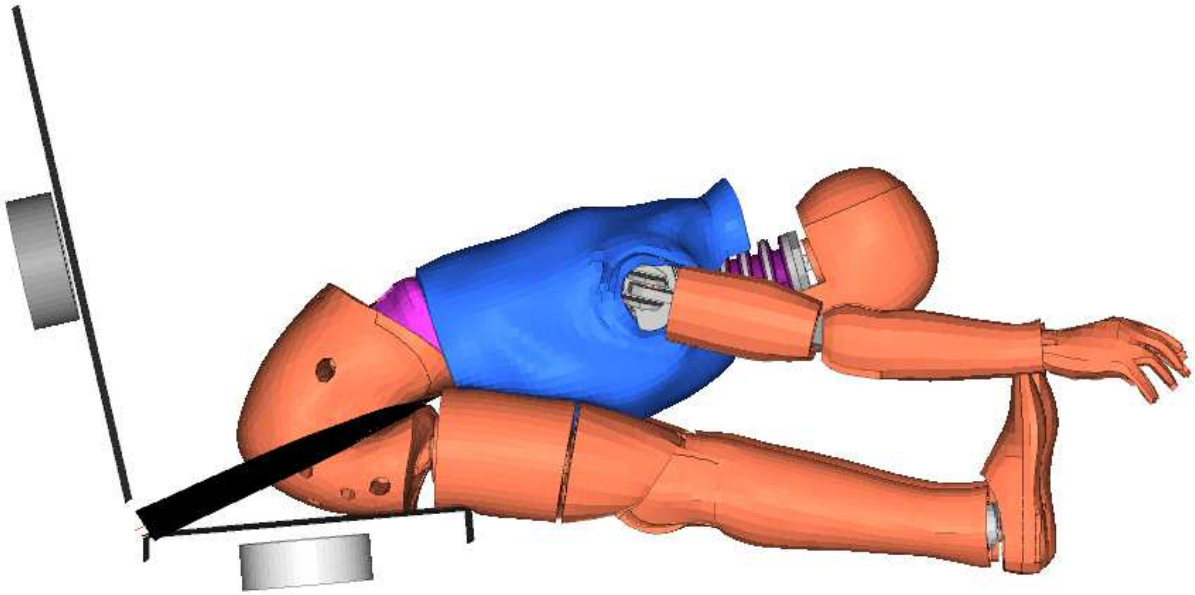

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AEROSPACE ANALYSIS METHODS AND TOOLS

Frank NJILIE, Ph.D – Workshop on Dynamic Modeling and Simulation - EASA Hq – Köln 30th August 2019

Altair

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OUTLINE

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OUTLINE

- Introduction
- Occupant Safety Tools
  - Dummy positioning
  - Seat Deformer
  - Belt routing
- Application : Typical Aircraft Seat Certification
- Conclusion

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INTRODUCTION

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INTRODUCTION : CBA TEST CONDITION

Dynamic test condition	CFR 14 part 23 section 562 Utility airplane	CFR 14 part 25 section 562 Transport airplane	CFR 14 part 27 section 562 Normal rotorcraft	CFR 14 part 29 section 562 Transport rotorcraft
Test 1 (vertical)				
Variation in the downward velocity (m/s) >=	**9.45 (31 ft/s)**	**10.67 (35 ft/s)**	**9.1 (30 ft/s)**	**9.1 (30 ft/s)**
Seat Pitch angle (°)	**60**	**60**	**60**	**60**
Seat Yaw angle (°)	**0**	**0**	**0**	**0**
Max acceleration (g) (more severe condition corresponds to the first row seat)	**19/15**	**14**	**30**	**30**
Time of max acceleration (ms)	**50/60**	**80**	**31**	**31**
Floor deformation (°)	**None**	**None**	**10 Pitch / 10 Roll**	**10 Pitch / 10 Roll**
Test 2 (horizontal)				
Velocity (m/s)	**12.8 (42 ft/s)**	**13.4 (44 ft/s)**	**12.8 (42 ft/s)**	**12.8 (42 ft/s)**
Seat Pitch angle (°)	**0**	**0**	**0**	**0**
Seat Yaw angle (°)	**±10**	**±10**	**±10**	**±10**
Max acceleration (g)	**26/21**	**16**	**18.4**	**18.4**
Time of max acceleration (ms)	**50/60**	**90**	**71**	**71**
Floor deformation (°)	**None**	**None**	**10 Pitch / 10 Roll**	**10 Pitch / 10 Roll**

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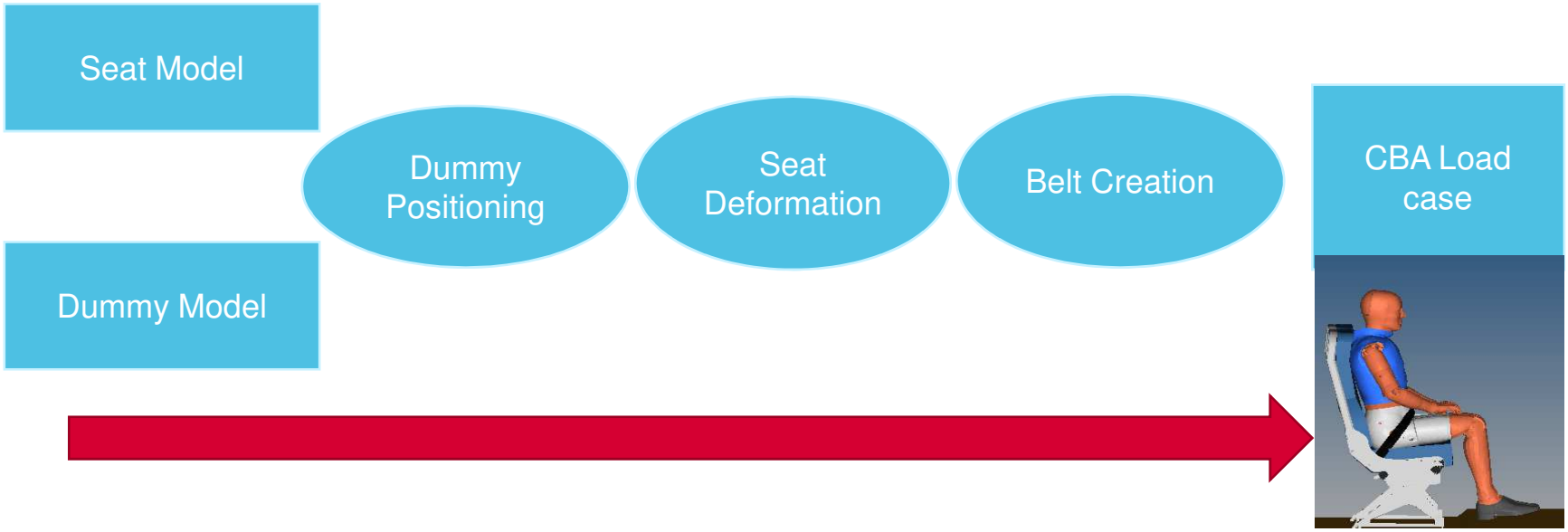
AIRCRAFT SEAT CERTIFICATION BY ANALYSIS

