LSC Barriers and Dummies

Dilip Bhalsod

12th Oasys LS-DYNA Indian Update Meeting
March 2019

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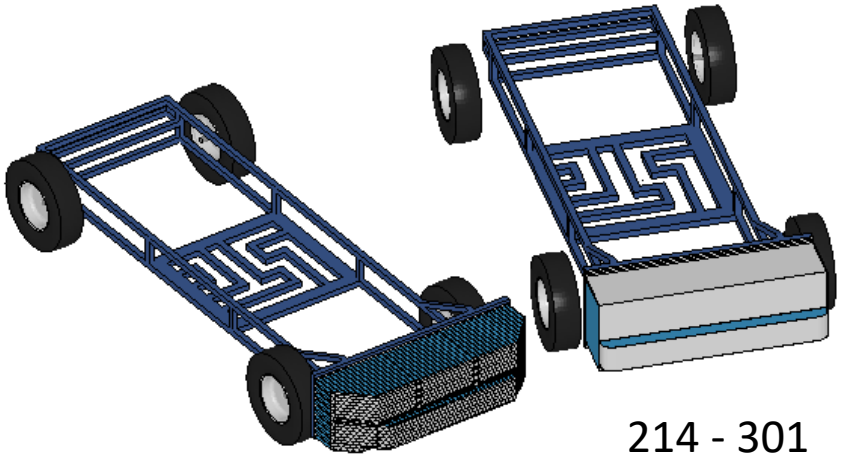
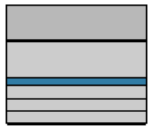
LSTC Family of Barriers

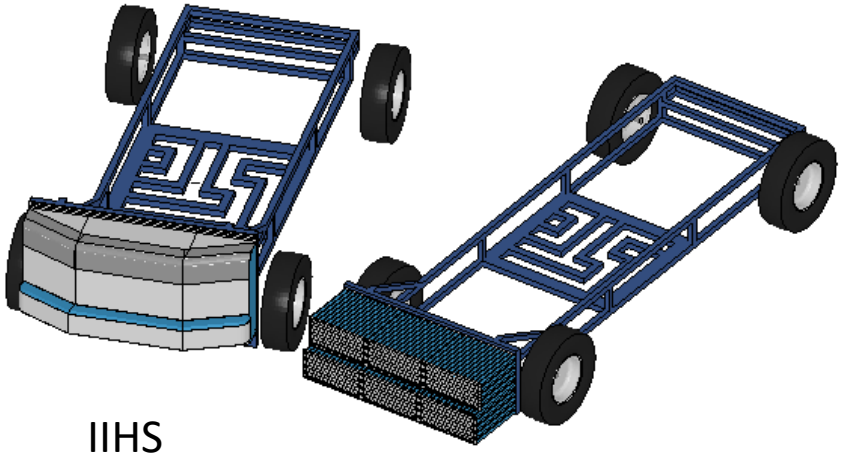


AE-MDB
shell



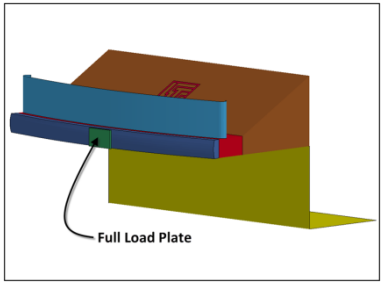
214 - 301
shell/solid

ODB
shell/hybrid

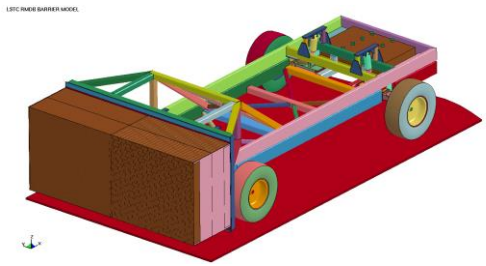


IIHS
shell/solid

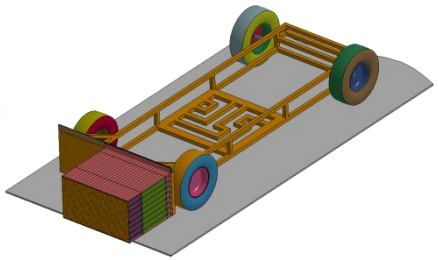
ECER95
shell



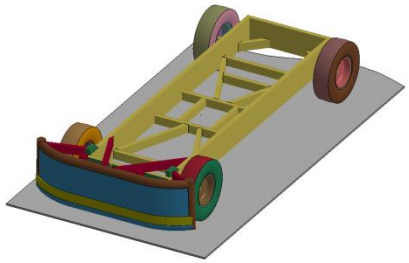
RCAR Barrier



OMDB



MPDB



MCB

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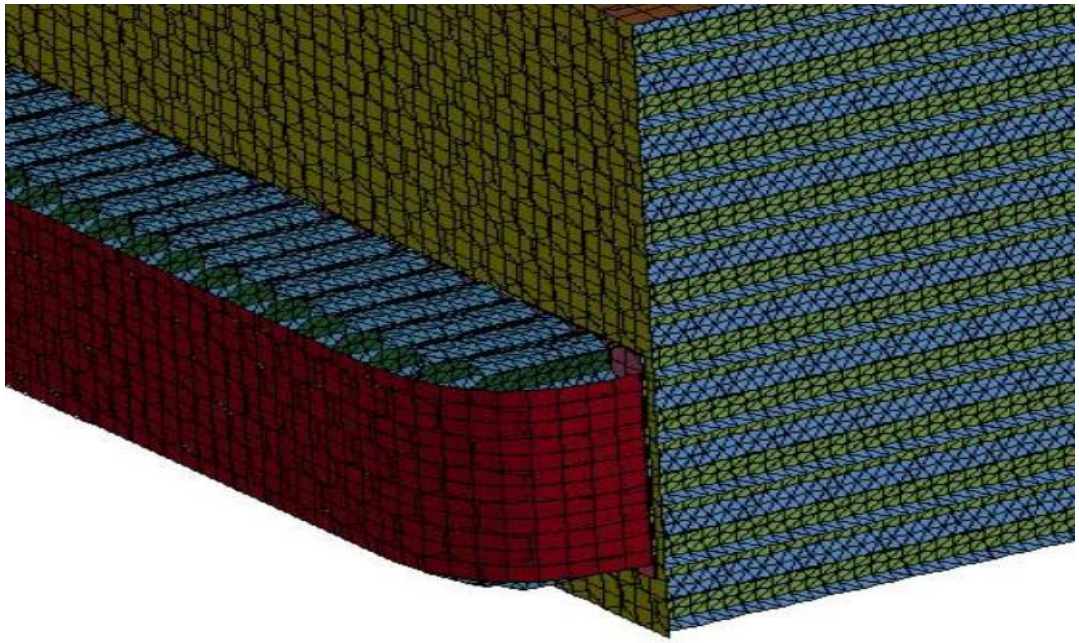
FMVSS 214 Barrier

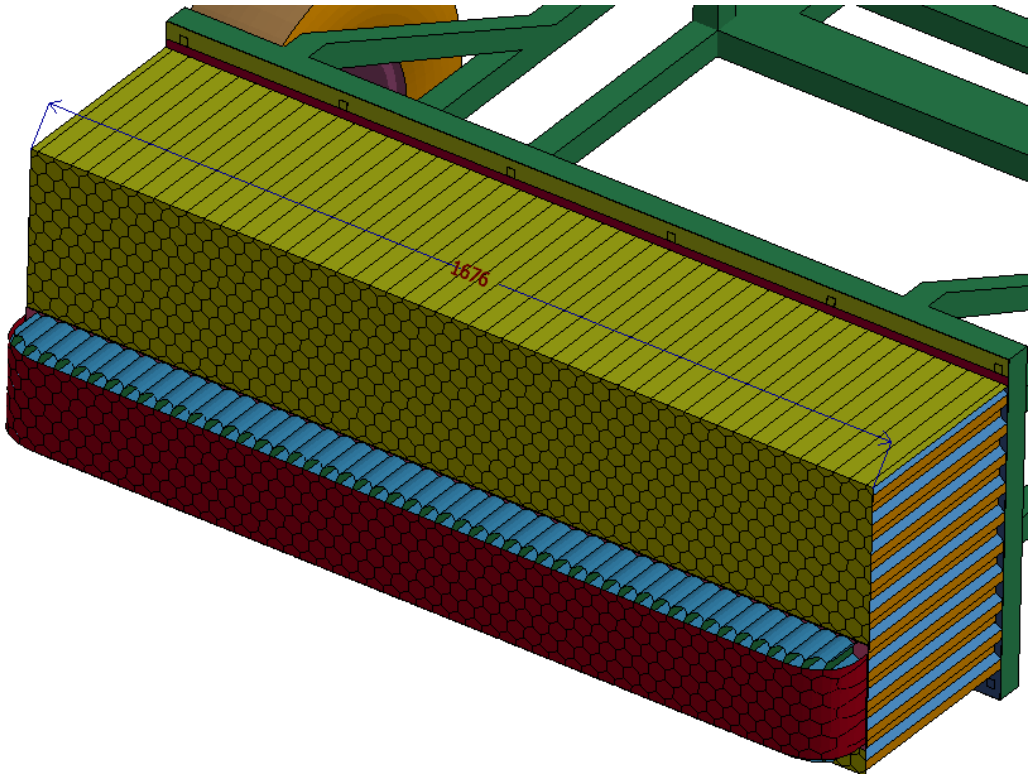
FMVSS 214 Barrier

- Pure solid element version - 145,000 elements
- Shell element main block and bumper - 550,000 shells.



FMVSS 214 Barrier - Updates

- The stiffness of the barrier honeycomb parts has been improved, based upon feedback from clients, for better correlation of force and deflection response in full vehicle crash tests.
- Soft Constraint Formulation (SOFT) on optional card A of *CONTACT_AUTOMATIC_SINGLE_SURFACE (CID: 3) definition corresponding to the self-contact of the barrier parts has been set to 1.
- This serves to decrease the computational expense associated with this contact.
- The width of the honeycomb impact face in the 214 barrier and 301 barrier models has been adjusted to 1676 mm, to meet the width specified in NHTSA guidelines



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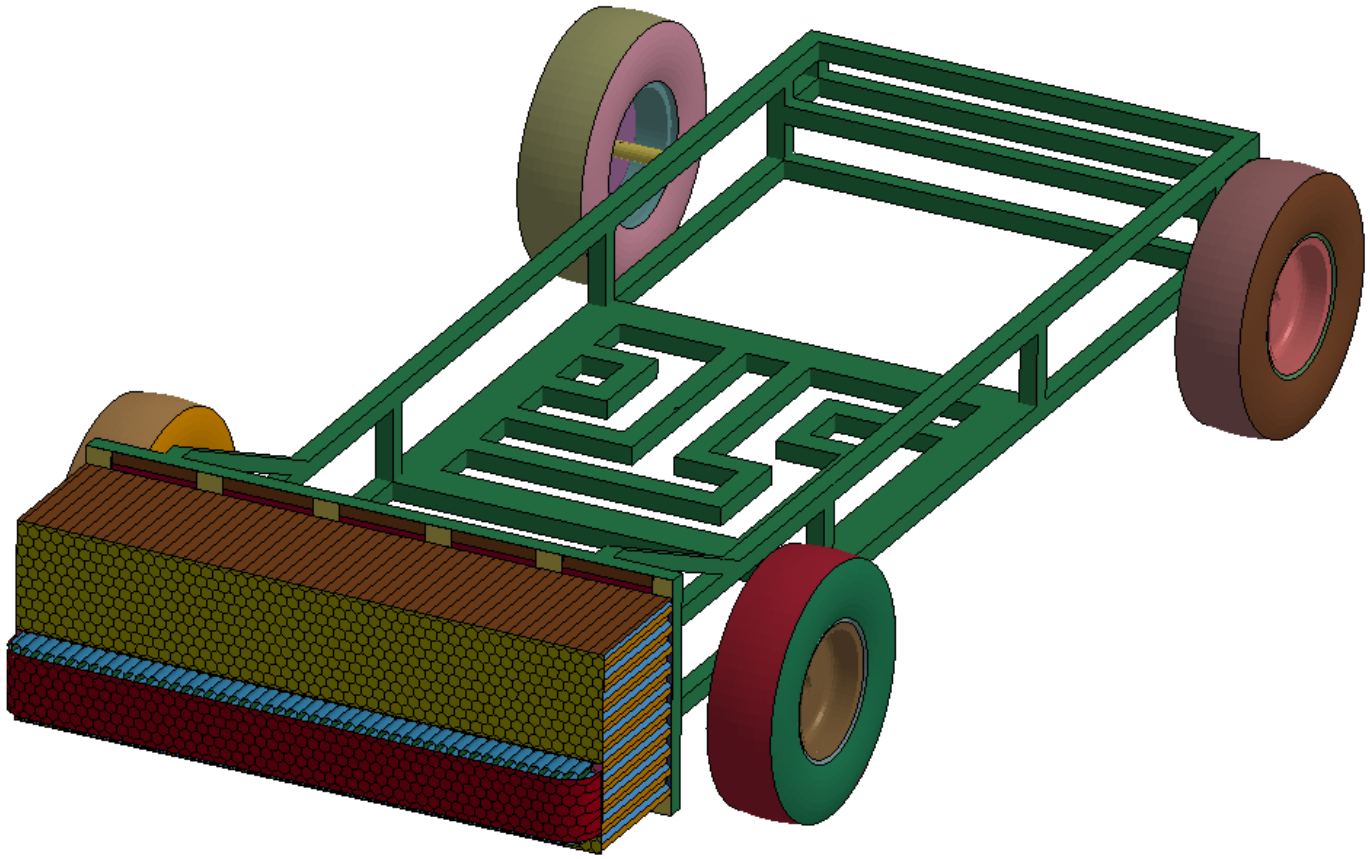
301 Barrier Construction

- 'FMVSS 301 Barrier' model has been developed based upon the 'FMVSS 214 Barrier' and calibrated to a series of customer proprietary tests.
- The 301 barrier model has been updated to represent the accurate ground clearance of 229 mm between the bottom of the honeycomb block and ground.



