Virtual simulations of side sled testing

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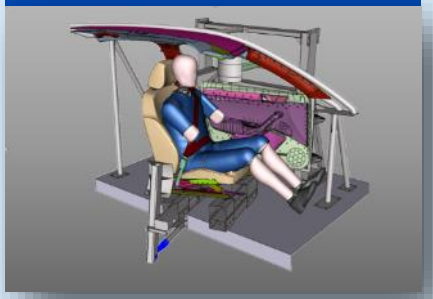
16th LS-DYNA Forum 2022/10/12

TÜV SÜD Czech. Mobility Division.

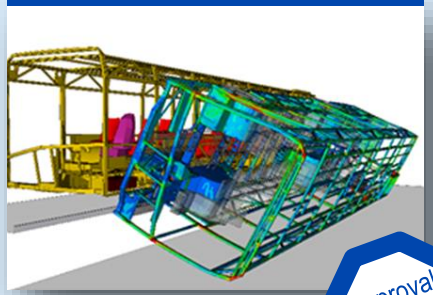
Pas. safety physical & **Virtual testing**



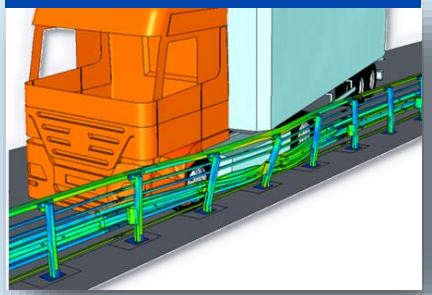
ADS physical & **Virtual testing**

Cyber Security

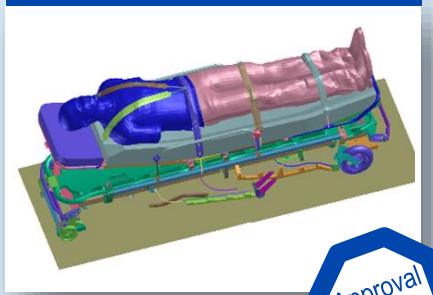
Bus roll-over



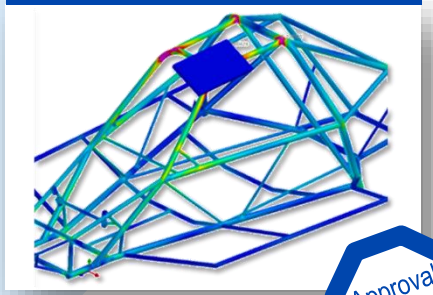
Road infrastructure



Medical equipment



FIA rollcage

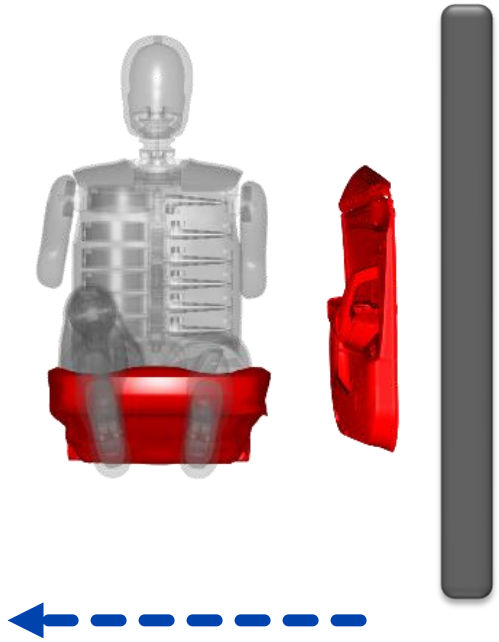


Functional Safety

Side sled testing. Methods.

Acceleration approach

With active door intrusion



Advantages:
- Precise intrusion control
- Variable design space
- Accurate results

Side s

Accelera

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DYCOT. Laboratory Equipment.

INSTRON CSA Advanced Catapult:

- **Max. force 2.5 MN**
- **Max. acceleration 90G at 1000 kg/35G at 5000 kg**
- Max. deceleration -35G at 800 kg
- Max. speed 100 kph
- Max. gradient 14 G/ms
- Low G simulation 5-12G
- **Repeatability 0.5 kph or 1G**
- Working stroke 1.7 m
- Sled pallet 3.5 x 1.8 m
- **Pulse iteration within 3 shots**

Facility

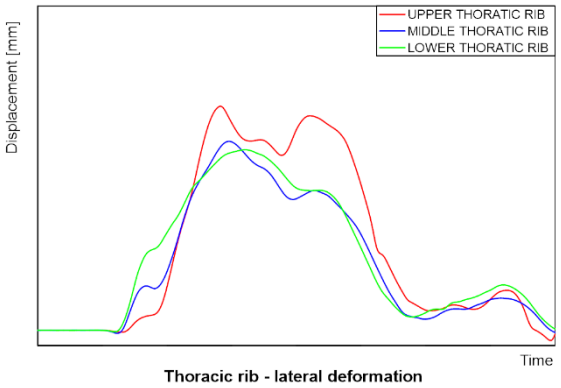
DYCOT. Laboratory Equipment.

