Aeronautic seat solution

User-friendliness & Multi domain optimization

August 2012 / Wichita

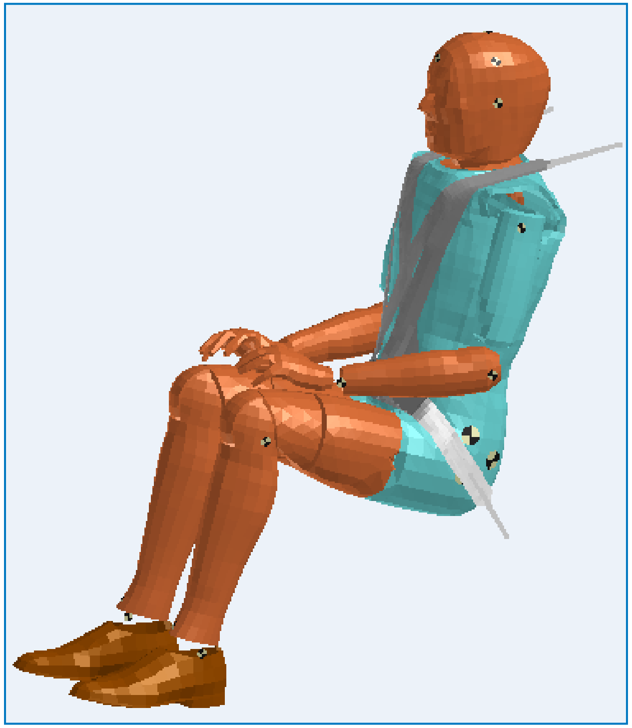
Christophe Jacob, PhD

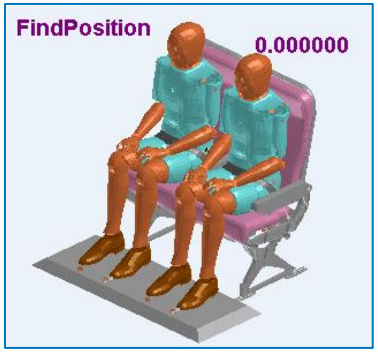
End-to-end virtual prototyping for seats

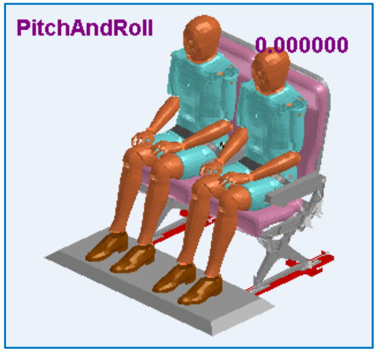
USER-FRIENDLINESS

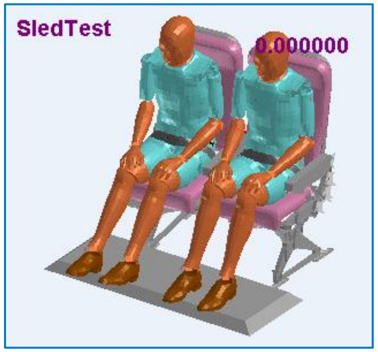
One compute model / One process

- The Dummy compute model: Hybrid II
  - Ready for automation
  - Equipped with standard belts
- The Process
  - Positioning
  - Pitch & Roll
  - Relaxation
  - Sled test
- One click solution
  - All the steps can be chained





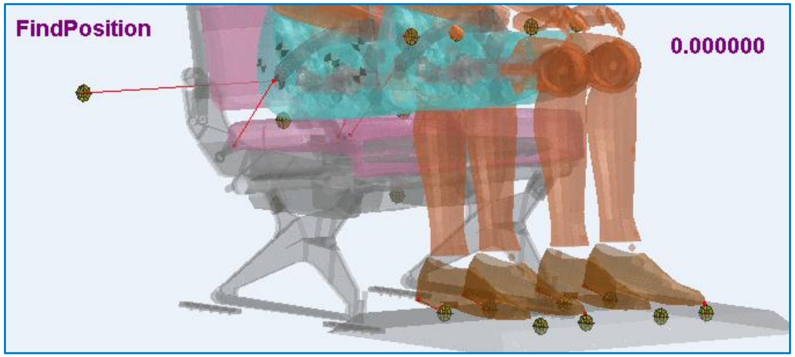




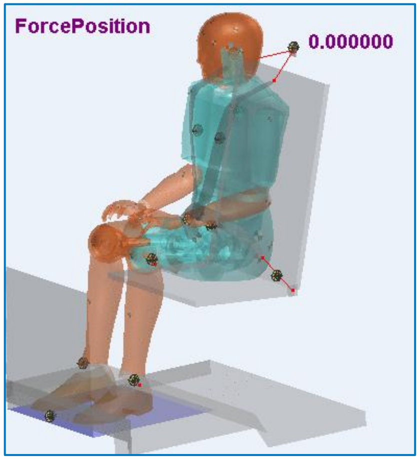
Positioning phase

Can predict a final position or reproduce experiment

- Find position
  - The dummy is pulled by bars in order to reproduce the gravity effects in a very short time (150ms)
  - The so found position respects gravity equilibrium and can be used for sled test of pitch&roll
  - Here, the pelvis is just pulled downward and backward while feet are pulled to predefined positions



- Force position
  - While performing a sled test experiment, it is common to use a 3D measurement device to get the exact location of some points of the seat and dummy
  - In this case, it is possible to pull the dummy points toward these locations (yellow targets), keeping reasonable efforts
  - Here, the pelvis, knees, head and ankles are pulled toward point measured during experiment tests. Like this the simulation is as near as possible from the experimental conditions



