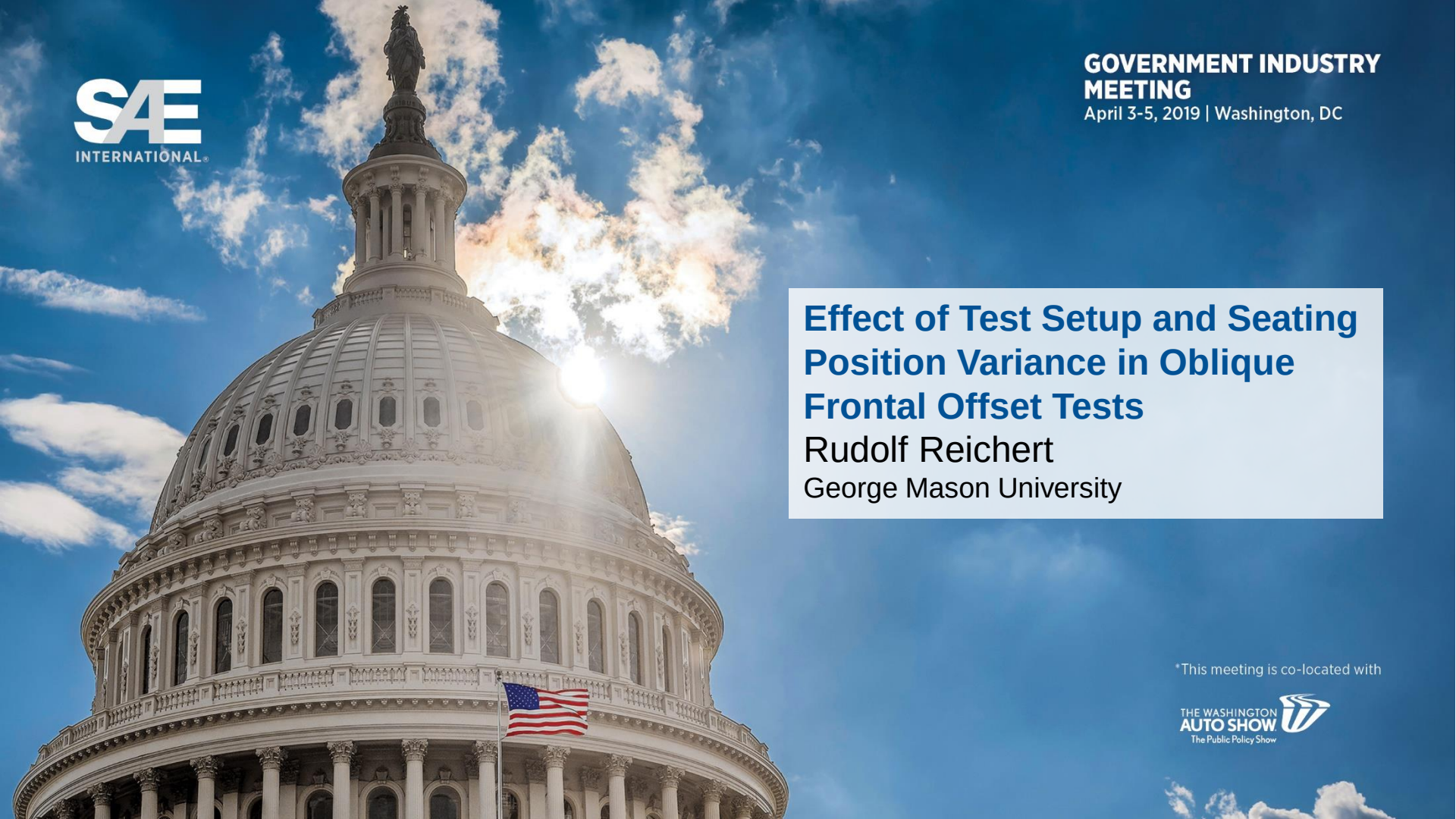


Effect of Test Setup and Seating Position Variance in Oblique Frontal Offset Tests

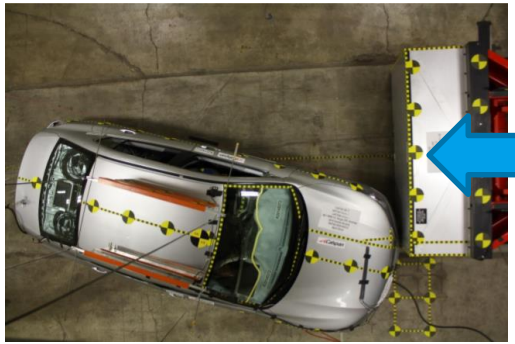
Rudolf Reichert
George Mason University

Background – Oblique Impacts

- Oblique impacts account for a significant amount of accidents
- Vehicle crash mechanisms and occupant kinematics differ from co-linear impacts

