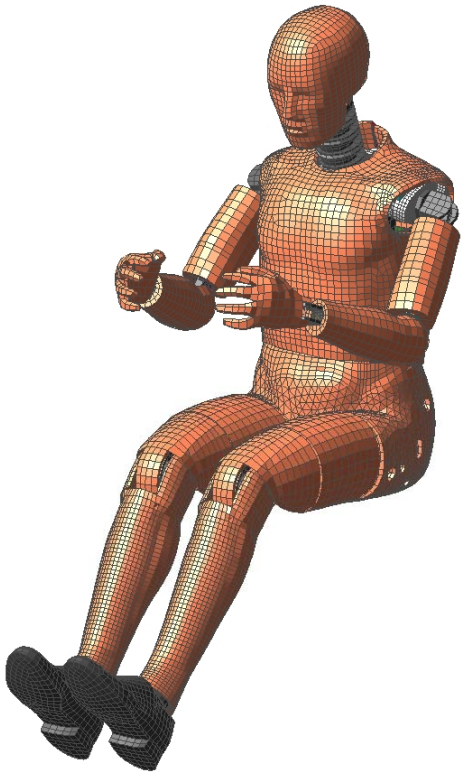
FTSS H350 v7.1 Model - LS-DYNA

Release Version 7.1

December 2009



For further information, contact:

	Fuchun Zhu	Jim Rasico
Tel:	+1 734 446 3139	+1 734 446 3073
Email:	fzhu@ftss.com	jrasico@ftss.com

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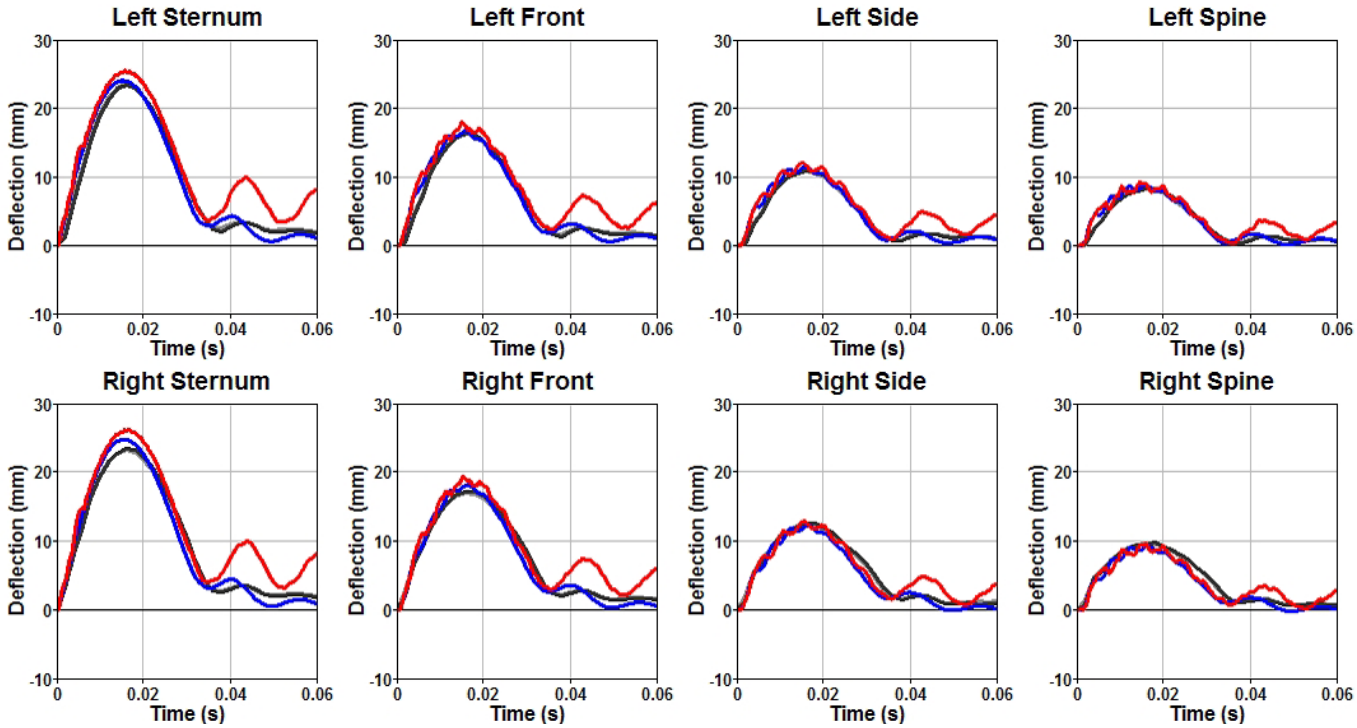
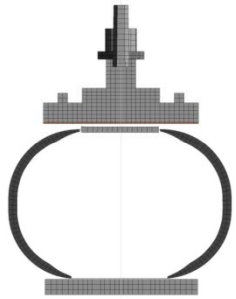
Rib Damping

The development of v7.1 included the goal to improve the chest deflection values, in particular the unloading phase. As FTSS has seen limitations using the VISCOELASTIC material model and promising improvements using the ANISOTROPIC material model for the SIDIIs rib damping, it was also investigated for the H350.

The performance was primarily evaluated in the PDB Sled test, with iterative tuning evaluated using the torso drop simulations. As the material model involves plastic behavior, it was a challenge to reduce this effect, while taking advantage of the two viscous parameters that softened the unloading phase. Using the ANISOTROPIC model is an improvement over VISCOELASTIC, but it seems a more appropriate model may yet be developed.

- **Orthogonal impact, Speed 3.0m/s**





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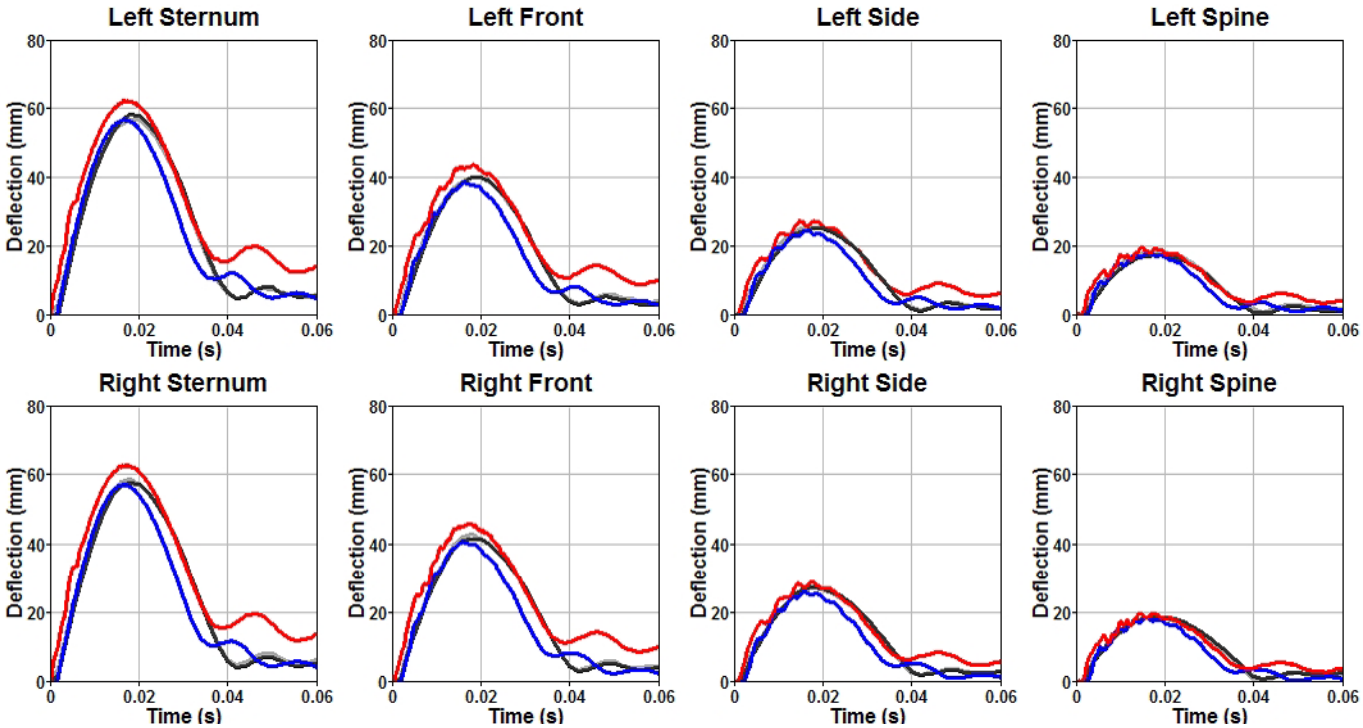
- **Orthogonal impact, Speed 6.7m/s**



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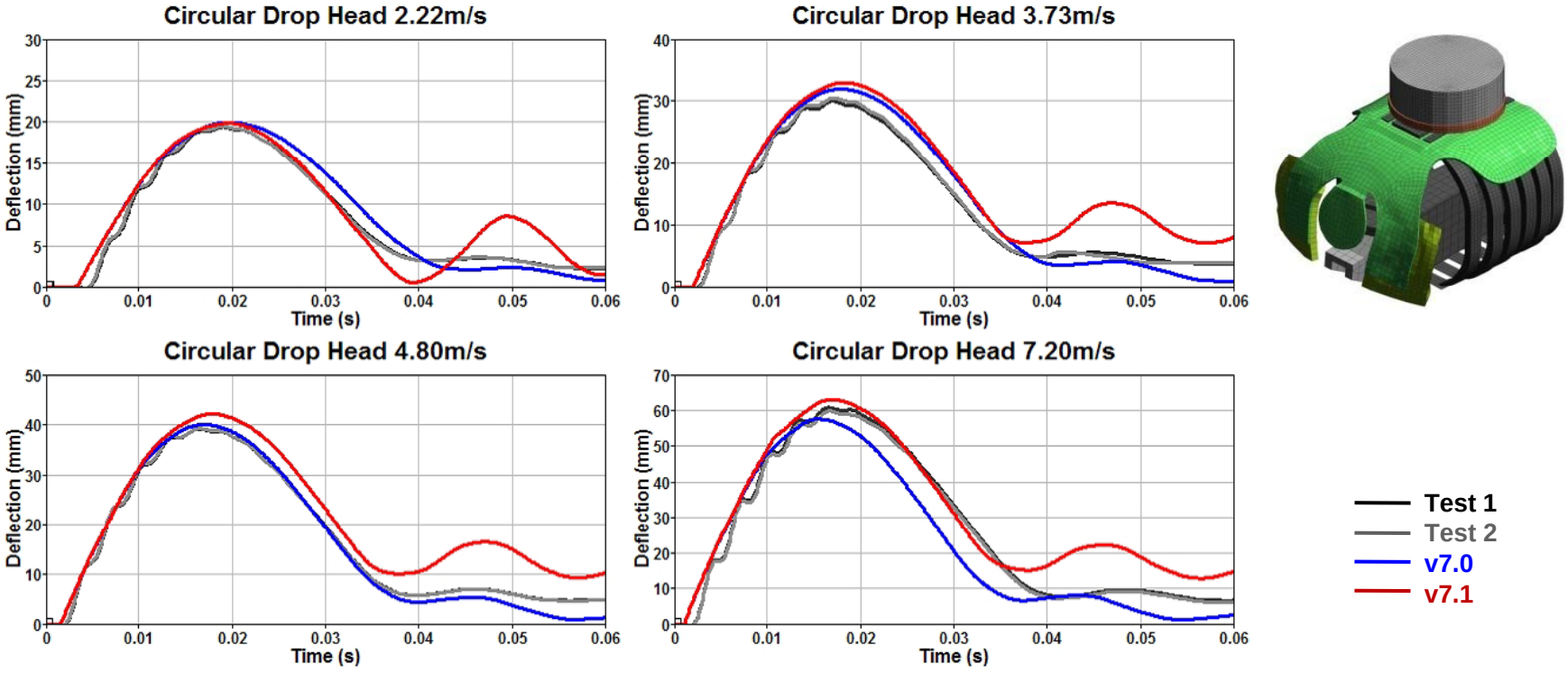
- **Circular Drop Head, Speed 2.22m/s, 3.73m/s, 4.80m/s, 7.20m/s**



