HUMANETICS
Innovative Solutions

LS-DYNA FORUM-BAMBERG
8TH OCTOBER 2014

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LATEST DEVELOPMENTS OF LS-DYNA TEST DUMMY MODELS

Humanetics Innovative Solutions

Index

- Harmonized Hybrid III Model Development
- THOR 50th Model
- Q10 Child Model

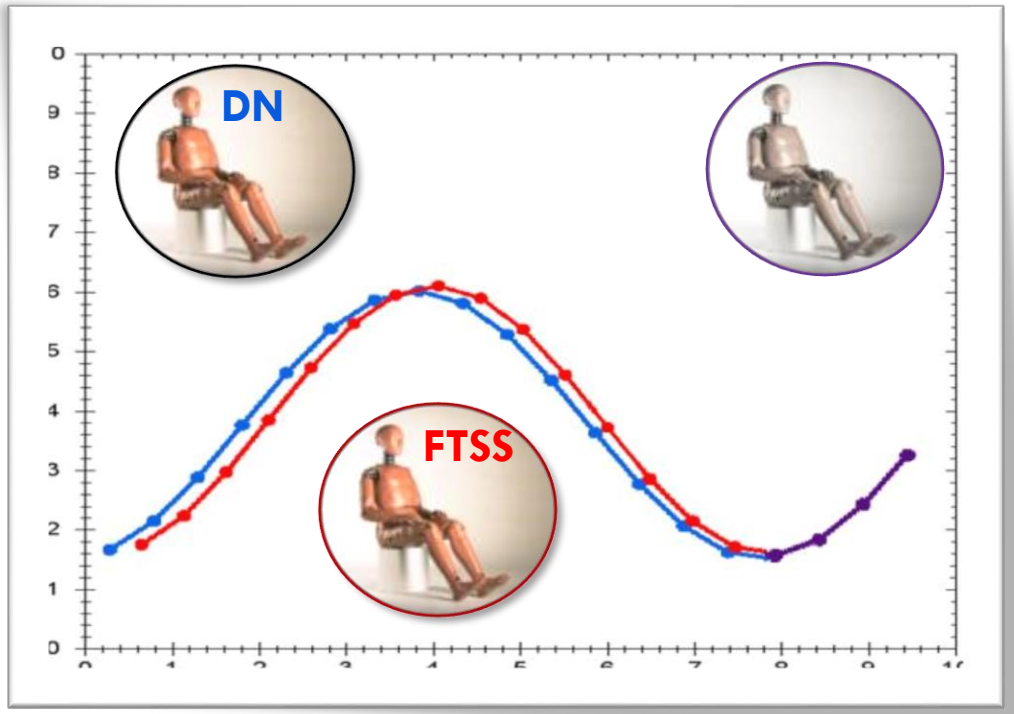
Harmonized Hybrid III Model Development

Humanetics Dummy Harmonization

DN = Denton Brand FTSS = FT Brand	Head	Neck	Upper Torso	Lower Torso	Legs & Feet	Arms & Hand
HIII 50th Male	DN	DN	FTSS	DN	DN	DN

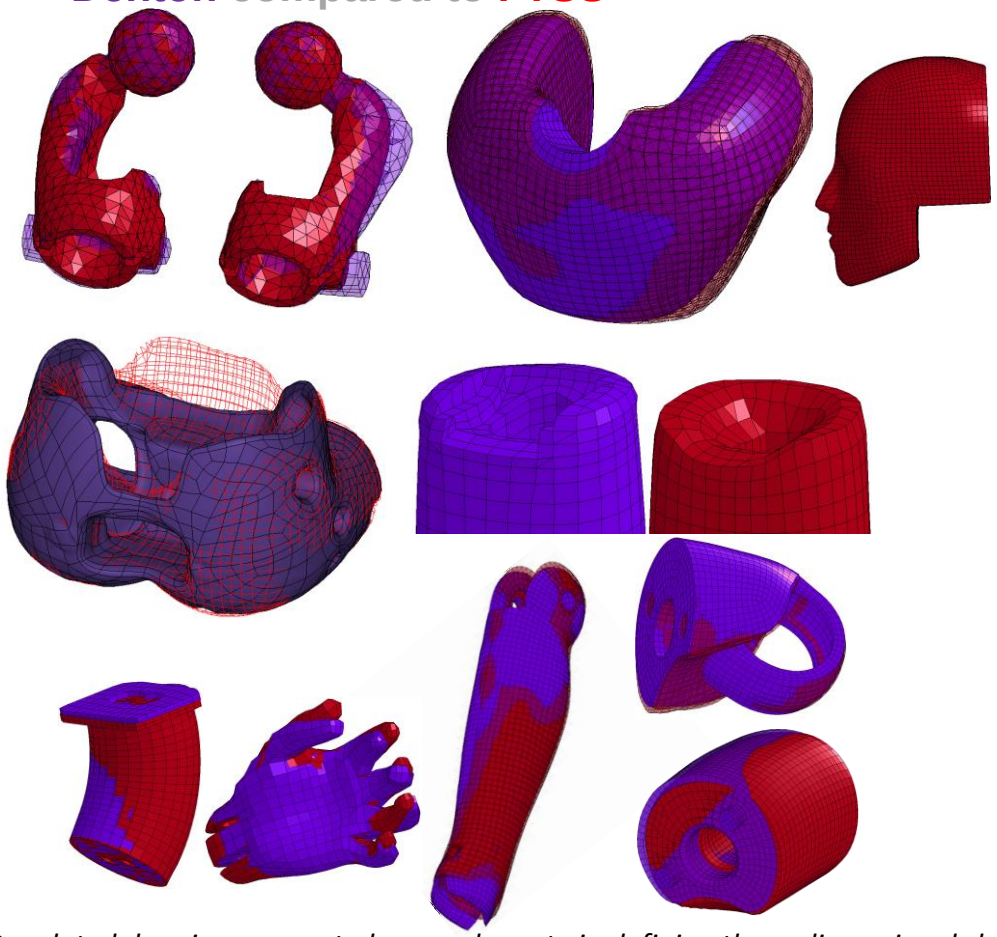
One Goal: Reduce Dummy Variation

Create a single brand of dummy to reduce test to test variation.



Items which may affect crash tests

Denton compared to **FTSS**



Hybrid III 50th

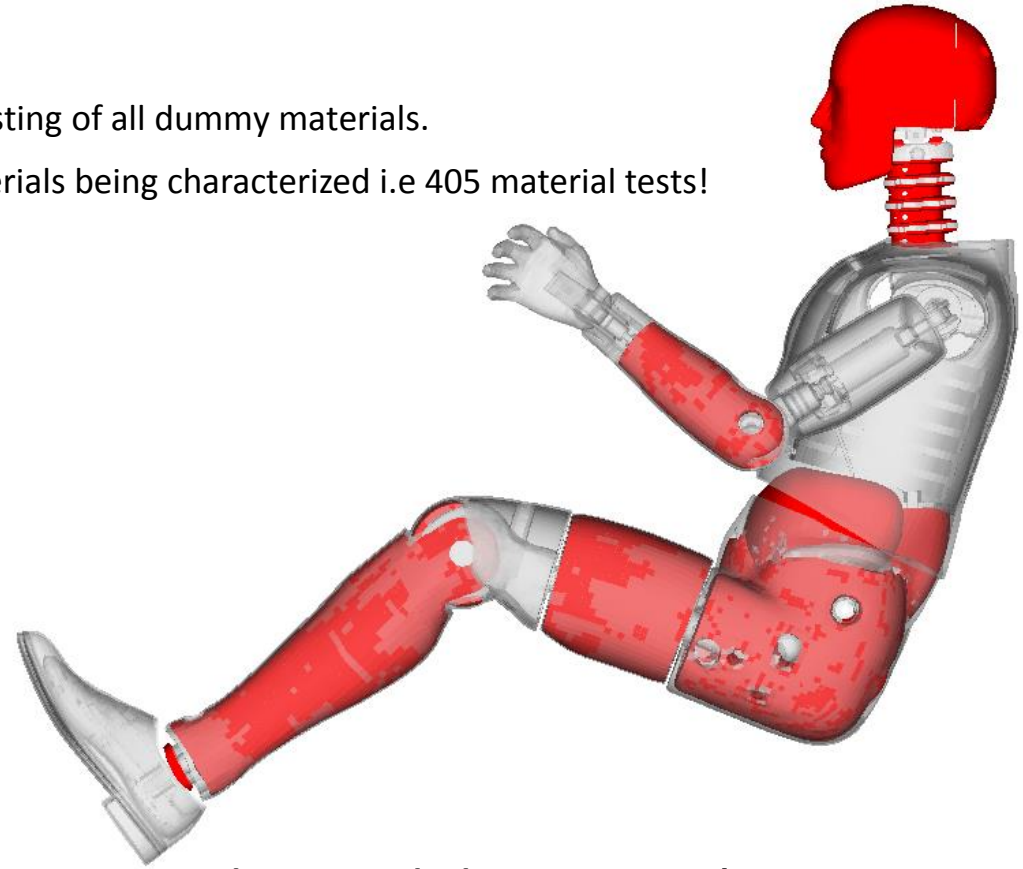
Geometry	FTSS	DENTON
Nose Vinyl	Solid	Hollow
Chin Vinyl	Straight	Angled
Forehead vinyl	Thicker	Thinner
Pelvis flesh	No cut-out	Cut-out for lumbar adapter
Abdomen	Different mould	
Femur heads	Different shape	
Hand	Different finger positioning	
Upper arm vinyl	Different pattern of vinyl on upper surface	
Thigh, knee, lower leg vinyl	Different moulds	

