Finite Element Models for European Testing:
Side Impact Barrier to WG13
Pedestrian Impactors to WG17

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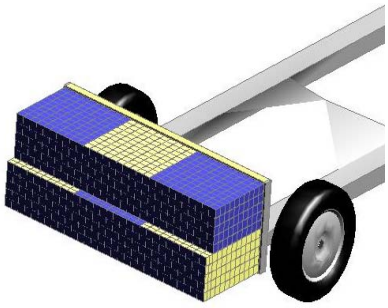
Side Impact Barrier to WG13

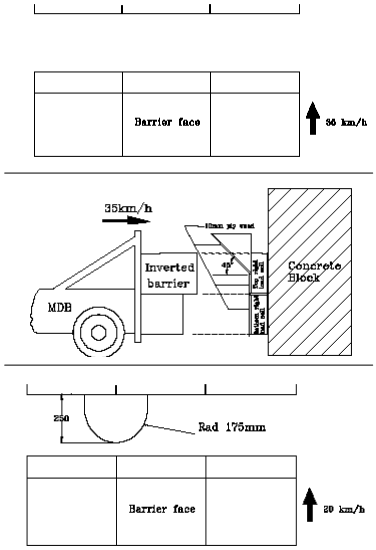
EEVC WG13 Revised Side Impact Barrier Specification - key points

- Revised Specification to improve consistency, repeatability and reproducibility
- Dynamic corridors unchanged
- Each block is a single continuous piece of honeycomb with progressively modified crush properties (multi-block or tapered honeycomb, foams, etc. no longer to be used)
- Higher spec glue & cladding properties to prevent failure
- Addition of a ventilation device



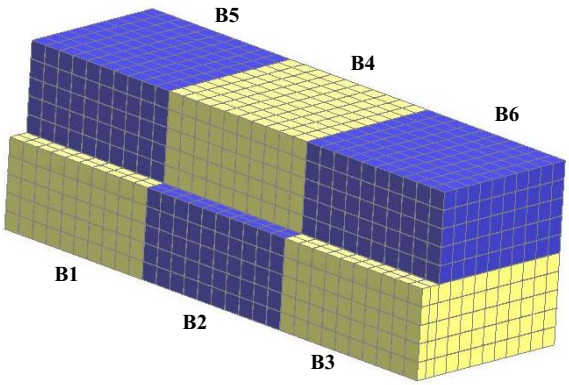
WG13 - Evaluation Tests

- Three tests used for evaluation:
  - Flat rigid load cell wall (35 km/h)
  - Rigid sill (35 km/h)
  - Offset pole (20 km/h)
- Results of these tests were used to validate the new LS-DYNA model



LS-DYNA Model Description

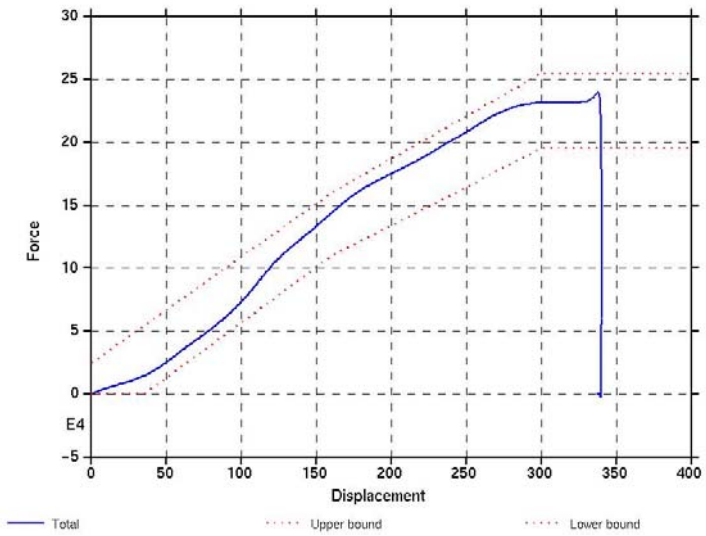
- Model uses blocks of 2x2 solid elements linked by type 6 beams to allow piercing - this method has been used successfully in other barriers for a number of years
- Total Barrier Mass: 0.950t
- Total Number of Elements: 72738
- Deformable Elements: 70790
- Rigid Elements: 1948
- Time Step: 1.02E-6 s



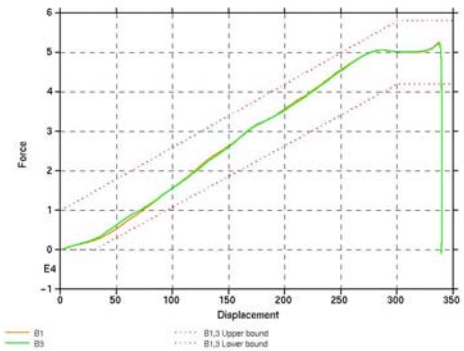
Model Calibration - Rigid Wall (1)

Component	Model	UTAC Target
Complete Barrier	44.94 kJ	45 ±5 kJ
Block 1	9.40 kJ	9.5 ±2 kJ
Block 2	15.15 kJ	15 ±2 kJ
Block 3	9.40 kJ	9.5 ±2 kJ
Block 4	3.86 kJ	4 ±1 kJ
Block 5	3.45 kJ	3.5 ±1 kJ
Block 6	3.45 kJ	3.5 ±1 kJ
Maximum Deformation	340 mm	330 ± 20 mm

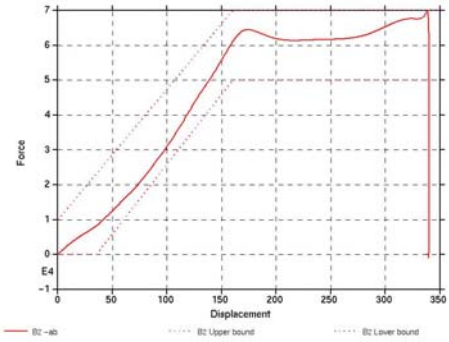
Model Calibration - Rigid Wall (2)



Model Calibration - Rigid Wall (3)

