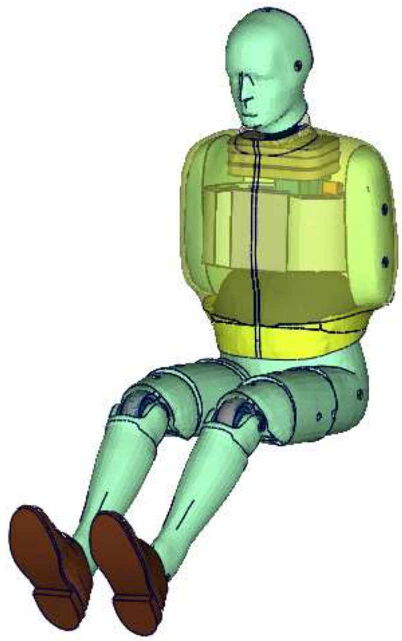
Documentation

FAT LS-DYNA

USSID 5.0



User's Manual
Manual Release 1.0 for Model 5.0
January 8, 2007
—
DYNAmore GmbH
www.dynamore.de
Germany

Authors:
Uli Franz
Sebastian Stahlschmidt
Bastian Keding

Contact Address:
Uli Franz
DYNAmore GmbH
Industriestr. 2
70565 Stuttgart
Germany
Tel: +49-(0)711-459600-0
uli.franz@dynamore.de

Contents

1 General Information

The development and validation has been performed on different platforms. The following LS-DYNA versions have been used:

LS-DYNA Version	Date	Revision Nr.
970 SMP	10/01/2005	5434a
970 SMP	28/11/2005	6763.169
970 MMP	10/01/2005	5434a
970 MMP	28/11/2005	6763.169

With the version 5.0 the following keyword files are delivered.

File name	Content
ussid_v5.0_mm_ms_kg.key	dummy model, the name might vary depending on unit system
ussid_v5.0_nullshells_.inc	contact shell elements, these elements can be used to close physical gaps in the dummy surface
barrier_v1-4_ussid_v5_v0.02.inc	plane barrier model
seat_v0.04.inc	seat model
solve_ussid_barriere.inc	master file for barrier test of ussid_v5.0
positioning_ussid_v5.0_mm_ms_kg.key	file for position the model in seat

The following numbering scheme is used.

Item	Min Node-/ Element-ID	Max Node-/ Element-ID	Total numbers
Nodes	10,000	75,319	64,706
Solids	11,000	110,539	99,540
Beams	10,001	110,642	104
Shells	110,643	159,801	49,159

Discrete elements	10,000	159,802	2
Mass	159,803	159,818	16
Accelerometers	1	10	10
Set_Node	1,007	1,018	10
Set_Part	1,001	1,501	13
Properties	1	211	184
Material	1,001	1,100	58
Sections	1,001	1,072	36
Hourglass	1,001	1,013	4
General joint stiffness	1	19	16
Joints	20	37	18
Contact	1	2	2
Local coordinate systems	1	27	23
Load curves/tables	1,201	1,285	45
Time history nodes	10,010	10,500	20
Time history beams	10,001	10,001	1

2 Used Keywords

The following control and database keywords are used.

*CONTROL_ACCURACY	*CONTROL_BULK_VISCOSITY
*CONTROL_CONTACT	*CONTROL_ENERGY
*CONTROL_OUTPUT	*CONTROL_PARALLEL
*CONTROL_SHELL	*CONTROL_SOLID
*CONTROL_TERMINATION	*CONTROL_TIMESTEP
*DATABASE_BINARY_D3PLOT	*DATABASE_DEFORC
*DATABASE_ELOUT	*DATABASE_EXTENT_BINARY
*DATABASE_GLSTAT	*DATABASE_HISTORY_BEAM
*DATABASE_HISTORY_NODE	*DATABASE_JNTFORC
*DATABASE_MATSUM	*DATABASE_NODOUT
*DATABASE_RBDOUT	*DATABASE_RCFORC
*DATABASE_RWFORC	*DATABASE_SECFORC
*DATABASE_SLEOUT	

The following materials are used.

*MAT_ELASTIC	*MAT_FU_CHANG_FOAM
*MAT_KELVIN-MAXWELL_VISCOELASTIC	*MAT_NULL
*MAT_PIECEWISE_LINEAR_PLASTICITY	*MAT_PLASTIC_KINEMATIC
*MAT_RIGID	*MAT_RIGID_TITLE
*MAT_SID_DAMPER_DISCRETE_BEAM	*MAT_SPRING_NONLINEAR_ELASTIC
*MAT_SPRING_NONLINEAR_ELASTIC_TITLE	*MAT_VISCOELASTIC
*MAT_VISCOELASTIC_TITLE	

The following other keywords are used.

*CONSTRAINED_EXTRA_NODES_SET
*CONSTRAINED_JOINT_CYLINDRICAL
*CONSTRAINED_JOINT_REVOLUTE
*CONSTRAINED_JOINT_SPHERICAL
*CONSTRAINED_JOINT_SPHERICAL_ID
*CONSTRAINED_JOINT_STIFFNESS_GENERALIZED
*CONSTRAINED_JOINT_TRANSLATIONAL

*CONSTRAINED_RIGID_BODIES
*CONTACT_AUTOMATIC_SINGLE_SURFACE_ID
*CONTACT_TIED_SHELL_EDGE_TO_SURFACE_CONSTRAINED_OFFSET
*DEFINE_COORDINATE_NODES
*DEFINE_COORDINATE_NODES_TITLE
*DEFINE_CURVE
*DEFINE_TABLE
*ELEMENT_BEAM
*ELEMENT_DISCRETE
*ELEMENT_MASS
*ELEMENT_SEATBELT_ACCELEROMETER
*ELEMENT_SHELL
*ELEMENT_SOLID
*END
*HOURGLASS
*KEYWORD
*NODE
*PART
*PART_CONTACT
*SECTION_BEAM
*SECTION_DISCRETE
*SECTION_SHELL
*SECTION_SOLID
*SET_NODE_LIST
*SET_PART_LIST
*SET_PART_LIST_TITLE
*TITLE

The following primer tree file keywords are used.

*ASSEMBLY	*DUMMY_END
*DUMMY_START	*H_POINT
*UNITS	

3 Extraction of Occupant Injury Criteria

3.1 Rib accelerations left

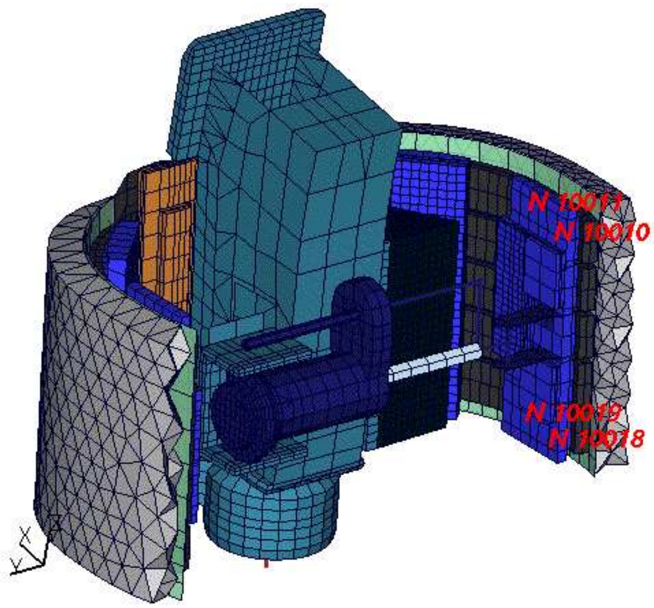


Fig. 1: nodes for extracting rib accelerations

Item	**Node-ID**	**Component**
Upper rib left, primary	10010	y-acceleration
Upper rib left, redundant	10011	y-acceleration
Lower rib left, primary	10018	y-acceleration
Lower rib left, redundant	10019	y-acceleration

3.2 Spine accelerations

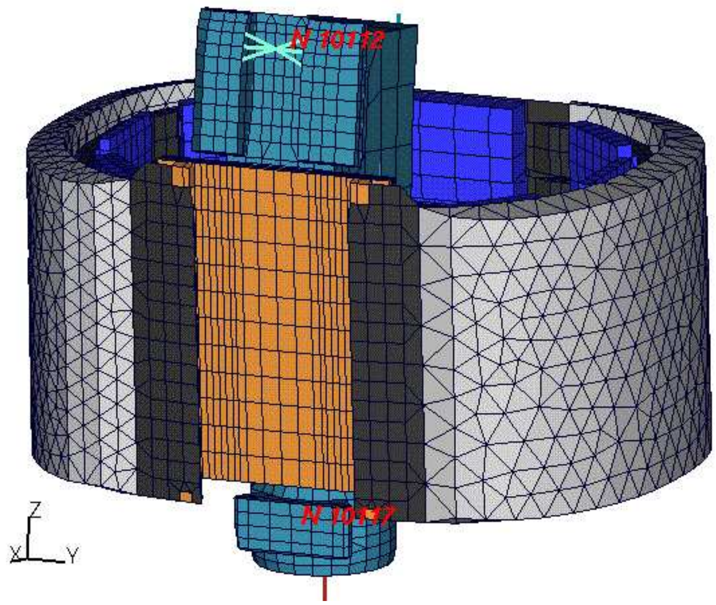


Fig. 2: nodes for extracting spine accelerations

Item	Node-ID	Component
Upper spine	10112	y-acceleration
Lower spine	10117	y-acceleration