ENCOPIM ALIS HDA actuators:

- **3 independently controlled actuators**
- Actuators with **force up to 60 or 120 kN**
- Maximum actuator stroke up to 500 mm
- Sled pallet 1.5 x 1.8 m
- Repeatability ±5% of controlled stroke
- Feed forward learning process
- **Fully controlled movement of actuators during the whole test** (close-loop control system)

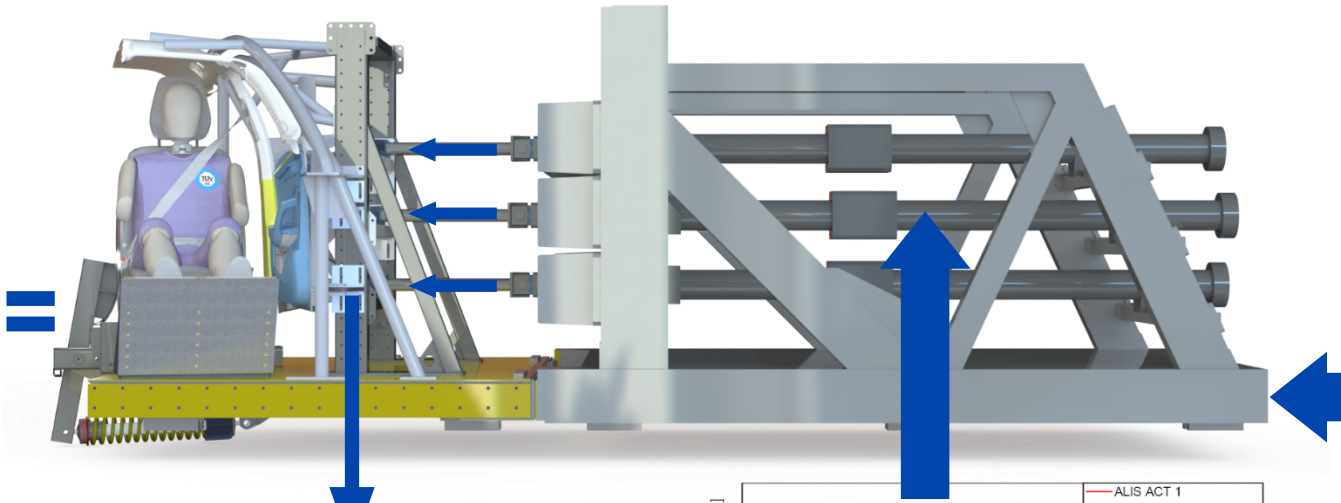
Facility

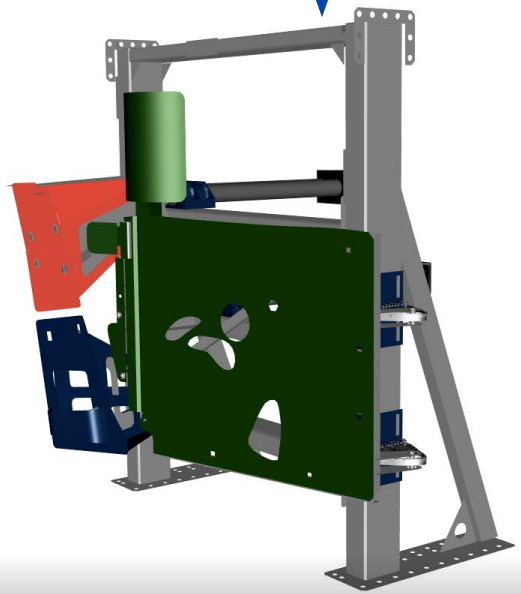
ALIS. Side sled tests with intrusion.

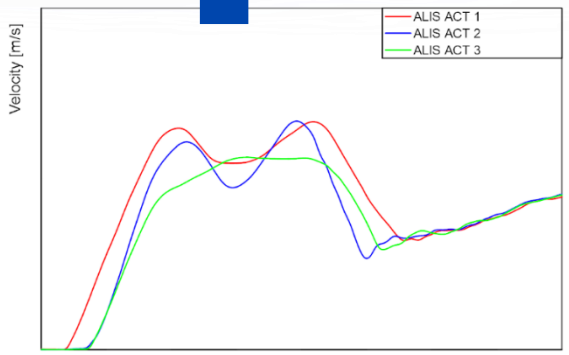


Thoracic rib - lateral deformation

- Results are biomechanical loads on the dummy or airbag deployment behavior

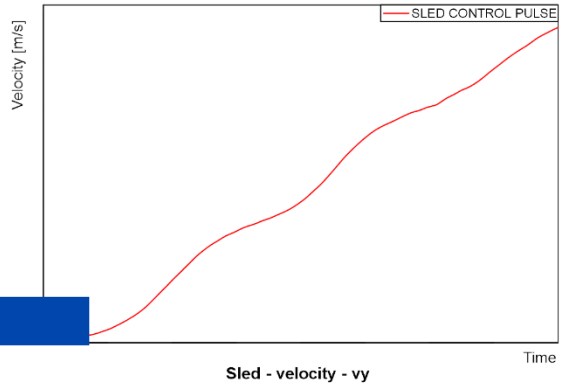






ALIS - velocity - vy

- ALIS actuators produce door intrusion, control pulses determined from reduced ALIS simulation, optionally corrected from crash test data



