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Innovation Intelligence®

Aircraft Seating Design, Analysis, and Optimization

Bob Yancey, Sr. Director Global Aerospace and Marine

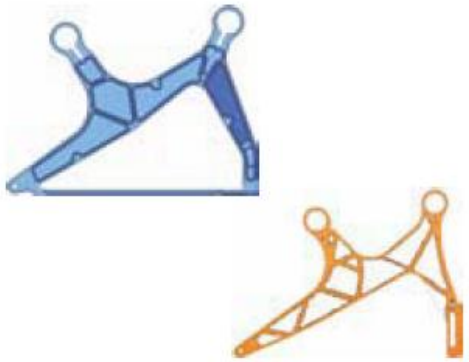
September, 2012

Industry Poll at the 2009 Aircraft Interiors Expo:

“The Drive to reduce weight across all elements of the cabin interior has never been stronger. Have we reached the limits of what currently can be achieved?

80% of the Industry disagrees!

Airplane Seating Key Technologies

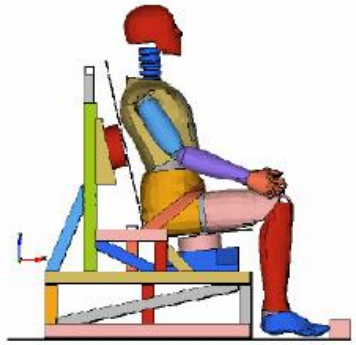


Design Optimization

Numerical Optimization Technology

Optimization Centers

Composites

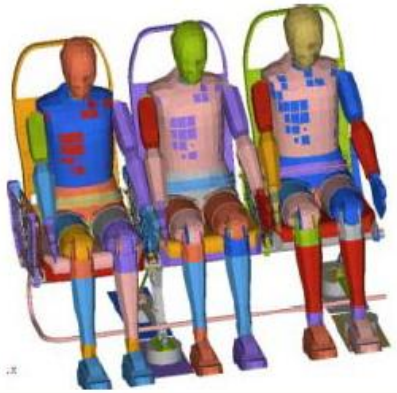


Design Efficiency

Rapid CAE Model Development

Integrated Desktop

Process Automation



Occupant Simulation

Methods Development

Dummy Model Development

Injury Criteria

Design Optimization

Driving Design towards a lighter solution

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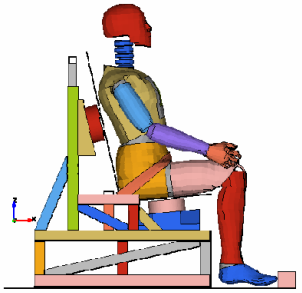
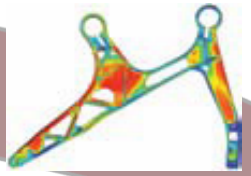
Concept
Design space

Realization of
Dynamic forces

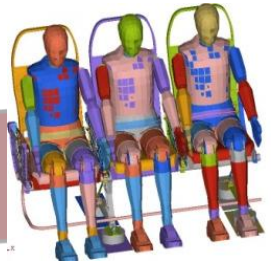


Topology Optimization

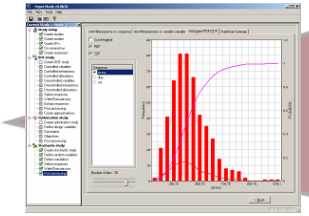


Size and Shape
Optimization

Validation of the new
design



Realibilty Test
Enhancement

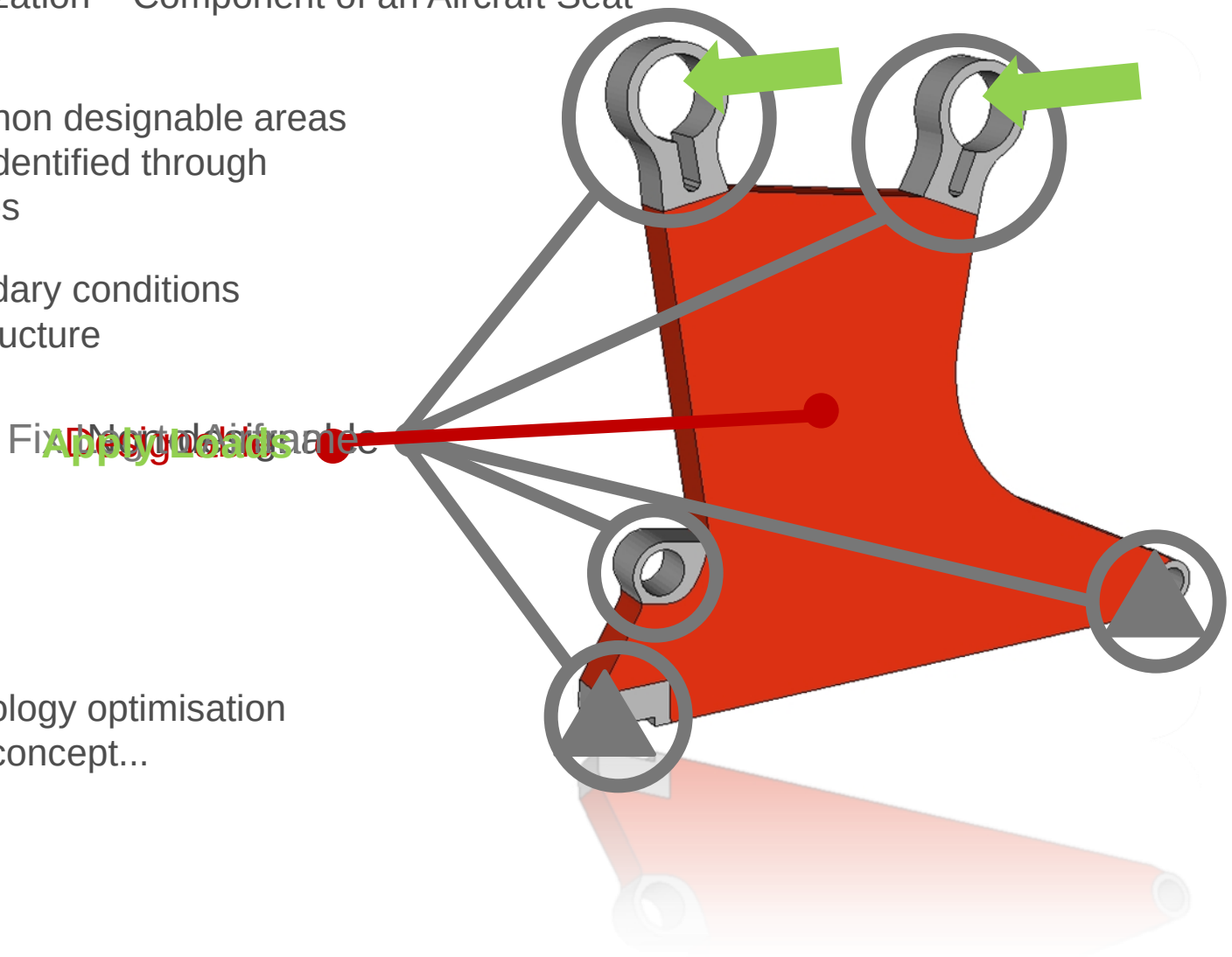


CAE Driven ProductDesign

Topology Optimization – Component of an Aircraft Seat

Designable and non designable areas of the structure identified through packaging studies

Loads and boundary conditions applied to the structure



Lets see the topology optimisation iterate to a new concept...