Regulated drawings are not always adequate in defining three-dimensional shapes, giving latitude for interpretation of key body parts.

Items which may affect crash tests

Hybrid III 50th

- Extensive testing of all dummy materials.
- 33 new materials being characterized i.e 405 material tests!

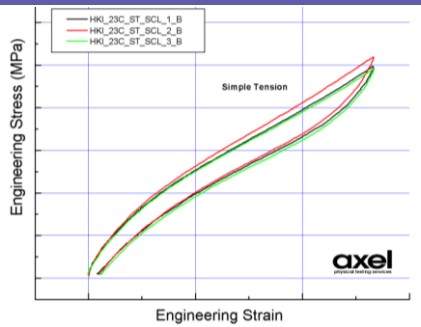


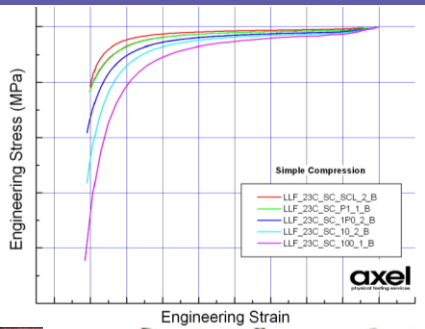
Materials
Neck Rubber
Nodding Block
Abdomen Insert (Foam)
Lower Arm Foam
Lower Leg Foam
Upper Leg Foam
Lumbar Spine
Head Skin
Cap Skin
Lower Arm Stop Assembly
Pelvis Foam
Knee Slider Rubber
Ankle Bumper

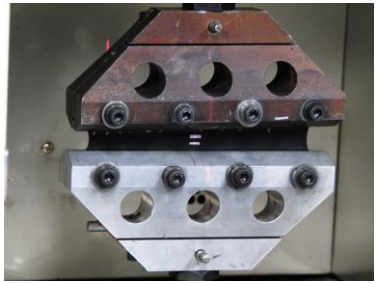
DENTON and FTSS did not use the same materials

New Material Tests & Methods

- Extensive testing of all dummy materials.
- Improved material curing process for better material quality.
- New material tests:
  - Uniaxial tension and compression
  - Equi-biaxial tension
  - Planar tension tests
  - Dynamic tests for rate sensitivity.
- New material modeling methodology or characterization.
- Multi-element coupon simulation for solver based accuracy.