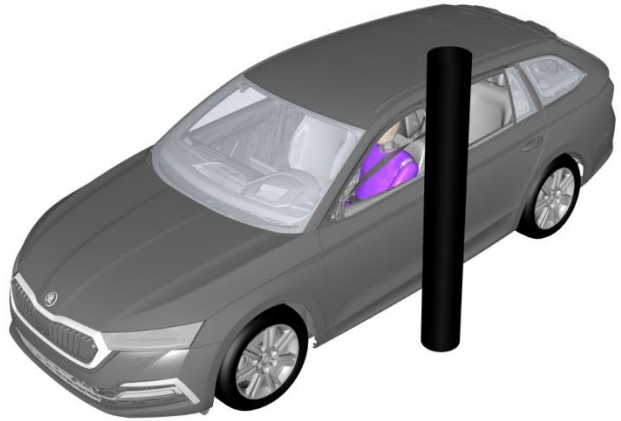
Sled - velocity - vy

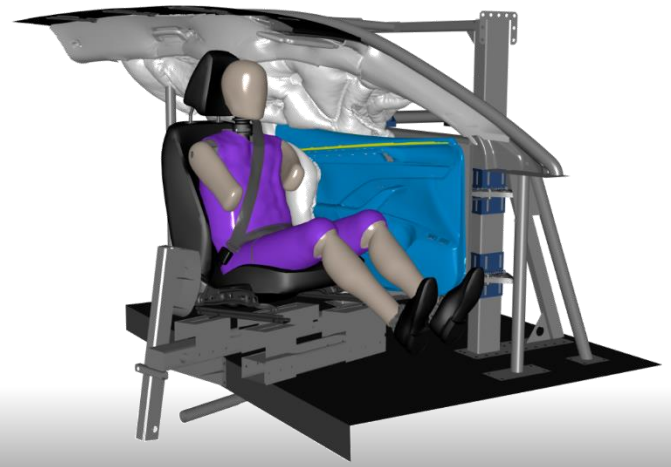
- Global CATAPULT control pulse determined from full scale simulation or crash test data

Crash simulation decomposition.

Crash decomposition:

- **Door and car trim**
- **Seat belt**
- **Airbags**
- **Seat**
- **Positioned dummy**
- **Any part important for interior deformation**



