Wir leben Autos.

Challenges and Developments in Child Safety CAE

Dr. Srinath Vadlamudi[1]
GME Vehicle CAE - Adam OPEL AG[1]

Content

1. Motivation

2. Child safety CAE Requirements
    a. CRS (Child Restraint System) Data
    b. Pre-Processing
    c. Load case setup
    d. Solver
    e. Post-Processing
    f. Validation

3. Conclusion

Wir leben Autos.

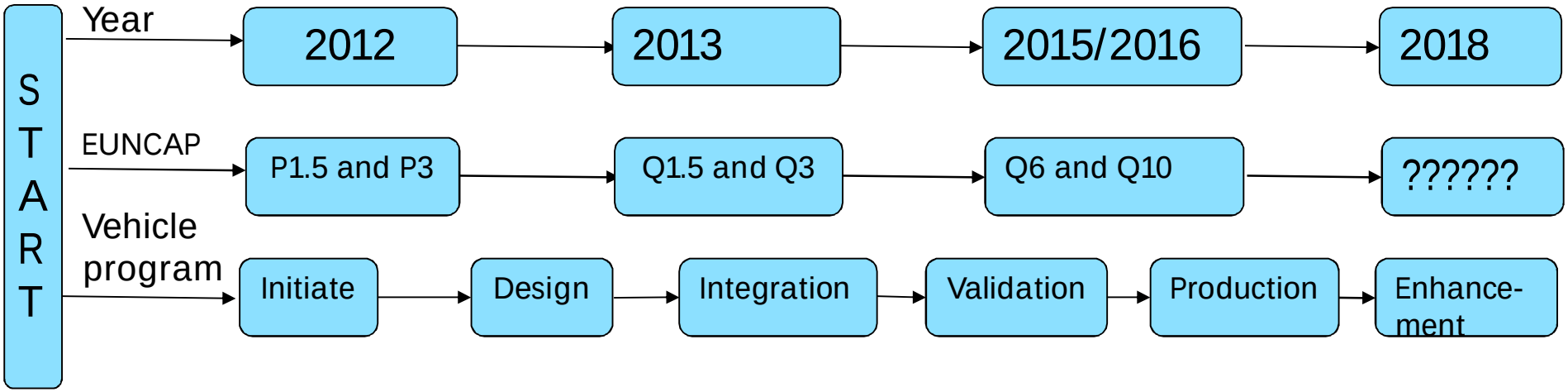
Motivation:

- Support vehicle and seat development process for better child Injury performance through simulation models and parameter variations in vehicle system.
- Minimize hardware tests and support through simulation
- Earlier prediction of Child Injury performance for Legal and NCAP load cases (Ex. Future EUNCAP 2015/2016) through virtual study during vehicle development process
- Documentation of Best practices for future designs

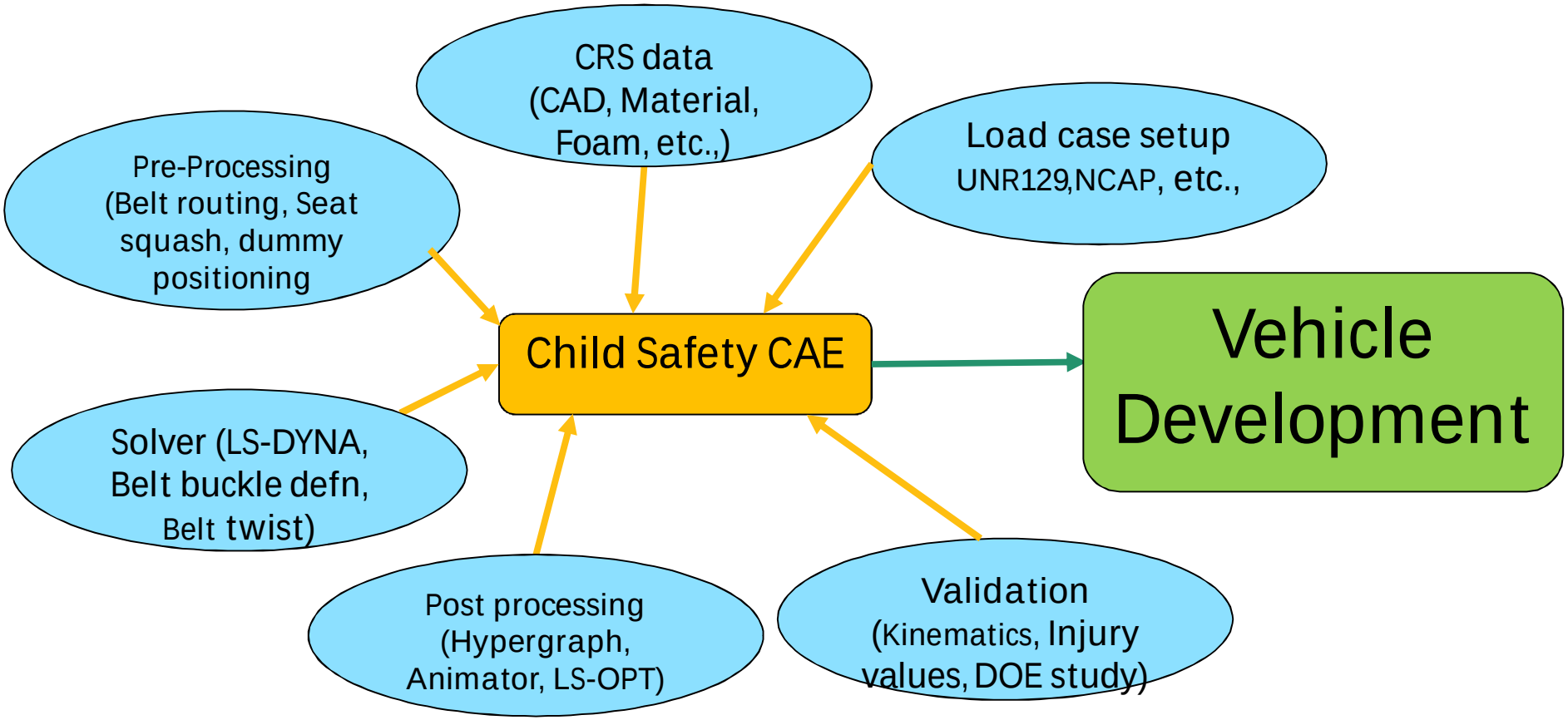
Motivation:

Example

- EUNCAP protocol is becoming more stringent year by year and difficult to achieve maximum star rating performance in coming years
- Child safety has 20% weighting factor to score EUNCAP points and needs Virtual development process in order to reduce Testing costs.
- A good virtual child seat in terms of quality, robustness and predictability is required to match the performance similar to the physical Test.

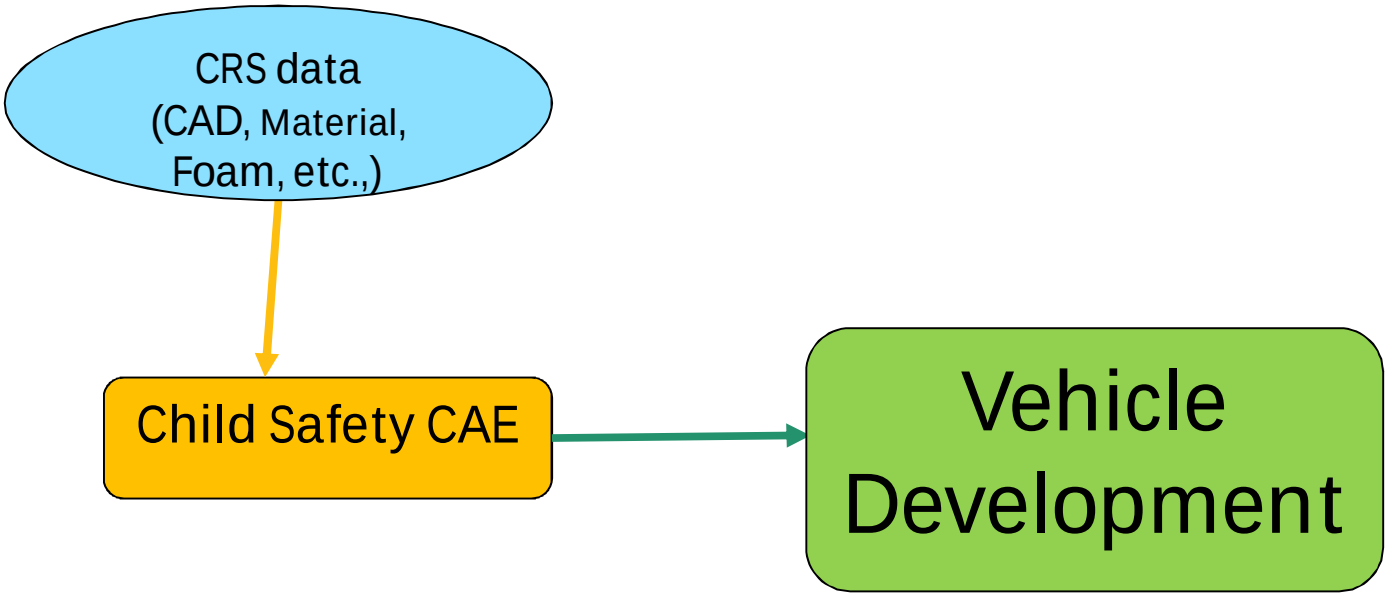


CAE requirements:



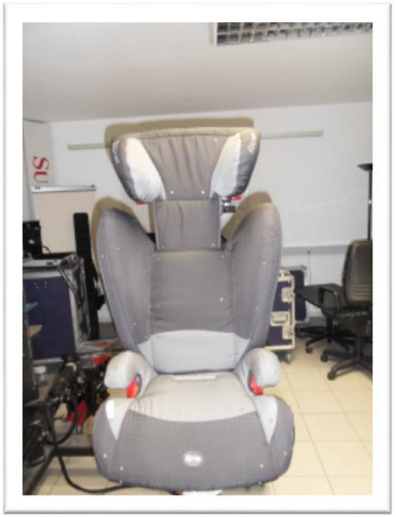
Wir leben Autos.

CRS Data:

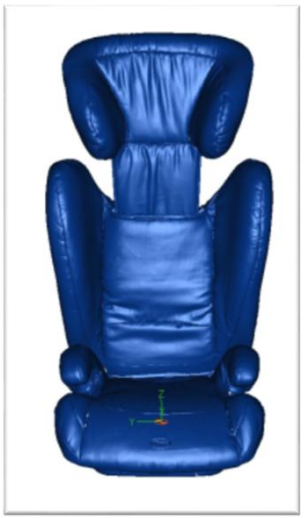

CRS data
(CAD, Material,
Foam, etc.,)
Child Safety CAE
Vehicle
Development

CRS Data:

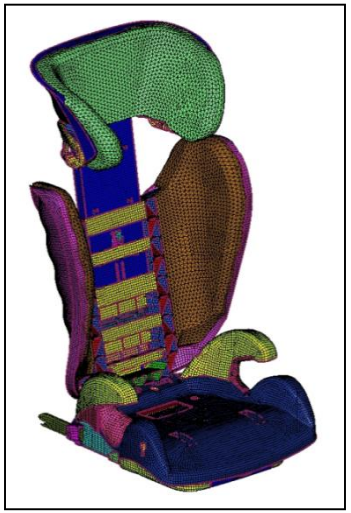
Physical seat



CAD model

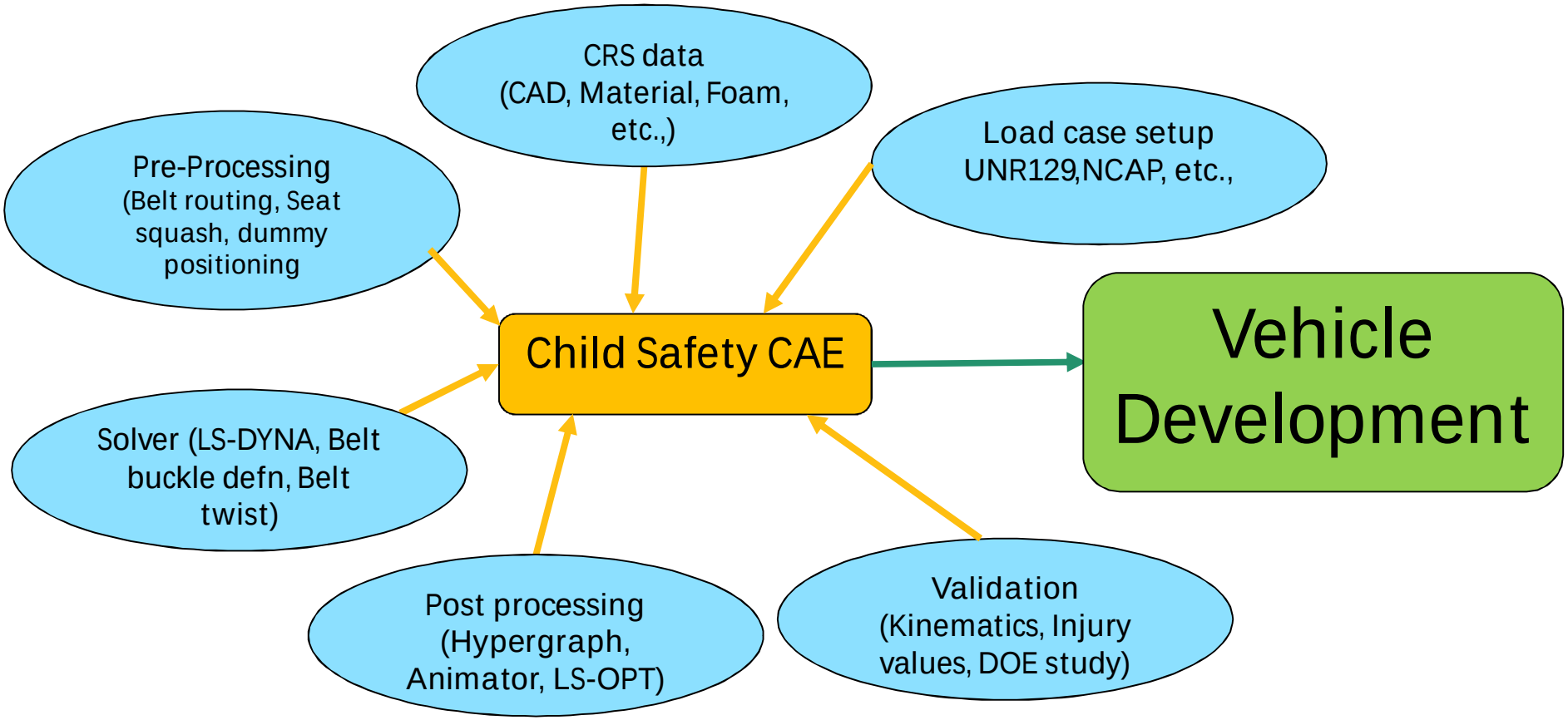


FEA model



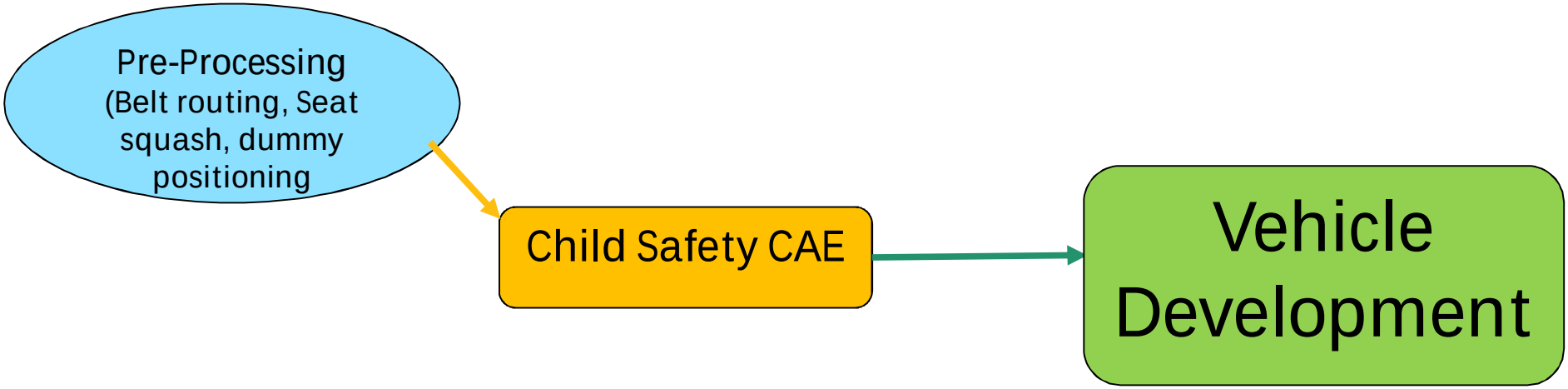
- Digitalize the hardware of Group 2-3 child seat (Roemer Kidfix) to create CAD data.
- Mesh and build FEA model with appropriate material and section data.
- Material data for FEA model doesn't exists and needs validation for good prediction of Child seat and dummy kinematics similar to the test.
- Validation of simulation model with hardware test for Child Injury performance and child seat Kinematics.