- CBA : Work Flow - From Validated Seat and ATD models



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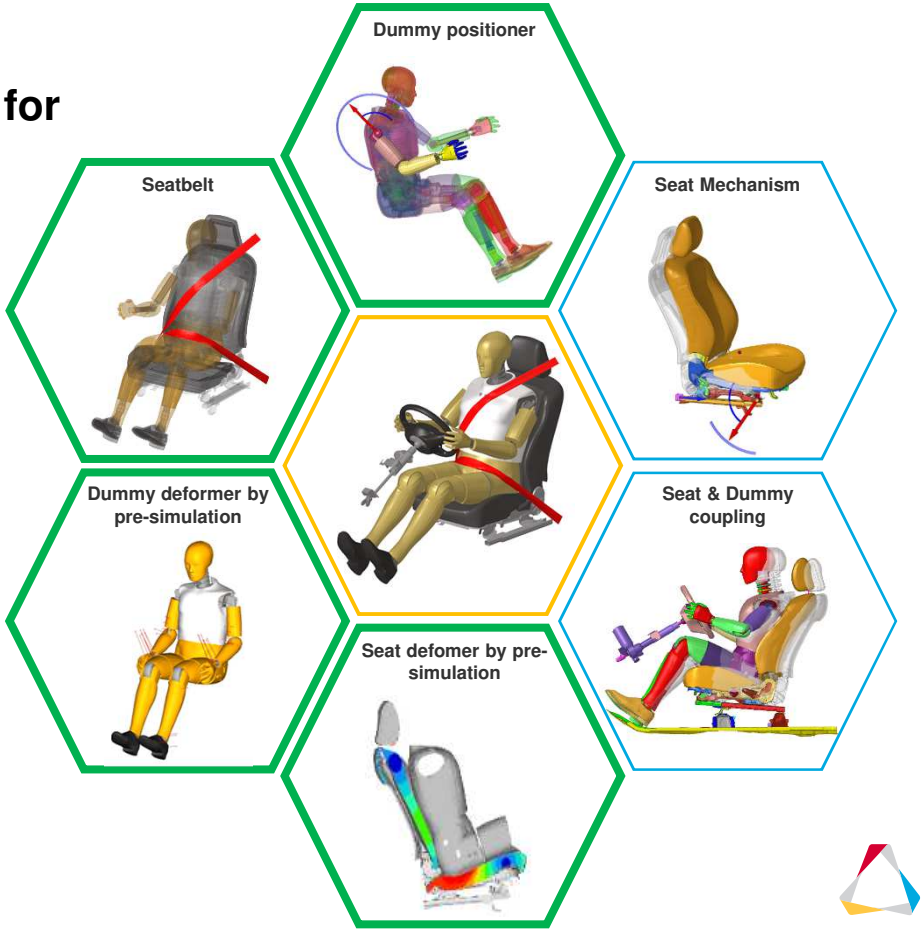
CBA : OCCUPANT SAFETY TOOLS

- HyperMesh 2019 offers a **complete solution for occupant safety application** for RADIOSS



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OCCUPANT SAFETY TOOLS

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DUMMY POSITIONING

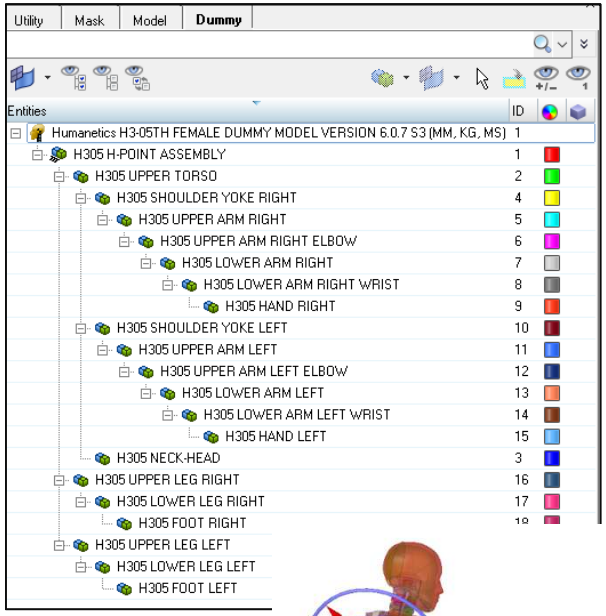
Geometric dummy positioning

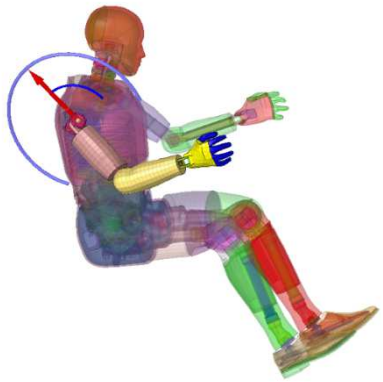
- Cannot avoid intersection
- Do not take into account material properties