Pitch & Roll

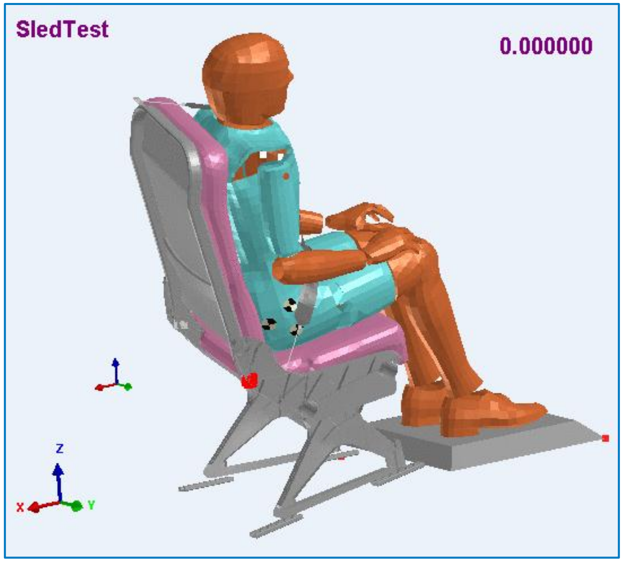
- It is possible to reproduce in a fast simulation the Pitch&Roll loads
  - With the belted dummy in its seat
    - The position when determined in the previous phase (find or force position)
    - From the positioning phase, pre-stresses in the dummy and in the seat are retrieved
  - For frontal or aft sled tests
    - The center of Pitch can be either on the front anchors either on the rear anchor
  - The dummy moves together with the seat
- It becomes easy to determine the worse Pitch&Roll situation
  - Just change the sign of the angle (+/-10° for both pitch and roll movements)
- Easy to set-up
  - Changing orientation of Pitch&Roll take less than 2 minutes
  - Then the simultation takes around 2~3 hours

Sled test

- Here also, location and stresses from pitch&roll or positioning phase are automatically introduced
  - It reproduces the stresses the real seat and dummy(ies) would get during a real experiment
- Two possibilities to generate the sled test pulse
  - Regulatory pulse: directly coded in the process
    - Part 23: Horizontal/Vertical, Crew/Passenger
    - Part 25: Horizontal/Vertical
    - Part27/29: Horizontal/Vertical

	Horizontal Crew	Vertical Crew	Horizontal Passenger	Vertical Passenger
Part 23	26G, 100ms	19G, 100ms	21G, 120ms	15G, 120ms
Part 25	--	--	16G, 180ms	14G, 160ms
Part 27/29	--	--	18.4G, 142ms	30G, 062ms

  - User-defined pulse (to reproduce and existing sled test): through the data file, directly read by the process
- Different orientations
  - Frontal, Aft, Pitch 60°
  - Automatic introduction of a yaw in the sled test, if any



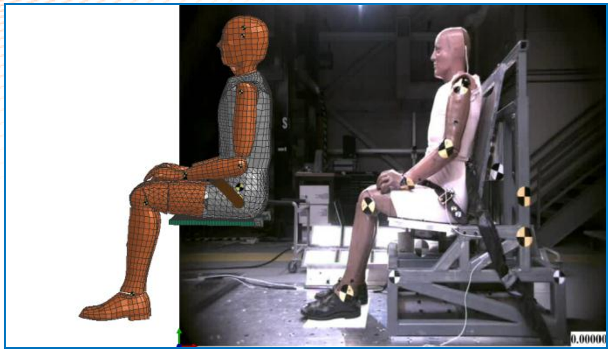
Automatic generation process

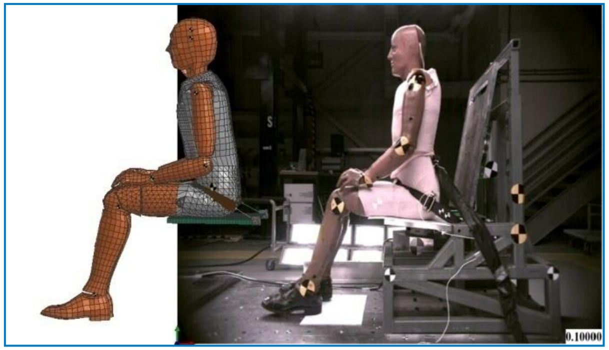
How it works

- You bring your seat, we bring our belted dummy
  - The process combines them and creates and creates the corresponding solver input
- Preview function makes it safer
  - It becomes possible to see in the pre-processing phase, i.e. before running the solver what will happen during the simulation
  - Pitch&Roll: movement of the tools defining the pitch and the roll of the seat tracks
  - Sled test: direction of the dummy movement (e.g. to avoid the dummy to go forward in an aft test)
- Parameterization is easy
  - Through simple parameters files
- It is possible to chain the phases
  - Like this you launch the process in the evening and you get the sled test results in the morning
  - The Three phases (positioning, pitch&roll, sled test) are automatically chained)