CAE Driven ProductDesign

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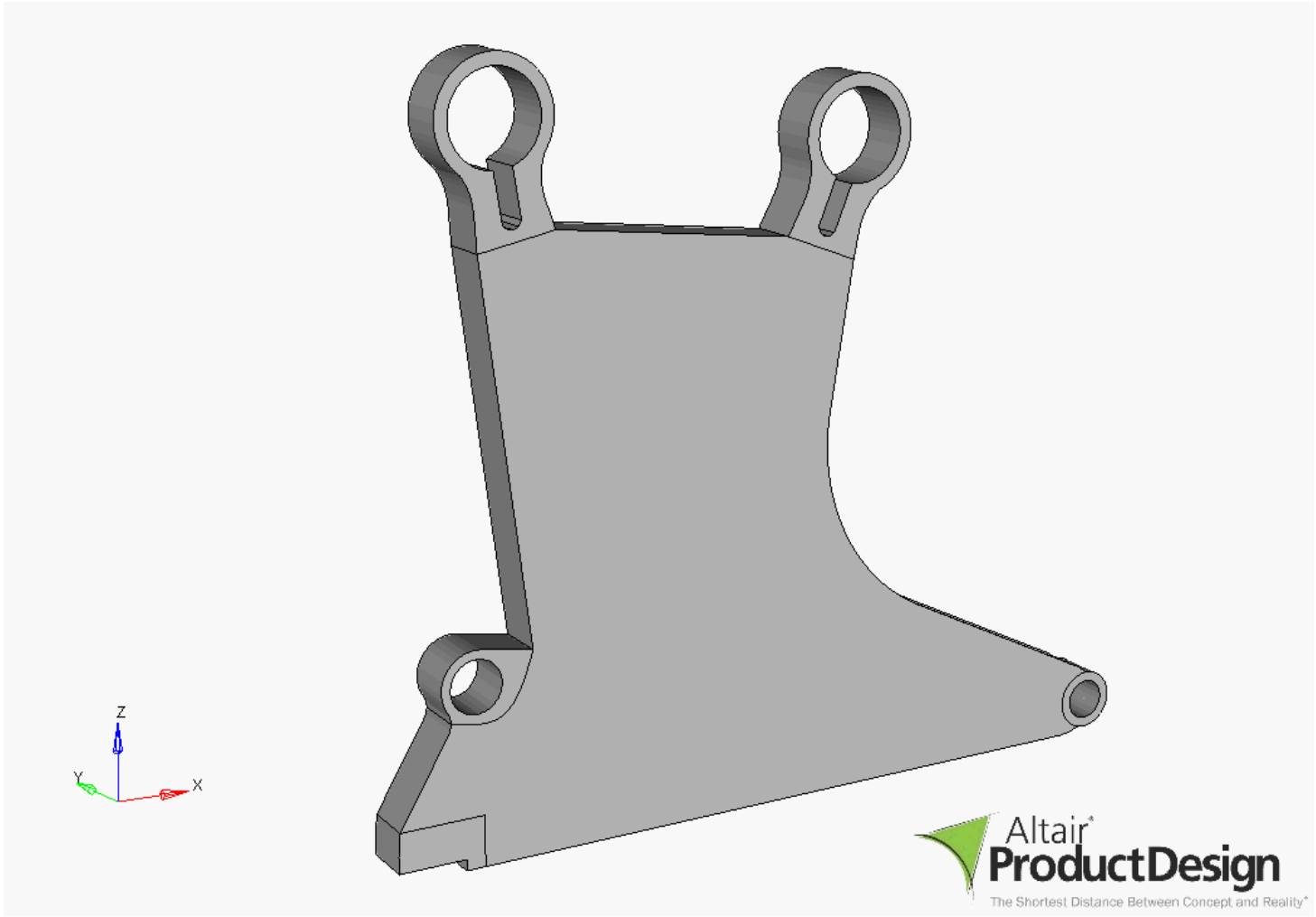
Topology Optimization – Component of an Aircraft Seat



CAE Driven ProductDesign

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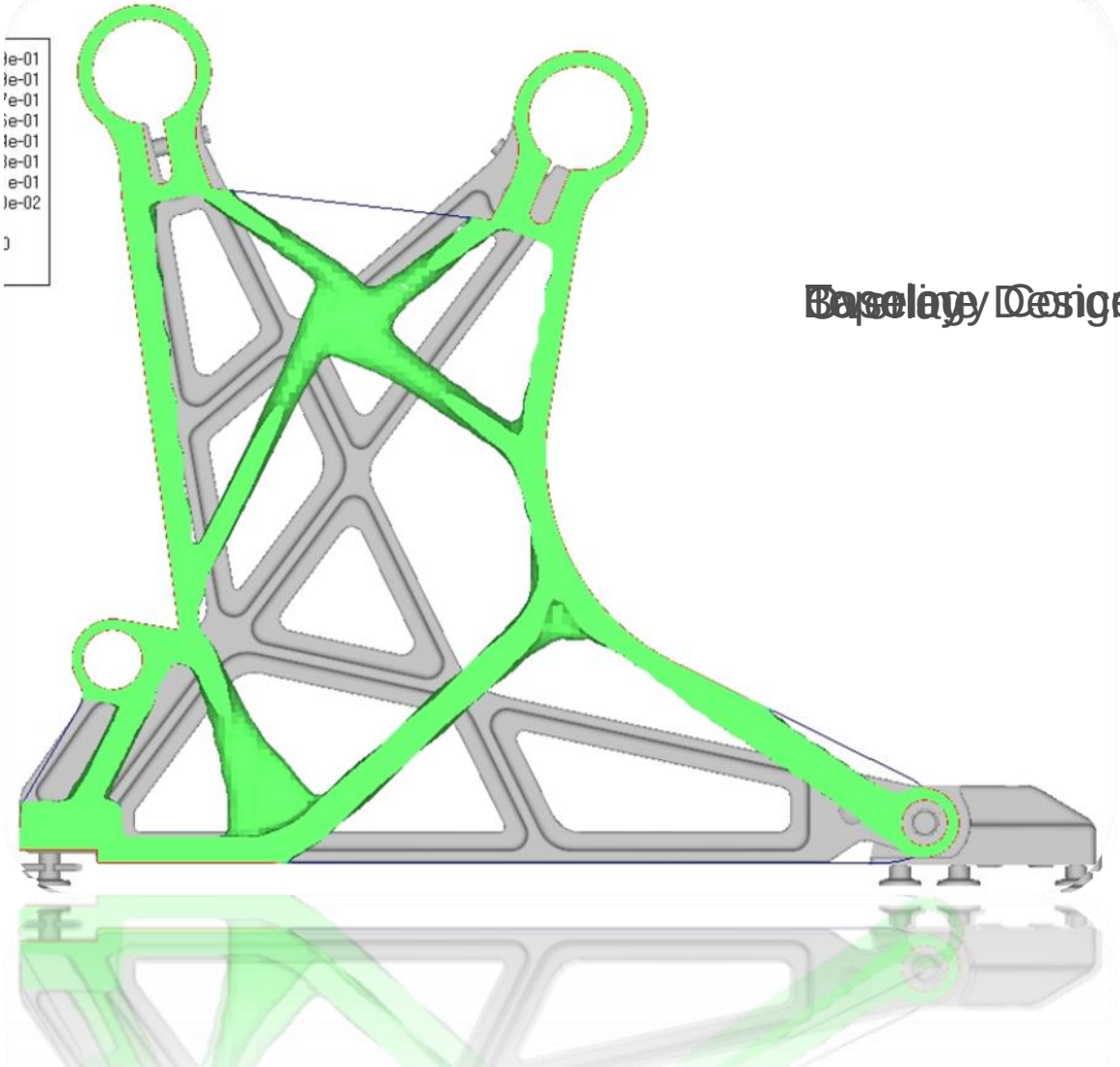