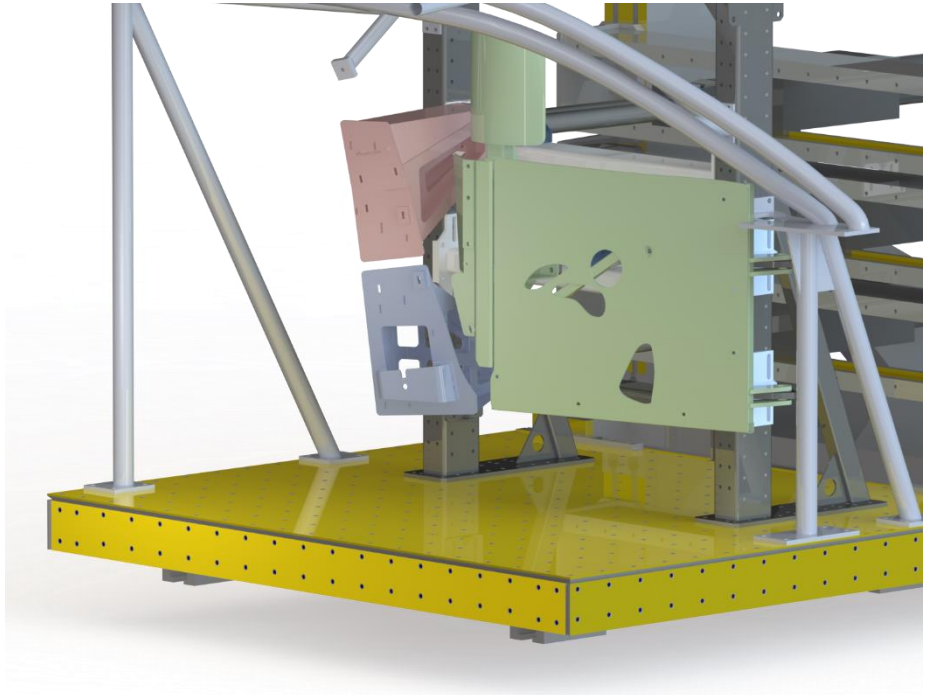


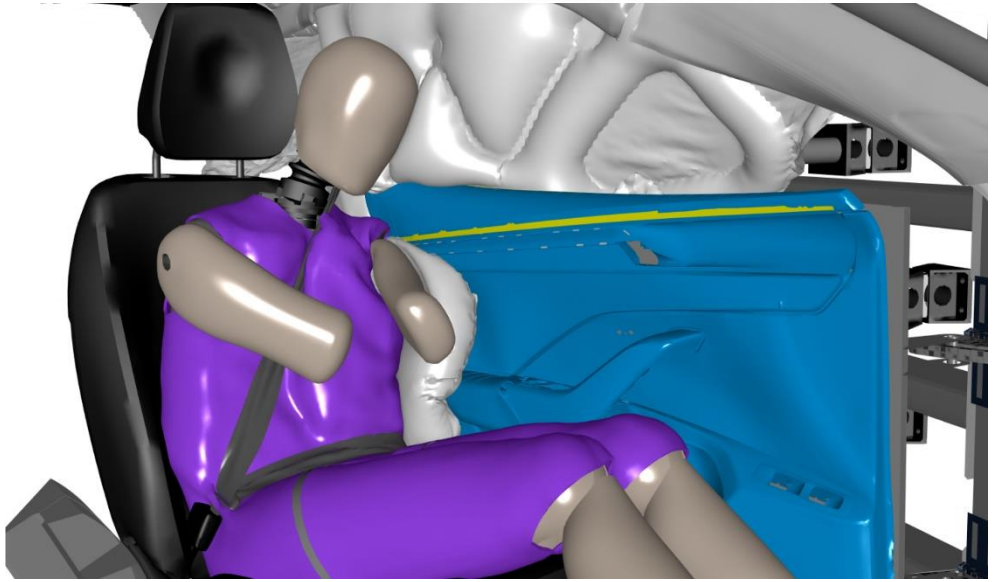
ALIS. Preparation phase.

- CAD design of INTRUSION MECHANISM
  - Each project has unique intrusion mechanism depends on:
    - Load case (xNCAP; IIHS;…)
    - Stiffness of the car body
    - Object of customer focus

- FE analysis of INTRUSION MECHANISM
  - Enclosed the behavior to real car structure

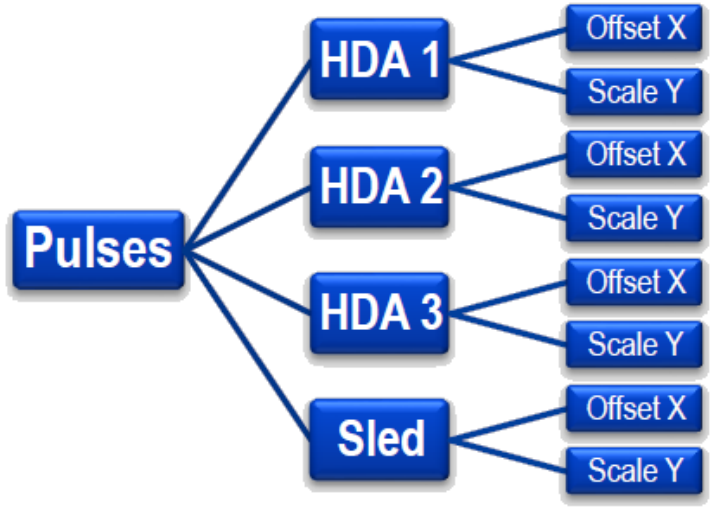
- ALIS system tuning to biomechanical loads
  - Iterative process
  - DoE analysis

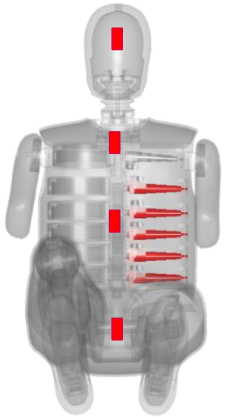


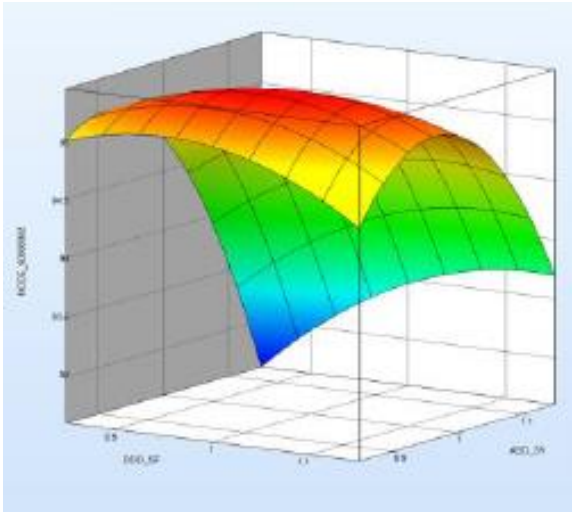


DoE analyses in ALIS process.

- Defining variables
  - Control pulses sled (Offset X, Scale Y)
  - Control pulses ALIS (Offset X, Scale Y)
    - 8 variables 8D space, 200 variants
- Define responses
  - Maximal deformation of ribs
  - Dummy kinematics (velocity in Y direction)
- Response surface
  - Correlation with crash simulation

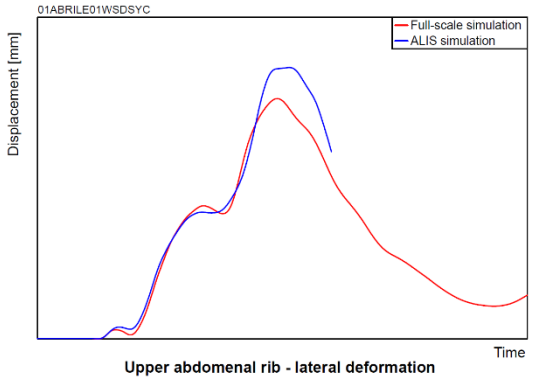




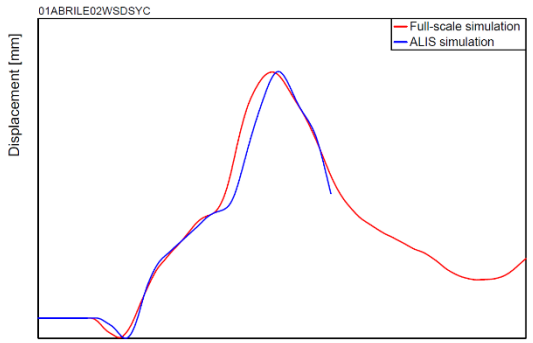


Simulation. Results. Biomechanical load.

