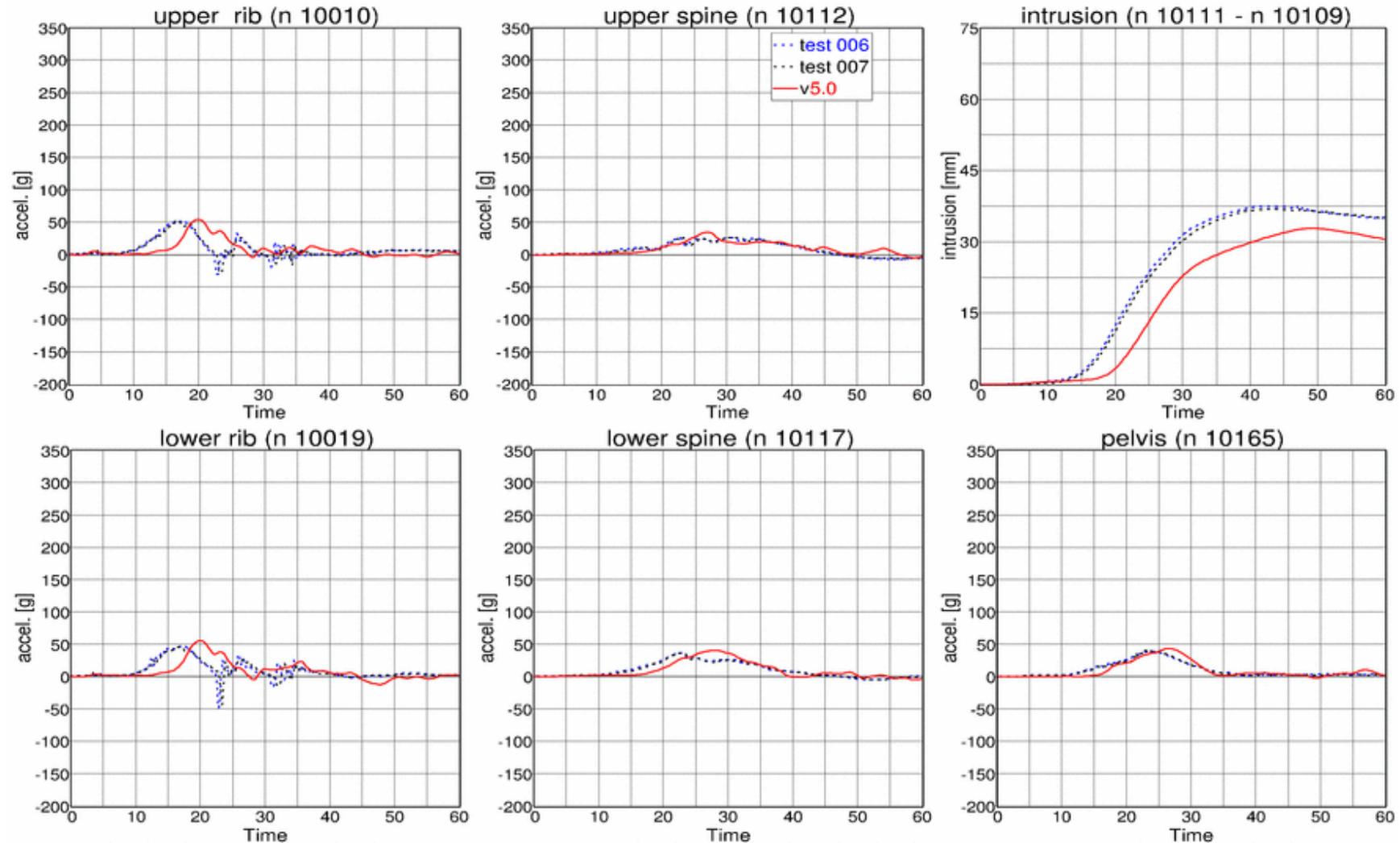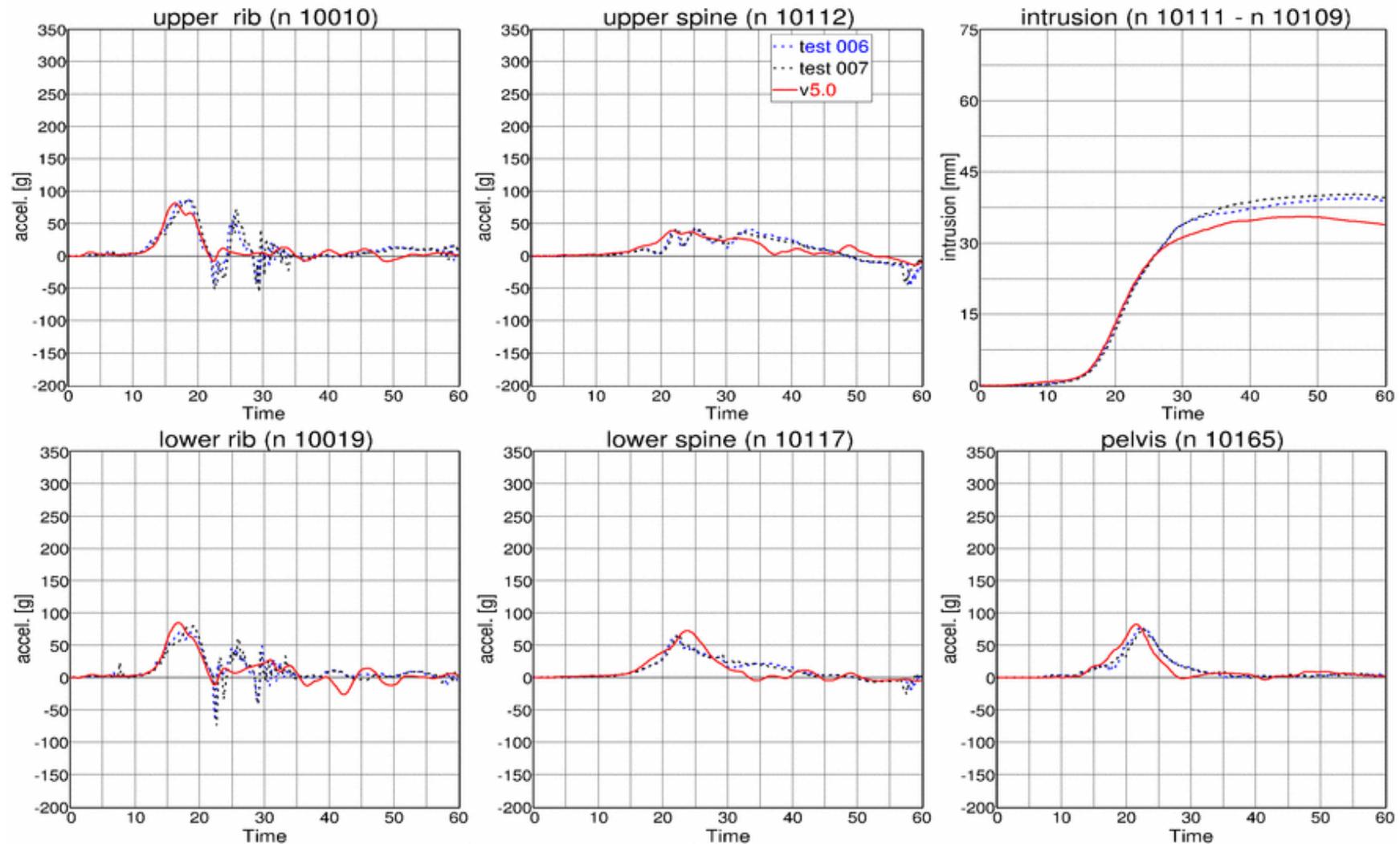
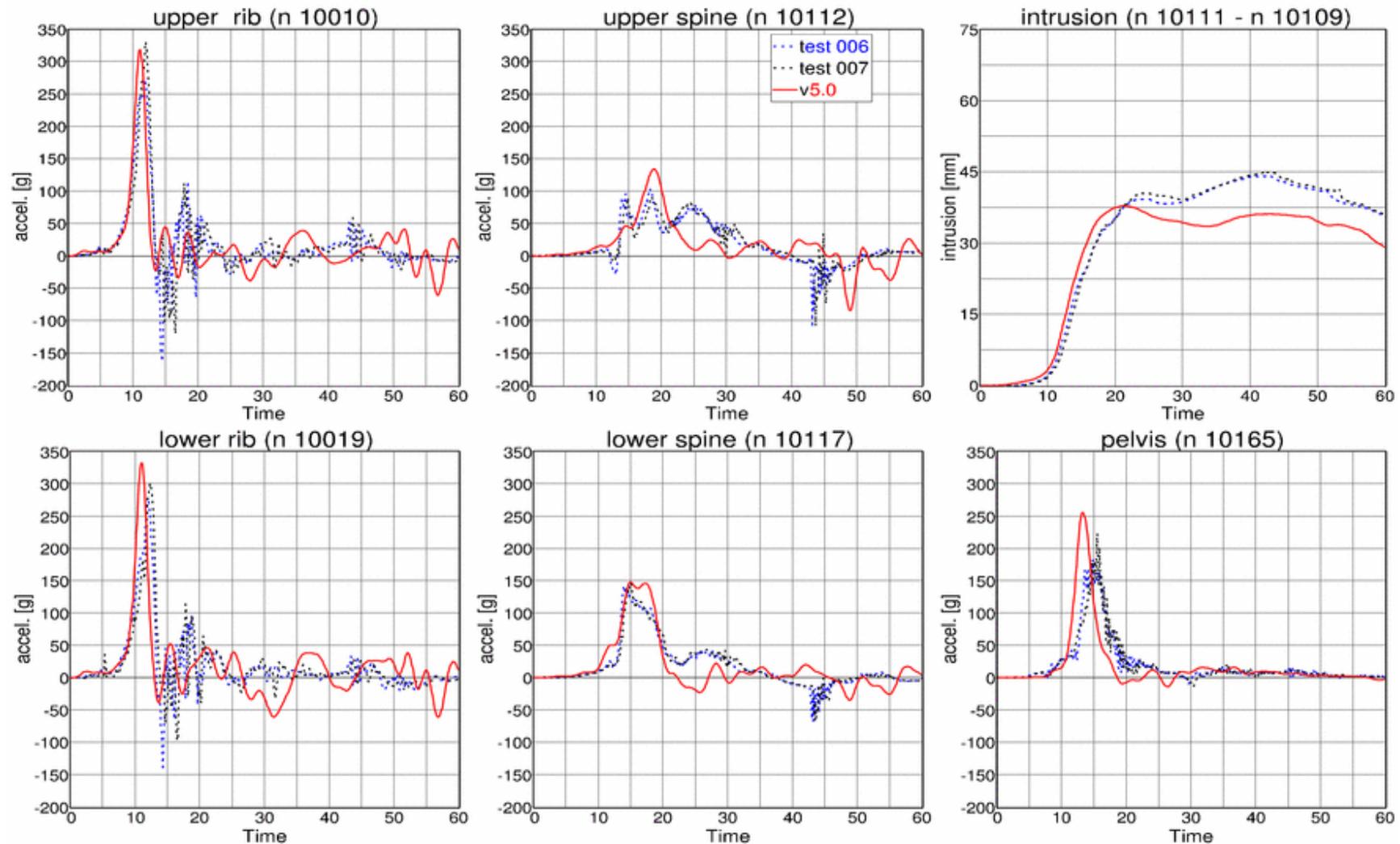- Thorax calibration test

- Plane barrier

- v1 m/s

- v2 m/s
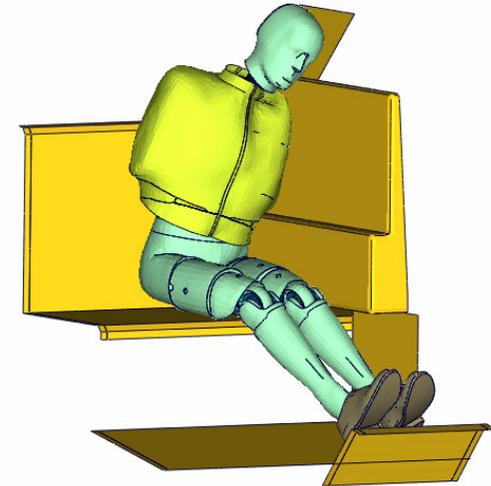
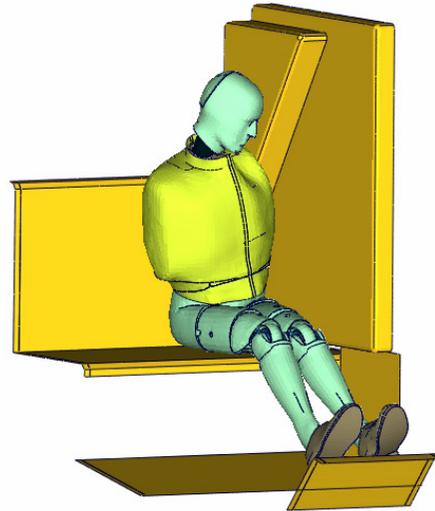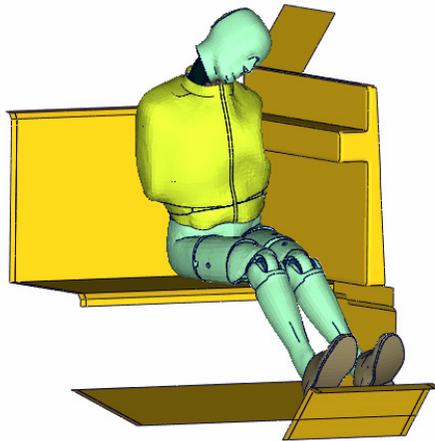- v3 m/s

- Plane barrier v1 m/s

- Plane barrier v2 m/s

- Plane barrier 8 m/s

- Further barriers used

- Results of complete set of barriers please see in the documentation of USSID v5.0.
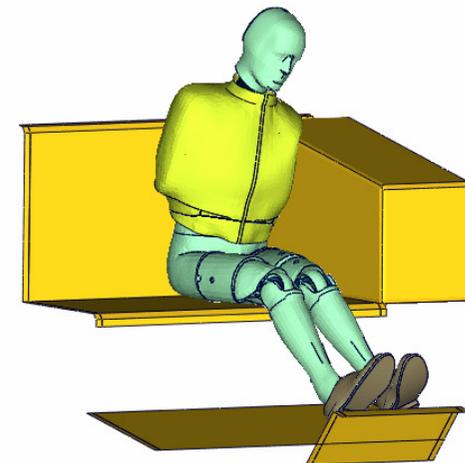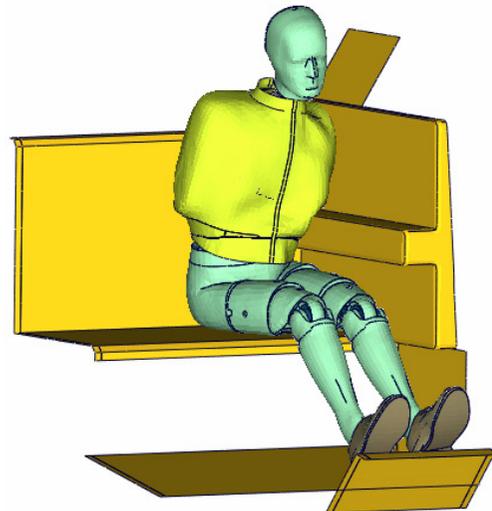
# FAT Dummy Models: Update and News

- SID and RID Models:

  - BioRID II v2.0 latest changes to the model

  - USSID v5.0 latest changes in the model

  - **ES-2, ES-2re v4.0 latest changes to the model**

  - ES-2, ES-2re news for the following release

  - Further developments for all DYNAmore dummy models

# FAT ES-2, ES-2re v4.0

- FAT ES-2/ES-2re:

  - ES-2 is used in the ECE / Euro NCAP and European 90° pole test

  - ES-2re proposed in new FMVSS 214 (barrier and 75° pole test)

  - Finite Element Models have been developed with FAT

  - FAT: German Association for Automotive Research

  - Members of the FAT:

  Audi   Autoliv   BMW
  Karmann   Mercedes   Opel
  Porsche   Volkswagen
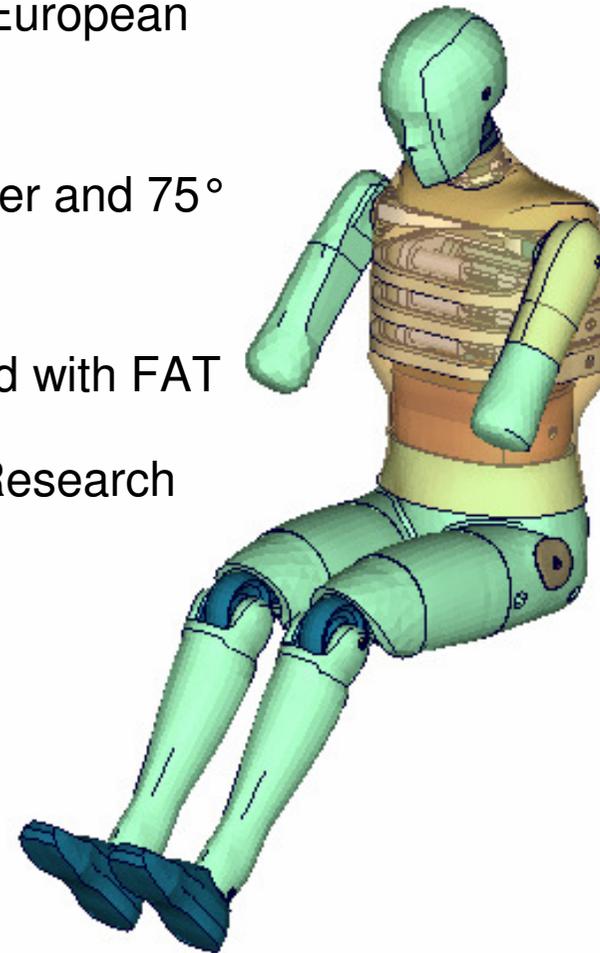
- FAT ES-2:

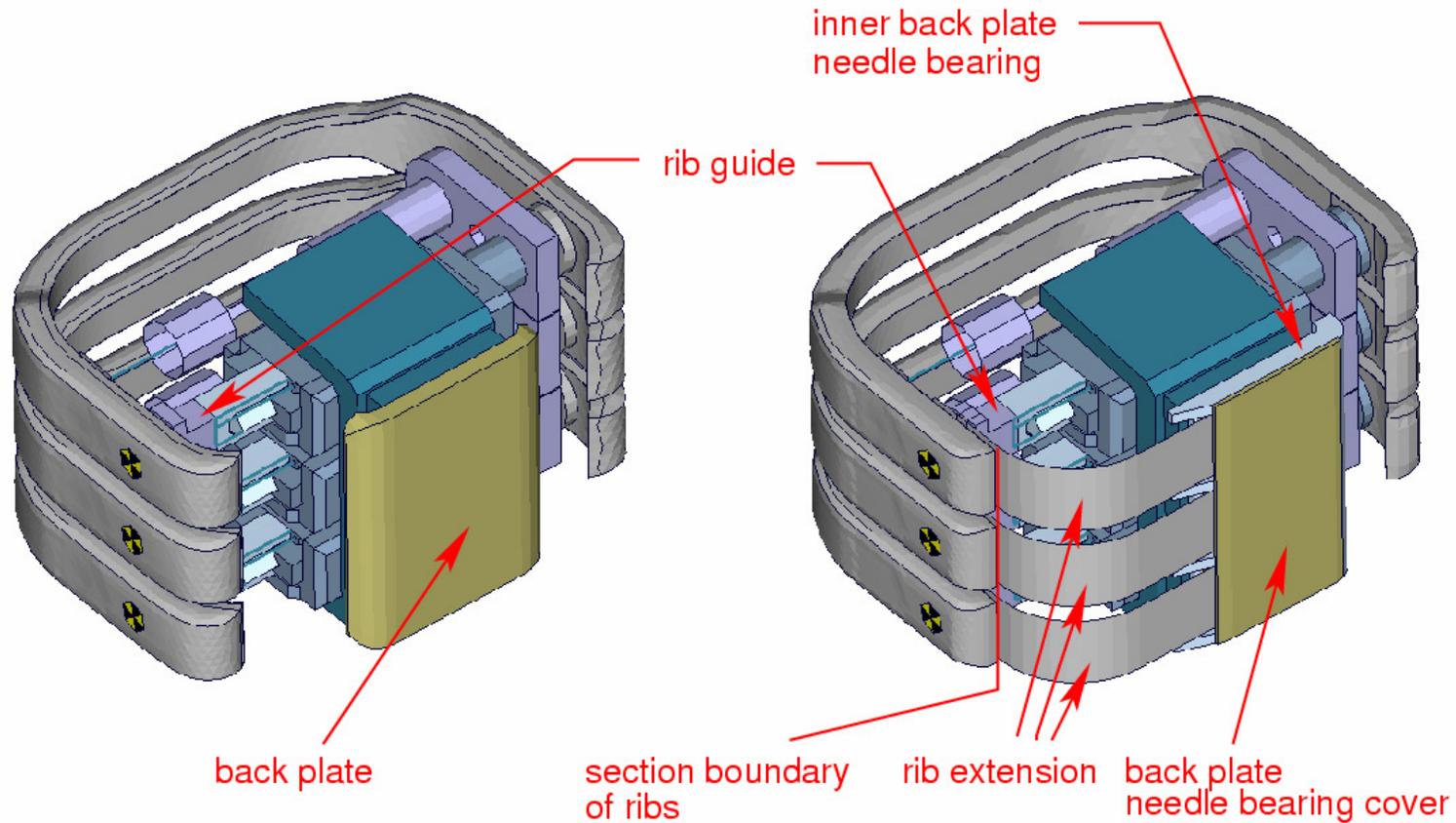   - Nodes: 84,060

    - Beams: 313

    - Shells   69,185

    - Solids: 130,631

    - Material: 109

    - Parts: 236
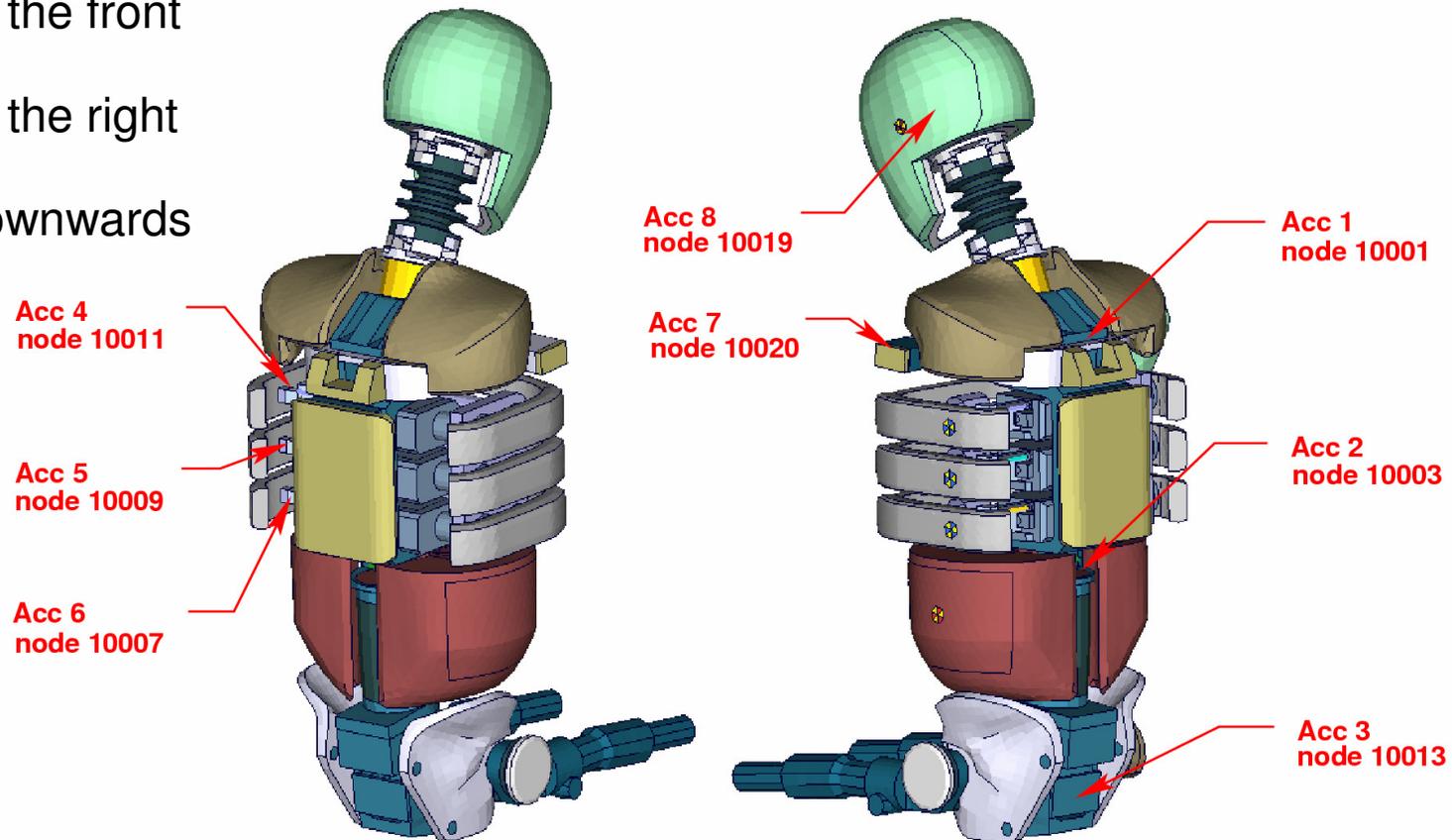
    - Joints   19

    - Contacts: 8
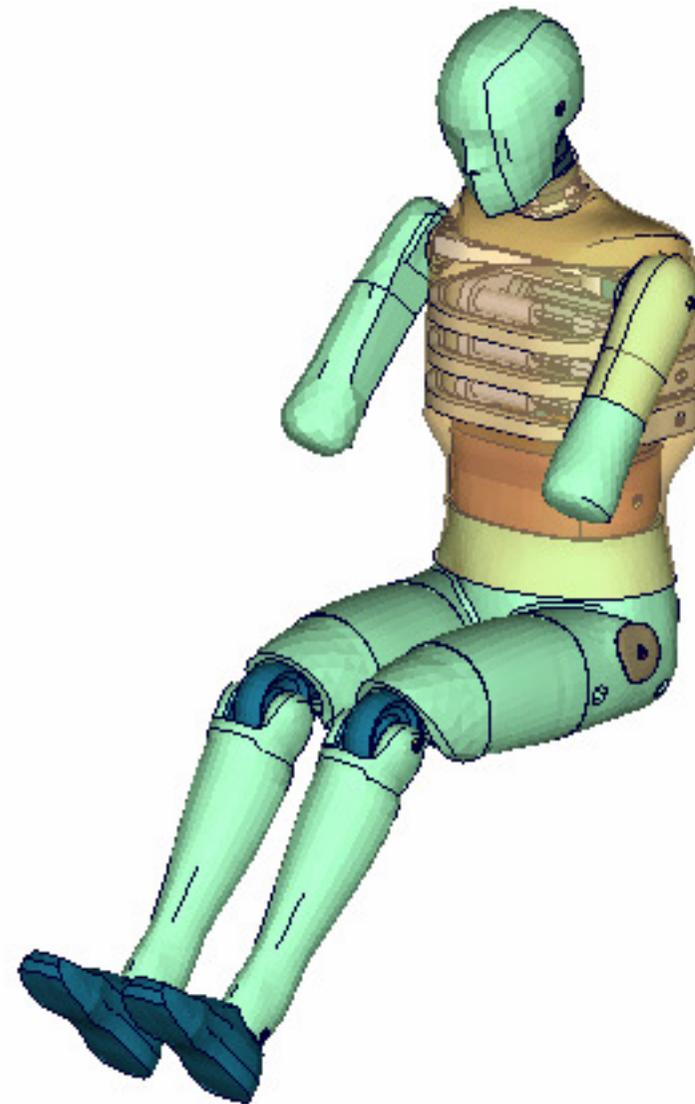
- Major differences between ES-2 and ES-2re

- Accelerometer in the ES-2/ES-2re are now oriented according to the SAE norm.

- In the standing position of the dummy the directions are:

- X-axis to the front

- Y-axis to the right

- Z-axis downwards

Acc 4
node 10011

Acc 5
node 10009

Acc 6
node 10007

Acc 8
node 10019

Acc 7
node 10020

Acc 1
node 10001

Acc 2
node 10003

Acc 3
node 10013

- Geometric modifications

  - Clavicle position of an physical dummy is measured very accurate and updated in the software model.

  - Straps between clavicle box and clavicle is remodeled and validated with the shoulder pendulum certification tests.

  - Arm joint has been modified to catch friction in the joint.

  - Shoes have been modeled to catch the heel point in the full car.

element 10002

**rigid Parts**

deformable Part

DYNAMORE
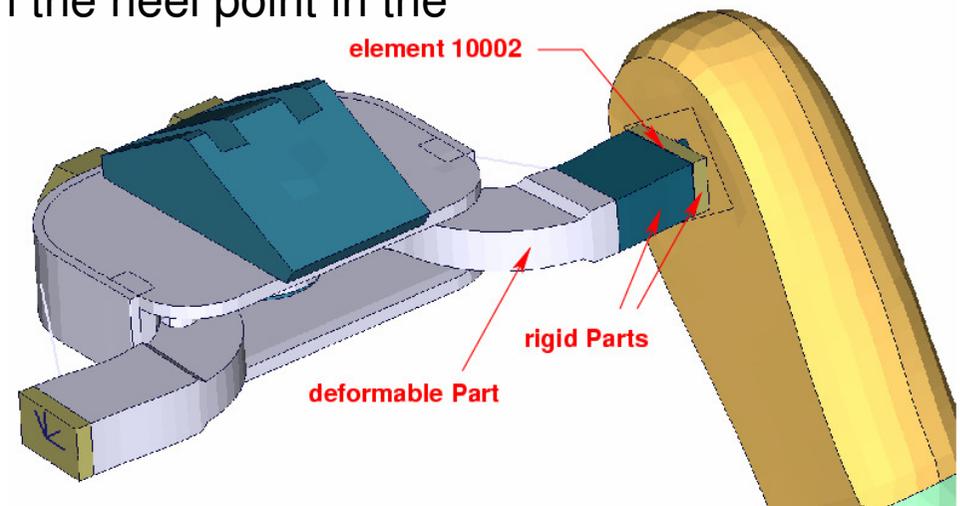
- Rib foam has been connected to the rib steel by merging the nodes of rib steel and rib foam (more stable behavior then using tied contact).

- Rib steel has been connected to the rib guide by using hexahedron elements.

- Rib guide joints have been elongated (increases stability for large deformations).
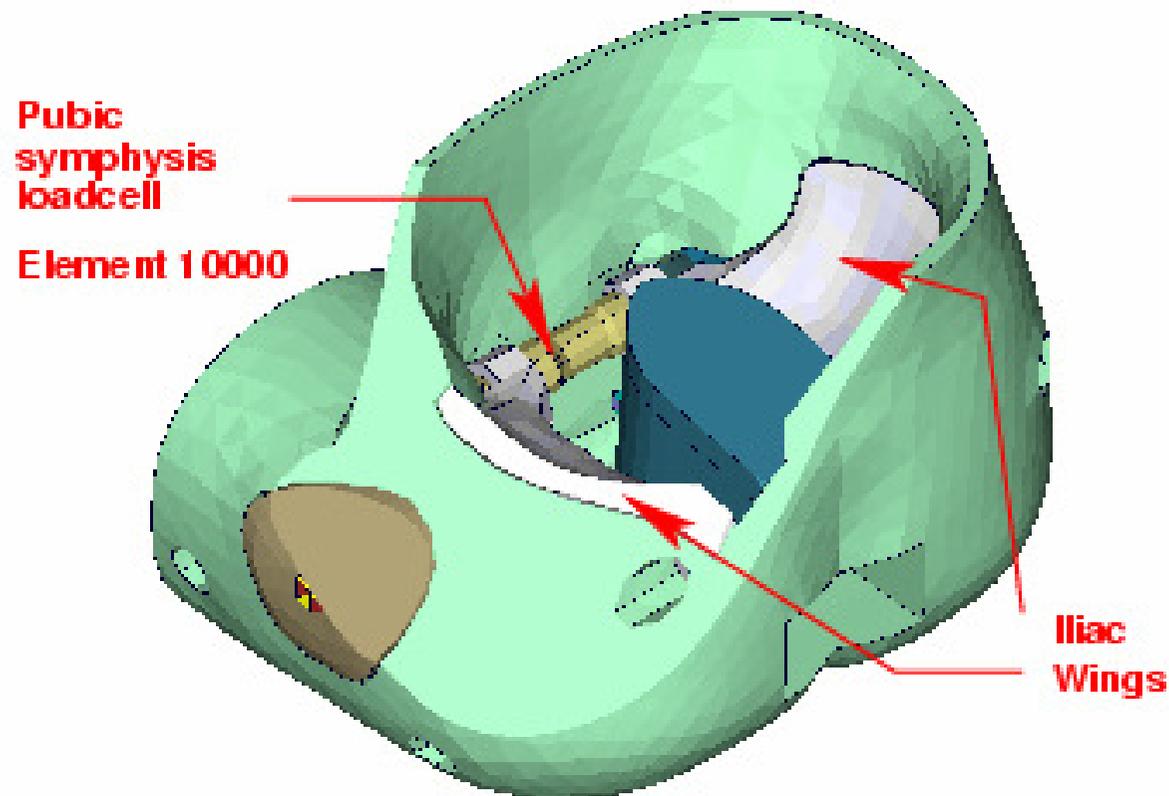

rib guide

back plate
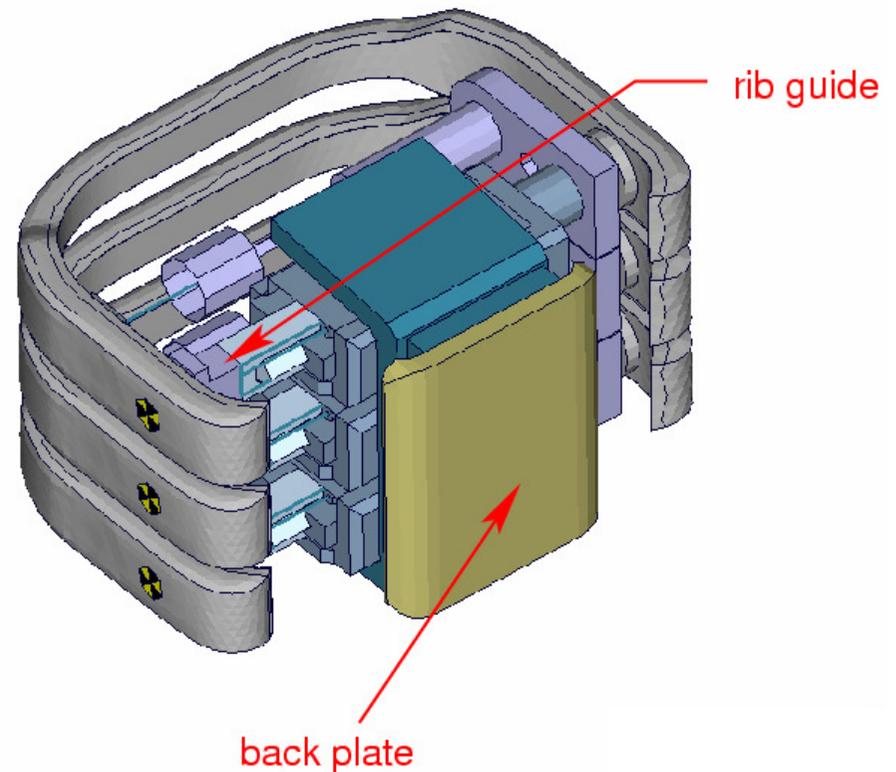
- A rubber stopper has been modeled to limit negative intrusions fore each rib.