3.3 Pelvis acceleration

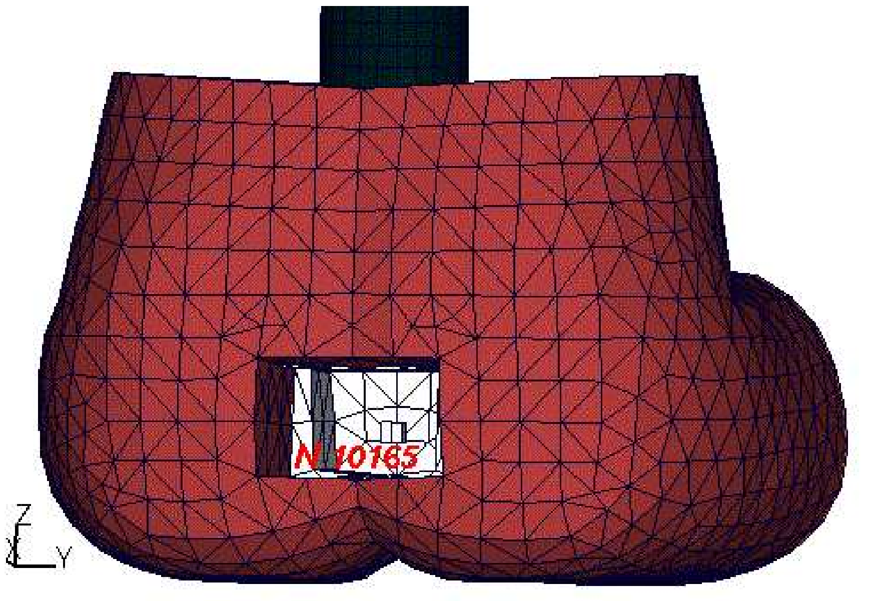


Fig. 3: nodes for extracting pelvis accelerations

Item	Node-ID	Component
Pelvis	10165	y-acceleration

3.4 Head acceleration

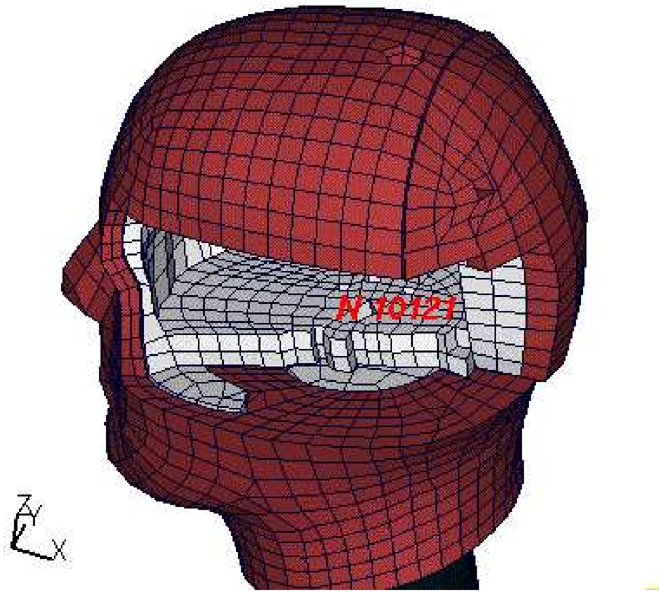


Fig. 4: nodes for extracting head accelerations

Item	Node-ID	Component
Head	10121	y-acceleration

3.5 Rib intrusion

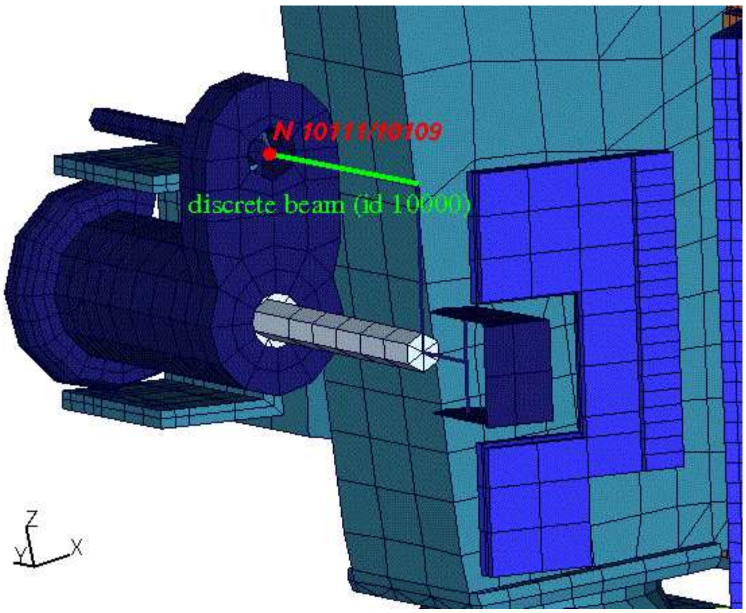


Fig. 5: nodes for extracting rib intrusion

Item	Node-ID	Component
Rib intrusion	10111 relative to 10109	x-displacement

Alternativ a discrete element can be used for measuring the rib intrusion.

Item	Discrete element-ID	Component
Rib intrusion	10000	deforc - change in length

3.6 Rib accelerations right

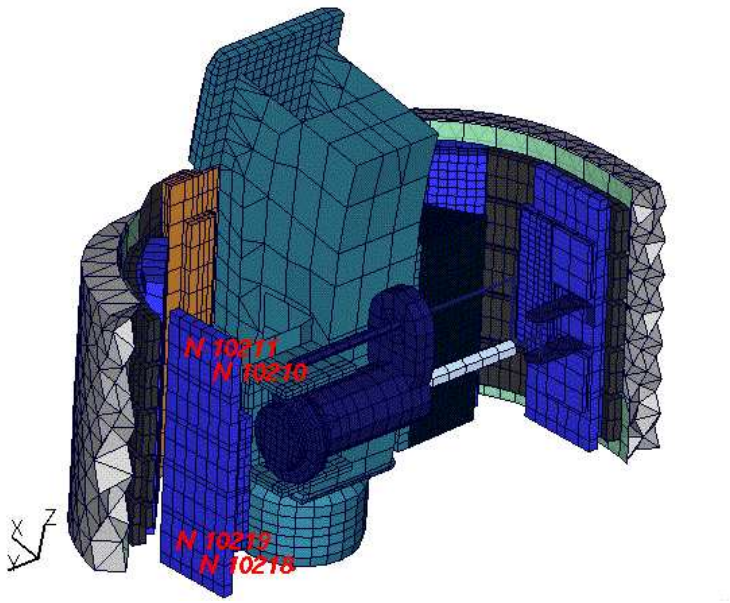


Fig. 6: nodes for extracting rib accelerations right hand side

Item	Node-ID	Component
Upper rib right, primary	10210	y-acceleration
Upper rib right, redundant	10211	y-acceleration
Lower rib right, primary	10218	y-acceleration
Lower rib right, redundant	10219	y-acceleration

4 Accelerometers

Location	Accelerometer ID	1st node	2nd node	3rd node
Upper rib, front left	1	10010	10087	10089
Upper rib, back left	2	10011	10087	10090
Lower rib, front left	3	10018	10088	10091
Lower rib, back left	4	10019	10088	10092
Potentiometer, piston rod	5	10111	10209	10205
Potentiometer, piston	6	10109	10206	10207
Head	7	10121	10122	10123
Upper spine	8	10112	10140	10139
Lower spine	9	10117	10116	10115
Pelvis	11	10165	10164	10169

5 Incorporating the Dummy in Vehicle Models

5.1 Positioning

- The node 10500 is located at the H-point.
- In the delivered file the H-Point coordinates are:

	x coordinate	**y coordinate**	**z coordinate**
H-Point	-128.67900	257.17041	402.50333

- The USSID model is delivered with a tree-file for OASYS-Primer preprocessor (may work also for ALTAIR-Hypermesh, not verified by DYNAmore). This allows the user to position the dummy and adjust the parts according to their degree of freedom. In the H-Point of the dummy model two coordinate systems are modeled. These coordinate systems are connected to each other by a spherical joint. One coordinate system is connected to global directions, that means only translations are possible, rotations are disabled. The other one is connected to the dummy, so it is posible to measure quick and easy the pelvis angle of the USSID during the positioning simulation. These coordinate systems are also used to determine the initial pelvis angle with OASYS-Primer.

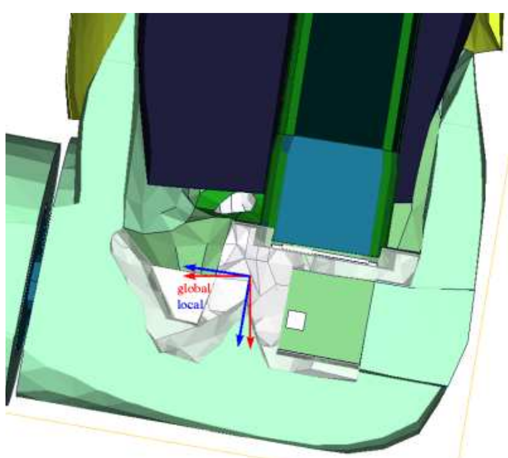


Fig. 7: coordinate system of pelvis

The pelvis angle of the delivered model is: 10.6 degree. It is measured as depicted in

the left picture below.
The right picture shows the model in the upright position, that means with a pelvis angle of 0.0 degree.

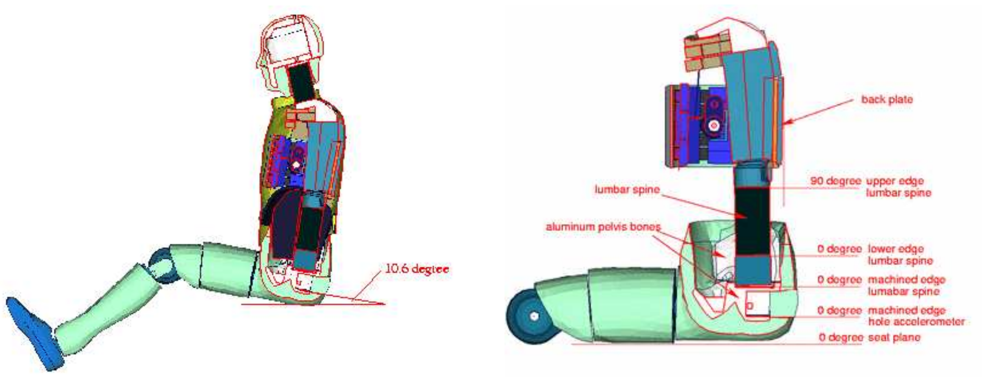


Fig. 8: delivered position

- No PART_INERTIA Cards are used. Hence, a common preprocessor may be used to handle the model.