Solution → Dummy positioning by simulation

Prerequisite for the effectiveness of the simulation method:

- ✓ the process not be time consuming
- ✓ All dummy segment shall be positioned simultaneously





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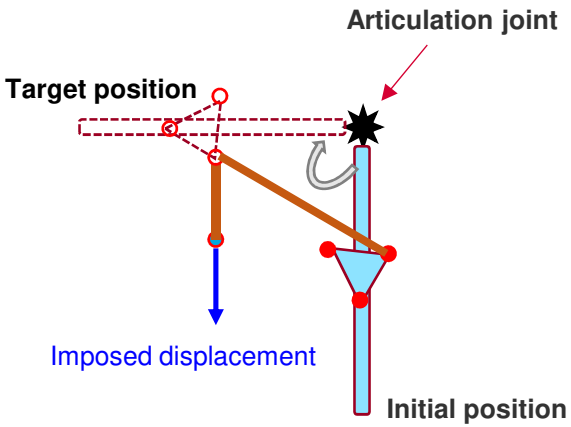
DUMMY POSITIONING : MARIONETTE METHOD



- Node @ initial position
- Node @ target position
- Additional node to define pulley element

```
#---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|----9----|---10----|
/DUMMY_START/1
HYBRID II 50TH dummy model - VERSION 2.1 S3 (mm, kg, kN, ms)
#---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|----9----|---10----|
/HPOINT/1500000
DUMMY HPOINT
#                Rx                  Ry                  Rz                skew
                  0                   0                   0                   0
#---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|----9----|---10----|
/ASSEMBLY/1
Torso
#   subset     grnod    childs    presim
         1         1         4         1
#subset id
        28
# grnod id
   1515091
#    child     Joint      node      dofs
         2   1500913   1500100         1-69.999949 179.99999         0         0         0         0
         3   1500914   1500101         1-180.00001 69.999985         0         0         0         0
         4   1500904   1500112       123-60.034377  59.96556-50.000158 19.999758-14.999965 55.000008
         5   1500905   1500113       123-59.999969 59.999968-49.999957 19.999958-54.999987 14.999986
#       N1        N2        N3
   1522158   1525244   1526340
#---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|----9----|---10----|
/ASSEMBLY/2
Yoke Left
#   subset     grnod    childs    presim
         1         1         1         1
#subset id
         2
# grnod id
   1514006
#    child     Joint      node      dofs
         6   1500911   1500102         1       -60 79.999946         0         0         0         0
#       N1        N2        N3
   1702139   1702310   1702024
```

+++ Amount of displacement imposed is **exactly** computed for each node

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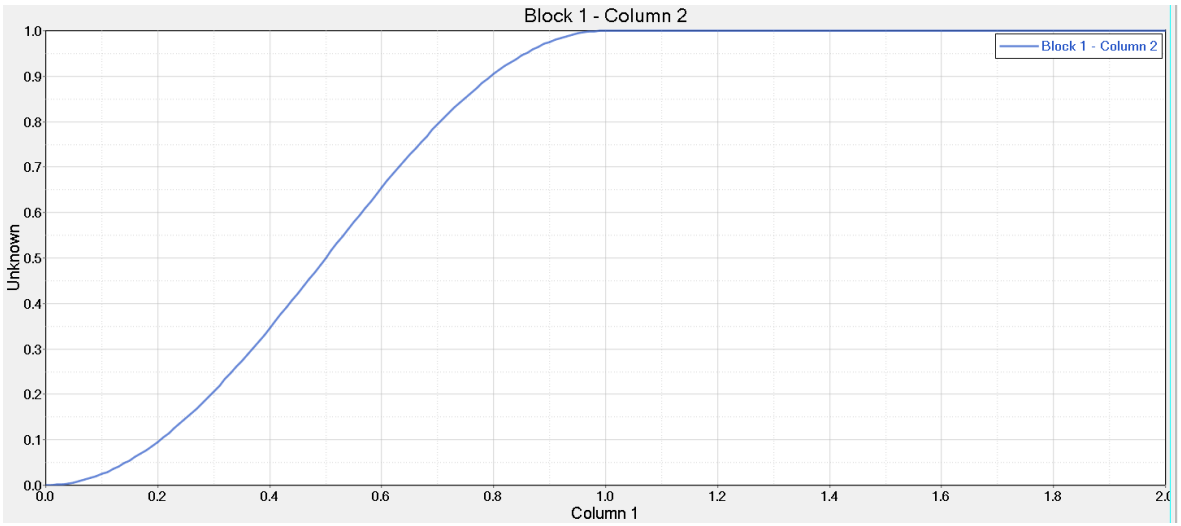
DUMMY POSITIONING : MARIONETTE METHOD

