Development of Advanced Finite Element Models of Q Child Crash Test Dummies

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- ► (Car) industry requirements for dummy models
- ► Highlights recent Q6 model development
- ► Q child model validation
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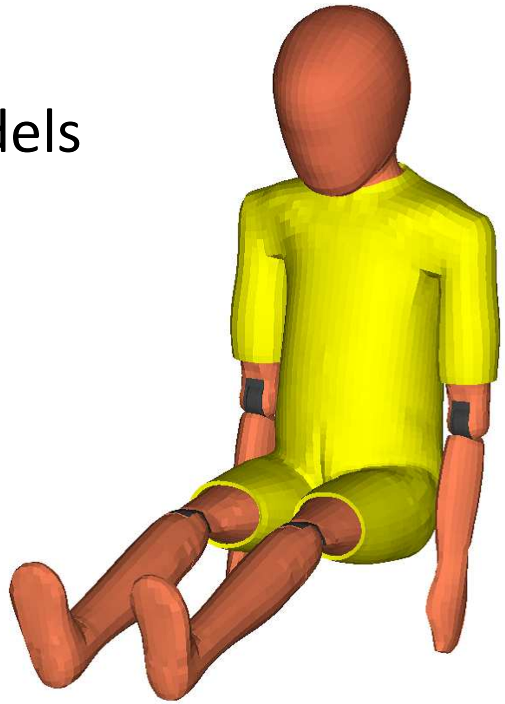

COMPUTER-AIDED ENGINEERING AND Q MODEL DEVELOPMENT

Child Safety and CAE

General CAE benefits

- ► Early and better analysis of design problems
- ► Optimization to solve design problem
- ► Shorten design time and reduce costs

Current bottlenecks for broad use of CAE in child safety domain

- ► Physical testing costs are relatively low
- ► No urgent need for OEM’s
- ► Availability of quality models:
  Child dummies, child restraint system, test procedures
- ► Limited experience at CRS industry

Child Safety and CAE

Expected developments

- ► Introduction of Q dummies increases testing costs
- ► Meeting future requirements is getting harder
- ► Euro NCAP is likely promoting older children
  - – Car restraint system is getting more important for child safety rating

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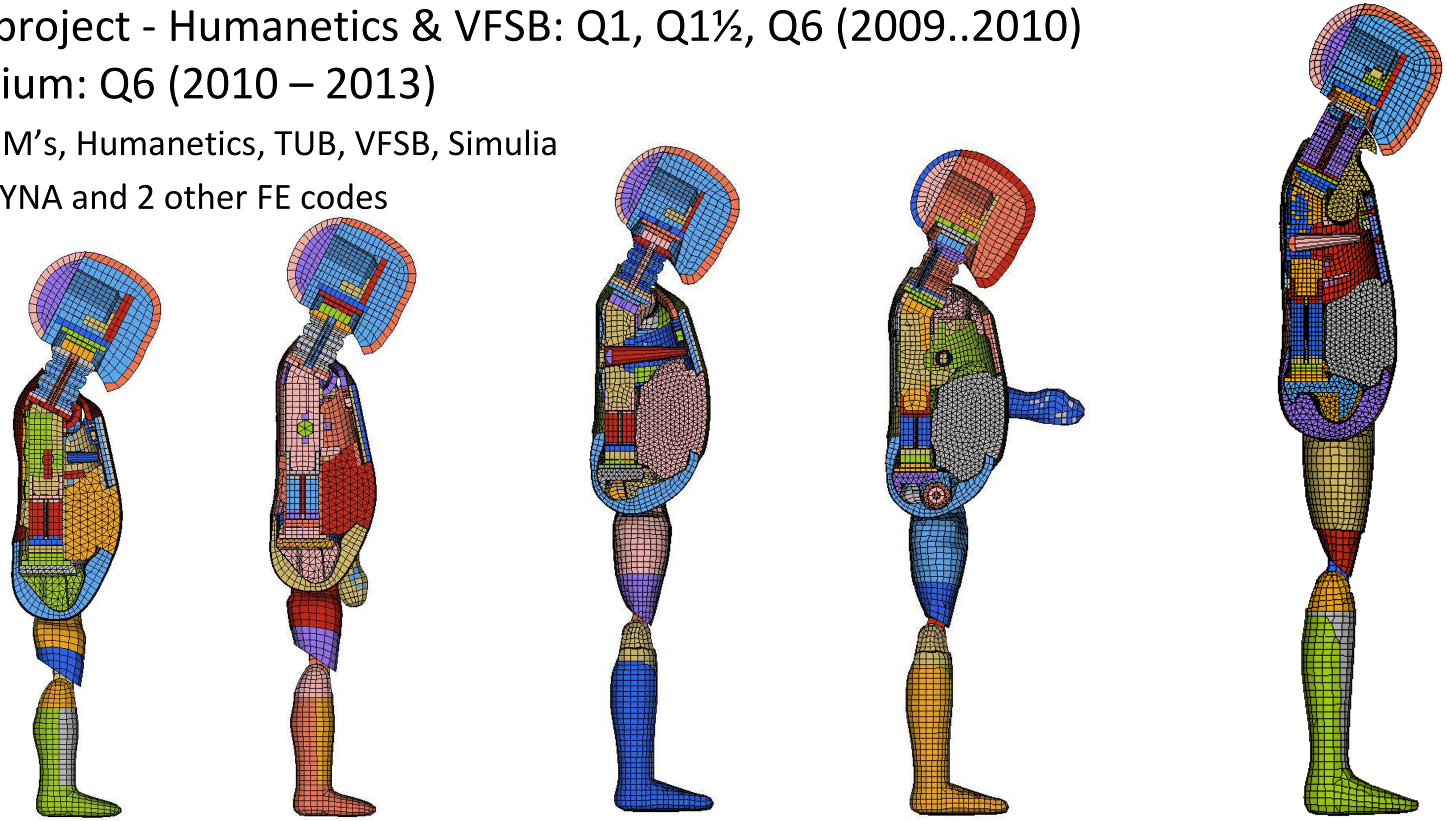
Child Safety and CAE