- The lower legs and feet have a rotational degree of freedom along the y-axis. The position of other parts of the body are determined by the H-point and the pelvis angle.
  The upper legs of USSID v5.0 model have also rotational degrees of freedom, but it is not recommendable to move them cause initial penetrations would occur. This reaction is based on the hardware model. That is the reason why the degrees of freedom for the upper legs are disabled in OASYS-Primer tree-file. Better to positioning upper legs by a presimulation. A special positioning-file <positioning_ussid_v5.0_mm_ms_kg.key> is delivered to do this presimulation.

- The positioning file of ussid is very easy to use. At the top of this file you will find a set of parameters you have to define. These parameters are shown in the following table.

term	**termination time**
tmove	time to move parts
trans_x	translation in x direction of whole dummy model
trans_z	translation in z direction of whole dummy model

lfemry	left femur rotation about y
rfemry	right femur rotation about y
lfemrz	left femur rotation about z
rfemrz	right femur rotation about z

As second step you have to fill in your include-files necessary for positioning the dummy model. Usually only seatmodel and dummy model are used for the positioning procedure. Please define a *CONTACT_AUTOMATIC_SURFACE_TO_SURFACE for contact between dummy to seat(environment). The USSID properties for this contact are prepared in the part set 1500.

- The axis of revolute joints can be defined by:

Joint	**1st node**	**2nd node**
Left knee	10800	10802
Left ankle	10808	10810
Right knee	10816	10818
Right ankle	10824	10826

- The centre of spherical joints can be defined by:

Joint	**node**
Left femur	10763
Right femur	10765

5.2 Numbering

- Nodes in the range of 10,000 to 11,000 are used for joints, accelerometers,... definitions.

- Nodes with node IDs above 11,000 are used only in *NODE and *ELEMENT cards.

- The following ranges of numbers are used for the FAT-USSID model. Please take care of it!

Item	**Minimal ID**	**Maximal ID**
Nodes	10,000	200,000
Elements	10,000	200,000
Discrete elements	10,000	200,000
Load curves/tables	1,000	2,000
Material	1,000	2,000
Sections	1,000	2,000
Hourglass	1,000	2,000
Properties	1	220
General joint stiffness	1	200
Local coordinate systems	1	30
Accelerometers	1	20

5.3 Contact definition

Dummy to Vehicle and Seat:

- For the contact of the dummy model to the vehicle and the seat an automatic surface to surface contact is proposed. For this contact definition a property set(*SET_PART, id: 1500) has been prepared in the dummy input-file. This property set includes all properties of the USSID model which are necessary for the dummy to environment contact definition.

- The usage of a single surface contact is not recommended. This might interfere with the contact definitions of the dummy model itself. To remove the dummy model from used automatic_single_surface contact a second property set(*SET_PART, id: 1501) has been prepared. This property set includes all properties of the dummy model, so it can quick and easy be added to a used exclude list of the automatic_single_surface contact for whole vehicle.

- The following figure depicts properties used in property sets 1500 & 1501:

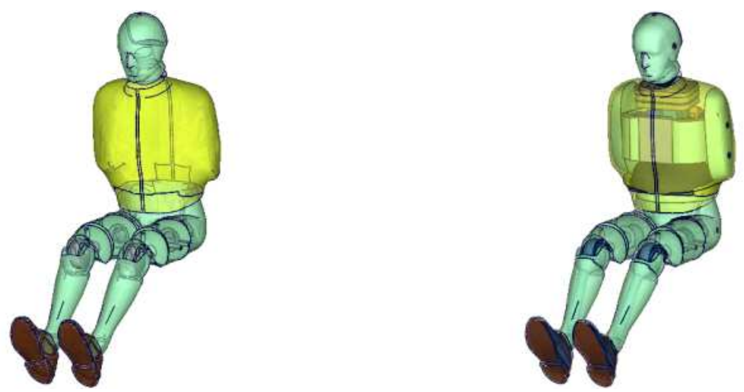


Fig. 9: contact faces

- A seperate property(id 211) has been defined. This property is used for nullshell elements closing physical gaps of the dummy model. (For example between head and jacket.) DYNAmore prepared a seperate include file. This include file is called ussid_v5.0_nullshells_.inc, it includes nullshell elements of property 211. These nullshells can be helpfull for some contact problems of dummy to environment contact. The usage of this contact shells is optional and will not change the results of the USSID barrier tests. The following picture shows the nullshell contact elements(red-colored).

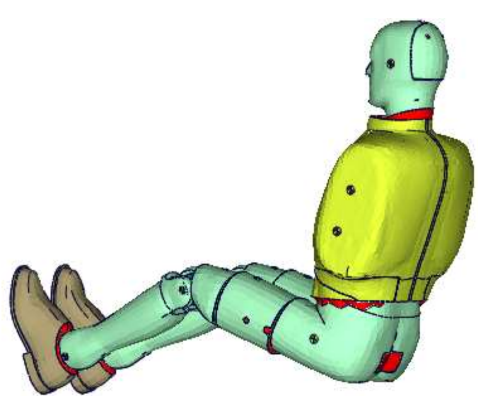


Fig. 10: nullshells

5.4 Additional remarks

- The modification of the *CONTROL cards of the dummy file may have influence on the performance and robustness of the model. Therefore the *CONTROL cards of the dummy models are proposed for integrated simulations as well.

- All nodes have a connection to an element, except third nodes of all beam elements.

- No massless nodes are in the input files of the dummy, except third nodes of all beam elements.

- The model is free of initial penetrations.

6 Release Notes

The following major modifications are made:

- The upper legs of the USSID model have been remeshed to have a more accurate geometry. The model behaves more stable in strong contact situations.

- The material properties of the jacket have been changed to enhance the rip intrusion of USSID model.

- New property set has been created. *SET_PART(id:1500) including all properties of the USSID model which are important for environment(vehicle,seat,airbag...) to dummy contact definition. *SET_PART(id:1501) includes all dummy properties. These properties can be used for the automatic_single_surface whole vehicle contact as an exclude list.

- The OASYS-Primer tree-file has been modified. Now initial pelvis angle is shown in the Primer. Also the pelvis angle can be measured quick and easy between the coordinate axis of PID 35 and 107 at the H-Point.

- A seperate file is delivered which can be used to position the upper legs by a presimulation.

- A second seperate file is delivered including elements defined of null-material(*MAT_NULL). These elements are used to close all physical gaps of the USSID model. This might be necessary if there are contact problems to the environment. The user can feel free about including these elements or not. Results of the barrier test are not influenced by using these elements.