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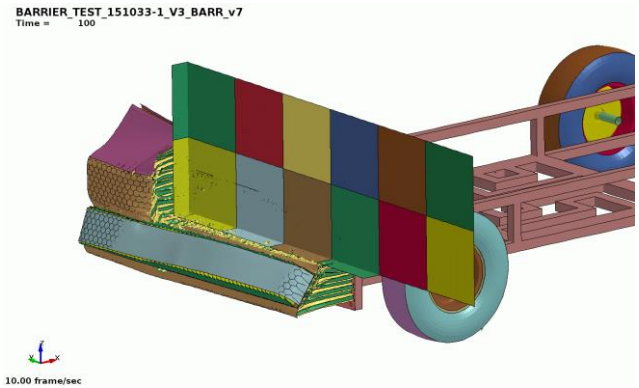
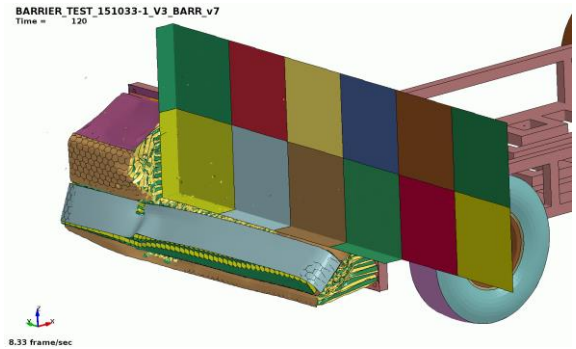
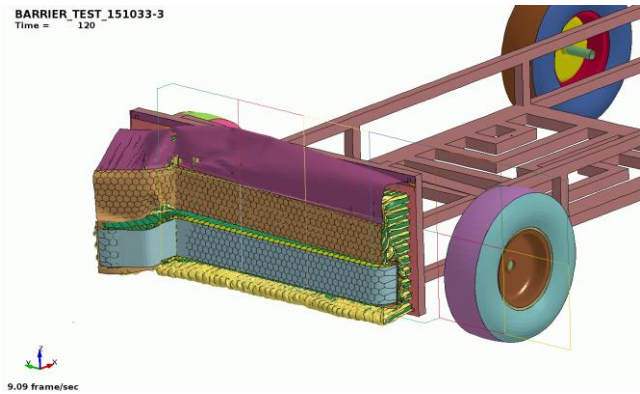
301barrier for 70% Rear offset tests

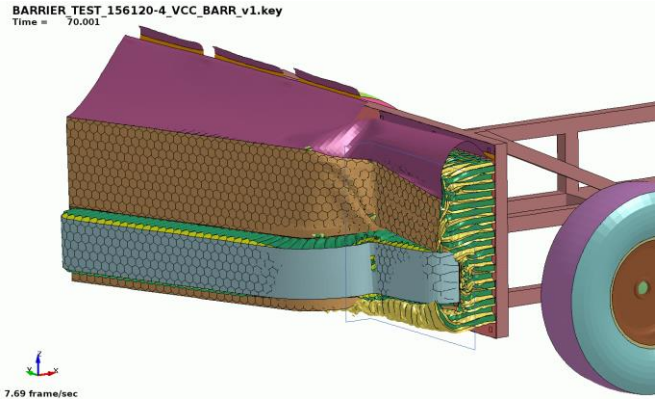
- This barrier was originally developed for side impact tests
- Energy levels are much higher and deformations are very high for these tests
- Recently modified to meet 6 customer tests
- Bumper now meshed using shells
- Model released in 2016

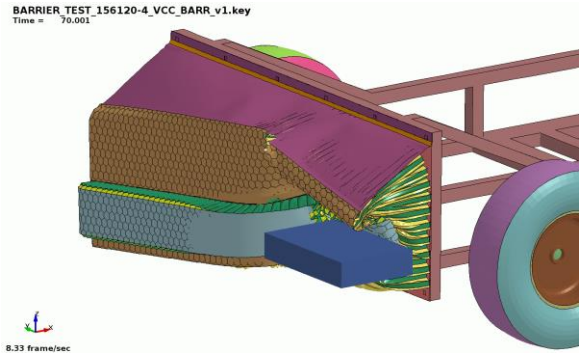
6 customer tests for 70% rear offset











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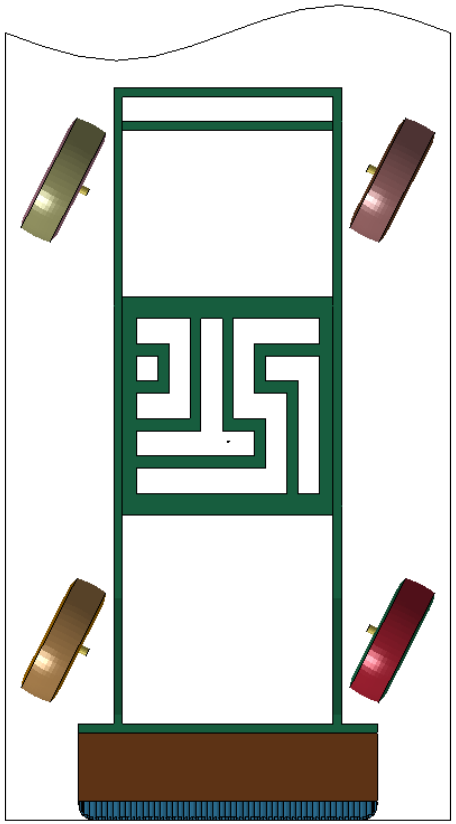
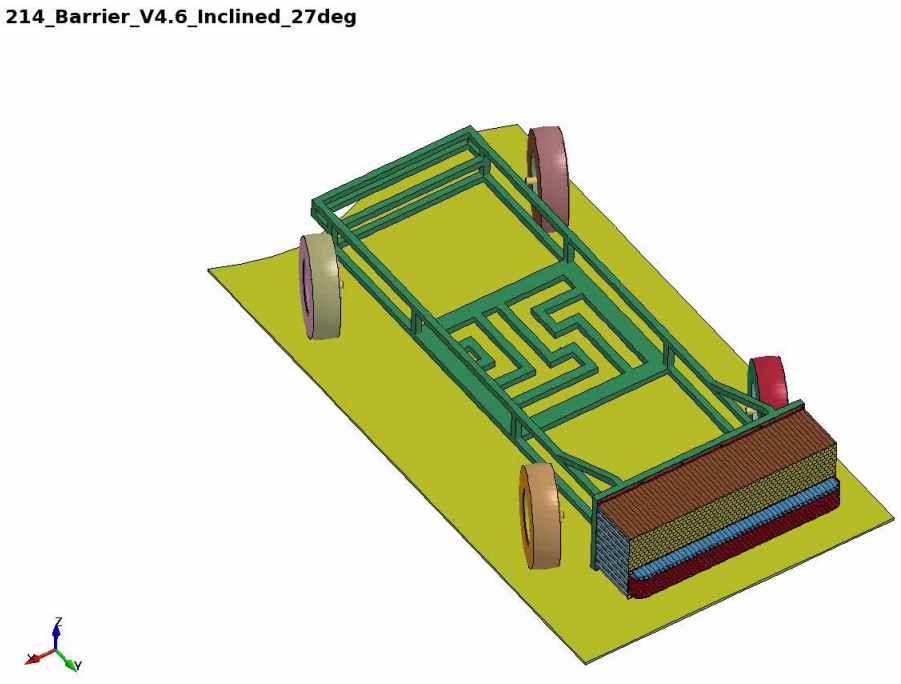
27 deg. Angled 214 Barrier

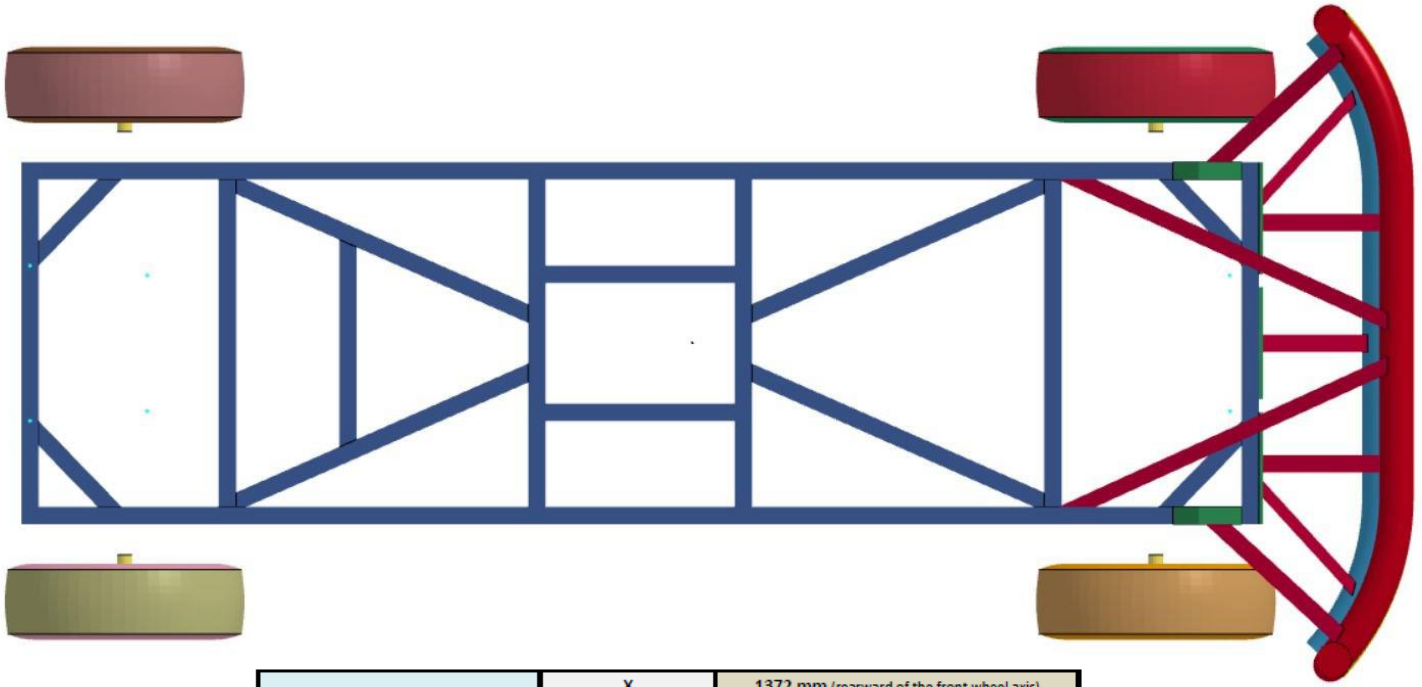
- 'FMVSS 214 Barrier' model with the four wheels inclined at 27 deg. to the longitudinal axis has been recently developed.
- *INITIAL_VELOCITY_GENERATION card has been added to spin the wheels of the cart.
- Spinning wheels enables accurate calculation of Kinetic Energy of the barrier in full vehicle impact simulation.





Moving Contoured Barrier - Overview

- Moving Contoured Barrier Model has been built for Fuel System Integrity testing of School Bus, based on the specifications given in the FMVSS Standard No. 301



Center of Gravity[1] (CG)	X	1372 mm (rearward of the front wheel axis)
	Y	0 mm (in the vertical longitudinal plane of symmetry)
	Z	401 mm (above the ground)
Total Weight of the Barrier[1] (kg)		1814 kg
Weight Distribution[1]	Front Axle	991.6 kg (495.8 kg at each front wheel)
	Rear Axle	822.4 kg (411.2 kg at each front wheel)
Moments of Inertia[2] (kg-mm^2)	I_{xx} (Roll)	5.80 e^8 kg-mm^2
	I_{yy} (Pitch)	2.54 e^9 kg-mm^2
	I_{zz} (Yaw)	2.92 e^9 kg-mm^2

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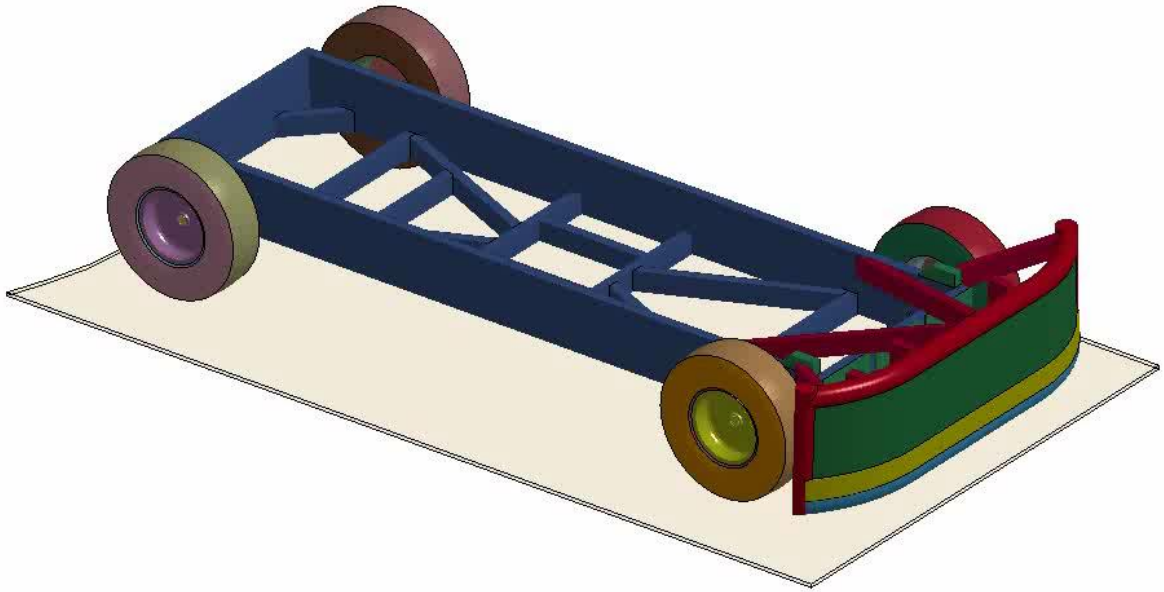
Moving Contoured Barrier - Overview