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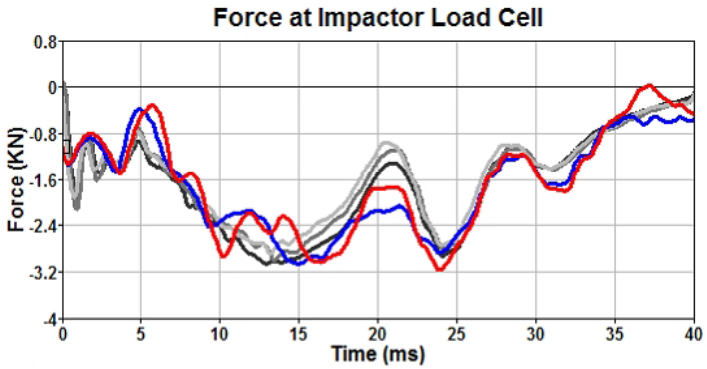
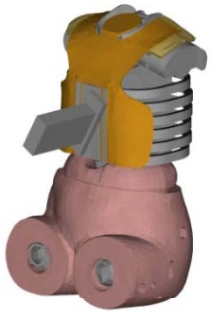
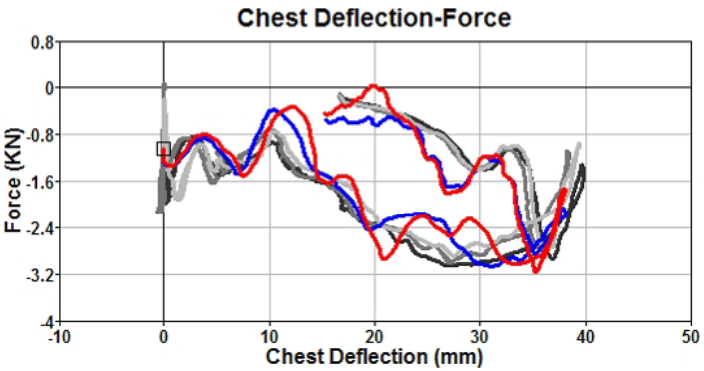
- **PDB Sternum Central Impact without Jacket – IP0_0_C2**







Test 1
Test 2
Test 3
V7.0
v7.1

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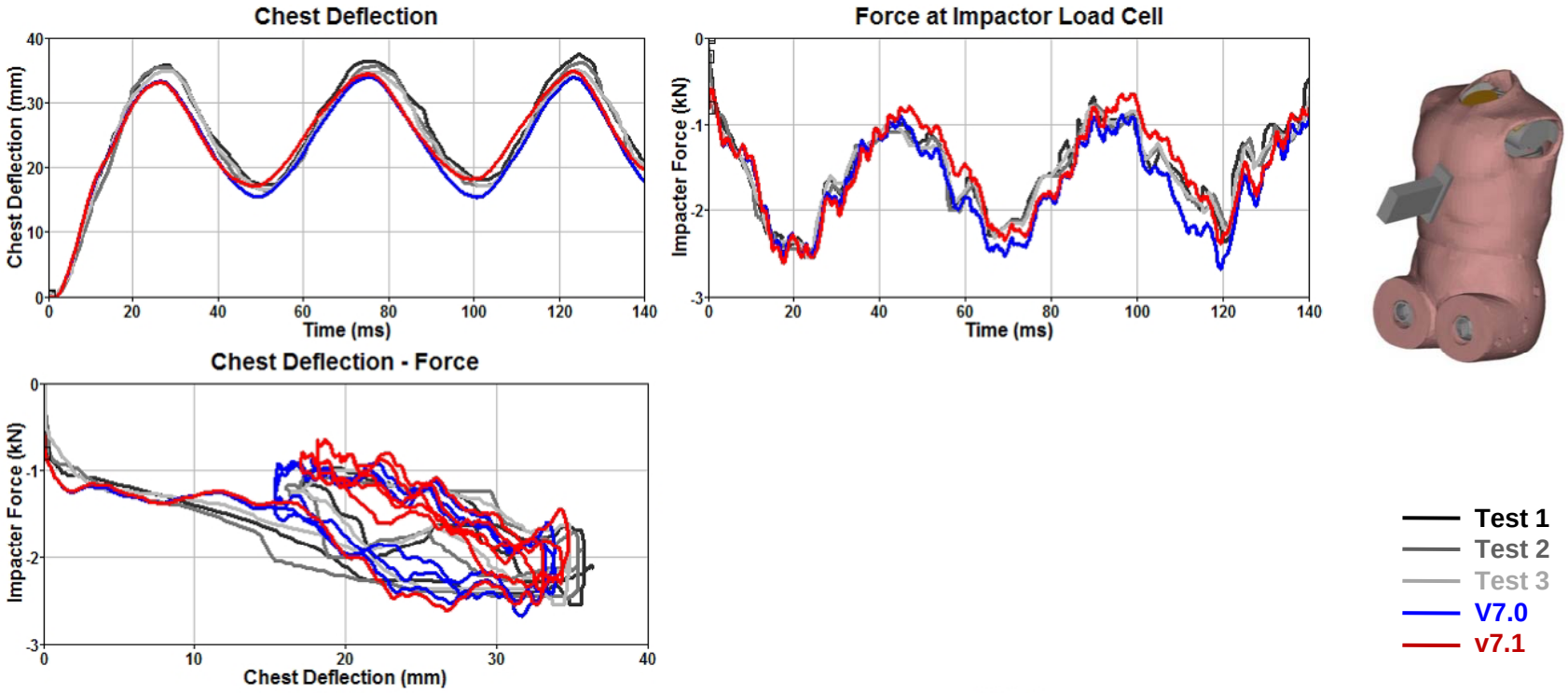
- **PDB Sternum Central Pulsating Impact IP0_1_P2 – 3 Pulse Updated**



Impactors forces showed small improvement in all Torso impact cases

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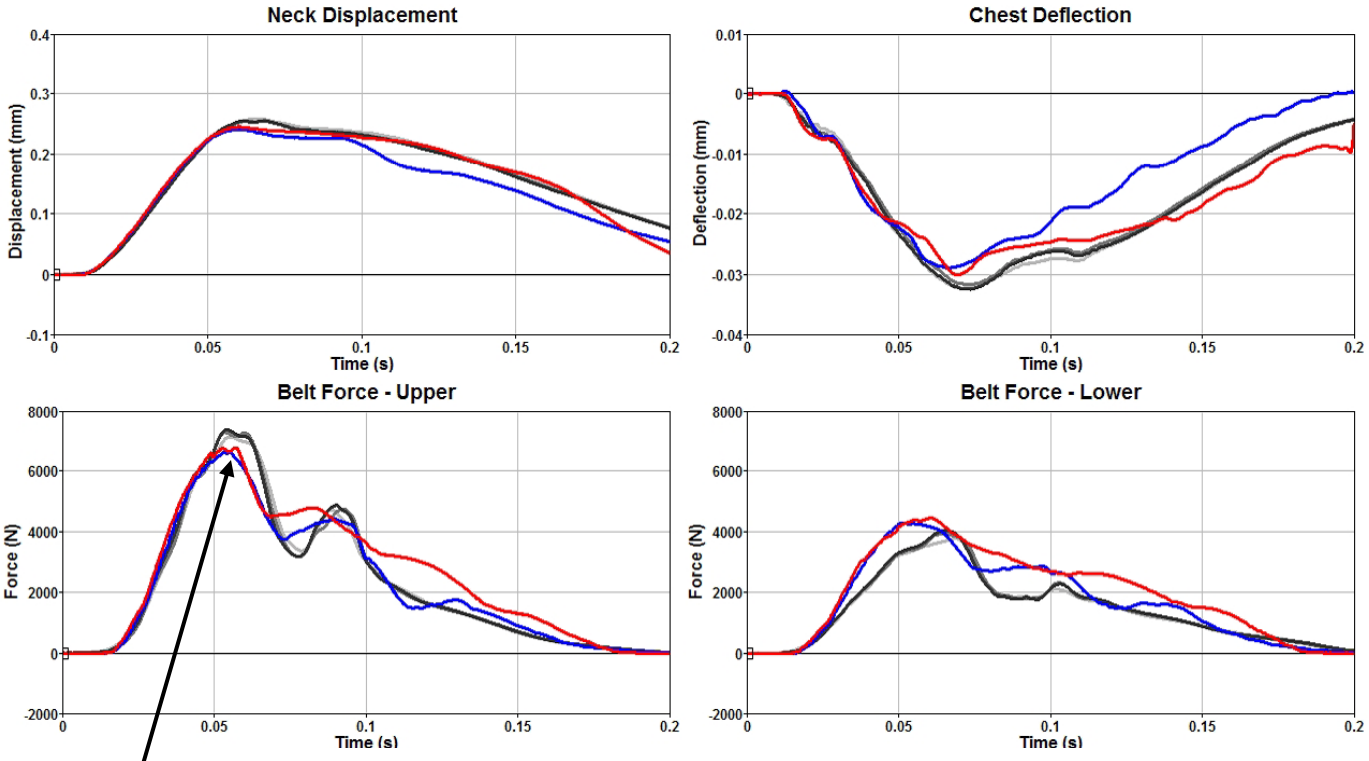
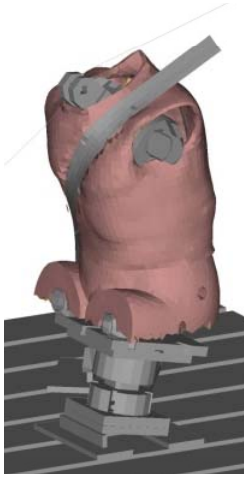
- PDB Torso Pull (Seatbelt) --- Non-Certification Test





Test 1
Test 2
Test 3
v7.0
v7.1

Increased belt force would likely further improve chest deflection. The loading mechanism and belts will be investigated in further developments.