7 Performance

7.1 Configuration A: Plane barrier

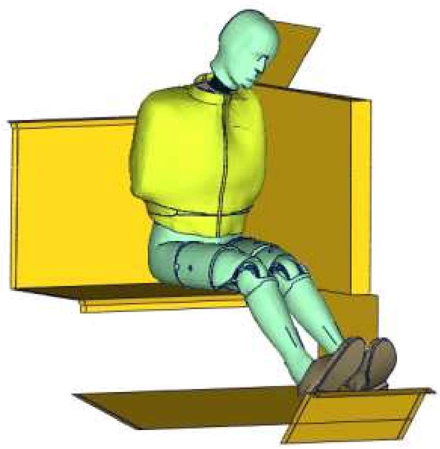
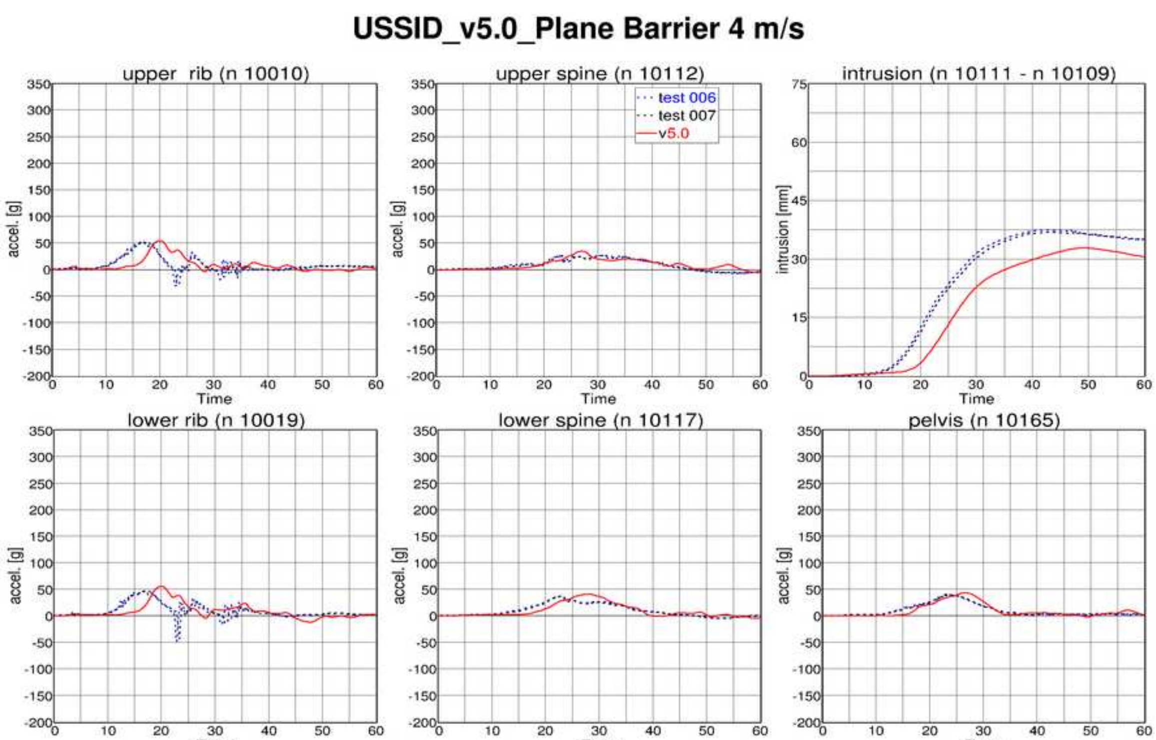
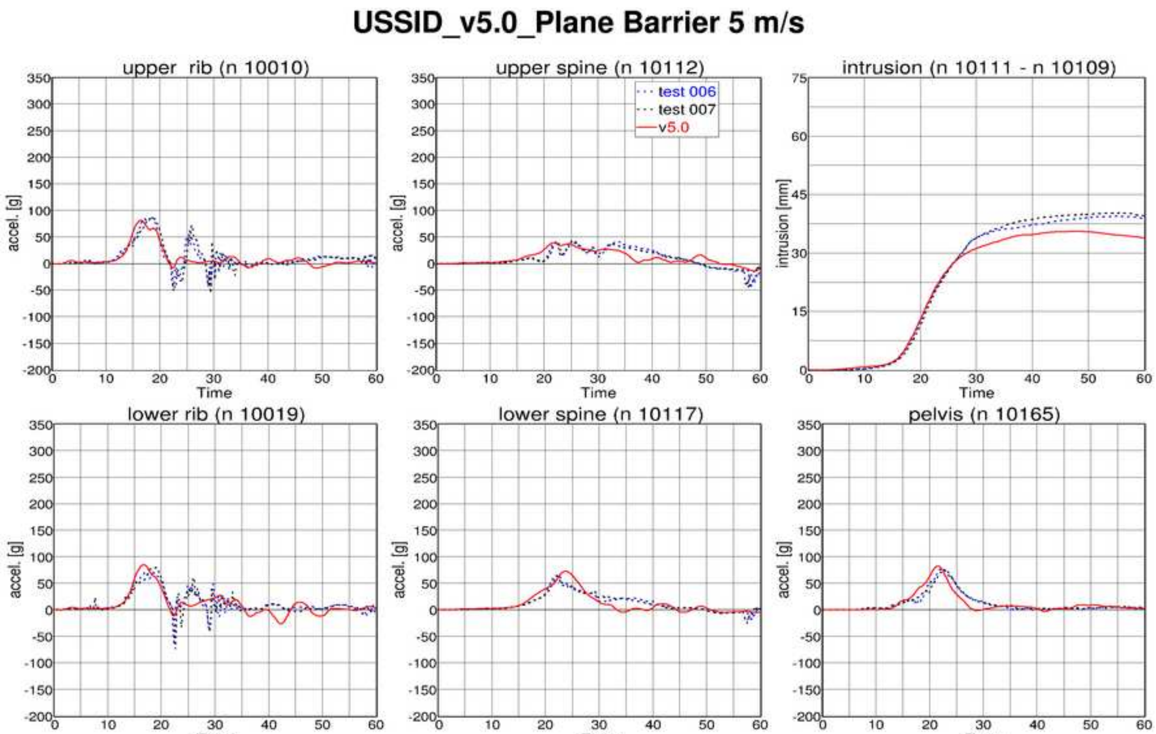
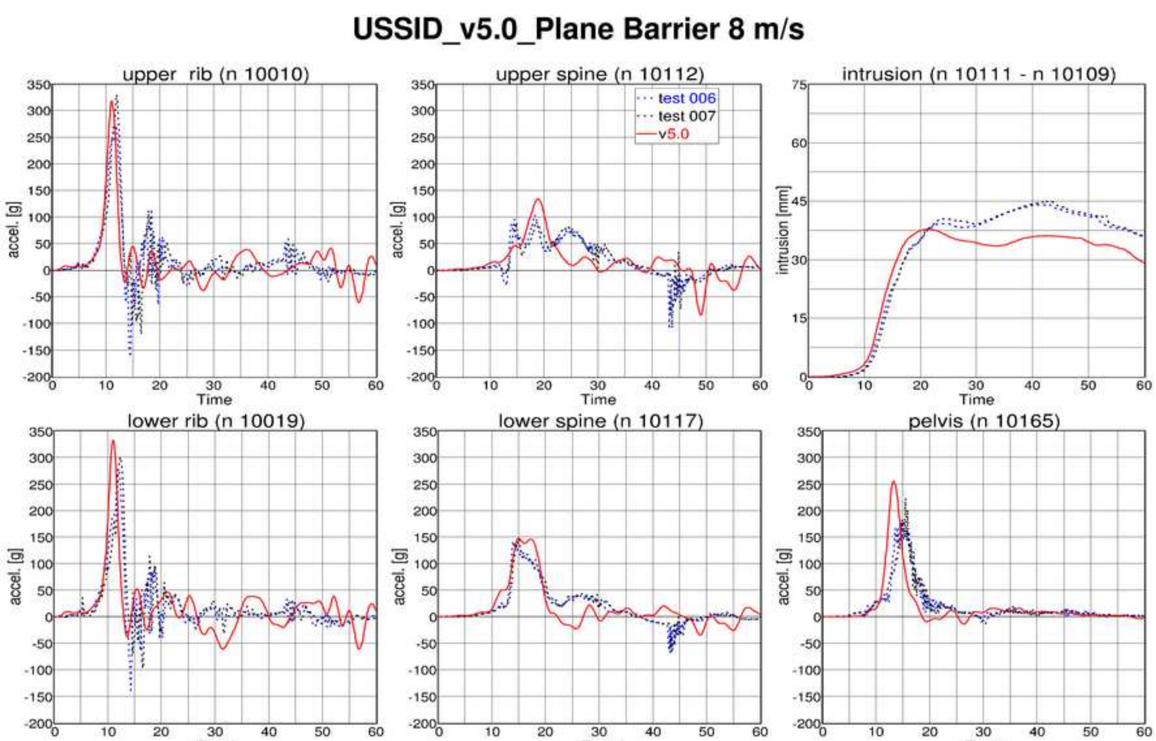


Fig. 11: Plane Barrier




USSID_v5.0_Plane Barrier 5 m/s
upper rib (n 10010)
upper spine (n 10112)
intrusion (n 10111 - n 10109)
test 006
test 007
v5.0
accel. [g]
intrusion [mm]
Time
lower rib (n 10019)
lower spine (n 10117)
pelvis (n 10165)


USSID_v5.0_Plane Barrier 8 m/s
upper rib (n 10010)
upper spine (n 10112)
intrusion (n 10111 - n 10109)
test 006
test 007
v5.0
accel. [g]
intrusion [mm]
Time
lower rib (n 10019)
lower spine (n 10117)
pelvis (n 10165)

7.2 Configuration B: Barrier with arm impactor

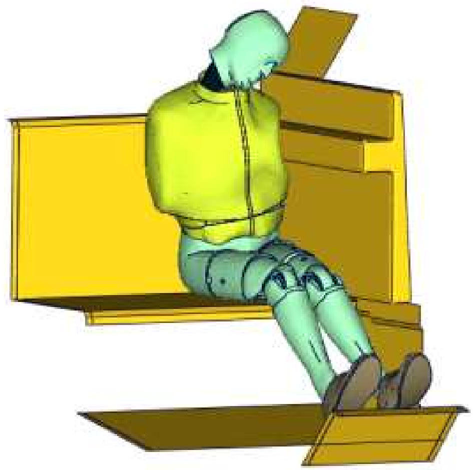
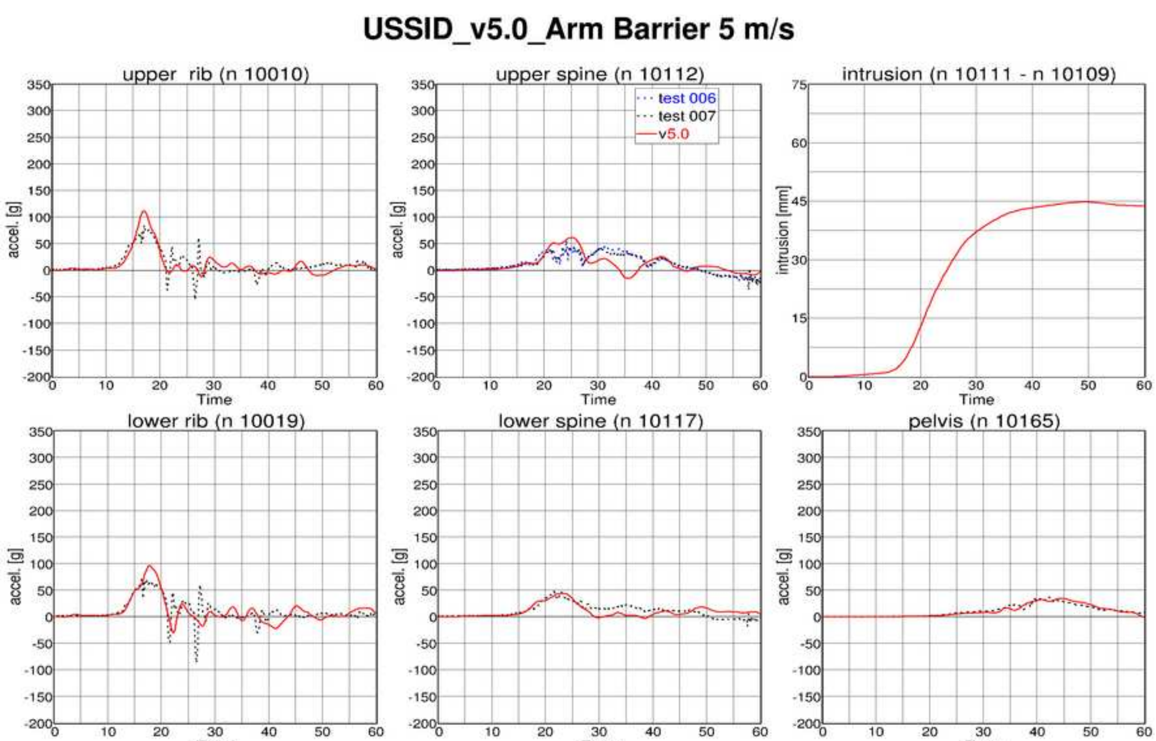
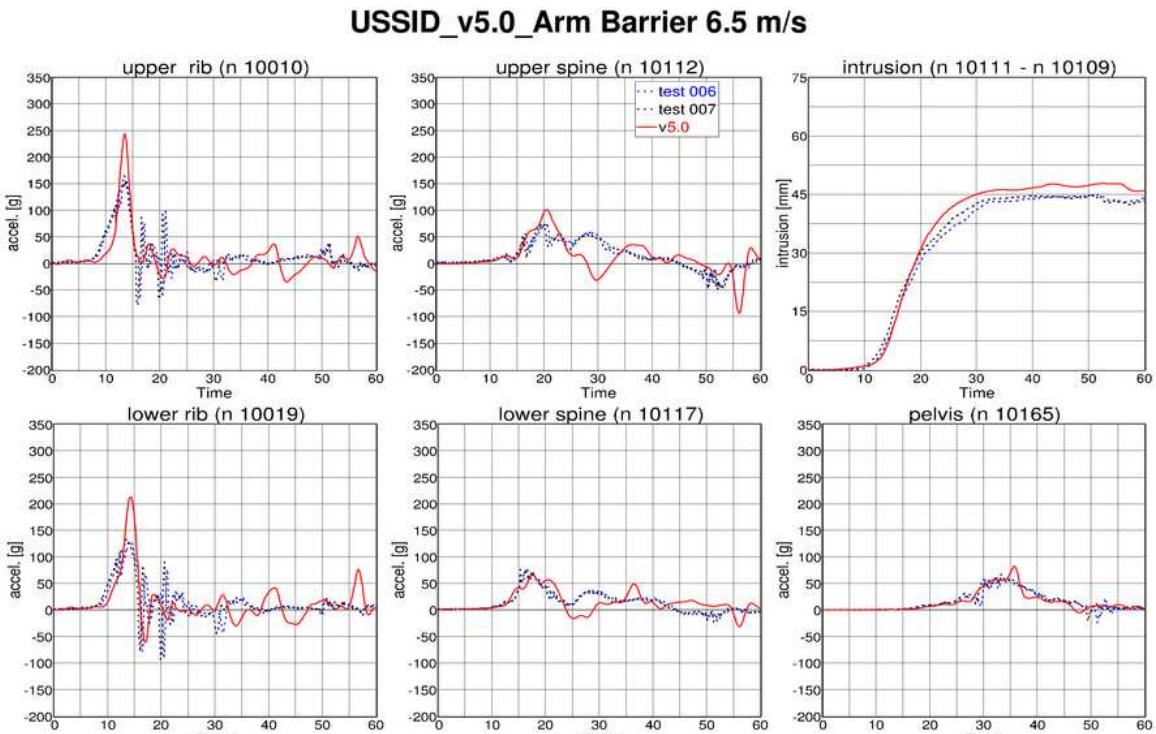