Q Modeling projects

- ► TUB: Q0 (2002...2006)
- ► Humanetics in-house: Q3, Q3s (2006..2007)
- ► Casper project - Humanetics & VFSB: Q1, Q1½, Q6 (2009..2010)
  Consortium: Q6 (2010 – 2013)
  - – 7 OEM's, Humanetics, TUB, VFSB, Simulia
  - – LS-DYNA and 2 other FE codes



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From left to right: Q1, Q1.5, Q3, Q3s, Q6

CAR INDUSTRY REQUIREMENTS FOR DUMMY MODELS

Car industry requirements

General:

- Harmonisation of hardware (Denton and FTSS)
- Models must represent the latest hardware
- Correct implementation of the hardware
  - Geometry, mass and inertia
  - Correct material properties
  - Implementation of all sensors
- Close collaboration between manufacturer of hardware and developer of models
  - Knowledge about the manufacturing process

Source: *Dr. -Ing. Christian Gehre*
Partnership for dummy technology and biomechanics
Automotive CAE Grand Challenge 2009

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Car industry requirements

Technical:

- Time step of approx. 1 microsecond (dummies) without mass scaling
  - No need to use highly detailed models in general
- Same geometry, mesh, joint angles for all codes (if possible)
- Numerically robust
- High level of predictability
- Detailed report of the validation process

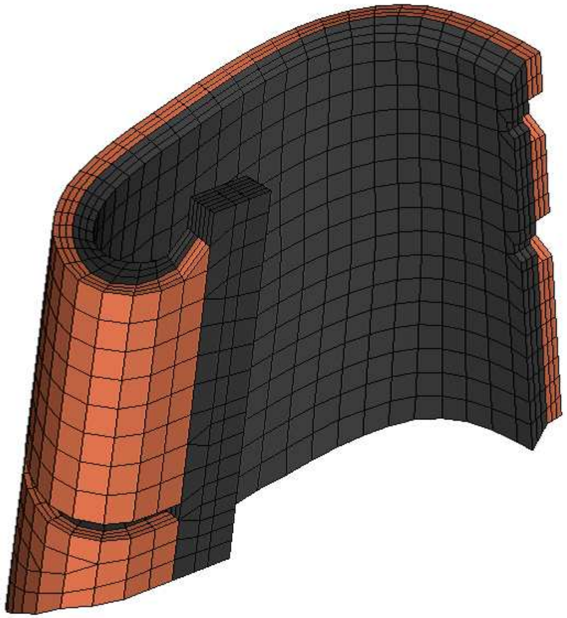
Support:

- Quick response time
- Regular updates and improvements

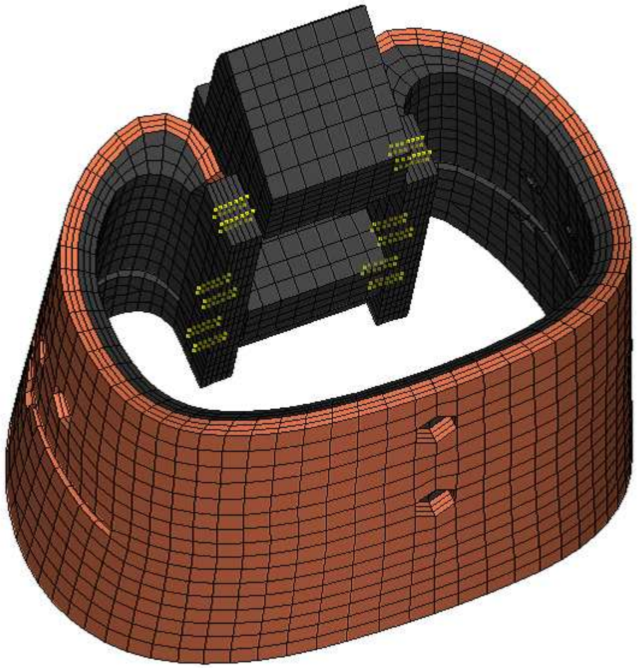
Source: Dr. -Ing. Christian Gehre
Partnership for dummy technology and biomechanics
Automotive CAE Grand Challenge 2009

HIGHLIGHTS RECENT Q6 MODEL DEVELOPMENT

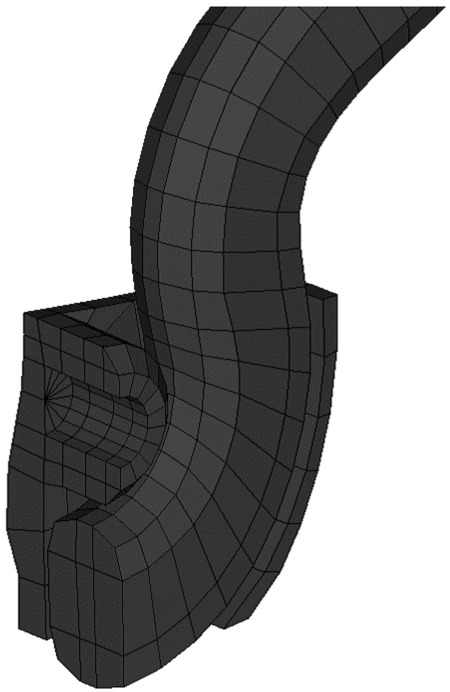
Q6 Model Development



Rib cage molding and skin:
Three layers of solid elements



Constraints between thoracic spine box
and rib cage at screw location



Detailed mesh of clavicle
and clavicle retainer to capture
contacts

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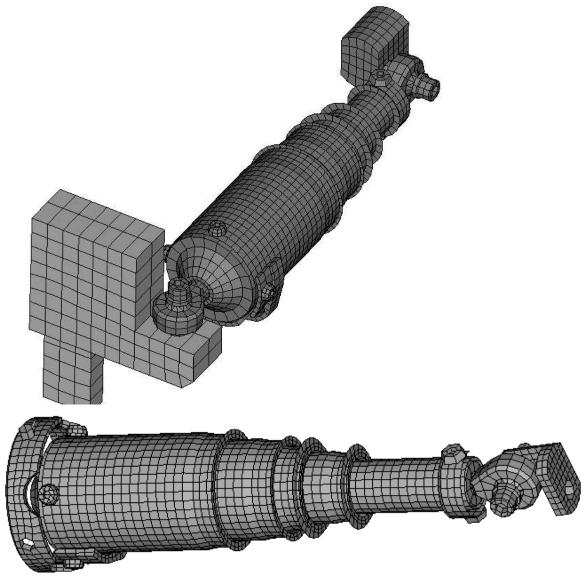
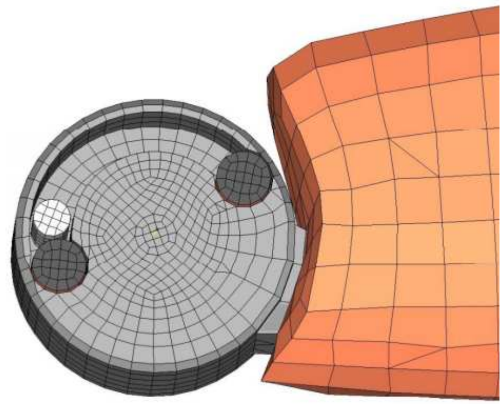
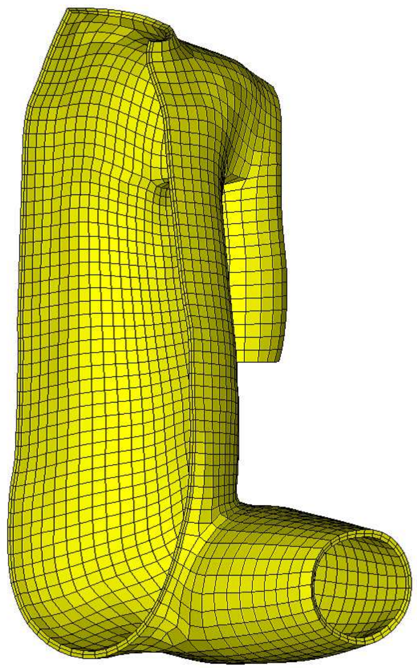
Q6 Model Development