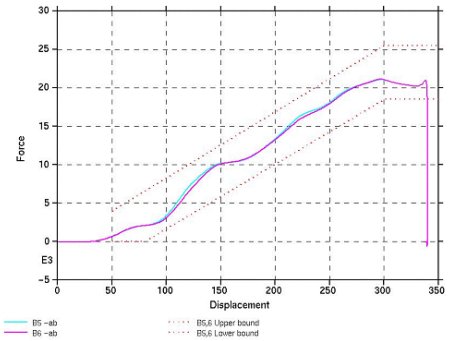


Blocks 1 & 3

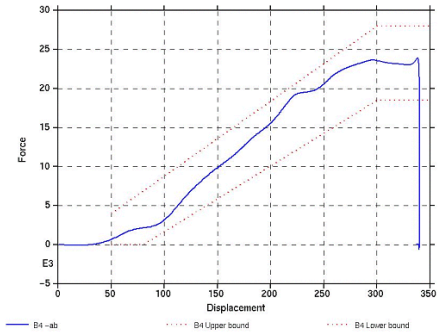


Block 2

Model Calibration - Rigid Wall (4)

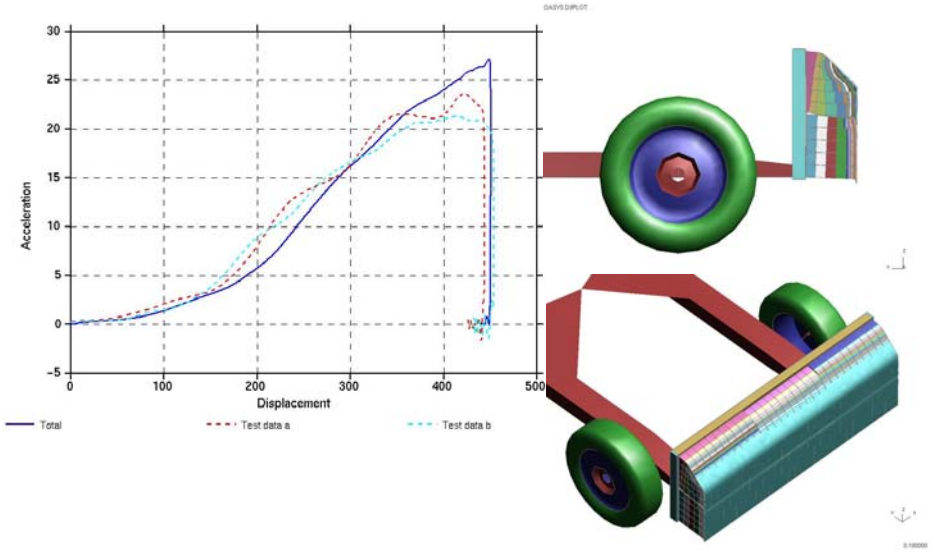


Blocks 5 & 6

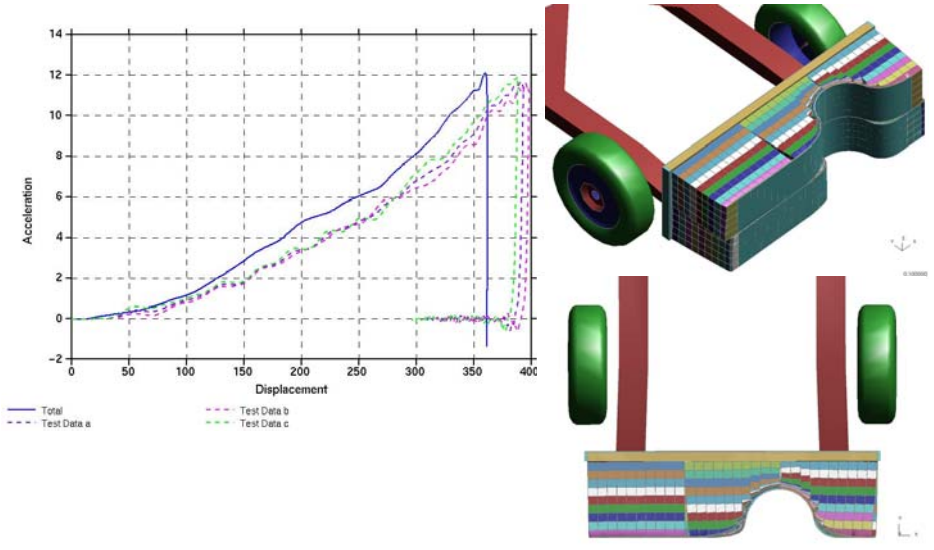


Block 4

Model Calibration - Sill Test



Model Calibration - Offset Pole Test

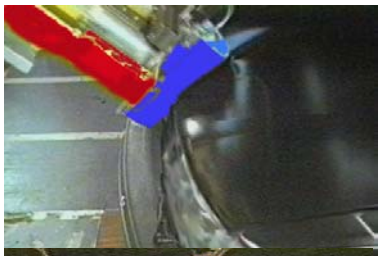


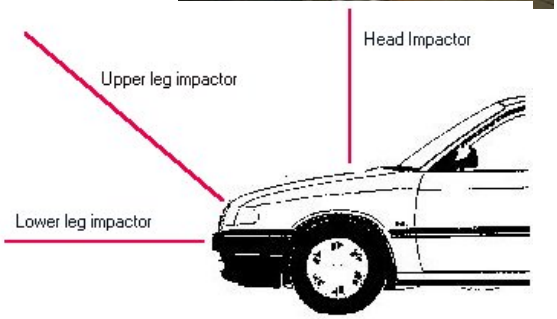
Pedestrian Impactors to WG17

WG17 Pedestrian Protection

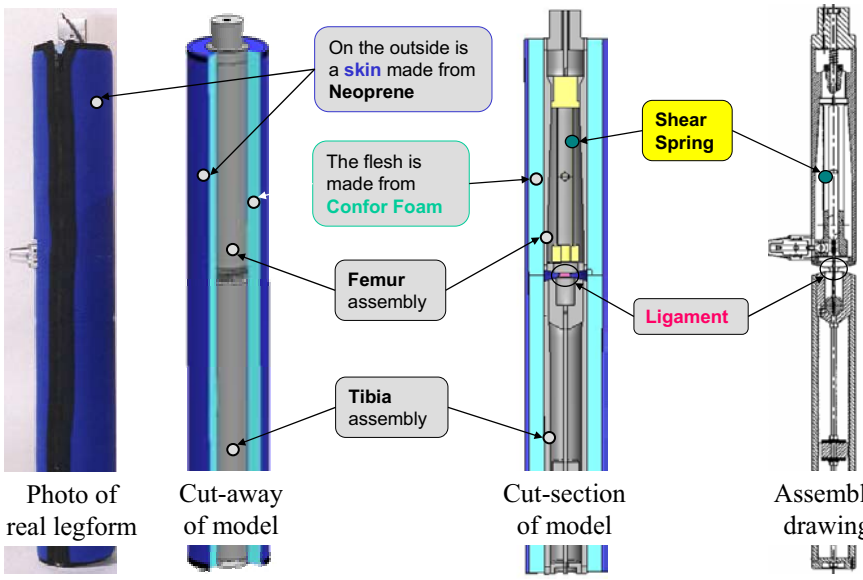
- Reviewed WG10 proposals (1994) and proposed a number of adjustments
- Impactor designs and calibration have been modified, final details agreed in 2002
- EuroNCAP has adopted WG17 methods