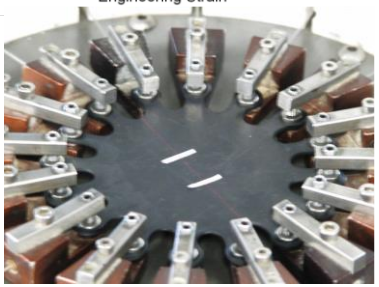




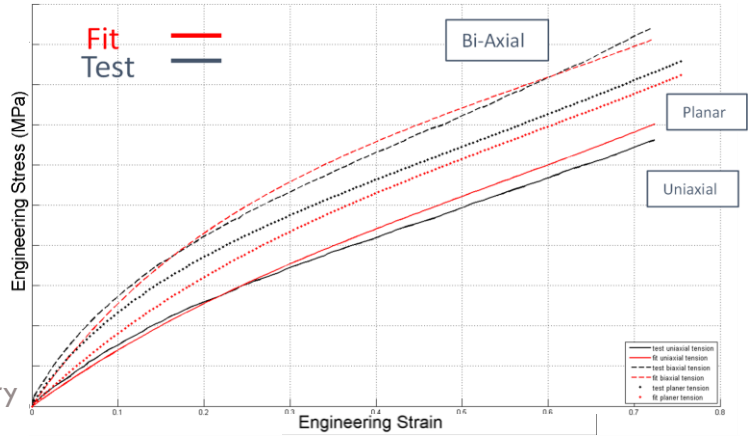


Planar Tension

Uniaxial Tension

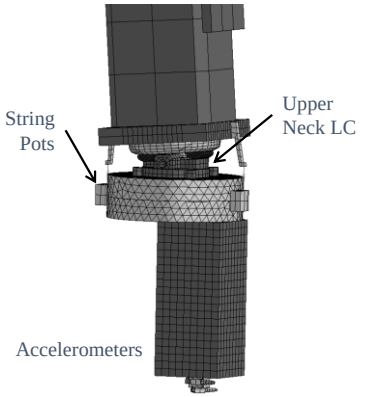


Bi-Axial Tension

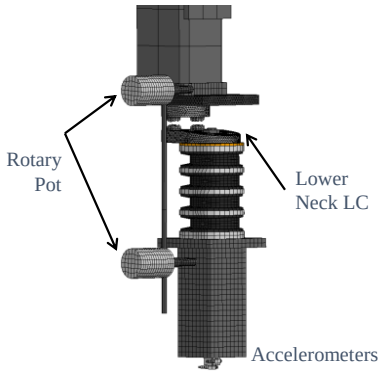


New Hardware Tests

Nodding Block and Neck Rubber Only Tests

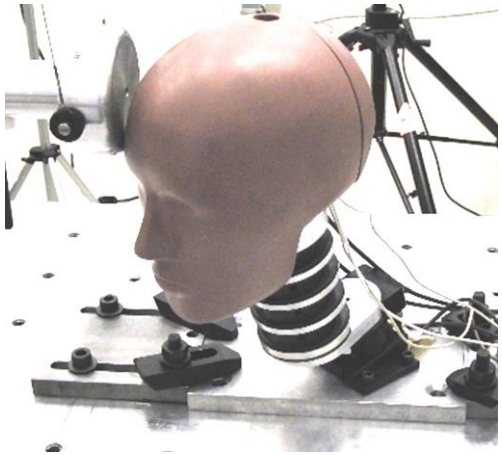


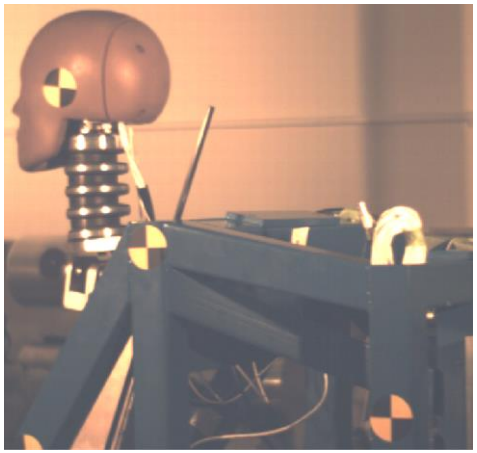
Nodding Joint Only



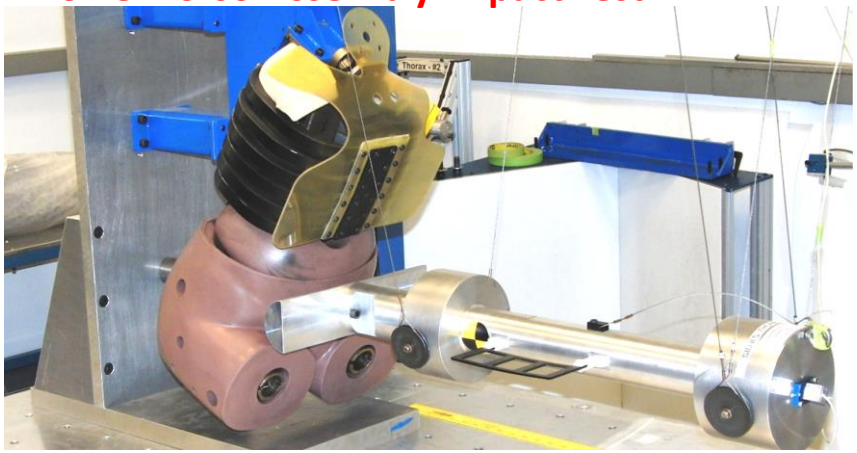
Neck Rubber Only

Head Impact and Neck Mini-Sled Tests

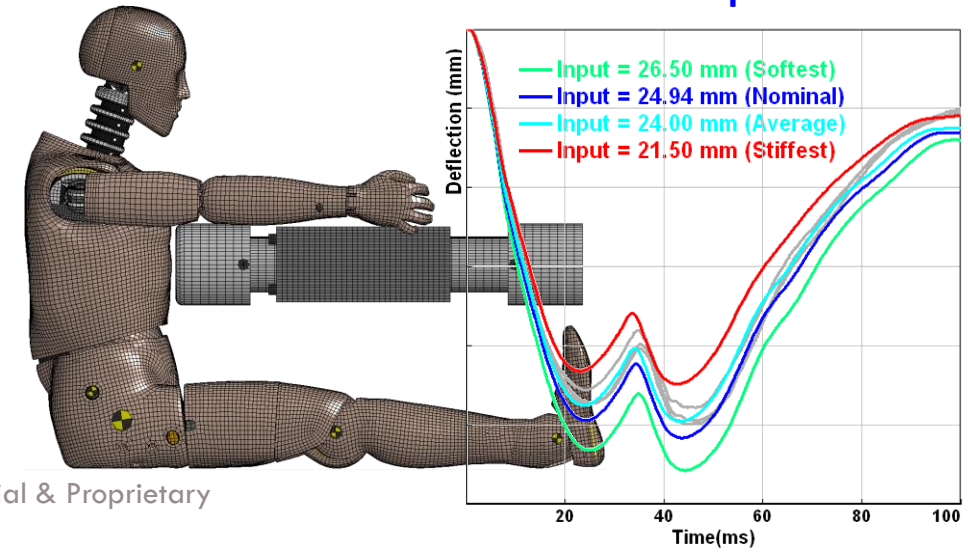




Lower Torso Assembly Impact Test



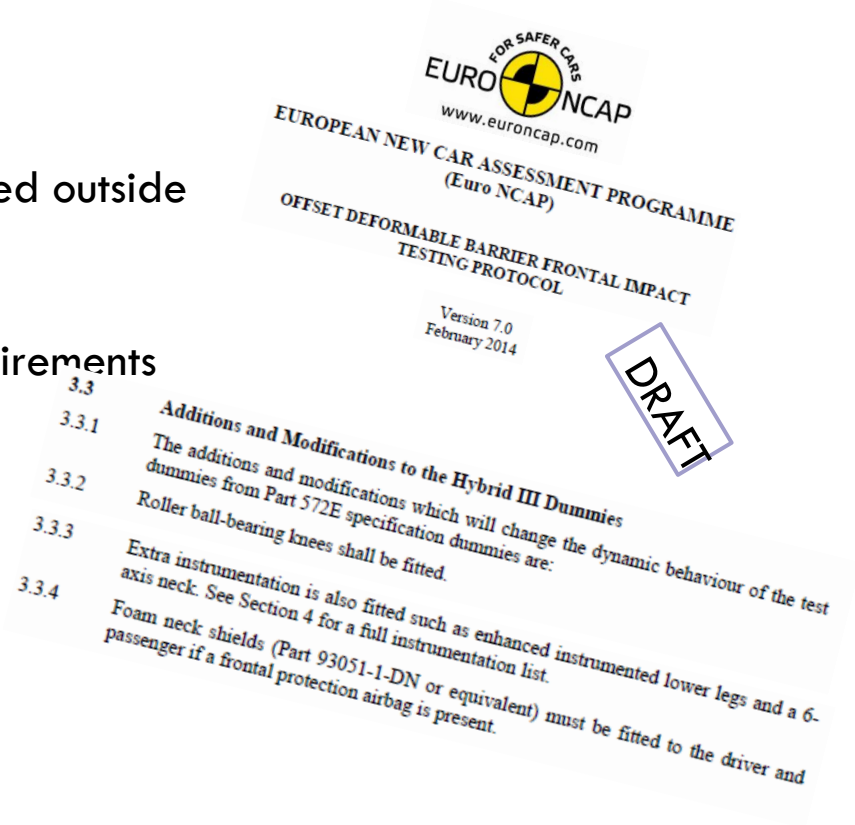
Thorax 'Twin' Pendulum Double-Impact Test



Harmonised HIII 50th

Harmonised Hybrid III Model has been evaluated outside Humanetics and is now being released

The harmonized H350 FE model meets the requirements As specified in the latest EuroNCAP protocol



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EUROPEAN NEW CAR ASSESSMENT PROGRAMME
(Euro NCAP)

OFFSET DEFORMABLE BARRIER FRONTAL IMPACT
TESTING PROTOCOL

Version 7.0
February 2014

DRAFT

3.3 **Additions and Modifications to the Hybrid III Dummies**

3.3.1 The additions and modifications which will change the dynamic behaviour of the test dummies from Part 572E specification dummies are:

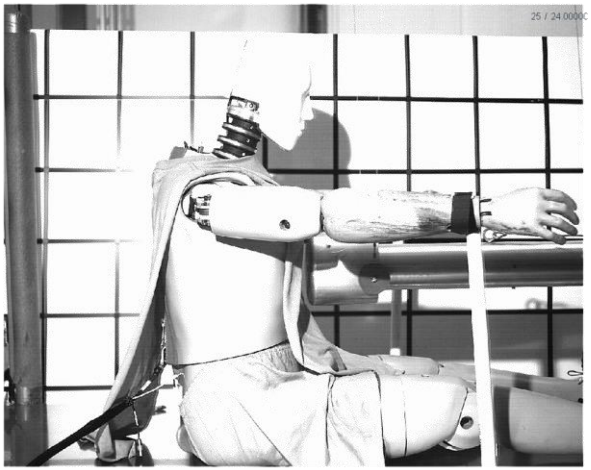
3.3.2 Roller ball-bearing knees shall be fitted.

3.3.3 Extra instrumentation is also fitted such as enhanced instrumented lower legs and a 6-axis neck. See Section 4 for a full instrumentation list.

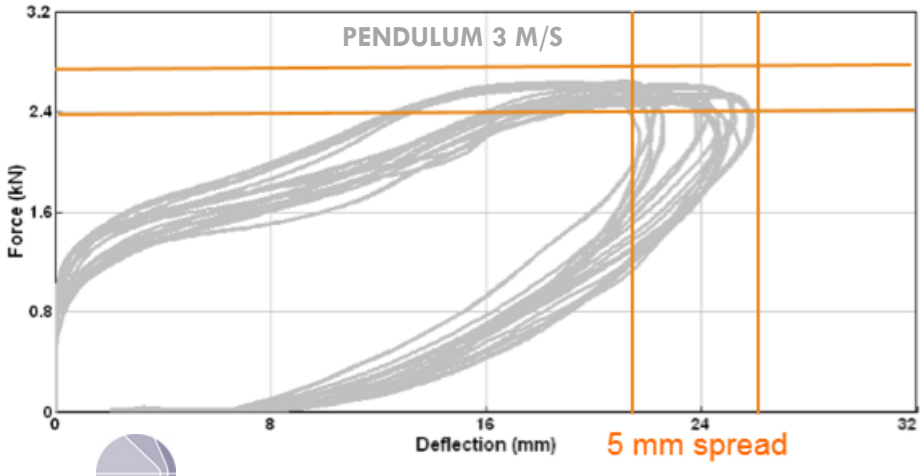
3.3.4 Foam neck shields (Part 93051-1-DN or equivalent) must be fitted to the driver and passenger if a frontal protection airbag is present.