LSTC_COMMON_CARRIAGE_W_CONTOURED_IMPACT_SURFACE_V1.0_170907_BETA



7.44 frame/sec

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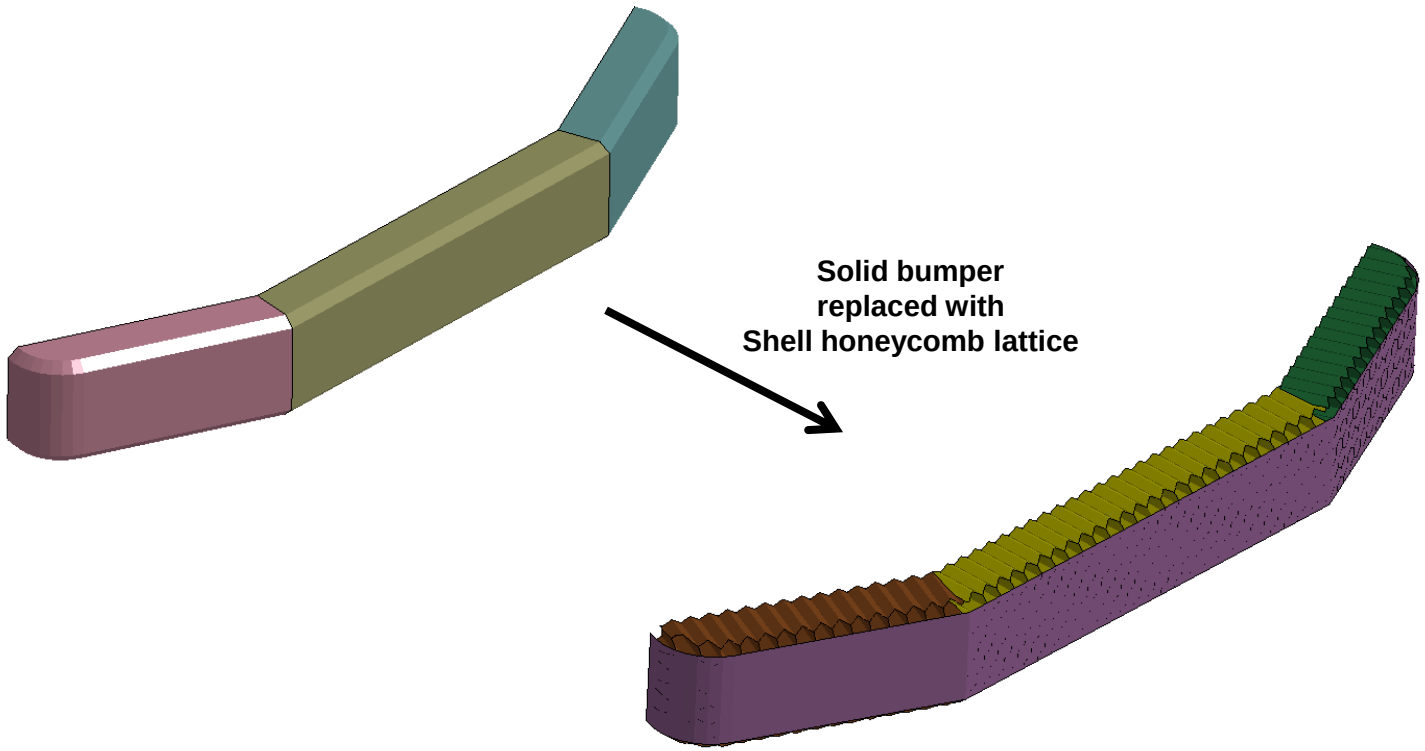
IIHS Barrier - Updates

- Shell thickness update parameter (ISTUPD) has been activated in the *CONTROL_SHELL card, with a part set of parts for thickness update assigned to the parameter PSSTUPD.

- A shell element bumper was constructed and added to the IIHS barrier model to replace the solid element bumper.



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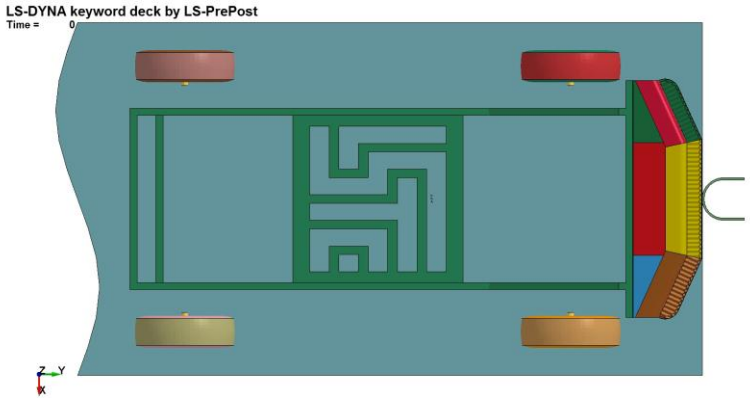
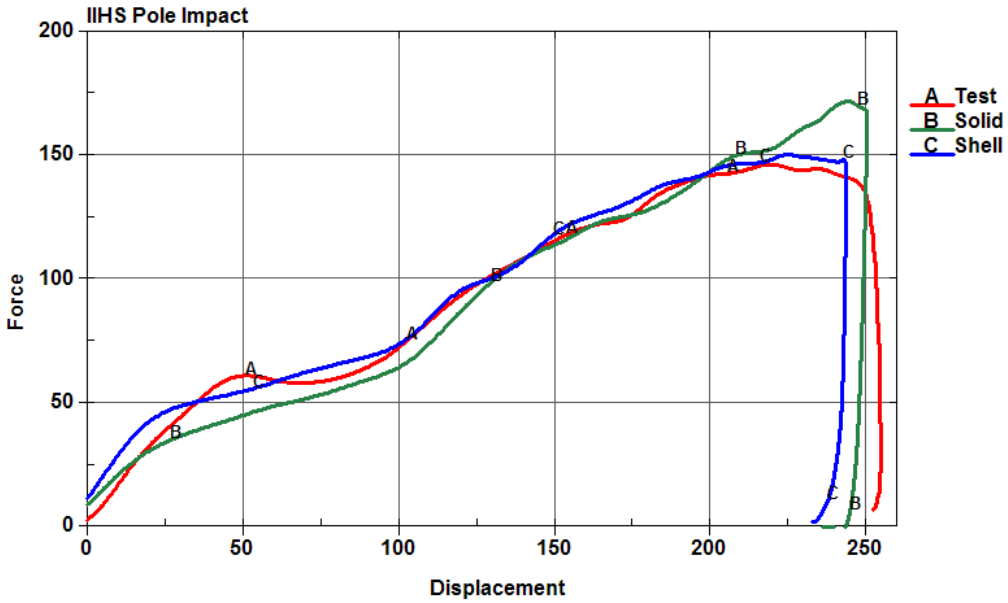
IIHS Pole

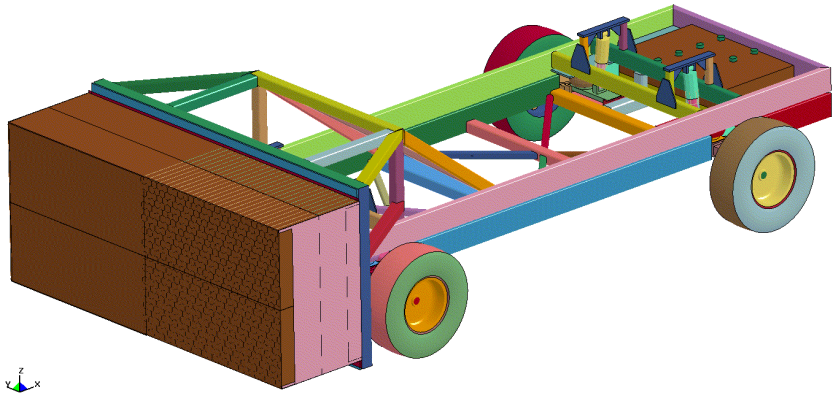


Solid element version – 120,000 elements
Shell element version – 570,000 elements



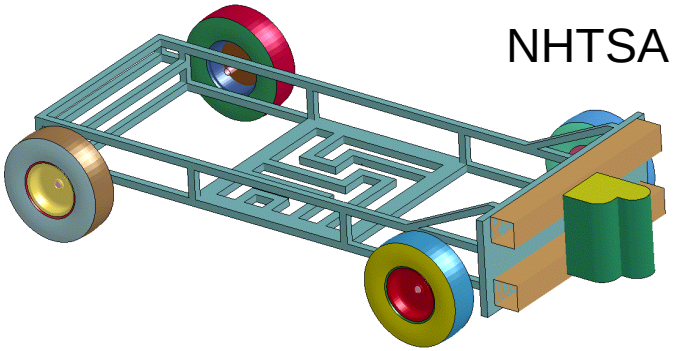
LSTC OMDB MODEL - VALIDATION

- The solid-shell barrier is comprised of 580,200 elements
- Un-struck side solid elements
- Struck side shell elements

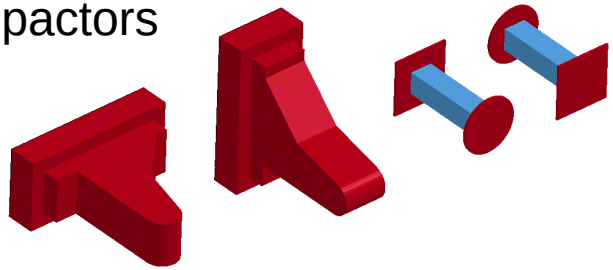


- Validated to 10 customer proprietary tests and 1 test from NHTSA

NHTSA



Ford Impactors



LSTC OMDB MODEL - UPDATE

- NHTSA impactor test for OMDB has been calibrated with SOFT=2 for barrier self contact definition.
- Significant computational expense and wall time can be saved by distributing this self-contact through the keyword:
  *CONTROL_MPP_DECOMPOSITION_CONTACT_DISTRIBUTE

*CONTACT_AUTOMATIC_SINGLE_SURFACE_(ID/TITLE/MPP) (1)

1	CID	TITLE						
	4	block self contact						
			MPP1	MPP2				
2	IGNORE	BUCKET	LCBUCKET	NS2TRACK	INITITER	PARMAX	UNUSED	CPARM8
	0	200		3	2	1.0005		0
3	UNUSED	CHKSEGS	PENSF	GRPABLE				
		0	1.0	0				
4	SSID	MSID	SSTYP	MSTYP	SBOXID	MBOXID	SPR	MPR
	1	0	2	0	0	0	0	0
5	FS	FD	DC	VC	VDC	PENCHK	BT	DT
	0.1500000	0.1000000	0.0	0.0	0.0	0	0.0	0.0
6	SFS	SFM	SST	MST	SFST	SFMT	FSF	VSF
	0.0	0.0	0.8000000	0.0	0.0	0.0	0.0	0.0
			A	AB	ABC	ABCD	ABCDE	ABCDEF
7	SOFT	SOFSCL	LCIDAB	MAXPAR	SBOPT	DEPTH	BSORT	FRCFRQ
	2	0.0	0	0.0	3.0	5	0	0
8	PENMAX	THKOPT	SHLTHK	SNLOG	ISYM	I2D3D	SLDTHK	SLDSTF
	0.0	0	0	0	0	0	0.8000000	70.000000

Decomposition contributes to 20% faster execution

*CONTROL_MPP_DECOMPOSITION_CONTACT_DISTRIBUTE (1)

1	ID1	ID2	ID3	ID4	ID5
	4	0	0	0	0

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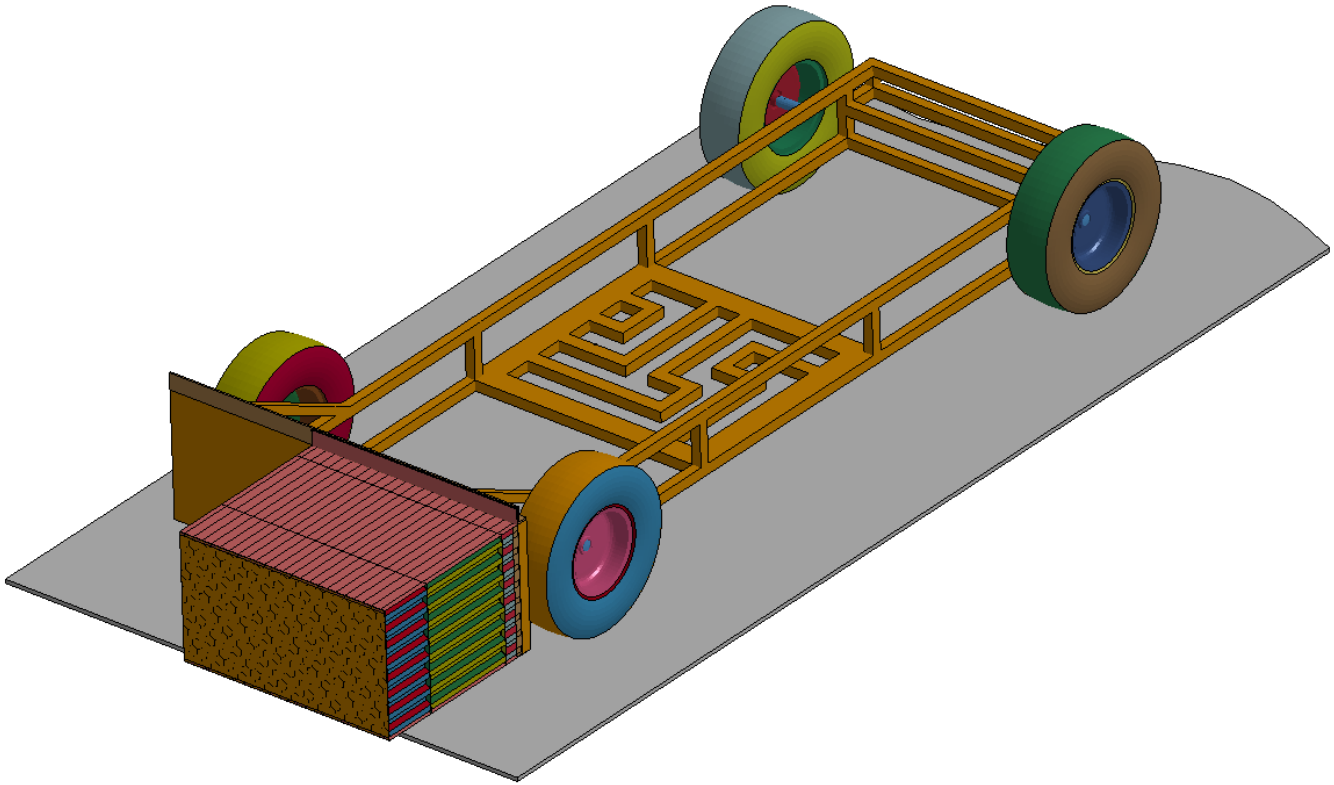
Mobile Progressive Deformable Barrier

Mobile Progressive Deformable Barrier - Background

- This is the initial release of Mobile Progressive Deformable Barrier.
- This model is based on revised specifications for the offset frontal impact procedure released by European NCAP Programme in October 2017.
- This model is expected to be used for 2020 European NCAP Programme.
- The deformable honeycomb face of the barrier is mounted on its cart.