- ACEA Part A proposals to apply from July 2005

Sub-system Impactor Concept

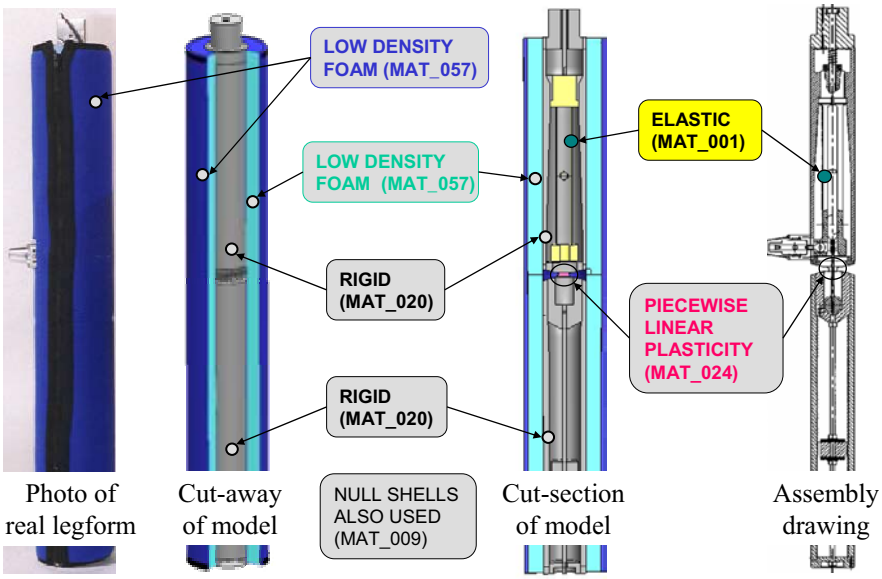




Legform Model - Basic Construction



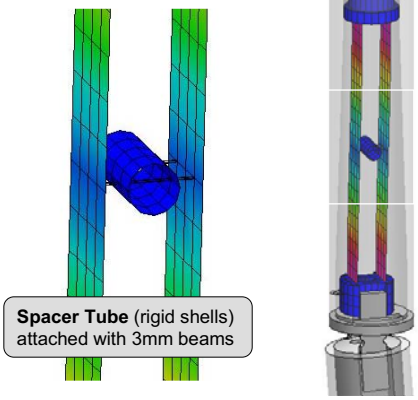
Materials

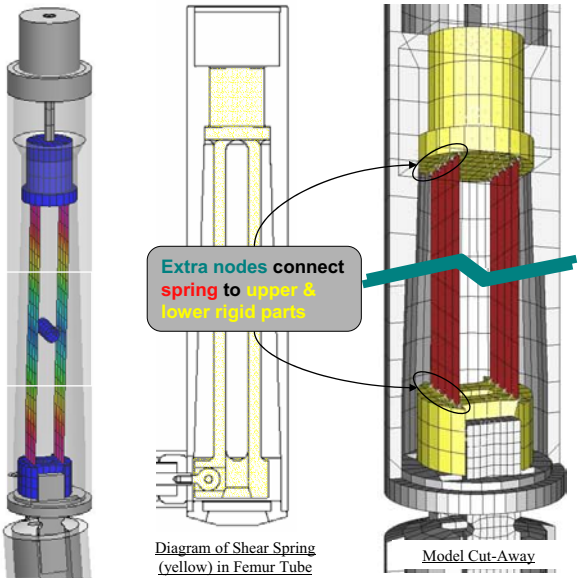


Shear Spring

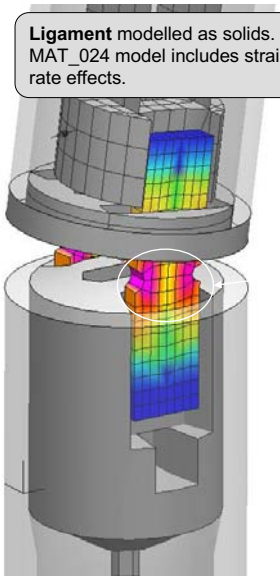
Shear Spring modelled as shells (elastic steel properties)

Solid elements were stiffer than theoretical bending stiffness.

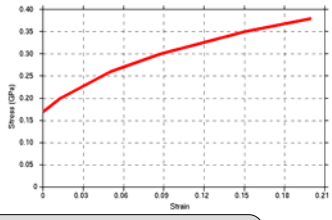




Ligament



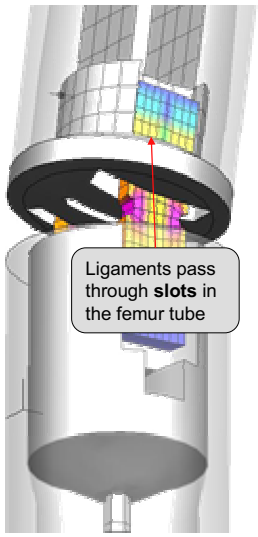
Ligament modelled as solids. MAT_024 model includes strain rate effects.



Small elements are needed for accurate bending stiffness, but they require a small timestep.