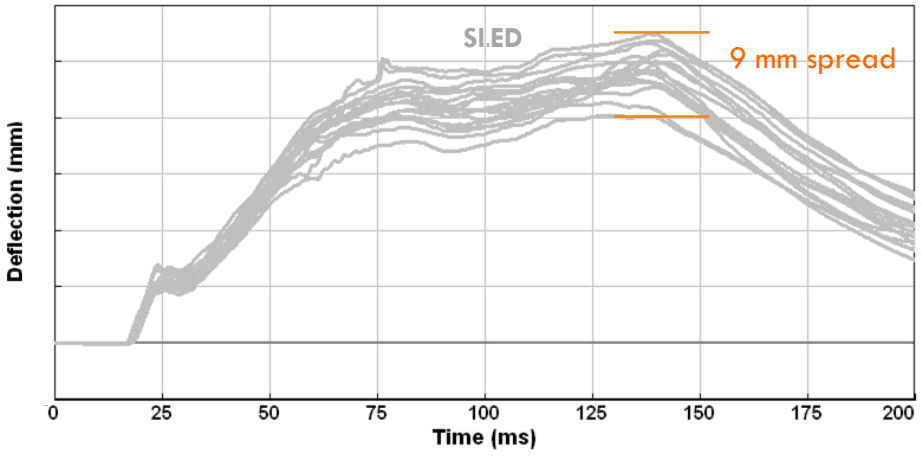
Tool to assist in dealing with Chest Variability

Hybrid III 50th Hardware Variation

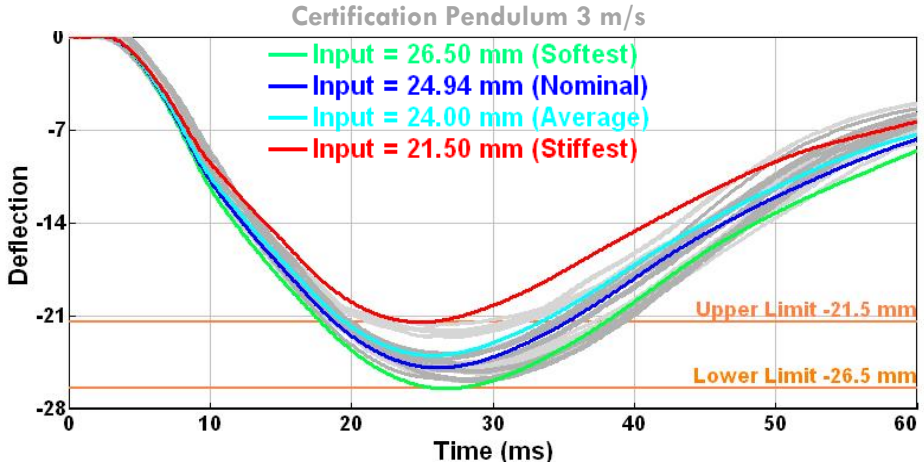


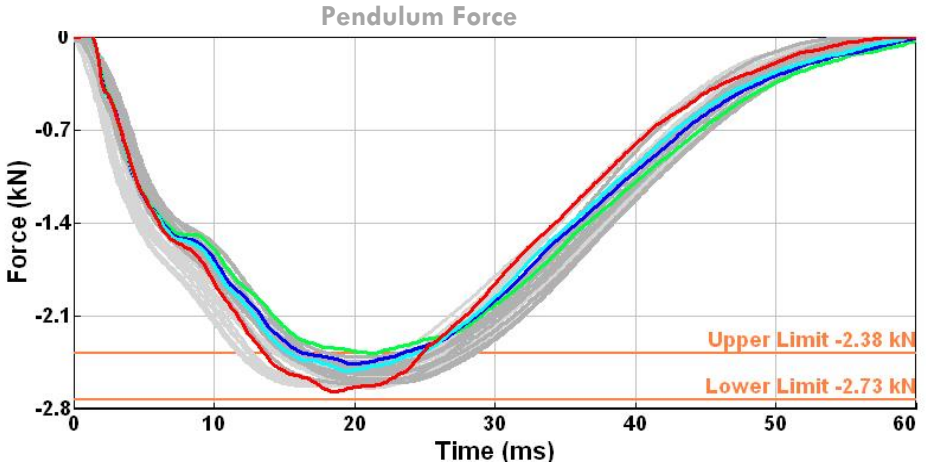
- The thorax pendulum certification test allows 5 mm chest deflection spread
- Spread is coming from differences in materials, manufacturing, positioning, climate, aging and other factors.
- Sled/vehicle tests show more chest deflection spread due to more complexities present.
- Chest variation can significantly influence sled/vehicle tests signals.