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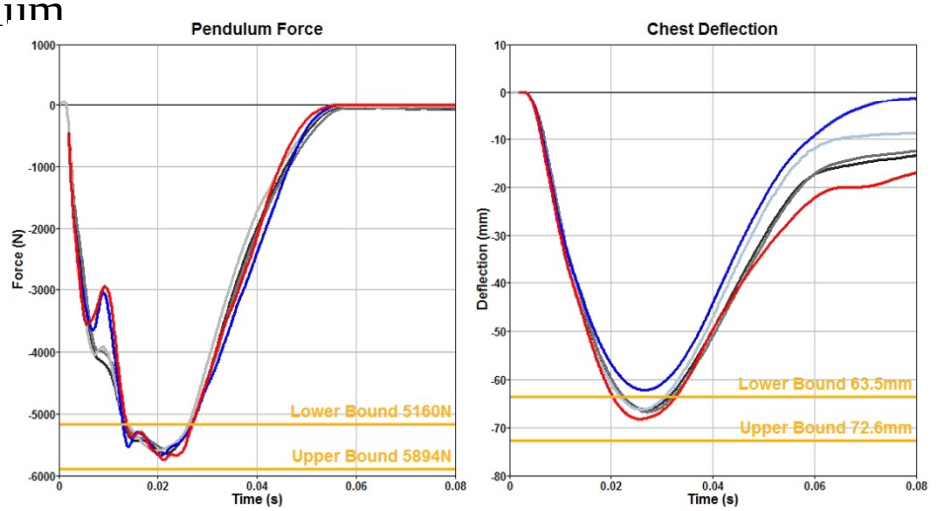
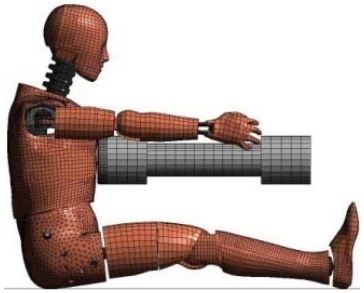
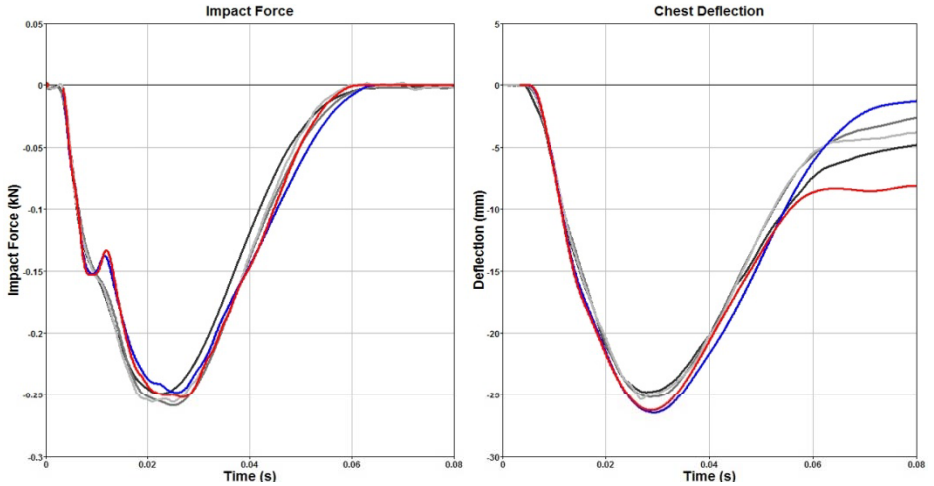
- Thorax Pendulum

Speed 6.71m/s





Speed 3.00m/s



Test 1
Test 2
Test 3
v7.0
v7.1

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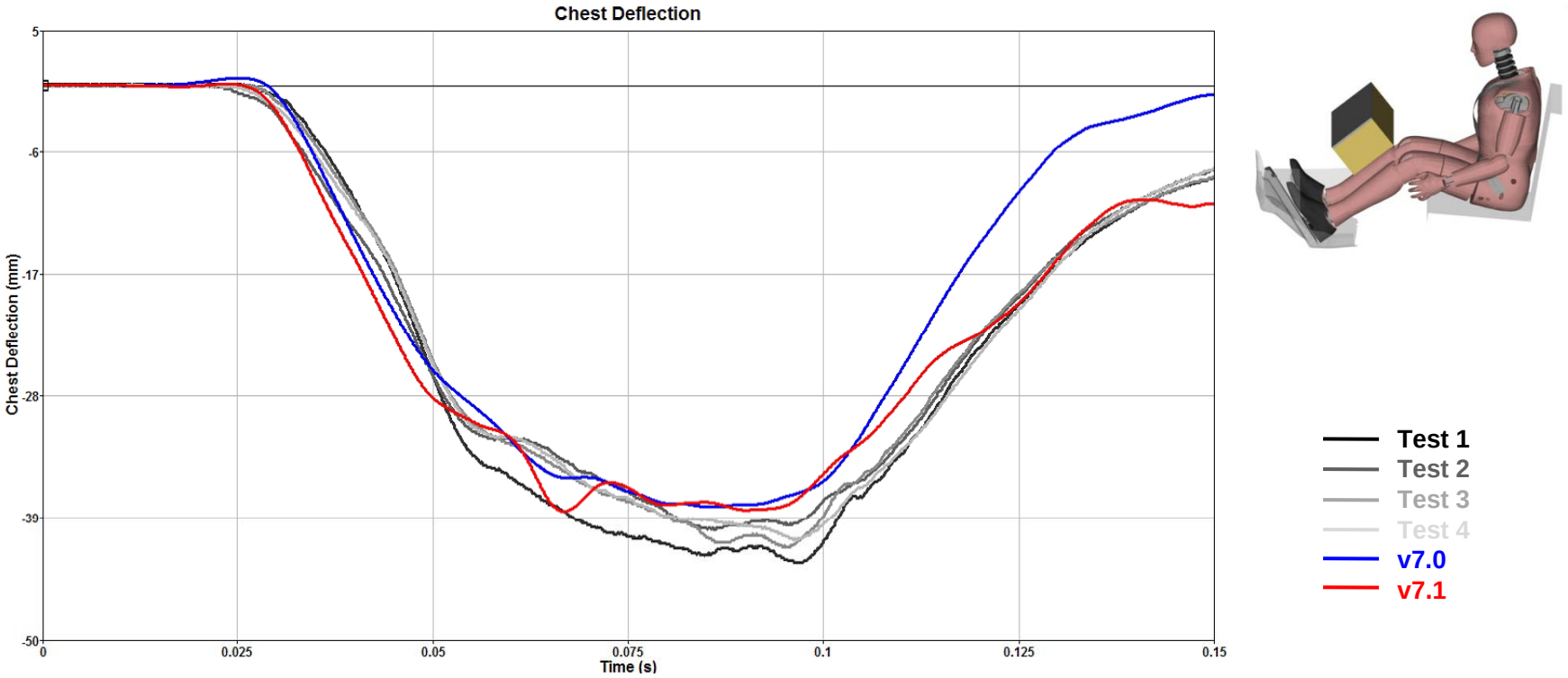
ACEA Sled



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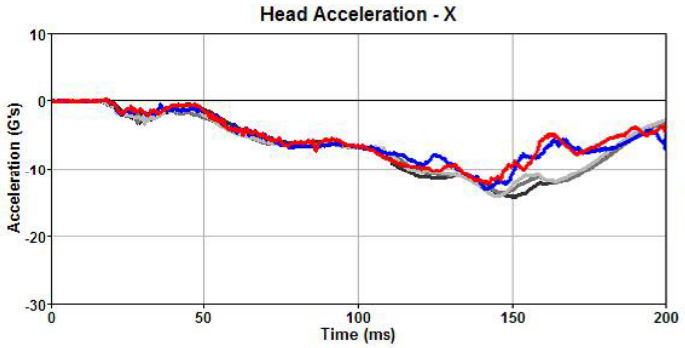
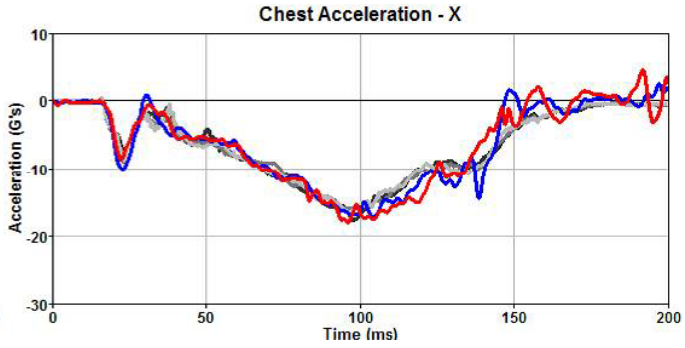
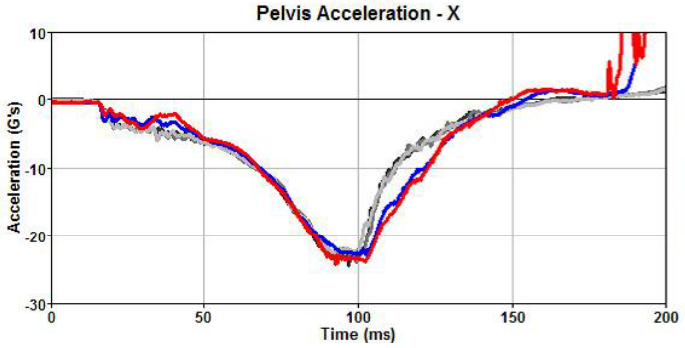
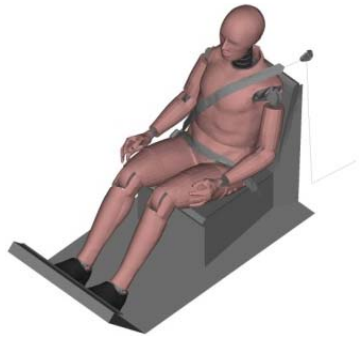
PDB Sled









Test 1
Test 2
Test 3
v7.0
v7.1

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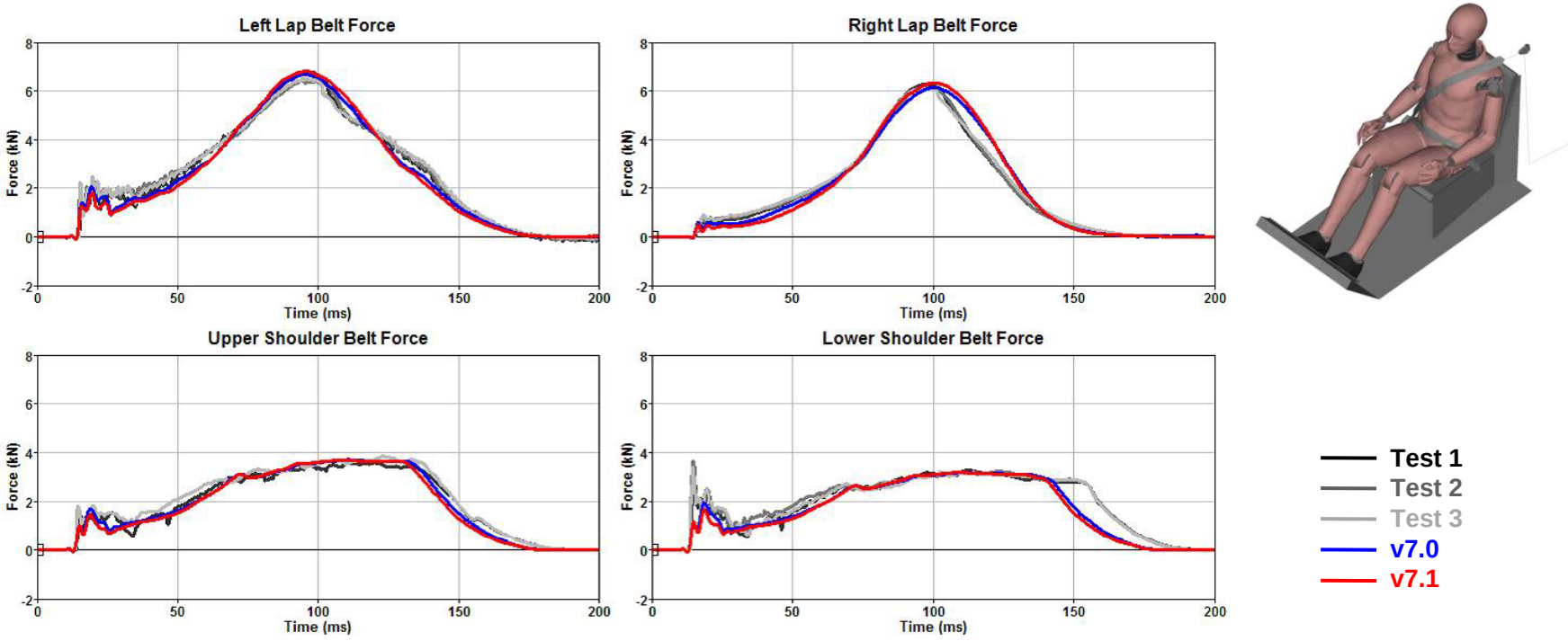
PDB Sled