Front and Lateral IR-TRACC

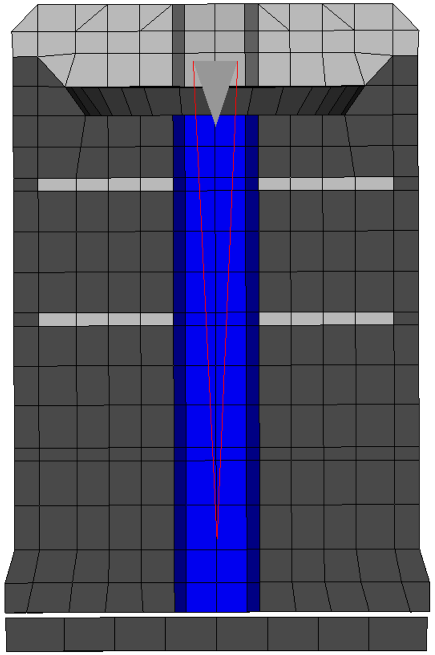


Contact of rigid pin and rubber stops to define the lower arm joint stop angles

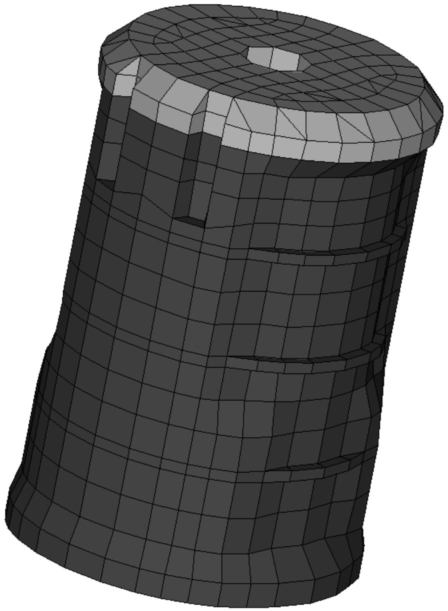


Continuous jacket mesh
Two layers of solid elements.

Q6 Model Development



V shape neck cable



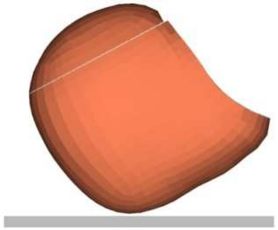
Recent Q6 hardware change:

Neck cavities filled with rubber
to improve bonding area

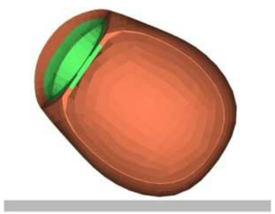
Q CHILD MODEL VALIDATION

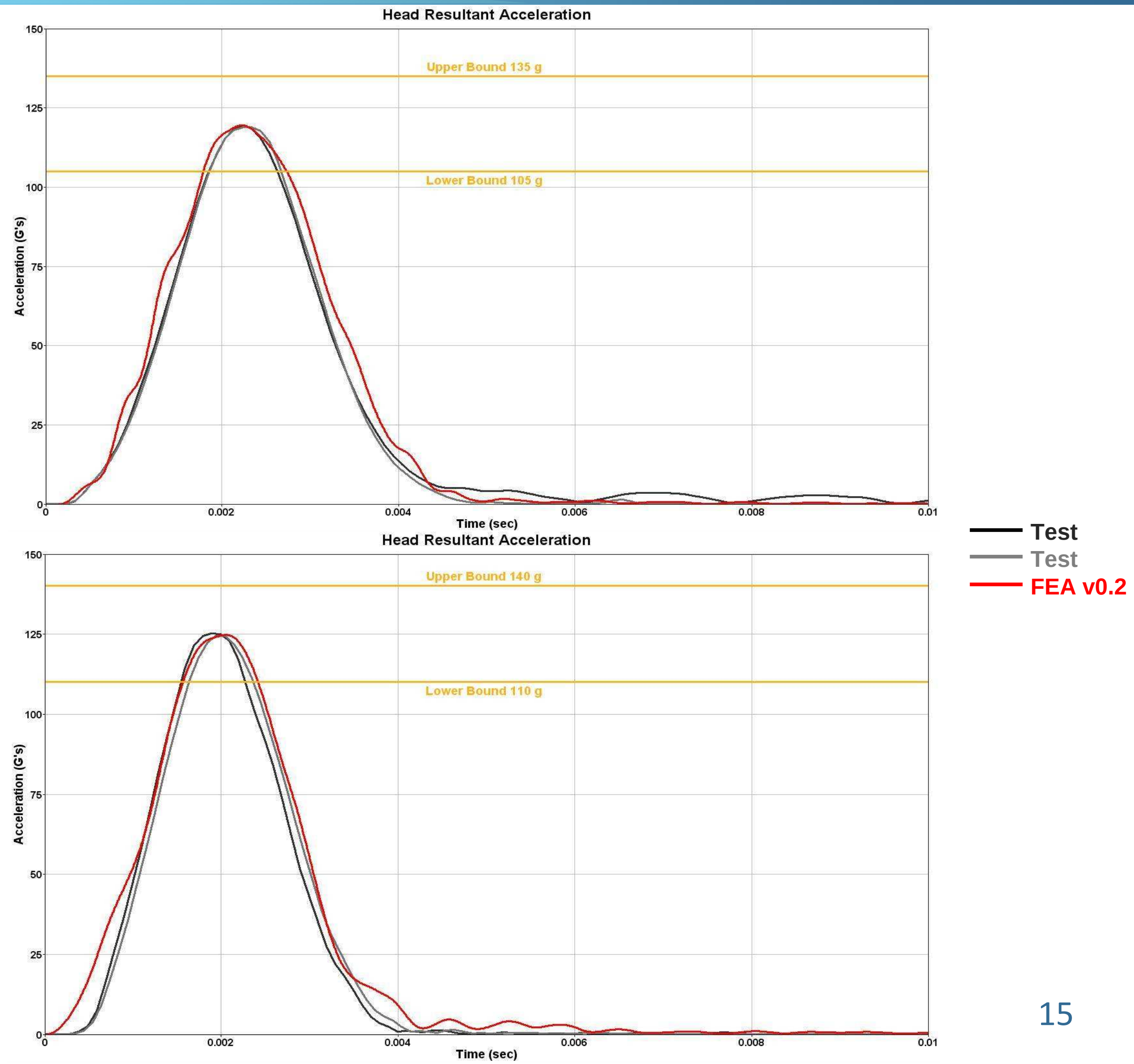
Head – Q6

Frontal



Lateral