CAE requirements:



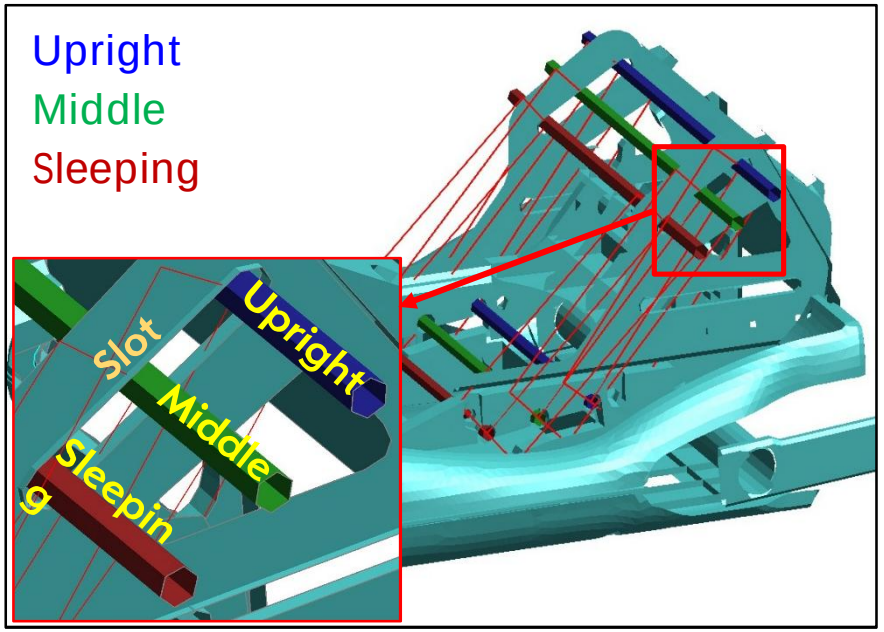
Wir leben Autos.

Pre-Processing:

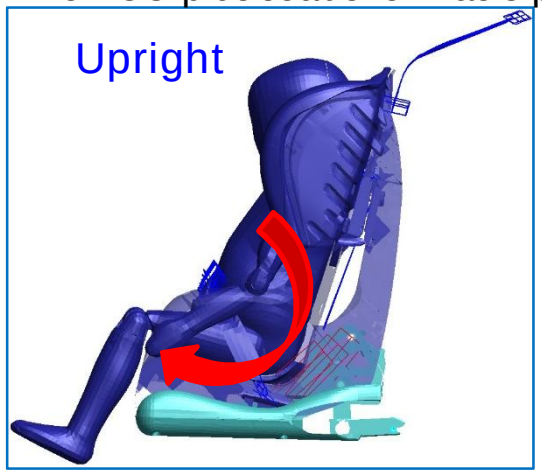


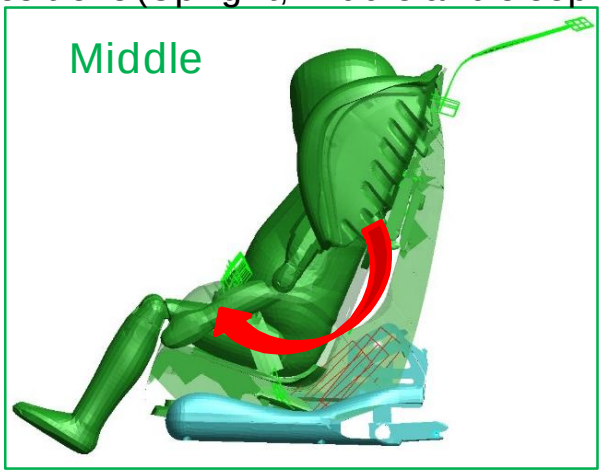
Pre-Processing:

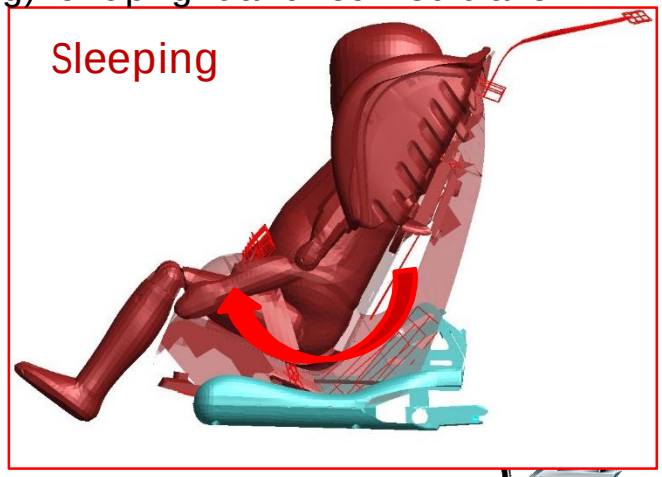
Mechanism Creation



The DUO plus seat shell has 3 positions (Upright, Middle and sleeping) for upright and reclined travel.



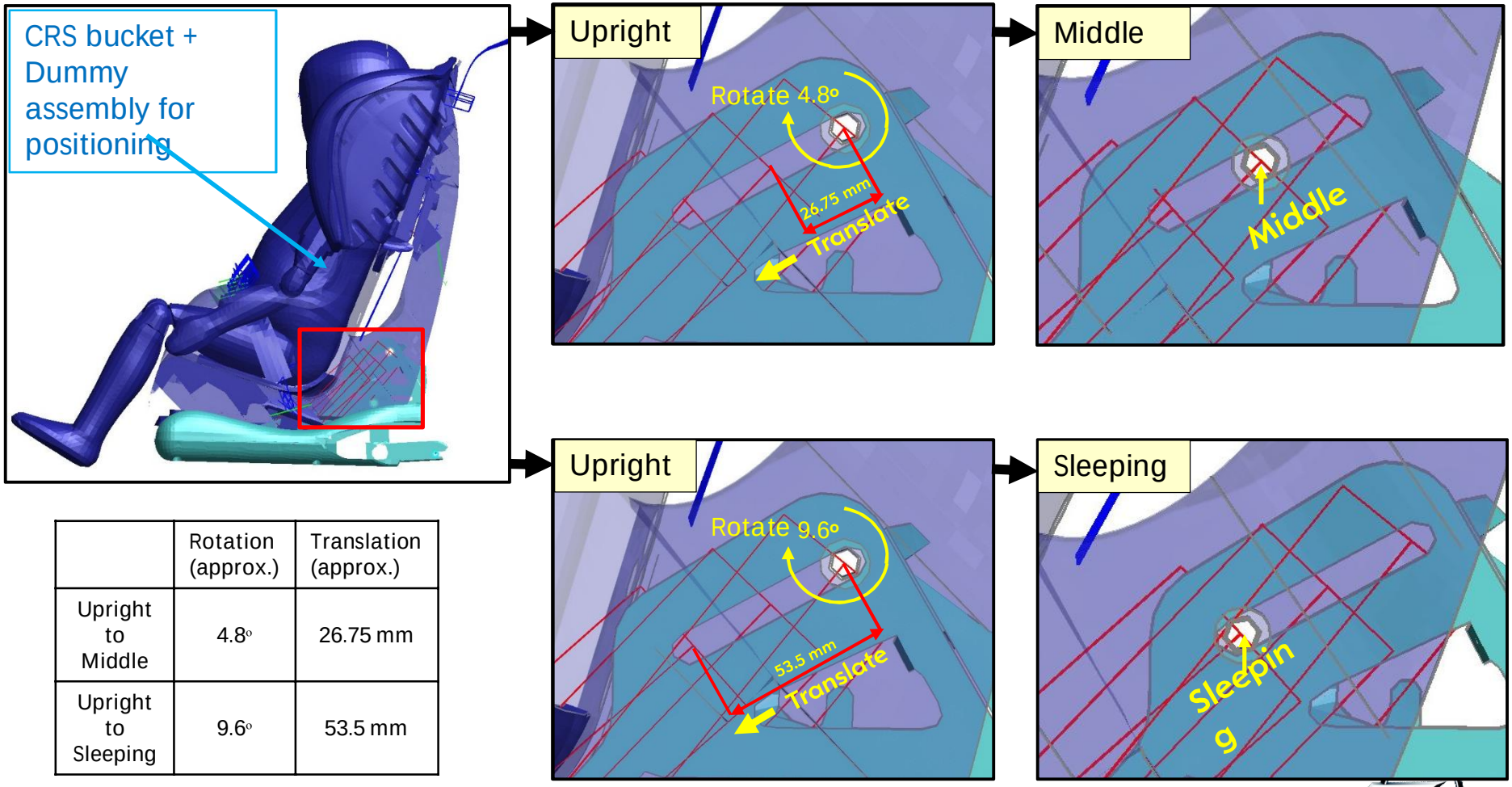




Pre-Processing:

Positioning using Mechanism

- CRS can be positioned from Upright to Middle and Sleeping positions using primer mechanisms.
- Dummy will be translated/rotated along with the CRS bucket, though it is included in the mechanism.

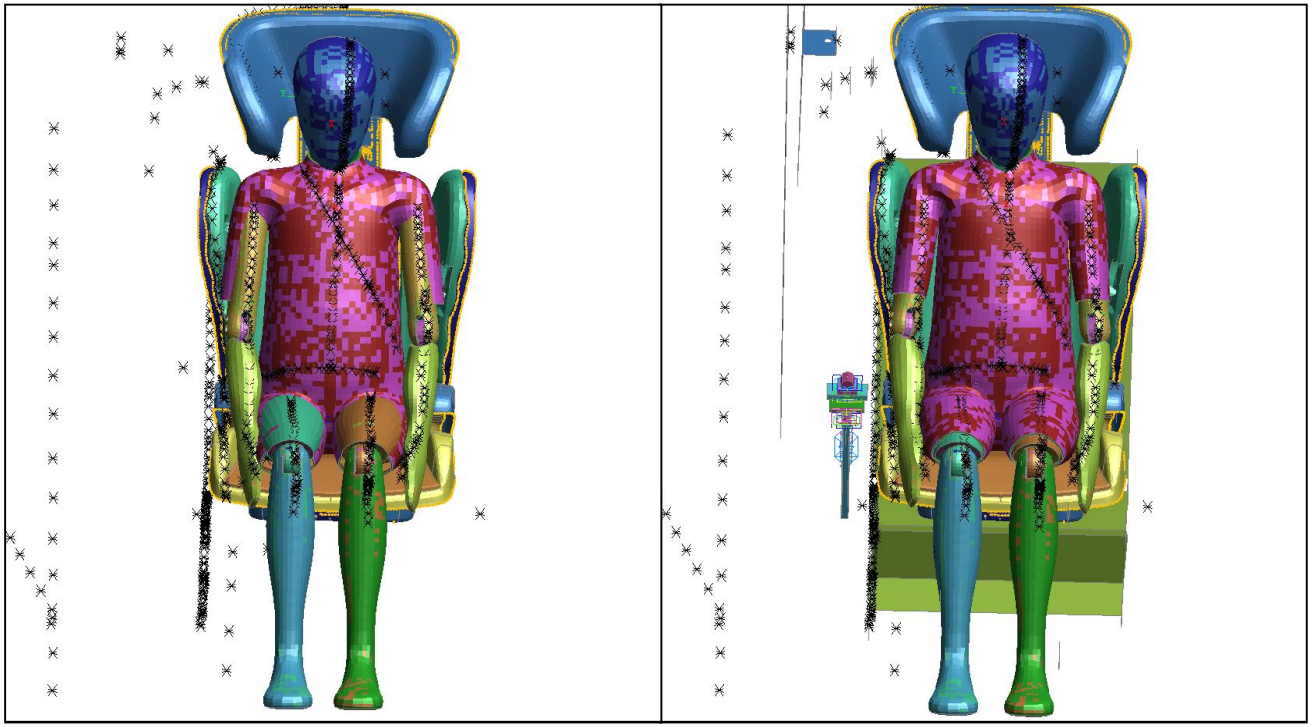


	Rotation (approx.)	Translation (approx.)
Upright to Middle	4.8°	26.75 mm
Upright to Sleeping	9.6°	53.5 mm

Pre-Processing:

Dummy positioning

Position of the Q10 dummy in CRS as per Test



Before Pre-simulation

After Pre-Simulation

CRS With Q3 Dummy

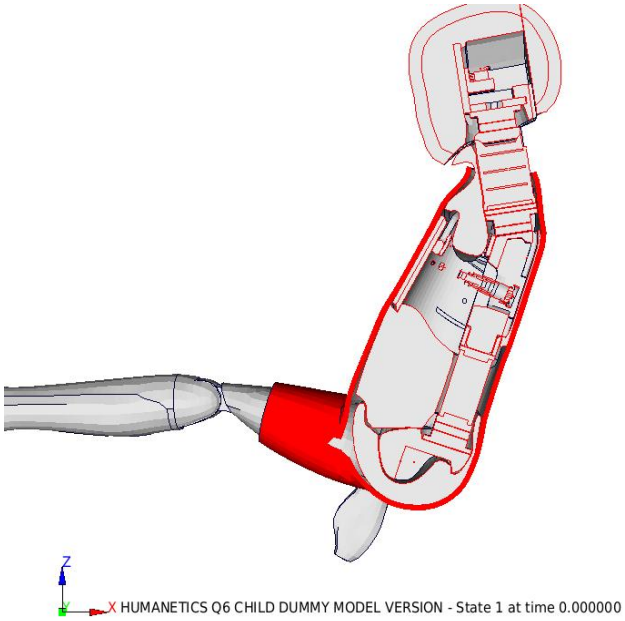
CRS With Q2 Dummy

Wir leben Autos.