- This gives very good correlations in single rib tests.
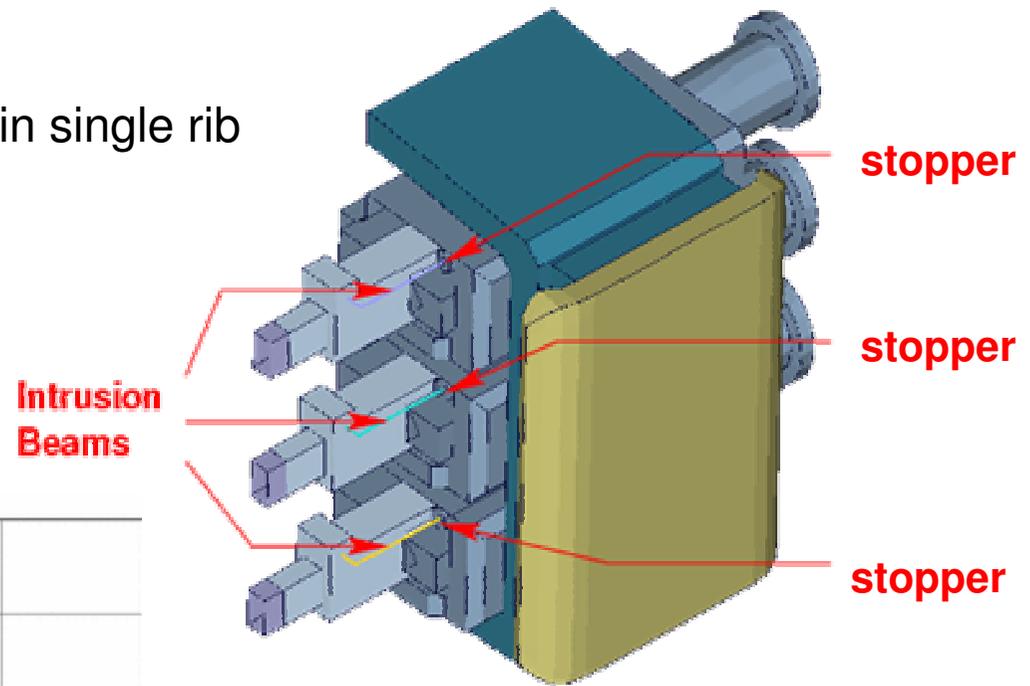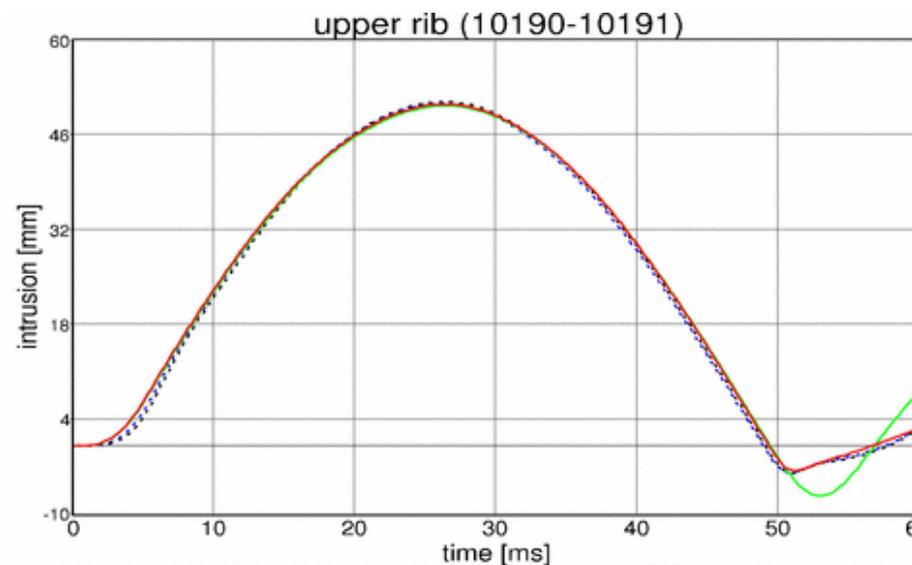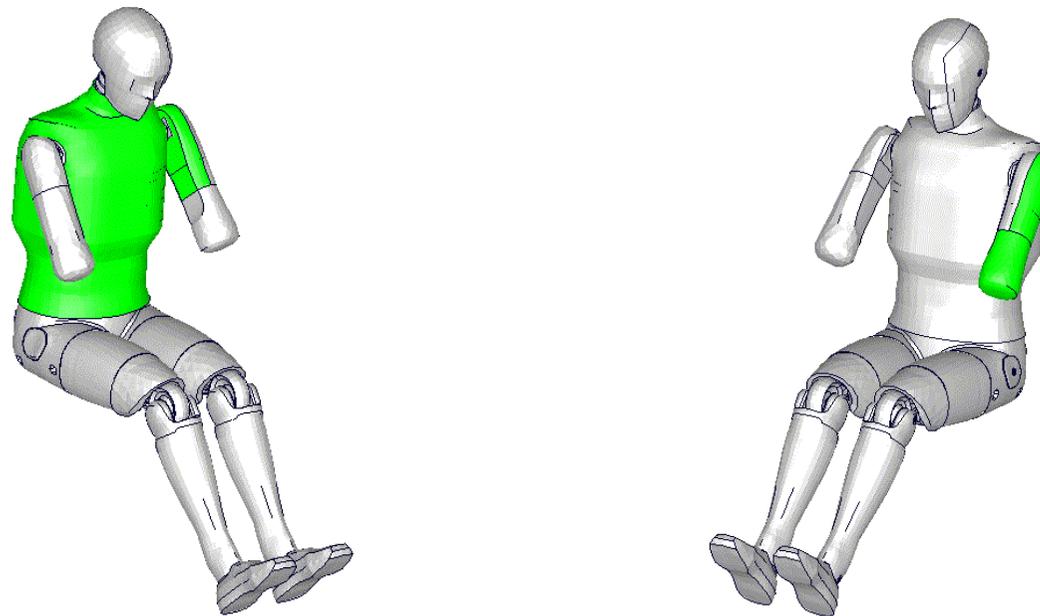
- Materials properties of pelvis, iliac, femur
 stopper and spine have been changed.

- Friction parameters have been changed.

- The friction values are tested for the BioRID II model and these results where also used for the ES-2.

- There through also the friction parameters between jacket and arm are changed → influence on arm kinematics.
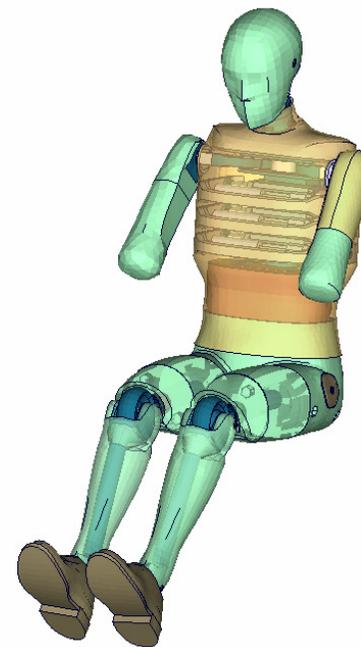
- Handling modifications

- New property sets 1500 and 1501 has been created to define contacts.
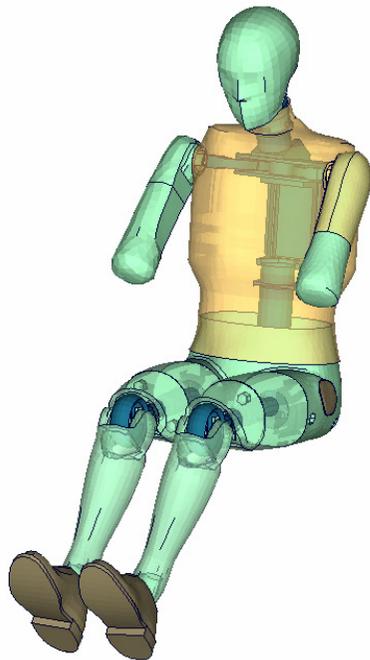
1500: dummy to environment


1501: exclude set for global contact

- Primer tree-file has been modified:

  - red: global coordinate system

  - blue: local coordinate system

  - The coordinate systems are located in the H-Point and they are connected by an spherical joint.

 - The initial pelvis angle is shown in the PRIMER
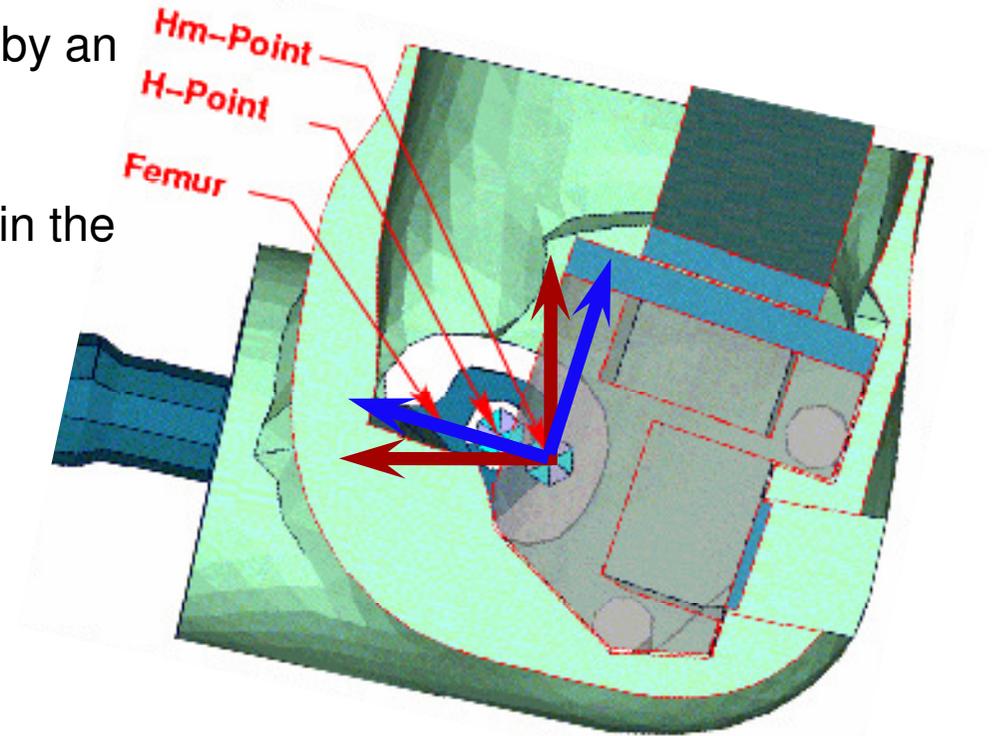
- A separate file including null shell elements to close gaps in the model.

- The user can feel free if he wants to use this Include file ore not.
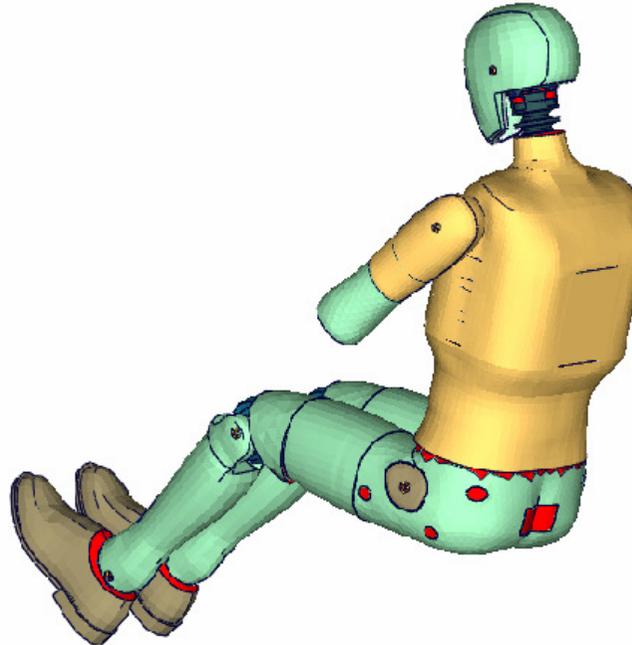
- A separate file to position (rotation without penetrations) the upper legs is delivered. Therefore the user has only to define the angels as parameters.

- Attention for a value of zero there must defined a very small value (do not use 0.0)

- Additional modifications on ES-2re:

  - The geometry of back plate has been modeled more accurate.

  - The friction parameters between back plate and rib extension have been changed.

machined aluminium inner back plate

needle bearing locations
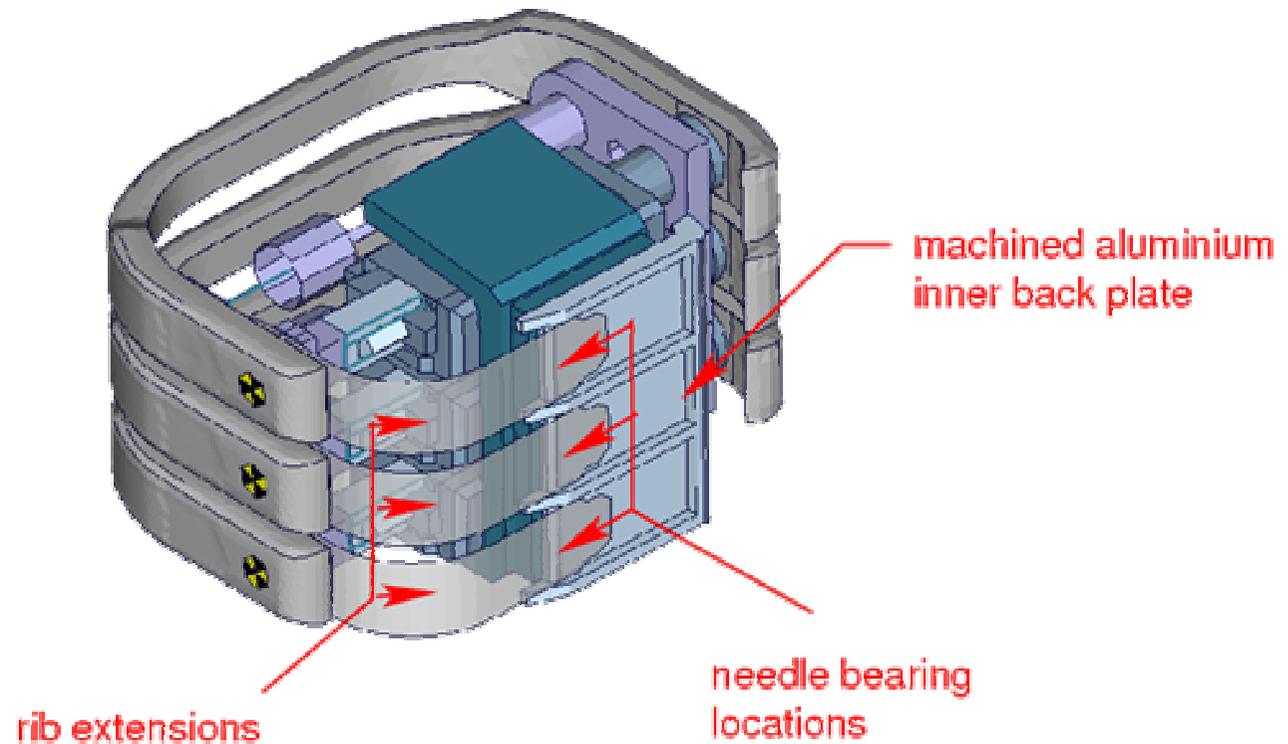
rib extensions

- Three new force transducer contacts have been added on the rib extensions.

- They can be used to measure forces between seat frame and rib extension

rib extension force – upper rib

rib extension force – middle rib
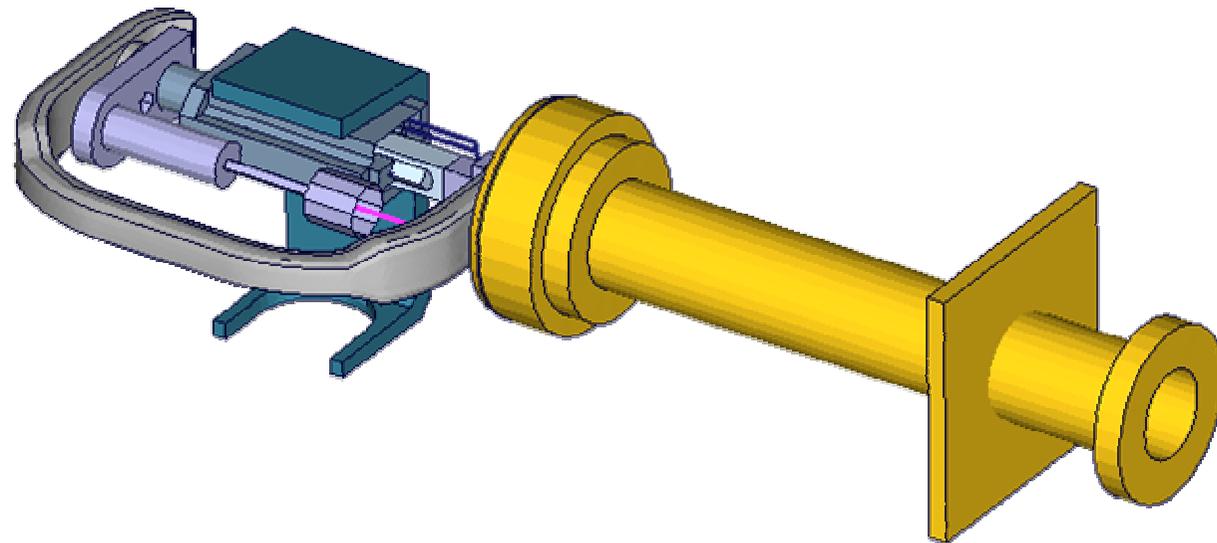
rib extension force – lower rib
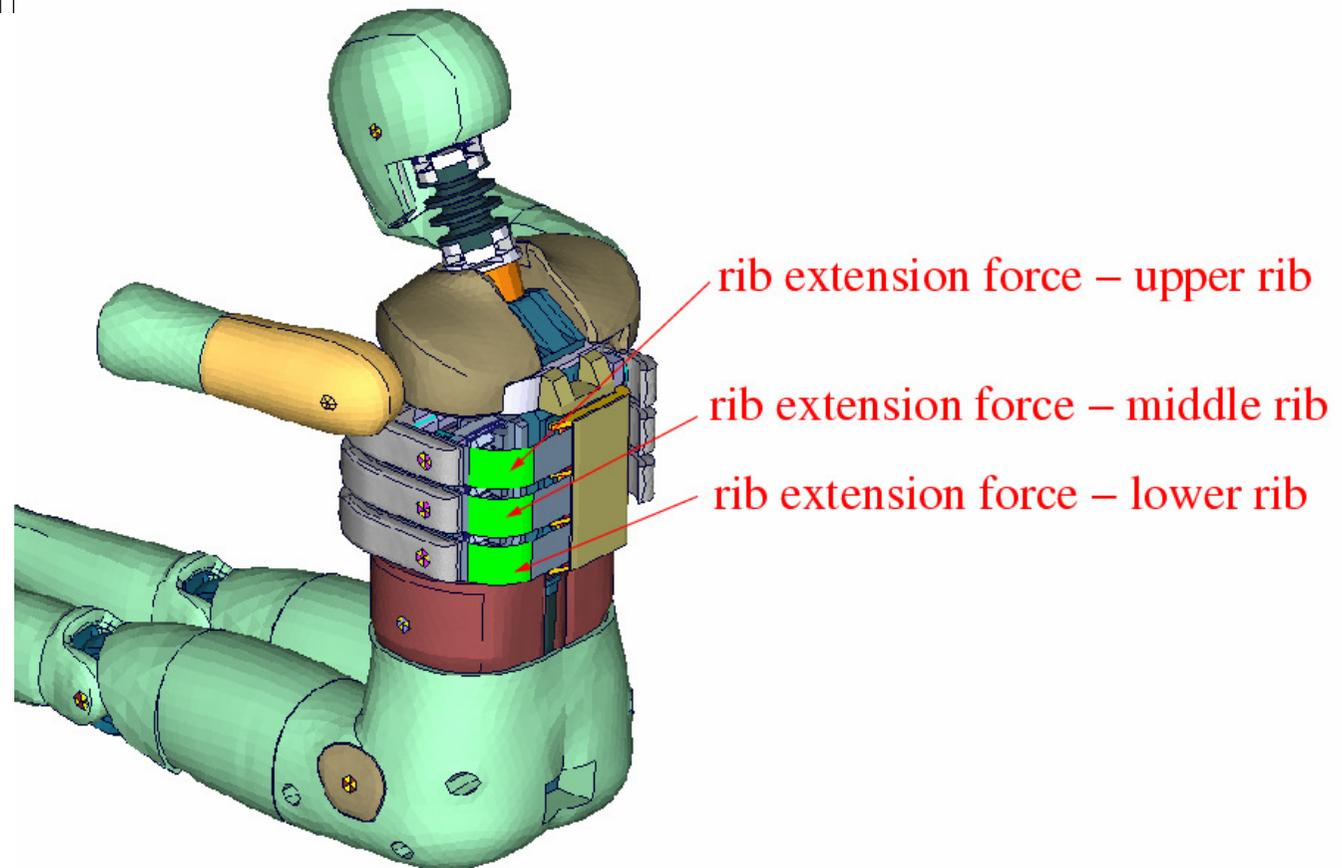
- ES-2re model has been validated with new pendulum test