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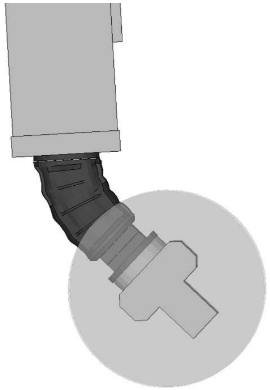
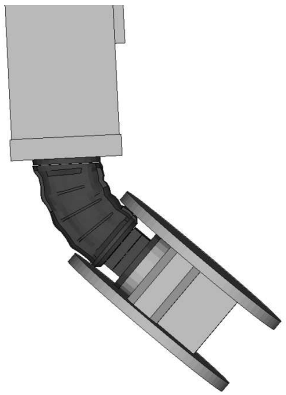
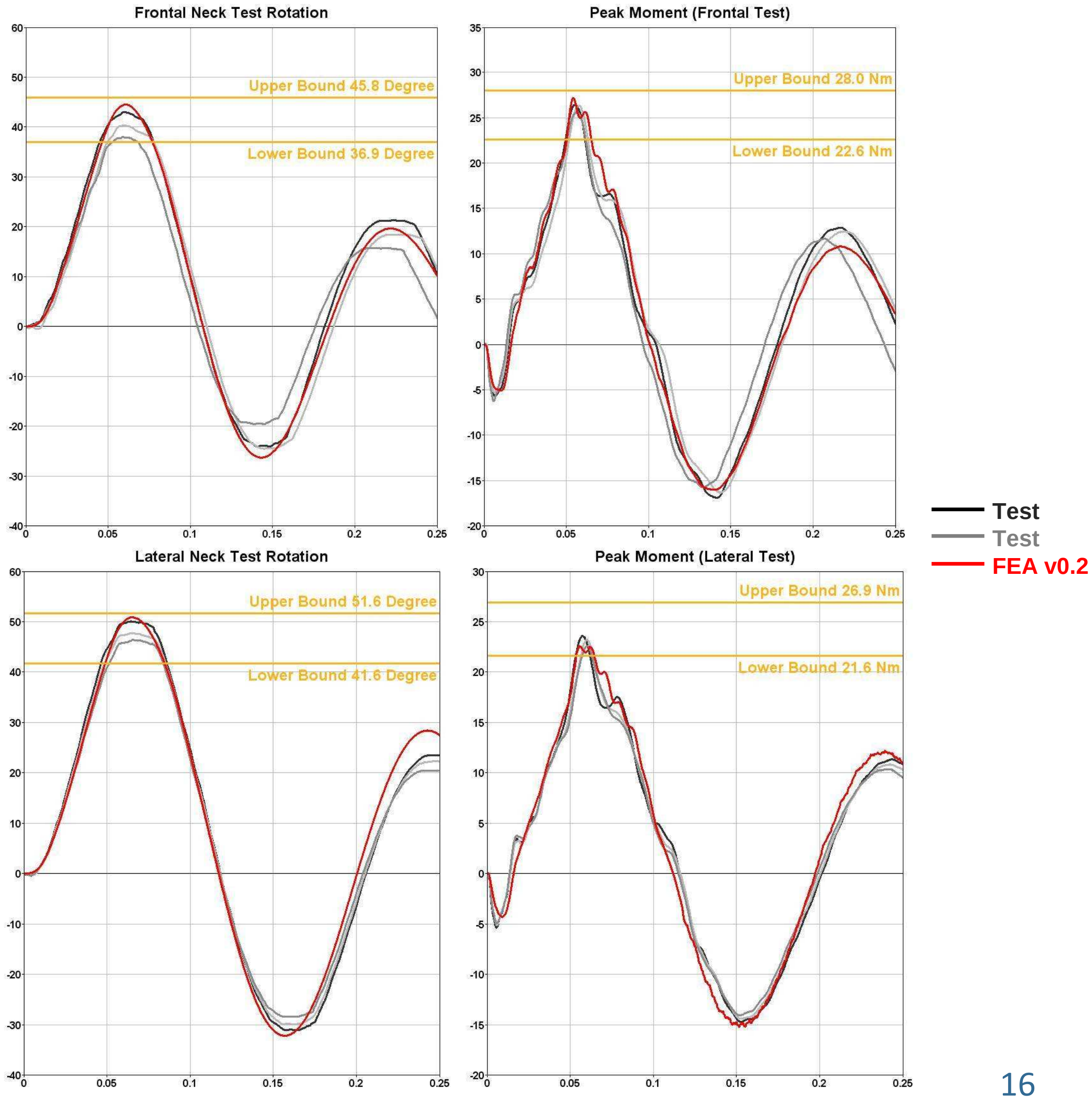
Neck - Q6

Frontal