Background – Test Procedure

- NHTSA has developed an oblique test procedure
- Test setup and seating position tolerances are immanent to full-scale testing



OMDB
90 km/h
2500 kg
35% overlap
15° oblique

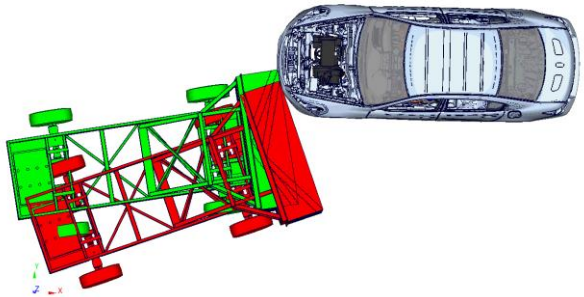
+/- 5mm
+/- 20mm

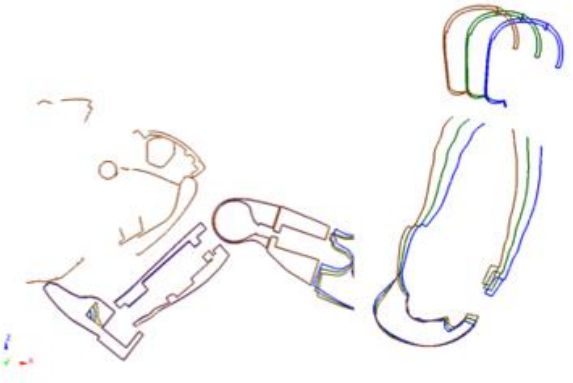
Objective

Evaluate effect of:

- OMDB test setup parameters (Test setup study)

- Seating position parameters (THOR position study)

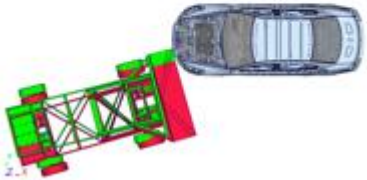


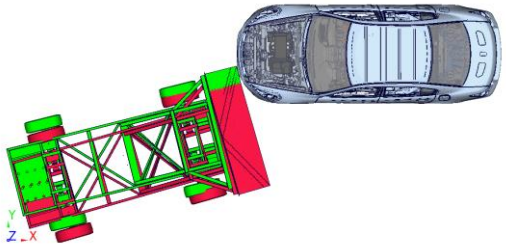


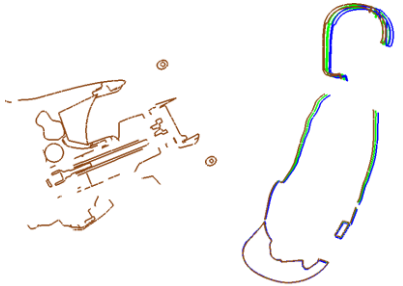
Definitions I

Repeatability Study:

Within test tolerances

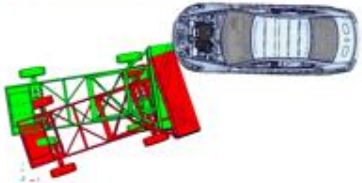


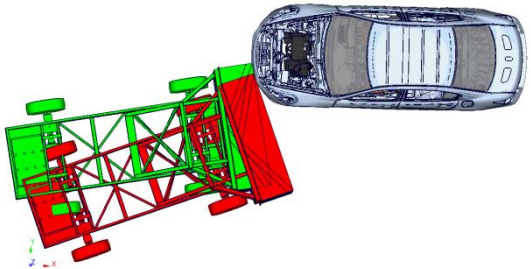


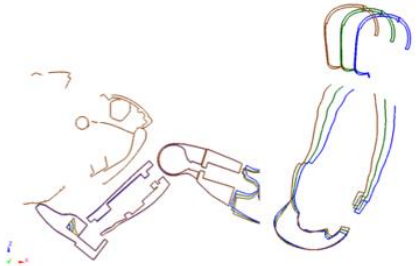


Sensitivity Study:

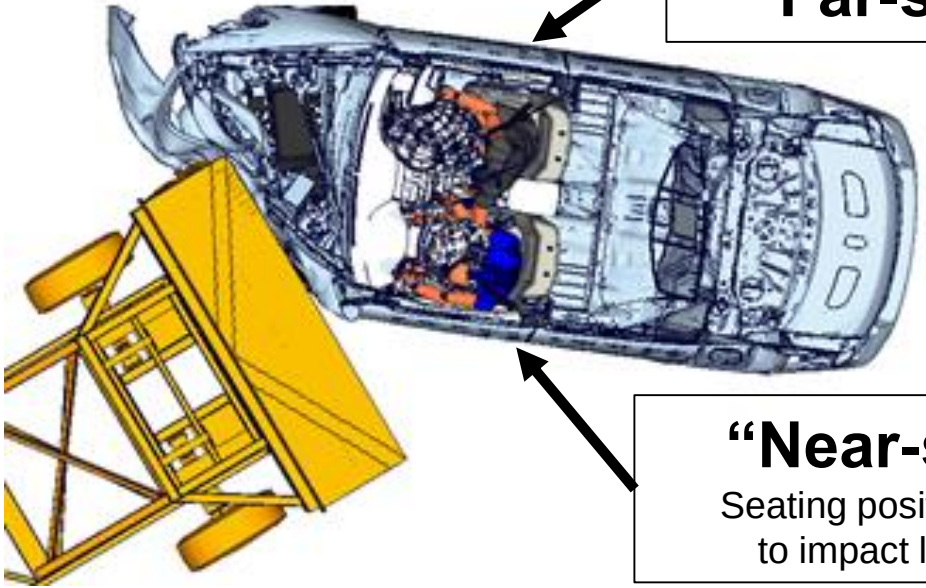
Beyond test tolerances







Definitions II



Seating position further away from impact location

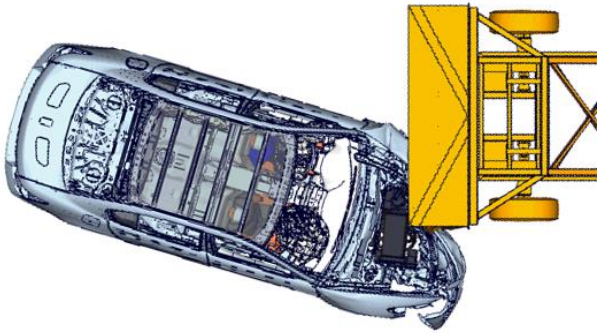
“Far-side”

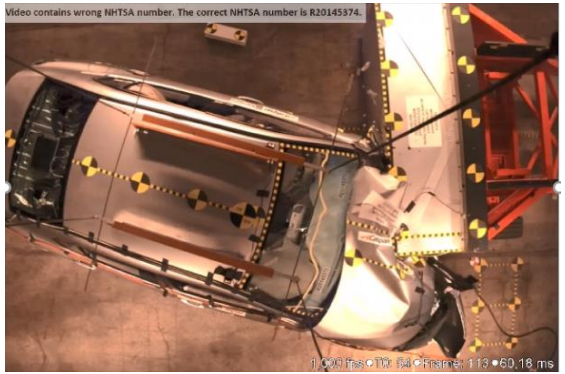
“Near-side”

Seating position closer to impact location

Methods – FE Simulation

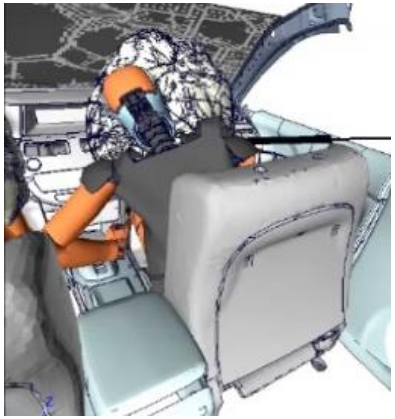
- A validated baseline model of a 2014 mid-size sedan was used
- The model with ~ 5.000.000 elements included the vehicle with interior and restraints, the OMDB, and two 50% THOR occupants
- Approximately 200 simulations were conducted