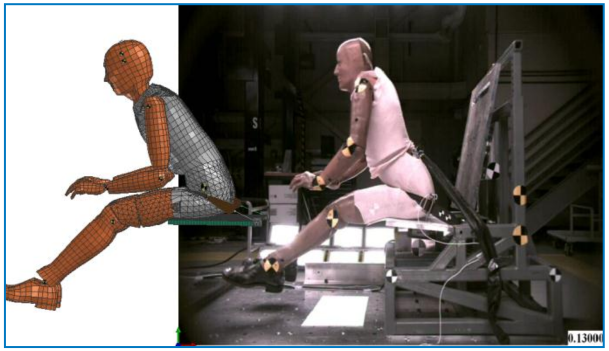
Lap belt

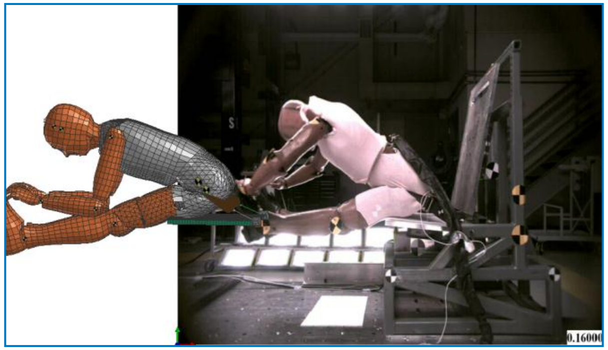
Pitch 0°

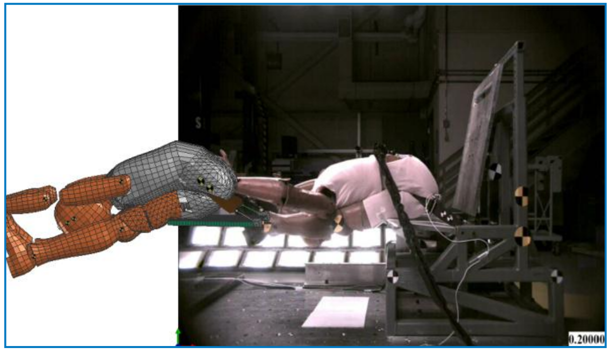


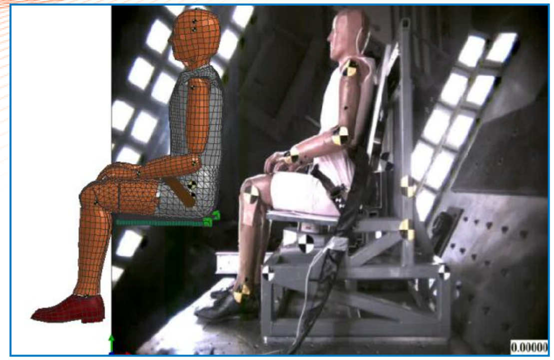


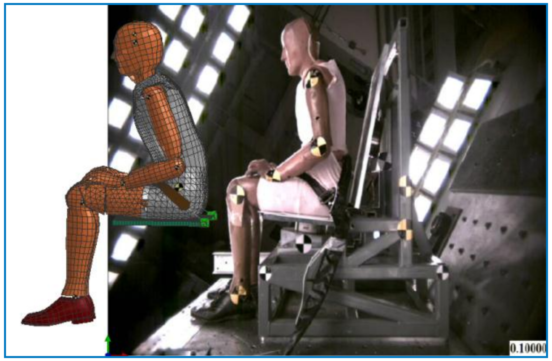
item	S&G phase, magnitude, comprehensive error	Allowable S&G Comp. error	Peak Difference	Allowable Peak Difference
Lf Lap Belt F	0.072, -0.007, 0.073	0.1	6.397%	10%
Rt Lap Belt F	0.072, 0.018, 0.074	0.1	1.631%	10%
Head CG X pos.	0.006, 0.047, 0.047	0.1	34.889	12.7mm
Head CG Z pos.	0.03, 0.015, 0.034	0.1		
Knee X pos.	0.022, -0.006, 0.023	0.1	14.686	6.35mm
Knee Z pos.	0.056, -0.007, 0.056	0.1		
Ankle X pos.	0.02, 0.005, 0.021	0.15		
Ankle Z pos.	0.039, -0.024, 0.046	0.2		
H-Point X pos.	0.023, 0.011, 0.026	0.1	6.114	6.35mm
H-point Z pos.	0.051, -0.081, 0.096	0.1	38.679	5.1mm







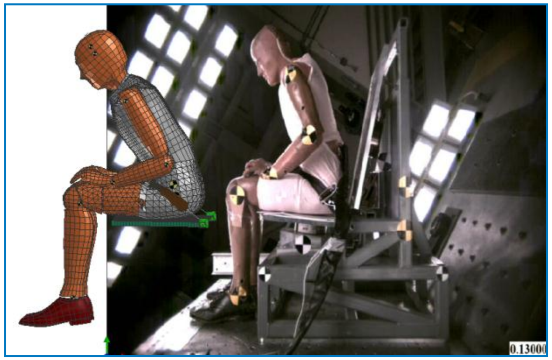


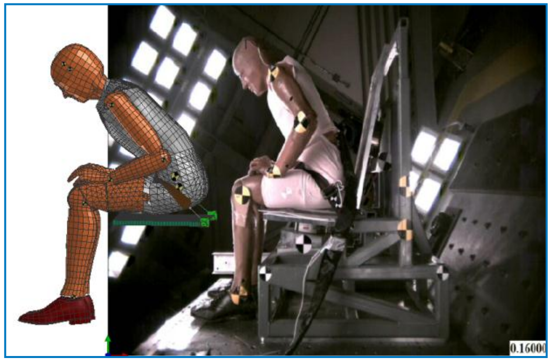


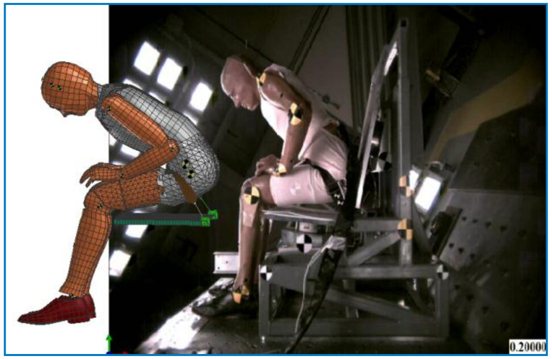
Lap belt

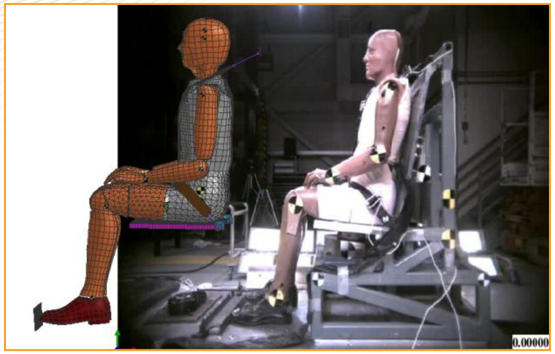
Pitch 60°

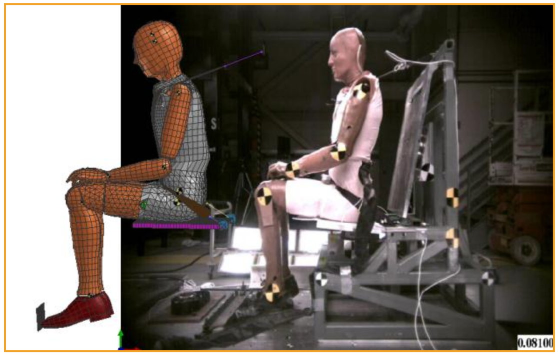
item	S&G phase, magnitude, comprehensive error	Allowable S&G Comp. error	Peak Difference	Allowable Peak Difference
Lumbar Fz	0.163, -0.178, 0.242	0.15	4.465%	10%
Lumbar My	0.203, -0.1, 0.226	0.25		
Head CG X pos.	0.007, 0.031, 0.032	0.1		
Head CG Z pos.	0.003, 0.019, 0.019	0.35		
H-point Z pos.	0.007, 0.016, 0.017	0.25	0.991	5mm
Pelvis angle	0.243, -0.099, 0.262	0.40	2.701	3deg