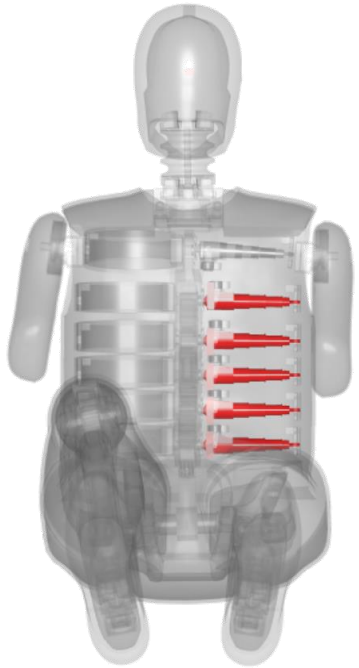
- Side POLE test
- Ribs compression DSY

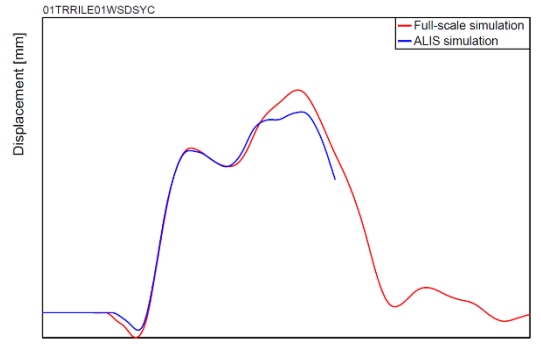


Upper abdomenal rib - lateral deformation

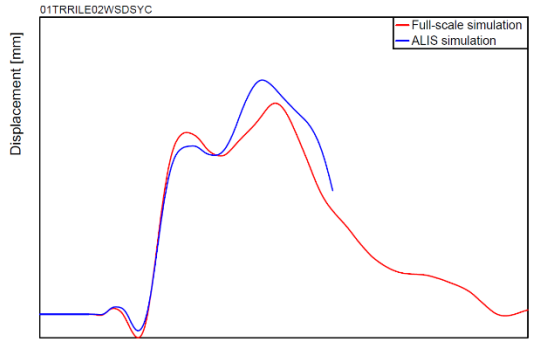


Lower abdomenal rib - lateral deformation

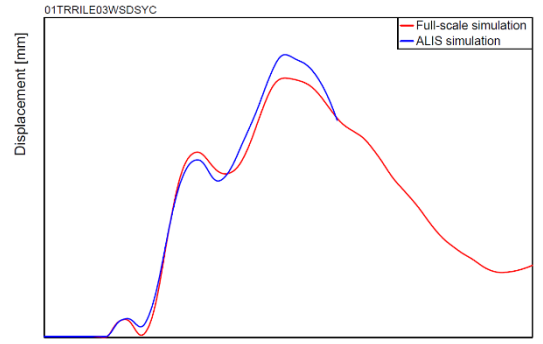




Upper thoracic rib - lateral deformation



Middle thoracic rib - lateral deformation



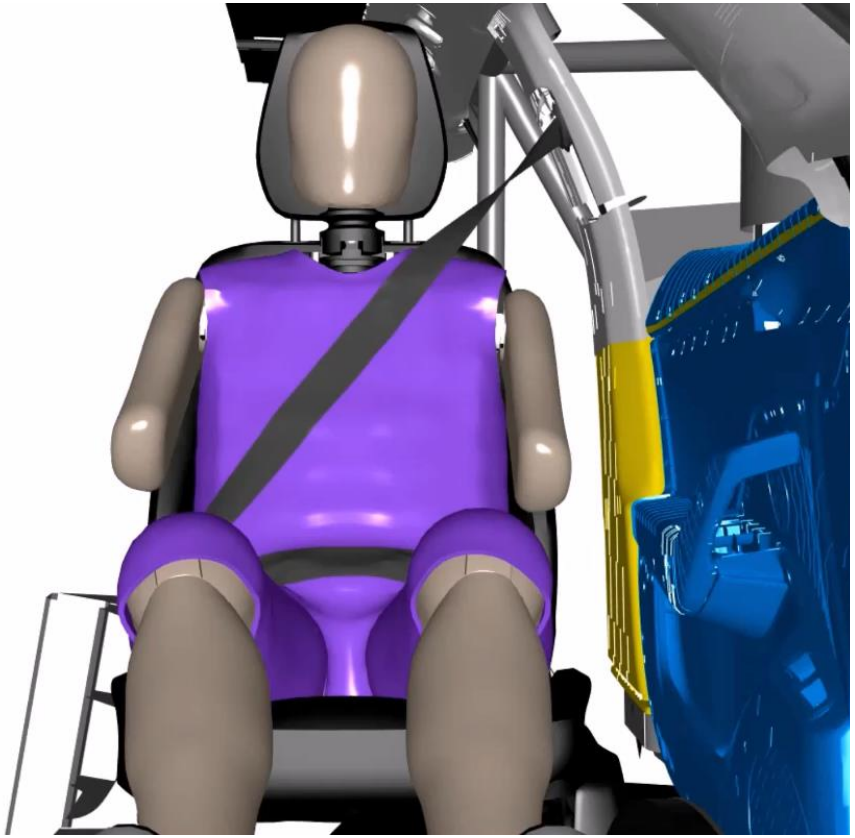
Lower thoracic rib - lateral deformation