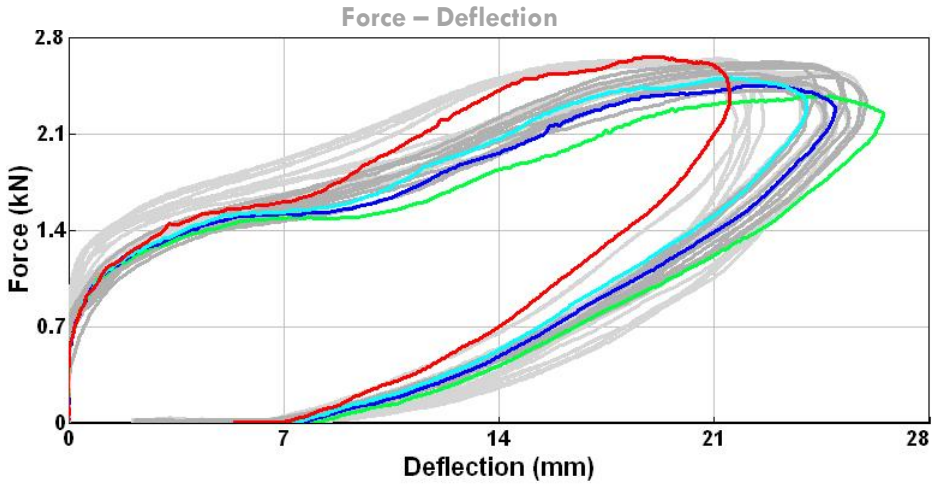




Borderline Chest Models - Customized Chest Model





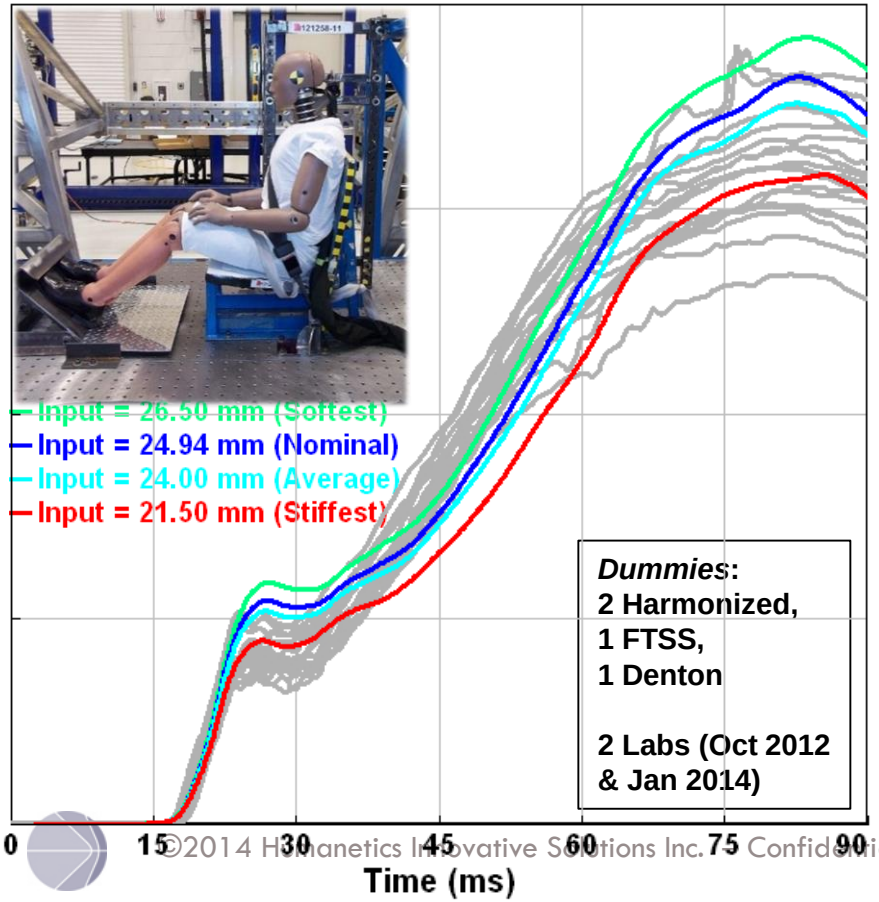


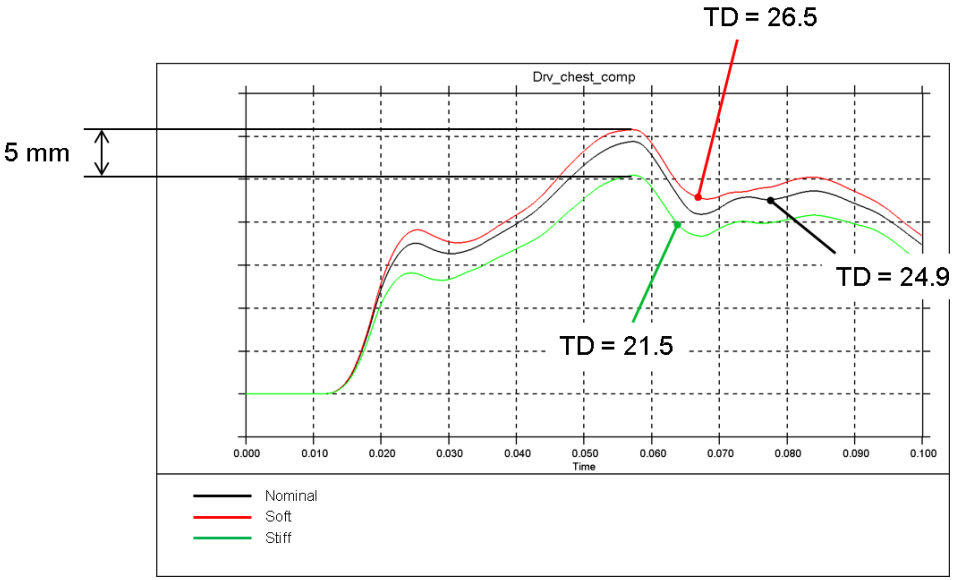
- Two borderline sets were identified that match reasonably well with the extreme test data profiles.
- A best match to any certification can be achieved.
- It is possible to quantify the influence of dummy characteristics as measured in certification at vehicle or sled level.
- The two-extreme sets have been parameterized.
- Intermediate sets can be interpolated from extremes.

Borderline Chest Model – Sled Validations

Sled C (27G)

- Rigid seat sled test having belt system (pretensioner, retractor & load limiters) with fixed footpan





Courtesy of Jaguar Land Rover

Harmonized HIII 5th

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EUROPEAN NEW CAR ASSESSMENT PROGRAMME
(Euro NCAP)

FULL WIDTH FRONTAL IMPACT TESTING PROTOCOL

Version 1.0
February 2014

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3.1 General

Hybrid III 05F test dummies should be used for the front driver seat and the rear passenger seat, at the opposite to the driver. They should conform to U.S. Department of transportation, Code of Federal Regulations Part 572 Subpart O, except for modifications and additions stated later. The parts of the dummy should be following the latest agreed brand harmonised design:

3.2 Additions and Modifications to the Hybrid III Dummies

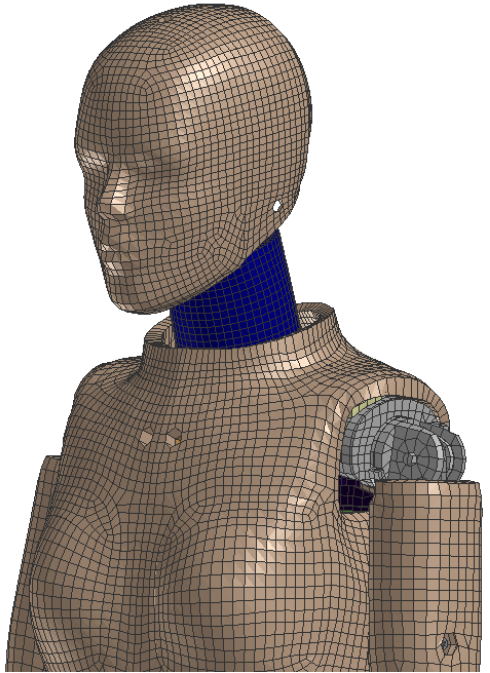
The additions and modifications which will change the dynamic behaviour of the test dummies from Part 572 O specification dummies are:

3.2.1 Neoprene neck shields, with part number ABA-211-DN, must be fitted to the driver and rear passenger.

3.2.2 The harmonized jacket, according to SAE J2921, must be fitted to the driver and rear passenger.

3.2.3 The "Denton" lower leg cavity must be fitted to the driver and passenger.

880105-000-1-BKS-H	H3-5TH, BBKS,T/C, ACCEL MT
Includes:	• Head skin T/C w/ chin Velcro • Neck Shield • Ball Bearing Knee Sliders* • Zippered Lower Leg Flesh • Harmonized ENCAP Rib set • Harmonized SAE jacket • NCAP Accel Mount Feet

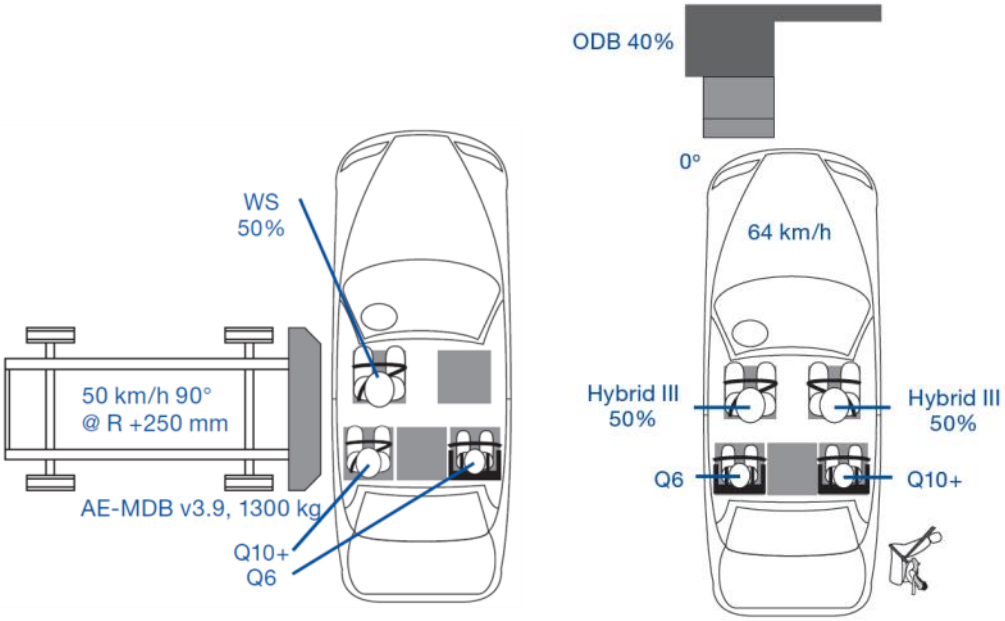


Euro NCAP Optimized H305 FE model needs to be realized

Work in Progress!