    - 0 degree pendulum with low and high velocities

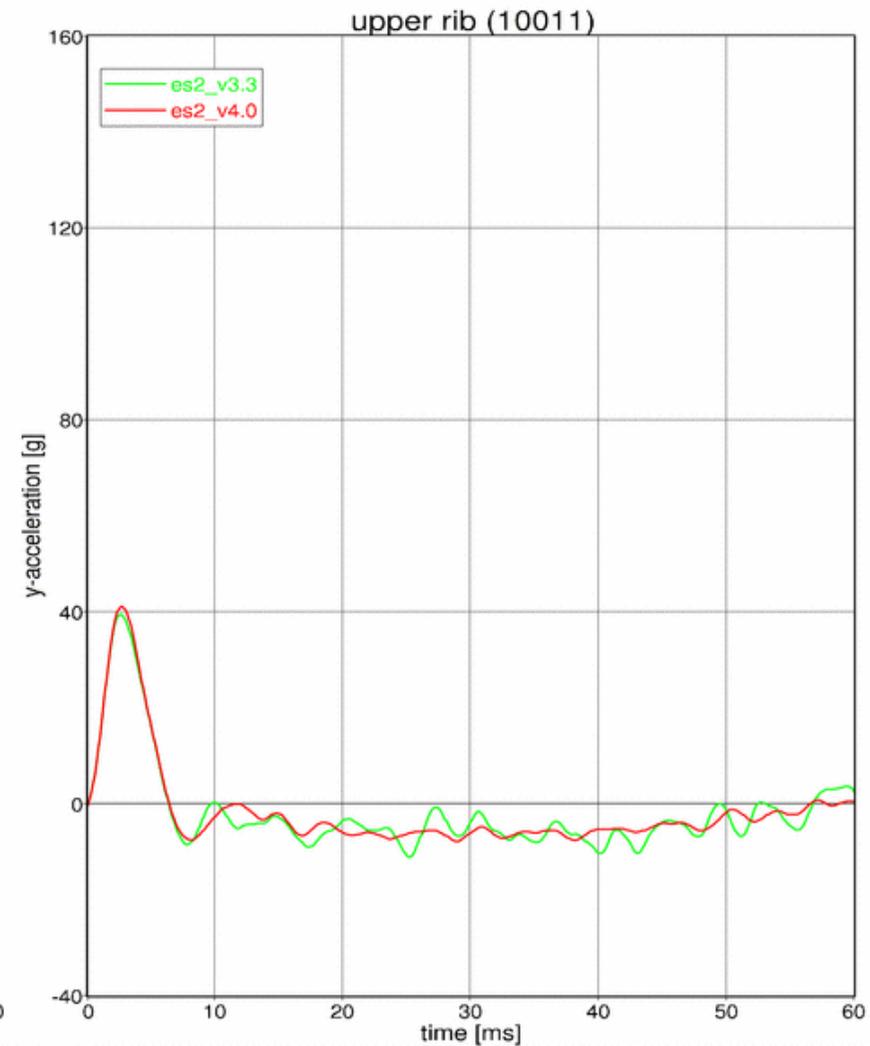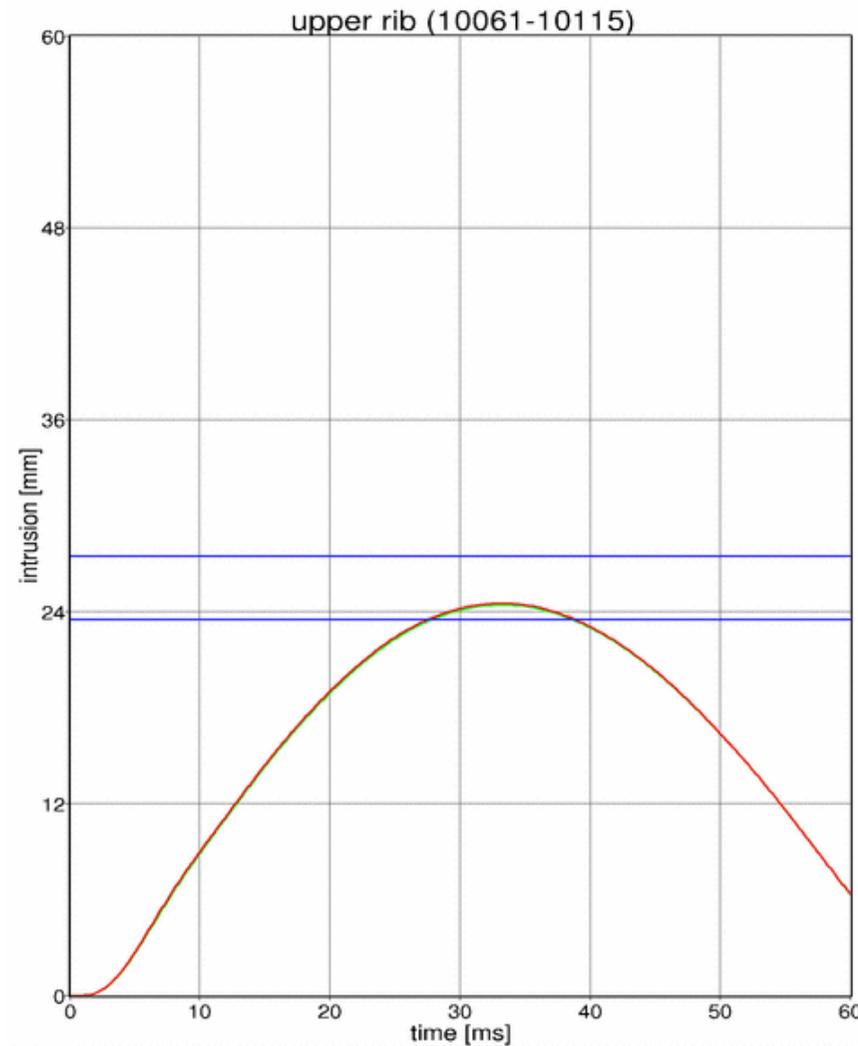   - 45 degree pendulum with two different velocities
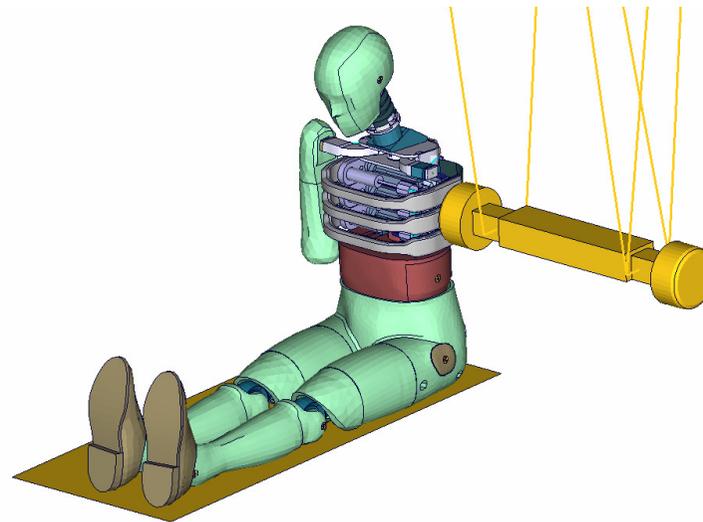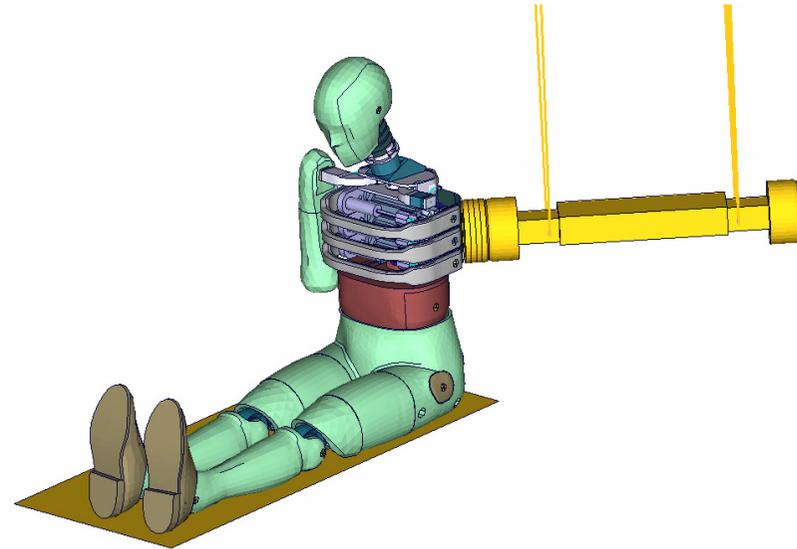
- Pendulum calibration tests on ES-2 rib module:

  - Target point is the center of the piston bearing

  - The spine is fixed in space.
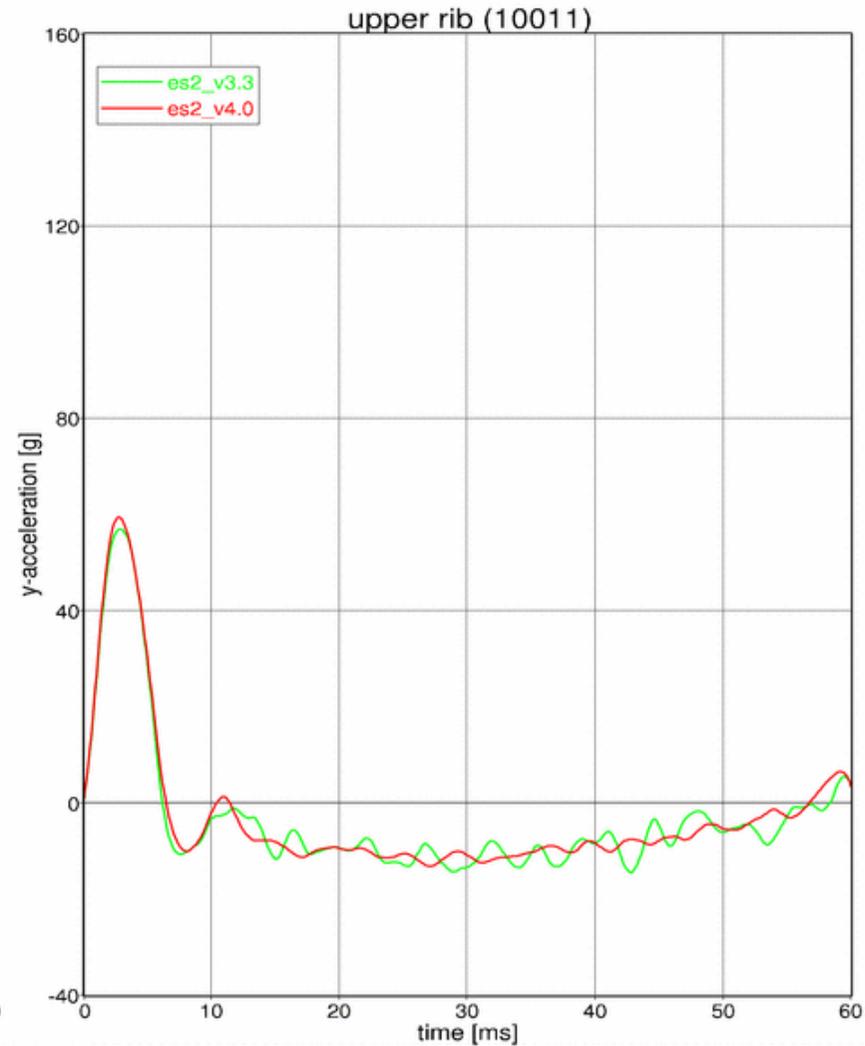
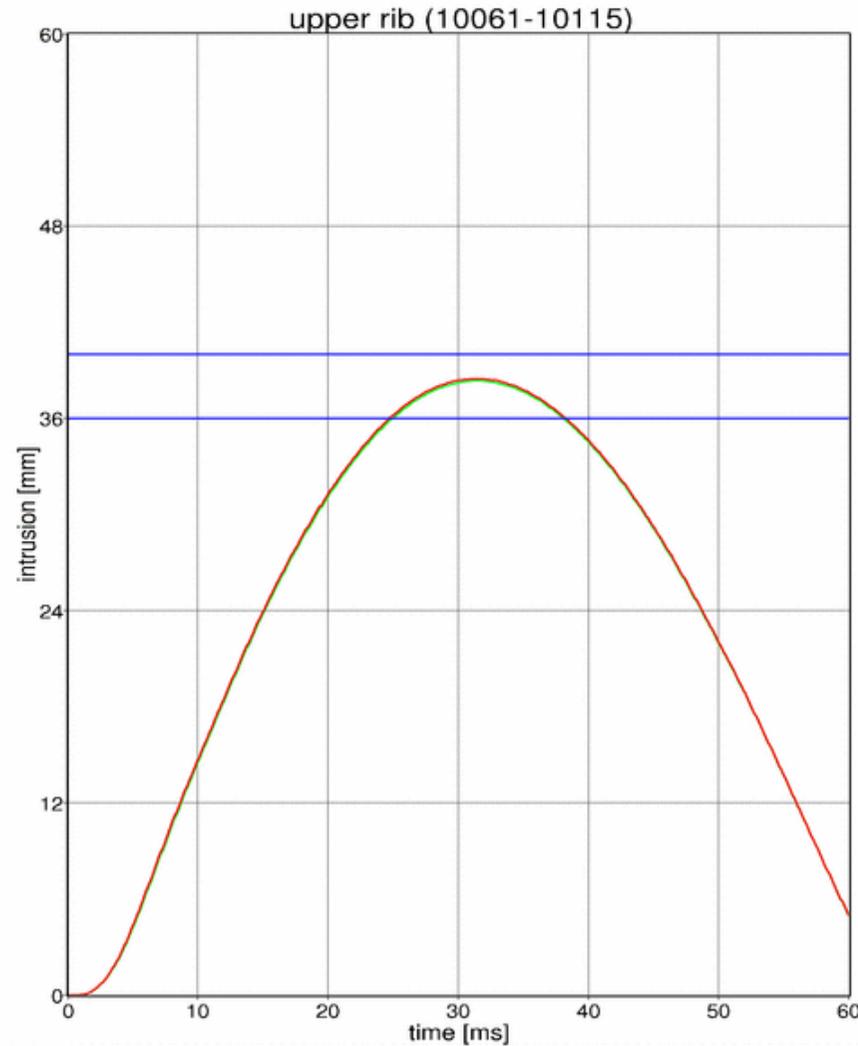 - Three different speeds