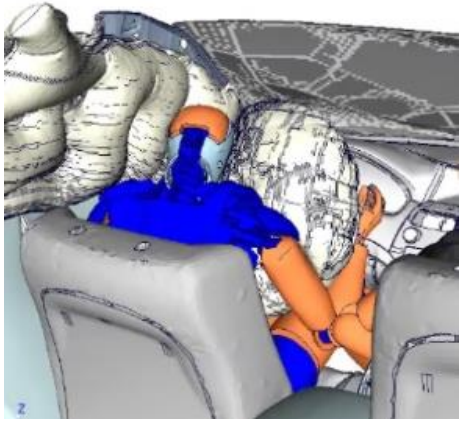


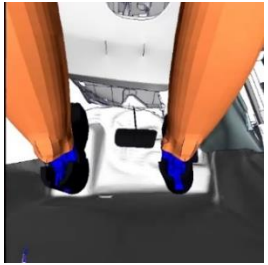


Methods – Baseline Model Correlation

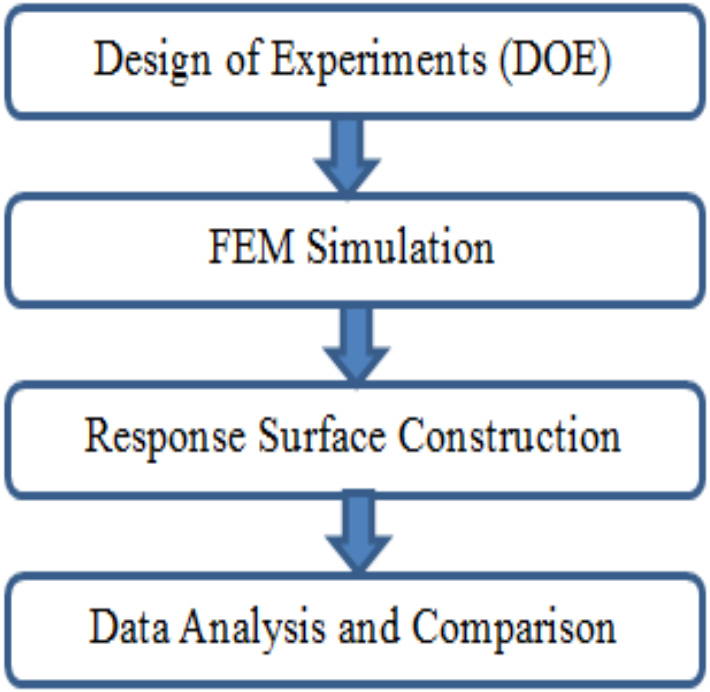
- Baseline model correlated reasonably well with full-scale test results (Test #8789 2014 Honda Accord 4 door sedan)