ALIS. Validation/Development.

- **Validation tests**
  - To adapt ALIS response to simulation response
- **Development tests**
  - To evaluate the safety system performance acc. to test matrix
  - Different SAB, CAB, HAB, vents, folding, TTF etc.
  - Structural parts development
  - Variable dummy configuration
- **Results**
  - Sensibility matrix
  - Recommendation of restraint system set-up
  - Validation of FE models

ALIS. Correlation.

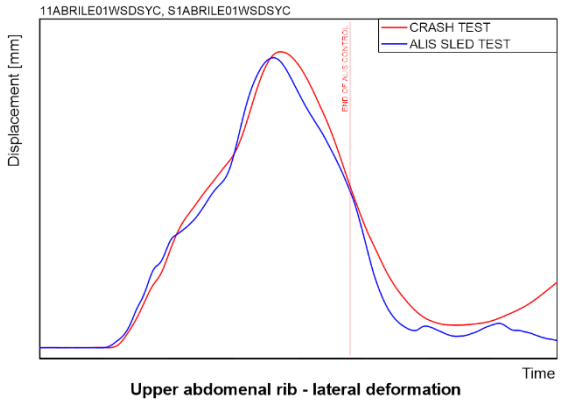
ALIS Simulation



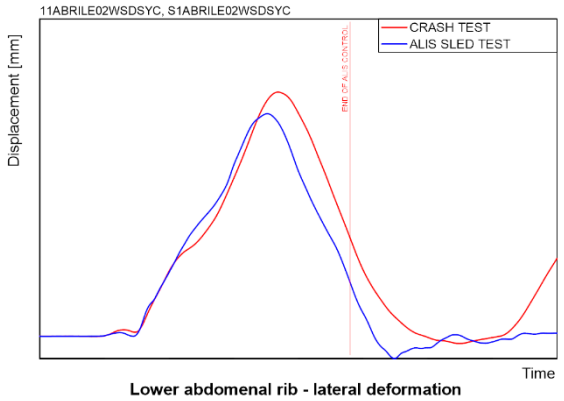
ALIS test

ALIS. Results. Biomechanical load.