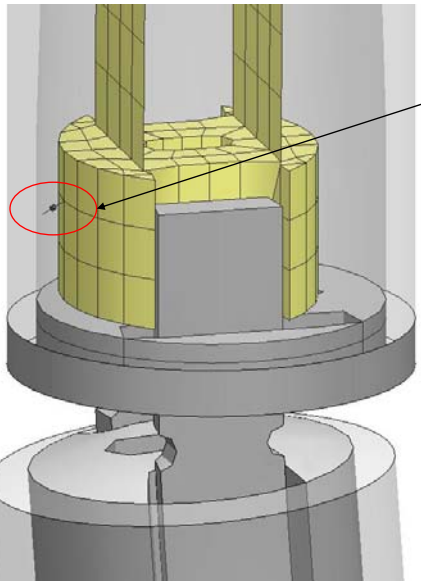
475g mass is added by DYNA (DY2MS mass scaling) to run at a global timestep of 0.9μ s.

! Model mass/inertia has been adjusted to allow for this added mass, so analysis must always run at 0.9μ s !



Ligaments pass through **slots** in the femur tube

Damper



Linear viscous damper added to model (500Ns/m)

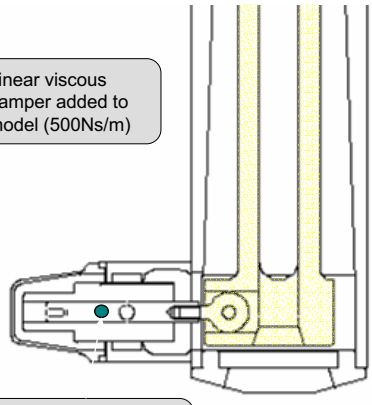
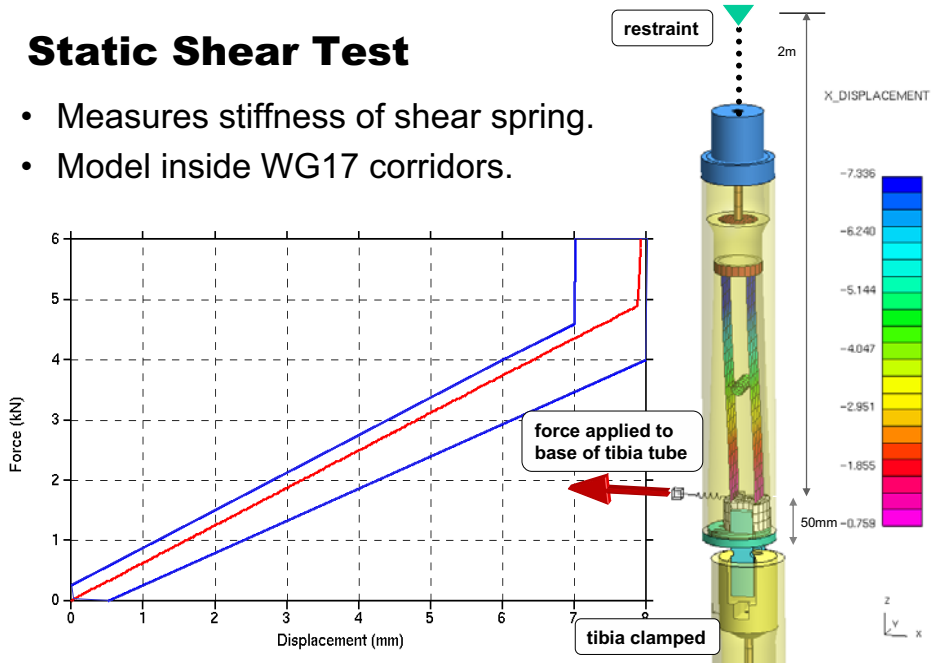


Diagram of real damper mechanism (TRL quote 500Ns/m)

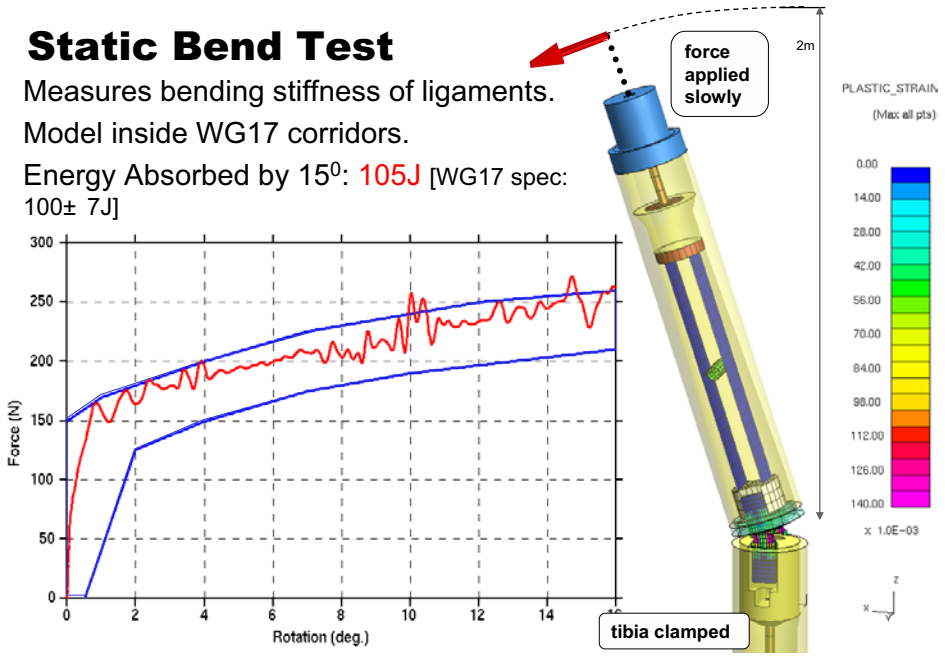
Static Shear Test

- Measures stiffness of shear spring.
- Model inside WG17 corridors.