TLOO X-Section

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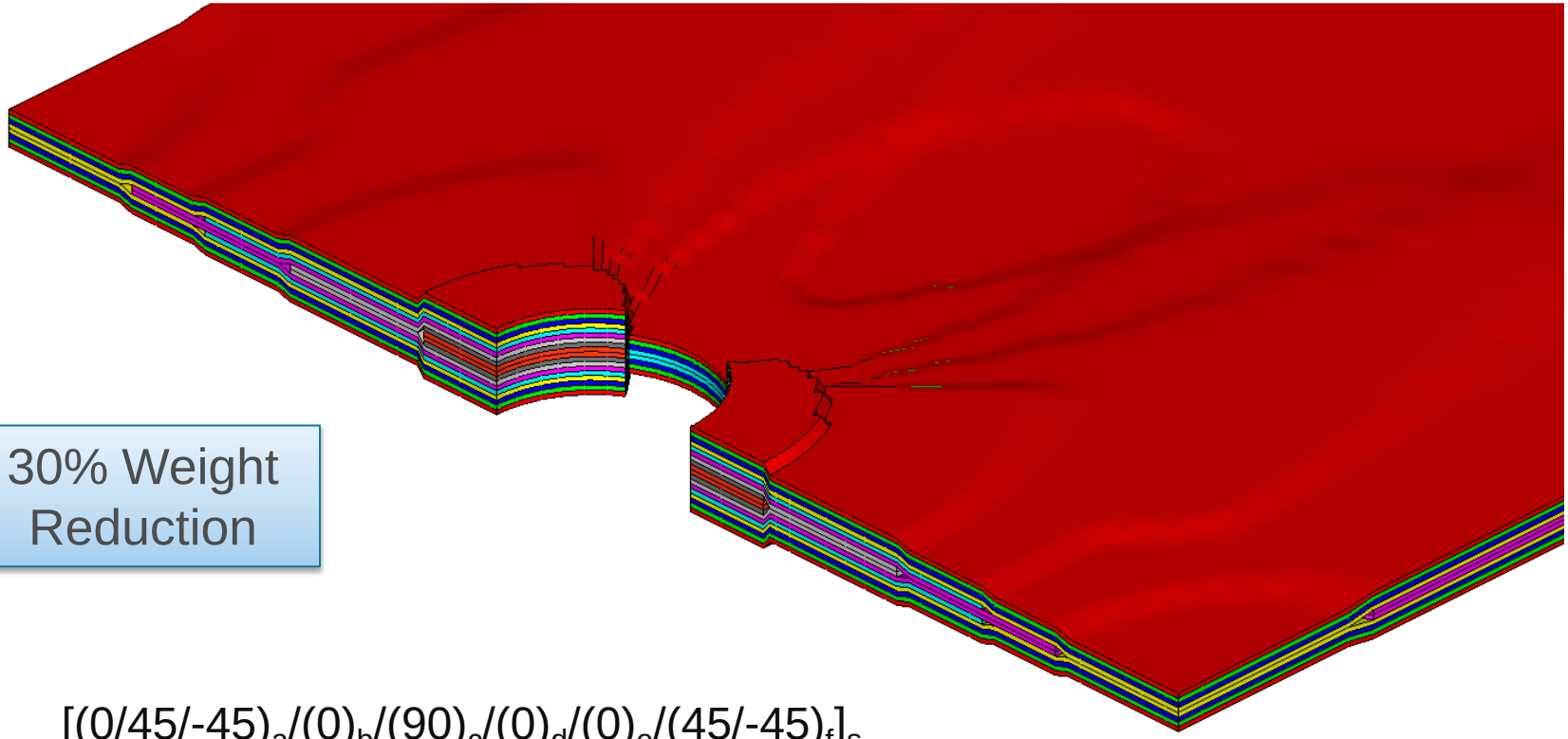
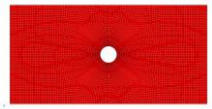


30% Weight Reduction

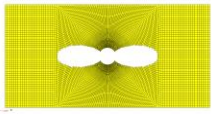
$[(0/45/-45)_a/(0)_b/(90)_c/(0)_d/(0)_e/(45/-45)_f]_s$

Shape a



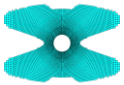
$(0/45/-45)_a$

Shape b



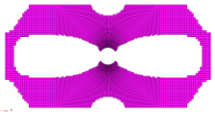
$(0)_b$

Shape c



$(90)_c$

Shape d



$(0)_d$

Shape e

$(0)_e$

Shape f

$(45/-45)_f$

Design Efficiency

Concept Design Technology

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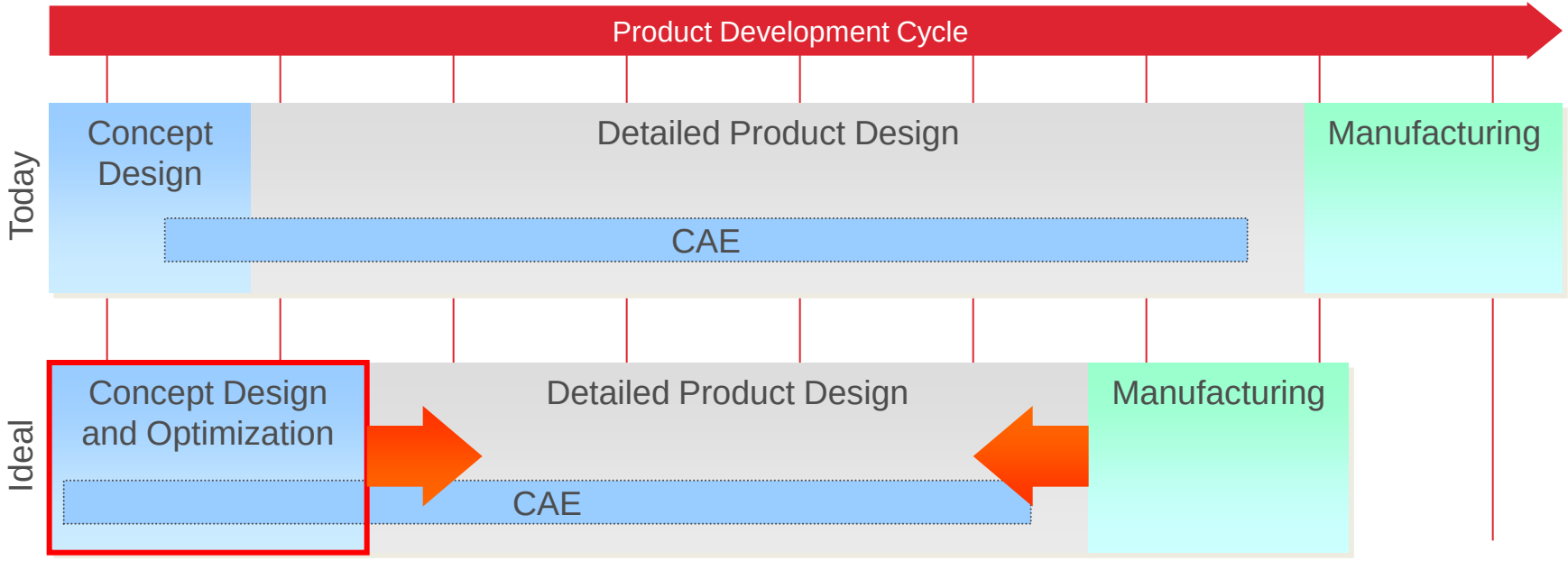
Move CAE Upstream!