Fig. 12: Arm Barrier





USSID_v5.0_Arm Barrier 6.5 m/s
upper rib (n 10010)
upper spine (n 10112)
intrusion (n 10111 - n 10109)
lower rib (n 10019)
lower spine (n 10117)
pelvis (n 10165)
test 006
test 007
v5.0
accel. [g]
intrusion [mm]
Time

7.3 Configuration C: Barrier with abdomen impactor

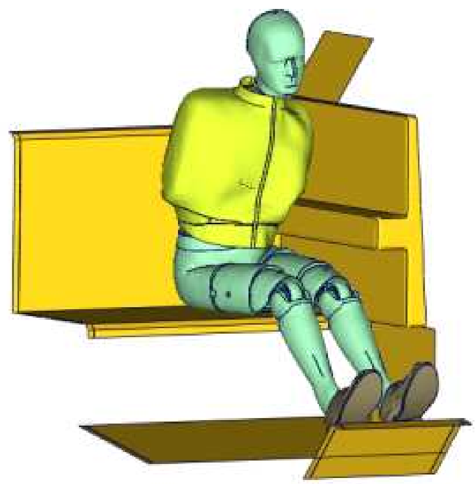
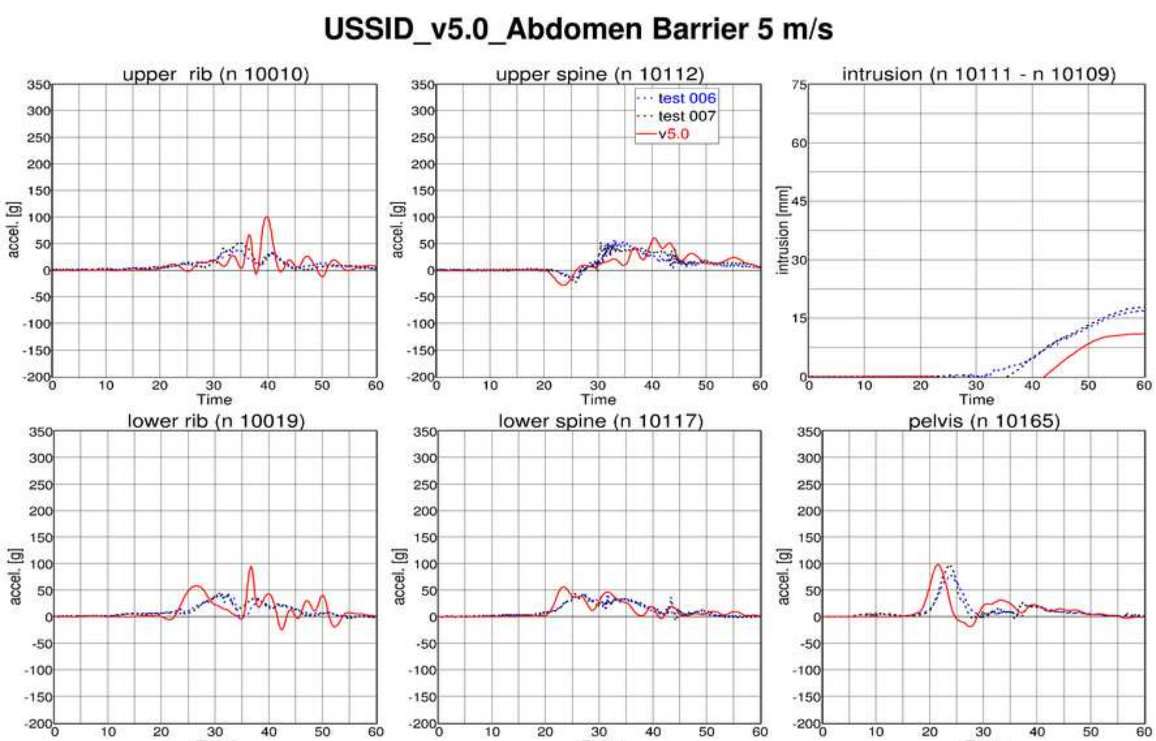


Fig. 13: Abdomen Barrier



7.4 Configuration D: Barrier with pelvis impactor

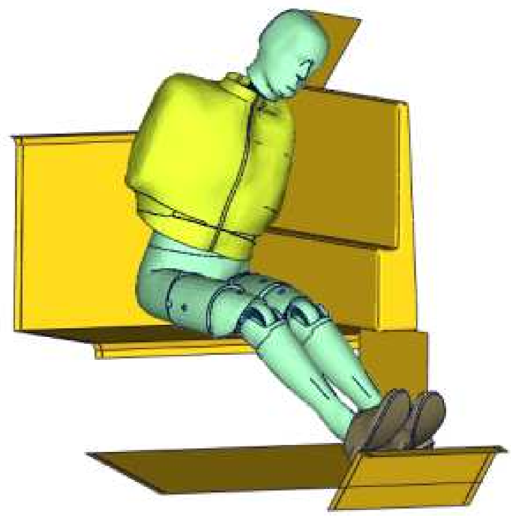
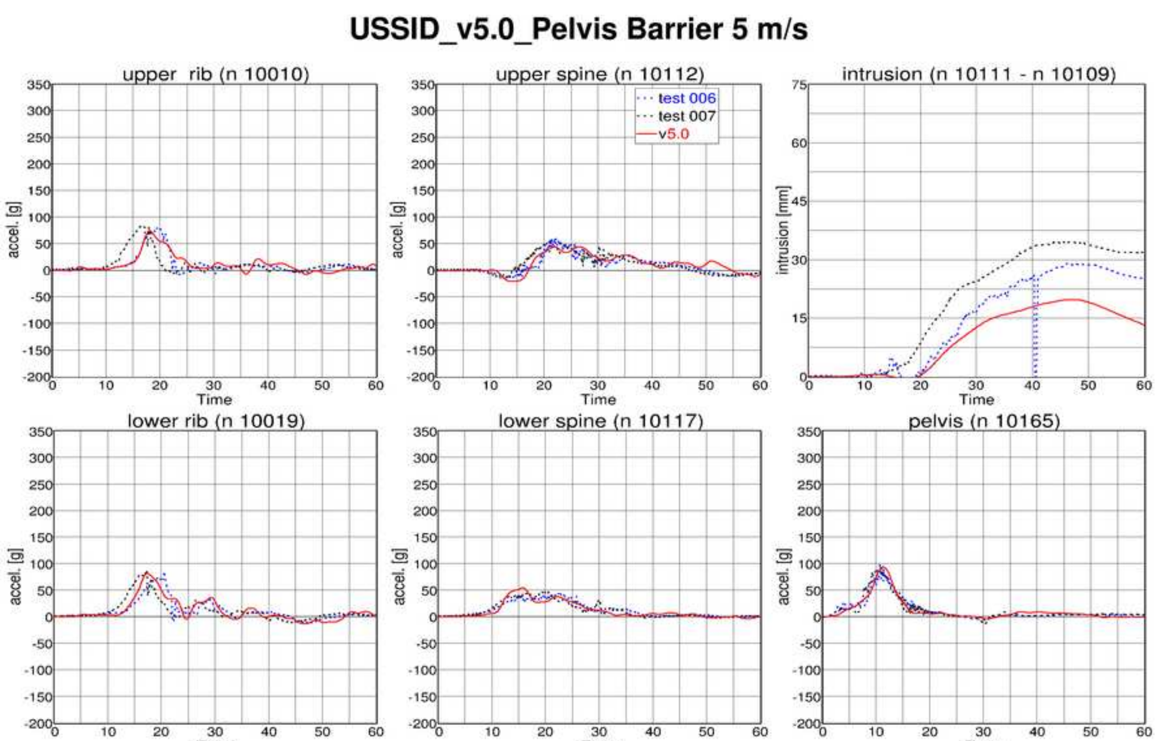
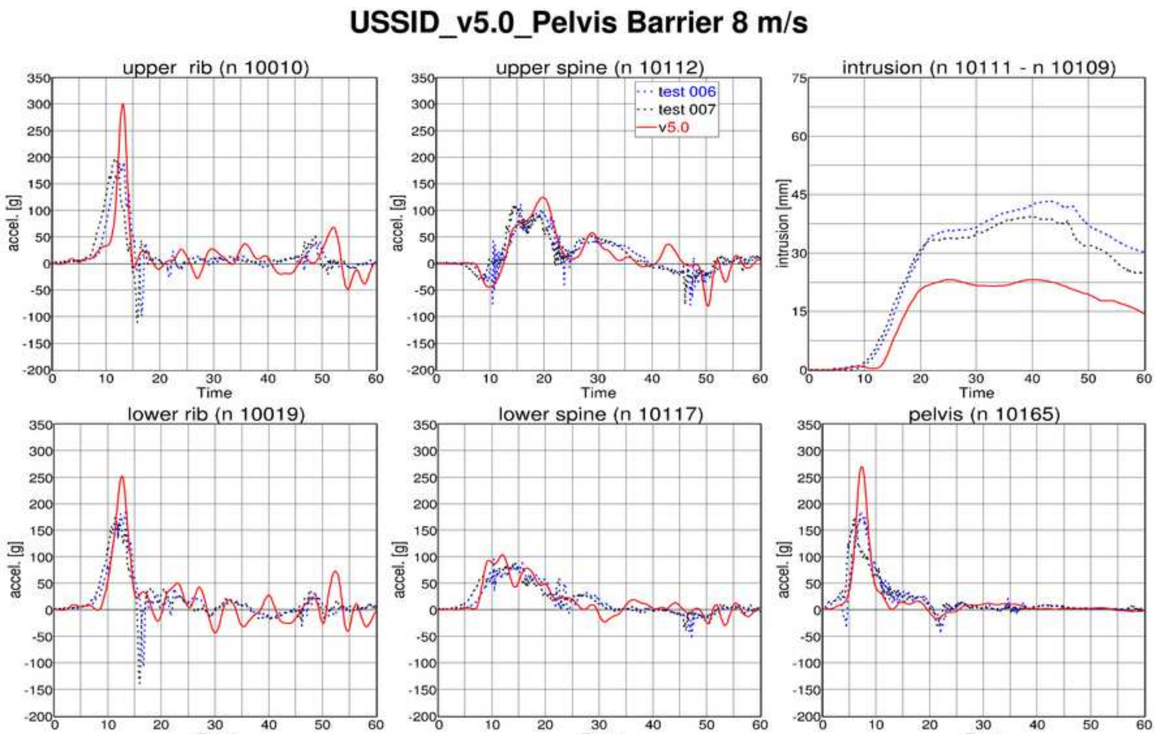