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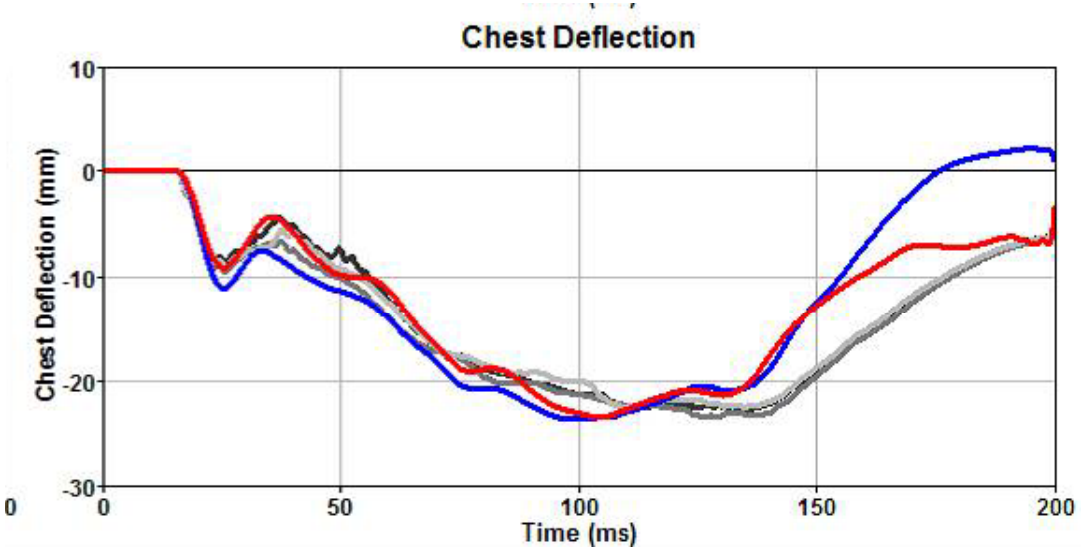
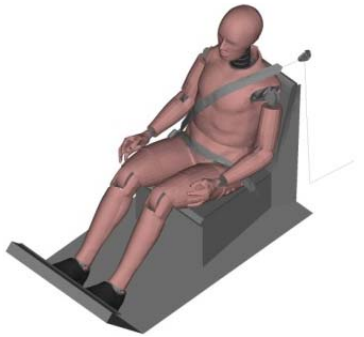
PDB Sled





Test 1
Test 2
Test 3
v7.0
v7.1

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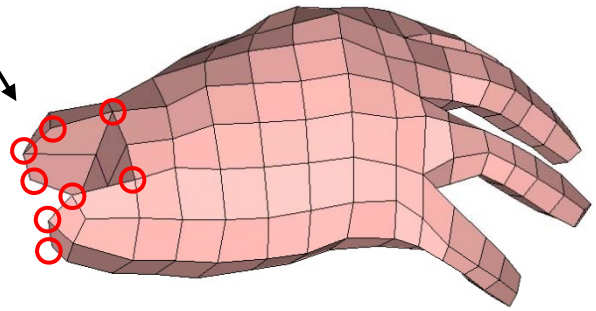
Geometry Updates

Hand – updated geometry

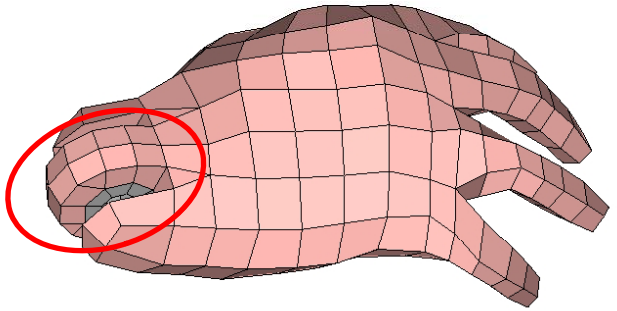
Updated Hand geometry
- Representation of bone at wrist updated
- Vinyl flesh covers hand bone at wrist

Nodes in rigid body

v7.0



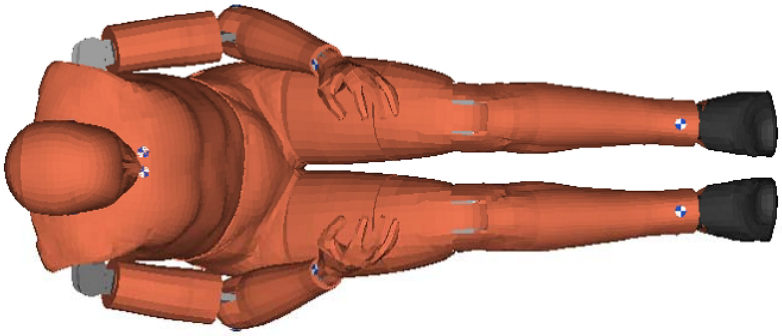
v7.1

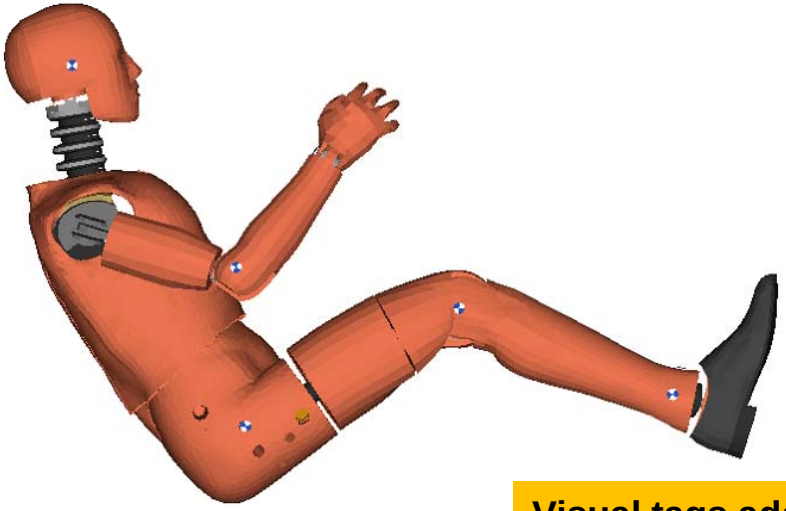


This change is expected to eliminate erroneous signal spikes as the wrist impacts the car interior.

Additional Data Requests

Tracking Points





***DATABASE_HISTORY_NODE_ID**

1612021	RIGHT LOWER ARM BOLT HEAD
1612039	RIGHT WRIST BOLT HEAD
1612049	LEFT LOWER ARM BOLT HEAD
1612059	LEFT WRIST BOLT HEAD
1612089	LEFT KNEE CLEVIS BOLT HEAD
1612099	RIGHT KNEE CLEVIS BOLT HEAD
1612109	LEFT FRONT SHIN BOLT HEAD
1612119	LEFT ANKLE BOLT HEAD
1612129	RIGHT FRONT SHIN BOLT HEAD
1612130	RIGHT ANKLE BOLT HEAD
1612170	RIGHT HEAD COG TAG
1612179	LEFT HEAD COG TAG
1612180	RIGHT HPOINT COG TAG
1612189	LEFT HPOINT COG TAG

***DATABASE_HISTORY_NODE_ID**

1500152	RIGHT SHOULDER BOLT
1500157	LEFT SHOULDER BOLT
1500286	OCCIPITAL JOINT
1517495	RIGHT SHOE HEEL POINT
1520227	LEFT SHOE HEEL POINT
1523446	NOSE TIP
1612167	GLOBAL HEAD TRACKING
1612168	GLOBAL CHEST TRACKING
1612169	GLOBAL PELVIS TRACKING
1515179	THORAX ANGLE UPPER POINT
1515193	THORAX ANGLE LOWER POINT
1547549	PELVIS ANGLE REAR POINT
1549524	PELVIS ANGLE FRONT POINT

Global output data to compare with test video

Visual tags added to help identify some landmarks

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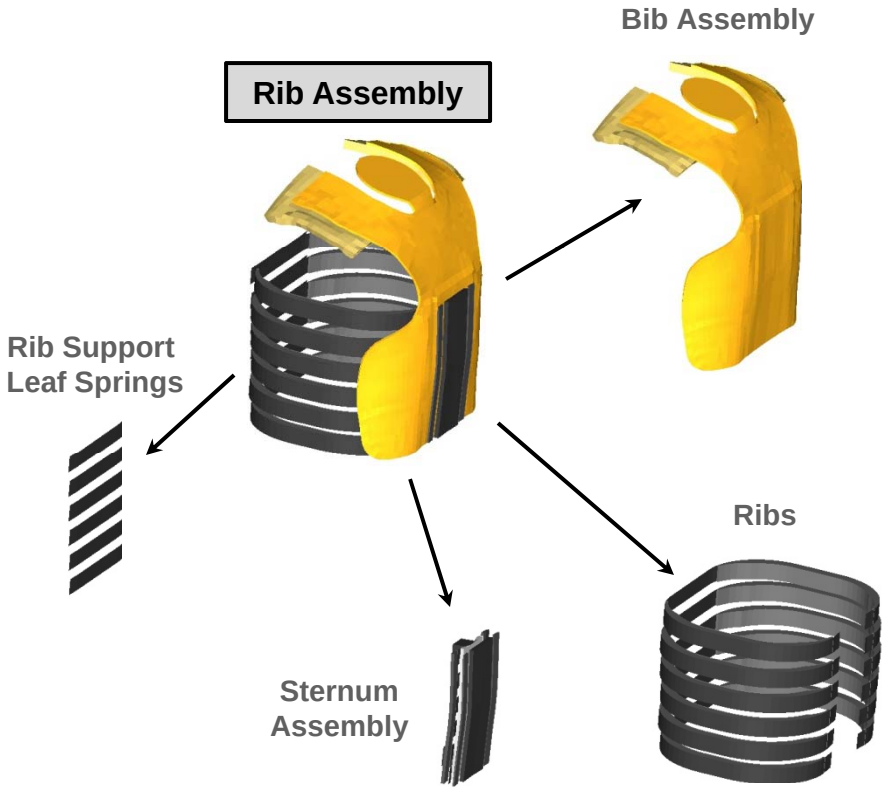
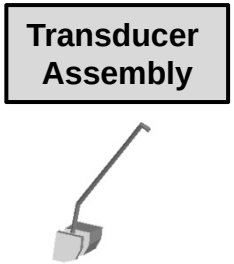
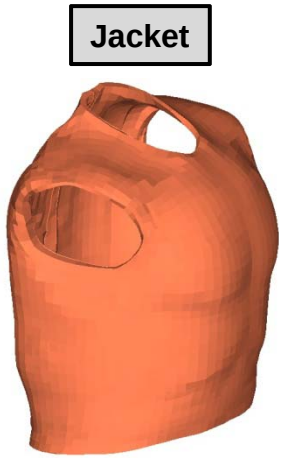
Mass Comparisons