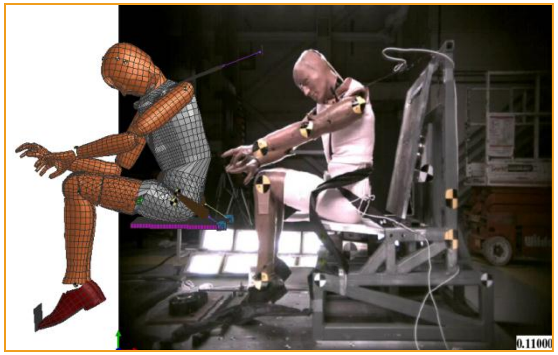


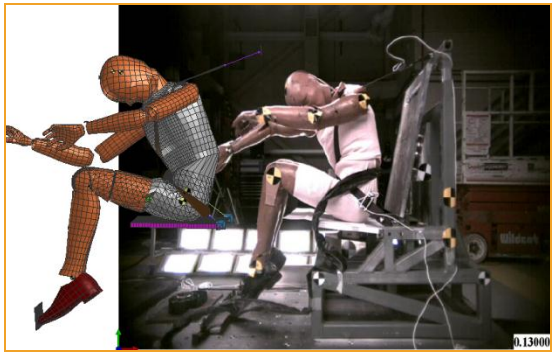


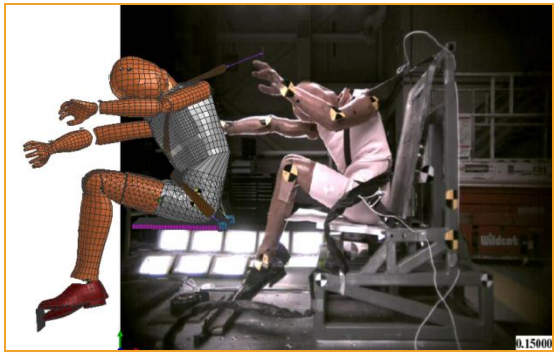
3 points belt

Pitch 0°

item	S&G phase, magnitude, comprehensive error	Allowable S&G Comp. error	Peak Difference	Allowable Peak Difference
chest Ax	0.046, 0.108, 0.117	0.1	7.837%	10%
Lf Lap Belt F	0.032, -0.049, 0.058	0.1	0.256%	10%
Rt Lap Belt F	0.031, 0.007, 0.032	0.1	3.395%	10%
Shoulder Belt F	0.06, -0.092, 0.11	0.1	2.241%	10%
Head CG X pos.	0.037, -0.086, 0.094	0.1	38.308	44.5mm
Head CG Z pos.	0.014, 0.013, 0.019	0.3		
H-Point X pos.	0.023, -0.104, 0.107	0.2	19.492	31.8mm
shoulder pos x	0.053, -0.235, 0.241	0.15	92.637	50.8mm
shoulder pos z	0.009, -0.026, 0.028	0.4		