Fig. 14: Pelvis Barrier




USSID_v5.0_Pelvis Barrier 8 m/s
upper rib (n 10010)
upper spine (n 10112)
intrusion (n 10111 - n 10109)
lower rib (n 10019)
lower spine (n 10117)
pelvis (n 10165)
test 006
test 007
v5.0
accel. [g]
intrusion [mm]
Time

7.5 Configuration E: Barrier with B-pillar impactor

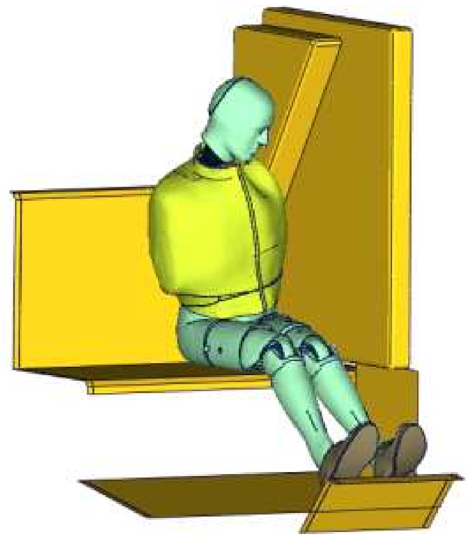
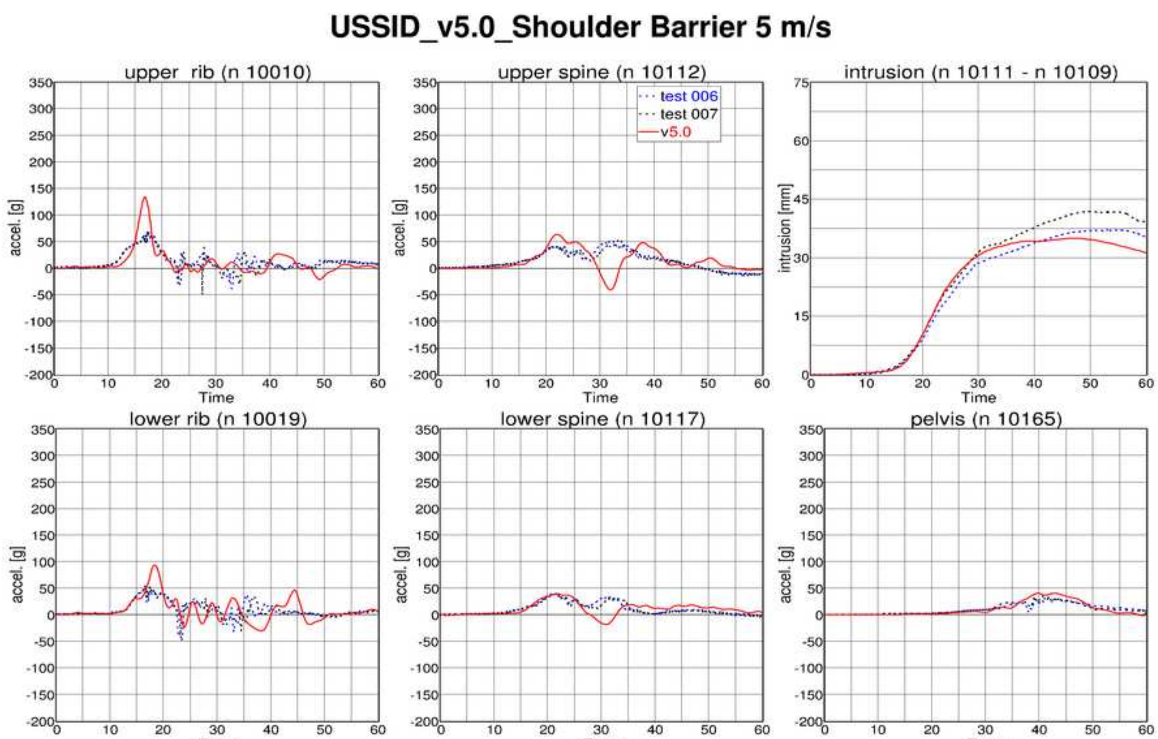
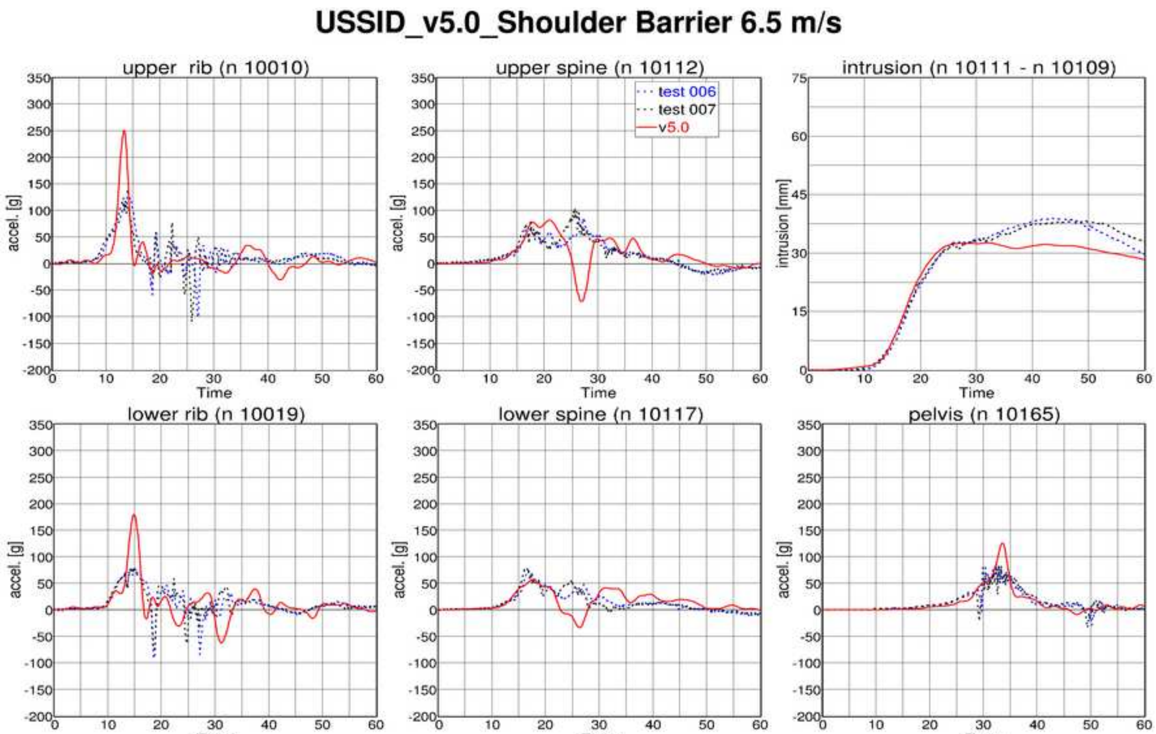


Fig. 15: Shoulder Barrier




USSID_v5.0_Shoulder Barrier 6.5 m/s
upper rib (n 10010)
upper spine (n 10112)
intrusion (n 10111 - n 10109)
lower rib (n 10019)
lower spine (n 10117)
pelvis (n 10165)
test 006
test 007
v5.0
accel. [g]
intrusion [mm]
Time