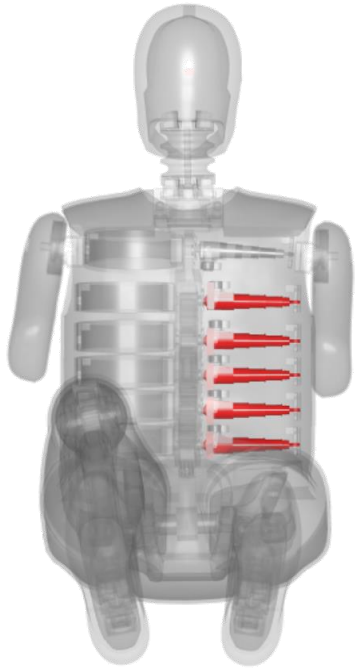
- Side POLE test
- Ribs compression DSY

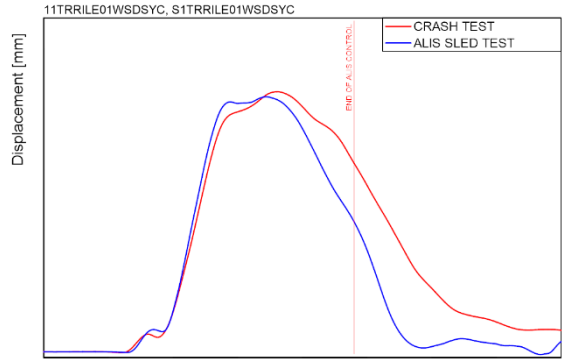


Upper abdomenal rib - lateral deformation

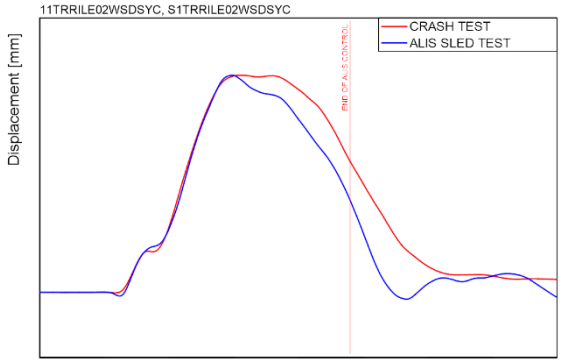


Lower abdomenal rib - lateral deformation

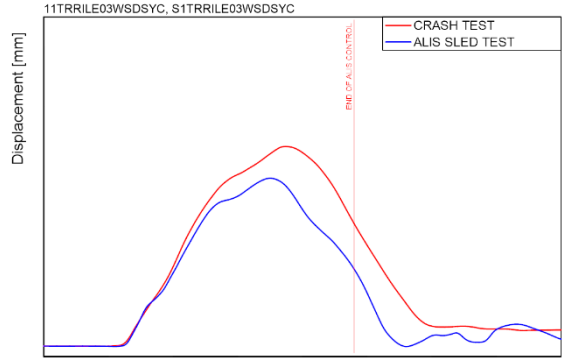




Upper thoracic rib - lateral deformation



Middle thoracic rib - lateral deformation

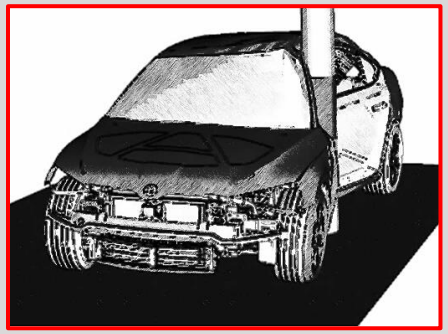


Lower thoracic rib - lateral deformation

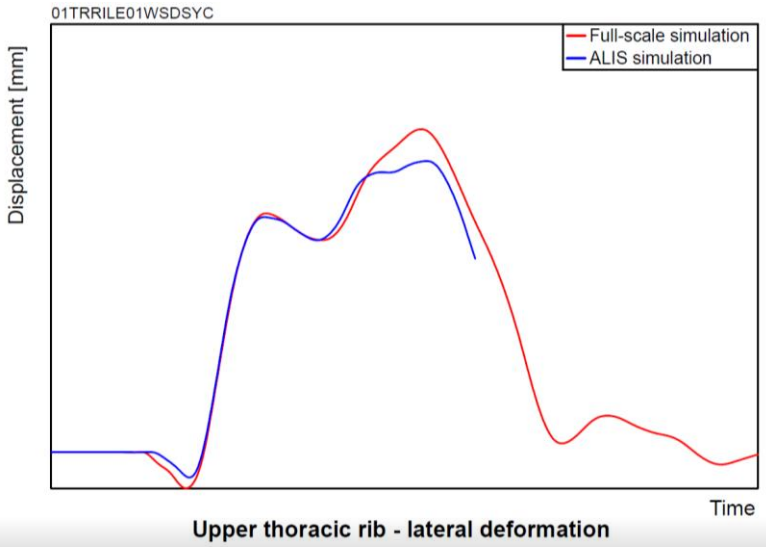
Side sled testing approach.

Simulations

Full-scale simulation



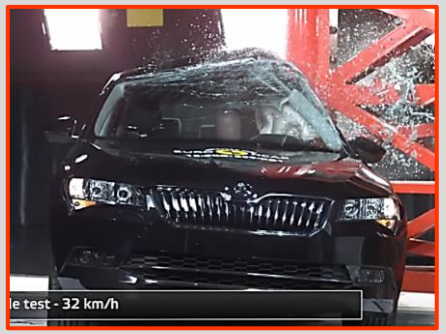
Reduced ALIS simulation



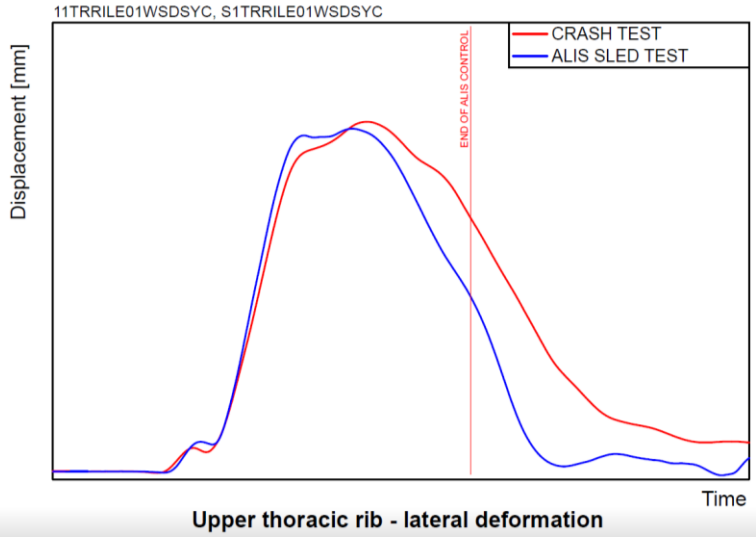
Upper thoracic rib - lateral deformation