Typical function used

Scale X and Y axis according to among of displacement and time duration



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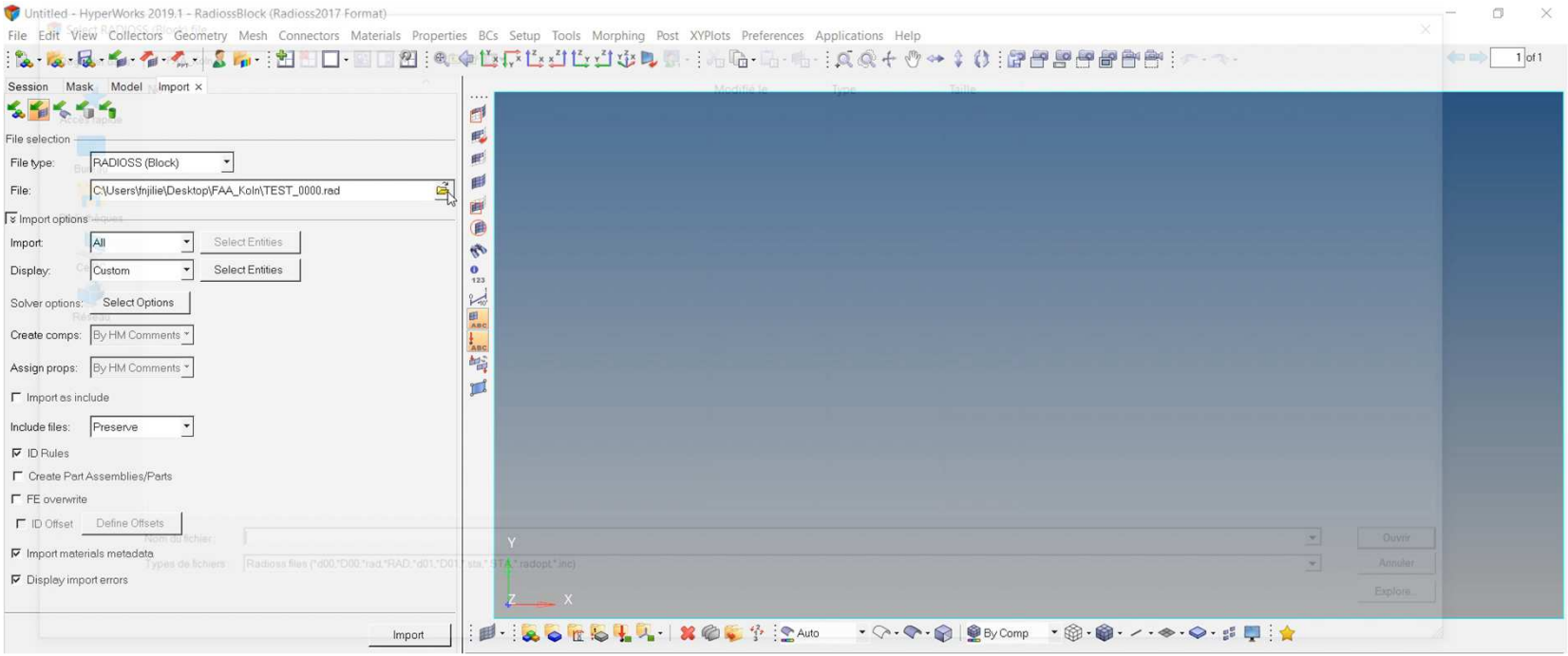
DUMMY POSITIONING : MARIONETTE METHOD



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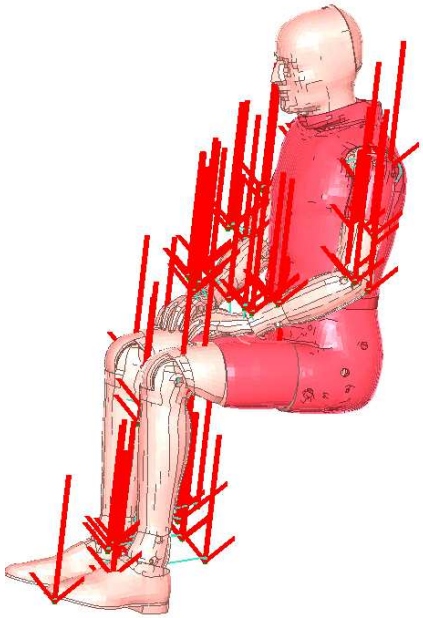
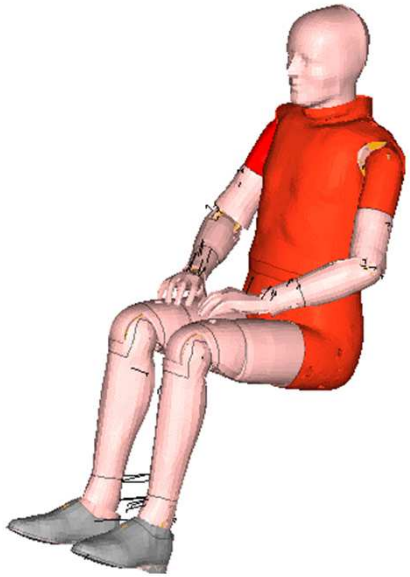
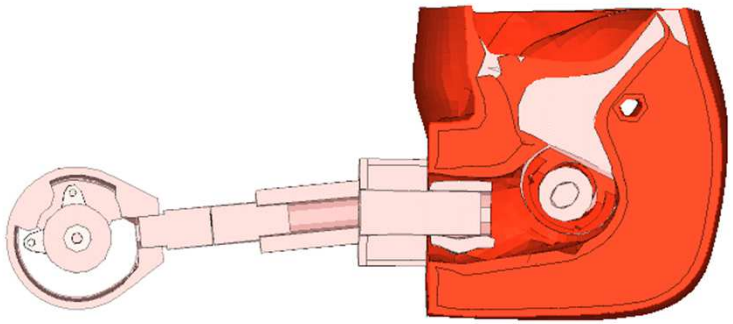
DUMMY POSITIONING : MARIONETTE METHOD