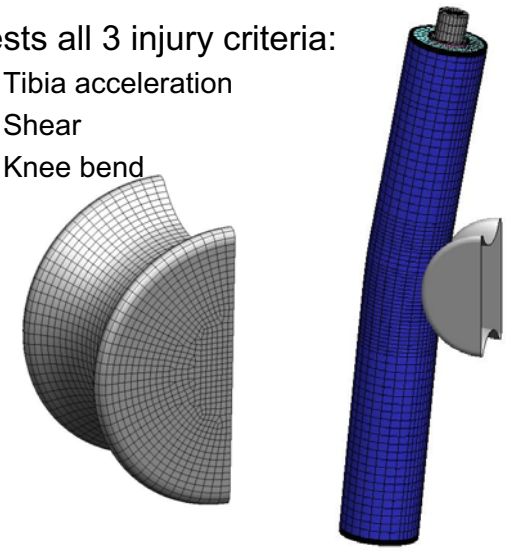
Static Bend Test

- Measures bending stiffness of ligaments.
- Model inside WG17 corridors.
- Energy Absorbed by 15^0: 105J [WG17 spec: 100± 7J]



Dynamic Impactor Test

- Tests all 3 injury criteria:
  1. Tibia acceleration
  2. Shear
  3. Knee bend



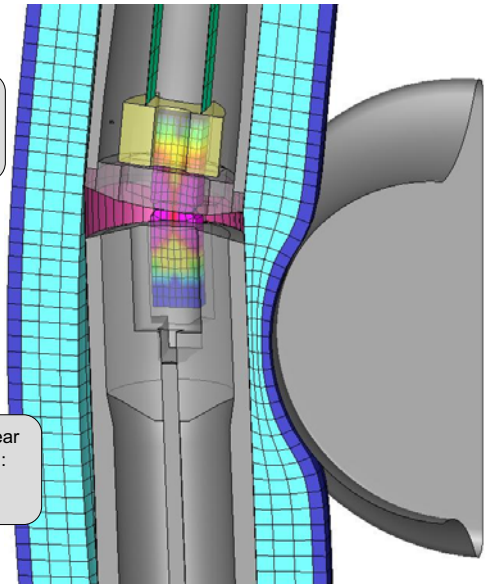
Impactor: rigid, linearly guided 9kg 7.46m/s

Contact friction: 0.1
TRL said their impactor is “smooth”.

31.999502

Dynamic Impactor Test

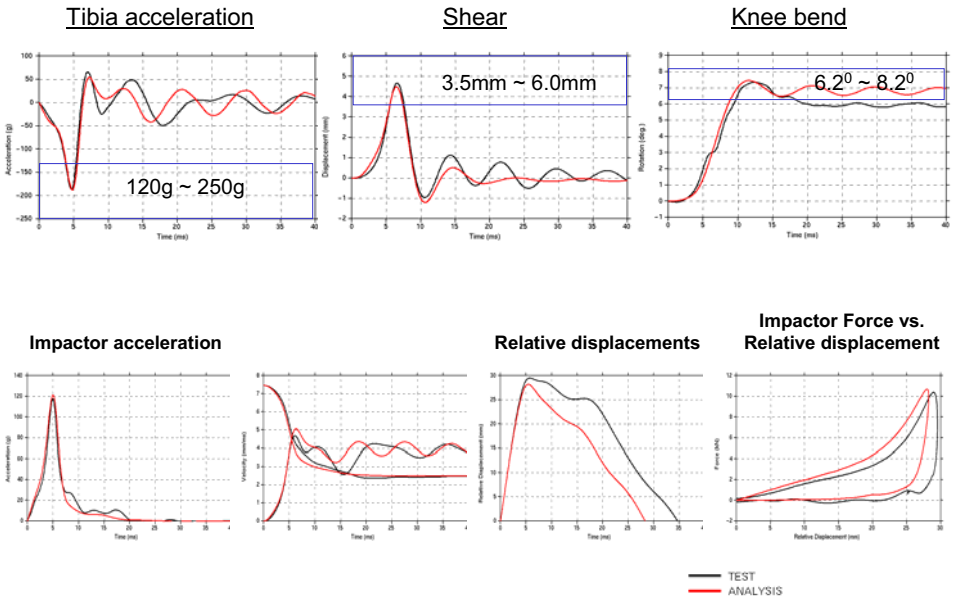
Max accel & shear occurs at ~6ms



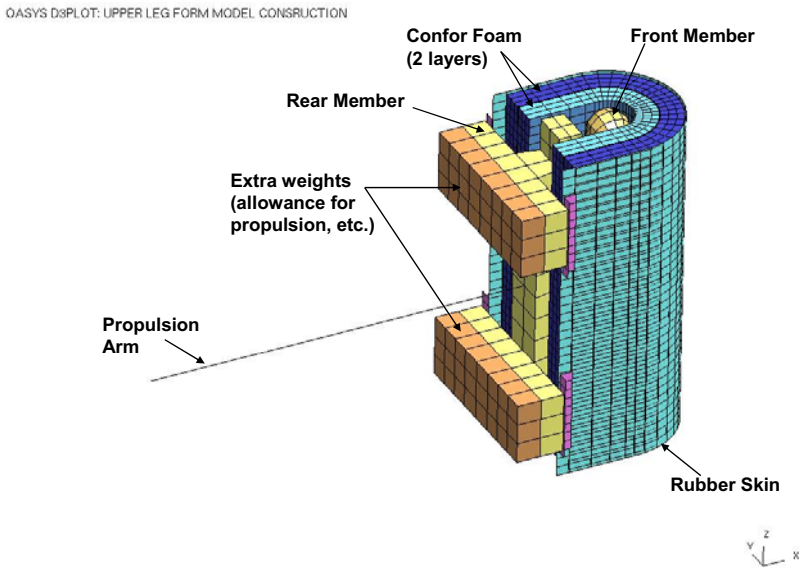
Force to generate shear is dependent on:
1. Force into tibia
2. Mass of femur