Experiment

Crash test



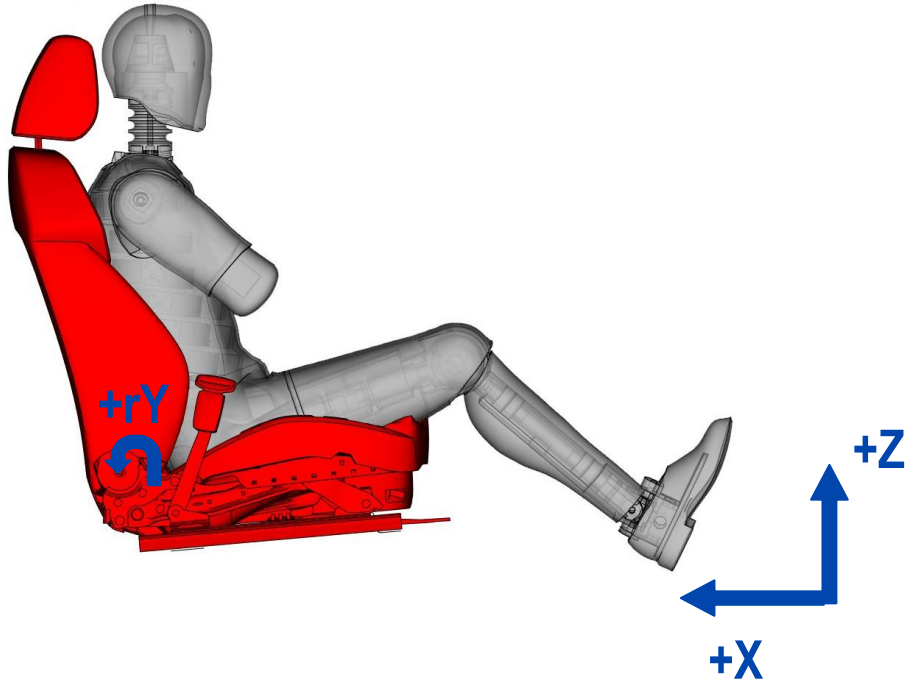
ALIS side sled test

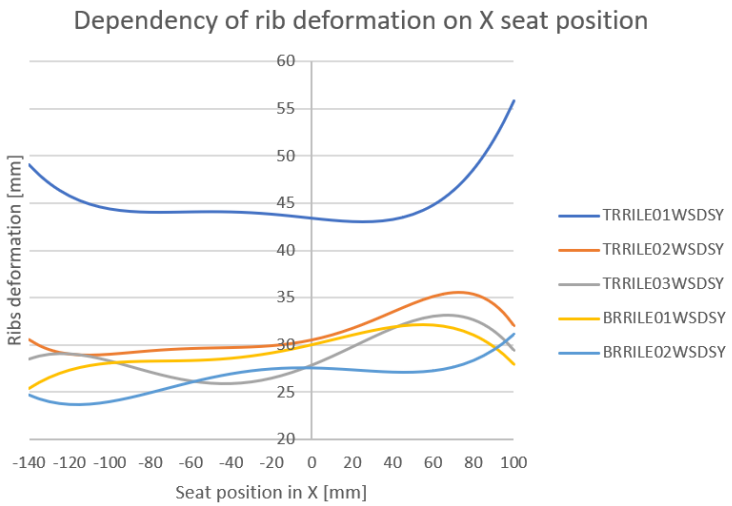


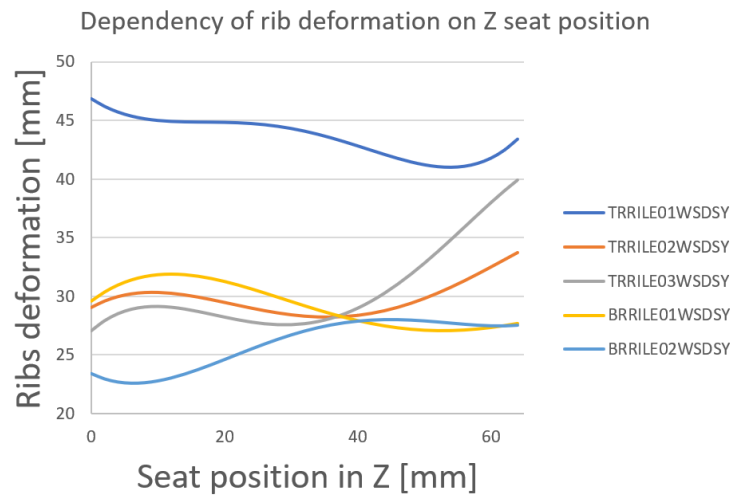
Upper thoracic rib - lateral deformation

DoE dummy position.

- **Motivation**
  - Robustness of restrain system
  - Definition of critical position
- **Setup**
  - WorldSID dummy - NCAP standard position
  - Seat movement X and Z, backrest rotation
    - In the range of standard seat movement
  - Tests are focused on rib deflection
- **Results**
  - Map of increasing and decreasing value of rib deflection
  - Map of the peak value is different for every rib
  - Worst case position could be defined for physical test







Conclusion.

Unique task	Combination of FE simulation and sled testing can exactly represent the behavior during the crash test
Speed up!	Development process can be significantly fasten by ALIS sled test
Variability	Sled tests can evaluate robustness of restrain systems and can be applied on new areas of development
Validation	Sled test can dramatically increase validity of component FE models
Results	Three out of four best rated cars in EuroNCAP 2021 were tested on ALIS

Mobility Division

Add value.
Inspire trust.

Virtual simulations of side sled testing

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