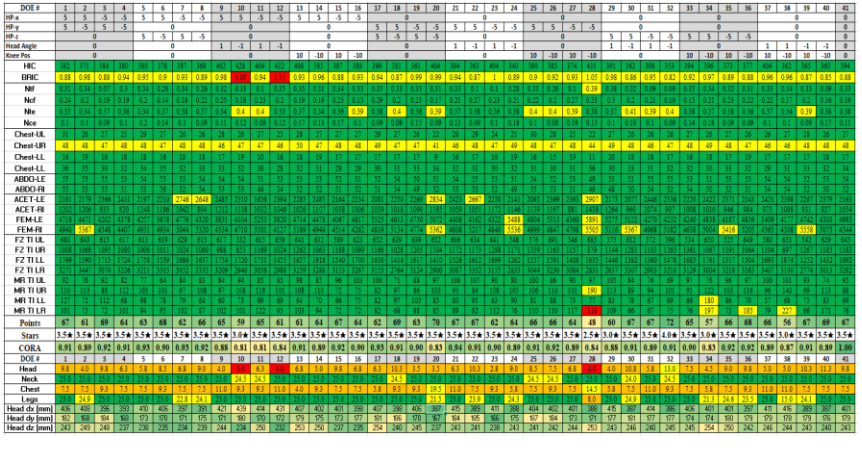




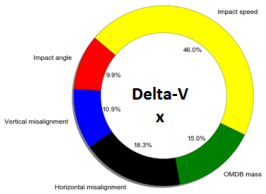


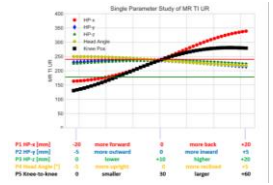
Methods – DOE

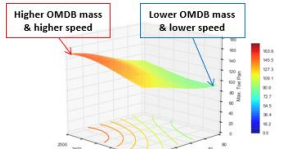




Parameter Importance Index



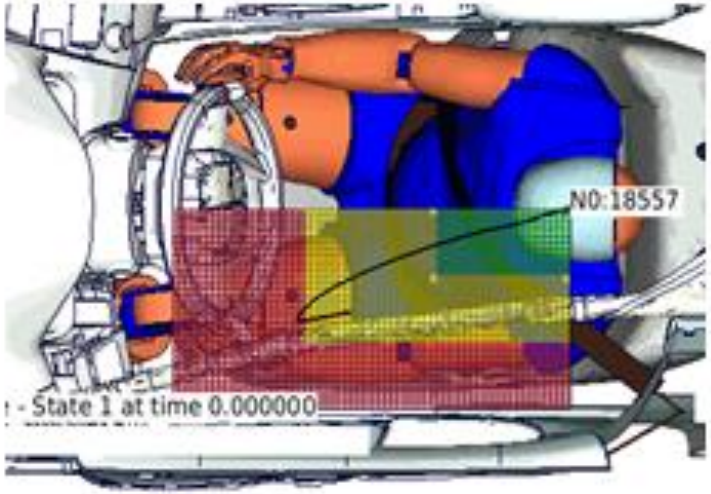




Methods – Data Analysis

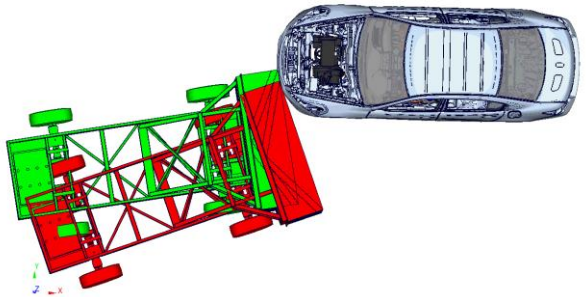
Evaluation Criteria

- Vehicle kinematics and intrusions
- Occupant kinematics and injury criteria
- Comparison of time history data using CORA/ISO 18571, e.g. GOOD > 0.8



Test Setup Study Parameters

Effect and importance of OMDB test setup parameters within and beyond defined tolerances were evaluated.



Parameter	Range		
Impact angle [degree]	14	15	16
Vertical Misalignment (MA) [mm]	-50	0	50
Horizontal MA [mm] / Overlap	-50 (33%)	0 (35%)	50 (38%)
OMDB Mass [kg]	-50	2486	+50
Impact speed [km/h]	89	90	91

Repeatability Study

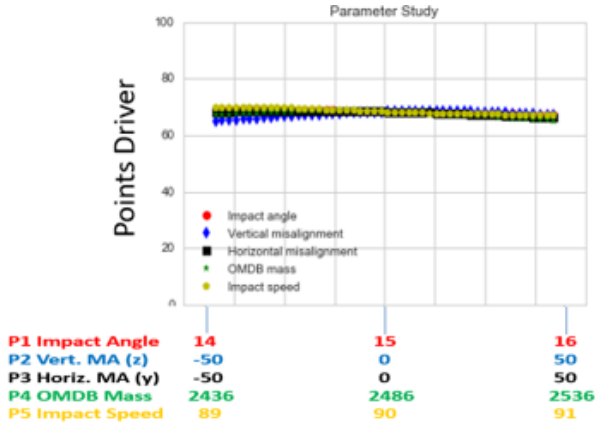
Parameter	Range			
Impact angle [degree]		10	15	20
Overlap [%]		30	35	40
OMDB Mass [kg]	2000	2250	2500	
Impact speed [km/h]	80	85	90	

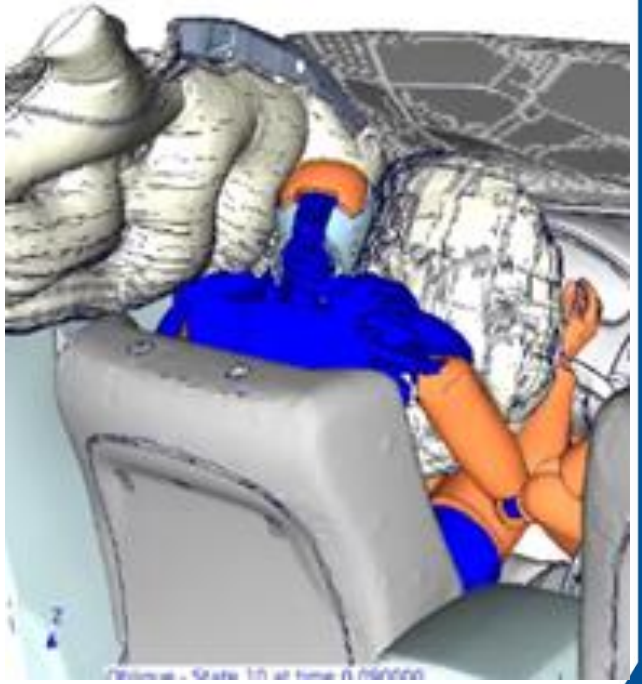
Sensitivity Study

Results – Test Setup Repeatability Study Driver

Near-side occupant kinematics well controlled

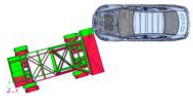
Similar overall injury risk and CORA ratings greater than 0.86 indicate good test repeatability