7.6 Configuration F: Barrier with door shape

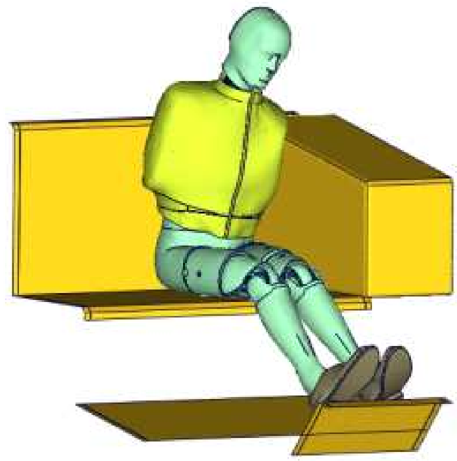
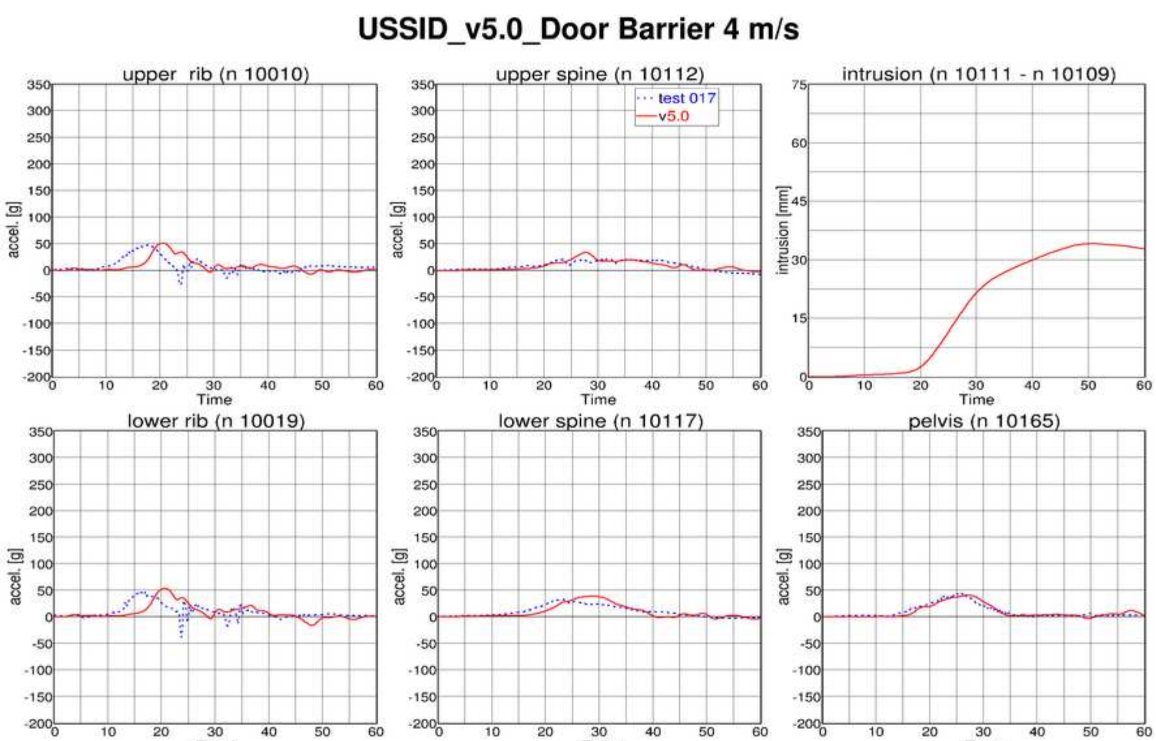


Fig. 16: Door Barrier



7.7 Thorax certification pendulum

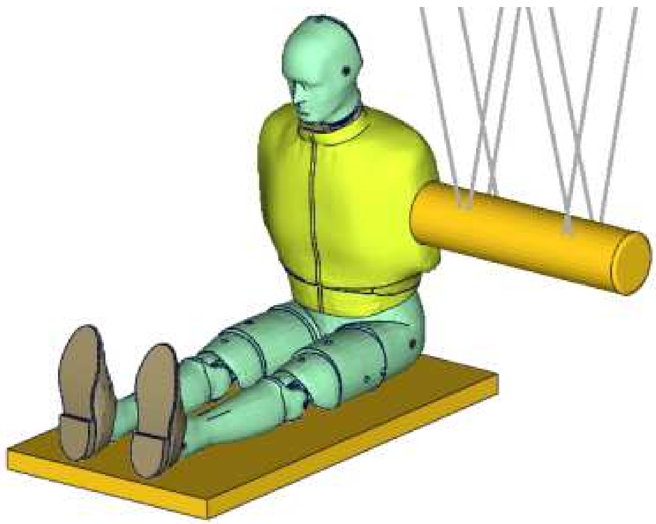
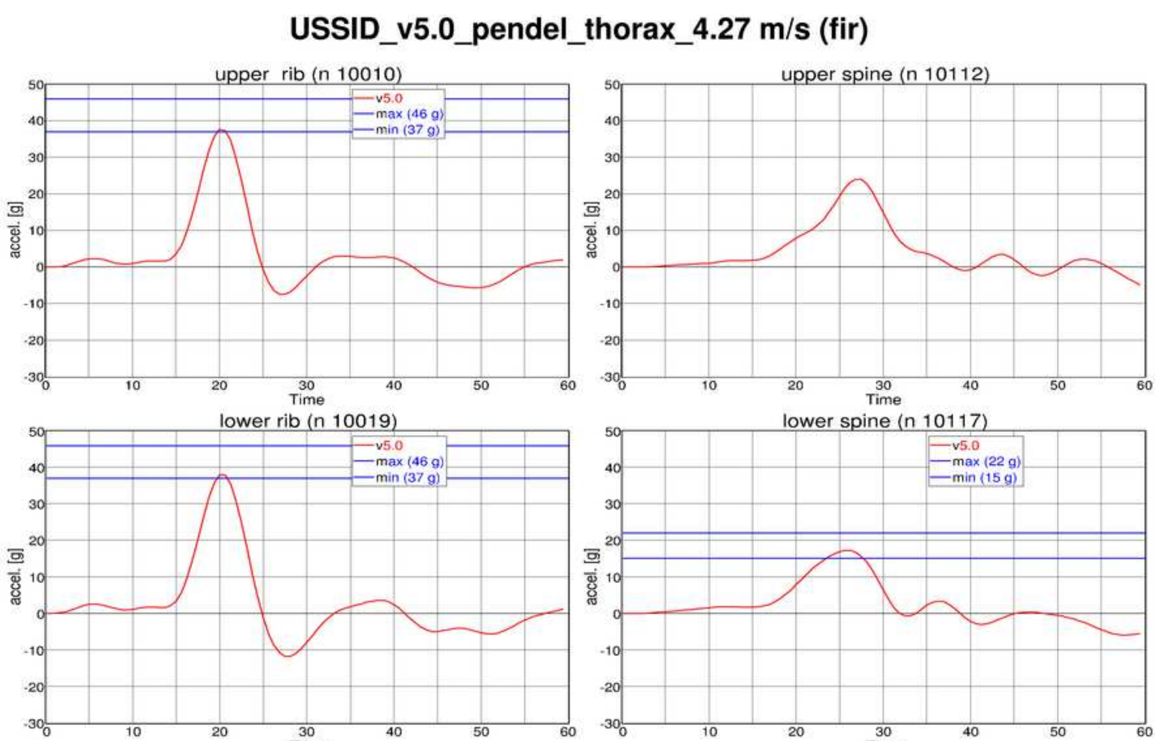