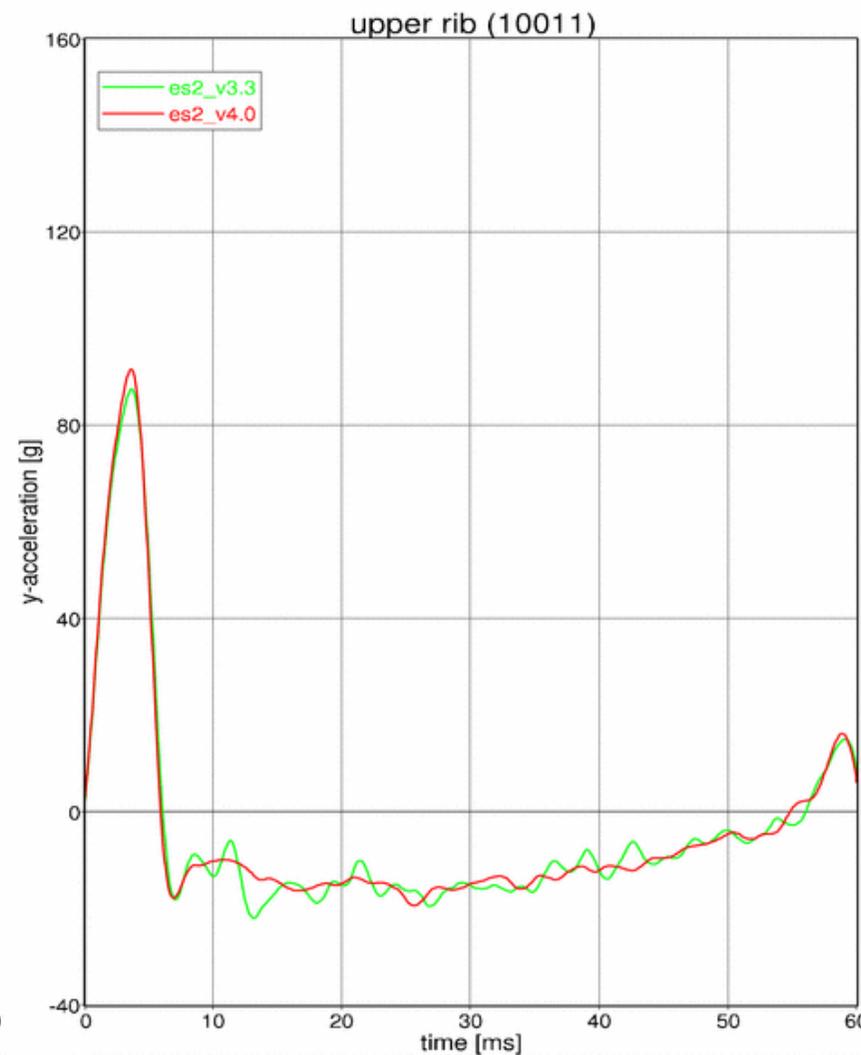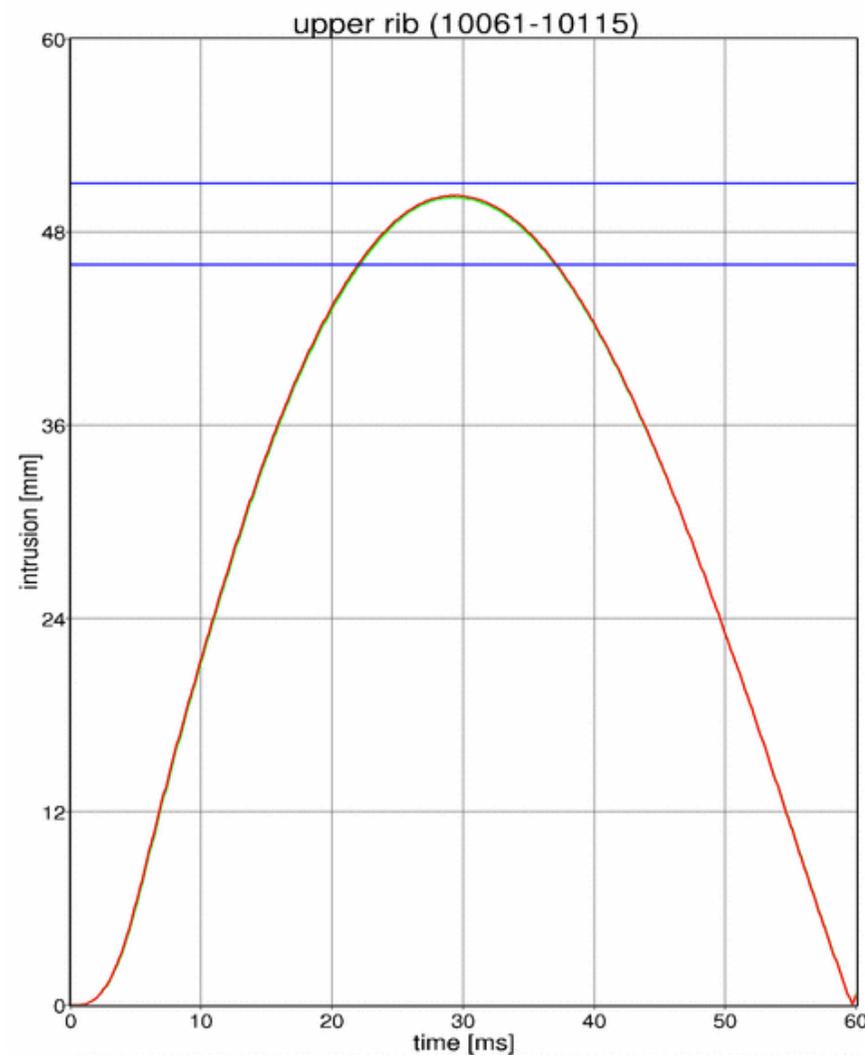 - v1 m/s

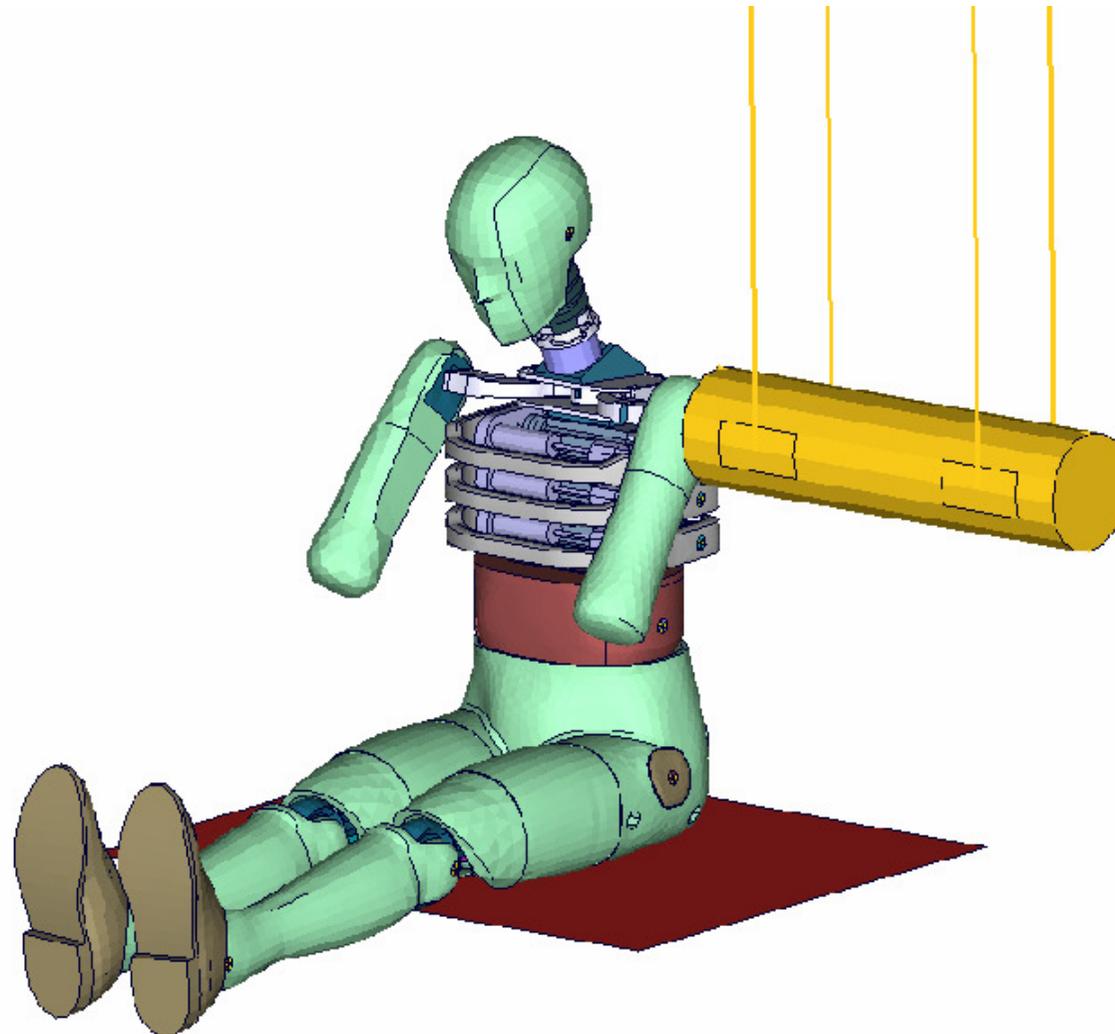 - v2 m/s

  - v3 m/s

- Pendulum v1 m/s
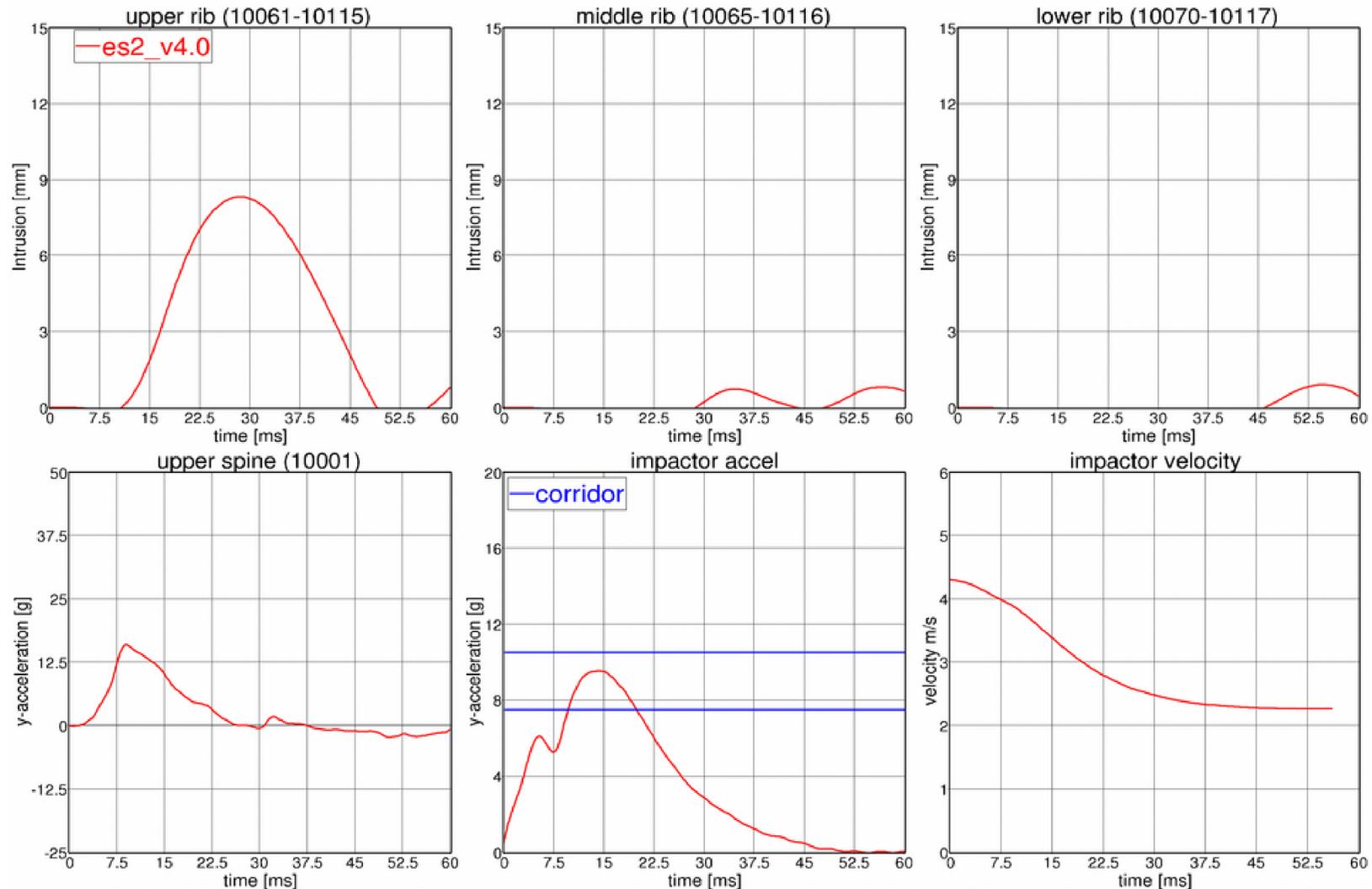
- Pendulum v2 m/s

- Pendulum v3 m/s

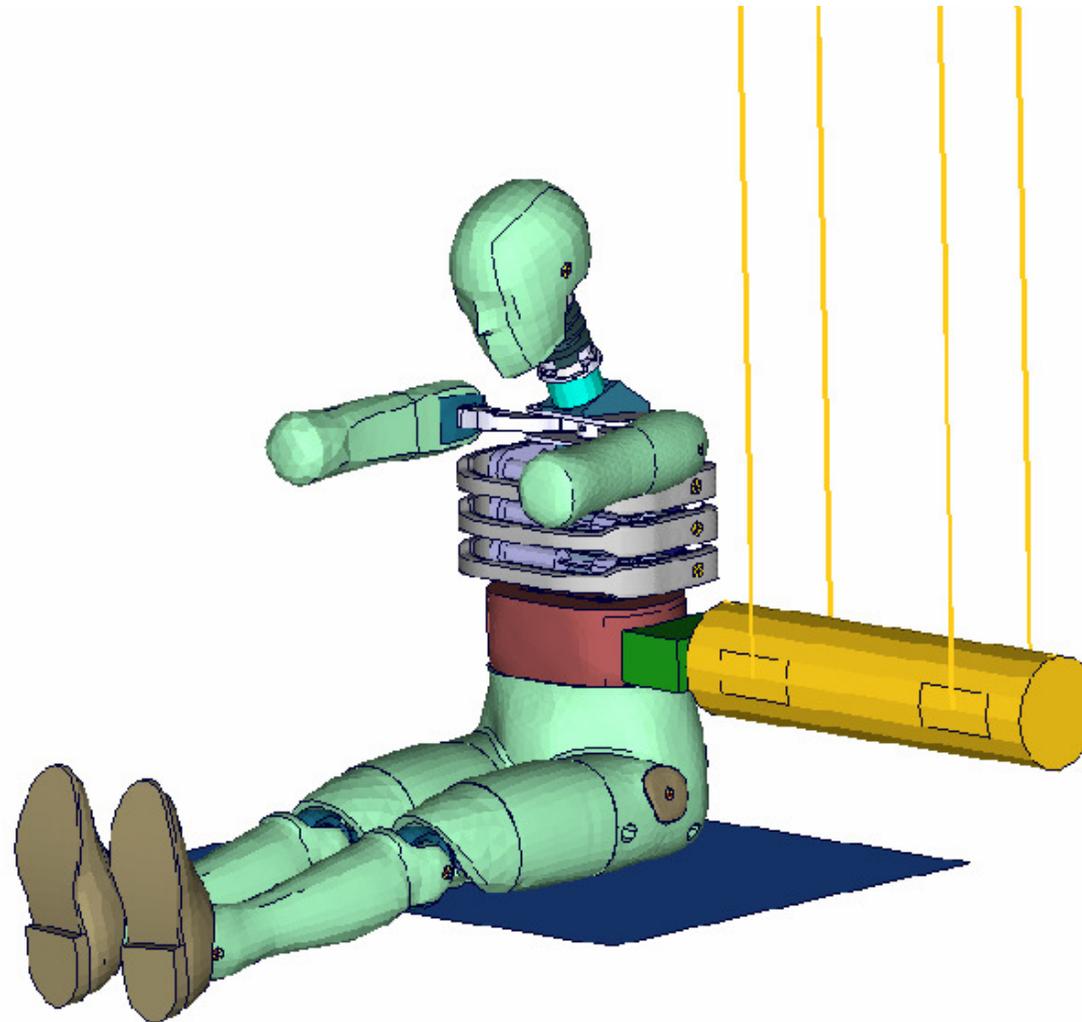- Shoulder pendulum calibration tests on ES-2

- v1 m/s

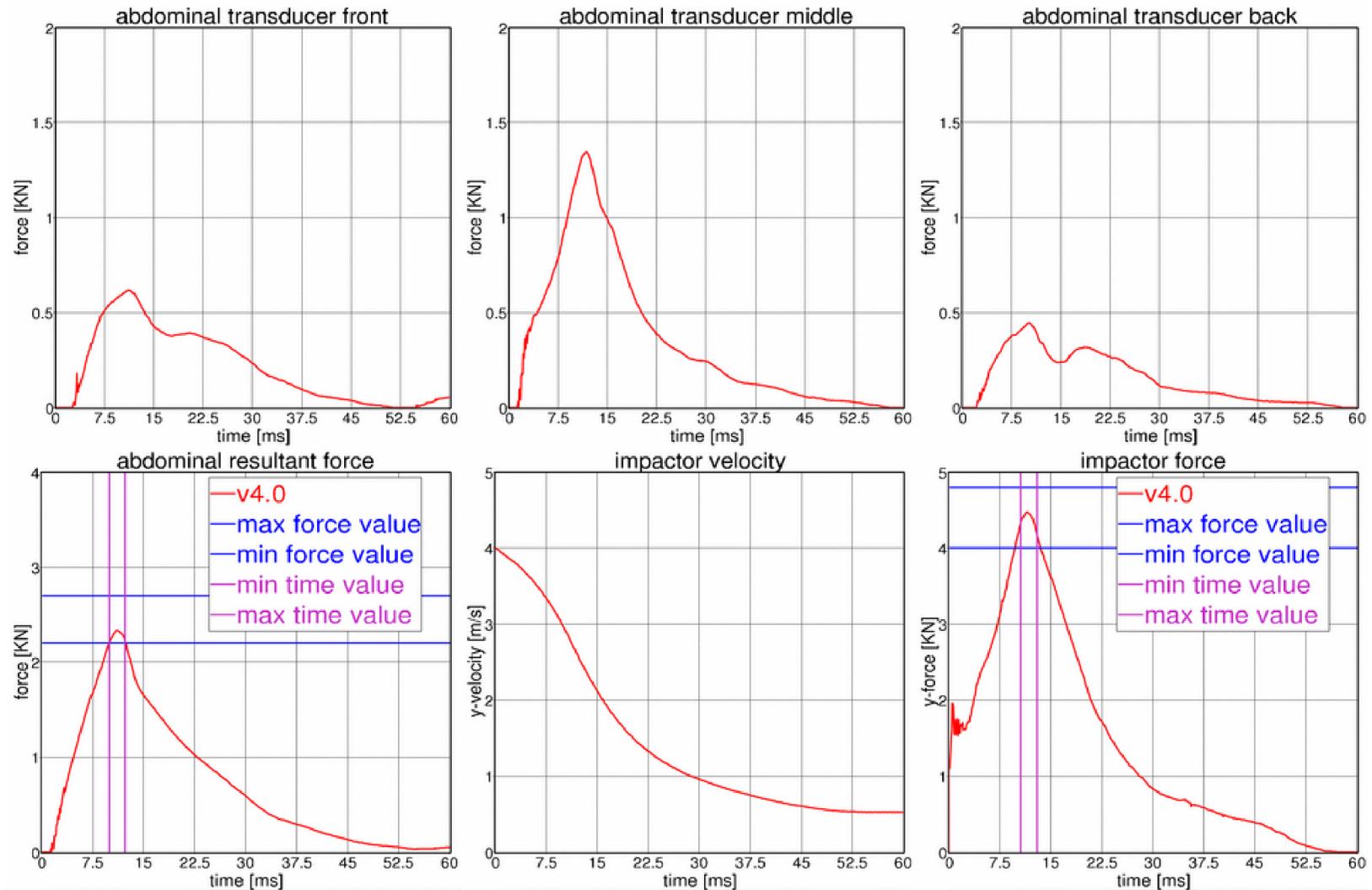- Shoulder calibration pendulum
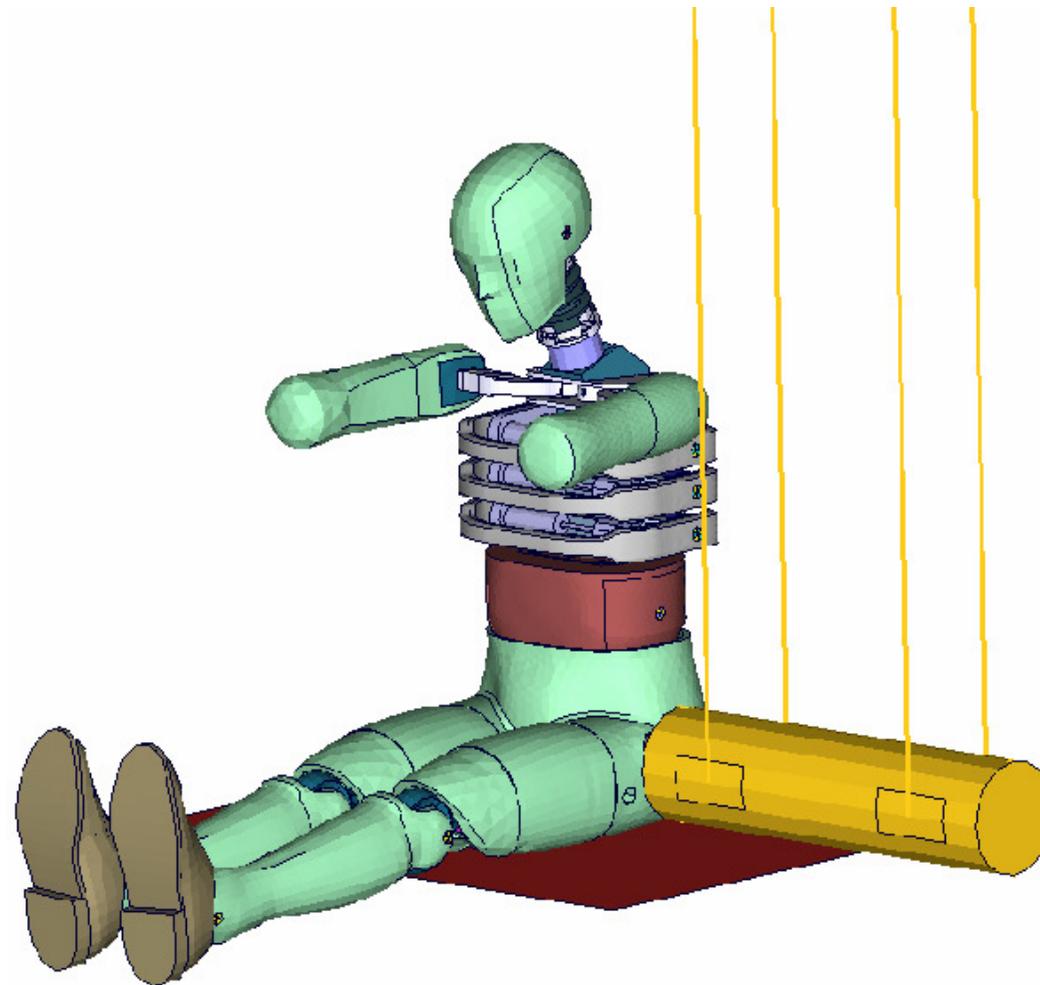
- Abdomen pendulum calibration tests on ES-2