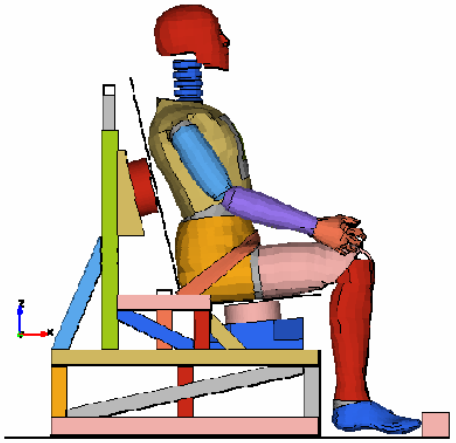
Occupant Simulation

Role of Altair in the SAE Seat Commitee

- **Altair is an Active member of the Technical committee for SAE Seat Committee working on Certification by Analysis**

Ongoing Work

- Presentation of a NIAR sled test simulation using different dummies (0 degrees 16 g):
  - HII Rigid FAA
  - HII semi-rigid
  - HIII 50% (last version)
- Springback Simulation



HII Aero Dummy

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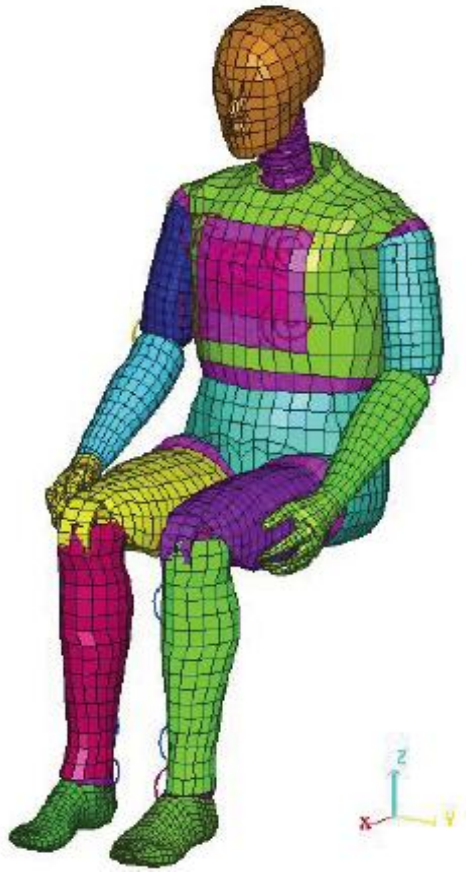
Hybrid II RB Aero 50th dummy



General features :

5630 nodes
5003 shells elements
230 bricks
41 springs
42 parts

Time step = 5.3 µs
Total mass = 74.06 kg.

HII Aero Dummy Instrumentation

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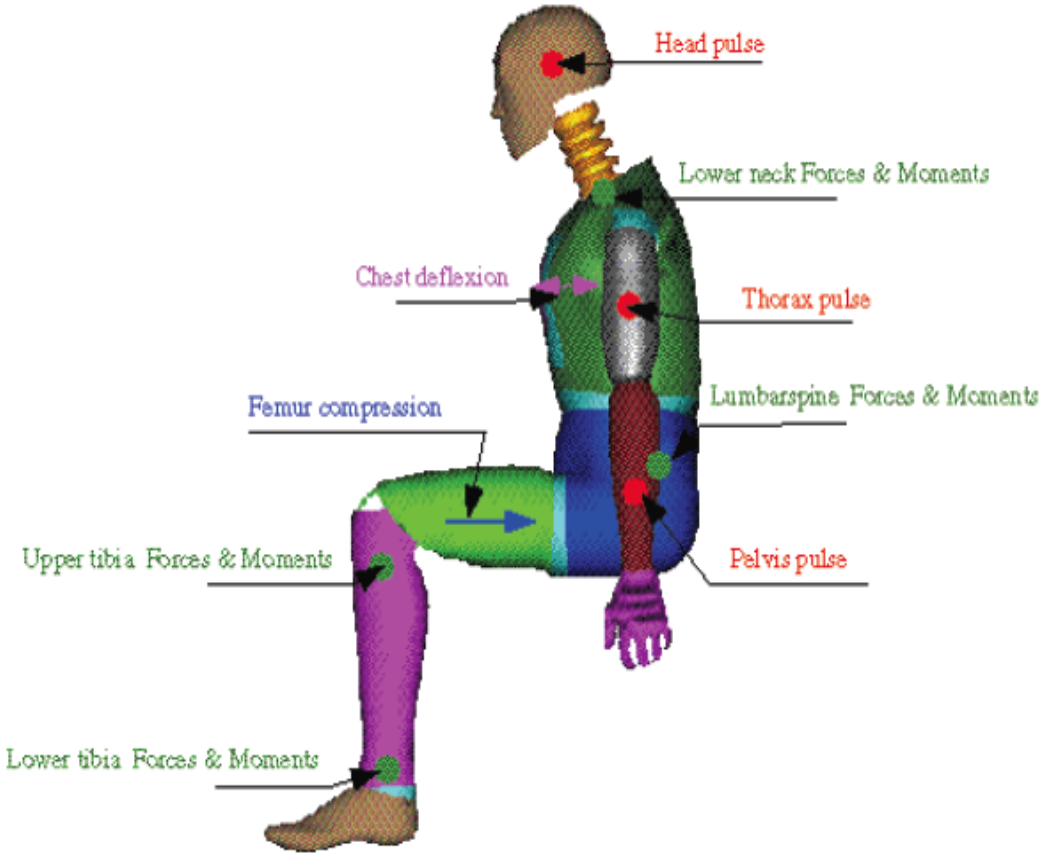
Hybrid II Instrumentation

- Accelerometers
  - Head
  - Chest
  - Pelvis
- Force and moment sensors
  - Lower & Upper neck
  - Lower & Upper lumbar spine
  - Left and right femur
  - Left and right upper tibia
  - Left and right lower tibia
- Deflection sensors
  - Chest deflection