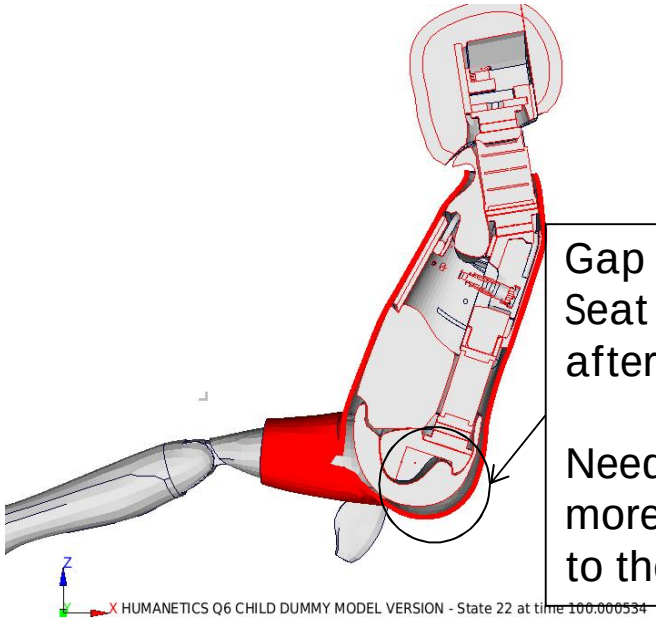
Pre-Processing:

Dummy positioning

Pre simulation for dummy positioning of Q6 V 0.2



Before Pre simulation



Gap between jacket and Seat base introduced after pre simulation.

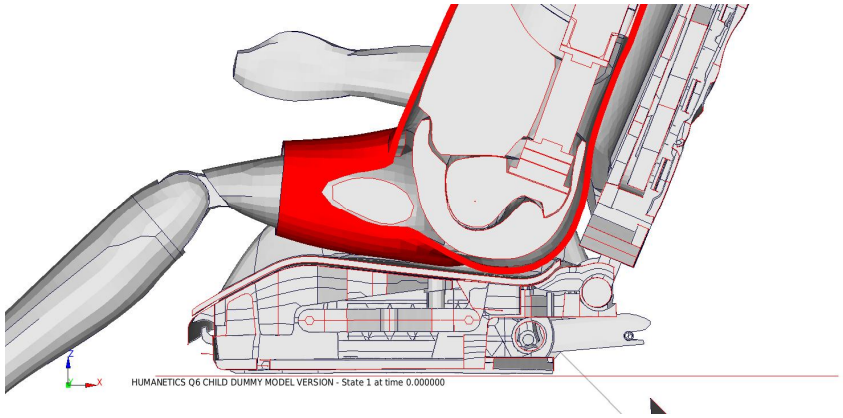
Needs to perform one more pre simulation to fit to the seat base.

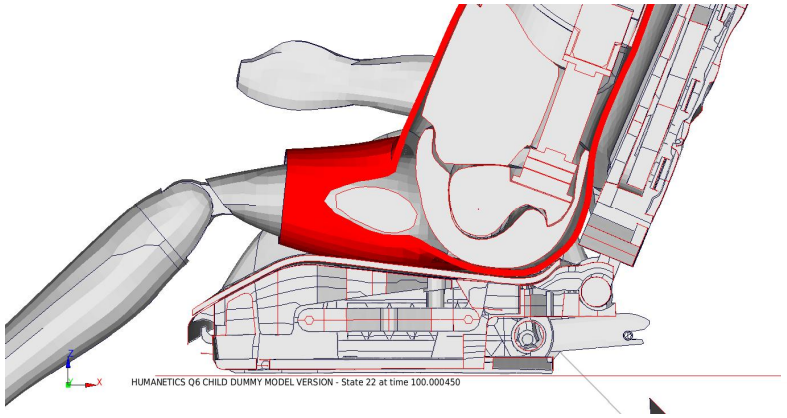
After Pre simulation

Pre-Processing:

Dummy positioning

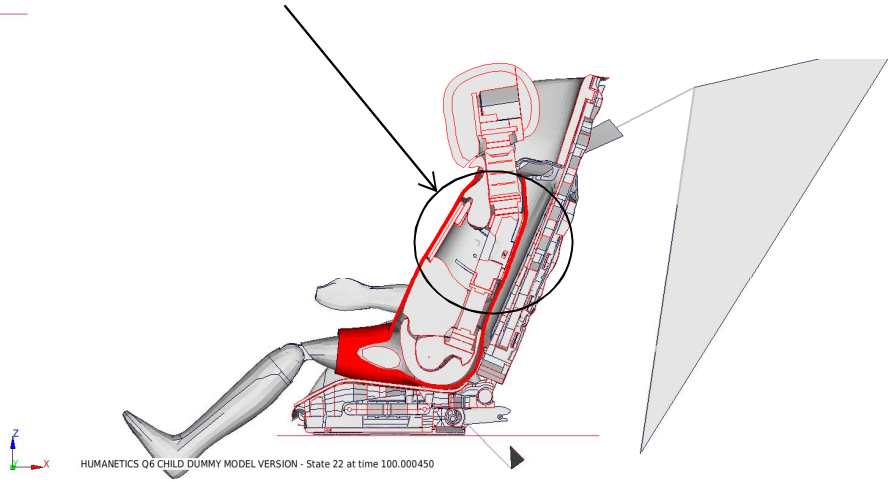
Second Pre simulation for dummy to fit in child seat





Rigidized all dummy parts except the Jacket.

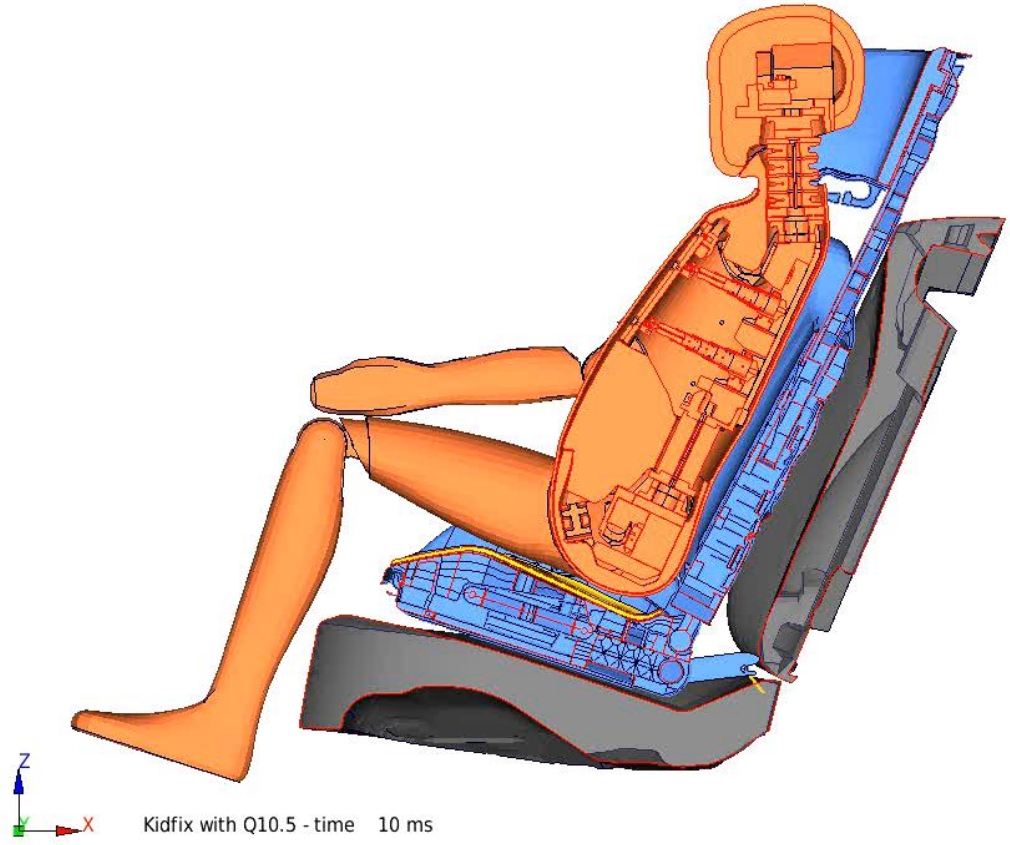
Tied contact used between rigid dummy and Jacket to avoid slipping of Jacket



Wir leben Autos.

Pre-Processing:

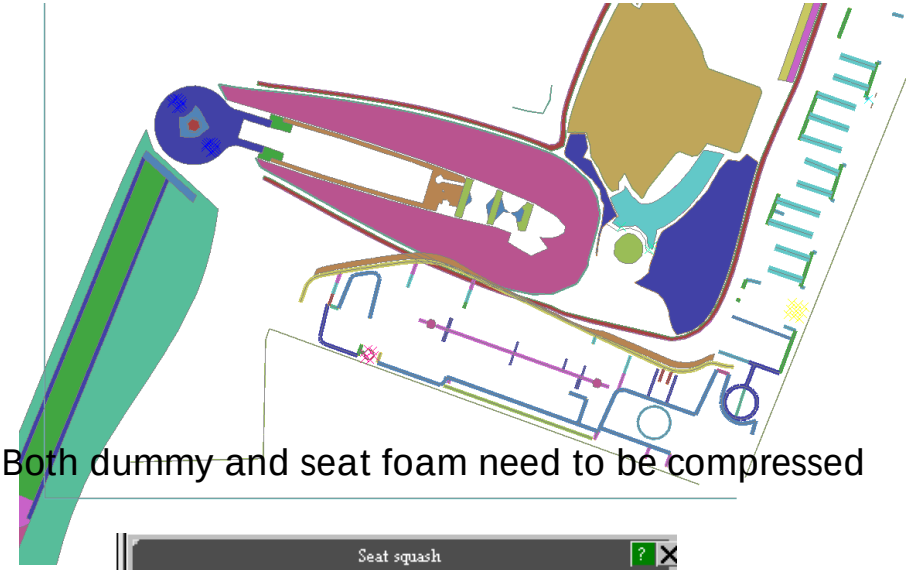
Dummy positioning-Automation



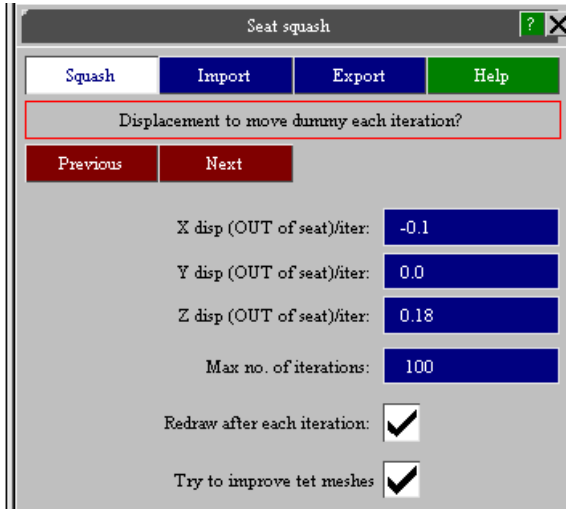
Wir leben Autos.

Pre-Processing:

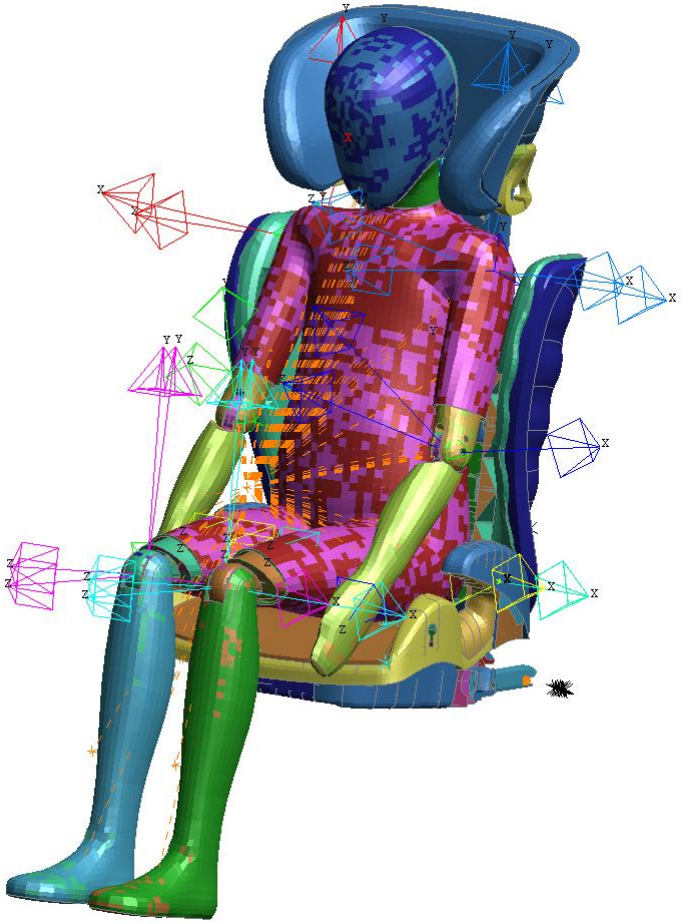
Seat Squash



Both dummy and seat foam need to be compressed



X –disp -10mm
Z – disp 18mm selected
Based on dummy penetration with seat

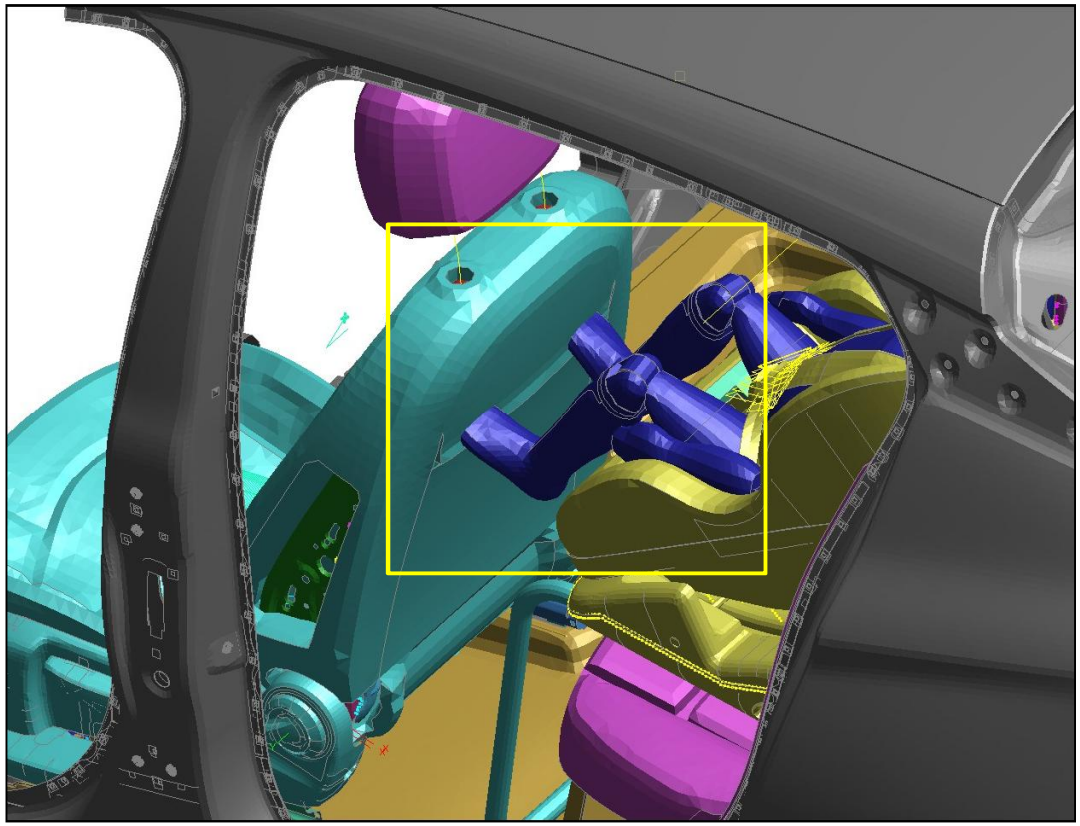


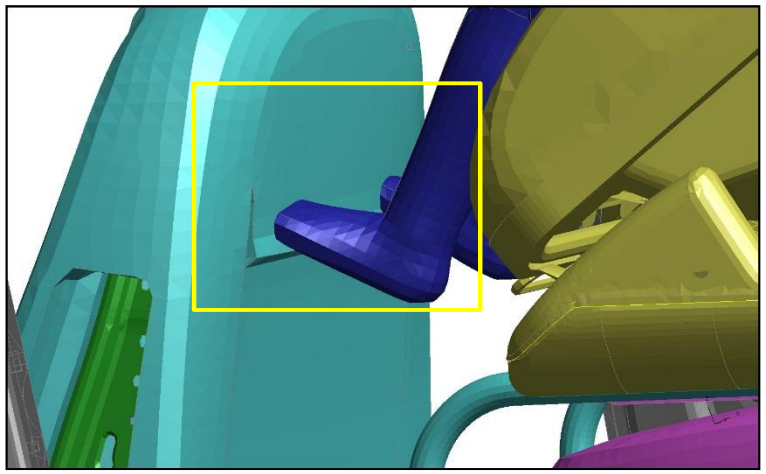
Primer DYNA method was selected for foam and dummy compression

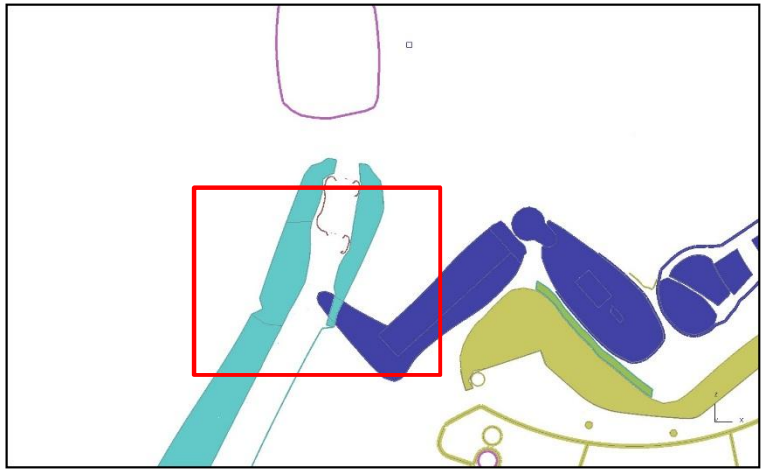
Wir leben Autos.

Pre-Processing:

Leg Interaction with front seat needs to be resolved





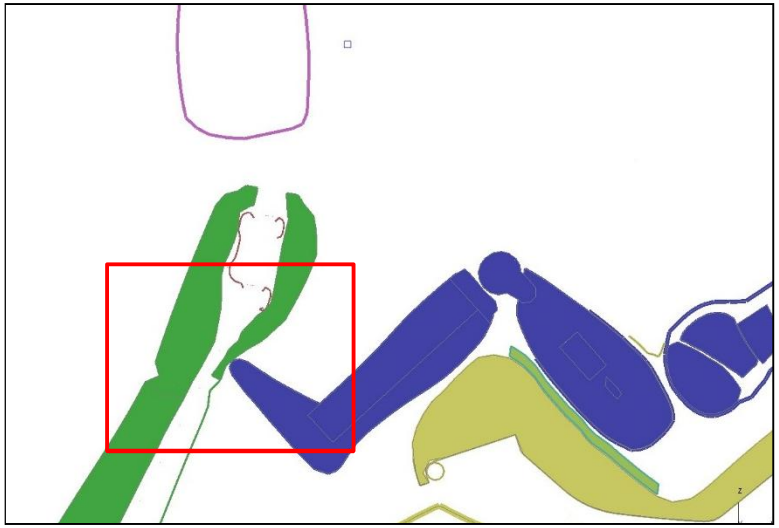


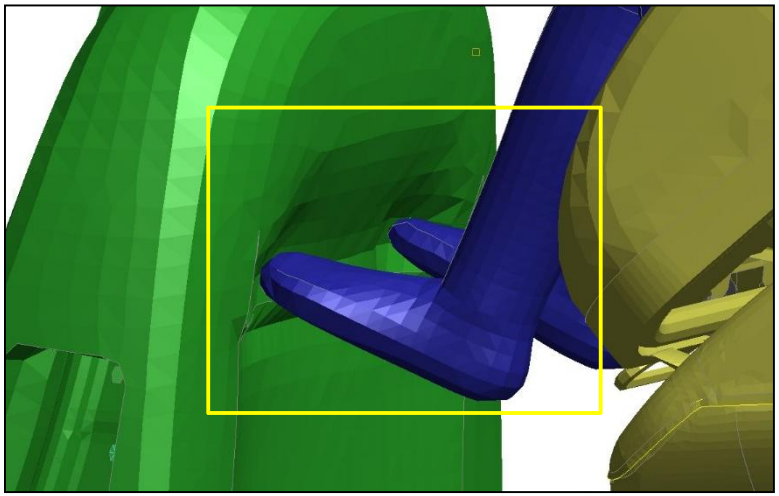
Wir leben Autos.

Pre-Processing:

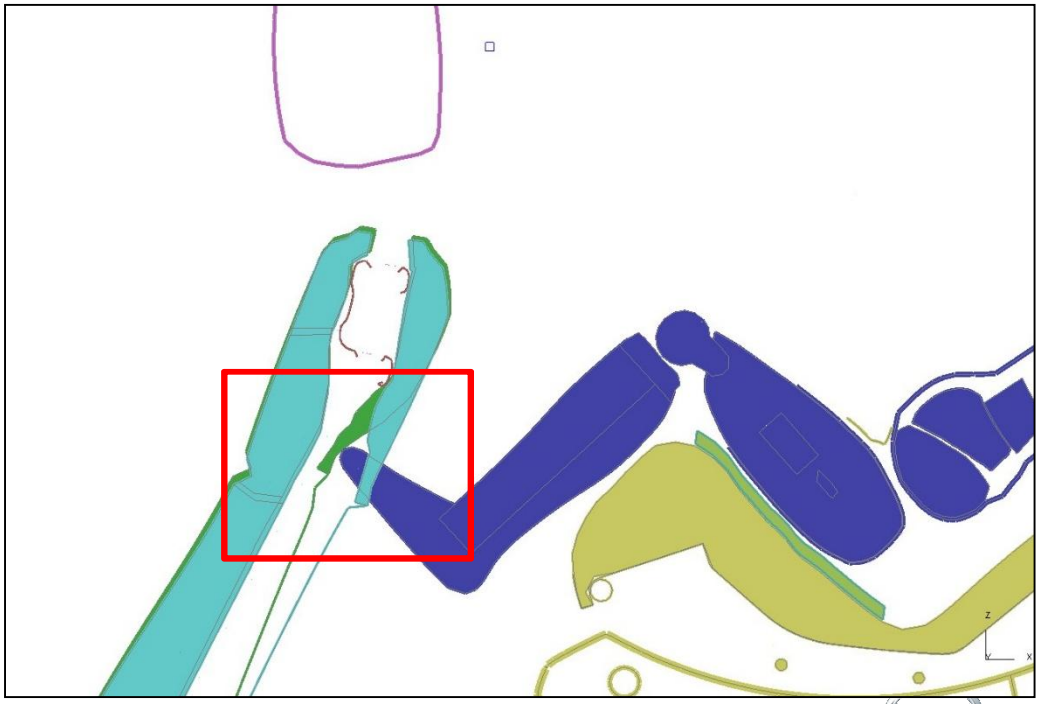
Leg Interaction with front seat resolved

After Front seat compression





Comparison -Before/After front seat compression

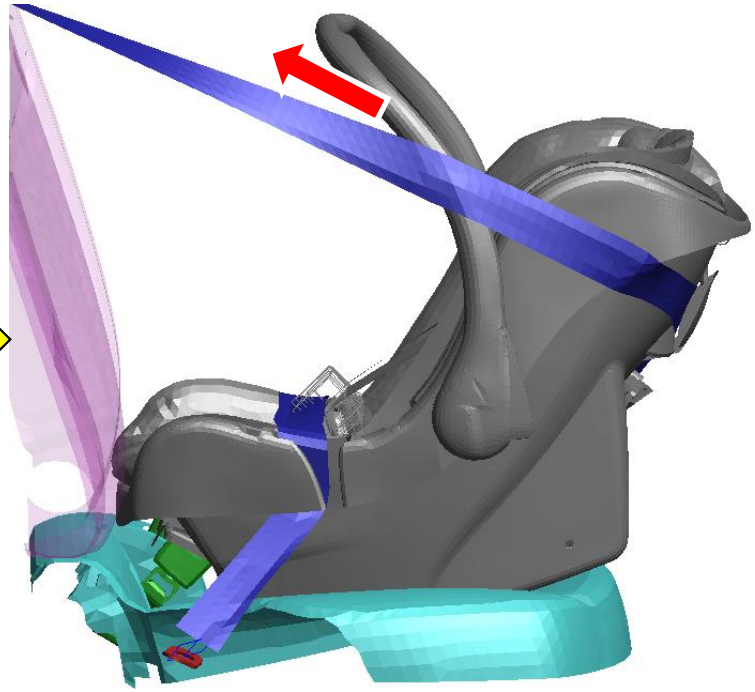


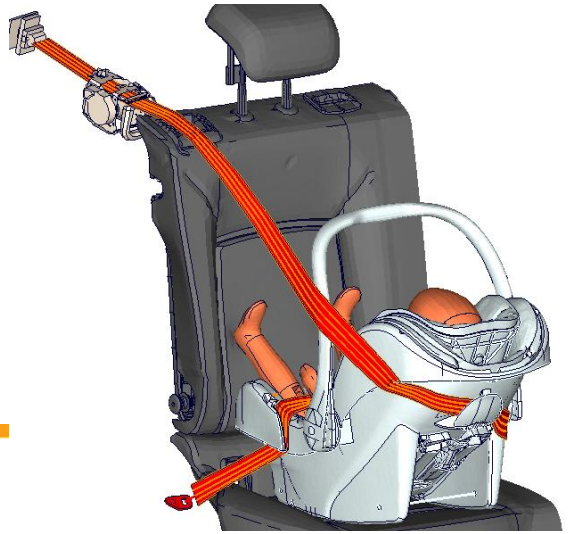
Pre-Processing:

Belt Routing

CRS with Vehicle Seatbelt (Universal)