- v1 m/s

- Abdomen calibration pendulum

- Pelvis pendulum calibration tests on ES-2
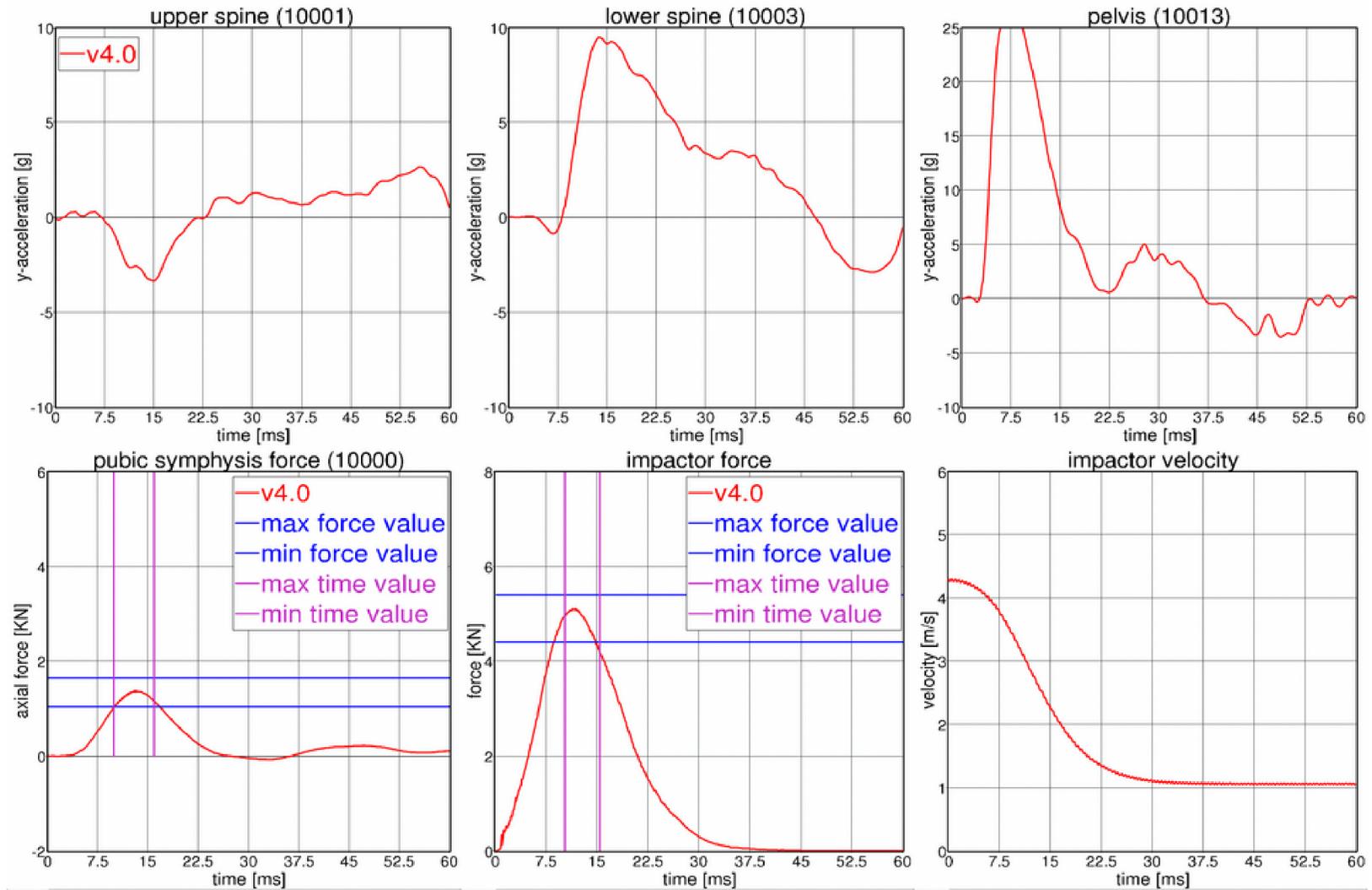
- v1 m/s

- Pelvis calibration pendulum

- Plane barrier

- Rigid barrier

- Middle velocity

- 40° arm position
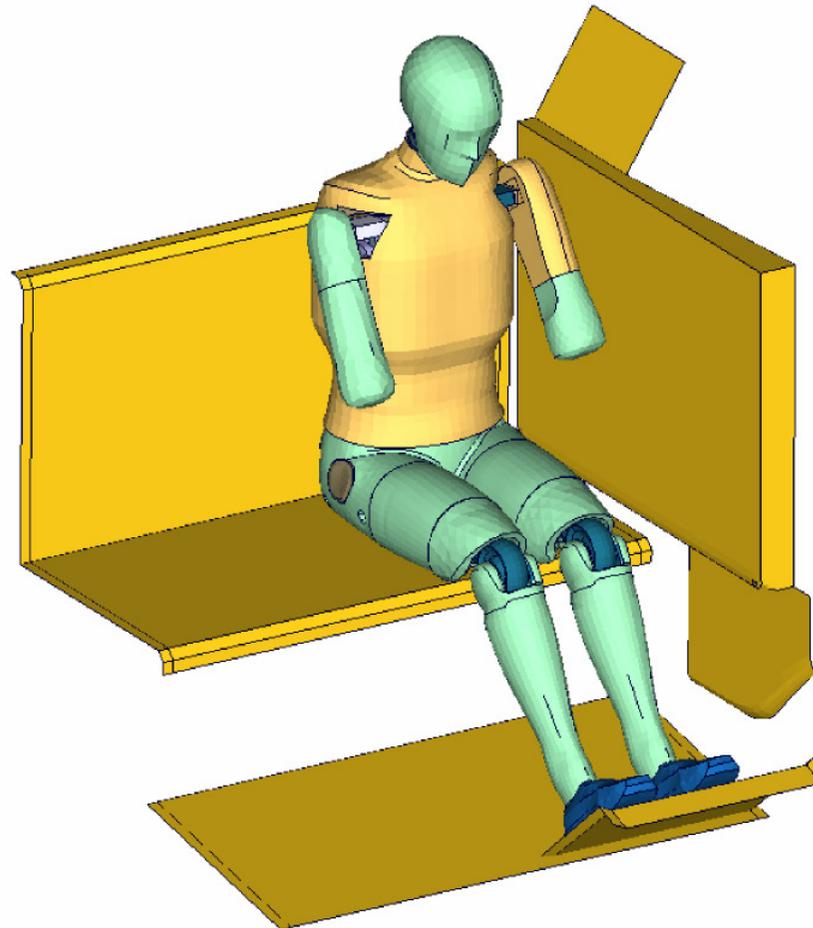
- Plane barrier middle velocity
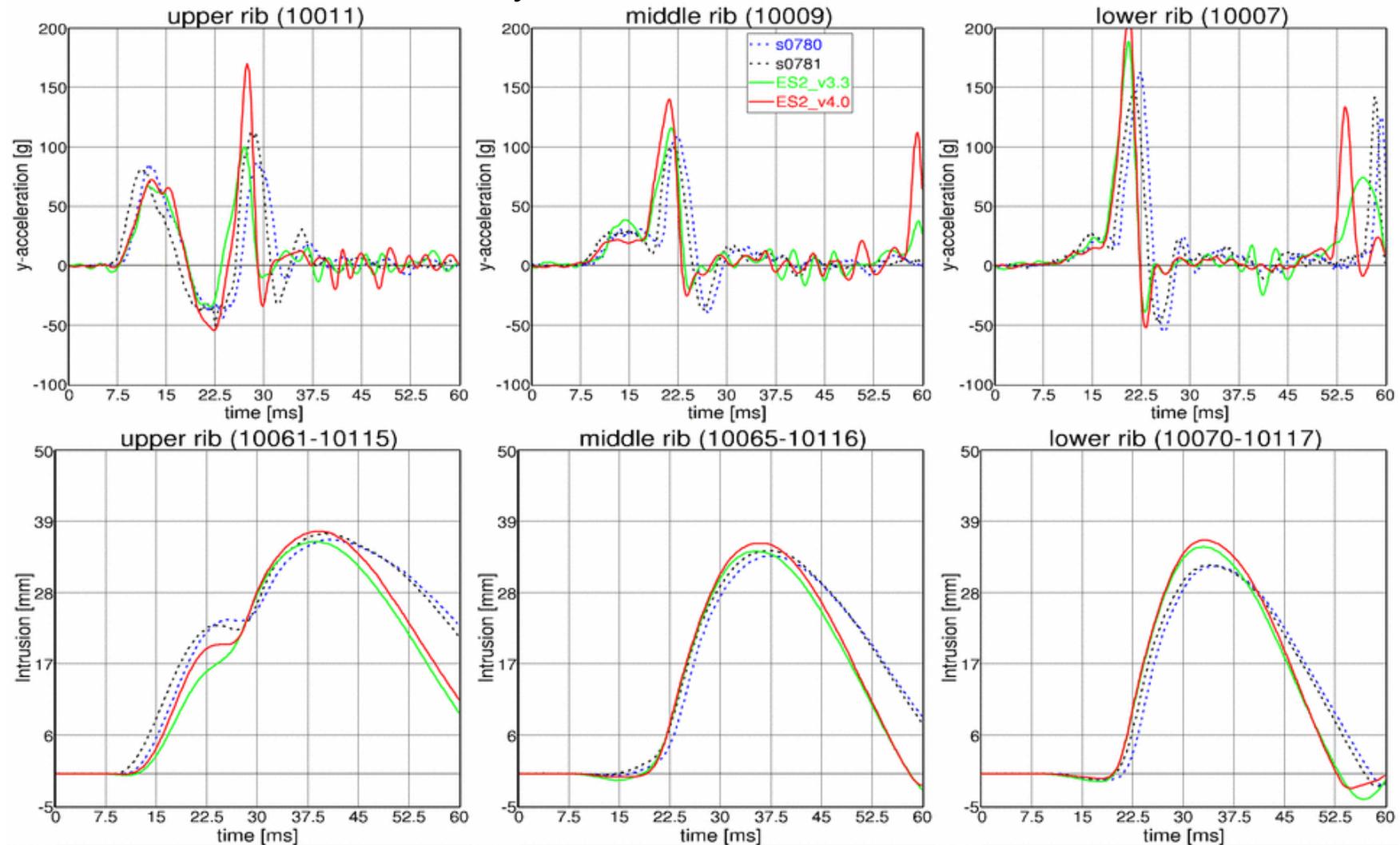
- Plane barrier middle velocity
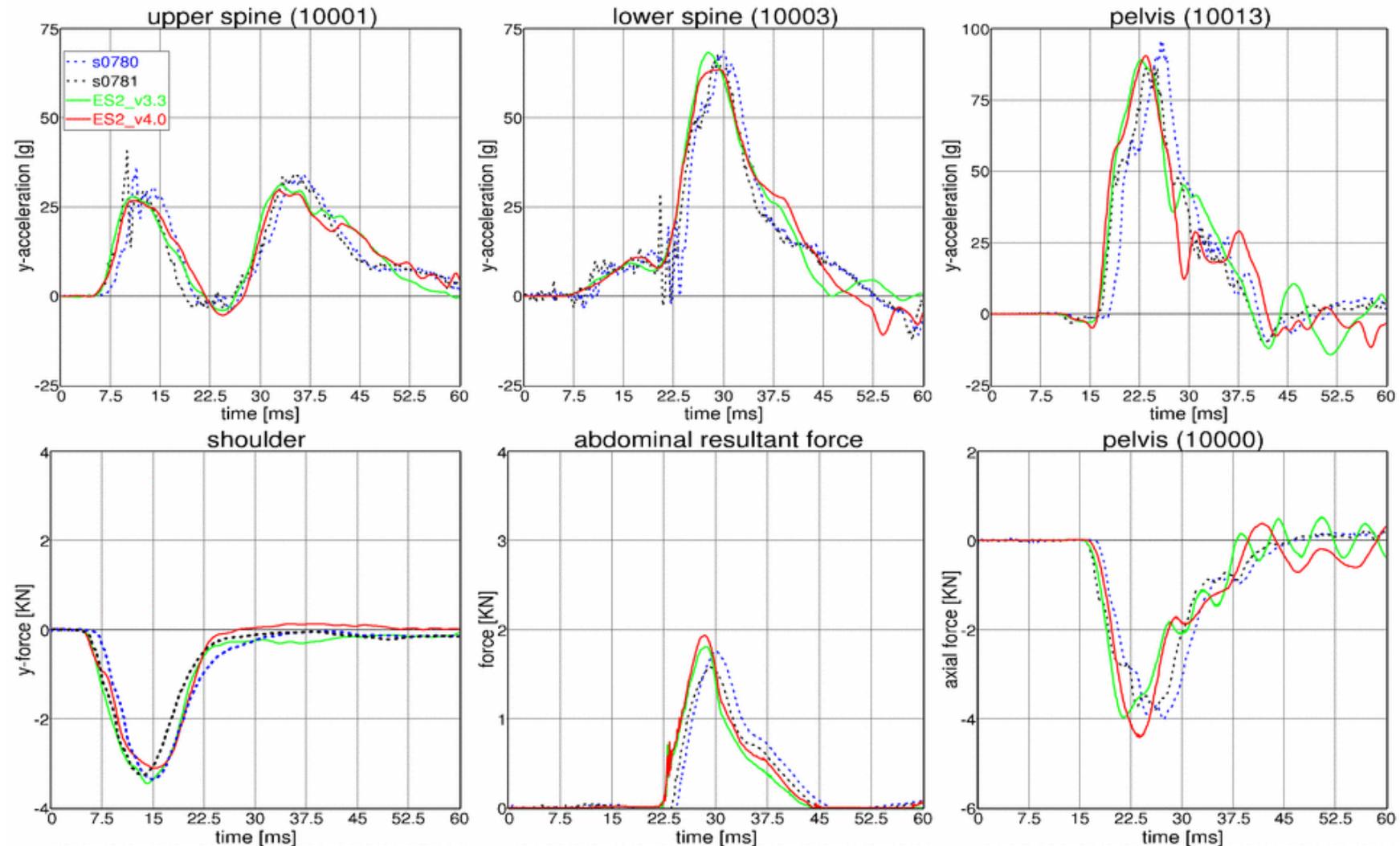
- Plane barrier middle velocity
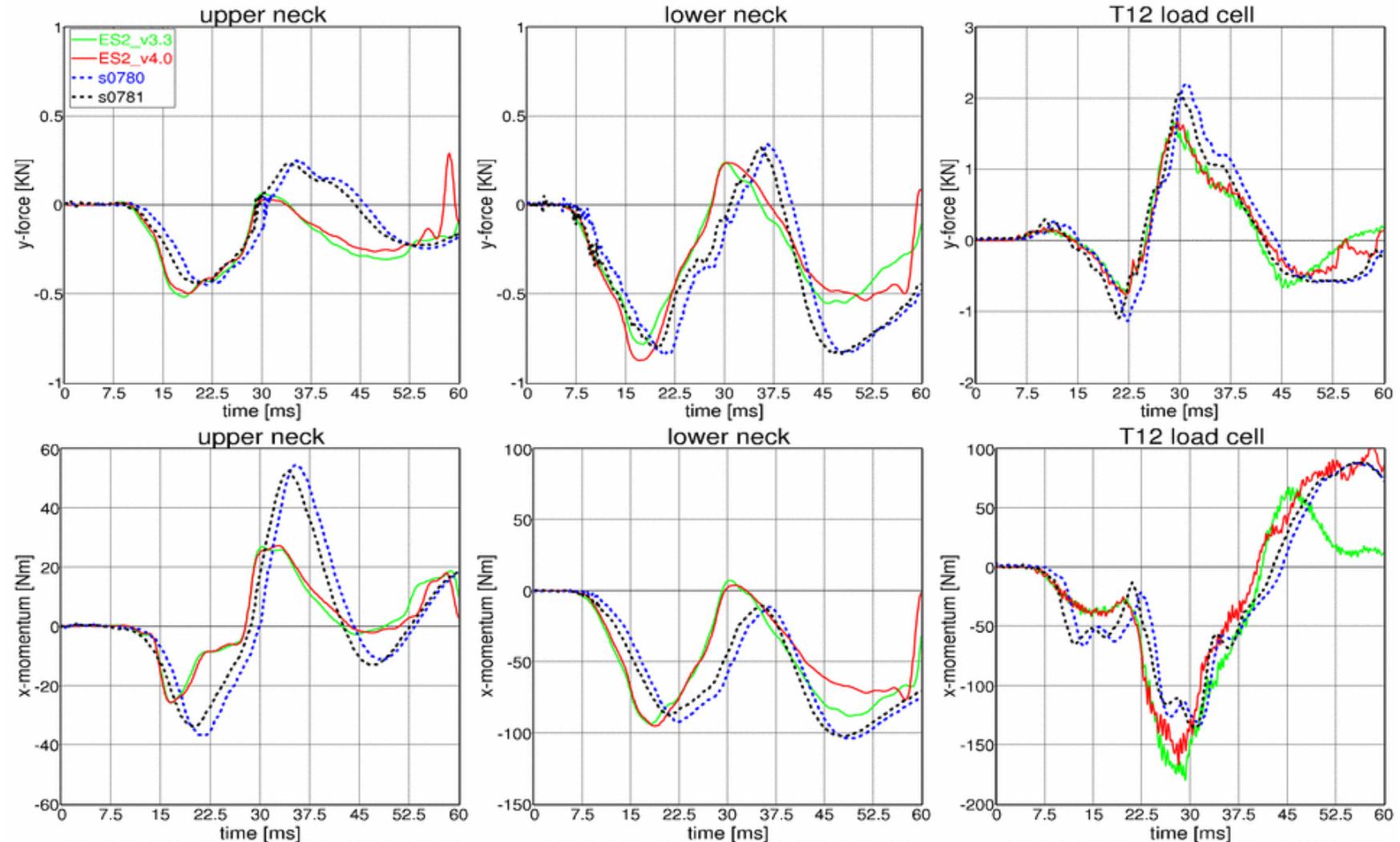
- Further barriers