Q10 CHILD MODEL

Euro NCAP

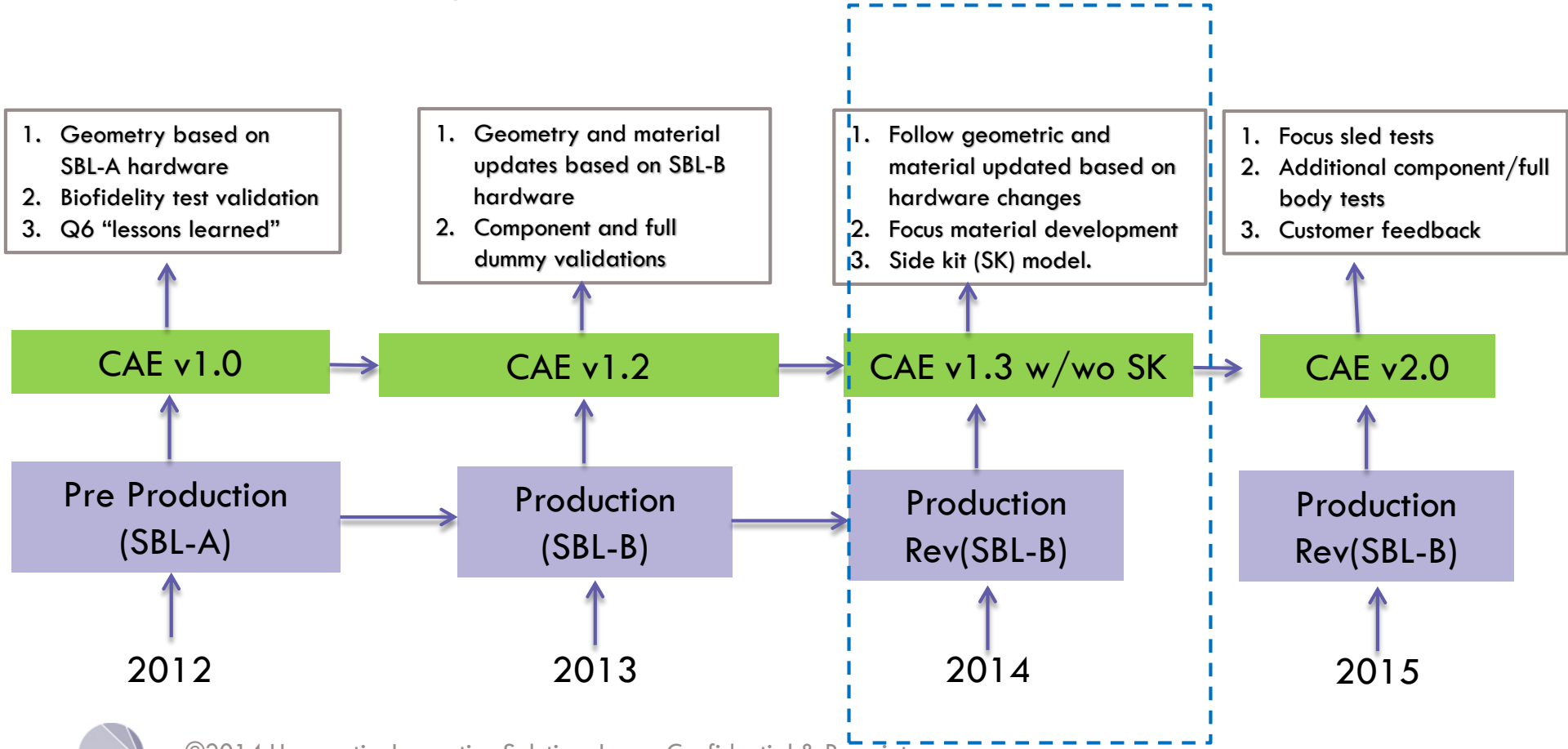


Courtesy Carsh Training

- Q6 and Q10 option for rear seats for front and side tests
- Q10 side kit for AE-MDB application.
- Q10 standard configuration for frontal 40% ODB tests.
- Discussions started in Child Occupant Protection group for introduction per 2016
  - Dummy seating positions, including arms, legs
  - Dummy validation, sign-off build level, sensor layout
  - Injury criteria, sliding scales and scoring
  - Update of penalties for head contact, excursion, …

Q10 model development

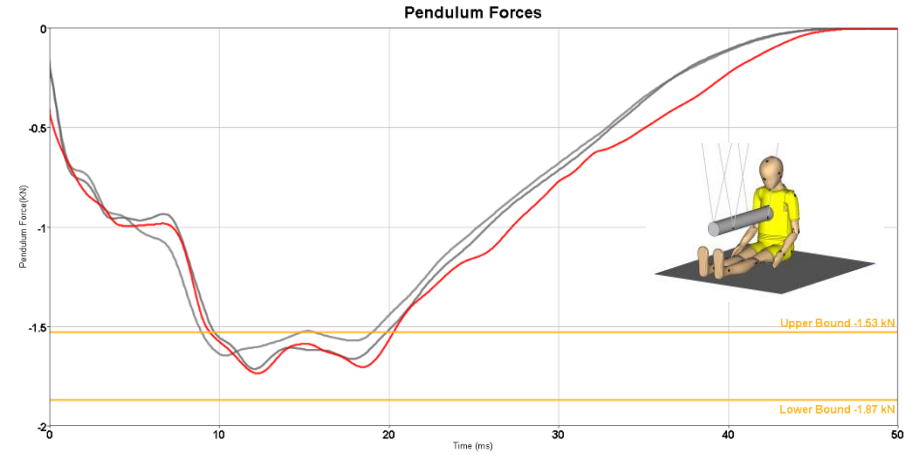
Q10 roadmap

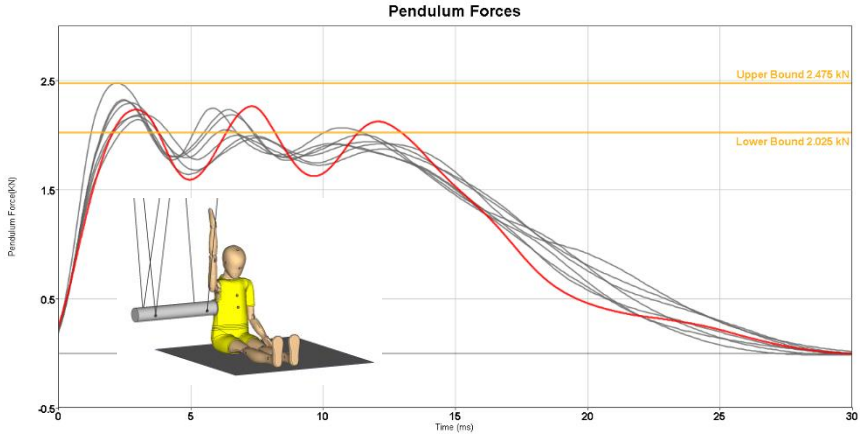


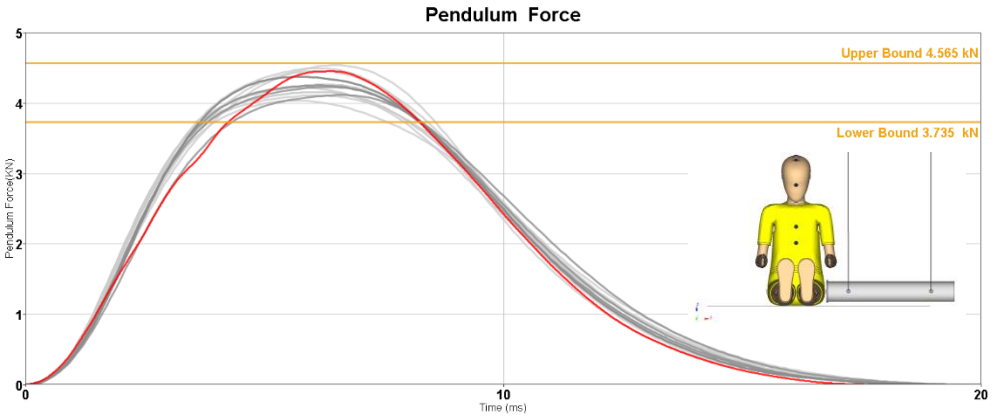
Status Q10 v1.3

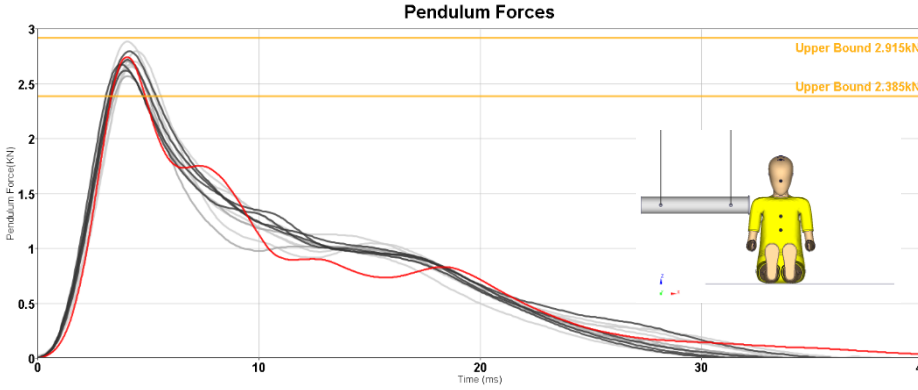
- The Q10 v1.3 FE model Geometry is built based on the SBL-B hardware
- Finalized hardware corridors are now available for standard certification tests.
- Material validations are carried out at coupon level for foam/rubber/plastic parts

Status Q10 v1.3





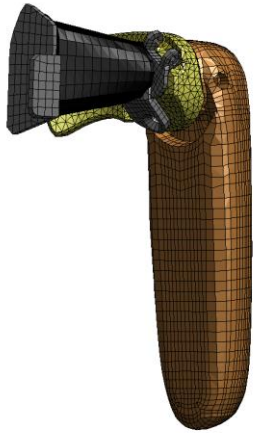




- Model validations based on standard full dummy certification test data.
- Minimal need to calibrate soft materials in component/full dummy tests after detailed material level validation.