Belt Routing in CAE

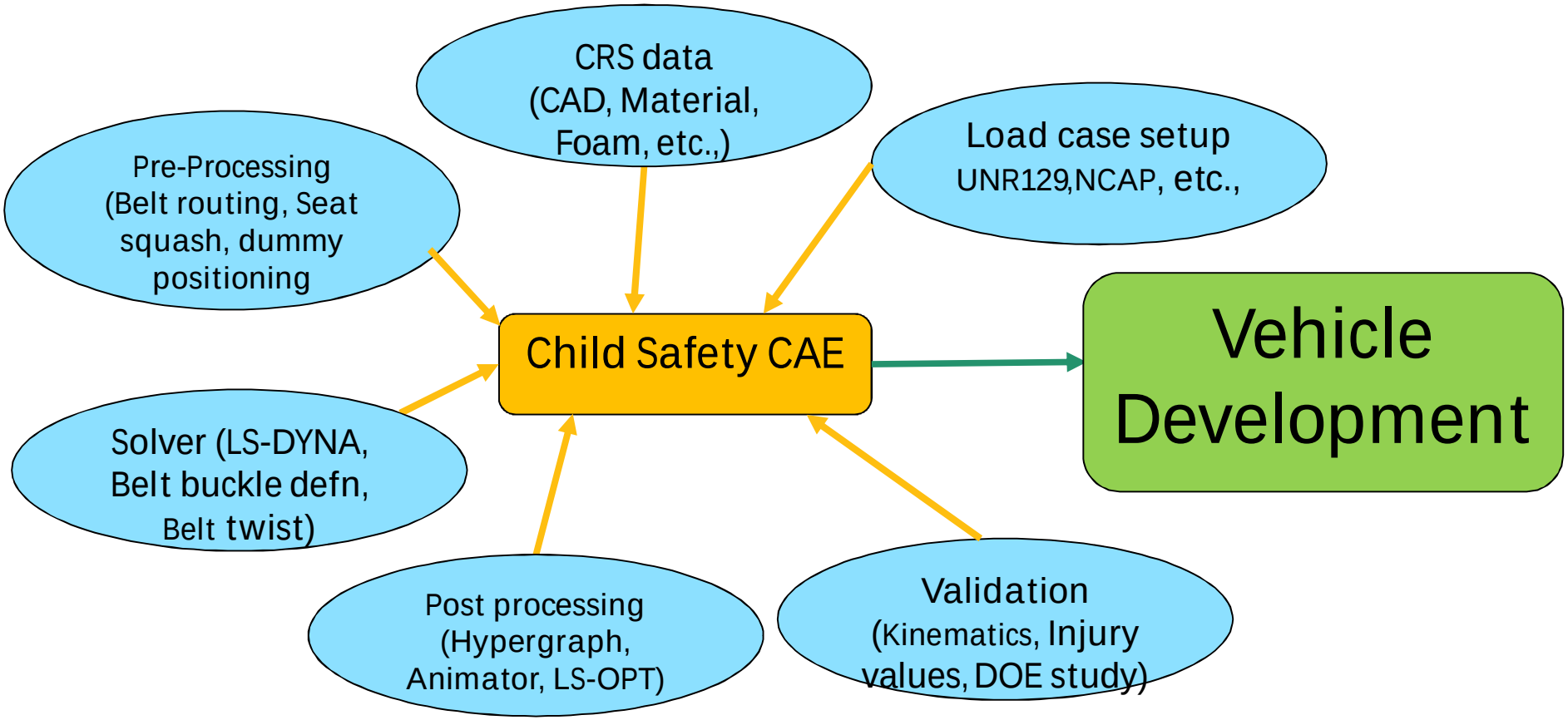




- Use 2-D seatbelt to have proper contact with vehicle seat and CRS

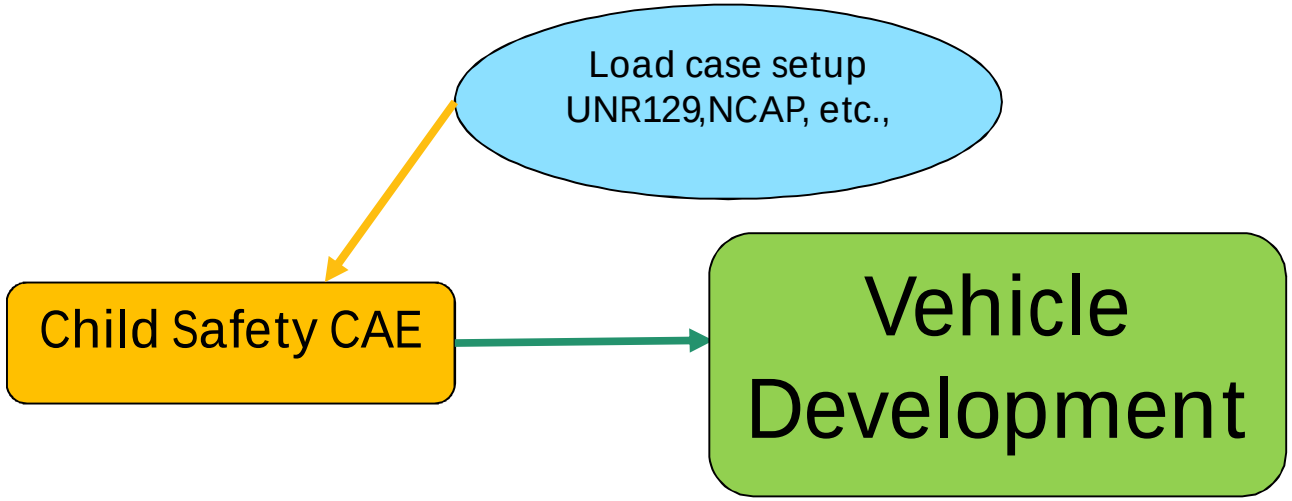
Wir leben Autos.

CAE requirements:



Wir leben Autos.

Load case setup:

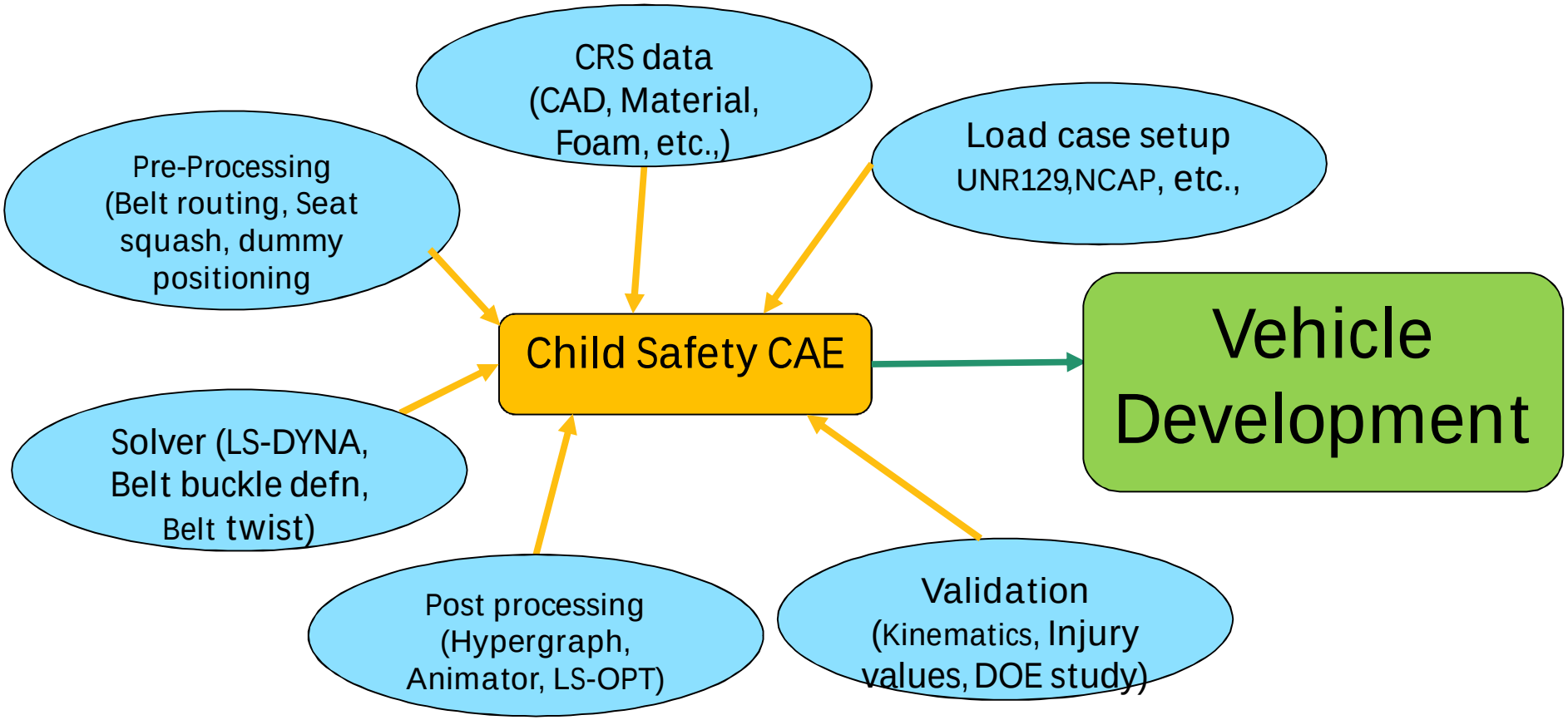


Load case setup:

Unknown factors

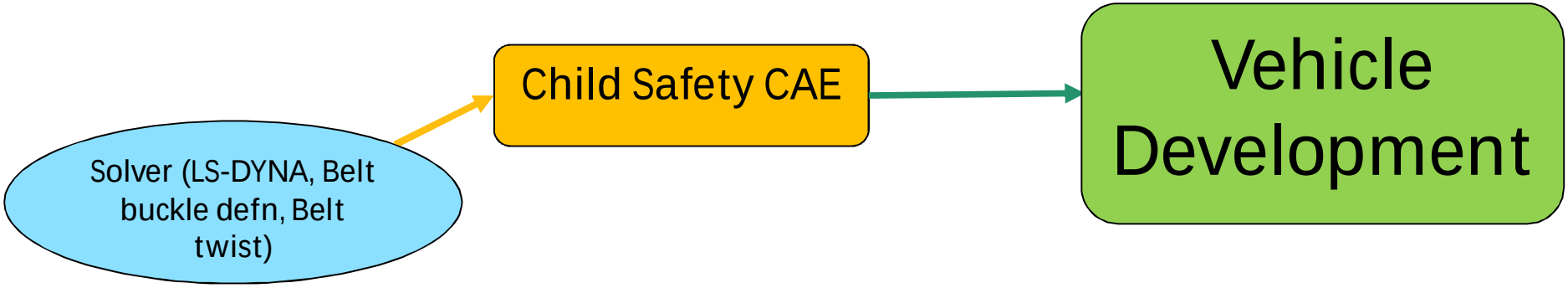
- Load-case adoption year-2015 or 2016??
- Dummy-P3, Q3, Q6,Q10??
- Dummy Position- Behind driver or Co-driver??
- CRS-with booster, without booster, booster with backrest??
- Injury Criteria- Head contact, HIC, Neck force, Chest deflection??

CAE requirements:



Wir leben Autos.

Solver:

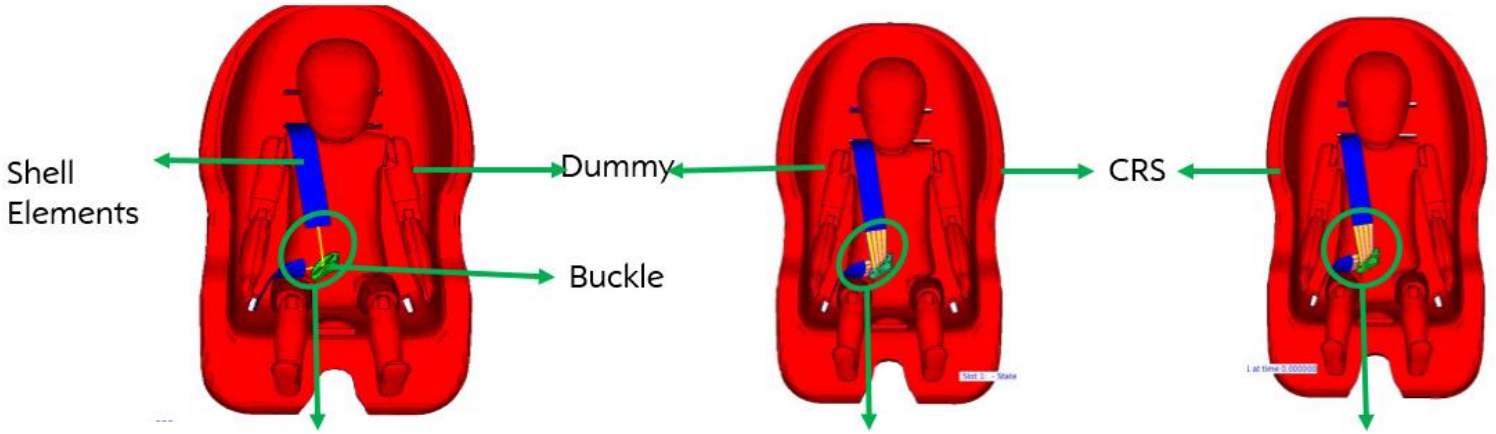

Solver (LS-DYNA, Belt buckle defn, Belt twist)
Child Safety CAE
Vehicle Development

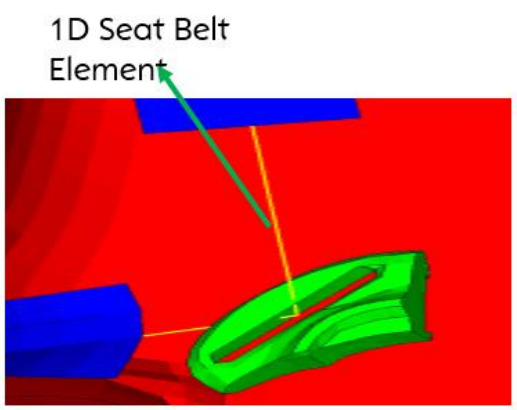
Solver:

- Belt movement in CRS buckle.
- Sensitivity of CRS buckle interaction with abdomen and chest.
- Belt twist in lap belt.

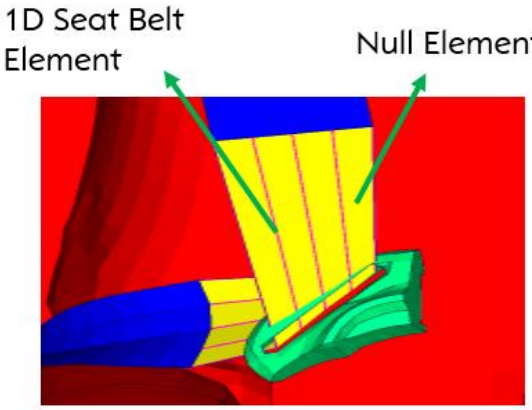
Solver:

Belt movement in CRS buckle

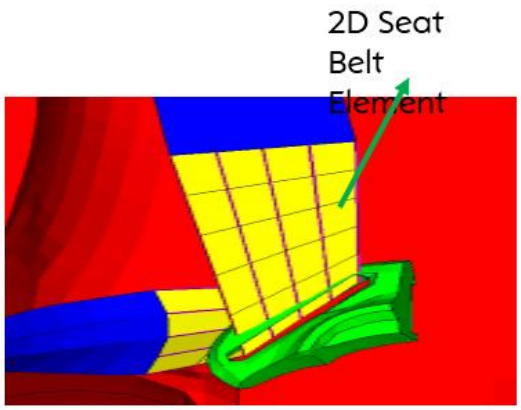




1D Seat Belt
Method



5 1D Seat Belt
Method

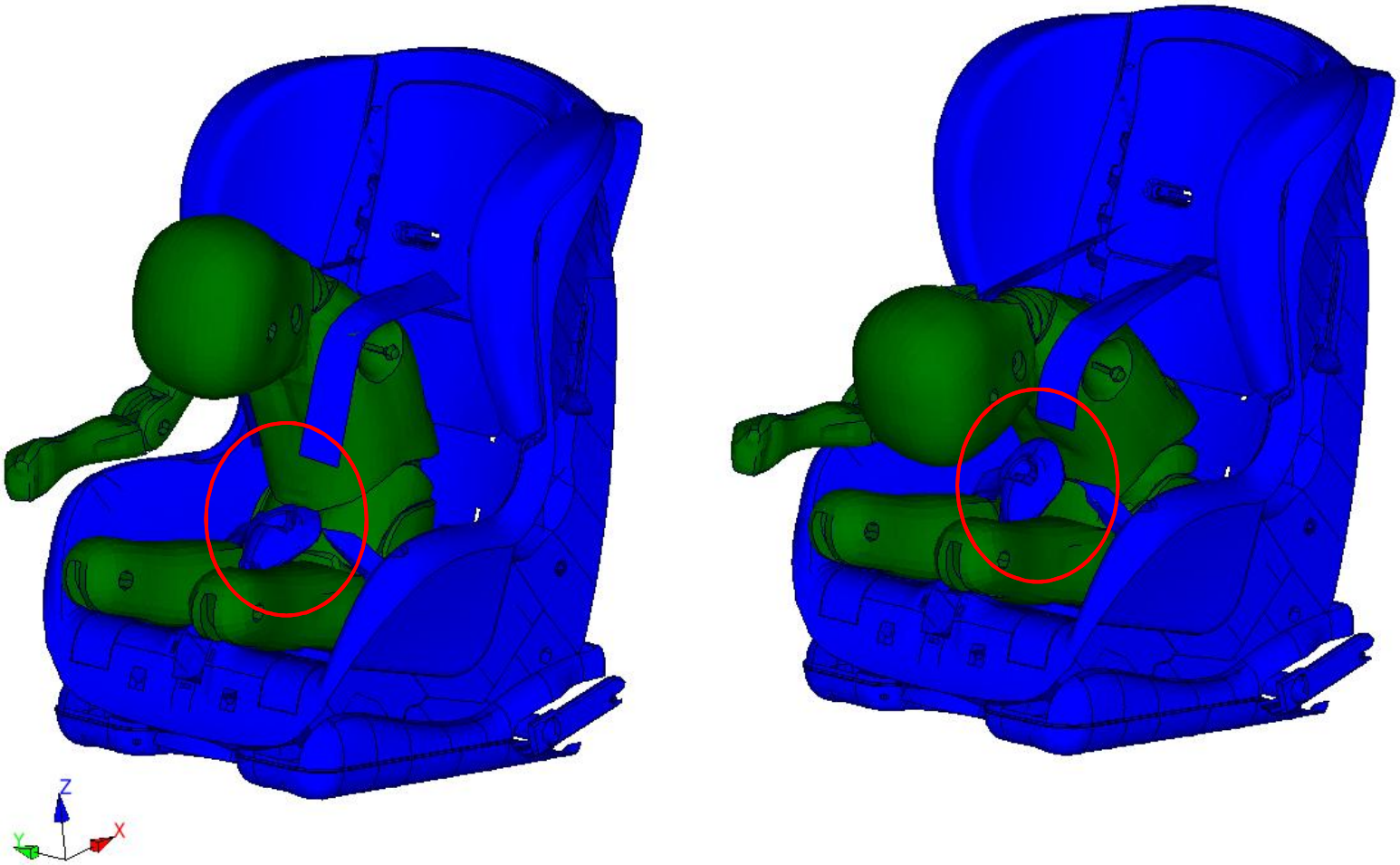


2D Seat belt
Method

Wir leben Autos.