Lateral





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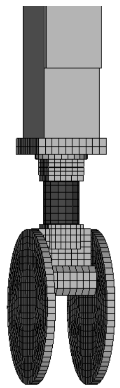
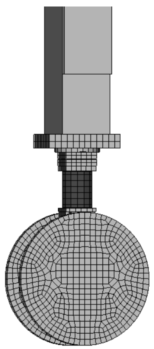
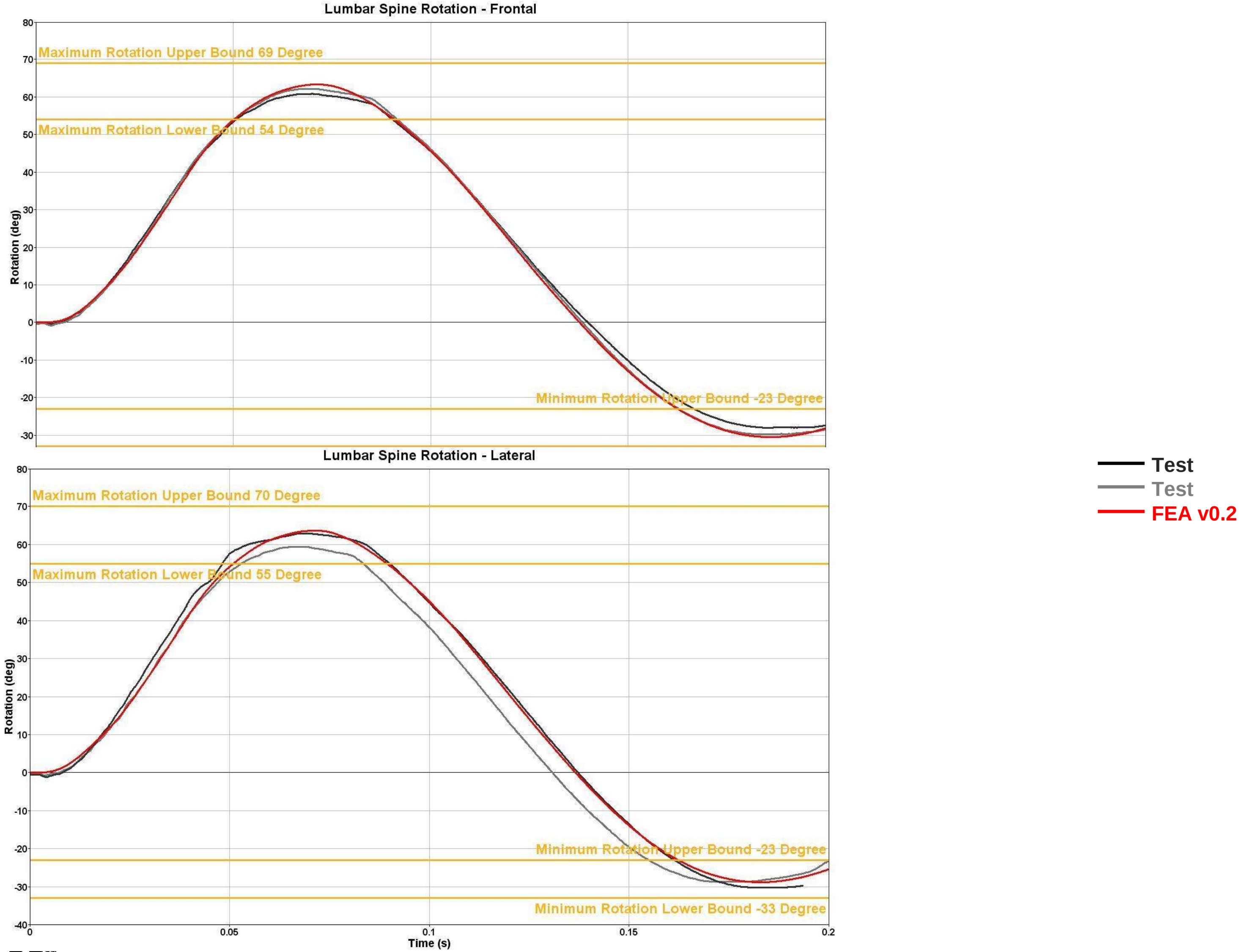
Lumbar Spine - Q 6