Boundary conditions automatically created by HC/HM positioning module





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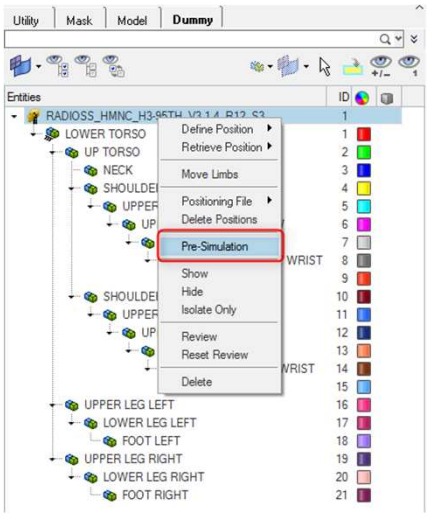
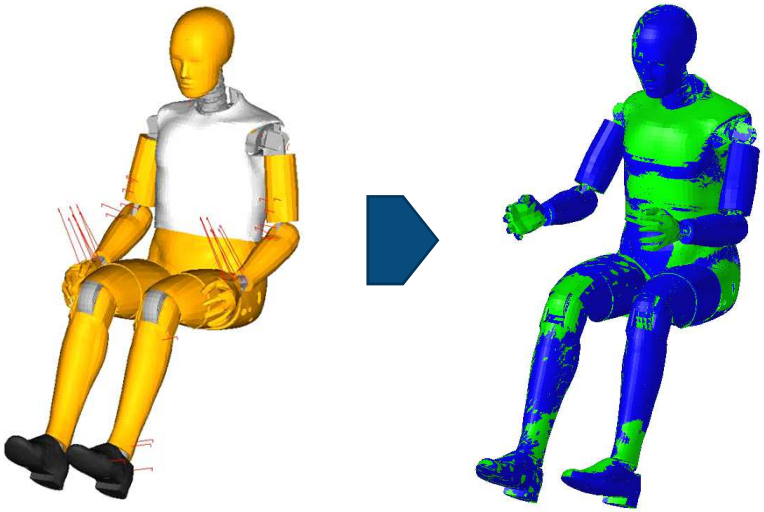
DUMMY POSITIONING : MARIONETTE METHOD





Initial position from dummy positioner

Simulated dummy position

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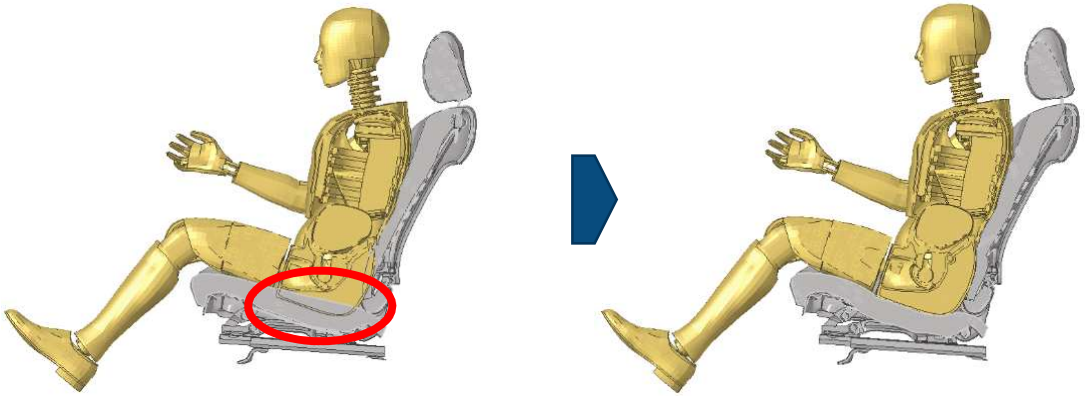
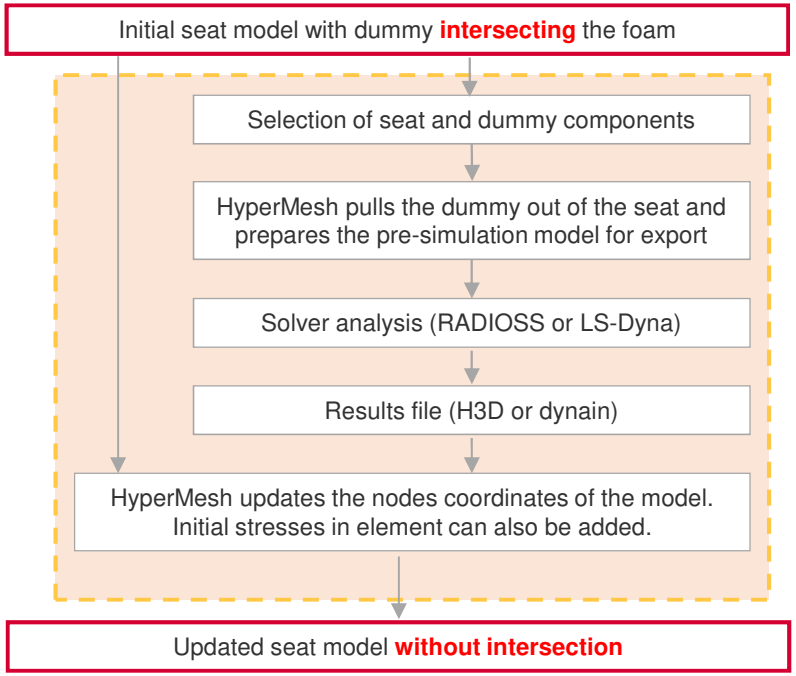
SEAT DEFORMER

- Intersections often occurs when seating the dummy on undeformed cushion foam





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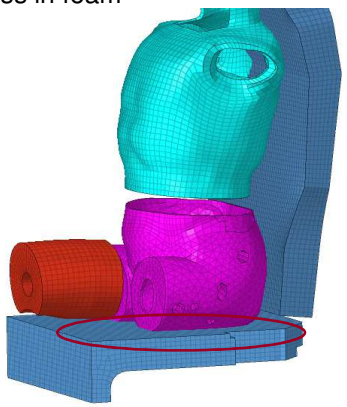
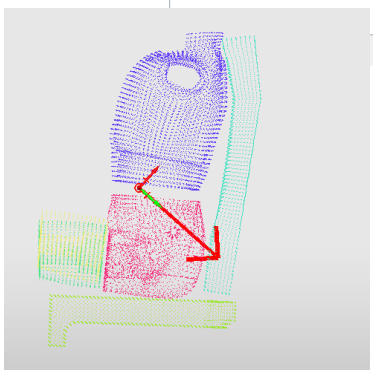
SEAT DEFORMER