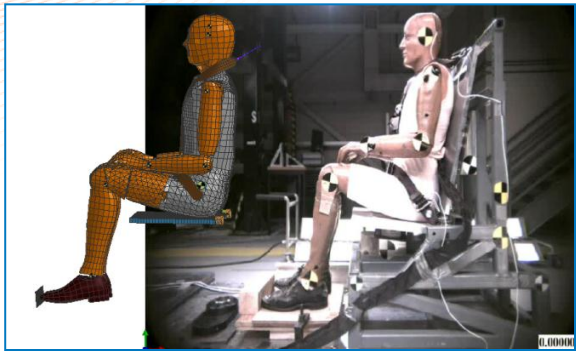


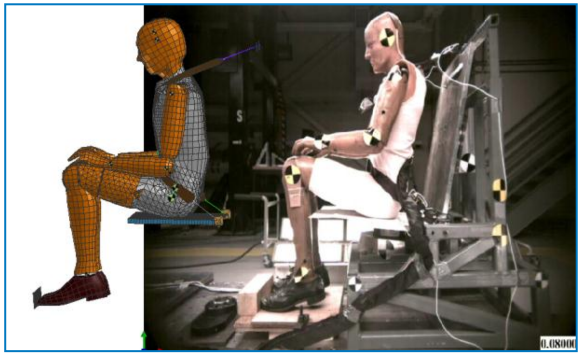


get it right®

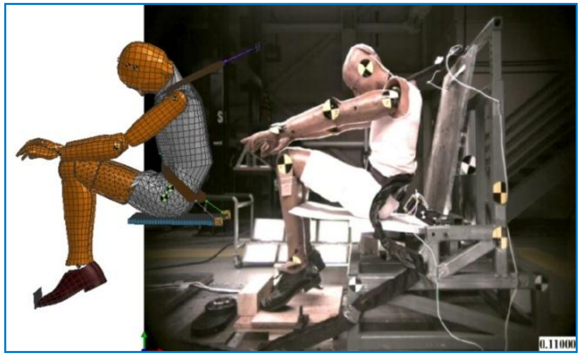
Harness

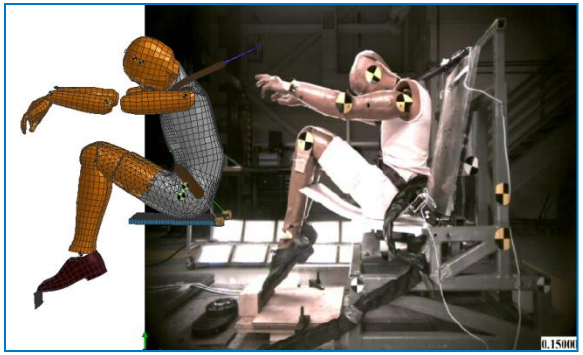
Pitch 0°

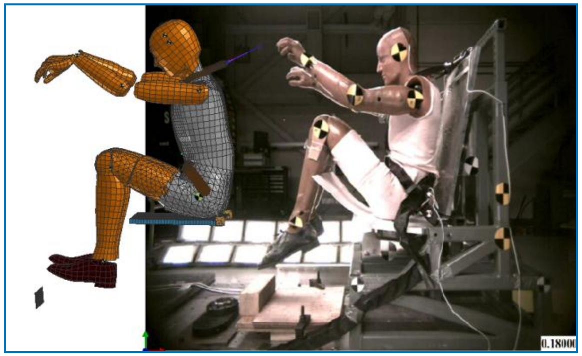




item	S&G phase, magnitude, comprehensive error	Allowable S&G Comp. error	Peak Difference	Allowable Peak Difference
chest Ax	0.103, 0.061, 0.12	0.15	15.483%	20%
Lf Lap Belt F	0.075, -0.022, 0.078	0.1	4.548%	10%
Rt Lap Belt F	0.076, 0.019, 0.078	0.1	13.391%	10%
Shoulder Belt F	0.1, -0.063, 0.118	0.15	11.168%	15%
Shoulder Belt F	0.093, -0.04, 0.101	0.15	10.444%	15%
Head CG X pos.	0.05, -0.065, 0.082	0.1	45.868	38.1mm
Head CG Z pos.	0.011, 0.032, 0.034	0.2	15.405	25.4mm
H-Point X pos.	0.007, 0.041, 0.042	0.25	7.742	31.8mm
Knee X pos.	0.01, -0.046, 0.047	0.25	43.35	31.8mm
Knee Z pos.	0.026, 0.28, 0.281	0.6		
shoulder pos x	0.046, -0.179, 0.185	0.2	57.033	31.8mm
shoulder pos z	0.014, 0.004, 0.014	1.0	9.072	44.5mm







End-to-end virtual prototyping for seats

MULTI-DOMAIN OPTIMIZATION

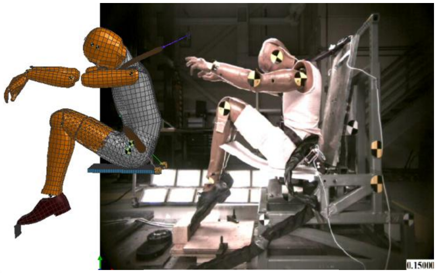
VIRTUAL SEAT PROTOTYPING

HOW TO ACHIEVE THIS GOAL ?

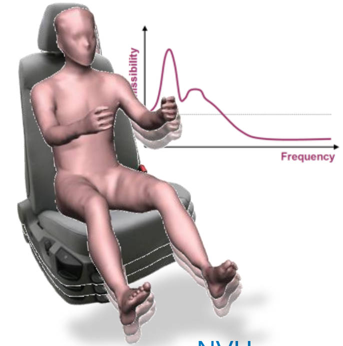
What does ESI propose ? Virtual Performances

Seat single core model virtually manufactured

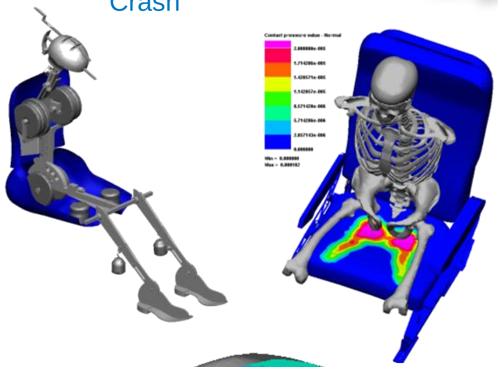
- Seat crash model
  - 14 CFR 23.562
  - 14 CFR 25.562
  - 14 CFR 27.562
  - …
- Seat comfort model
  - H-Point with HPM1
  - Pressure with Human (take off, cruising, landing)
  - Pressure with Human (sleeping mode)
  - …
- Seat NVH model
  - Transfer function
  - Acoustic absorption of porous materials
  - Durability
  - …
- Seat thermal model
  - Water dummy
  - Human model
  - …