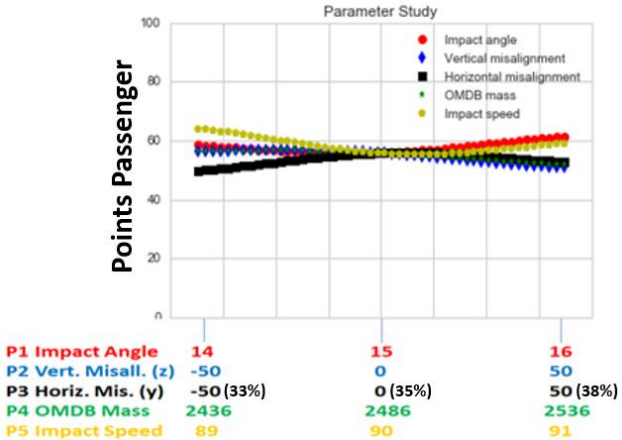
Results – Test Setup Repeatability Passenger

Repeatability Study:
Within test tolerances

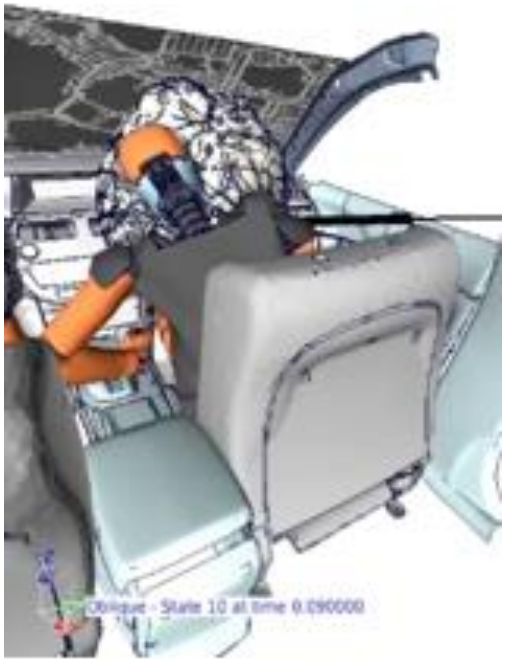


Far-side occupant kinematics less controlled

CORA ratings between 0.81 and 0.94 indicate good test repeatability



P1 Impact Angle	14	15	16
P2 Vert. Misall. (z)	-50	0	50
P3 Horiz. Mis. (y)	-50 (33%)	0 (35%)	50 (38%)
P4 OMDB Mass	2436	2486	2536
P5 Impact Speed	89	90	91



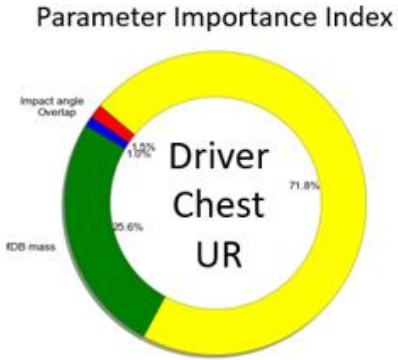
Results – Test Setup Sensitivity Study Driver

Impact speed most important for chest (72%) and overall risk (49%)

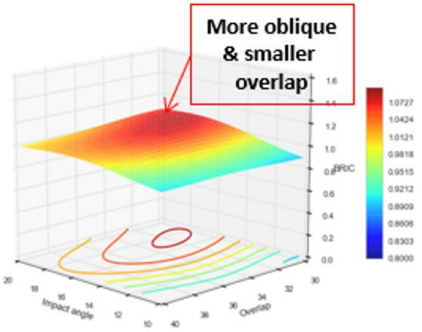
Higher impact speed correlated with higher chest deflection and overall injury risk

More oblique angle and smaller overlap correlated with higher BRIC and lower HIC

CORA scores between 0.71 and 0.87



Impact speed



BRIC

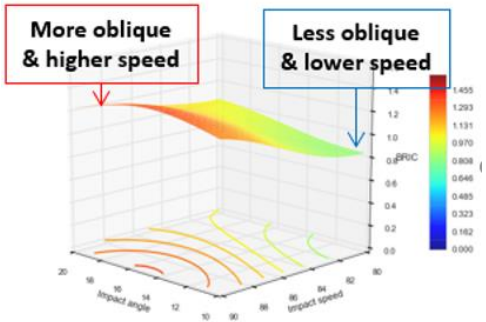
Results – Test Setup Sensitivity Passenger

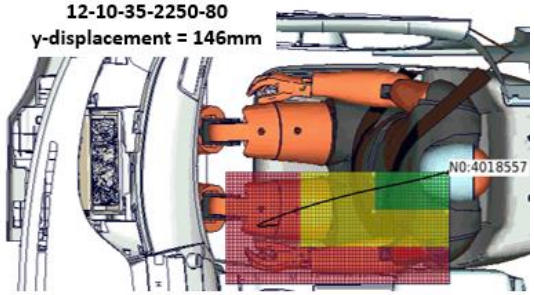
Significant differences in occupant kinematics