Frontal



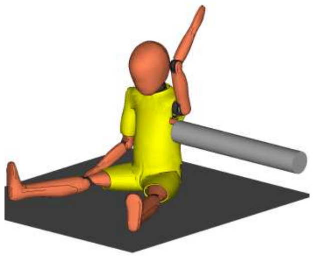
Lateral

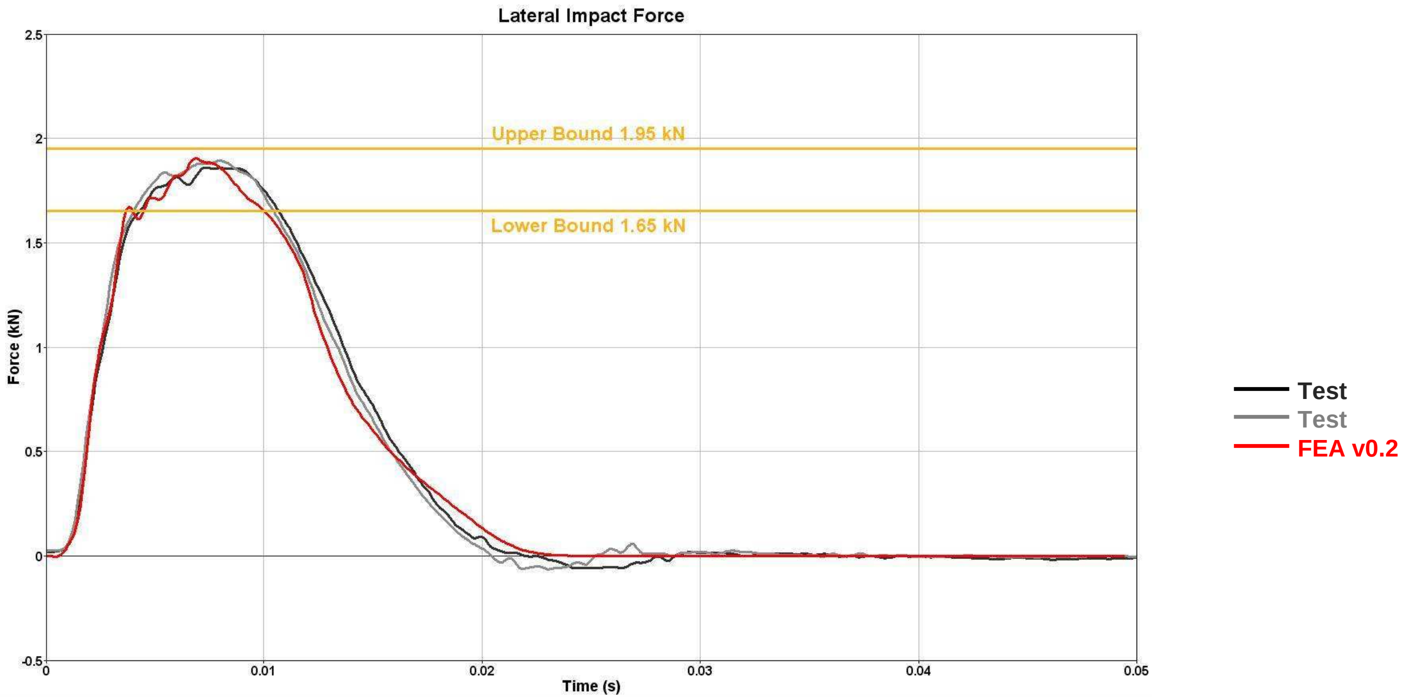




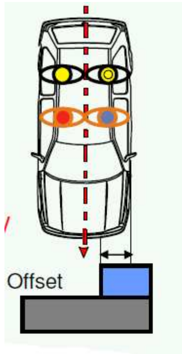
Full certification - Q 6

Lateral

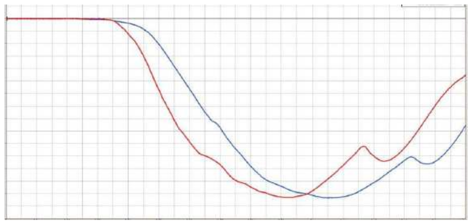




Design of Q6 Frontal sled test

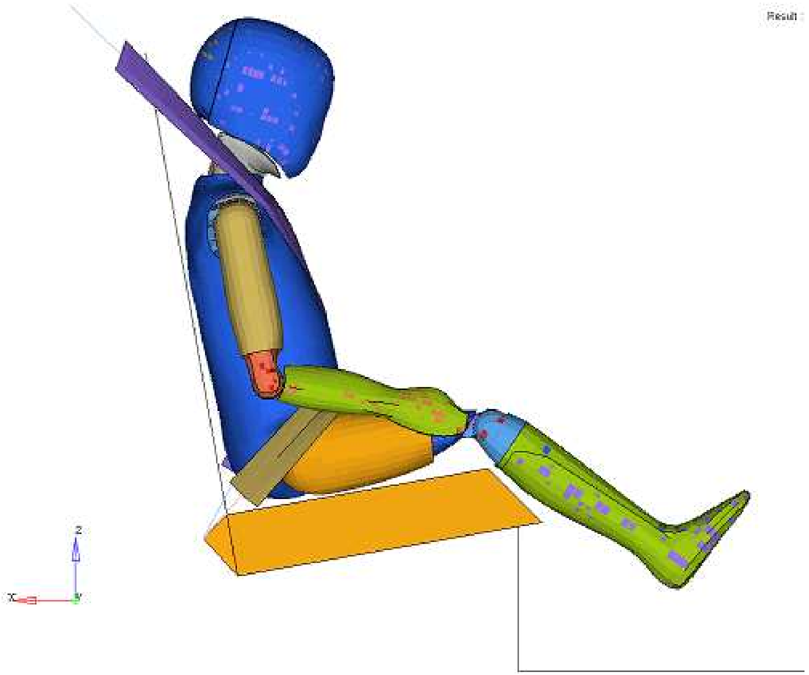


Target data



Courtesy of
Adam Opel GmbH

Pre simulation of validation test



Current Q6 consortium task

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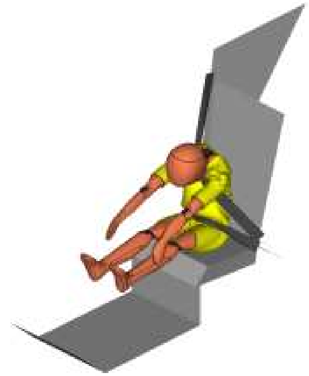
Design of Q6 Frontal sled test

Time=0ms

Time=40ms



Time=80ms

Time=100ms

Time=120ms

Time=140ms

SUMMARY

Summary

- For the introduction of CAE methods in the development process high quality Q Child Dummy Models are necessary
- LS-DYNA models of the Q1, Q1½, Q3, Q3s and Q6 have been developed
  - Models are validated on material, component and full leg form level for several loading conditions
- Q6 models are being further developed and extensively validated in a 3-year consortium project to develop CAE and hardware related knowledge and target fully reliable simulation.
- Humanetics LS-DYNA Models are supported and can be made available by Alyotech, DYNAmore, ERAB and ARUP

THANKS!