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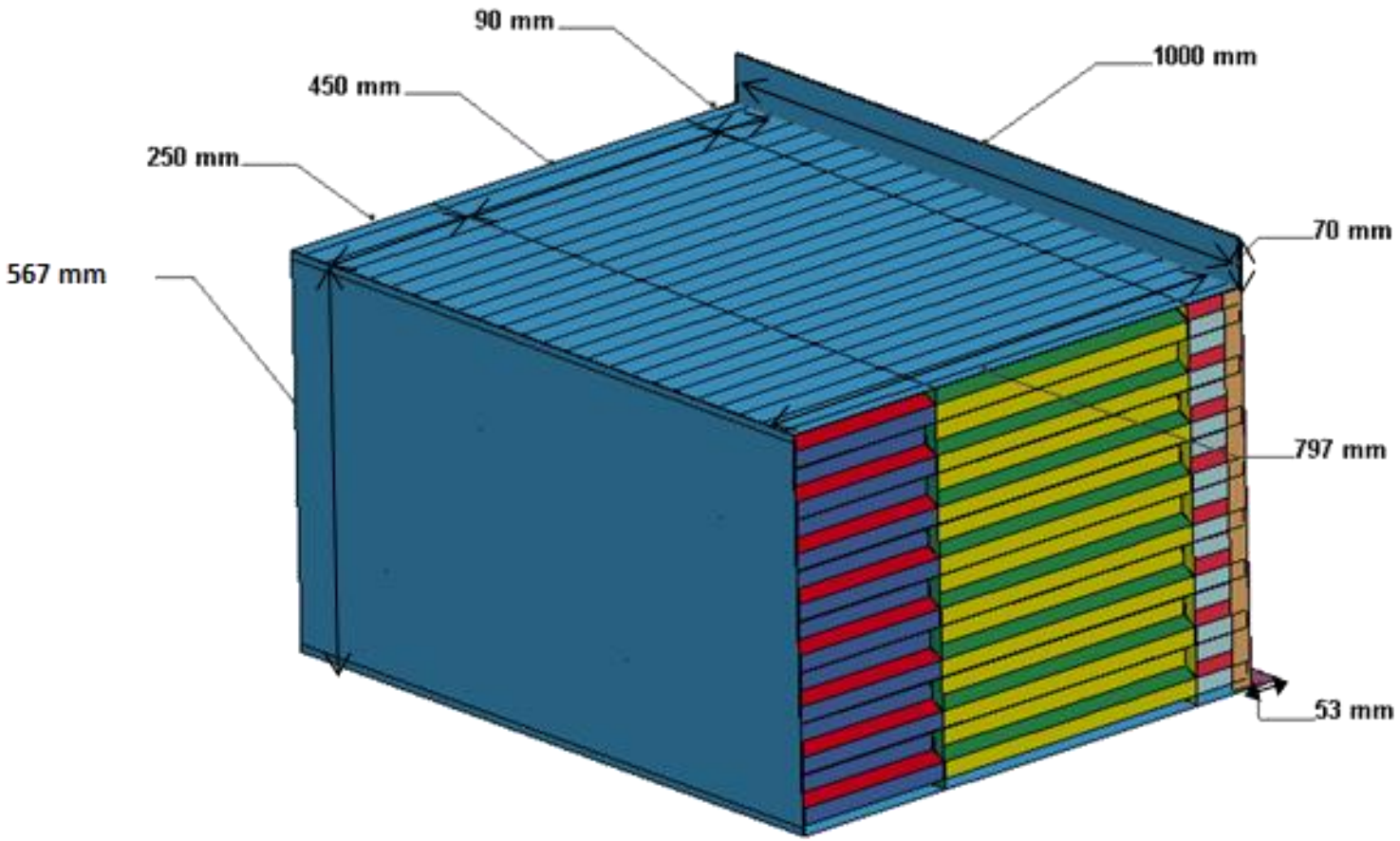
MPDB Dimensions

- The height of deformable honeycomb face of Mobile Deformable Barrier is 567 mm.



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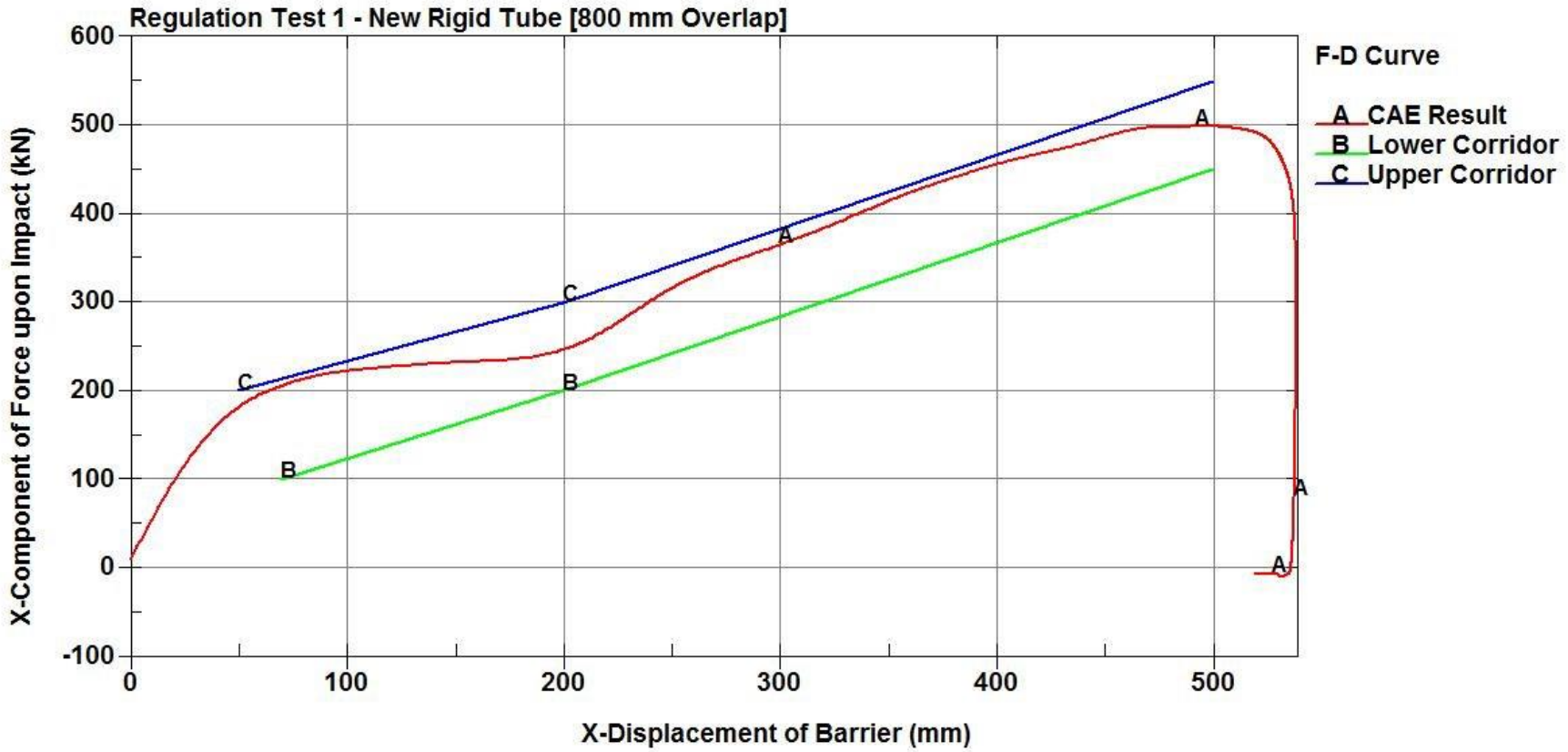
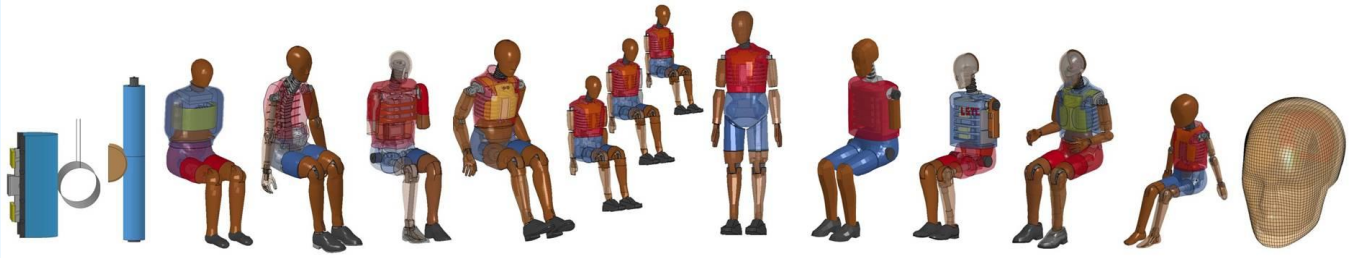
Validation Tests – Force vs Deflection Behavior



LSTC Dummy Models
Update February 2019



Current Developments and Improvements

Improvements:

- Hybrid III 50th
- Hybrid III 95th
- Hybrid III 5th

We have an ongoing project to update the Hybrid III adult dummy models.

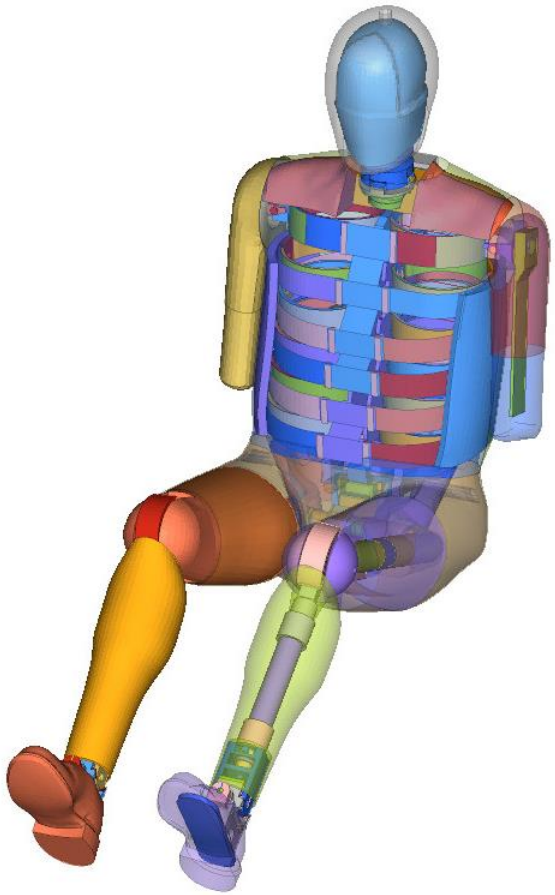
Current Developments and Improvements

New Developments:

- WorldSID 50th
- Hybrid III 3-year old
- Hybrid II

First version of WorldSID 50th detailed model was released in June 2018

WorldSID 50th



Number of nodes	~450K
Number of elements	~430K
Number of parts	268
Constrained joints	14

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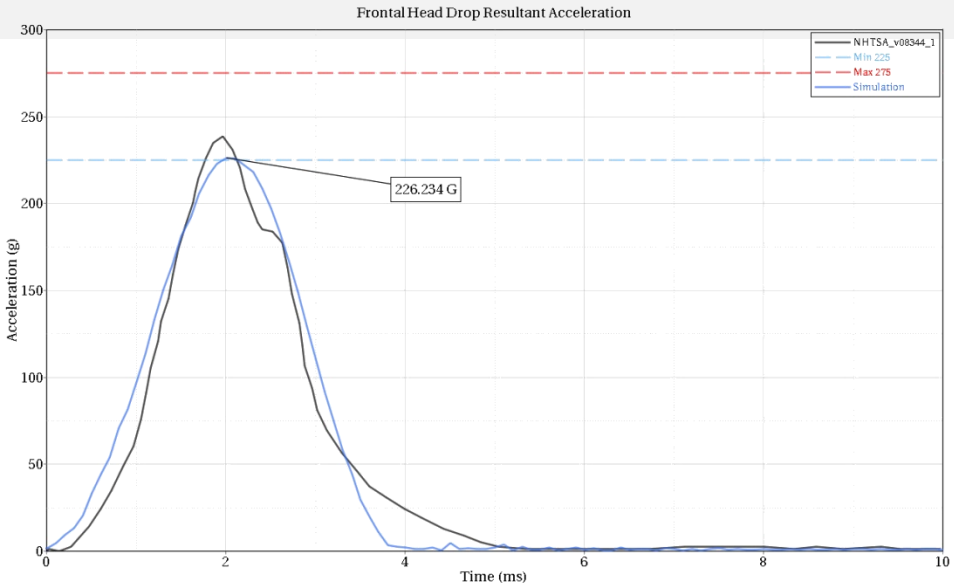
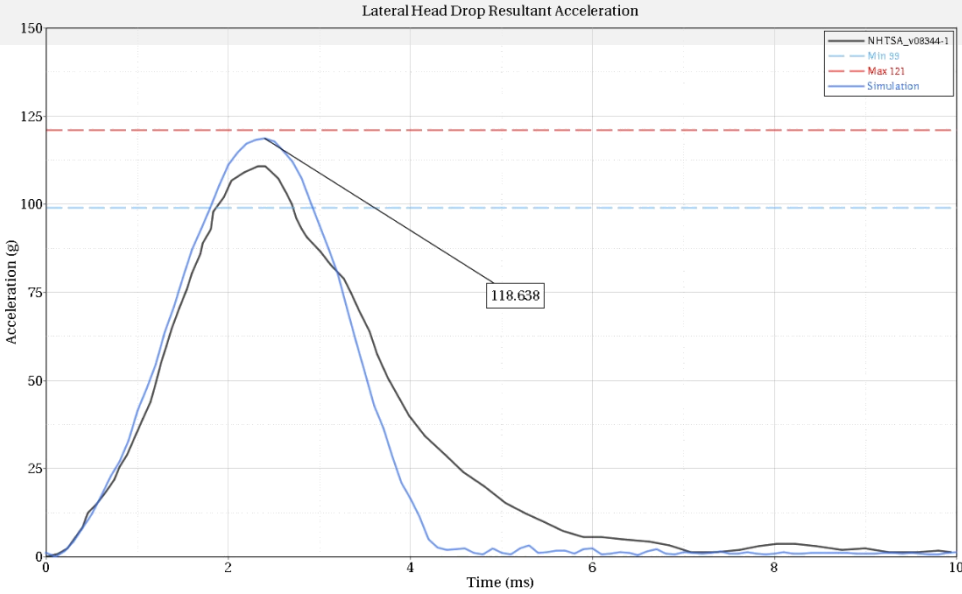
WorldSID 50th Head Drop