Upper torso mass accuracy taken from assembly level to component/sub-assembly

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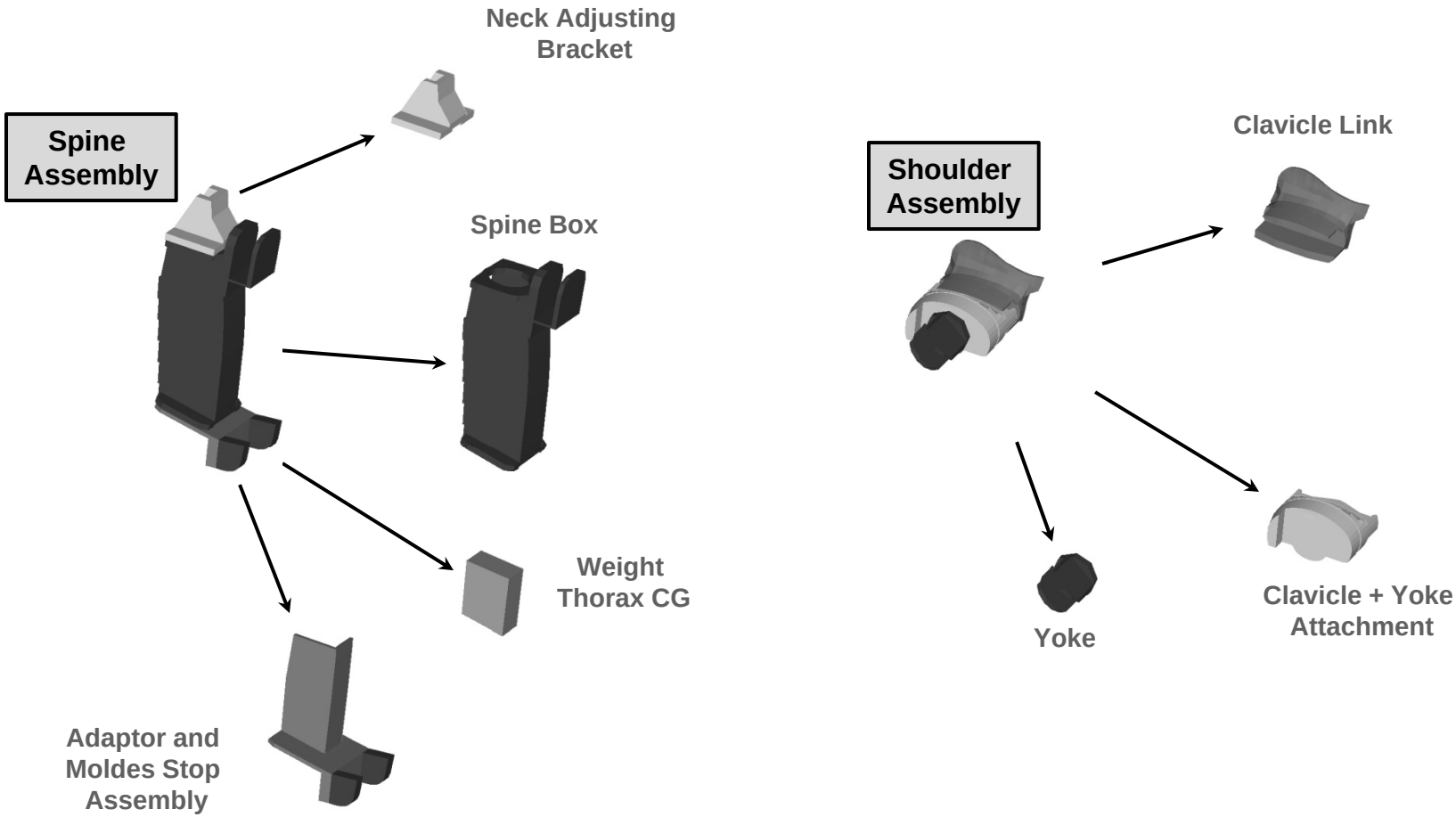
Mass Comparisons



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Mass Comparisons

	Hardware	Bolts	v7.1	diff [g]
Rib Assembly				
sternum assembly	392	Yes	383	-9
bib assembly	374	No	371	-3
ribs	2176	No	2175	-1
rib support leaf spring	266	No	267	1
sum of chest components	3208		3196	-12
Spine Assembly				
neck adjusting bracket	372	No	374	2
spine box	3014	Yes	3012	-2
weight thorax CG	1811	Yes	1811	0
adaptor and moldes stop assemb	1720	Yes	1718	-2
sum of spine assembly	6917		6915	-2
Transducer Assembly	102	Yes	99	-3
Left Shoulder Assembly				
Yoke	675	Yes	678	3
Clavicle + Yoke Attachment	712		713	1
Clavicle Link	740	Yes	741	1
sum of shoulder assembly	2127		2132	5
Right Shoulder Assembly				
Yoke	675	Yes	678	3
Clavicle + Yoke Attachment	712		713	1
Clavicle Link	740	Yes	741	1
sum of shoulder assembly	2127		2132	5
Beam Elements			17	
Sum of Thorax Without Jacket	14481		14491	10
Jacket	2740		2742	2
Total Torso	17221		17233	12

Foam Stability Improvements

Robustness Improvements – Foams

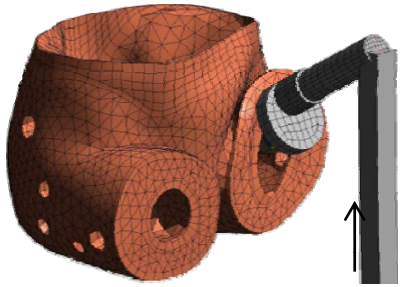
Some customers have reported negative brick volume (NBV) errors with the H350 model, usually in severe load cases.

With v7.1, all the foam stress/strain curves were updated. The curves in the high range of compression (> 80%) have been stiffened to help prevent NBV.

- In most cases, the validation models predict exactly the same.