Solver:

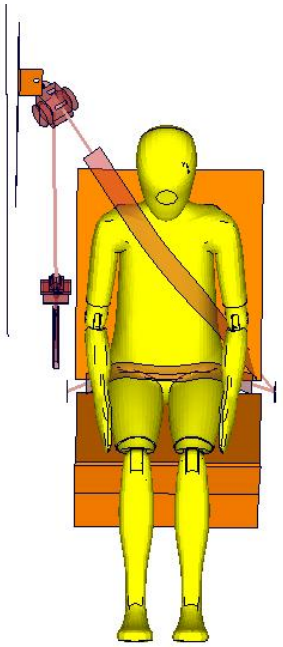
Sensitivity of CRS buckle interaction with abdomen and chest

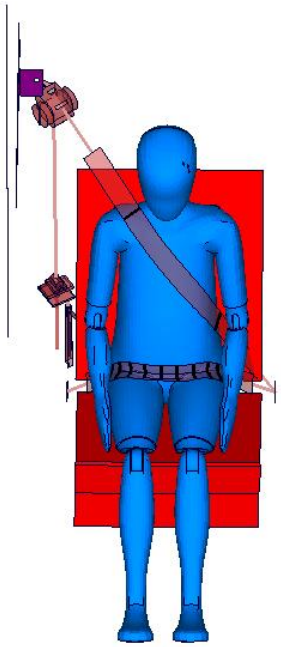


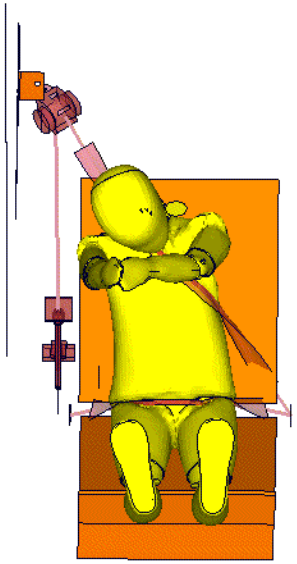
Wir leben Autos.

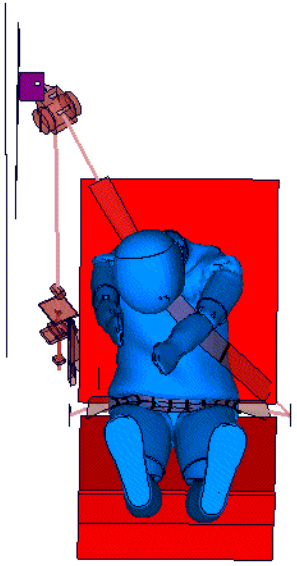
Solver:

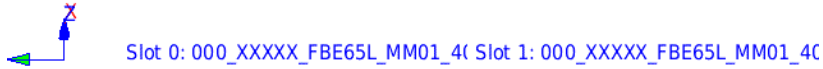
Belt twist in lap belt
Ex: Q6 Dummy on rigid sled

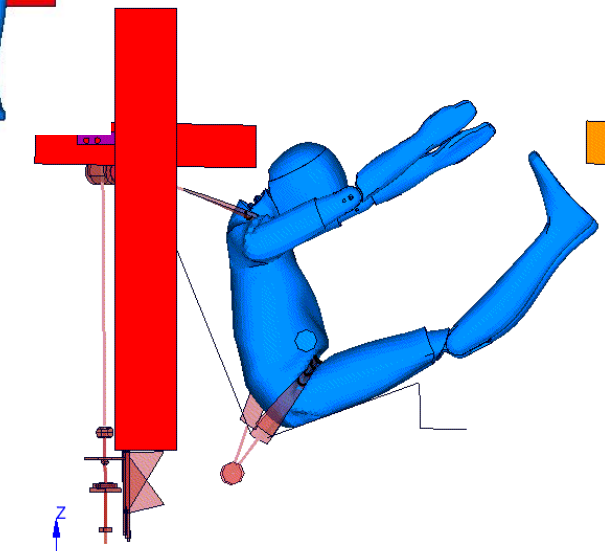


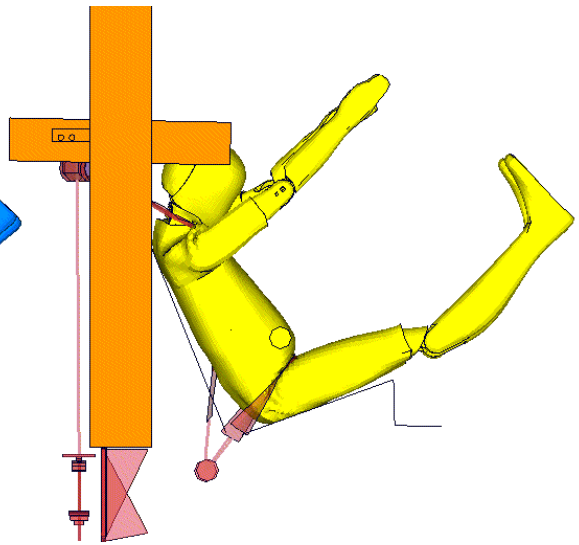




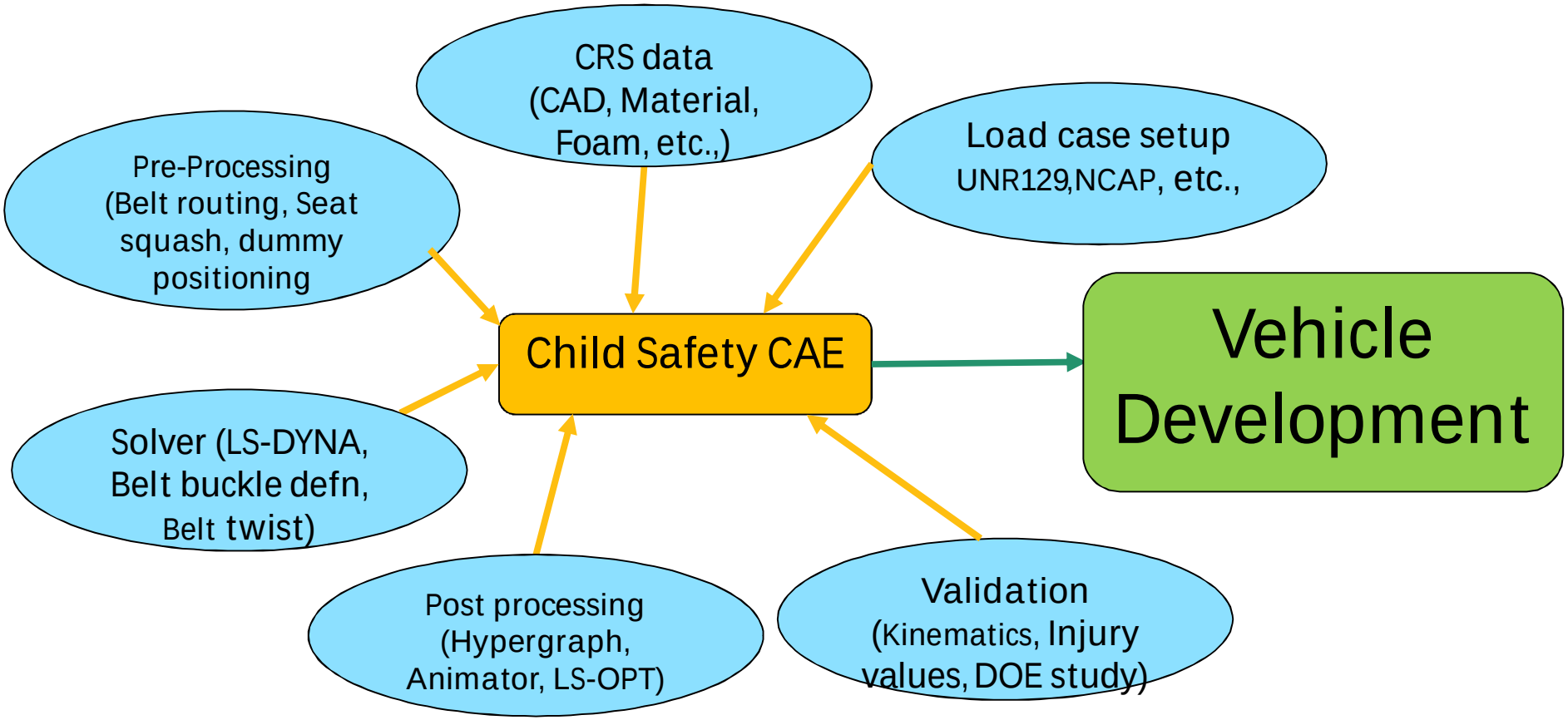






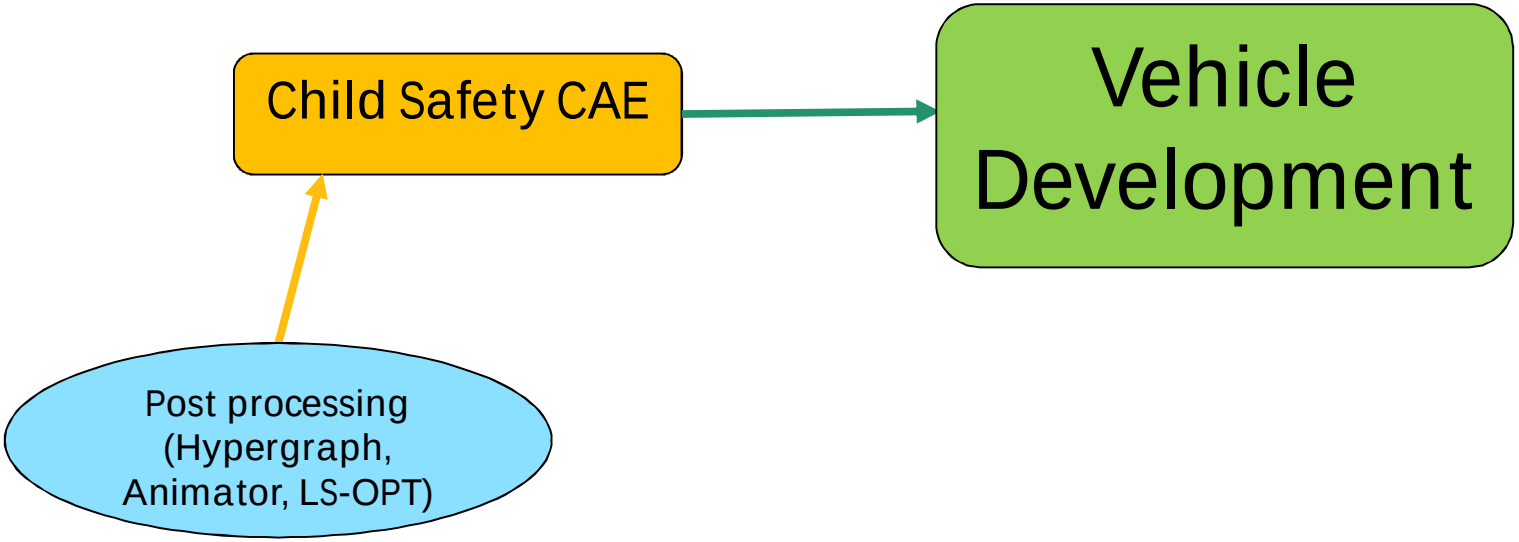


CAE requirements:



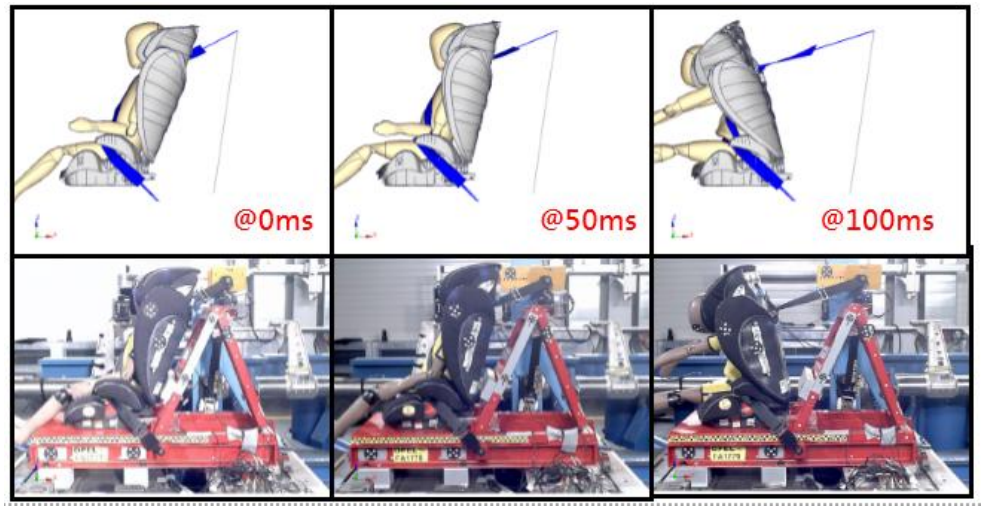
Wir leben Autos.