Fig. 17: Thorax Pendulum



7.8 Pelvic certification pendulum

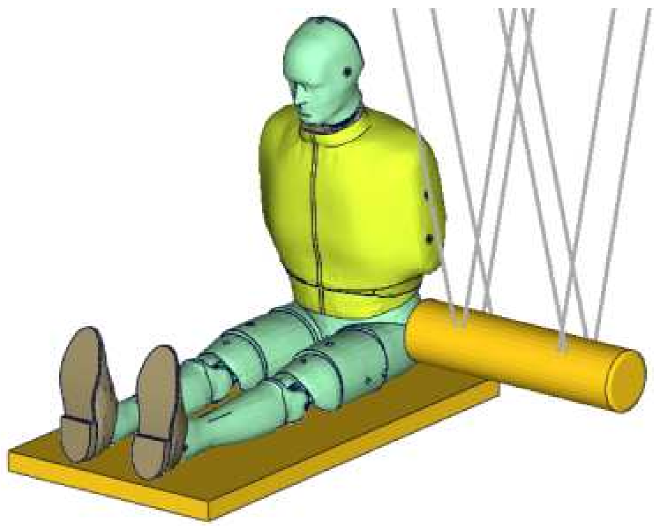
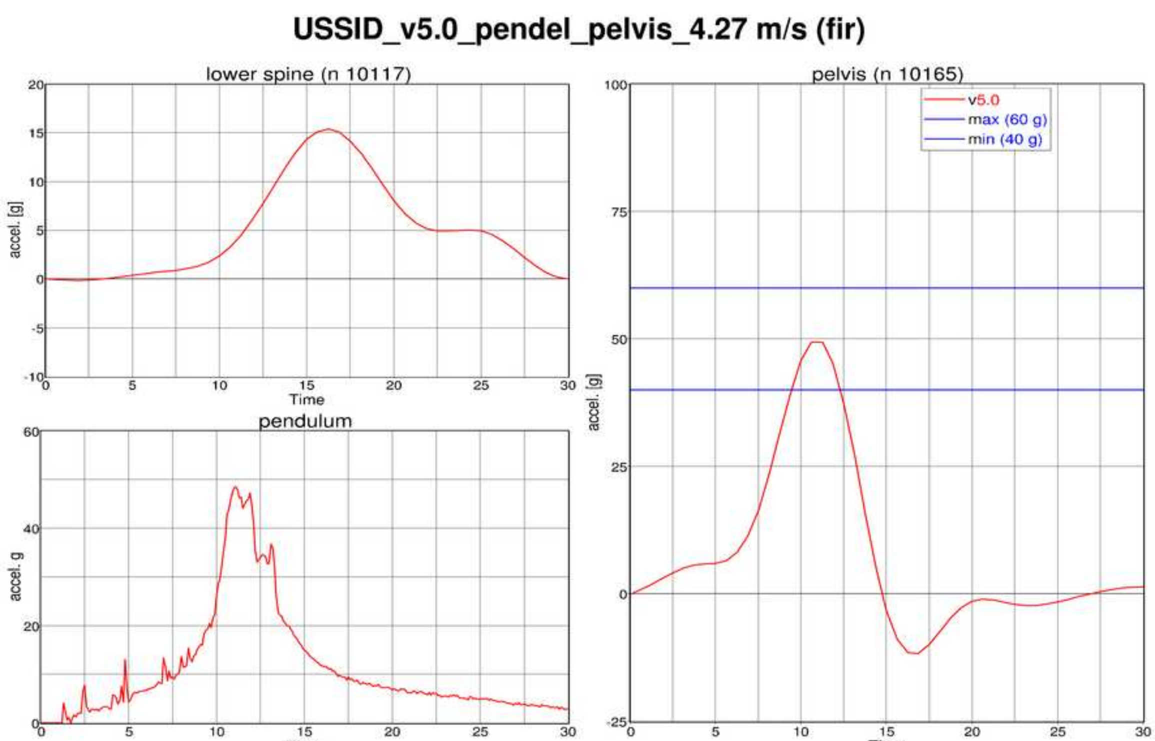
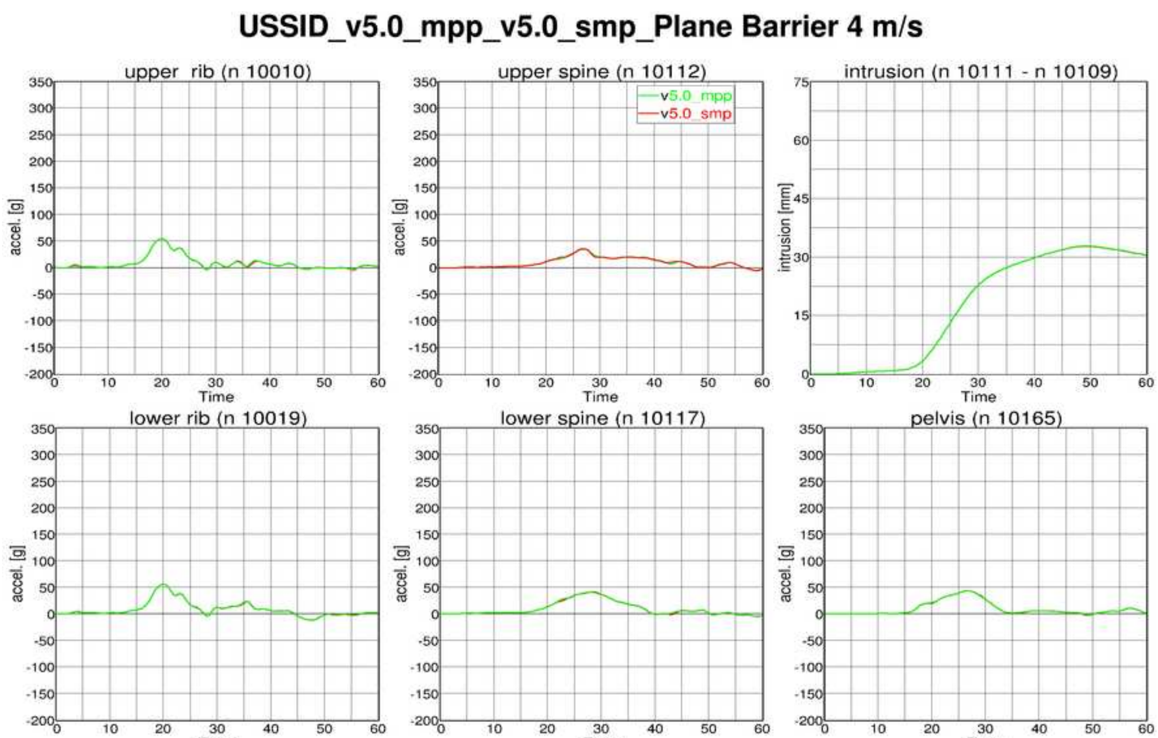


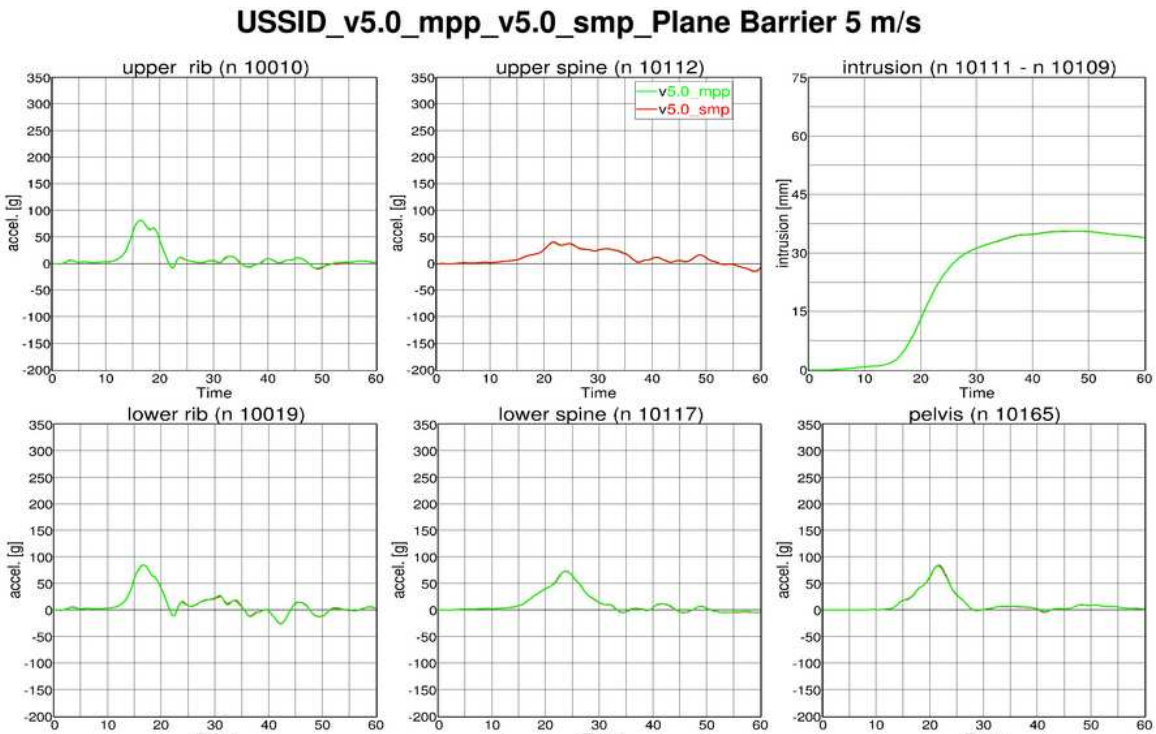
Fig. 18: pelvic pendulum

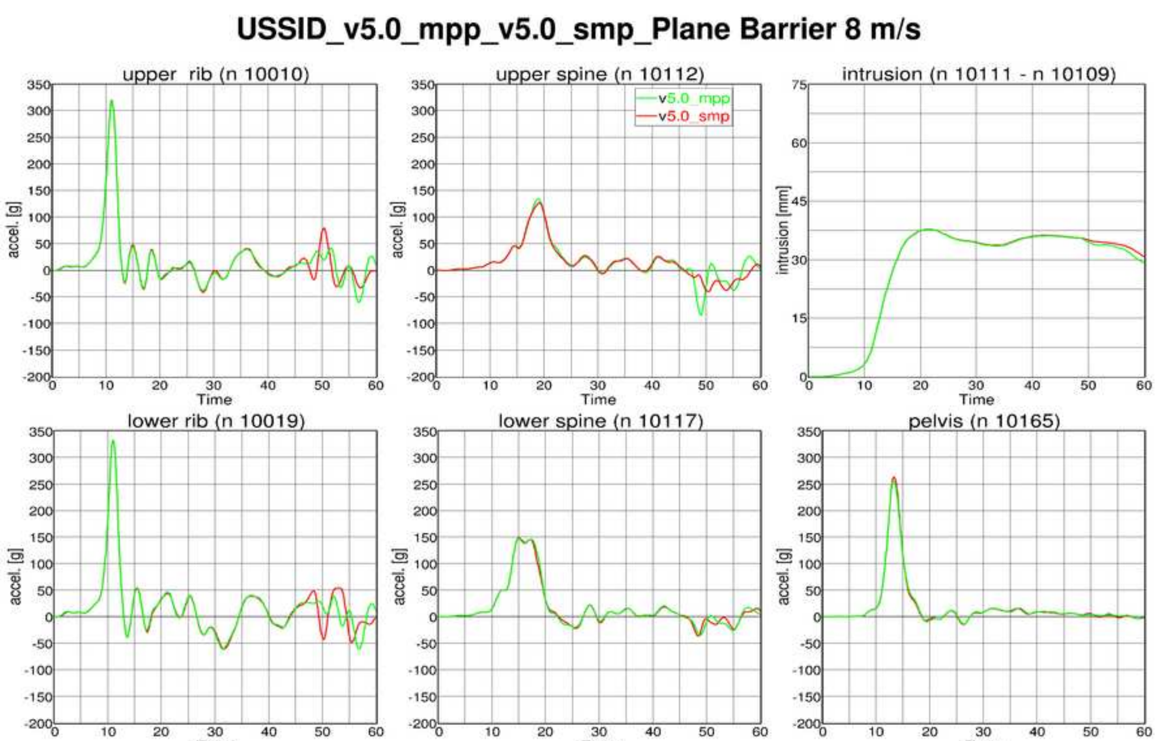


7.9 Performance under MPP

The results of two different runs on SMP and MPP-machines are depicted below.
The results are obtained on:
SMP: 4 CPU AMD Linux LS-DYNA version 970 Revision 6763
MPP: 16 CPU Opteron Linux LS-DYNA version 970 Revision 6763




USSID_v5.0_mpp_v5.0_smp_Plane Barrier 5 m/s
upper rib (n 10010)
upper spine (n 10112)
v5.0_mpp
v5.0_smp
intrusion (n 10111 - n 10109)
lower rib (n 10019)
lower spine (n 10117)
pelvis (n 10165)
accel. [g]
intrusion [mm]
Time


USSID_v5.0_mpp_v5.0_smp_Plane Barrier 8 m/s
upper rib (n 10010)
upper spine (n 10112)
v5.0_mpp
v5.0_smp
intrusion (n 10111 - n 10109)
lower rib (n 10019)
lower spine (n 10117)
pelvis (n 10165)
accel. [g]
intrusion [mm]
Time