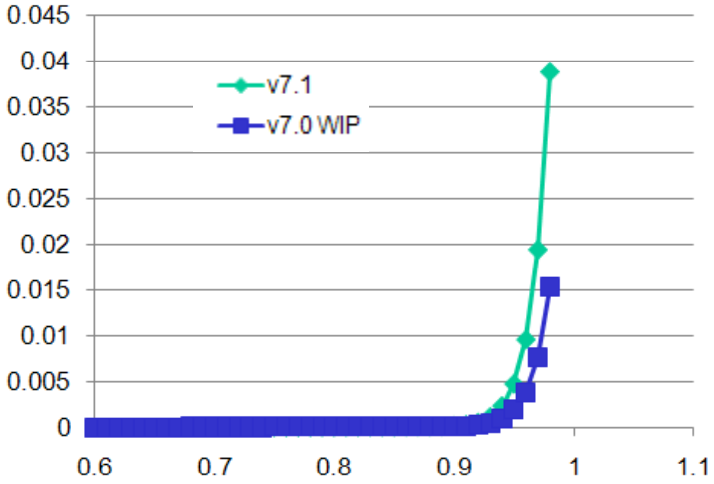
Foam Stability Improvements

Robustness Improvements – Pelvis Foam

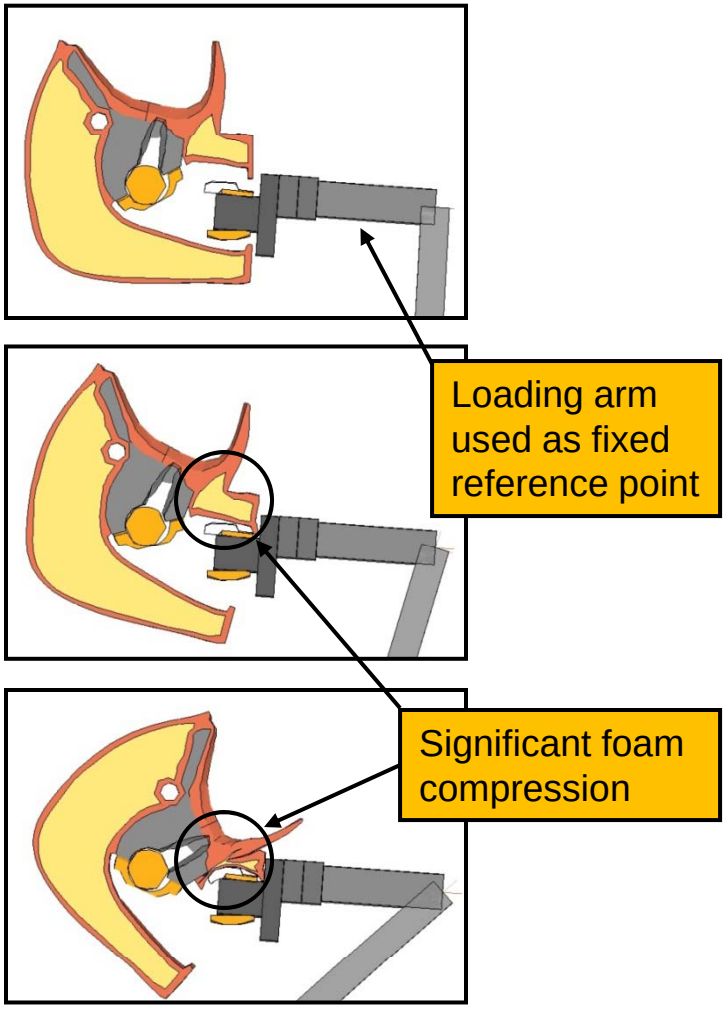


Certification Test
HROM

Strain Rate 0.0 -- Stress/Strain Curve



2.5 x stiffer after 88% strain



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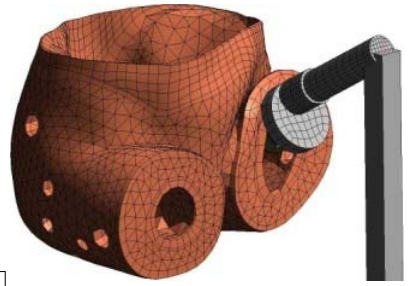
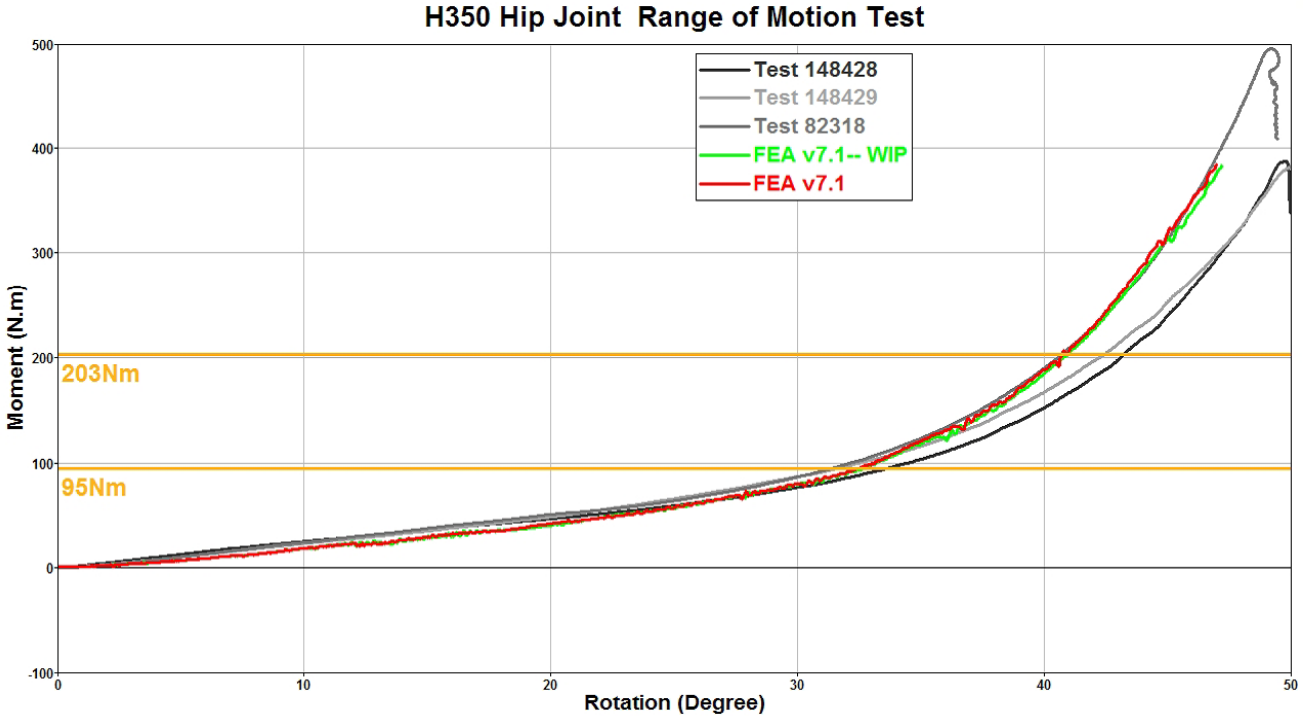
Foam Stability Improvements

Robustness Improvements – Pelvis Foam



Certification Test – Quasi-static



Stiffer curves have minor effect on correlation

NOTE: Jacket Ensolite is on average 9 times stiffer at end of curve for each rate, with negligible affect on performance

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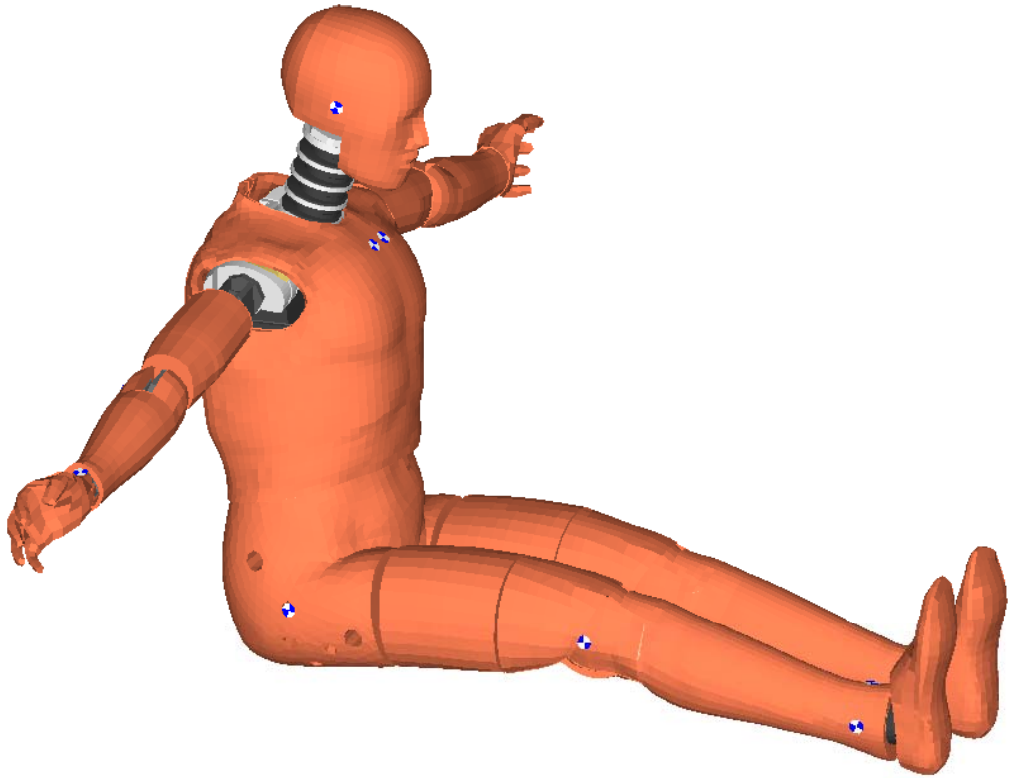
Proposed Standard for Joint Definitions

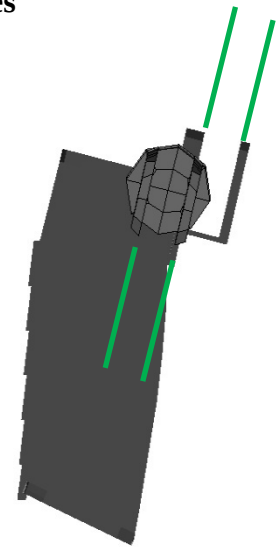
New Zero Position Definitions for Joints



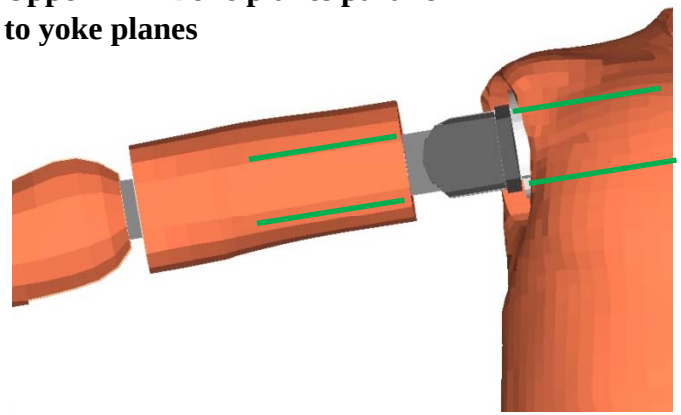
Proposed Standard for Joint Definitions

New Zero Position Definitions for Joints

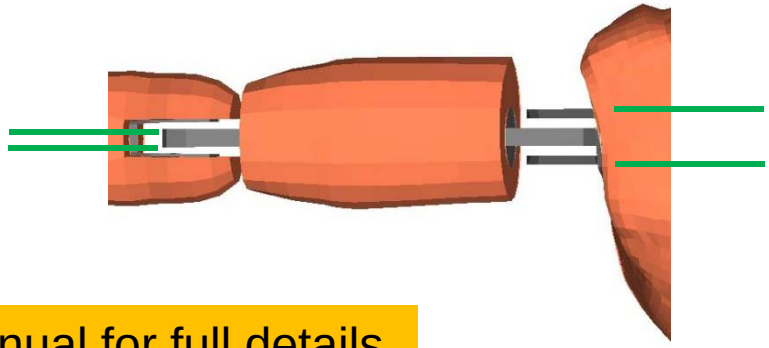
Yoke planes parallel to sternum-clavicle attachment planes



Upper Arm Bone planes parallel to yoke planes



Elbow planes parallel to yoke planes



The zero position for the head/neck, thorax and new lumbar spine fake joints are consistent with the design geometry.

See User Manual for full details

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Curve-based Joint Stops

The hard stops in the v7.0 model were replaced with stiffness curves to reduce signal noise. Curves below also represent new zero definitions. The users need to follow the table of ranges shown previously for pre-processor positioning.

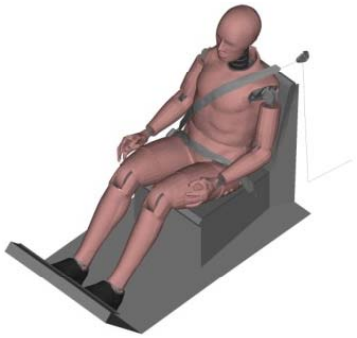
v7.0 Clavicle Link

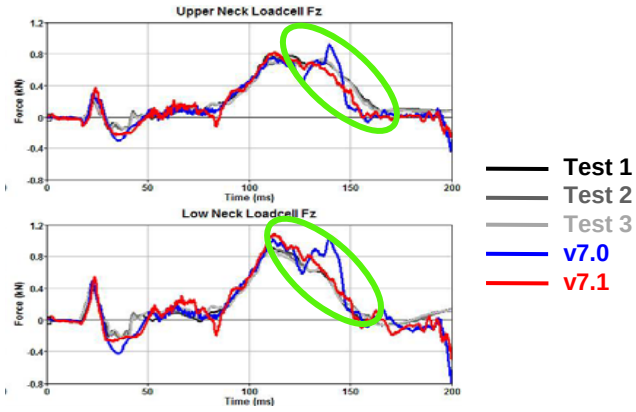
12007	0	1.745E-2	1000.0
	-2.5000000		-9.4759785E-2
	-2.0000000		-4.7379892E-2
	0.0		0.0
	2.0000000		4.7379892E-2
	2.5000000		9.4759785E-2

v7.0 Clavicle Link

12007	0	1.745E-2	1.0
	-65.800003		-510000.0
	-8.5000000		-1095.0
	-2.5000000		-95.0
	-2.0000000		-47.0
	0.0		0.0
	2.0000000		47.0
	2.5000000		-95.0
	8.5000000		1095.0
	65.800003		510000.0

PDB Sled





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New Component Tests

With customer input and internal review, FTSS began planning for a new set of lumbar spine and neck component tests for the H350 dummy model. The availability of a mini-sled allowed for component tests using compressive loading. These new load cases were planned to complement (or replace) existing tensile loading, pendulum tests.