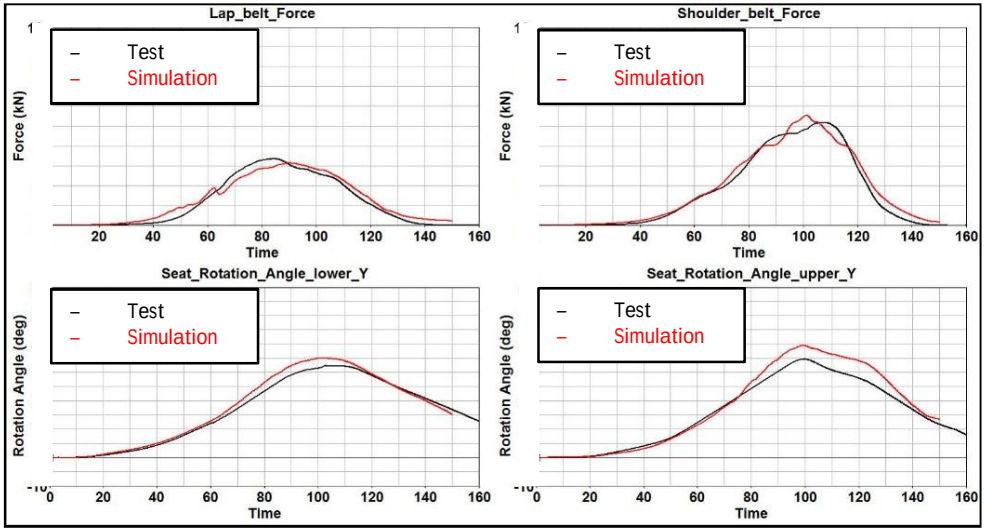
Post-Processing:



Post-Processing:

- Animator for Kinematics comparison
- Hypergraph for Injury curve comparison
- LS-OPT for robustness and Sensitivity study

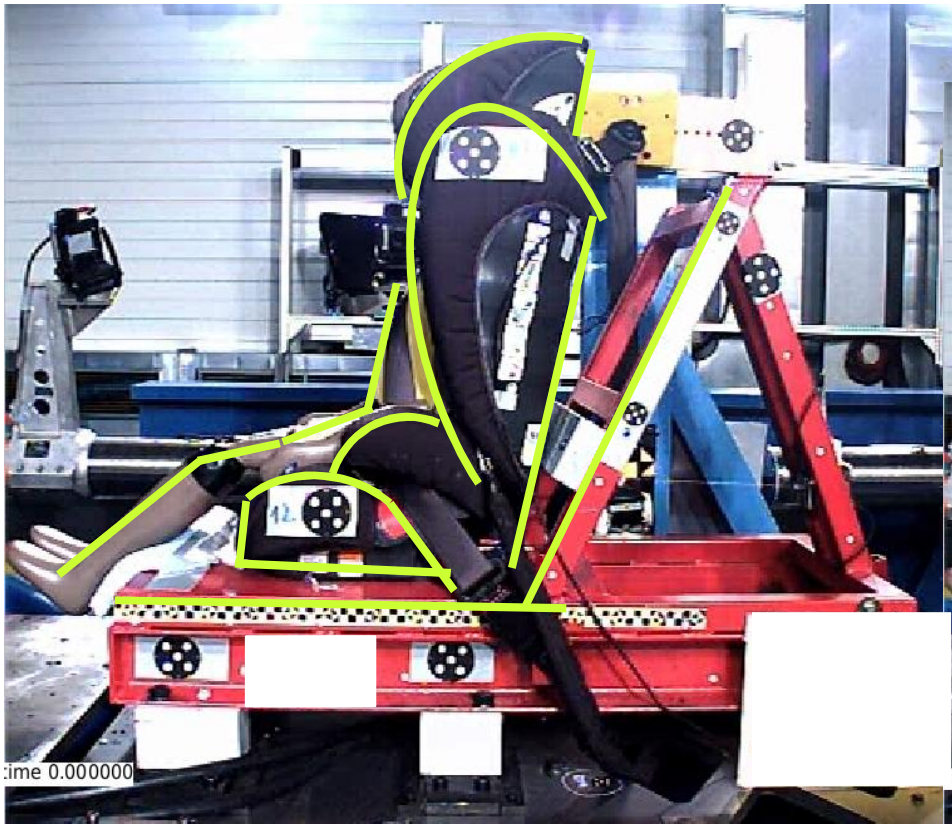




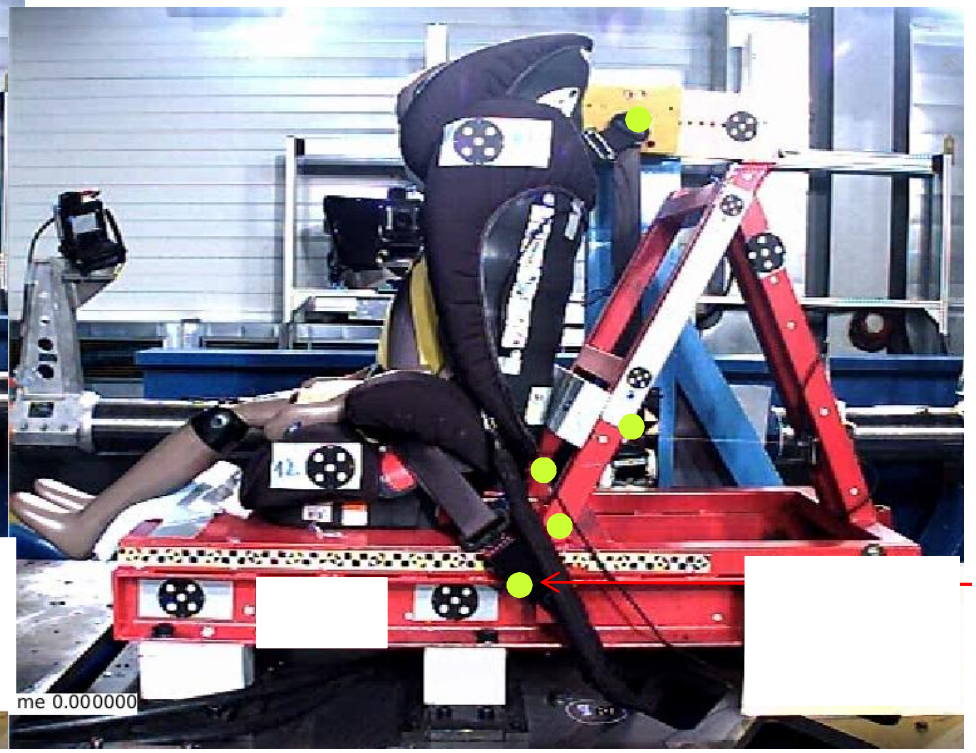
Wir leben Autos.

Post-Processing:

Scan co-ordinates points as highlighted in order to overlay in Animator for Kinematics comparison



Scanned co-ordinates of Dummy, Belt, Child seat and sled base.

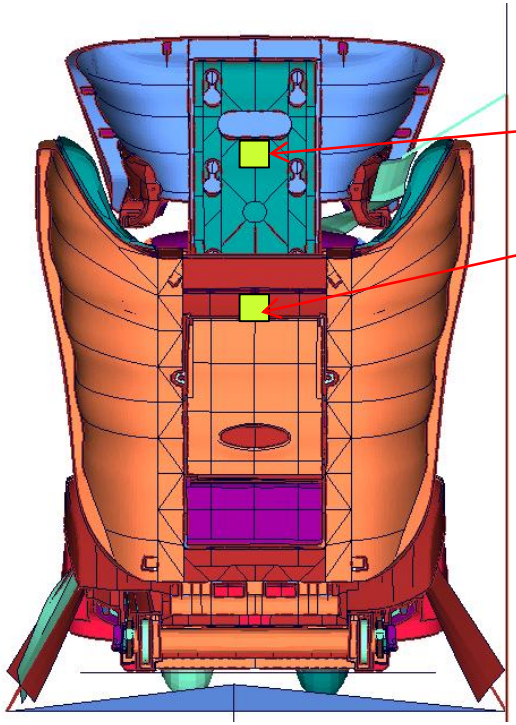


Measure Coordinates of D-ring ,Buckle, Lap anchor left and Right, Retractor and Isofix fixation points.

Wir leben Autos.

Post-Processing:

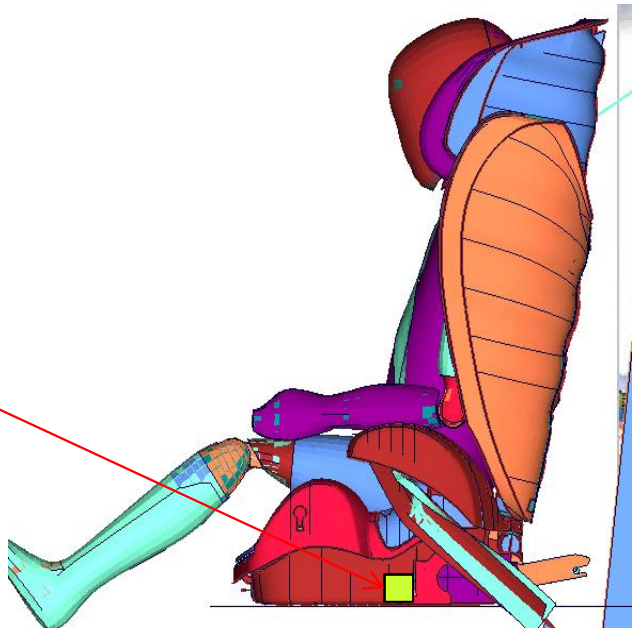
- 3D angular acceleration sensors at head rest, Seat back and Seat base and their Co-ordinates.
- Measurement values relative to Isofix points on sled.



Head rest-sensor

Seatback

Seat base

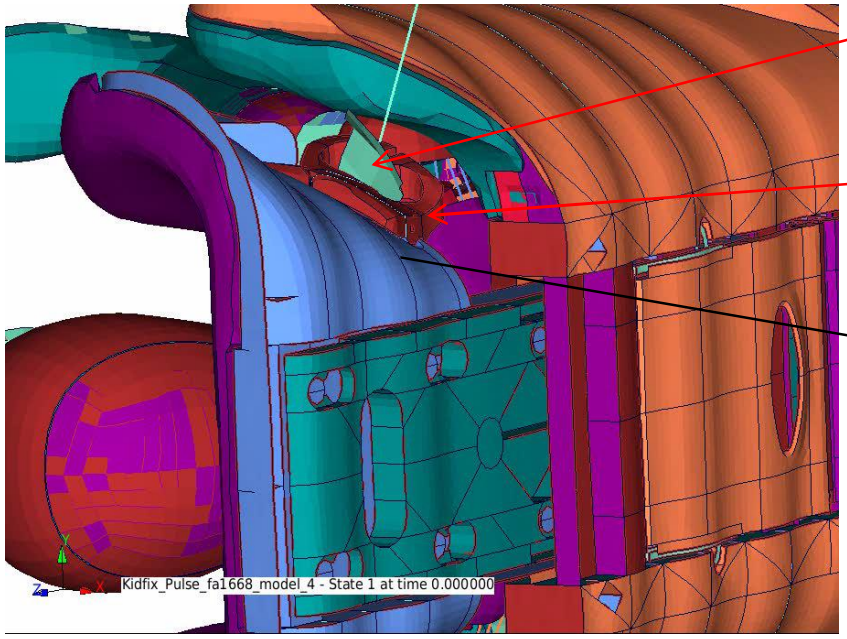


Wir leben Autos.

Post-Processing:

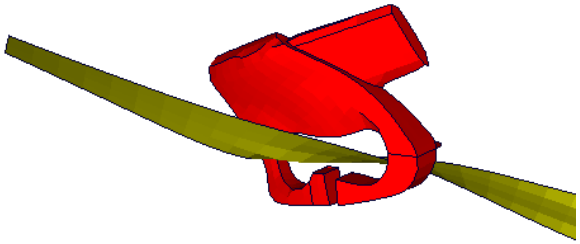
Camera views:

- Camera views similar to Test and co-ordinates of camera position.
- Additional camera view to observe kinematics of belt and belt guide of child seat head rest