HIII 50% Deformable

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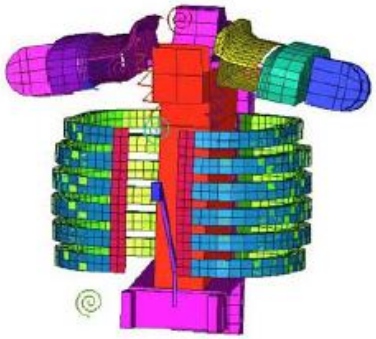
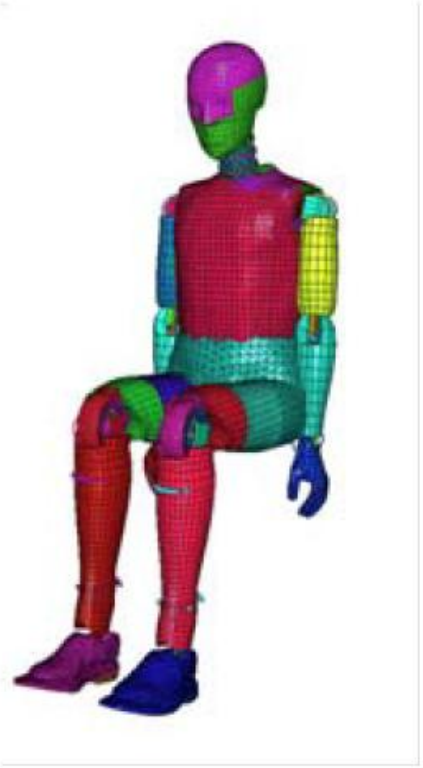
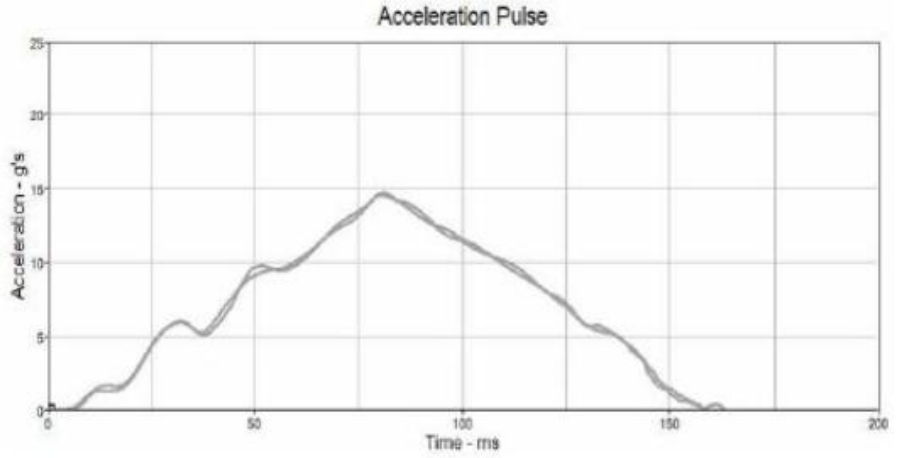
The new Hybrid III 50%o dummy full deformable is available for aeronautic seat design too.
It has been developped in collaboration with FTSS





HII Aero Dummy - Validations

- NIAR Test: 60° pitch test with 2 points belt & 14g acceleration



NII Aero Dummy – NAIR 60° 2PB 14g

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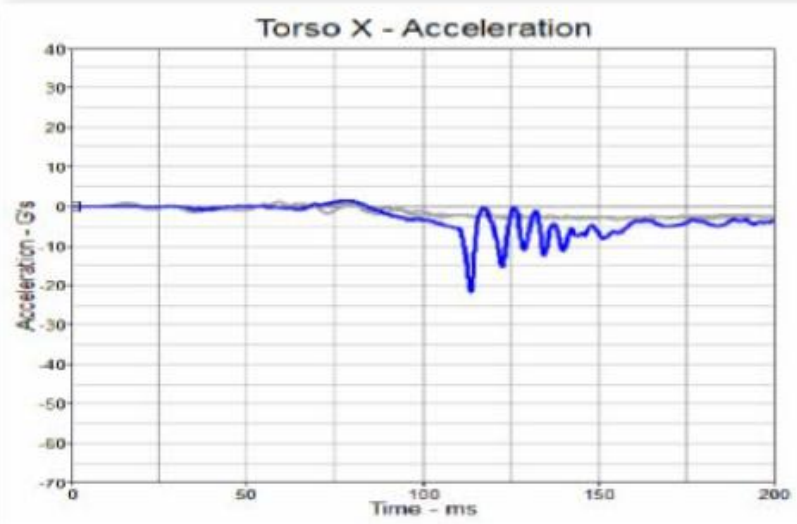
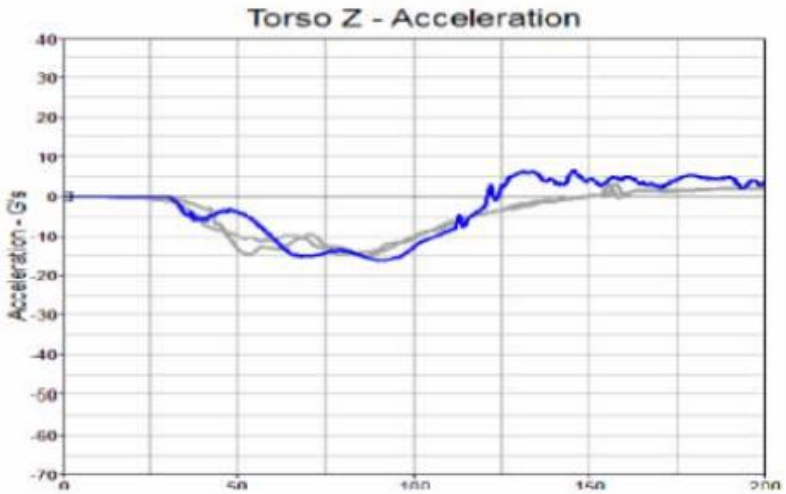
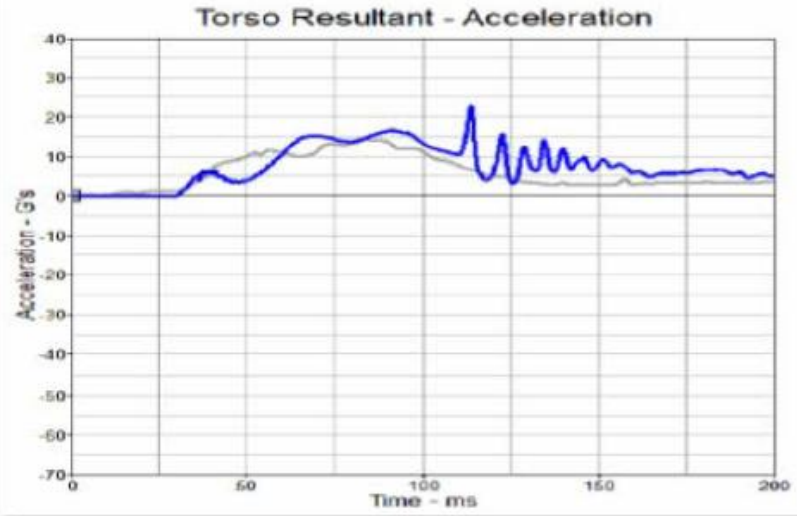
- **Torso Acceleration**