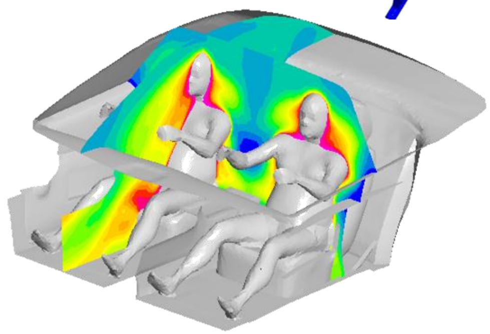
Crash



NVH



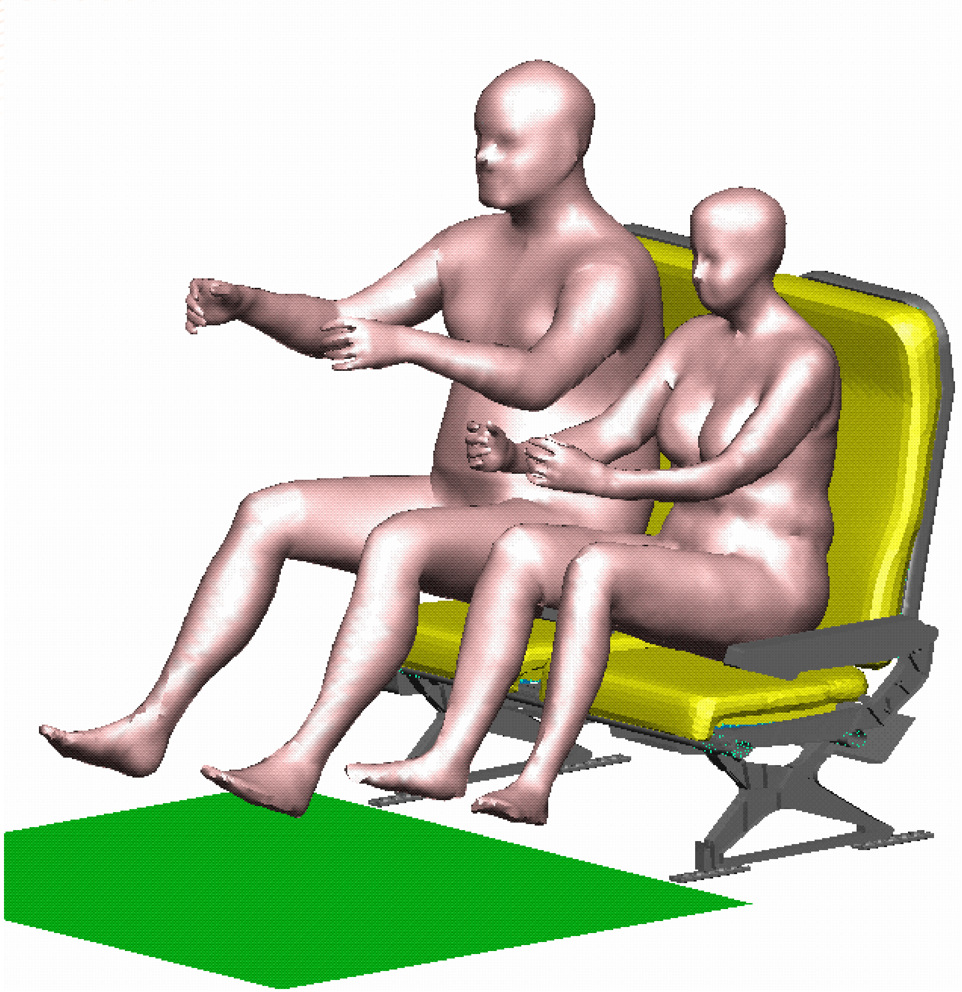
Comfort

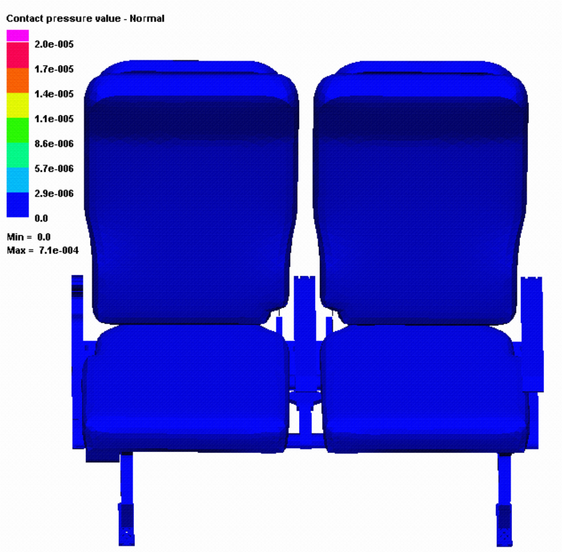


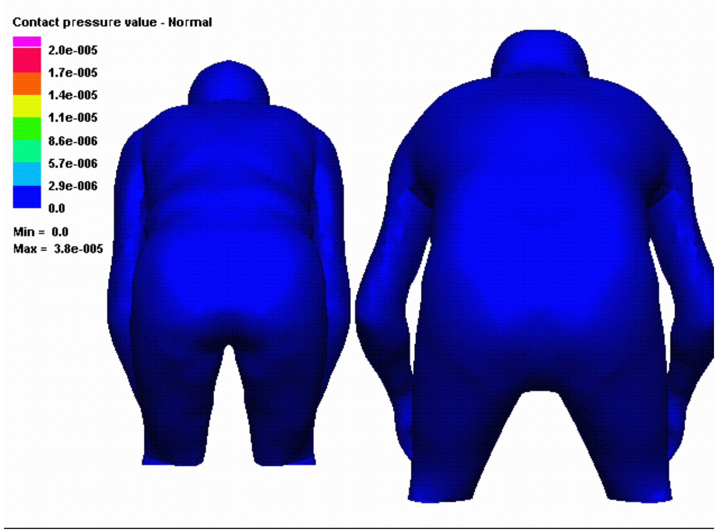
Thermal comfort

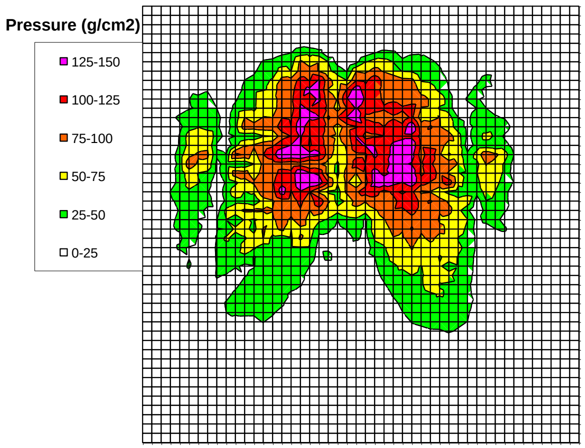
Sustainable only with a single core model and an end-to-end solution