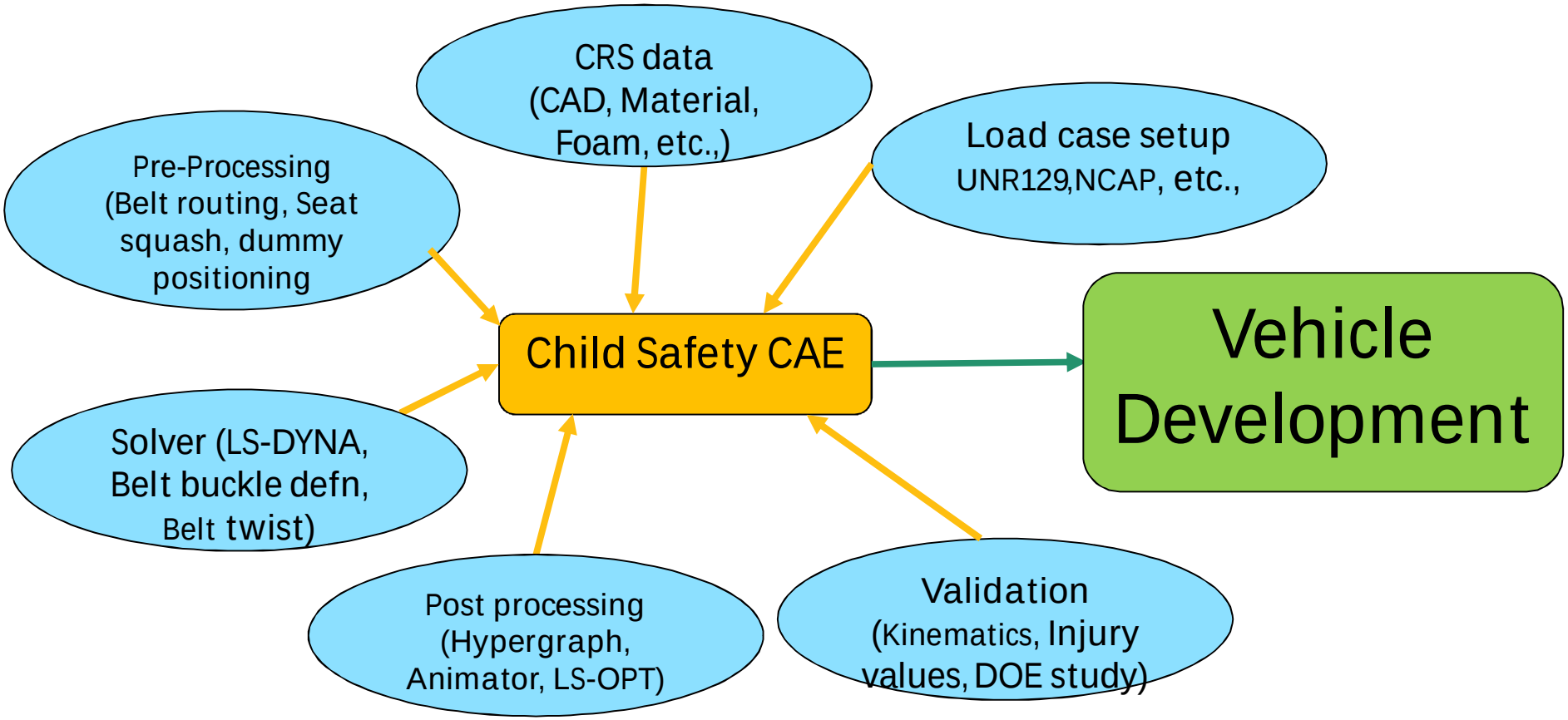
Shoulder belt

Child seat belt guide



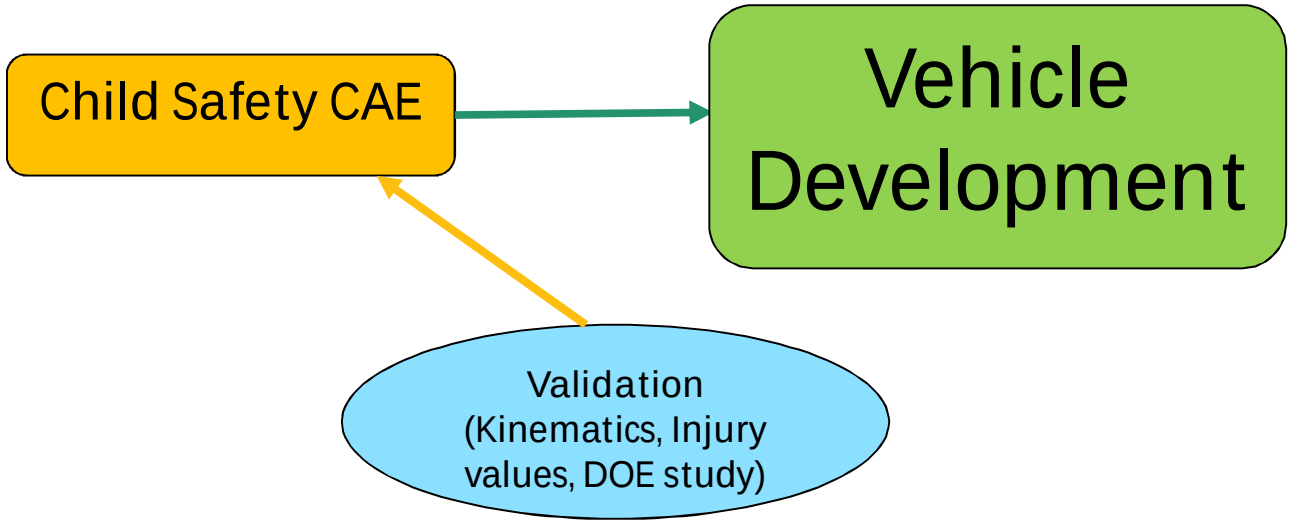
Wir leben Autos.

CAE requirements:



Wir leben Autos.

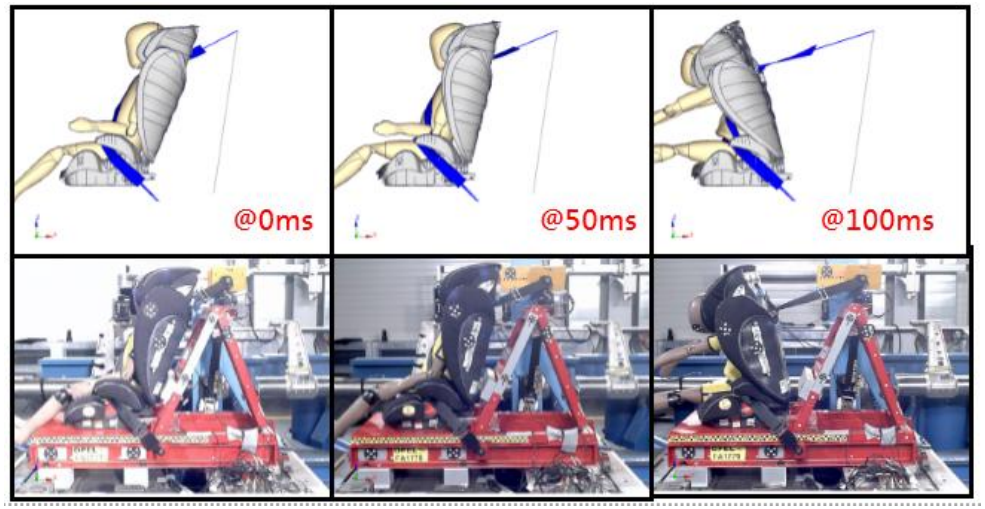
Validation:

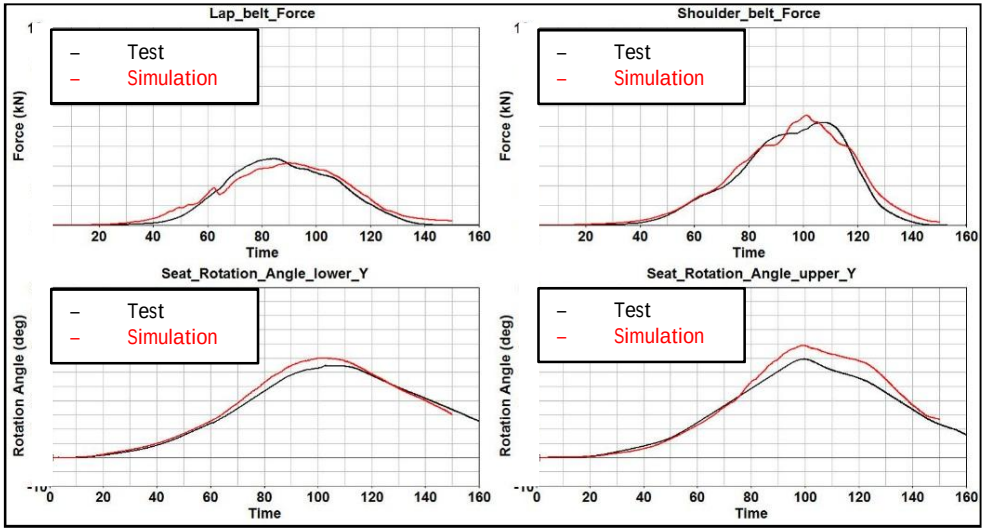


Wir leben Autos.

Validation:

- A good virtual child seat in terms of quality, robustness and predictability is required to match the performance similar to the physical Test.
- Validation of simulation model is required with hardware test for accurate Child Injury performance and child seat Kinematics



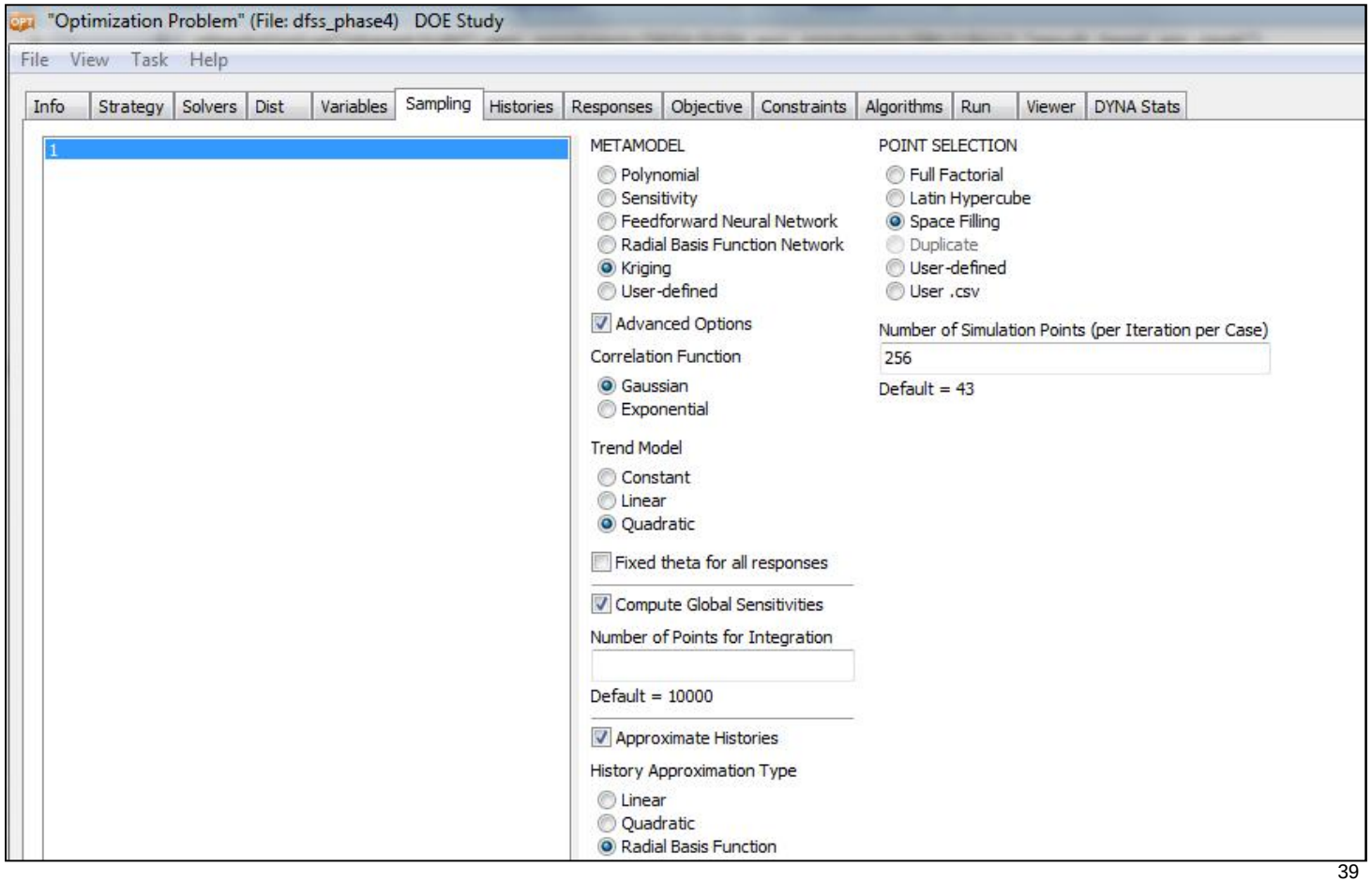


Wir leben Autos.

Validation:

Validation of simulation model to the test using LS-OPT DOE study

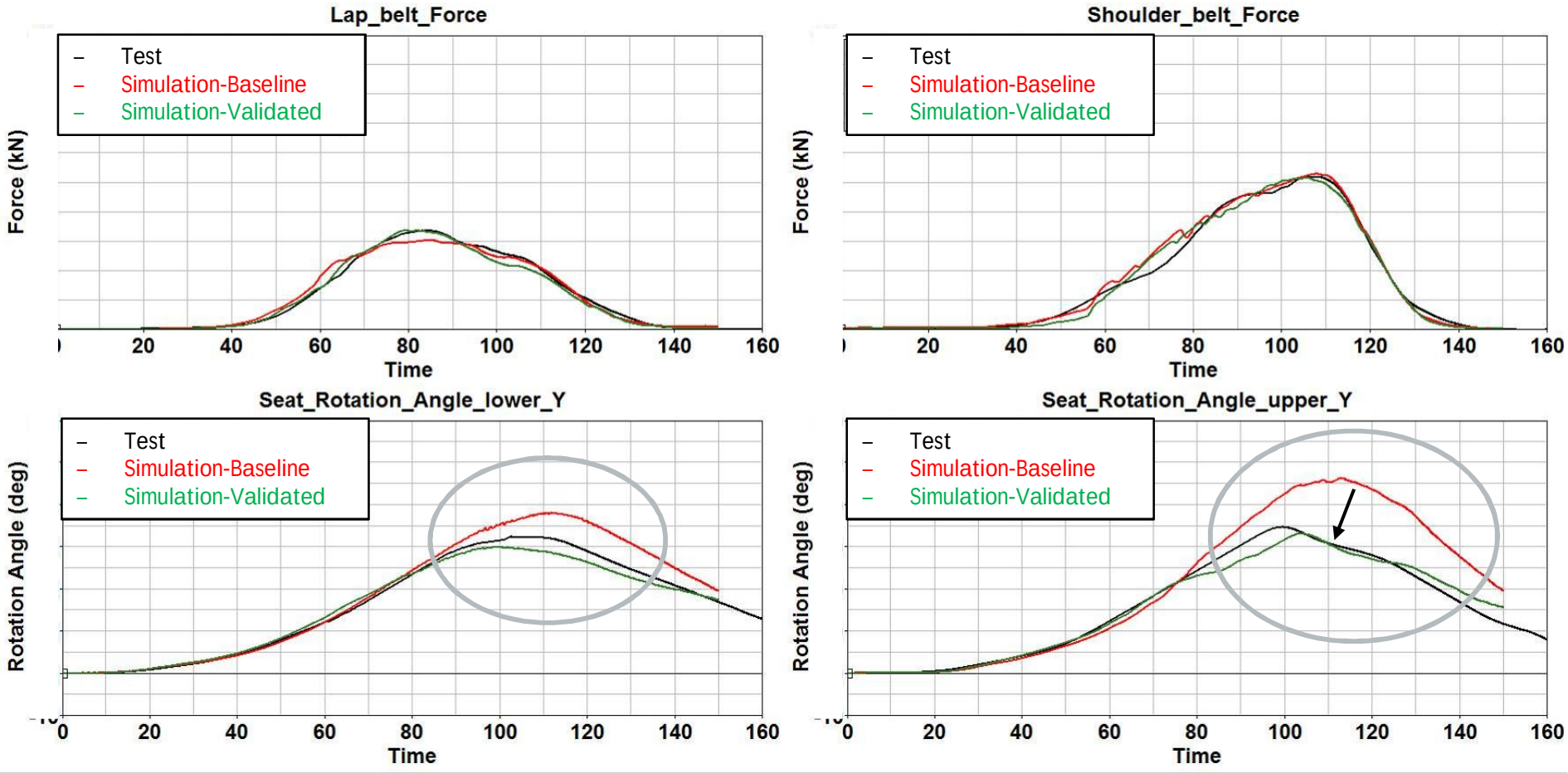
Kriging sampling through LS-OPT used to generate designs



Validation:

Test, baseline and validated simulation compare

- Belt forces and Seat rotations



Conclusion

- Good collaboration between CRS manufacturers and Vehicle OEM's and Pre-processing tool suppliers is required to generate good quality of Child safety CAE models.

- Best practices and learnings were documented to help daily work of CAE engineers working on child safety.

- Implementation of pretensioners may improve adult child Injury performance in second row seats.

Dr. Srinath Vadlamudi

Thank you

Wir leben Autos.