- How does it work

  - ✓ Set dummy components as Rigid Body
  - ✓ Translate the dummy to get rid of the intersection
  - ✓ Define adequate load case and BCS to bring back the dummy to the target position
  - ✓ Export the deck and run it
  - ✓ Update seat geometry
  - ✓ Possible to account for initial stress in foam





PreSimulation Tool

Name	Value
	PreSimulation
PreSimulation Set-Up	
PreSimulation type	Seat Deformer
Unit System	mm,ms,kg
Dummy	4 Components
Seat	2 Components
Fixed Nodes Of Seat	5 Nodes
Dummy Displacement Direction	-0.70710678118655, 0, -0.70710678118655
Export File	C:/Users/fnjilie/Desktop/FAA_Koln/toto_0000.rad
Generate XREF for initial stresses	☑
Simulation Parameters	
Dummy Velocity	0.1
Time Step	0.001
Scale Materials Density	10.0
Dummy Displacement Step	10.0
Friction	0.0
Stmin	1.0
Gap_Min	0.5
IGAP	2: variable gap + gap scale correction of the compute...

Export | Import h3d File | Close

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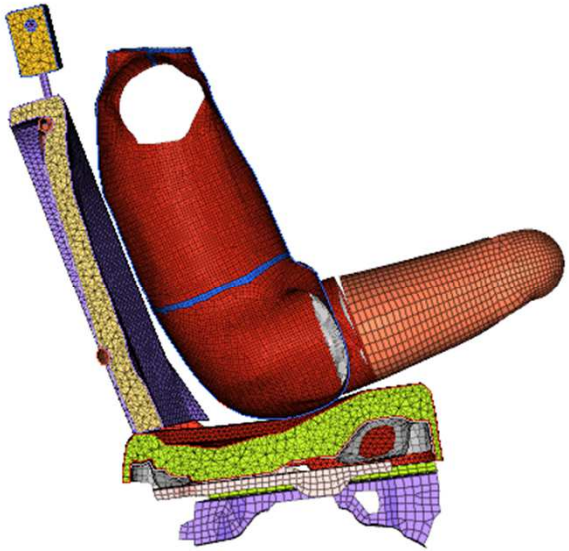
SEAT DEFORMER



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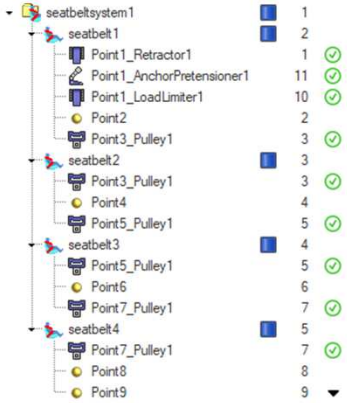
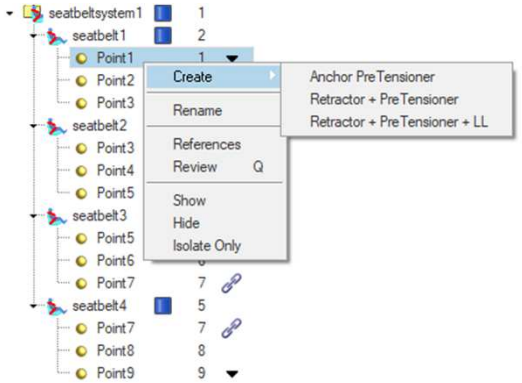
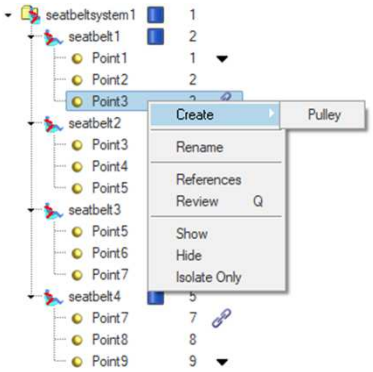
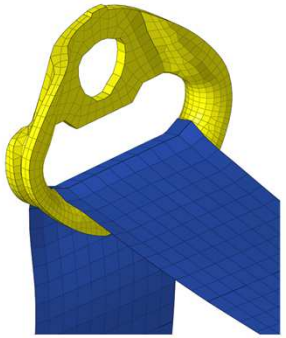
SEATBELT TOOL

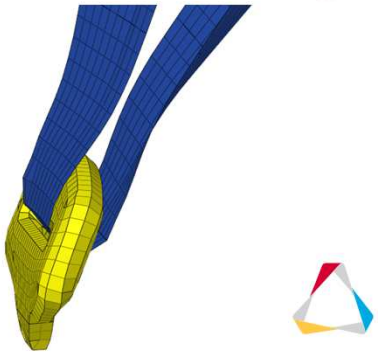
- **Seatbelt Tool:**
  - Allow the full modeling of a seatbelt system
  - Including slipring, retractor, pre-tensioner, load-limiter elements
  - Automatic definition of contact between belt and wrapping components
  - Modeling of full shell meshed seatbelt
  - Automatic seatbelt update upon dummy











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SEATBELT TOOL

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APPLICATION : AIRCRAFT SEAT CERTIFICATION BY ANALYSIS

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AIRCRAFT SEAT CERTIFICATION BY ANALYSIS

- Typical Seat (Burn Seat)

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AIRCRAFT SEAT CERTIFICATION BY ANALYSIS

- Horizontal Test : 2 Points Belt, 0°,16G

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AIRCRAFT SEAT CERTIFICATION BY ANALYSIS

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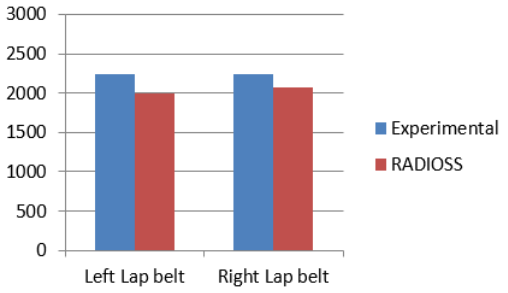