Frontal Drop	Requirements	Simulation
Peak resultant acceleration	225 to 275 G	226.23
Peak lateral acceleration (avg)	< 15 G	<1
Maximum percentage, subsequent-to-main peak (%)	<10 G	<1
Lateral Drop		
Peak resultant acceleration	99 to 121 G	118.64
Peak longitudinal acceleration	<15 G	<1
Maximum percentage, subsequent-to-main peak (%)	<10 G	<1

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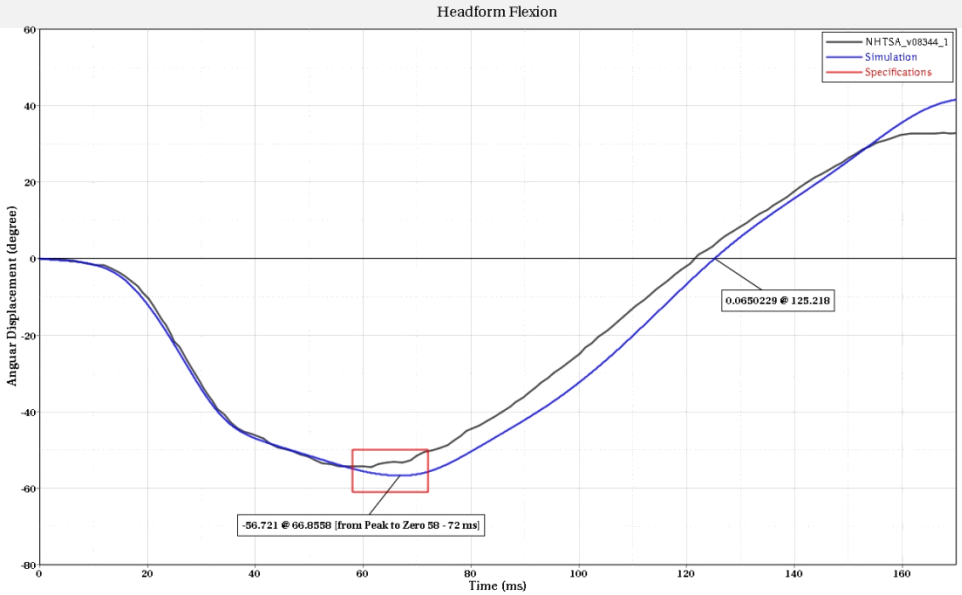
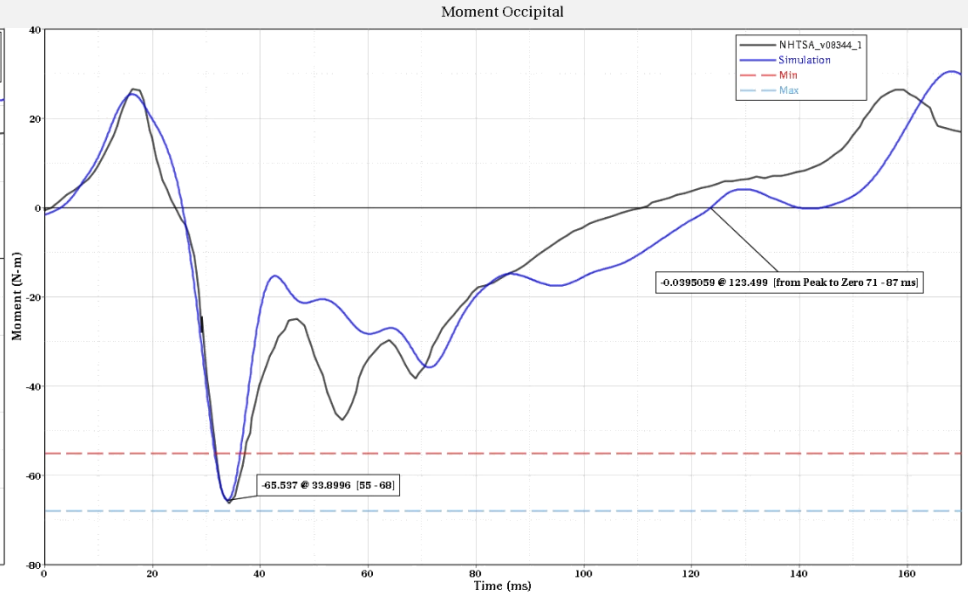
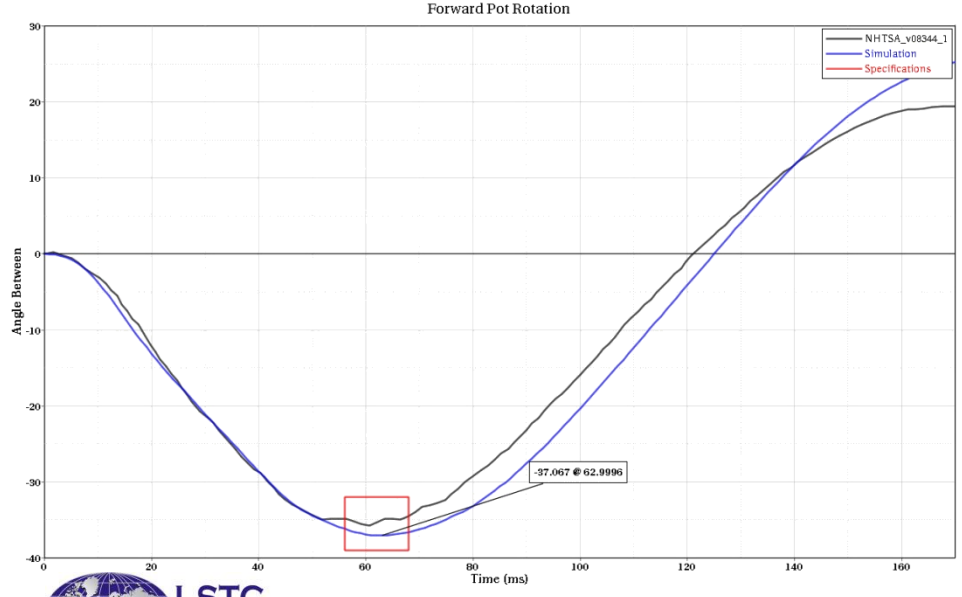
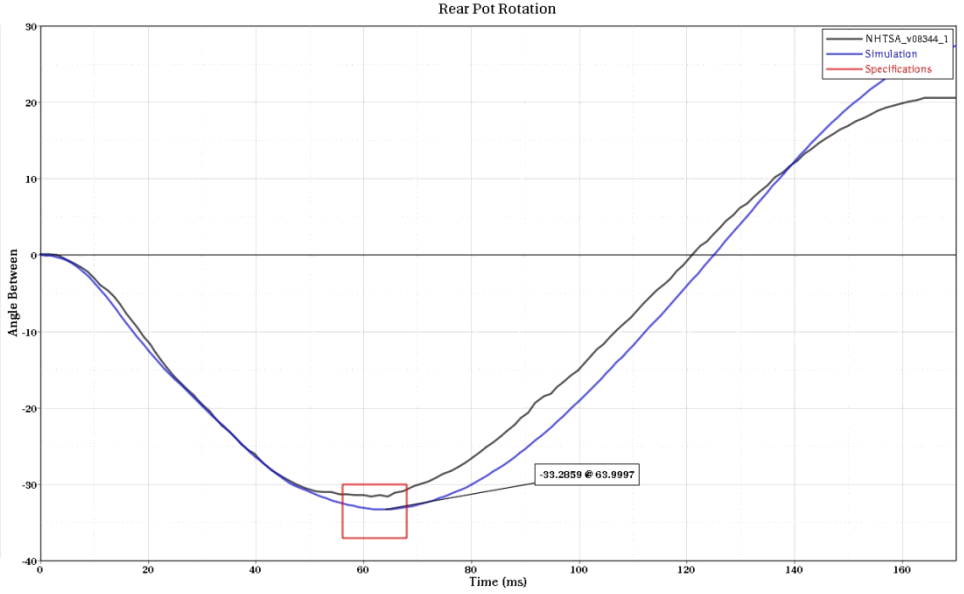
WorldSID 50th Neck Flexion









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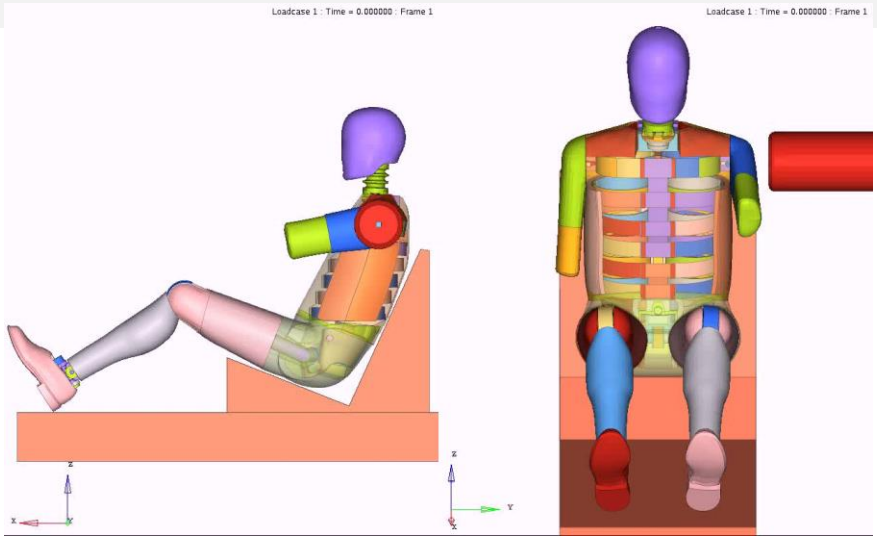
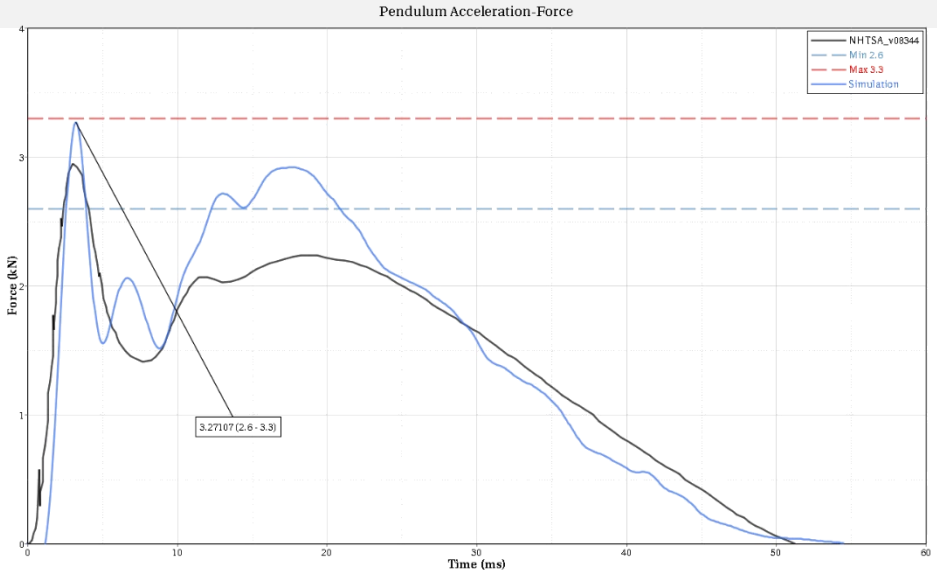
WorldSID 50th Neck Flexion

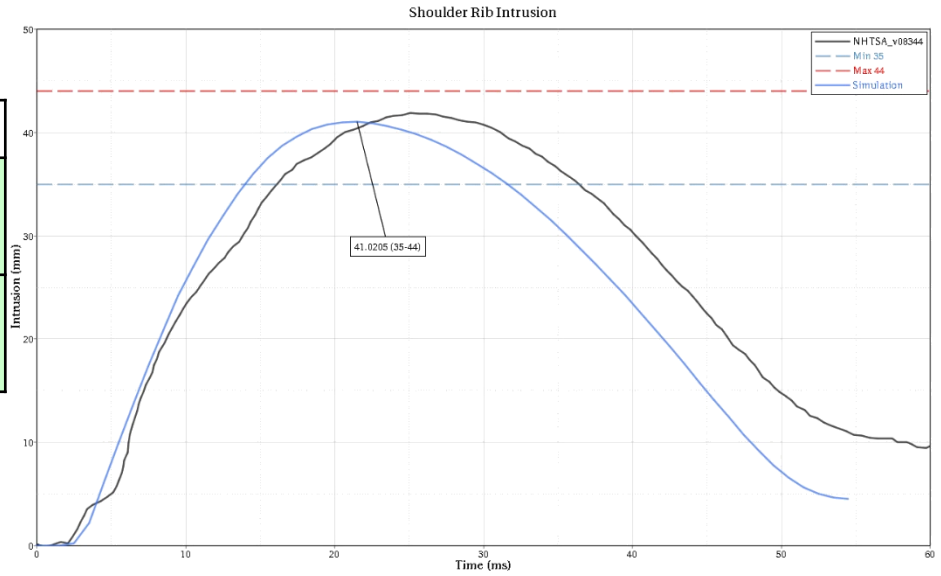
Variables	Requirements	Simulation
Pendulum Velocity change at 4 ms	0.77 to 1.04	0.870
Pendulum Velocity change at 8 ms	1.6 to 2.16	2.087
Pendulum Velocity change at 12 ms	2.43 to 3.29	3.130

Variables	Requirements	Simulation
Max headform flexion angle, beta (degree)	50 to 61	56.721
Decay time of peak headform flexion to 0 degrees (ms)	58 to 72	58.362
Peak occipital condyles moment (Nm)	55 to 68	65.537
Peak occipital condyles moment decay to zero (ms)	71 to 87	89.599
Peak forward potentiometer ang. disp. (degree)	32 to 39	37.067
Time for peak forward potentiometer angular disp. (ms)	56 to 68	63.000
Peak rearward potentiometer ang. disp. (degree)	30 to 37	33.286
Time for peak rearward potentiometer angular disp. (ms)	56 to 68	64.000

WorldSID 50th Shoulder Certification







Variables	Requirements	Simulation
Peak pendulum force	2.6 to 3.3 kN	3.27107
Shoulder rib deflection	35 to 44 mm	41.0205