10ms

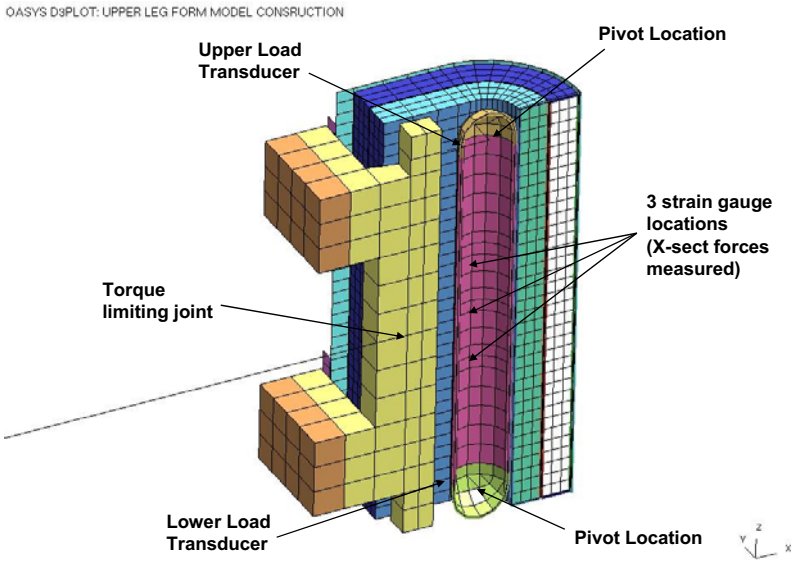
WG17 Calibration – Dynamic Results



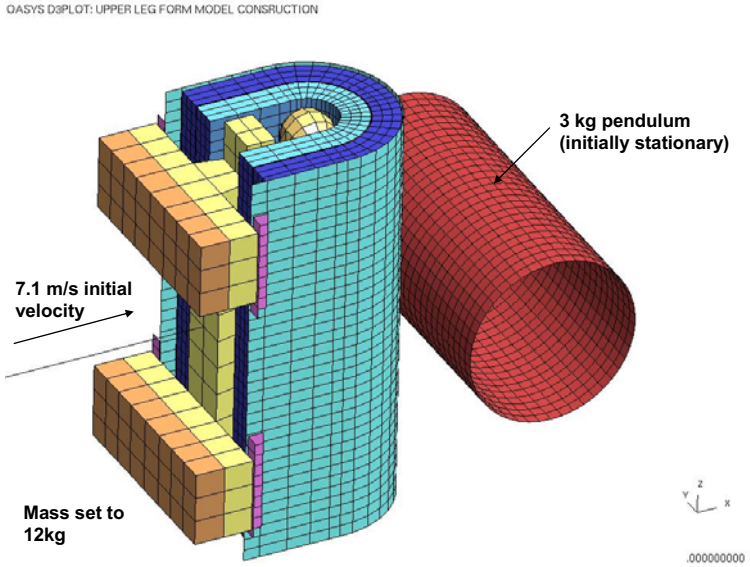
Upper Legform - Basic Construction



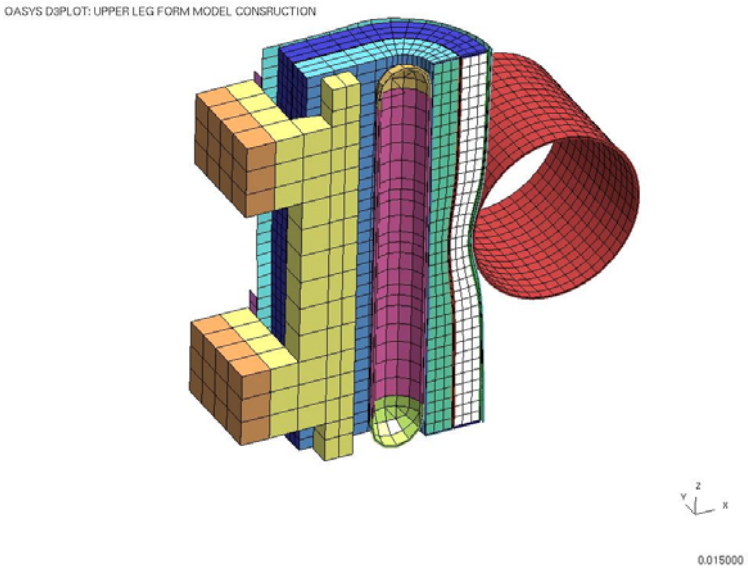
Upper Legform - Basic Construction



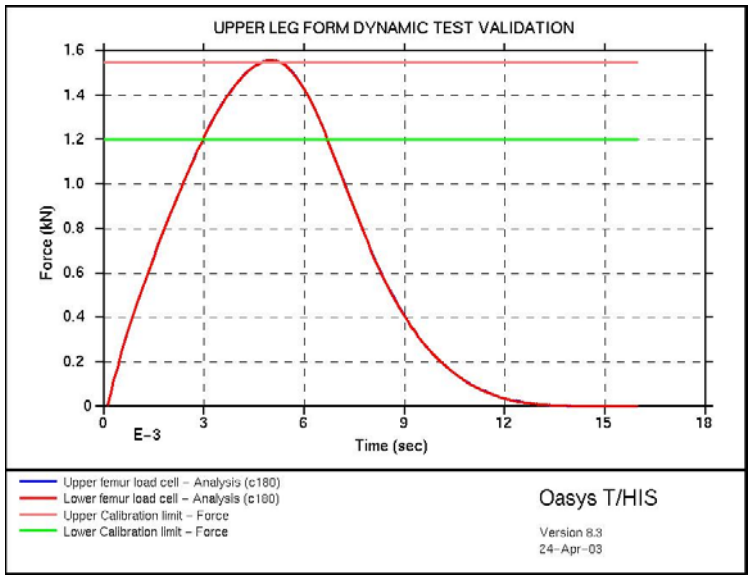
Dynamic Impactor Test



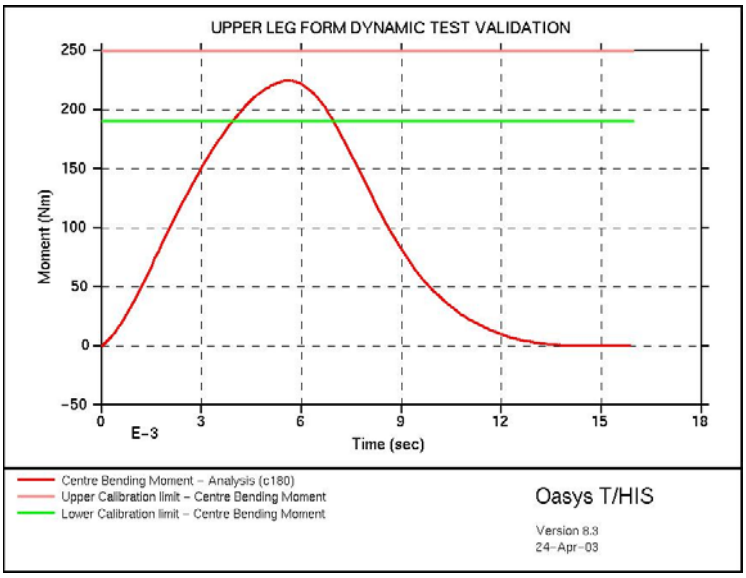
Dynamic Impactor Test



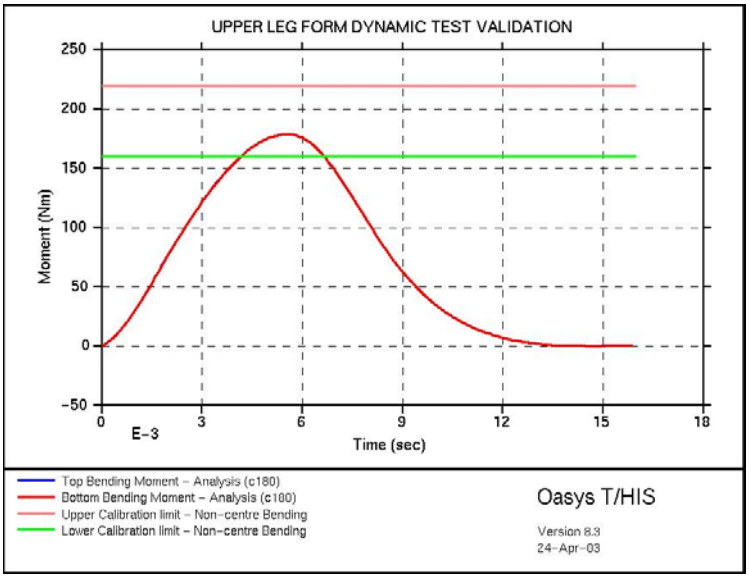
Dynamic Impactor Test - Load Cell Force



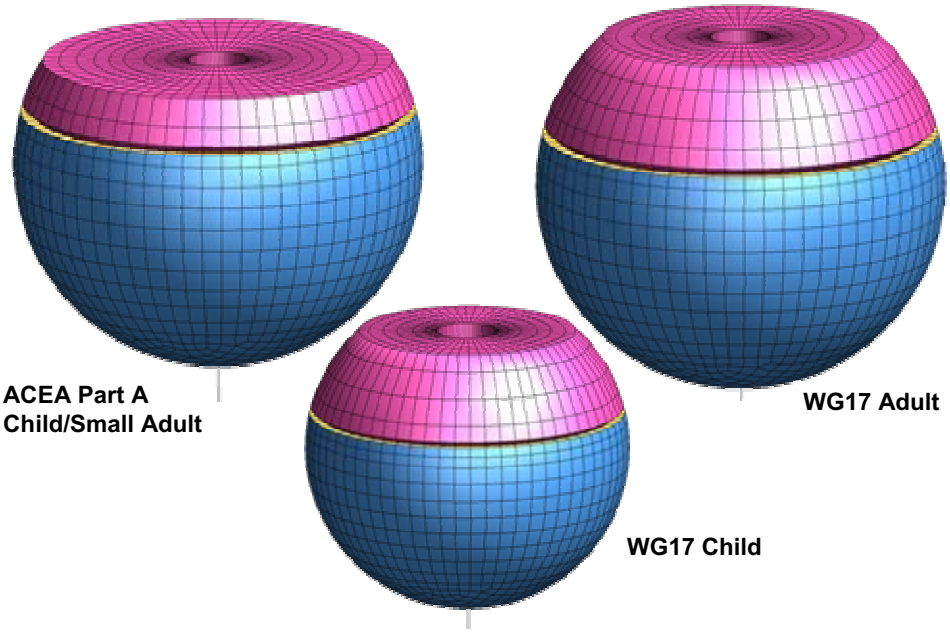
Dynamic Impactor Test - Moments



Dynamic Impactor Test - Moments



Headform Models - Basic Description