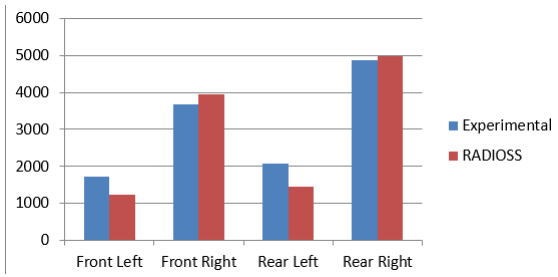

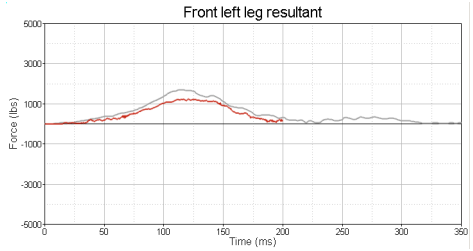

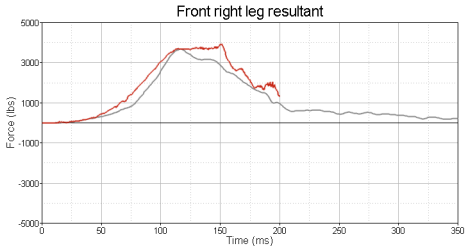

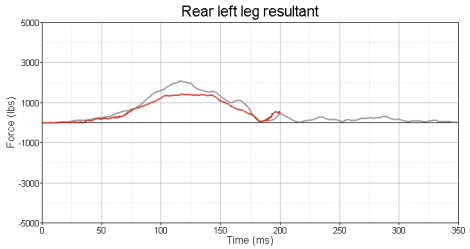

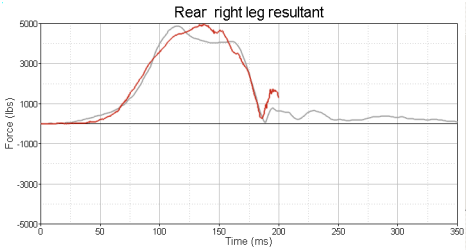

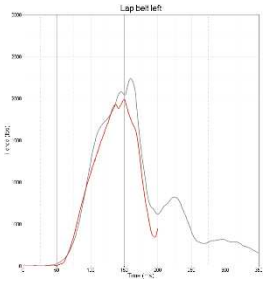

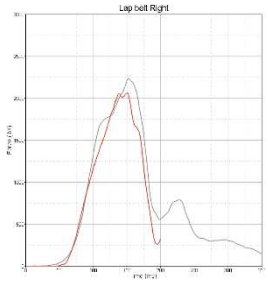

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AIRCRAFT SEAT CERTIFICATION BY ANALYSIS

- Vertical Test : 2 Points Belt, 60°,19G

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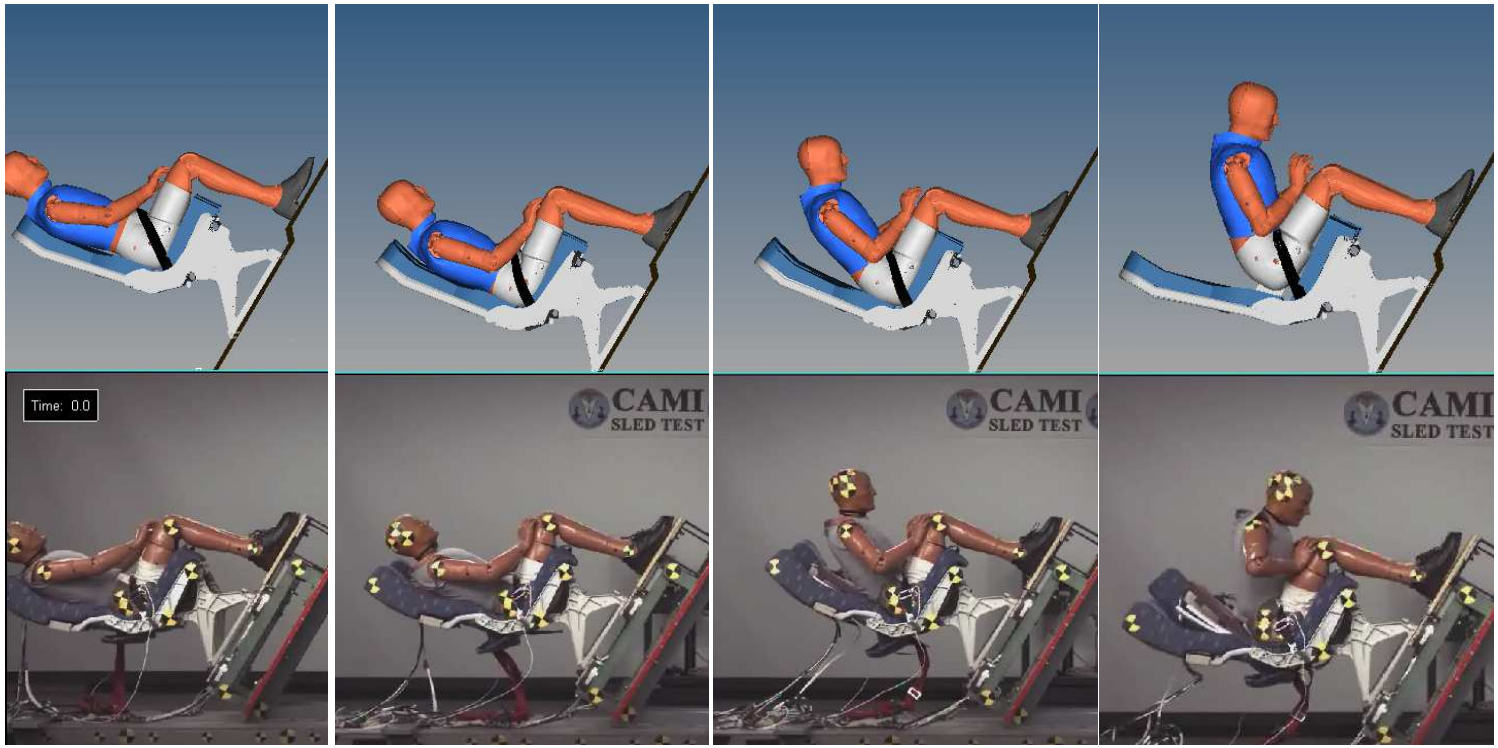
AIRCRAFT SEAT CERTIFICATION BY ANALYSIS