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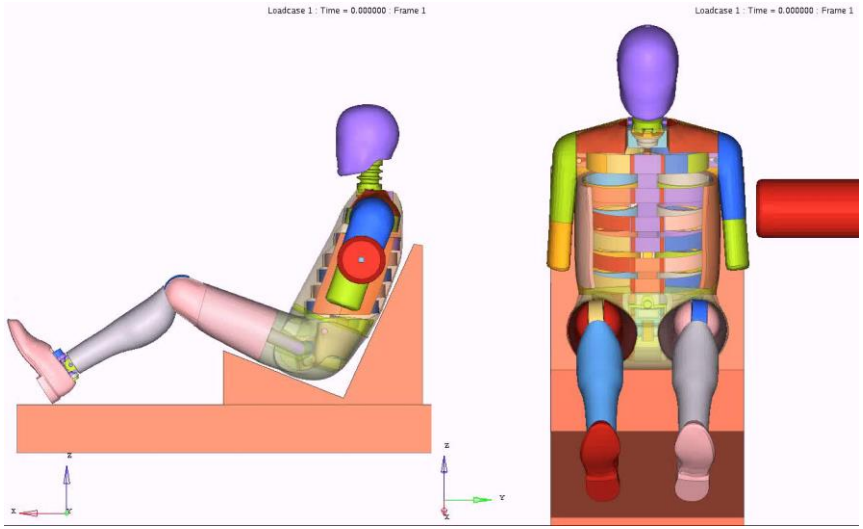
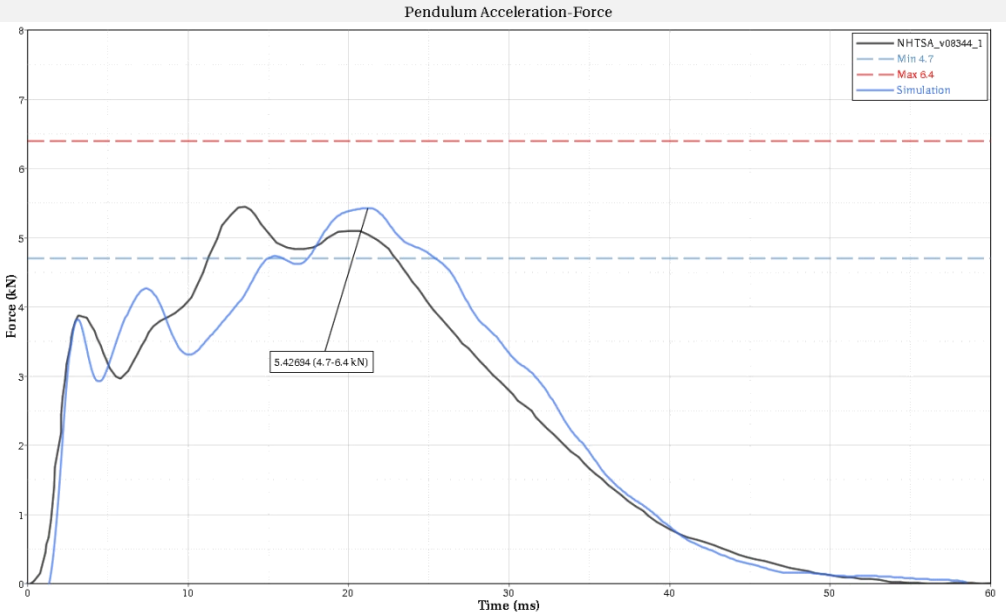
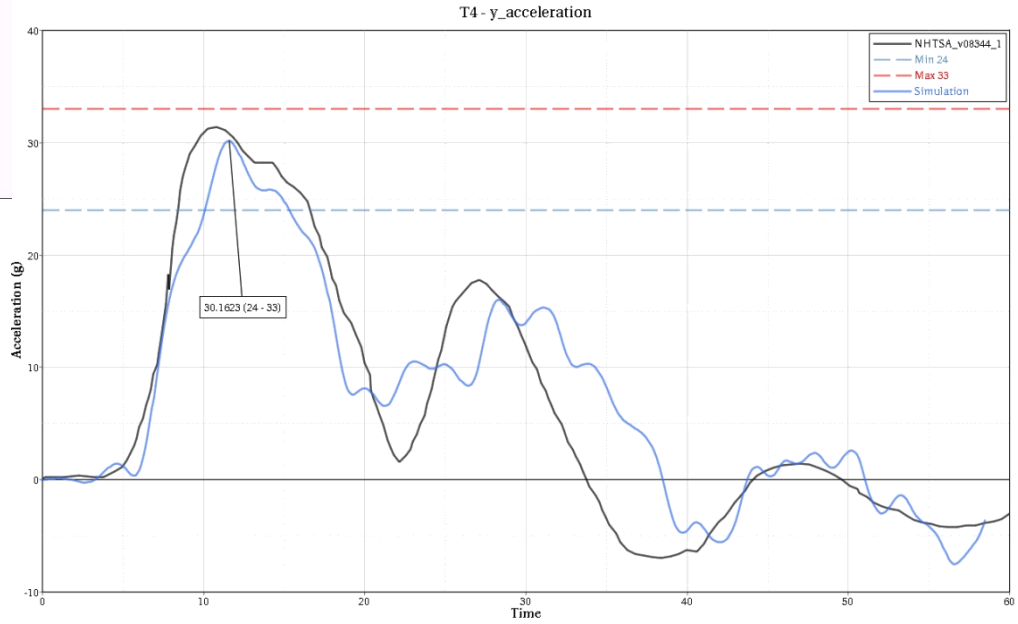
WorldSID 50th Thorax Certification (with arm)







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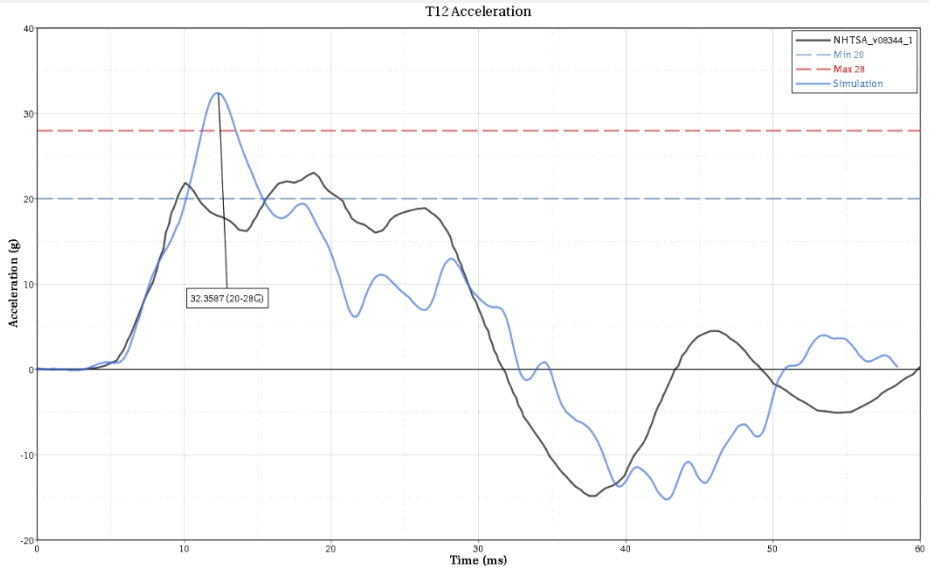
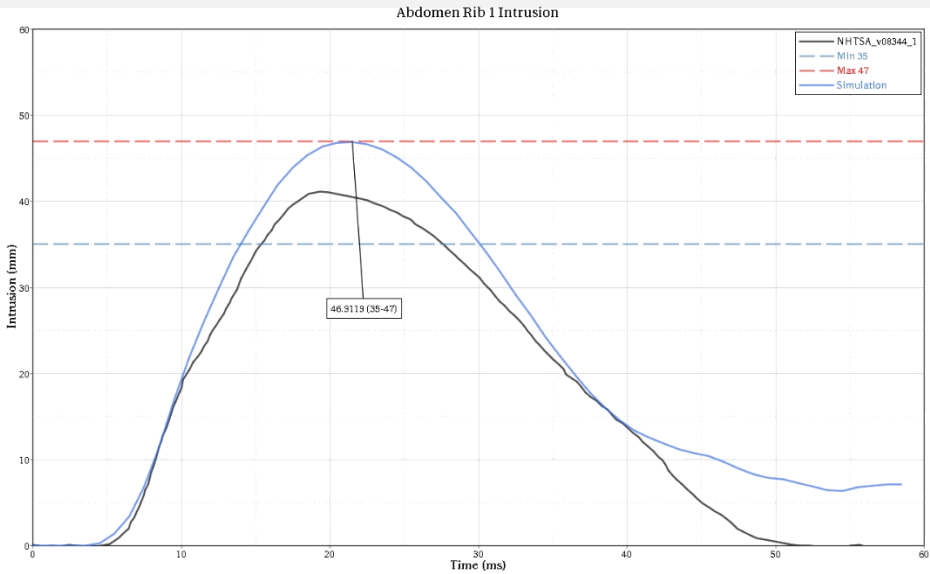
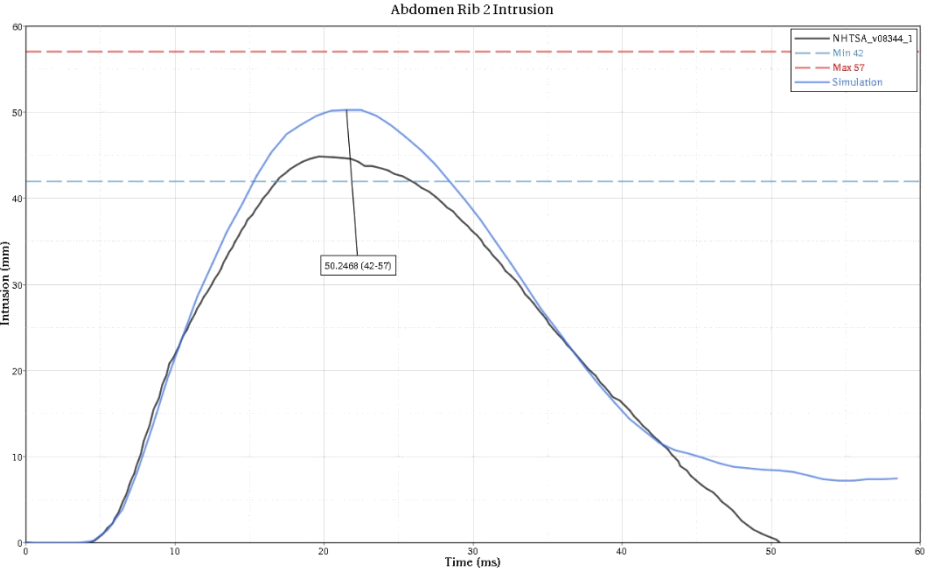
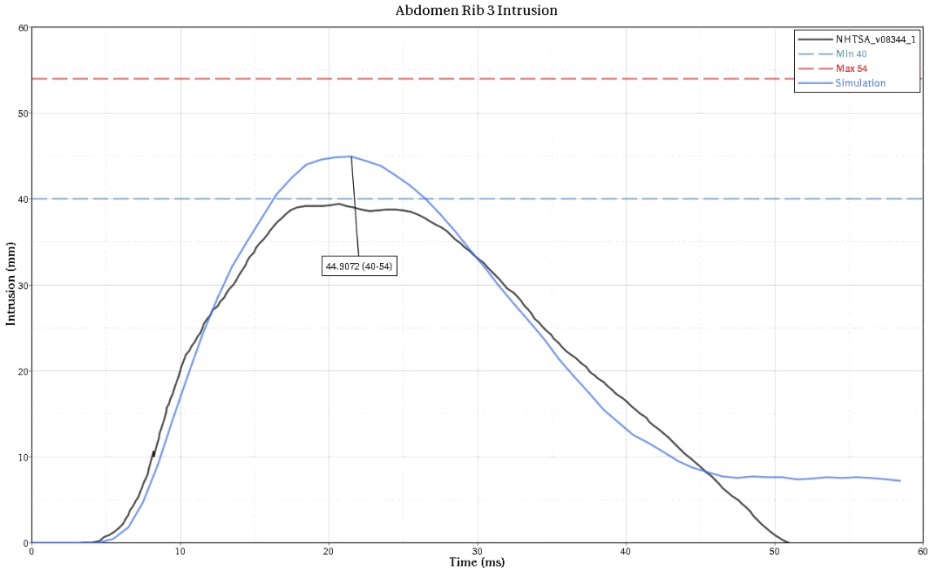
WorldSID 50th Thorax Certification (with arm)