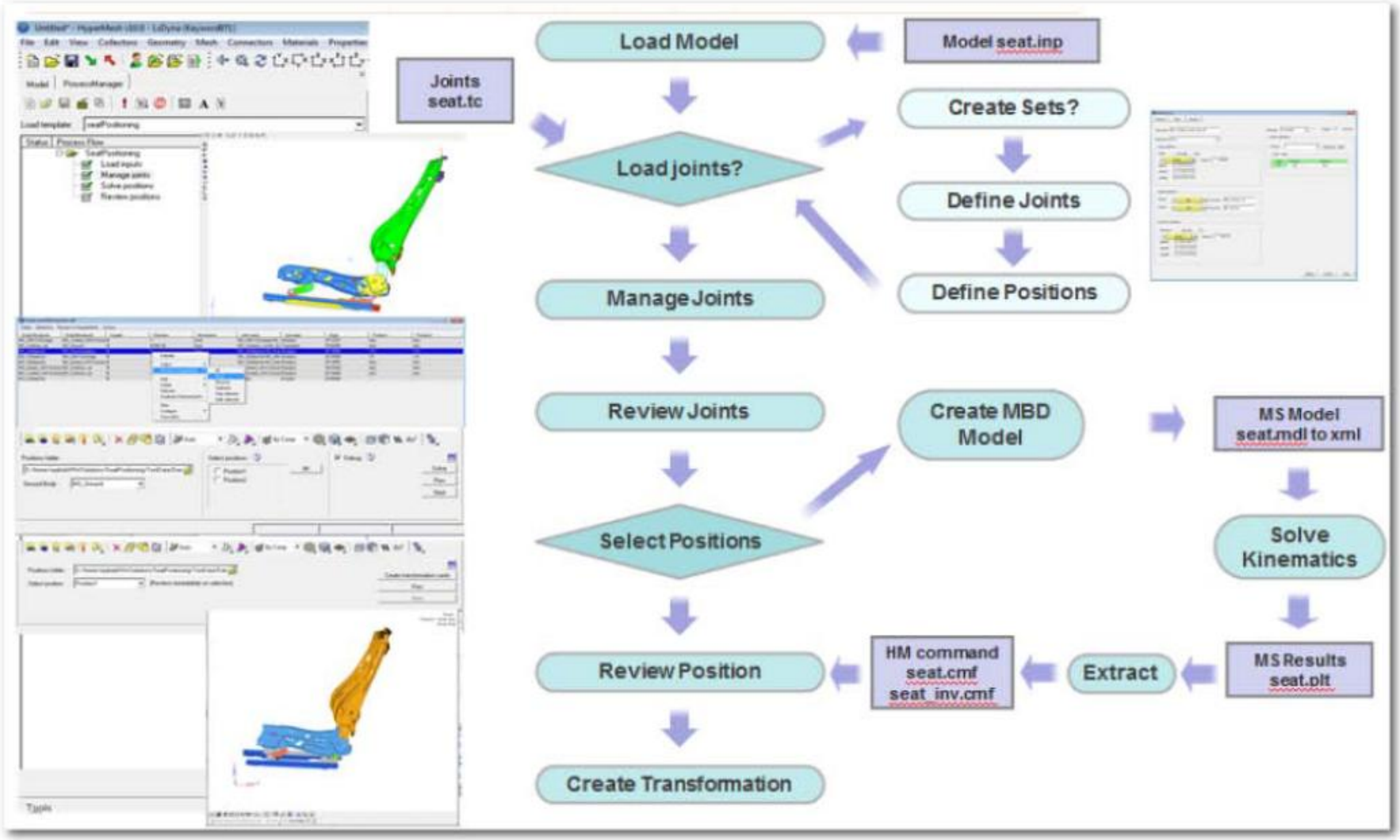




--Radioss

--Tests

Seat Positioning – MotionSolve MBD solution



Pitch and Roll are resolved thru simulations

Human Model for Safety (HUMOS)

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- **History**
  - HUMOS 1 & 2 projects – supported by the European Community
  - HUMOS 1 model – 50th percentile male model
  - HUMOS 2 models are a family of human models (5th female, improved 50th male, 95th male, standing 50th male)
- **Includes skeleton, muscles, organs, ligaments, …**
- **Accurate 3D finite element model of the real human body**
- **61000 Nodes/102000 Elements**

HUMOS 2 for Aircraft Seat Certification

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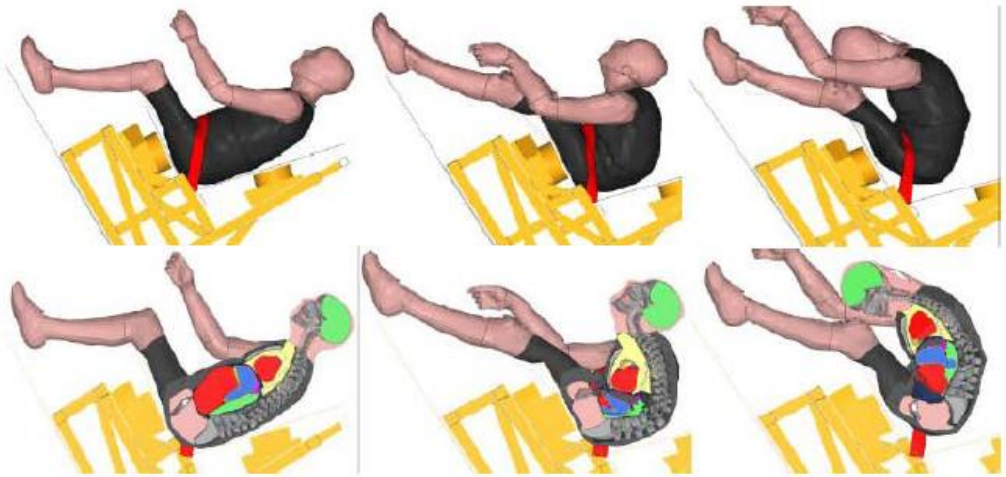
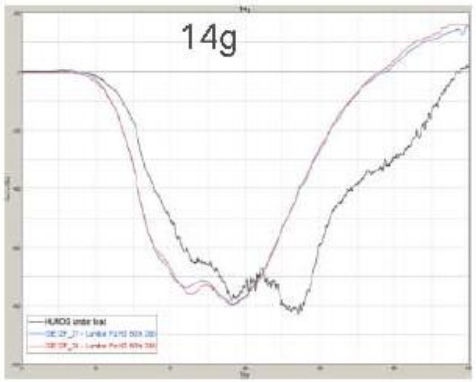
- **Common R&D work between NIAR and Altair Development France**
- **Objectives**
  - In Automotive industry, human models are getting more and more used for crashworthiness purpose to better understand injury mechanisms leading to effective design of injury countermeasures
  - “Emergency landing dynamic conditions” => Hybrid II and/or FAA-Hybrid III anthropomorphic test devices (ATDs)
  - Do dummy measures provide accurate and wide information on potential injuries occurring on aircraft seat occupant in case of survivable crash?
  - This work is done with the belief that there is a need to enhance the knowledge of injury mechanism with the aircraft survivable crash event.
- **Goals**
  - Adapt the Radioss automotive human model (Humos 2) to aircraft seating posture
  - Validate Humos 2 with the aircraft crash scenarios (horizontal-vertical load cases)
  - Use the validated Humos 2 model to enhance injury biomechanical knowledge in aircraft crash scenario