Status Q10 v1.3 Side Kit

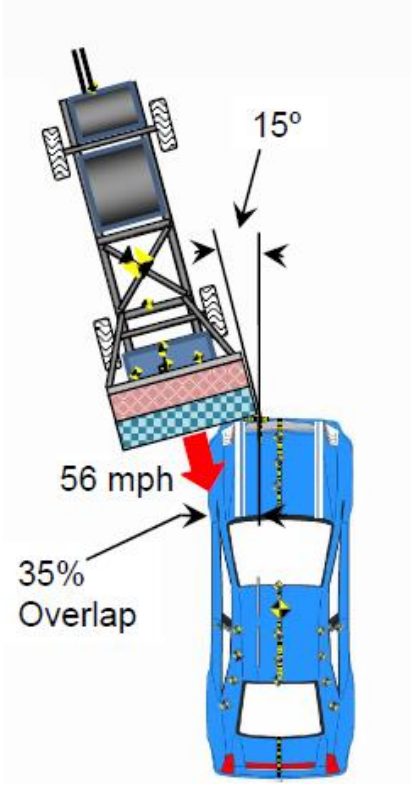
- Humanetics realized side impact kit with shoulder load cell that can easily be mounted on the dummy
  - Based on WorldSID 5th arm design
  - Total about 10 parts
  - Biofidelity evaluations done by BASt and TRL
  - Results will be reported in 2014 IRCOBI paper
  - FE model to be released in November 2014



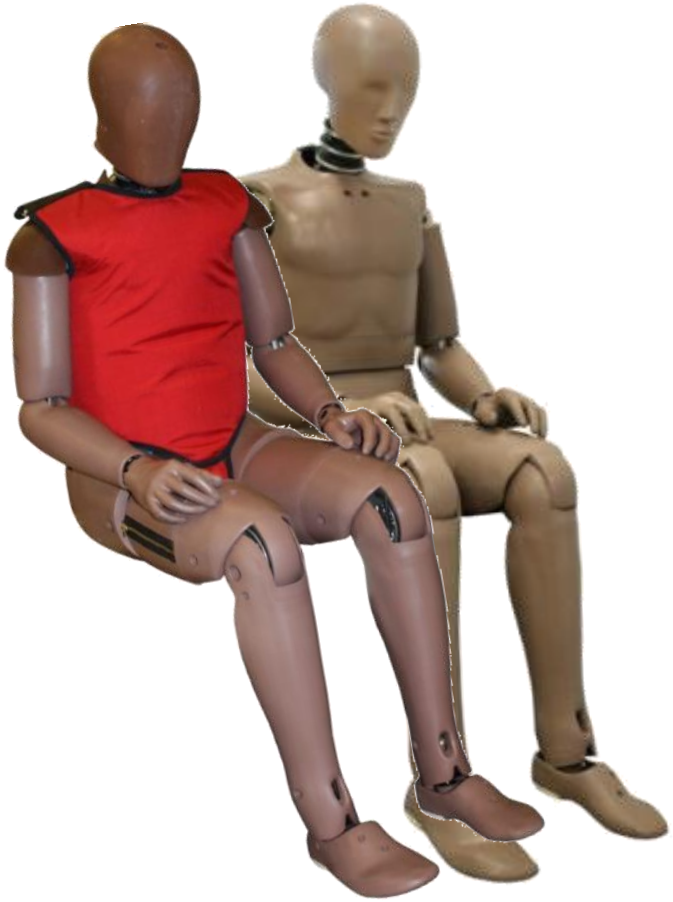
THOR

THOR-Status Hardware

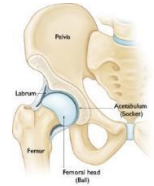
- NHTSA and EuroNCAP recently announced “steps forward for THOR”
- Interest: small overlap / oblique

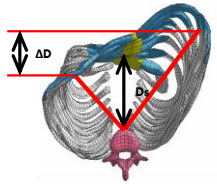


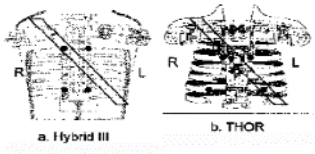
Differences THOR – HIII 50th



- Same weight: 78 kg
- Additional measurement capabilities like
  - load cells face
  - additional acceleration sensors
  - Acetabulum load cells
  - 4- point deflection measurement chest
  - 2 Point penetration measurement abdomen
- Design
  - Slouched versus erect
  - Humanlike chest geometry
  - Advances in every body part
- More compliant chest, lumbar and other body parts
  - Higher forward displacement with THOR
  - More rotation about z axis
  - Higher chest deflections
- Positioning
  - 5 tilt sensors to support positioning
  - Larger distance between thorax (~35 mm) and IP as well as face (~110 mm) and IP



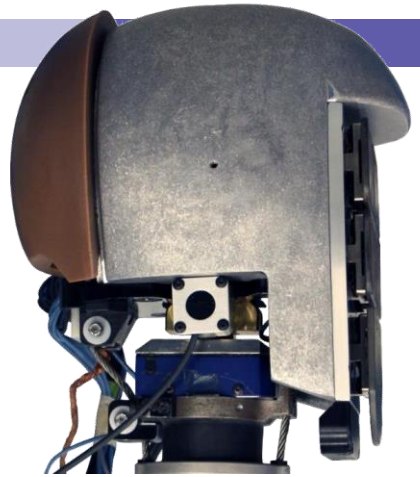


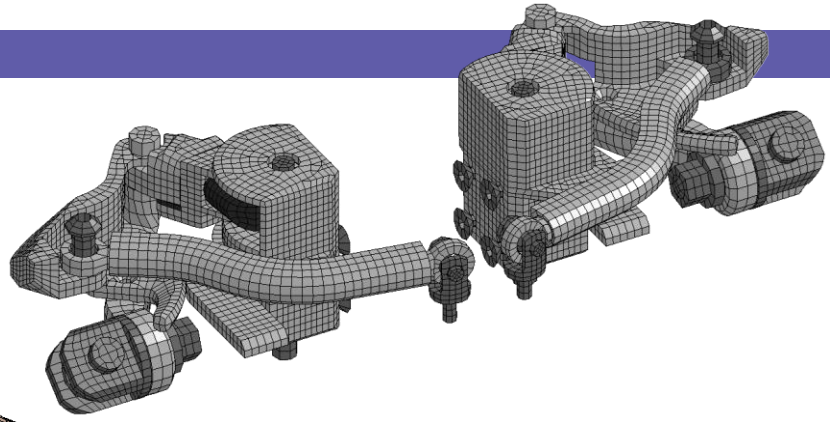


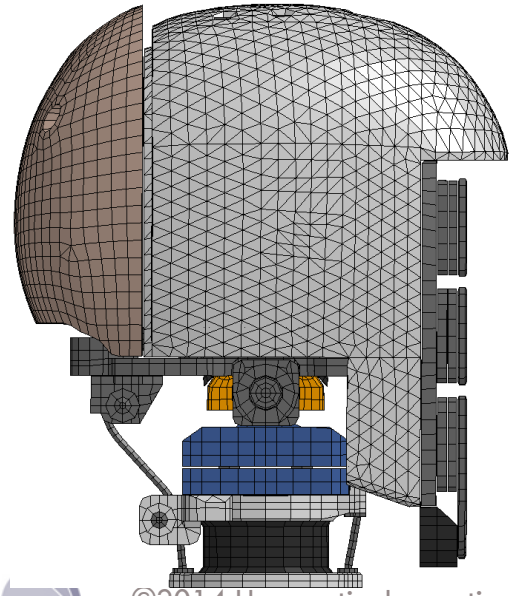
GOALS FIRST VERSION THOR Model

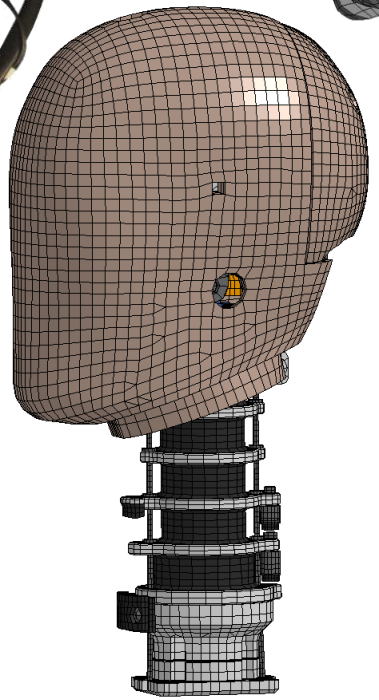
- Deliver an initial THOR model version 0.6 by mid 2014
- Capable to represent the complex THOR kinematics
- Including all latest hardware components like SD3 shoulder and LX leg
- Baseline model representing every detail that might affect performance
- Extensive material testing as presented
- Certification test validation for first release
- Non certification tests for Neck and Rib
- Extensive robustness testing in H350 sled environment
- Model capable to support further THOR hardware development