COMFORT
Pressure distribution

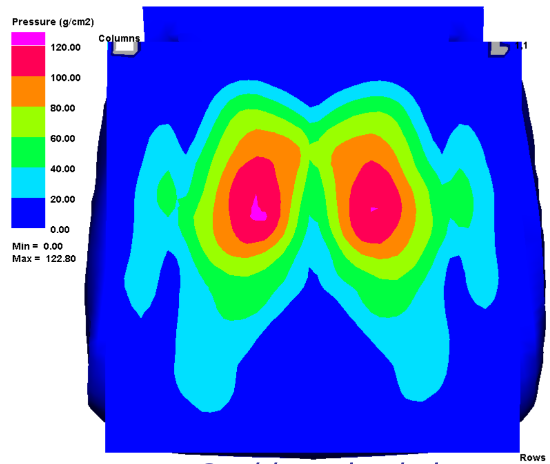




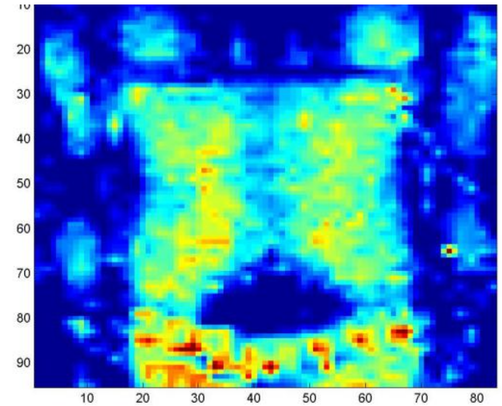




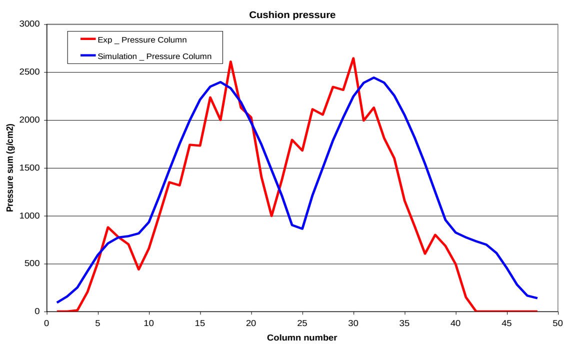
Cushion: physical test



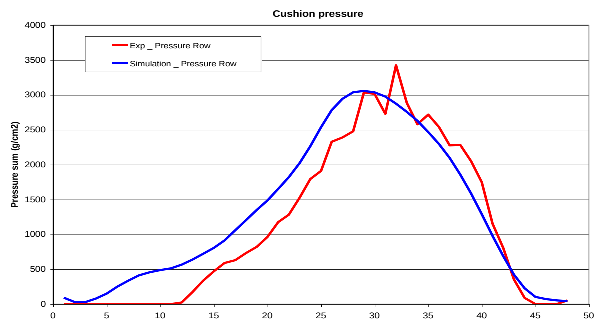
Cushion: simulation



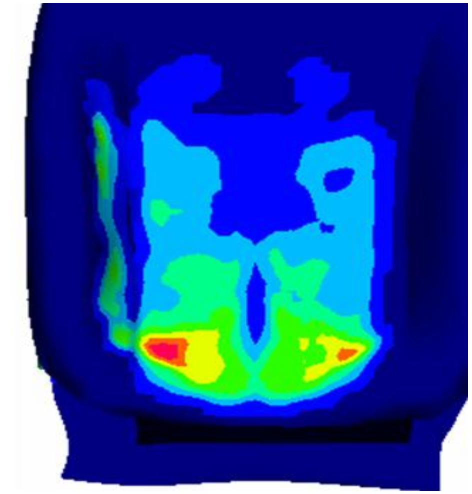
Backrest: experiment



Right *Left*



Front *Rear*



Backrest: simulation

Example of PAM-Comfort results:
Physical tests vs simulation for contact pressure rows & columns

Courtesy Hyundai

Courtesy Renault

Fig. 1: Experimental set-up

Nominal foam	Experi-ment	Simulation	Difference	Difference %
F_{Gmax}	7.0 Hz	7.0 Hz	0.01 Hz (± 0.2)*	+0.1% (± 3%)*
G_{max}	6.7	7.1	0.5 (± 0.5)*	+7% (± 10%)*
$F_{G=1}$	10.4 Hz	10.4 Hz	0.01 Hz (± 0.2)*	+0.1% (± 2%)*
$G_{f=10Hz}$	1.13	1.12	-0.01 (± 0.1)*	-1% (± 10%)*

** criteria of acceptance of the results*

This good correlation between simulations and tests confirms the ability to assess the riding seat comfort in a full virtual process.

Ex. Renault: « Virtual Seat Comfort Assessment for Low-Frequency Ride Comfort », SIA 2008