  - Plane barrier

  - Oblique impacting
    surfaces

  - Low friction coating

  - Different arm positions

- Results of complete set of
  barriers please see in the
  documentation of ES-2/ES-
  2re v4.0.
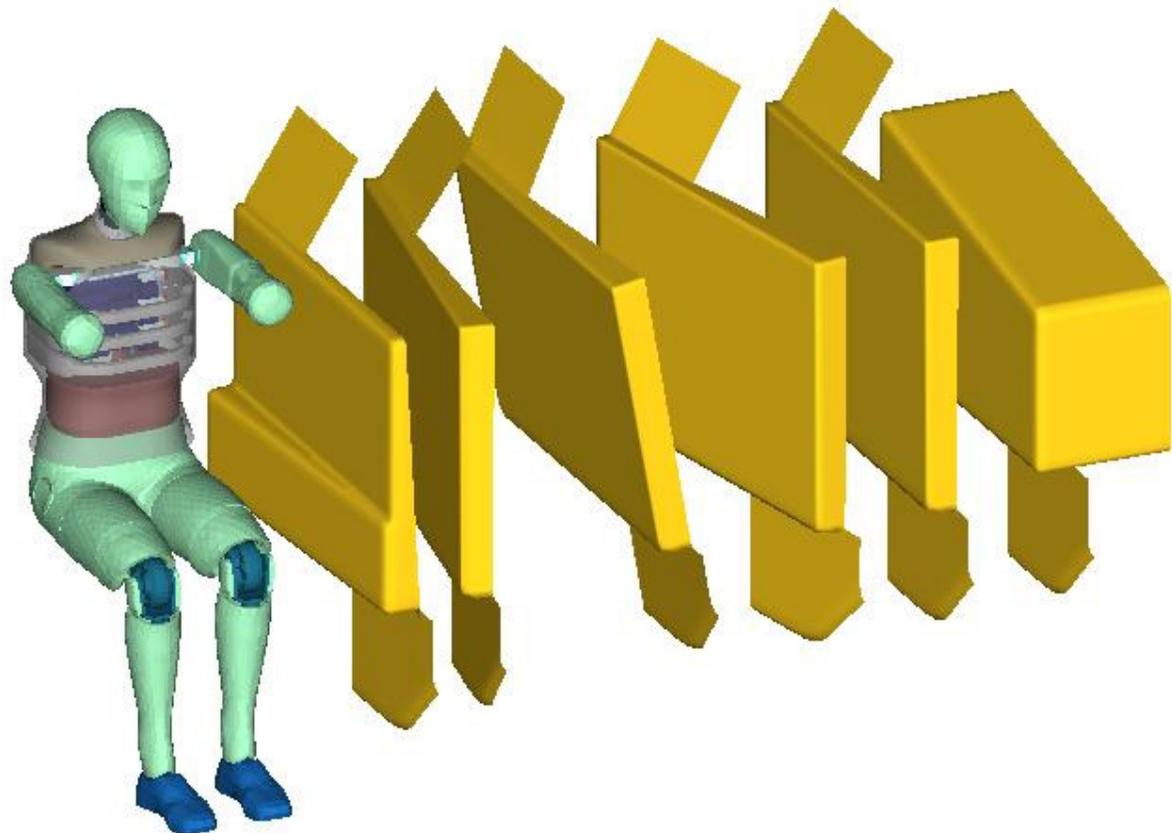
- Latest pendulum test on ES-2re

- Without dummy jacket and arm

- -45 degree

- High velocity
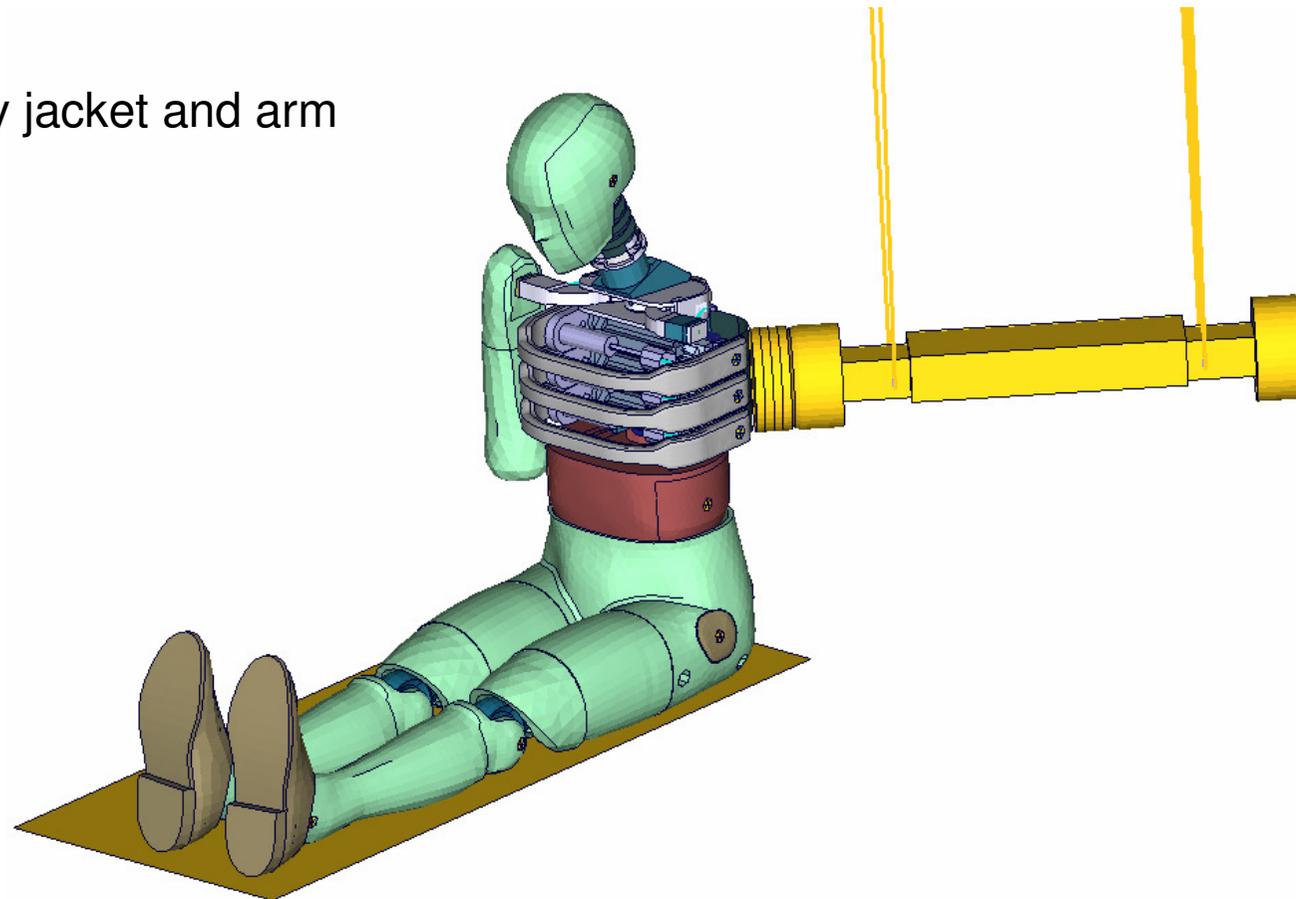
- Pendulum Test of ES-2re
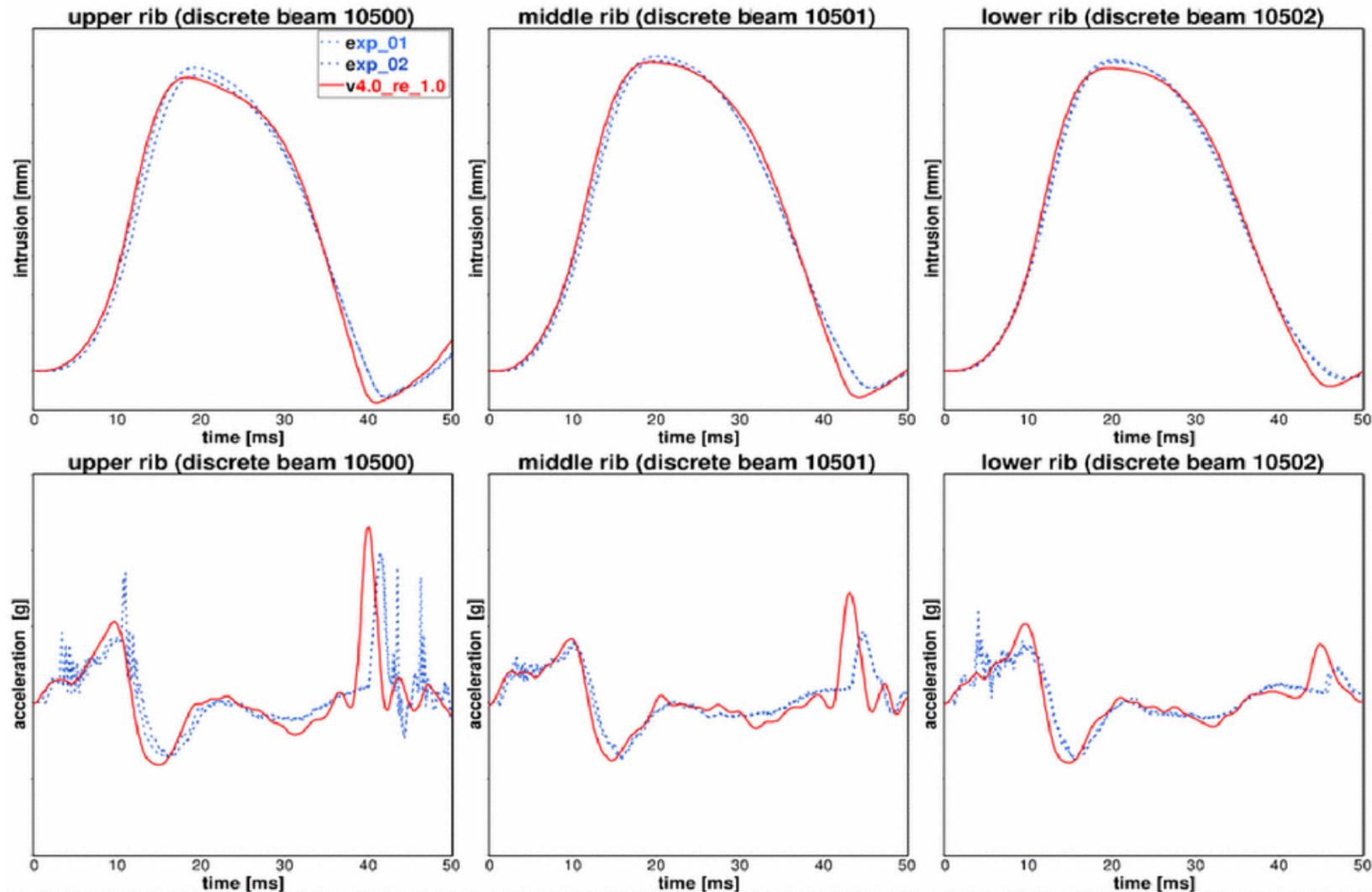
- Pendulum Test of ES-2re
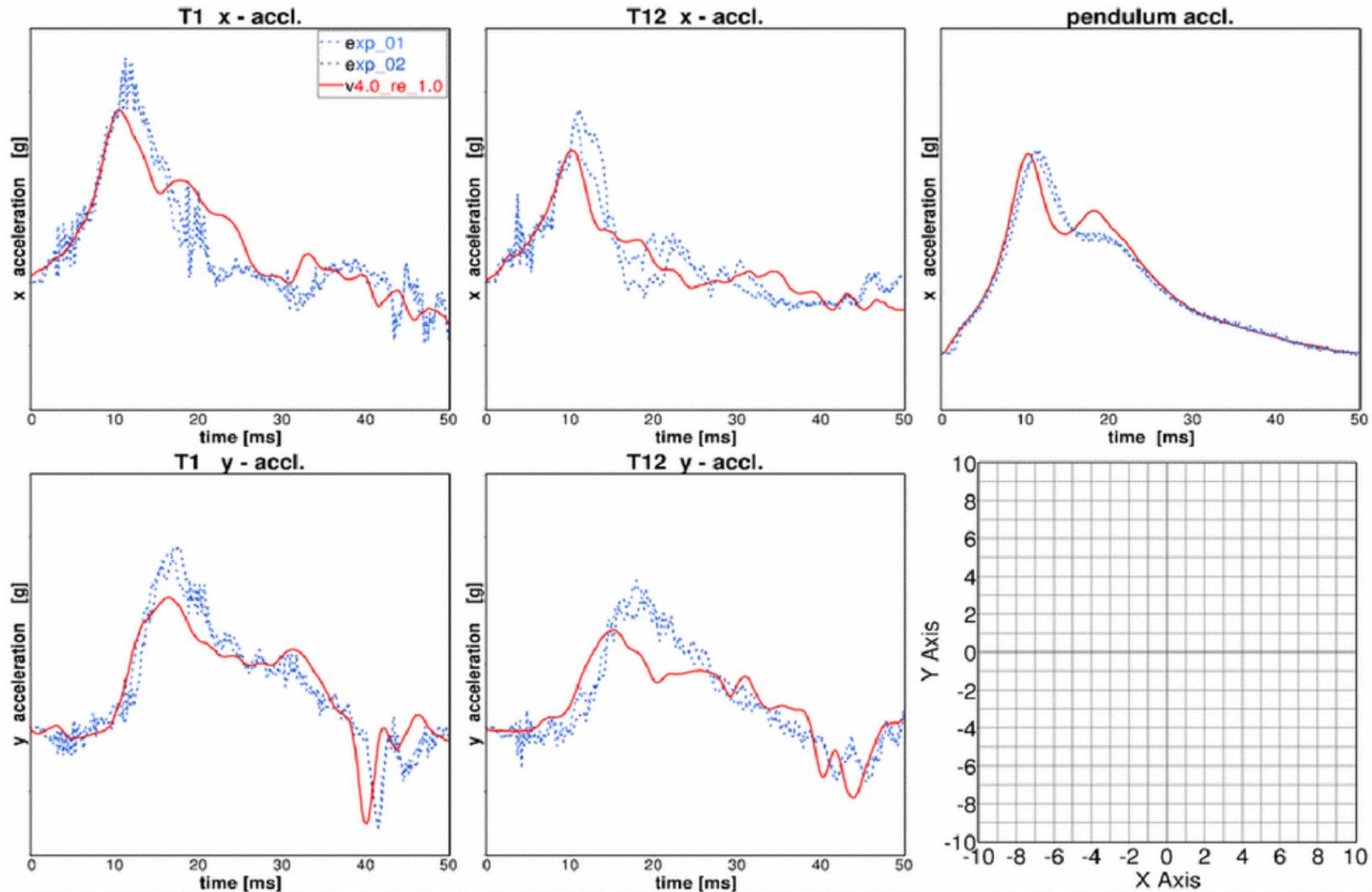
FAT Dummy Models: Update and News

- SID and RID Models:

  - BioRID II v2.0 latest changes to the model

  - USSID v5.0 latest changes in the model

  - ES-2, ES-2re v4.0 latest changes to the model

  - **ES-2, ES-2re news for the following release**

  - Further developments for all DYNAmore dummy models

- To fulfill the head drop test the deformable part (red colored) of ES-2 head is enlarged.

- Pre-stress of clavicle straps will be increased from 40 N to 54 N.

- **Some discontinuities** in the rib foam material will be removed.

- Contact between jacked and ribs will be changed from Soft 1 to Soft 2 option with edge to edge contact.

- The finer mesh area of the jacket will be enlarged.
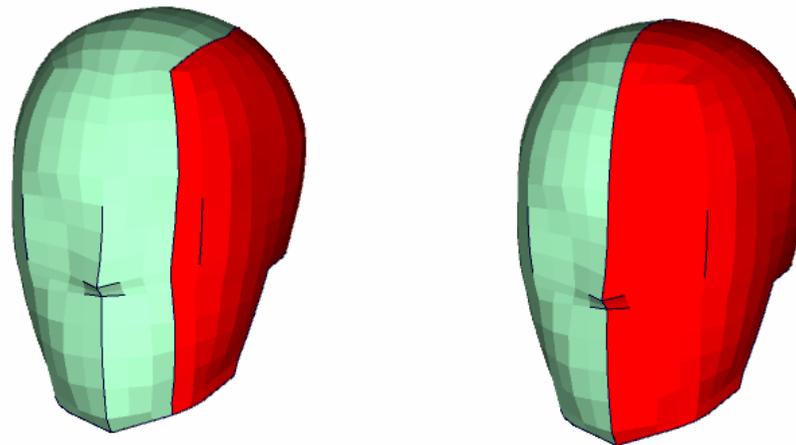
- Abdomen will be refined to get a better force distribution for front, middle and back abdomen forces.