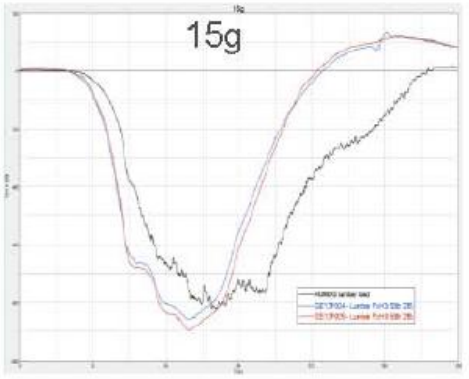
HUMOS 2 for Aircraft Seat Certification

- **HUMOS 2 vs. standard HII in aero sled tests**





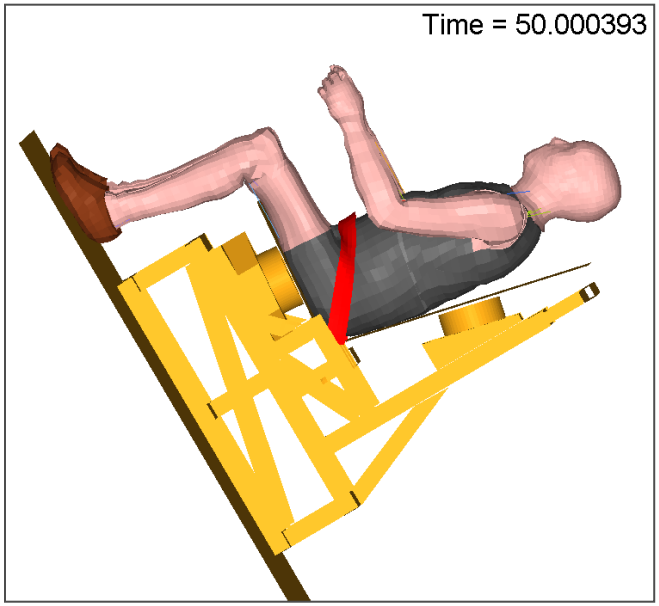
Spine loads

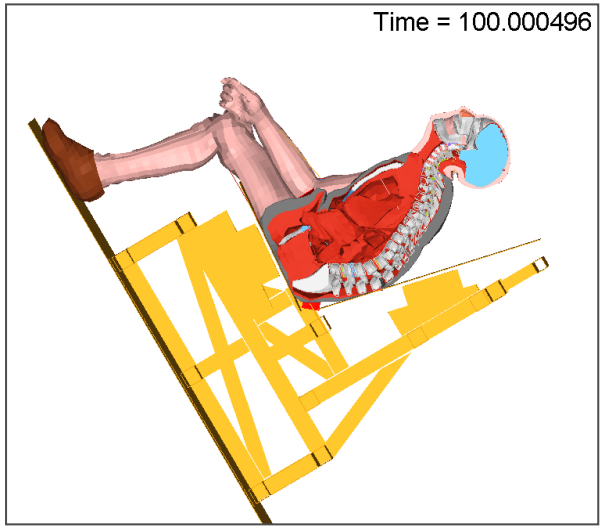


Vertical 14g – kinematics

For vertical load cases, there are 3 stages:

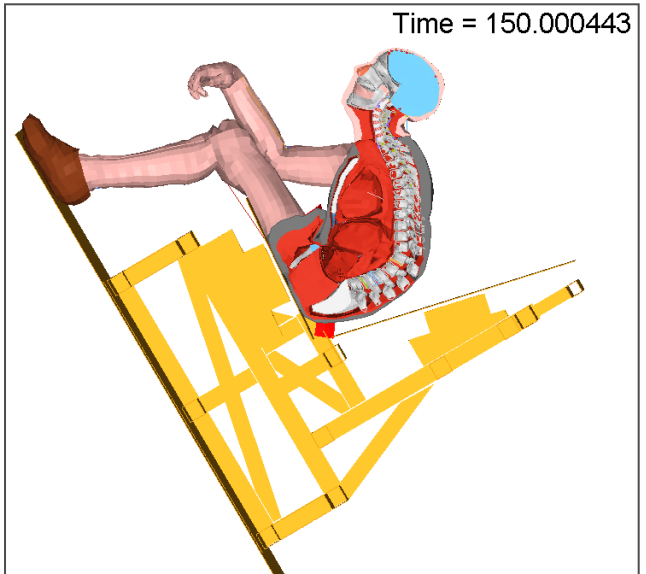
- Stage 1: Compression of the spine → from 0ms to 50ms