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AIRCRAFT SEAT CERTIFICATION BY ANALYSIS

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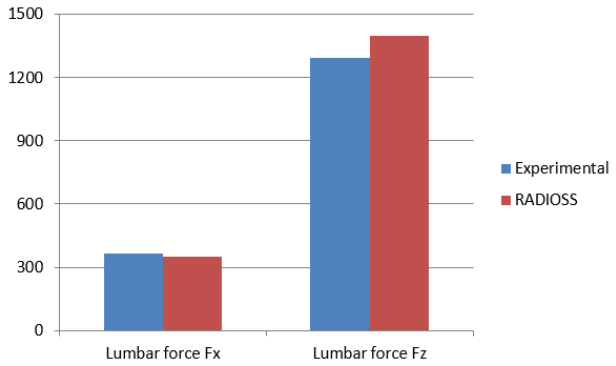

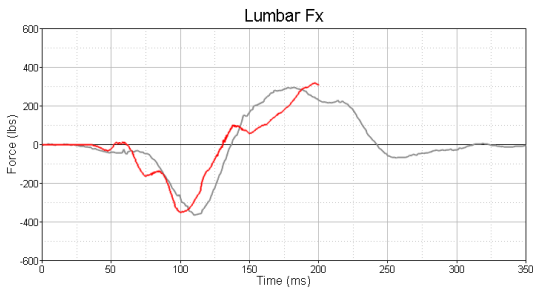

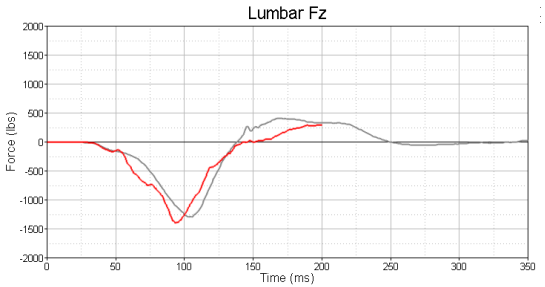

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CONCLUSION

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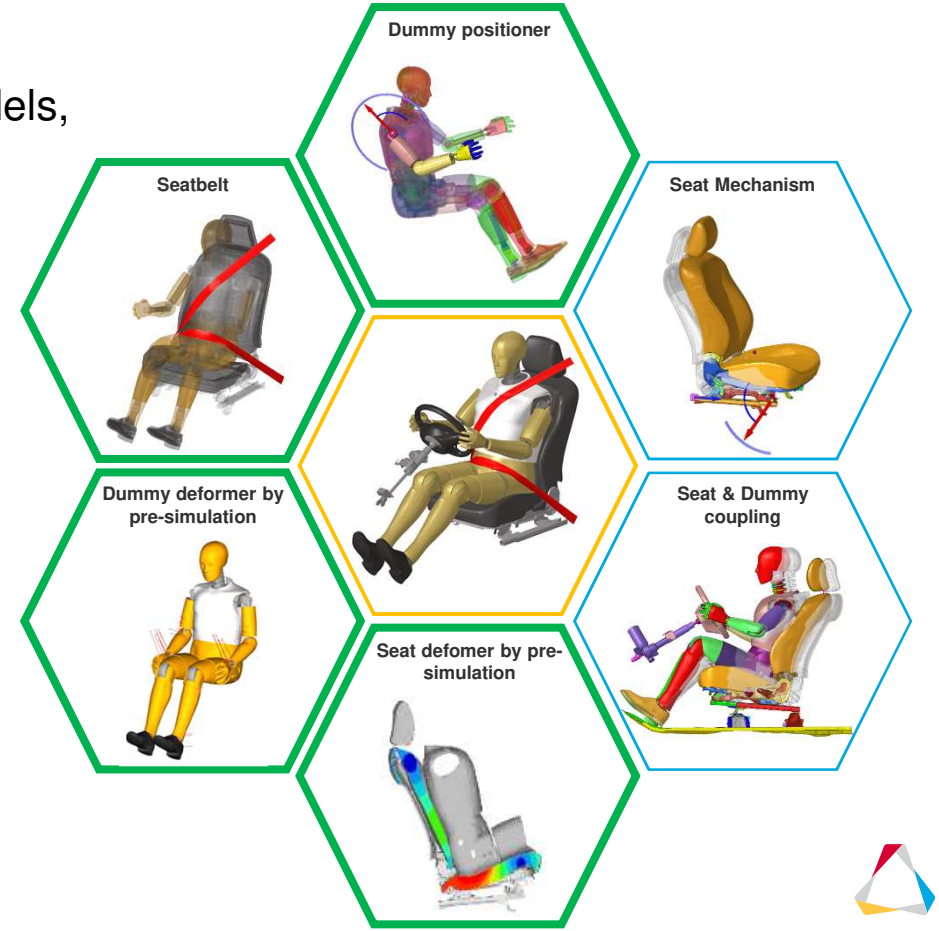
CONCLUSION

- Beside validated ATDs Models and Seat Models, CBA is a process that requires advanced occupant safety tools
- A complete set of occupant safety tools are available from HM 2019
- RADIOSS and LS Dyna solvers are fully covered



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