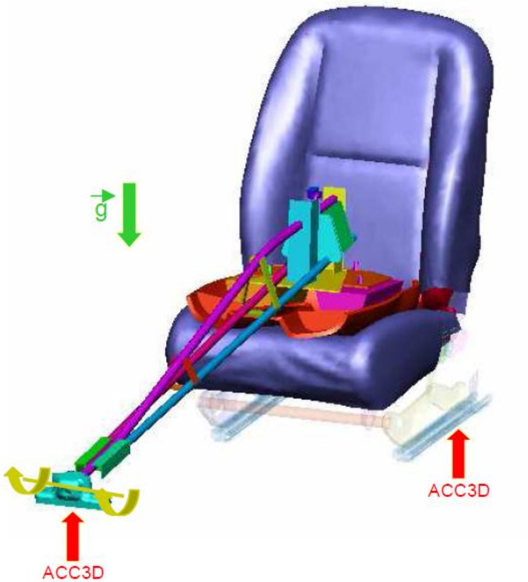
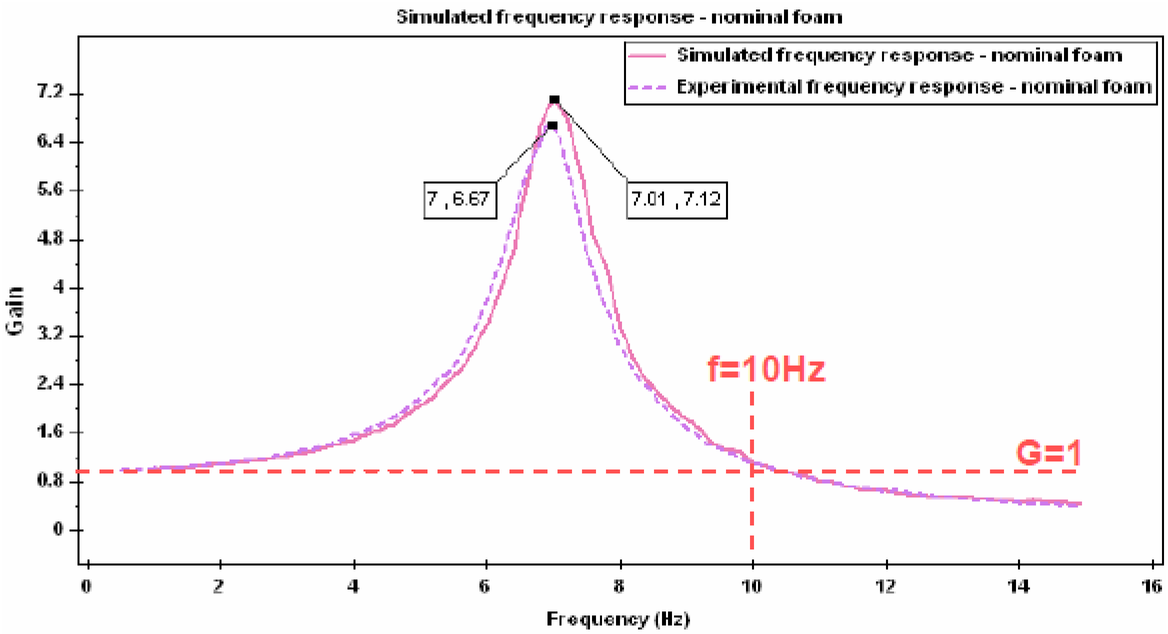
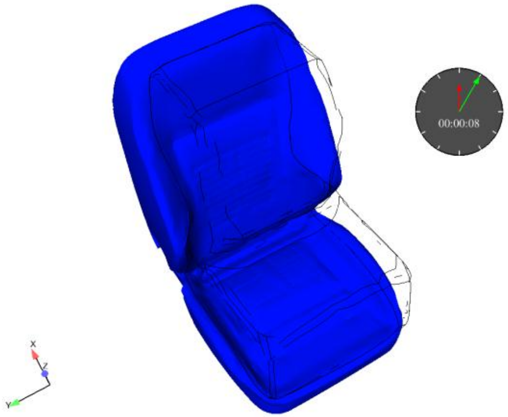
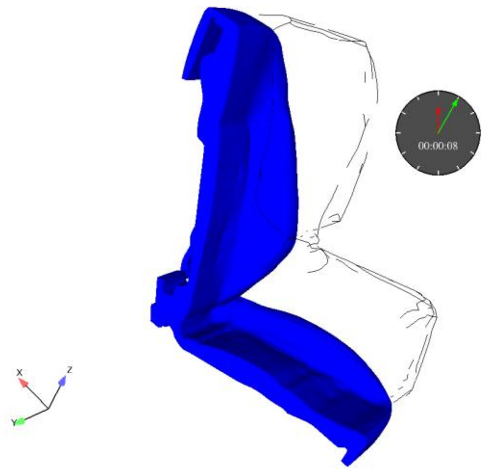
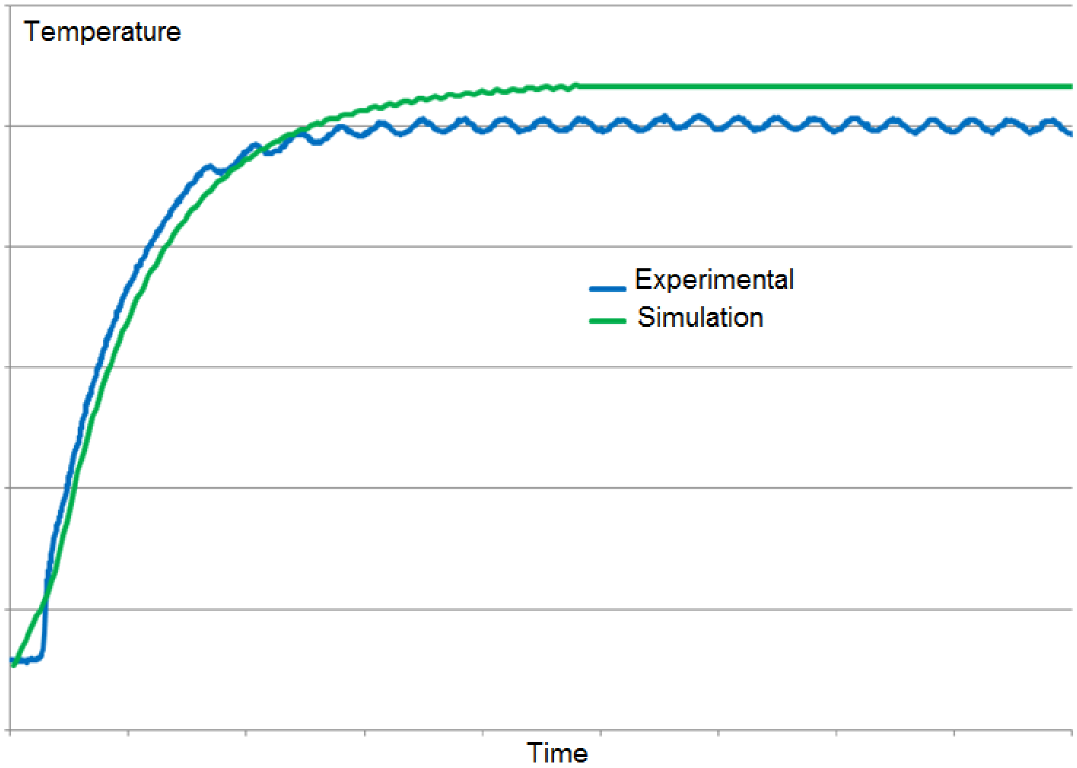


Fig. 2: Finite Element model









The oscillations on the experimental curve are due to the thermostat.

The seat is initialized at 22°C

End-to-end virtual prototyping for seats

FINALLY

- With the same model, you can achieve many analysis
  - First step toward the multi-domain optimization
  - Less expensive: same software & hardware

- You can easily perform safety analysis
  - You bring your seat model, we bring the dummy and the process
    - We have automatic converters for Nastran, LS-Dyna and RADIOSS
  - Lowers the risk of mistakes

get it right®

www.esi-group.com

Thank you