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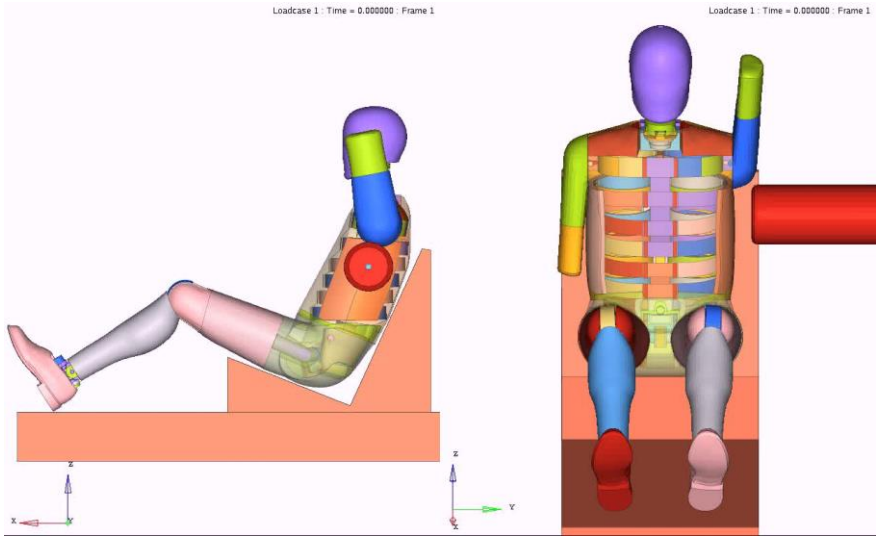
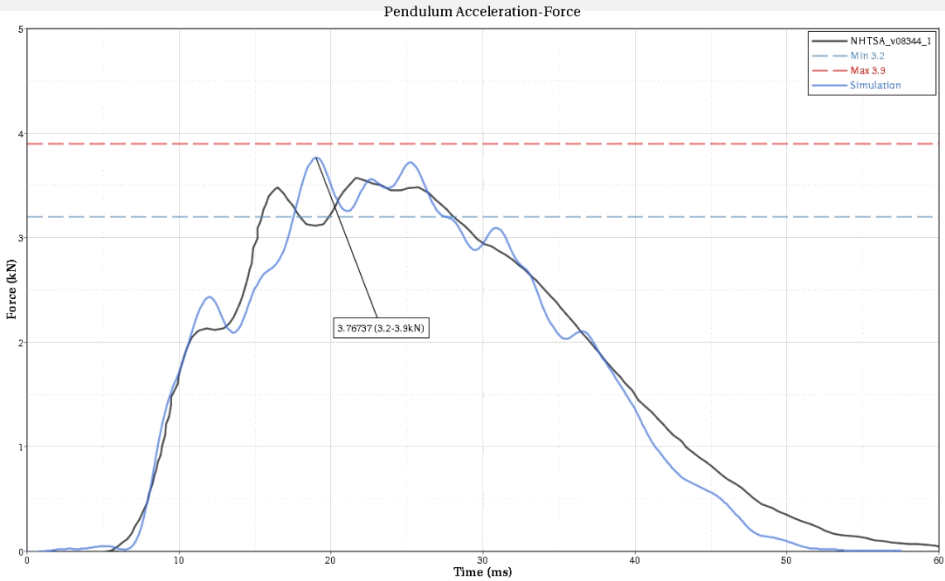
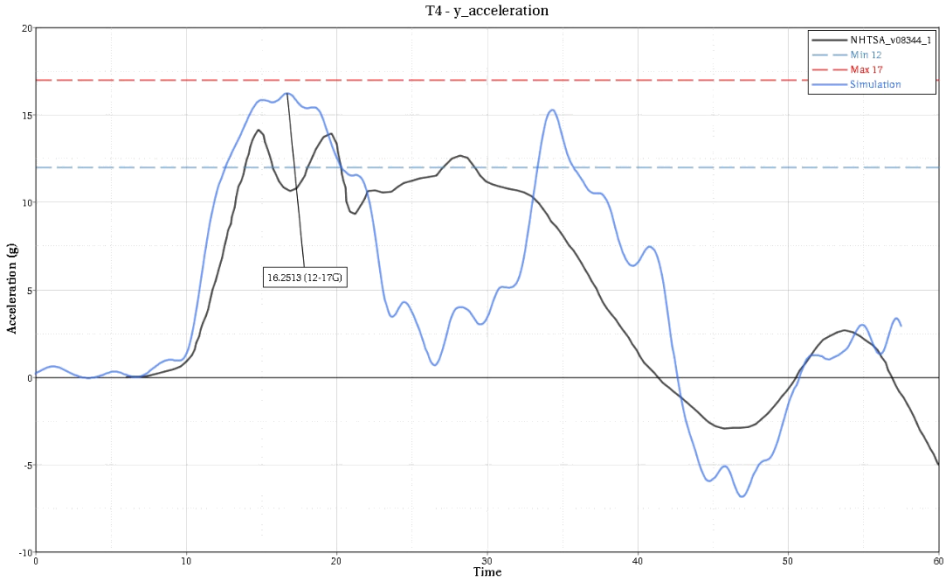
WorldSID 50th Thorax Certification (with arm)

Variables	Requirements	Simulation
Pendulum force	4.7 to 6.4 kN	5.42694
Peak T4 acceleration	24 to 33 G	30.1623
Peak T12 acceleration	20 to 28 G	32.3587
Peak thorax rib 1 deflection	35 to 47 mm	46.9119
Peak thorax rib 2 deflection	42 to 57 mm	50.2468
Peak thorax rib 3 deflection	40 to 54 mm	44.9072

WorldSID 50th Thorax Certification (without arm)







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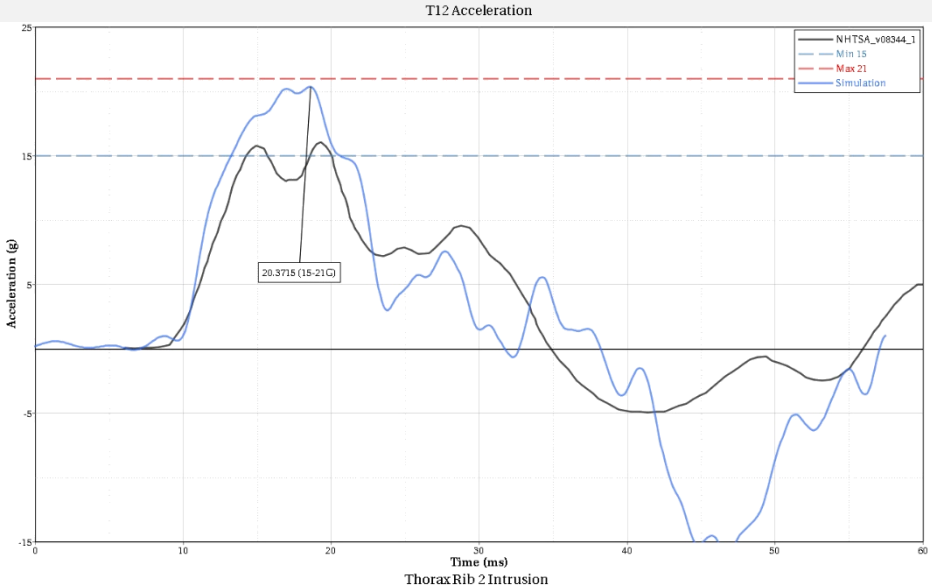
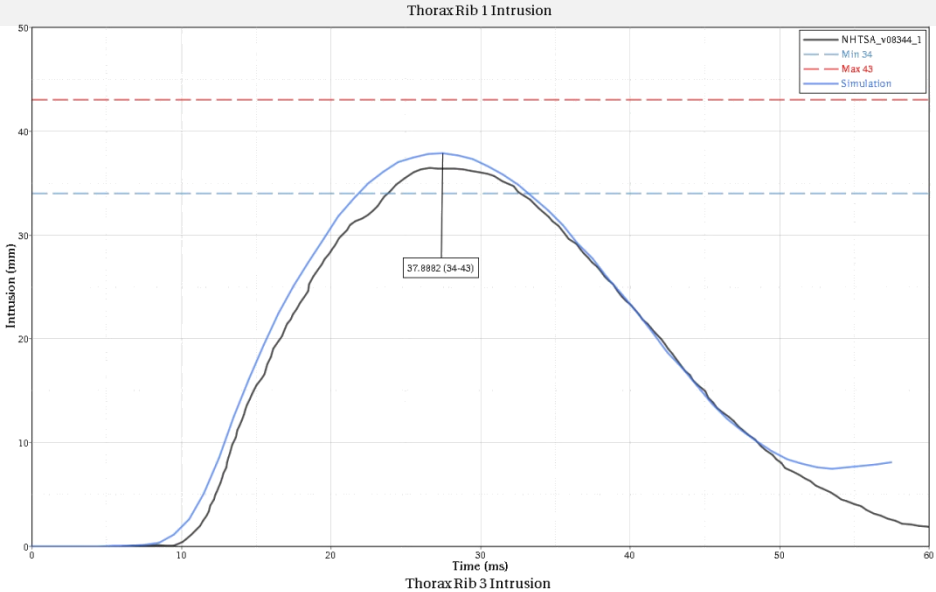
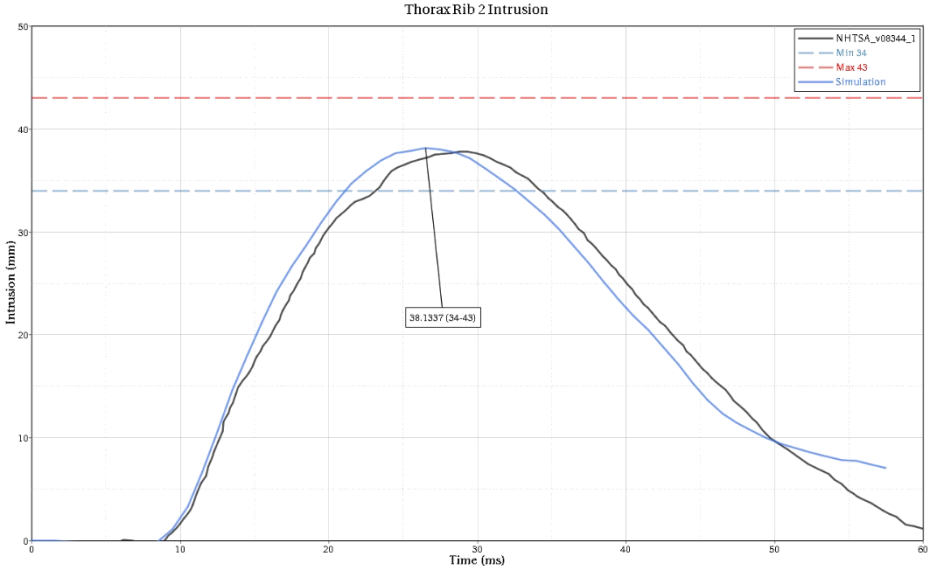
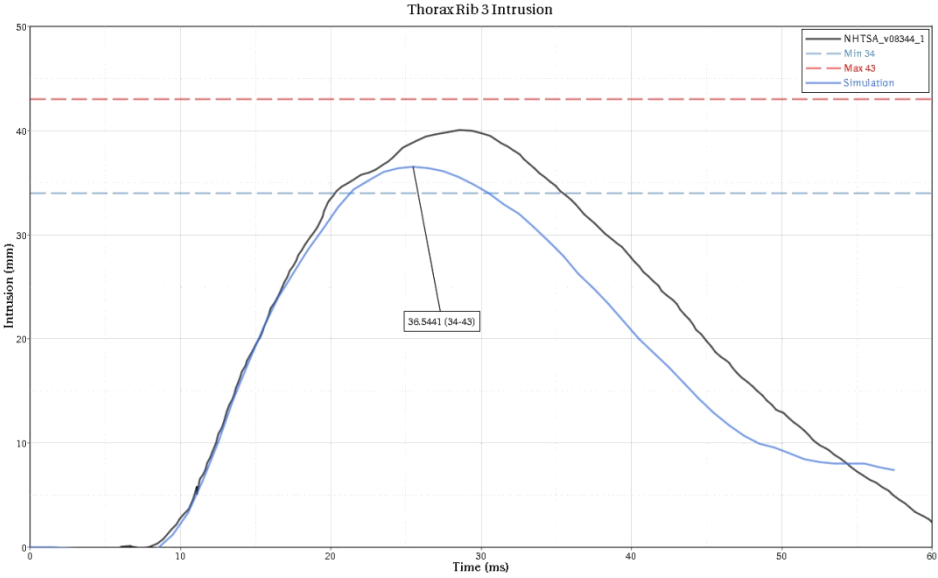
WorldSID 50th Thorax Certification (without arm)









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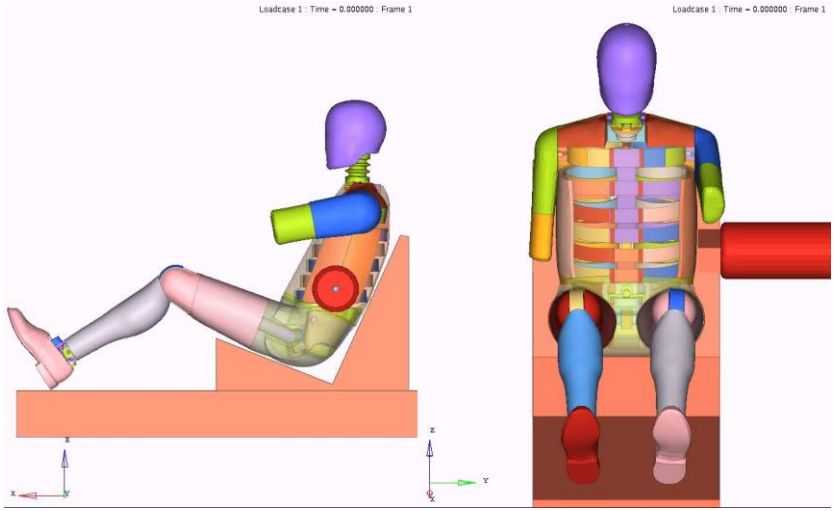
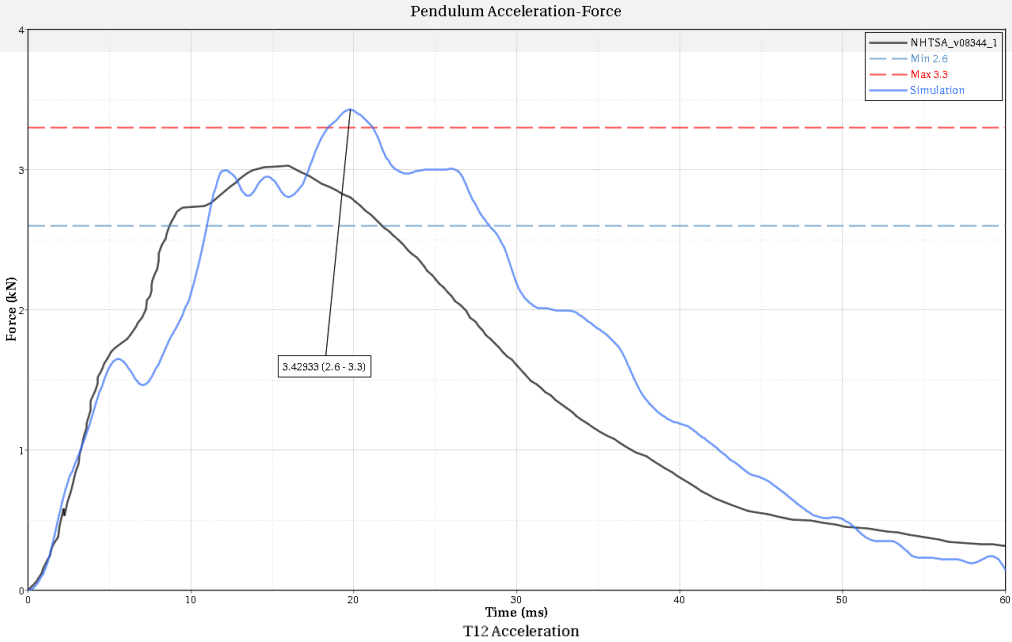
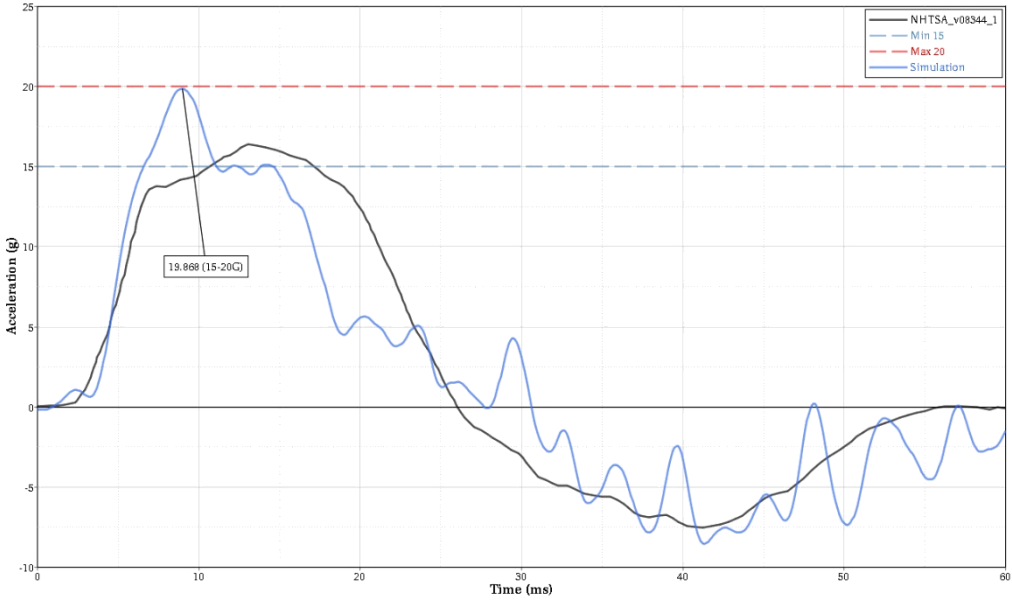
WorldSID 50th Thorax Certification (without arm)