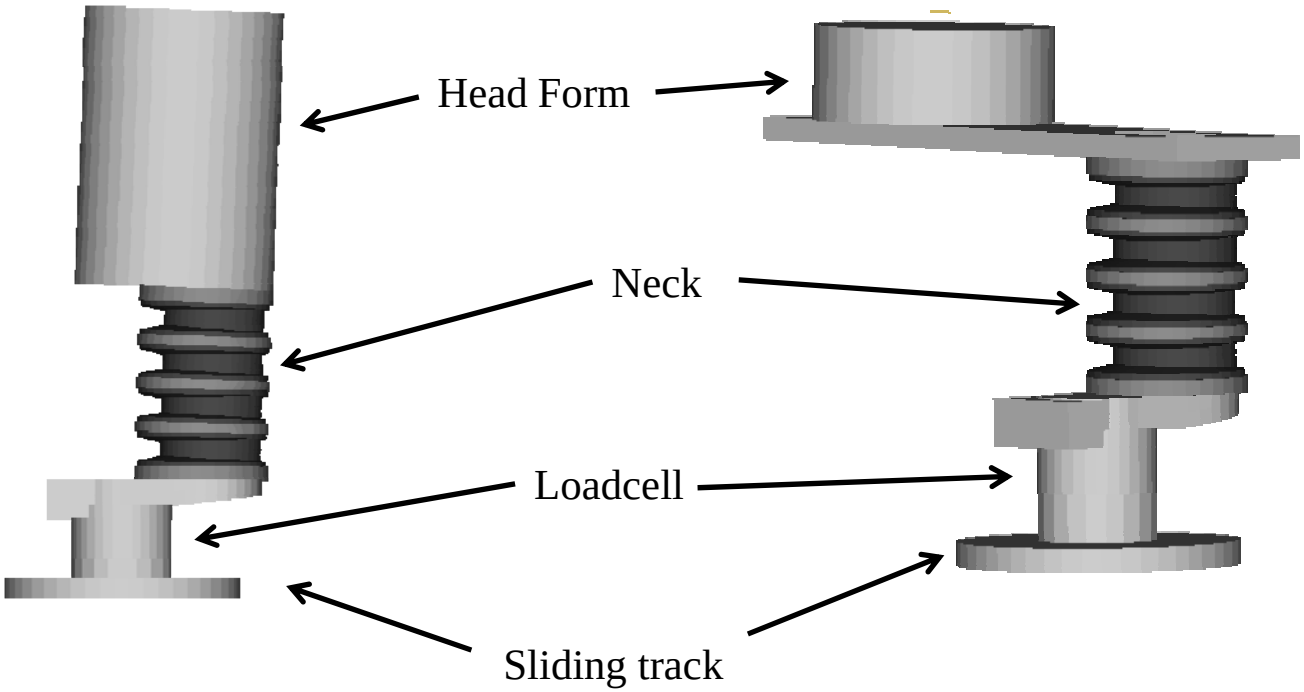
FTSS consulted with customers to determine vehicle level loads to target with the new neck and lumbar spine component tests.

Testing without cable was performed to isolate the material behavior of the rubber. Testing with cable(s) were used to correlate behavior of the neck or spine sub-assembly.

Samples of the vehicle data, tests results and development plots follow.

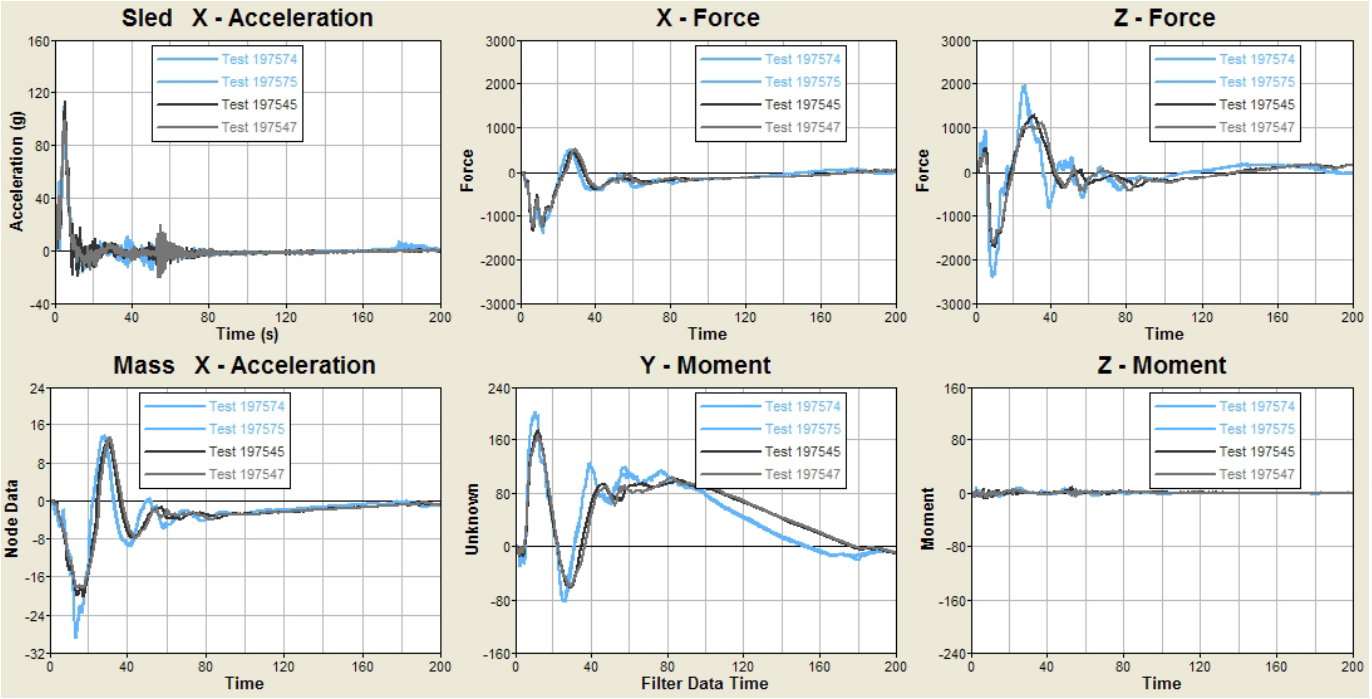
New Component Tests – Neck

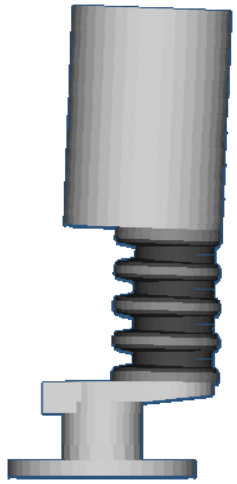
- Non-Certification Test – Neck Sled Test (flexion, extension, torsion)
- Speed 2 m/s, 4 m/s



New Component Tests – Neck

Flexion -- 9.4 Kg mass 4 m/s





Without Cable
With Cable

A full set of test data for neck and spine is available in the Technical Report

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New Component Tests – Neck

Neck Tuning Evaluation

Multiple optimization runs were performed attempting to improve correlation for the mini-sled in-line, offset, and pendulum cases simultaneously. This resulted in only small changes to mini-sled performance, but had a significant negative effect on the pendulum cases for both flexion and extension. The following slides show the general trend resulting from these optimizations (extension results are reviewed).

V7.0 is the "**original**" material and the optimized result is the "**tuned material**".

New Component Tests – Neck

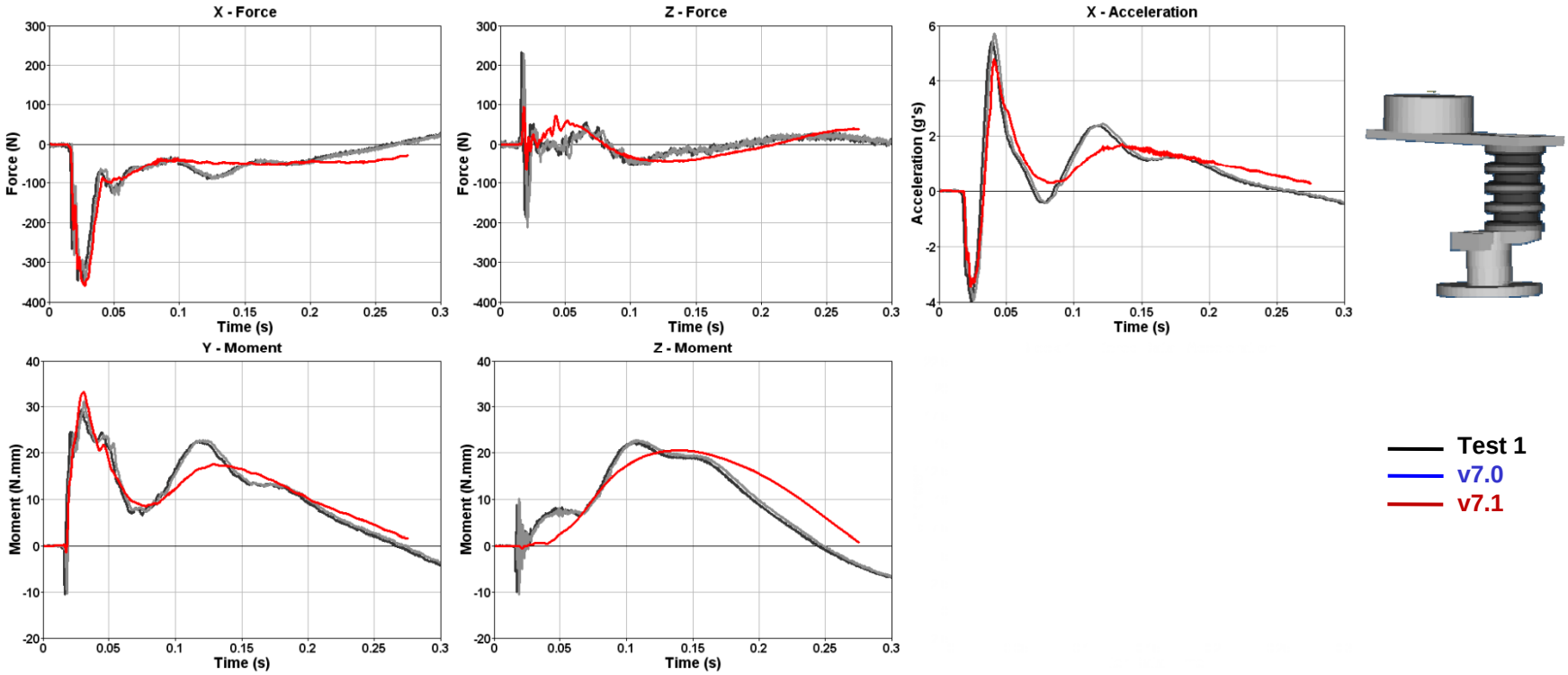
Neck Tuning Evaluation

The v7.0 neck properties correlate much better in the mini-sled torsion load cases than the in-line load cases. It was difficult to achieve neck loading levels similar to vehicle data with the FTSS mini-sled for the in-line load cases. The resulting tests had high accelerations with short durations. This may be the reason for correlation/optimization difficulties. Additionally the higher speed cases often resulted in the head form striking the sled, causing significant noise and changing the kinematics of the event. FTSS is considering new component testing for future neck development.

Due to reasonable correlation of v7.0 and the unsatisfactory results from the optimization effort, FTSS plans to release v7.1 with the same material properties as v7.0.

New Component Tests – Neck

- Non-Certification Test – Neck Sled Test At Speed Of 2 m/s flexion offset test without cable.