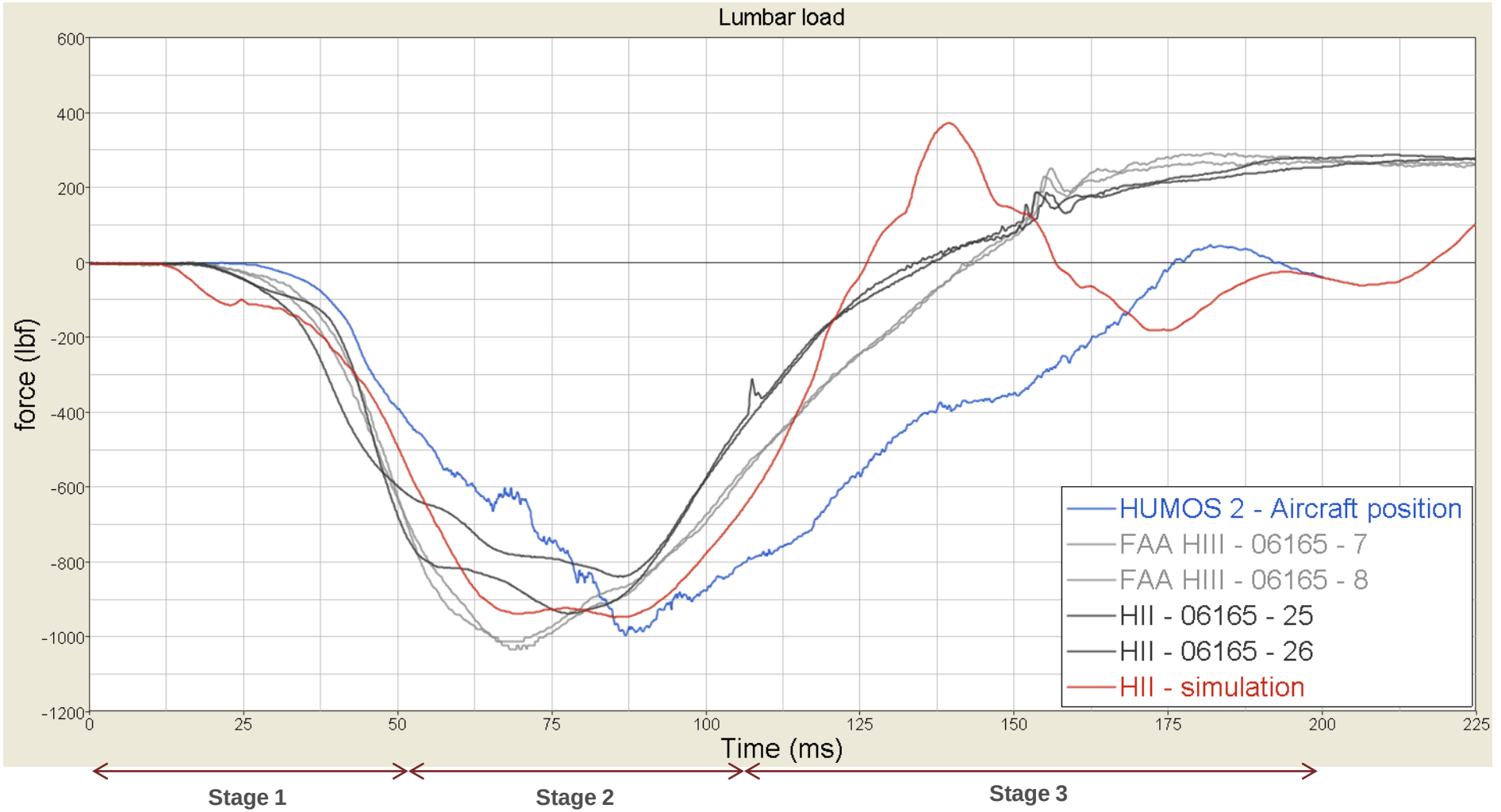


- Stage 2: Spine bending + sliding pelvis → from 50ms to 110ms

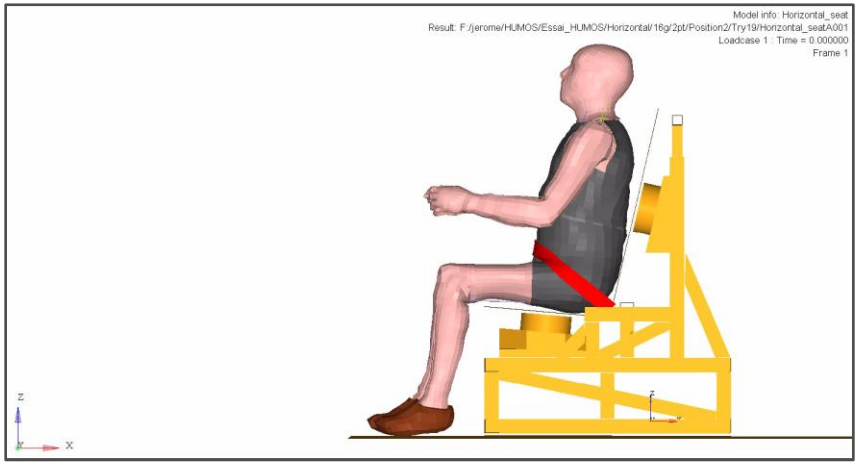
-Stage 3: Moving the torso forwards
→ from 110ms to 200ms



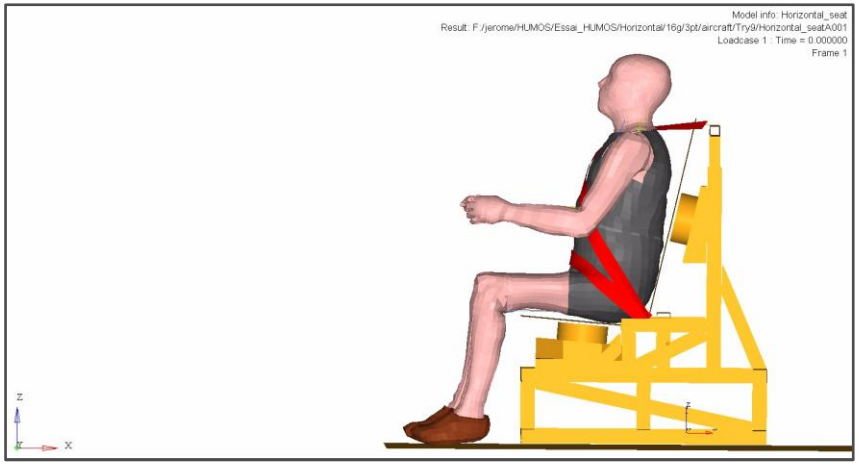
Results



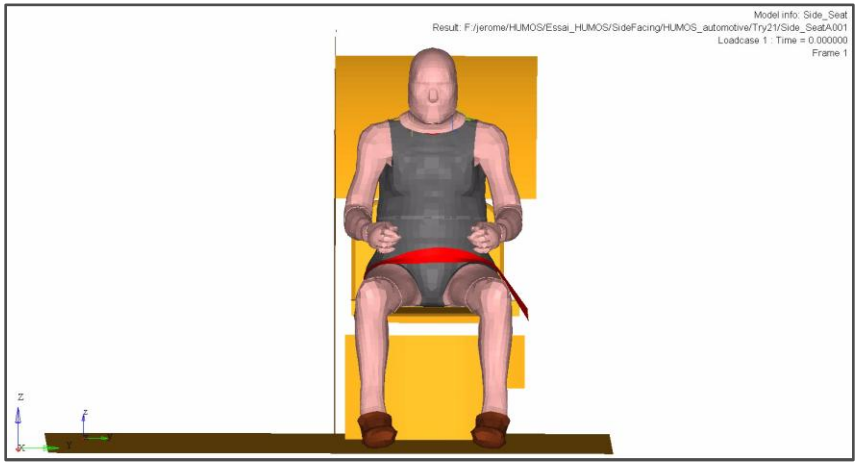
Occupant Simulation Results



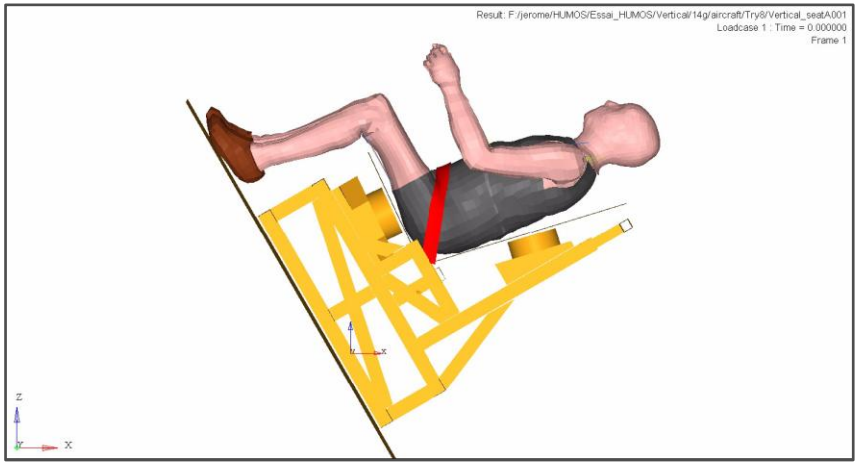
16g Horizontal – 2pt Lap Belt



16g Horizontal – 3pt Lap Belt



Side Load



14g Vertical – 2pt Lap Belt

Case Study - B/E Aerospace

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- **Challenge**
  - Weight reduction of primary structure
  - Cutting down Physical tests

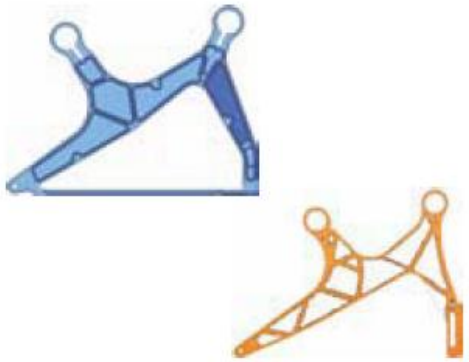
- **Solution**
  - Induction of Optistruct early in the design process
  - Crash Simulation using Hypercrash
  - Adding Hyperworks and CAE to the Product Cycle

- **Results**
  - 30% weight reduction
  - 60% saving in Physical testing
  - Accelarated Design cycle

"Altair HyperWorks is a great engineering tool in order to reduce program design cycle times, improve our first time yield during Dynamics testing, and to optimize the part design for weight and cost"

-Steve Kash and Jacod Valentine
-B/E Aerospace

Airplane Seating Key Technologies



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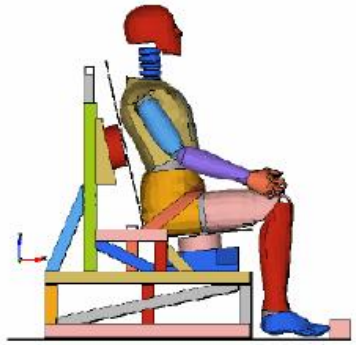

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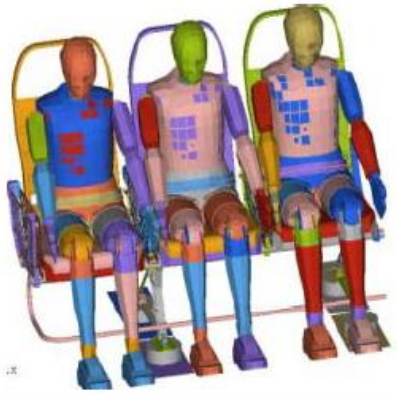

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