Variables	Requirements	Simulation
Pendulum force	3.2 to 3.9 kN	3.76737
Peak T4 acceleration	12 to 17 G	16.2513
Peak T12 acceleration	15 to 21 G	20.3715
Peak thorax rib 1 deflection	34 to 43 mm	37.8882
Peak thorax rib 2 deflection	34 to 43 mm	38.1337
Peak thorax rib 3 deflection	34 to 43 mm	36.5441

WorldSID 50th Abdomen Certification







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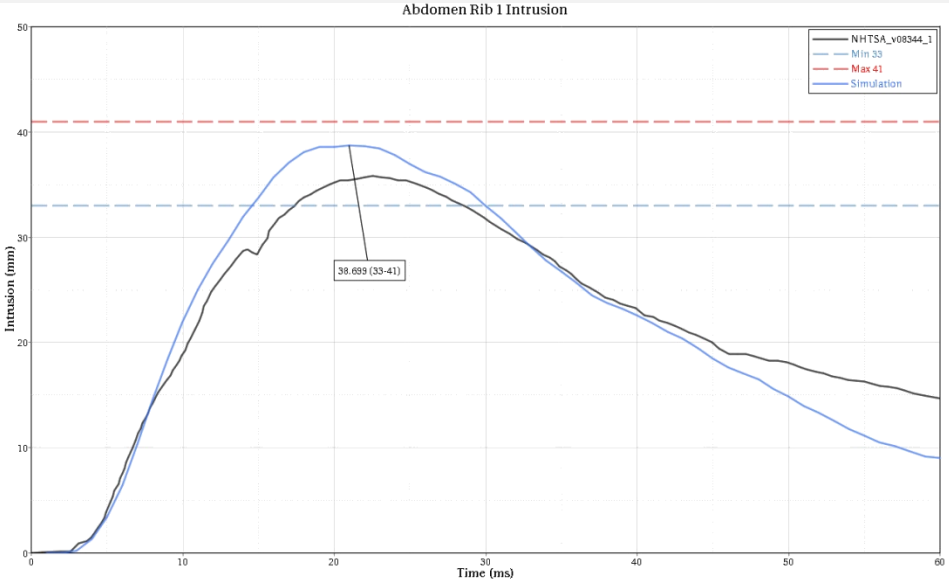
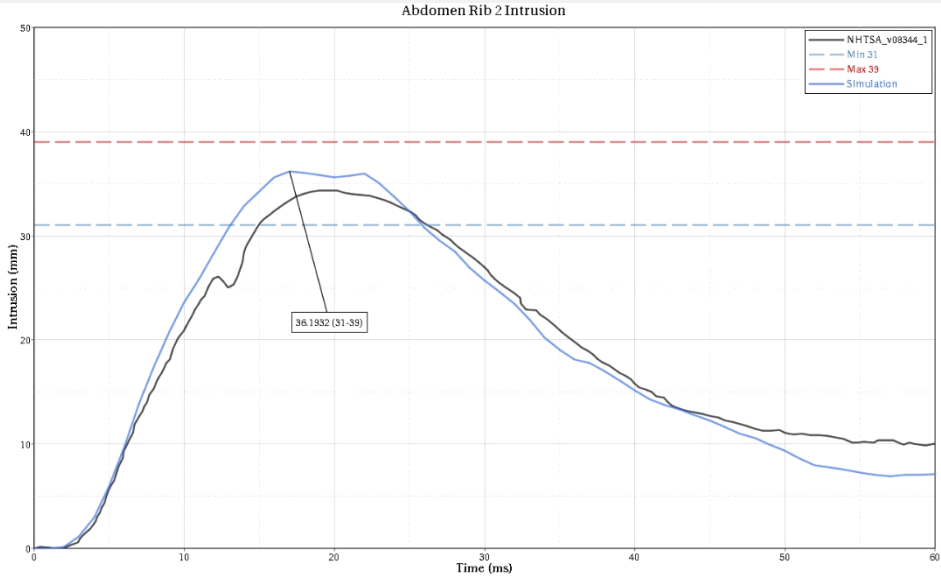
WorldSID 50th Abdomen Certification





Variables	Requirements	Simulation
Pendulum force	2.6 to 3.3 kN	3.42933
Peak T12 Y-acceleration	15 to 20 G	19.868
Peak abdomen rib 1 deflection	33 to 41 mm	38.6990
Peak abdomen rib 2 deflection	31 to 39 mm	36.1932

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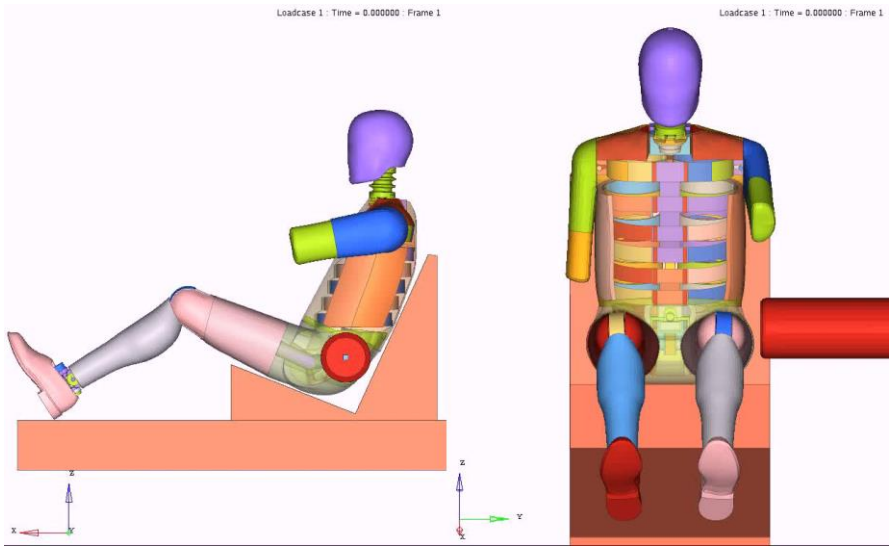
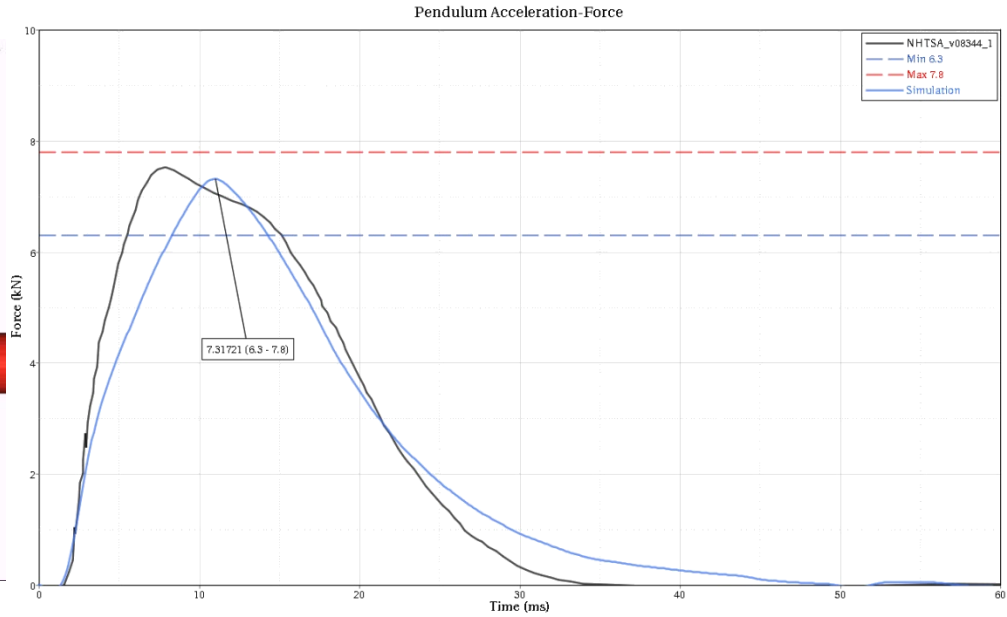
WorldSID 50th Pelvis Certification





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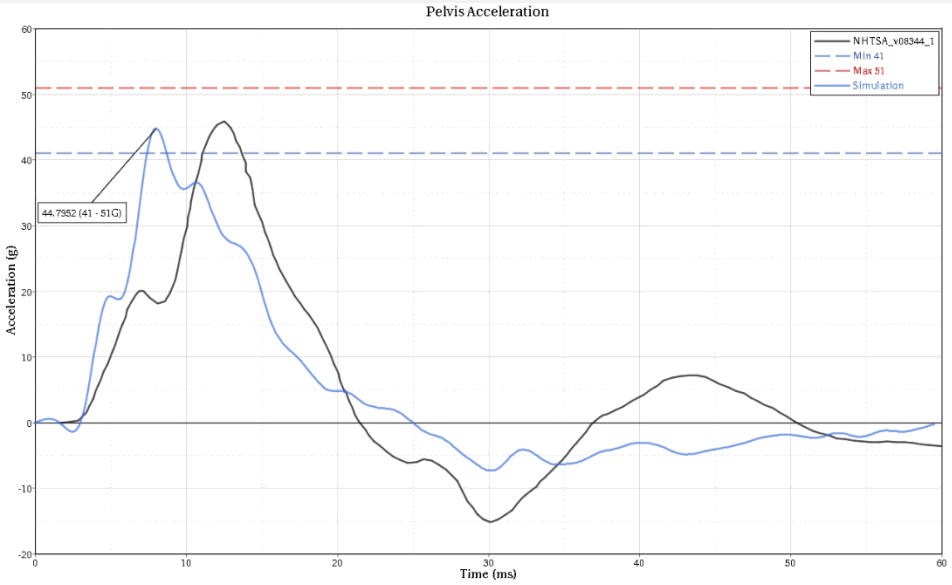
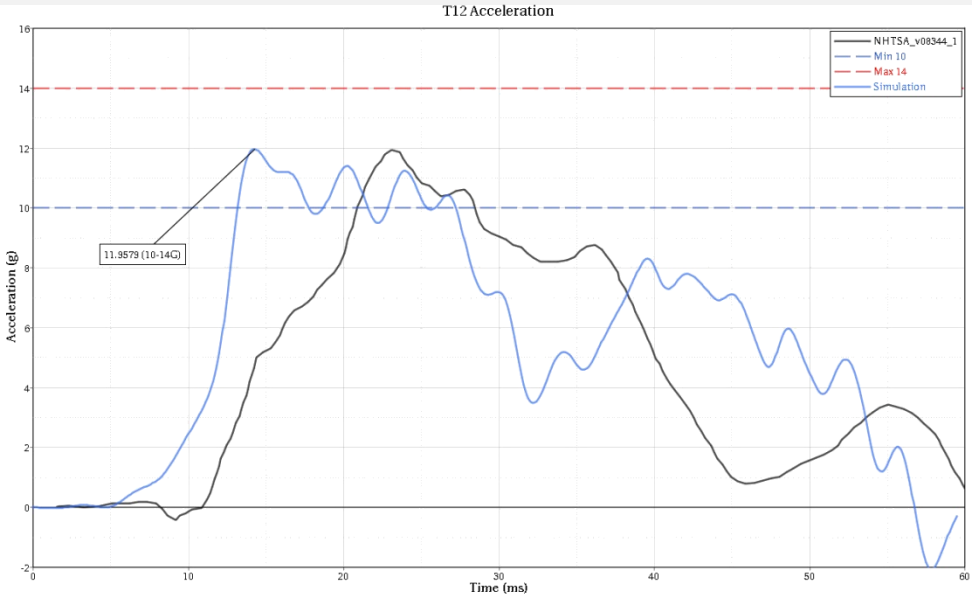
WorldSID 50th Pelvis Certification





Variables	Requirements	Simulation
Pendulum force	6.3 to 7.8 kN	7.31721
Peak acceleration along y axis	41 to 51 G	44.7952
Peak T12 Y-acceleration	10 to 14 G	11.9579

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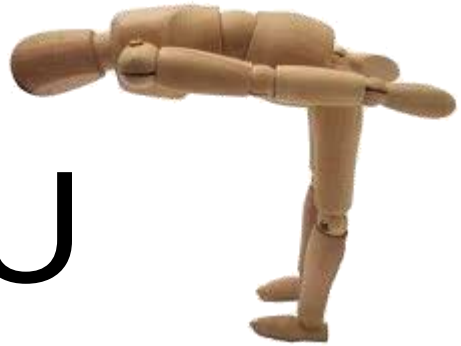
THANK YOU



We thank all the OEMs who provided us with the test data for the development of dummies and barrier models.