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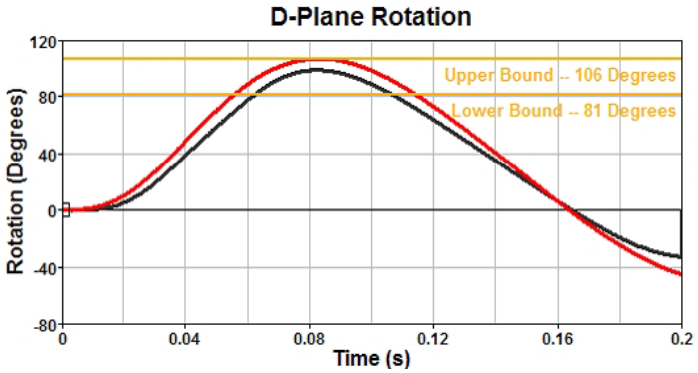
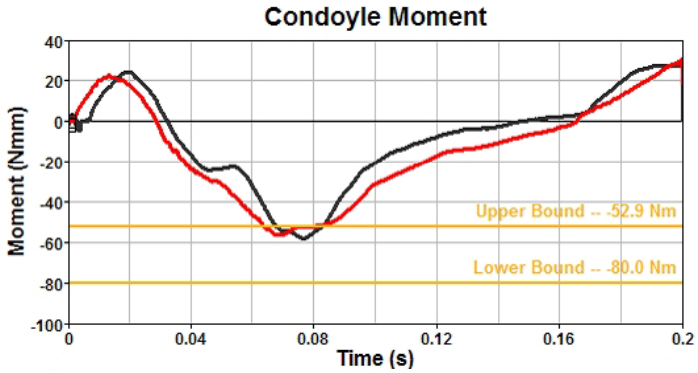
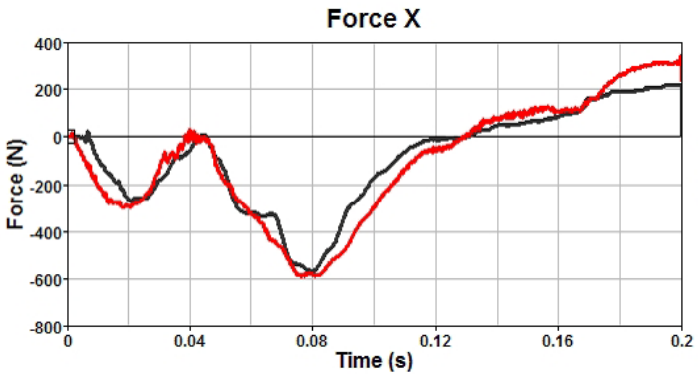
New Component Tests – Neck

- Certification Test – Neck Extension Straight Test At Speed Of 6.1 m/s







Test
v7.0
v7.1

A full set of results for the neck is available in the Technical Report

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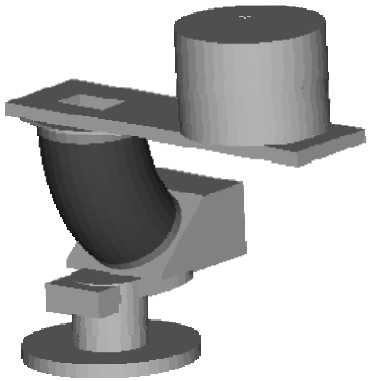
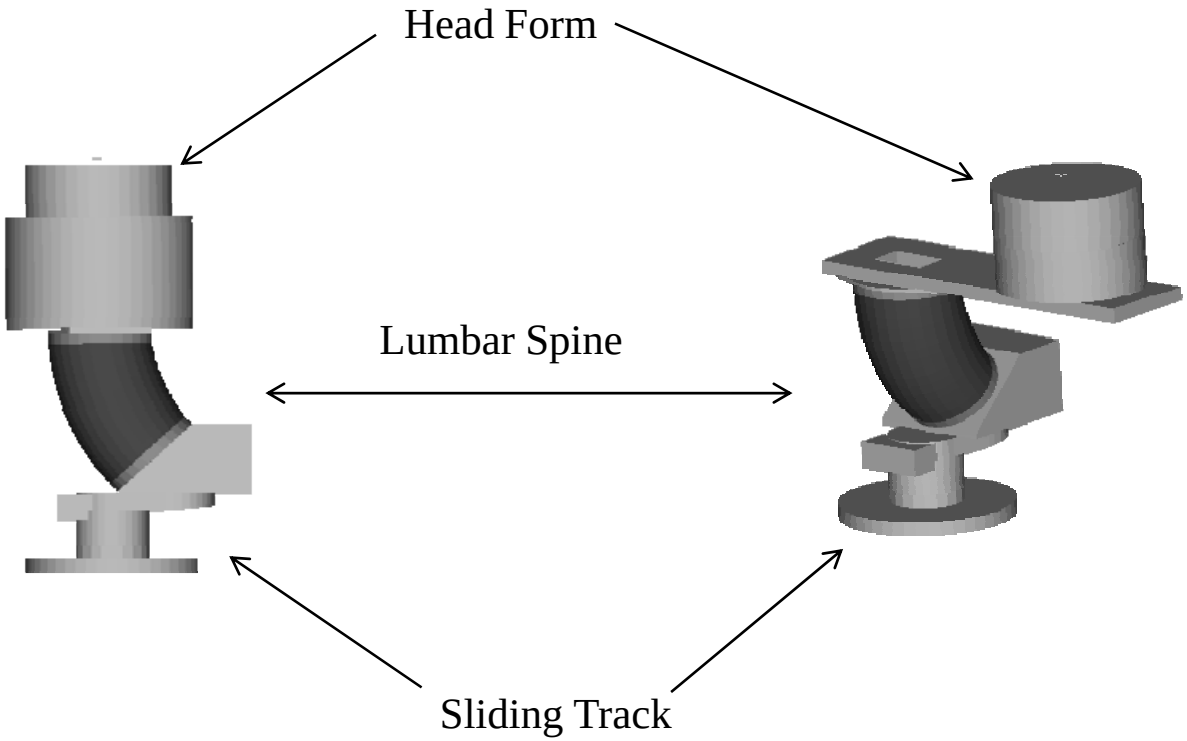
New Component Tests – Vehicle/Component Comparison



Injury Signal	Vehicle Peak	In-Line Component Peak	Offset Component Peak
Flexion			
Upper Neck X Force	600-1100 N	500-1500 N	350-1050 N
Upper Neck Z Force	900-1000 N	600-2500 N	250-800 N
Upper Neck Y Moment	50-70 NM	70-200 NM	30-100 NM
Extension			
Upper Neck X Force	350-500 N	500-1700 N	350-1200 N
Upper Neck Z Force	400-450 N	700-2000 N	100-500 N
Upper Neck Y Moment	55-75 NM	60-150 NM	35-80 NM
Lumbar Spine			
Lumbar X Force	1800-3300	1500-3800	800-2900
Lumbar Z Force	3000-4500	1300-3100	200-1500

New Component Tests – Lumbar Spine

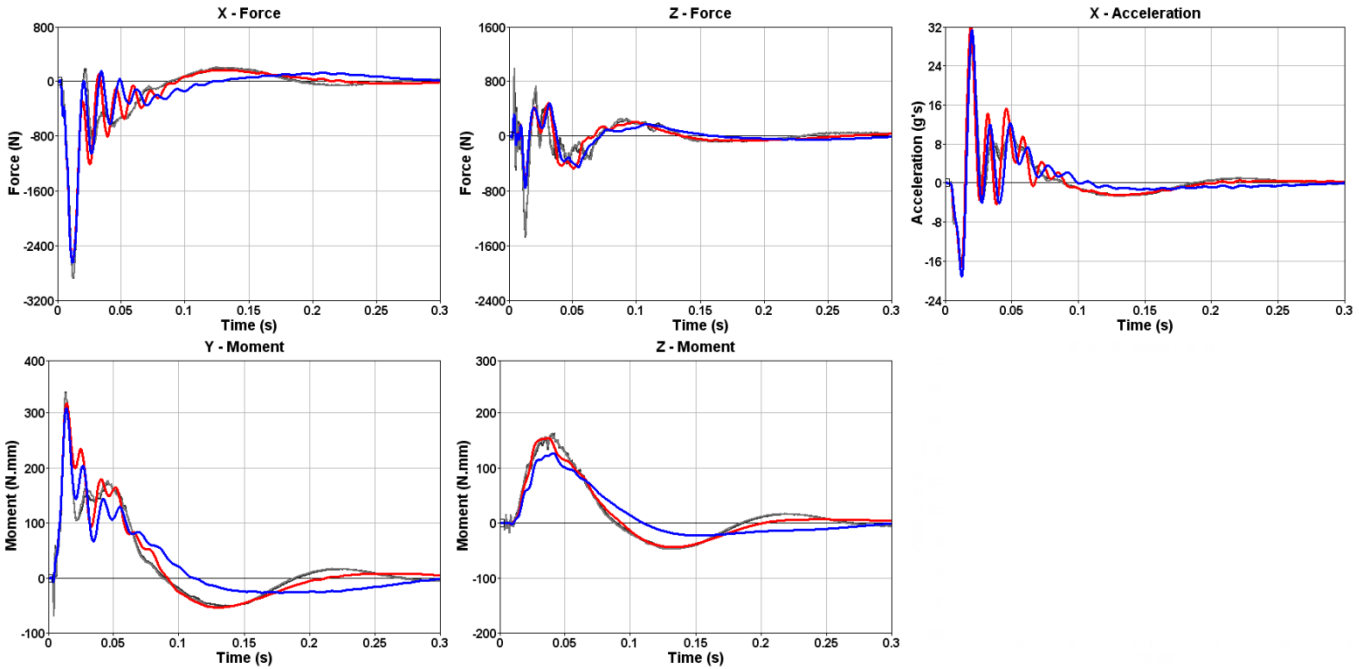
- Non-Certification Test – Lumbar Spine Sled Test (flexion in-line, small offset, torsion)
- Speed 2m/s, 4m/s

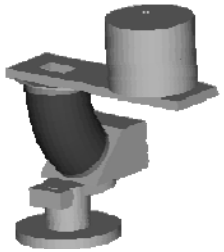


The acceleration of the mini-sled was recorded during the testing and used as input for the sliding track in the simulations

New Component Tests – Lumbar Spine

- Non-Certification Test – Lumbar Spine Torsion Test without cable, 4m/s





Test 1
Test 2
v7.0
v7.1

A full set of results for the lumbar spine is available in the Technical Report

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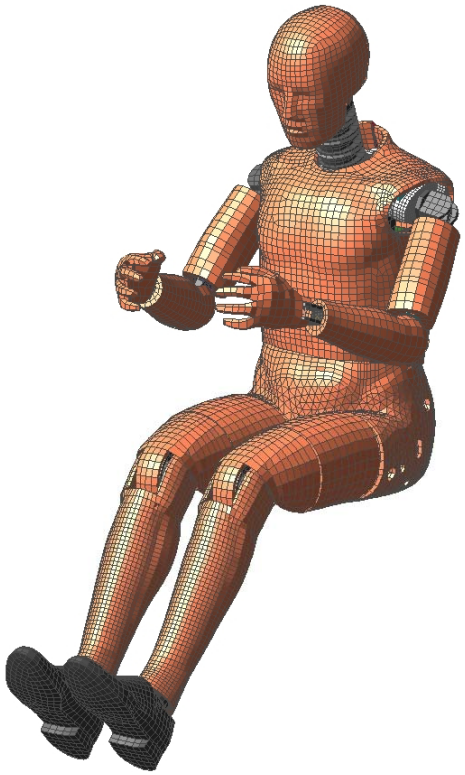
FTSS H350 v7.1 Model - LS-DYNA

Release Version 7.1

December 2009



For further information, contact:

	Fuchun Zhu	Jim Rasico
Tel:	+1 734 446 3139	+1 734 446 3073
Email:	fzhu@ftss.com	jrasico@ftss.com

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