- Different mesh types and densities are tested.

Base mesh of ES-2 v4.0
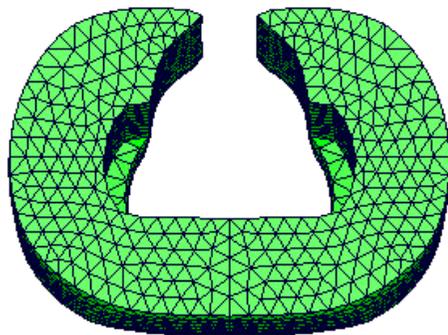
Mesh refined to half of edge length
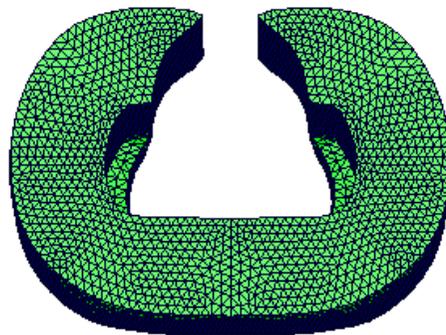
Only half of abdomen refined
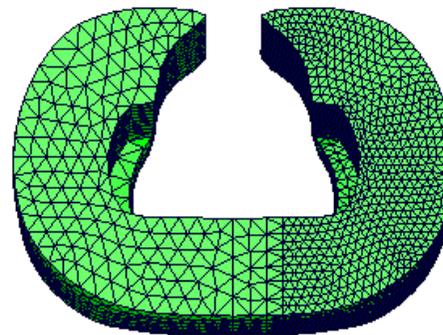
Abdomen completely meshed with hex. elements.

~ 16,000 Tets

~ 113,000 Tets

~ 65,000 Tets
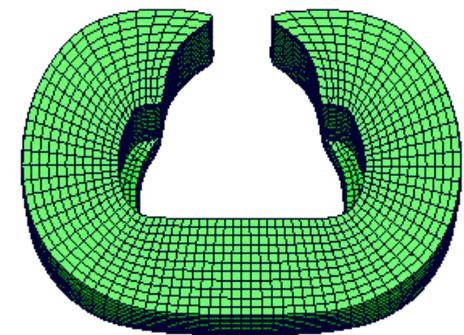
~ 23,000 Hex.

- Result of abdomen pendulum test
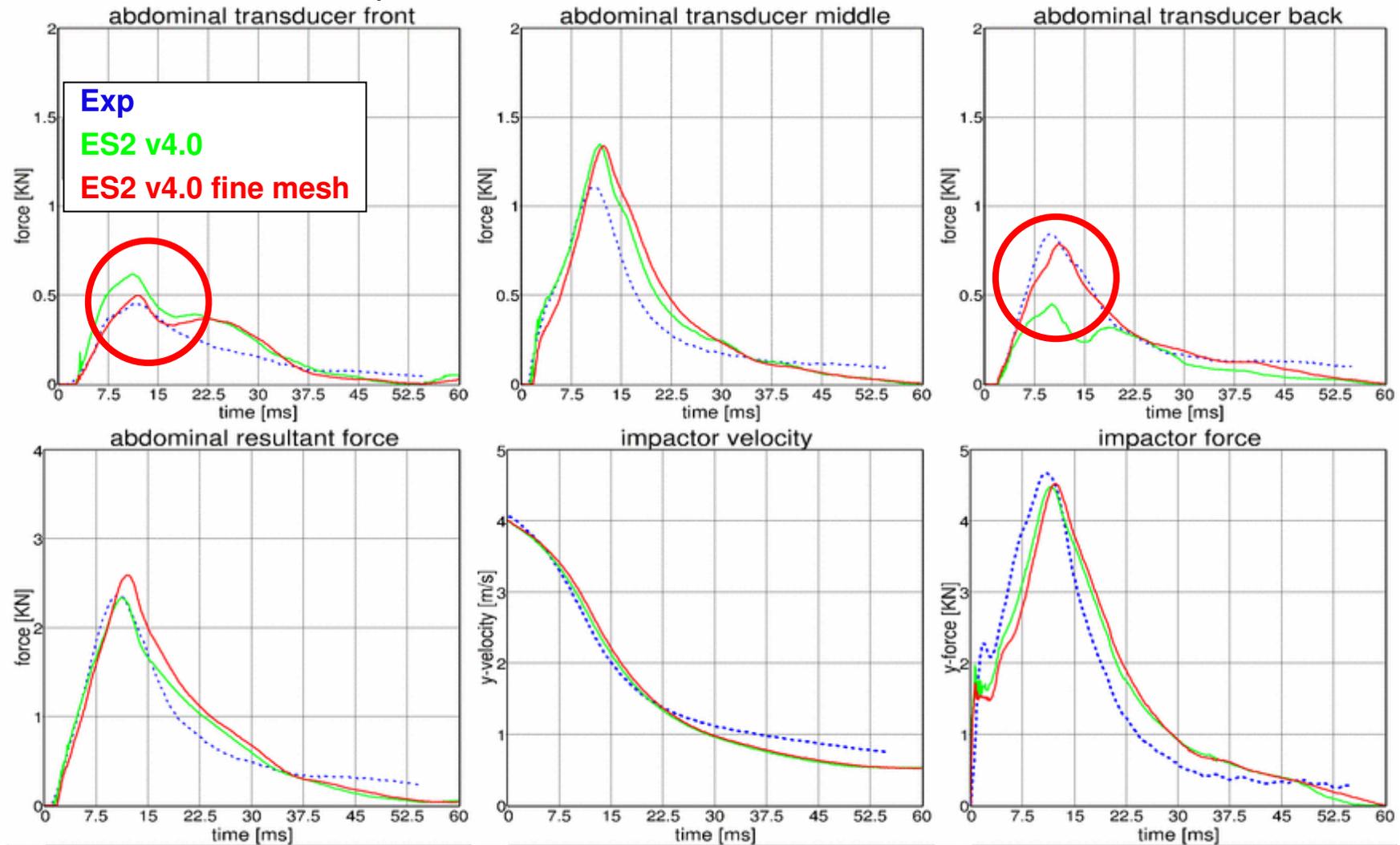
- The upper legs will be shortened of about 20 mm.

- This new geometry is the identical to the physical Dummy.

- The upper leg bone is mover the distance into the femur bone.

- The upper leg foam will be cut of then.
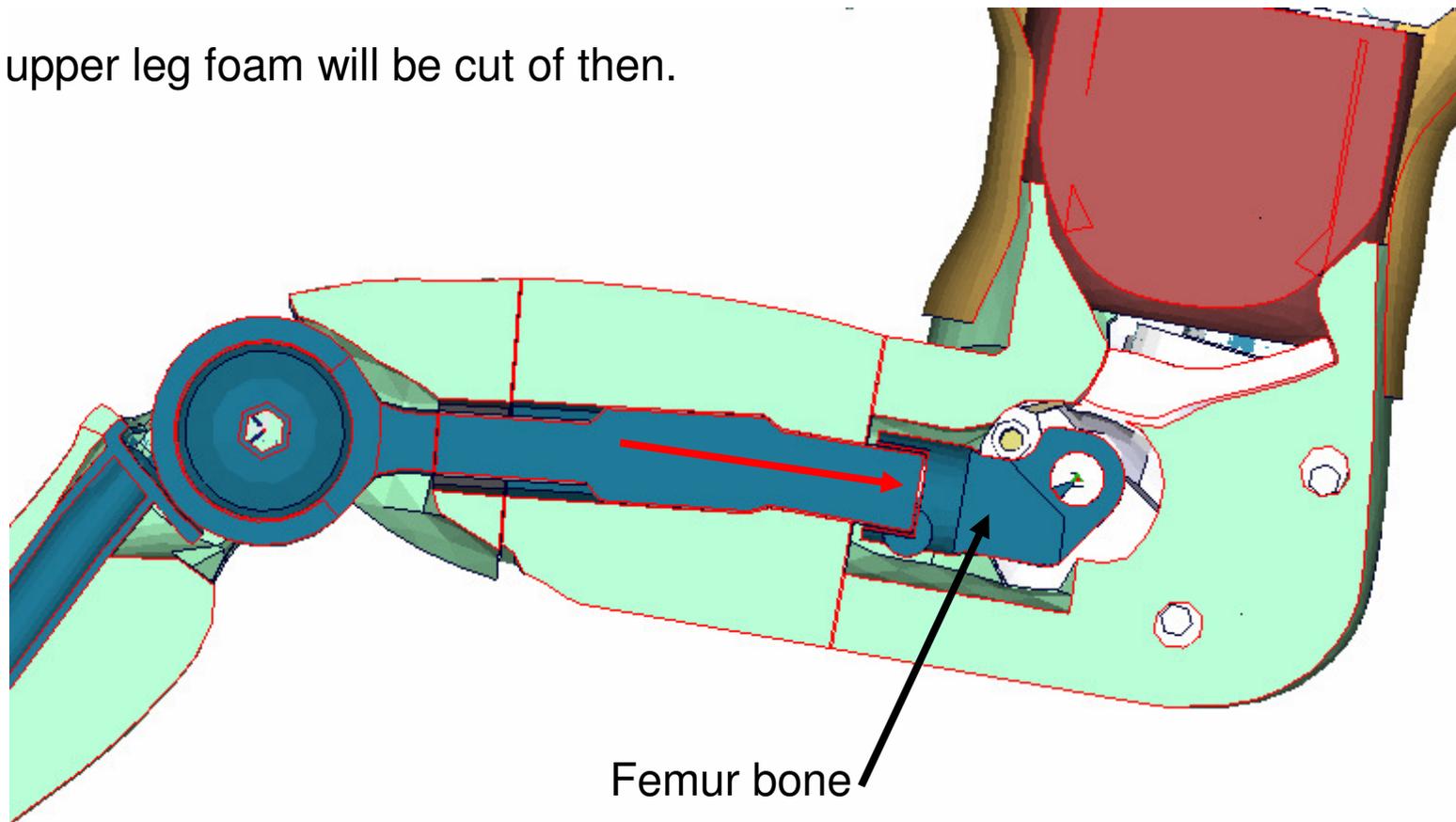
Femur bone

- Three additional load cells will be added in the model.

- Femur load cell left and right

- Lumbar load cell
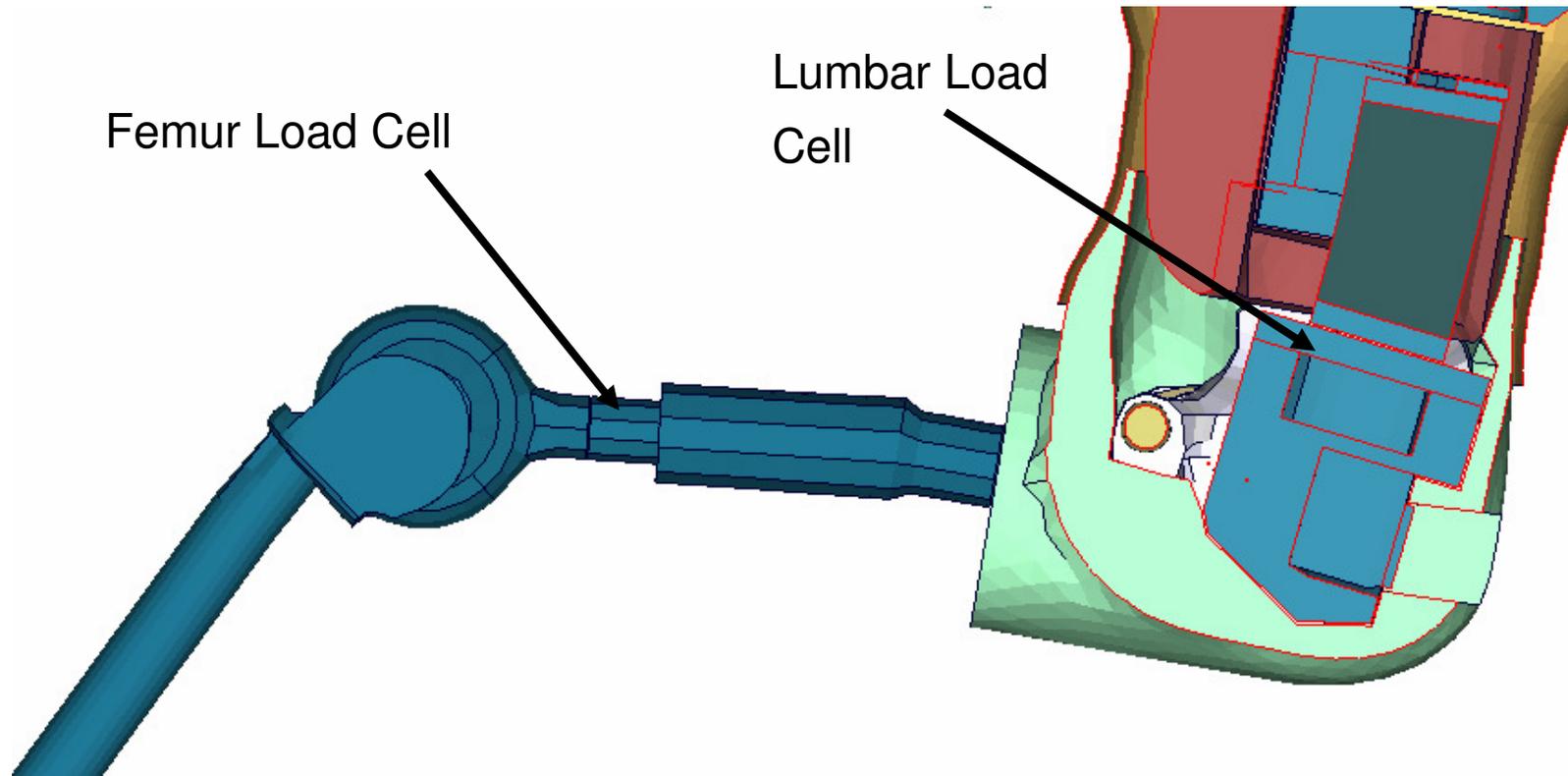
Femur Load Cell

Lumbar Load Cell

FAT Dummy Models: Update and News

- SID and RID Models:

  - BioRID II v2.0 latest changes to the model

  - USSID v5.0 latest changes in the model

  - ES-2, ES-2 re v4.0 latest changes to the model

  - ES-2, ES-2 re news for the following release

  - Further developments for all DYNAmore dummy models

- Positioning Templates:

  - The provided templates to position the dummy models will be enhanced.

  - Then it will be possible to bend the spine for different relative angels between pelvis and torso.

  - These files will be parameterized and should the be easy to use.

  - The idea is the to move the dummy into the seat and to deform the lumbar spine/pelvis foam in one single simulation.

Torso rotation relative to pelvis

Upper leg rotation relative to pelvis

Deforming seat foam by moving dummy into seat
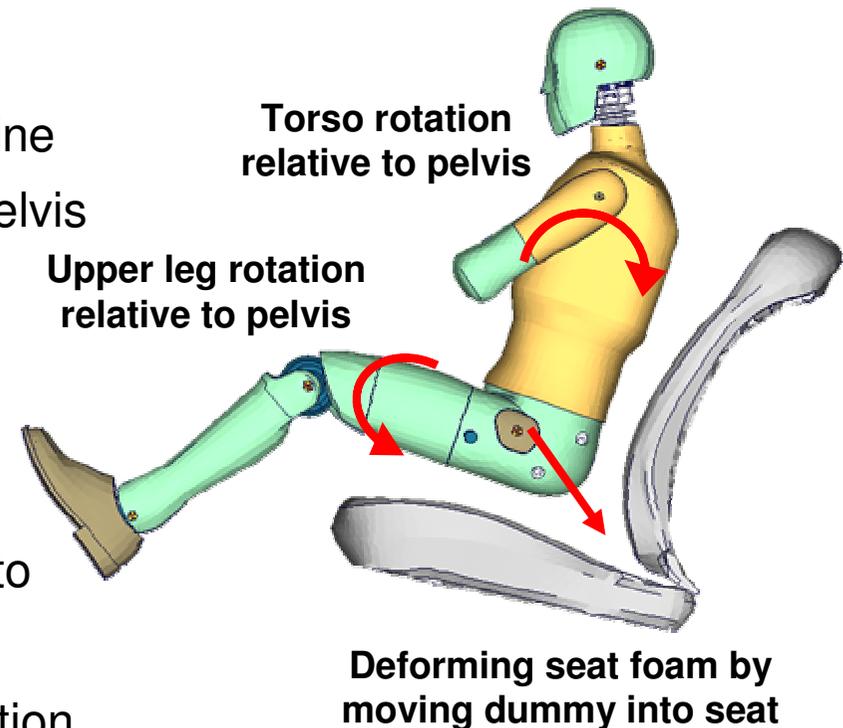
- Positioning Tree-Files:

    - The current used Tree-File is for Oasys Primer.

- Development of new tree file structure for LS-PP is soon finished.

    - Therefore we will supply an additional tree file for LS-PP to position the dummy models.
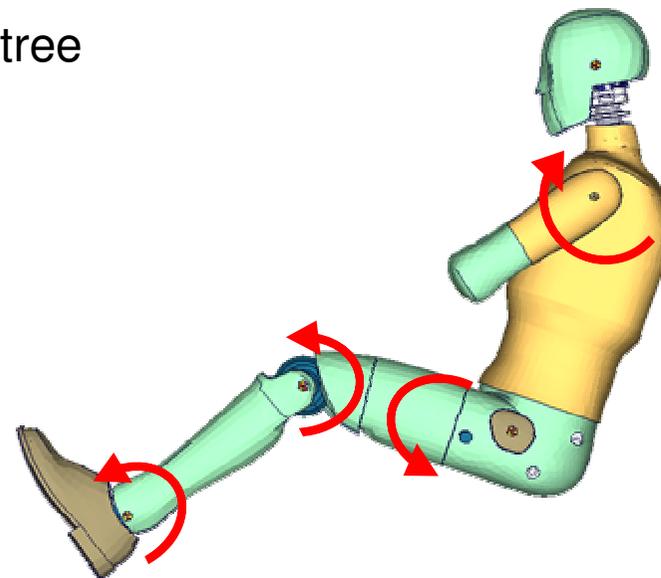
Further developments for all DYNAmore dummy models

- The current dummy models of DYNAmore are validated in use of all available test data , no test data is pending to be implemented (material / component / sled tests).

- To understand the kinematics of the model we will use robustness studies like for the BioRID II.

- An important issue for accurate and robust dummy models is to get frequently feedback of the users.

Pleases let us know your feedback, ideas and problems and don't hesitate to contact me for all issues.

→ ses@dynamore.de   ☺

Thank you !