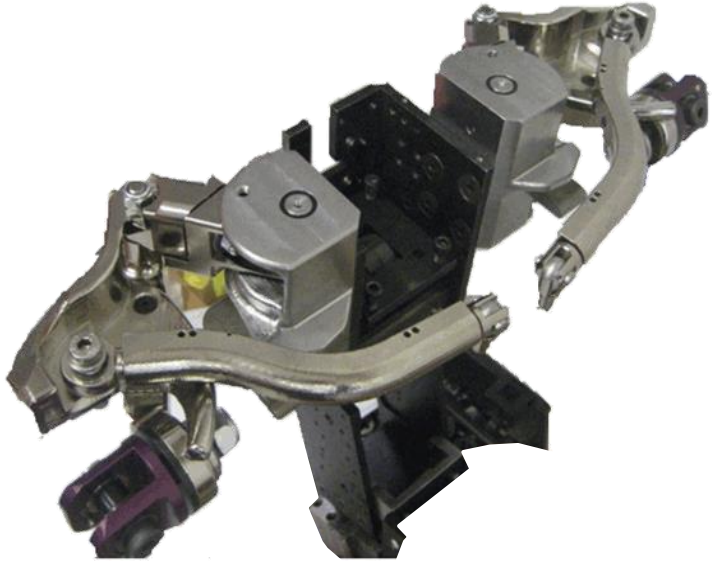
THOR –Head/Neck/Shoulders



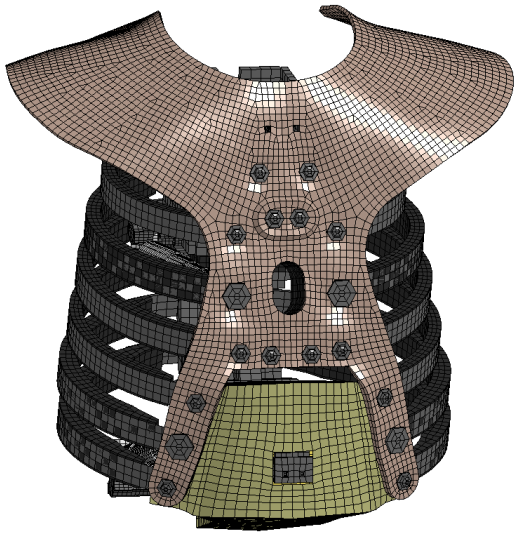


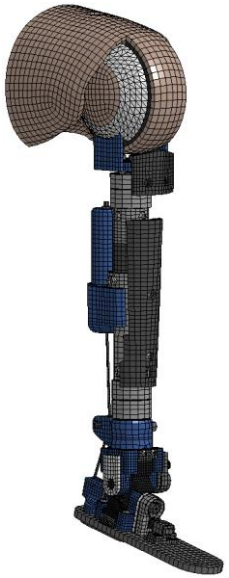


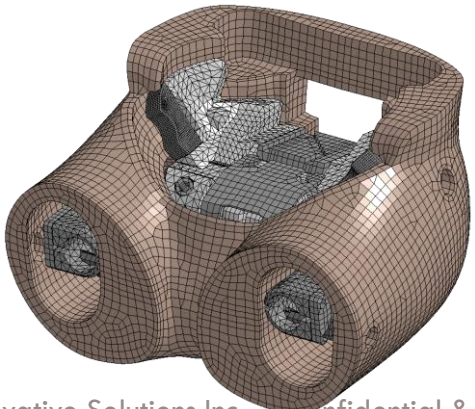
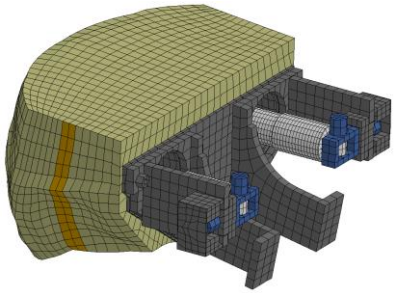




THOR –Thorax/Pelvis/Abdomen/Legs



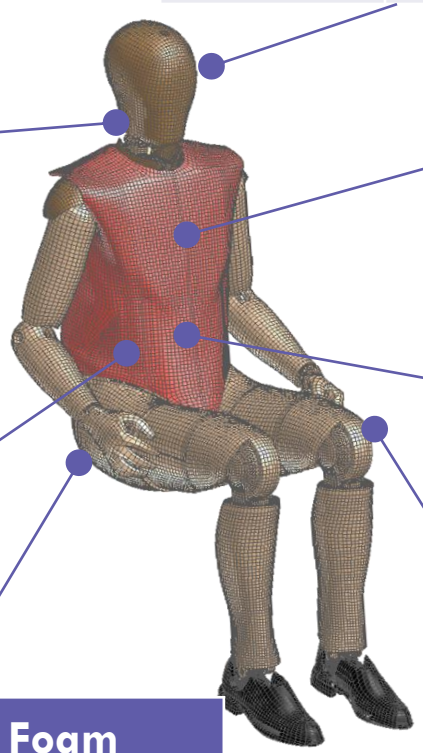




Examples of THOR material testing

Typical Vinyl Skin	
Test types	Strain rate variation
1-D Compression	
1-D Tension	4 strain rates
Relaxation	
Biaxial	
Planar	
Static shear	

Neck Rubber	
Test types	Strain rate variation
1-D Compression	5 strain rates
1-D Tension	5 strain rates
Relaxation	
Biaxial	
Planar	
Torsion	
Static Shear	

Jacket Damping Mat	
Test types	Strain rate variation
1-D Compression	
1-D Tension	3 strain rates
Relaxation	
Biaxial	
Static shear	



Typical Fabric	
Test types	Strain rate variation
1-D Tension	2 strain rates

Lumbar Rubber	
Test types	Strain rate variation
1-D Compression	
1-D Tension	4 strain rates
Relaxation	
Biaxial	
Planar	
Torsion	
Static shear	

Knee Bumper	
Test types	Strain rate variation
1-D Compression	
1-D Tension	2 strain rates
Relaxation	
Biaxial	
Static shear	

Typical Foam	
Test types	Strain rate variation
1-D Compression	5 strain rates
1-D Tension	2 strain rates

THOR Model Road Map

Items		V0.6 – Now	V1.0 ~ Q1 or Q2 2015	V1.5	V2.0
Mesh (Geometry compared to hardware)		All finished			
Mass compared to hardware					
Instrumentation		All instrumentation included			
Robustness testing		All internal tests passed without error and with reasonable kinematics			
Material validation		Partial material validation	Completed for all essential materials		
Model Validation	Certification	Most relevant certification validation at reasonable correlation	All at reasonable correlation and kinematics correct	All at reasonable correlationand kinematics correct	Full suite correlating well to nominal tests
	Sled		First sled tests roughly correlated and kinematics reasonable	Subset of all tests at reasonable correlation	Full suite correlating well
	Component/Assembly	Neck and rib validation	Neck and rib validation	Subset of all tests at reasonable correlation	Full suite correlating well
Customer Feedback			Critical performance feedback should addressed	Critical performance and important usability feedback addressed	All feedback is addressed
Positioning		Pre-sim files included			
Hardware status		Latest SD3 shoulder, ASIS loadcell update, THOR-LX legs included	Molded shoe/iliac wings		

Conclusion

- A new Hybrid III 50th model v1.0 has been developed that represents the exact harmonized hardware as being produced by Humanetics
- Soft and stiff chest models have been developed that represent the borderline hardware
  - Identify performance variability in sled tests coming from dummy chest
  - Provide a customized chest model for evaluation
- The existing H III 5th model is being updated to match new requirements of EuroNCAP.
- Q10 Child model version 1.3 is released
  - Focus: material model development
  - Next steps in progress to release a side kit model.
- A first version THOR DYNA v0.6 model has been released.

Thank you for your attention!

Do you have questions?