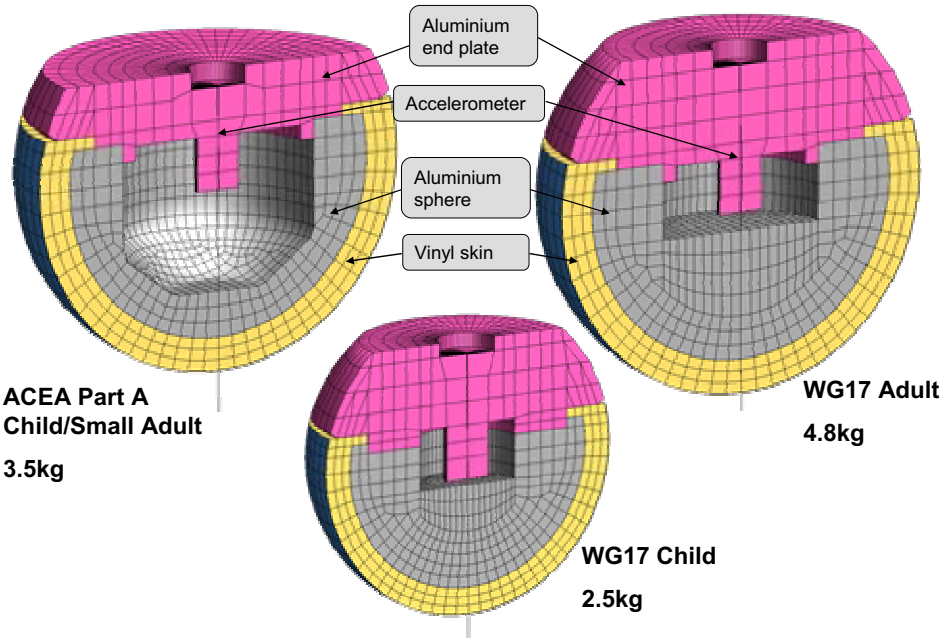


ACEA Part A
Child/Small Adult

WG17 Adult

WG17 Child

Headform Models - Basic Description

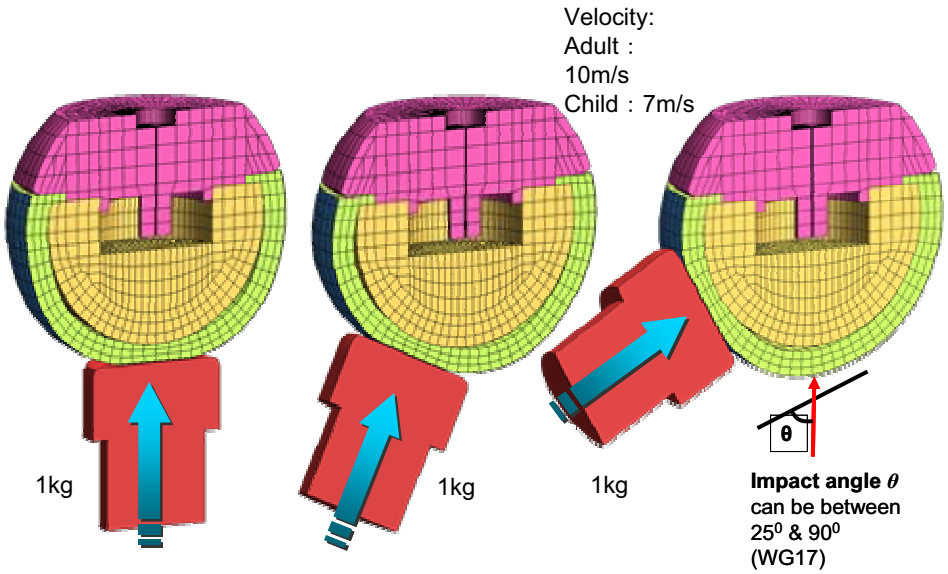


ACEA Part A
Child/Small Adult
3.5kg

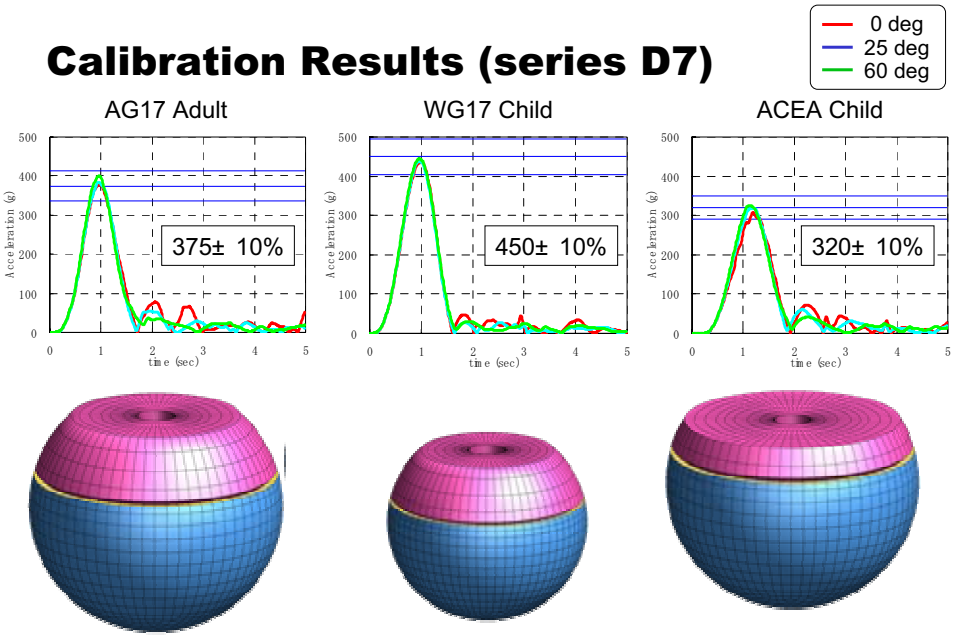
WG17 Adult
4.8kg

WG17 Child
2.5kg

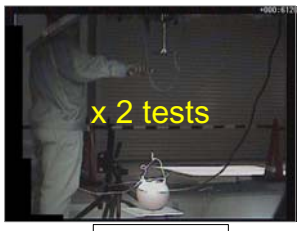
WG17 Calibration – 3 Angles



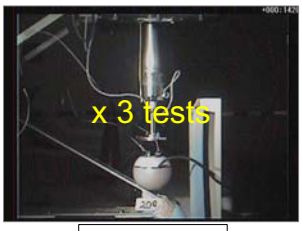
Calibration Results (series D7)



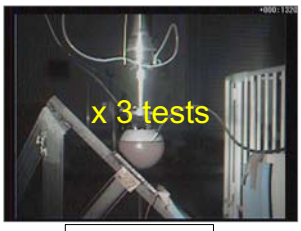
Rigid Plate Drop Tests (WG17 models only)



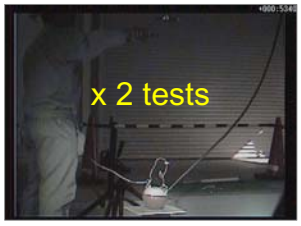
Adult 0deg



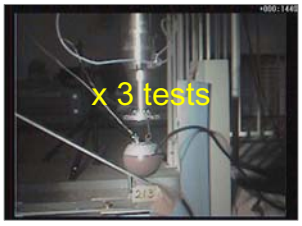
Adult 30deg



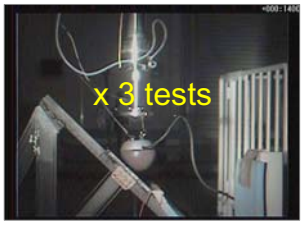
Adult 45deg



Child 0deg



Child 30deg



Child 45deg

Rigid Plate Drop Test Matrix

- 16 cases: 8 adult, 8 child
- 2 each @ 90deg – hi velocity, lo velocity
- 3 each @ 30deg – hi velocity, lo velocity, on paper
- 3 each @ 45deg – hi velocity, lo velocity, on paper

Key to graphs on next slide

	0 degree	hi vel	lo vel	paper	Number in each box is velocity in mm/s
adult	3661	4706	4206	4831	30 degree
	2531	5217	4444	5281	45 degree
child	3125	4928	3333	4850	30 degree
	2339	5344	4097	4989	45 degree

Series D7 Acceleration Vector