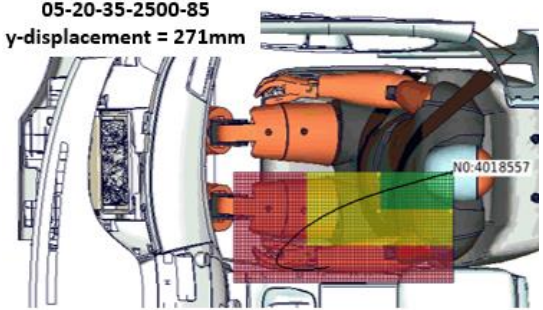
Impact speed most important parameter for overall injury risk (49%) and BRIC (69%)

More oblique angle and higher speed corelated with higher BRIC

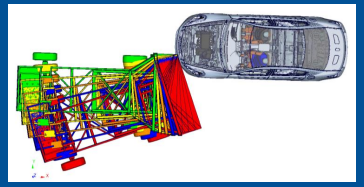
Cora scores between 0.73 and 0.9





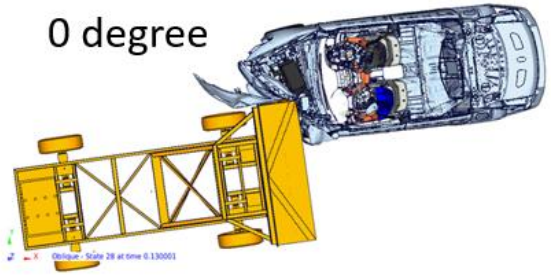


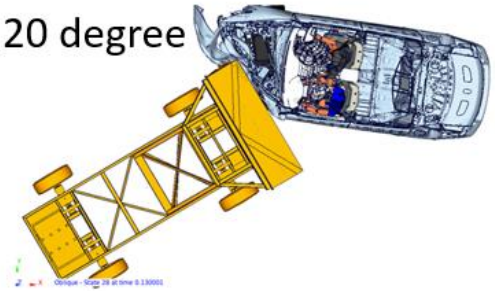
Results – Impact Angle Study Vehicle

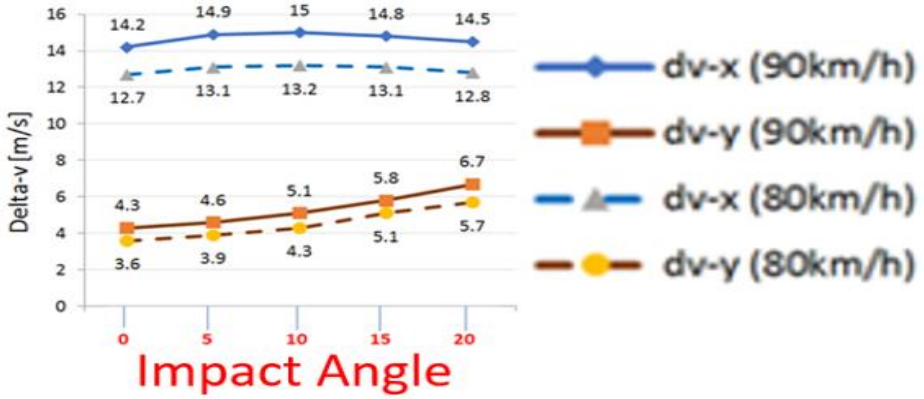


Varying impact angle from co-linear to +20° showed significant differences:

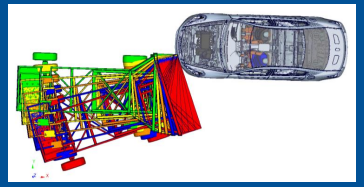
- Vehicle yaw
- Vehicle y-pulse





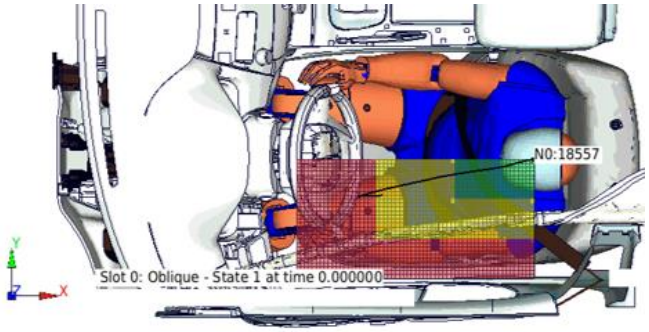


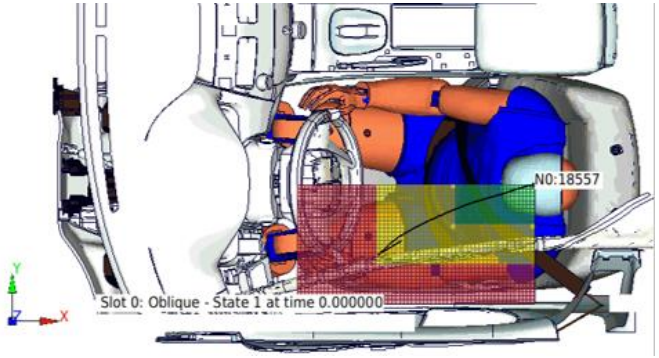
Results – Impact Angle Study Driver



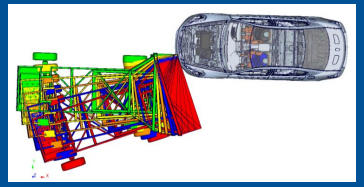
Similar overall injury risk for different impact angles were observed because:

- More oblique conditions correlated with higher BRIC values
- More oblique conditions correlated with lower chest deflection



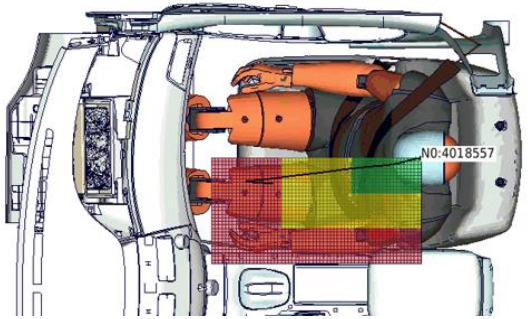


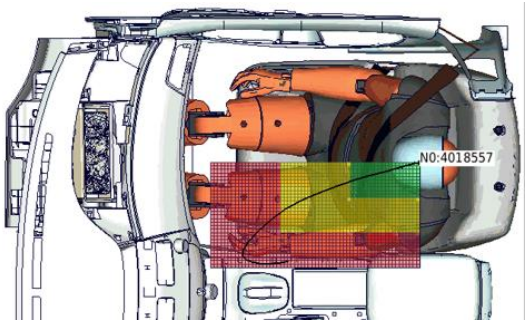
Results – Impact Angle Study Passenger



For the passenger, more oblique conditions correlated with:

- Larger lateral head trajectories
- Higher BRIC and tibia values
- Higher overall injury risk





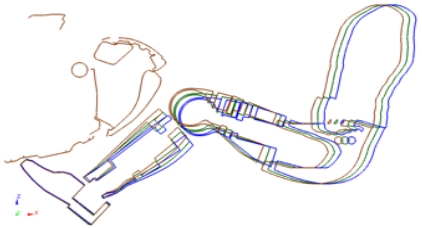
Seating Position Parameters

Effect and importance of THOR positioning parameters were determined

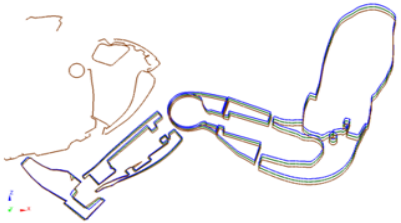
Repeatability Study	Range (Driver)		
H-Point (x)	-5	BL	+5
H-Point (Y)	-5	BL	+5
H-Point (Z)	-5	BL	+5
Head Angle	-1	BL	+1
Knee/Heel Position	-10	BL	+10

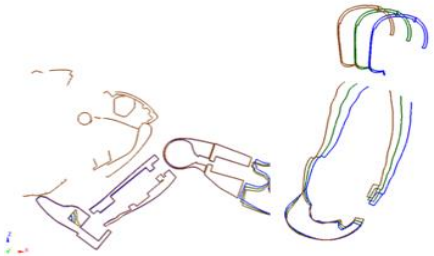
Sensitivity Study	Range (Passenger)			
H-Point (x)	-20	BL	+20	
H-Point (y)	-5	BL	+5	
H-Point (Z)		BL	+10	+20
Head Angle	-5	BL	+5	
Knee/Heel Position		BL	+30	+60

HP-x
+20/0/-20mm

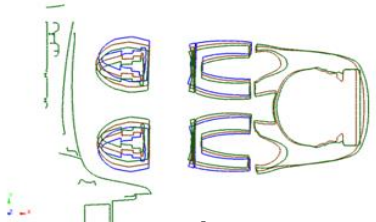


HP-z
0/+10/+20mm





Head/torso
+5/0/-5°

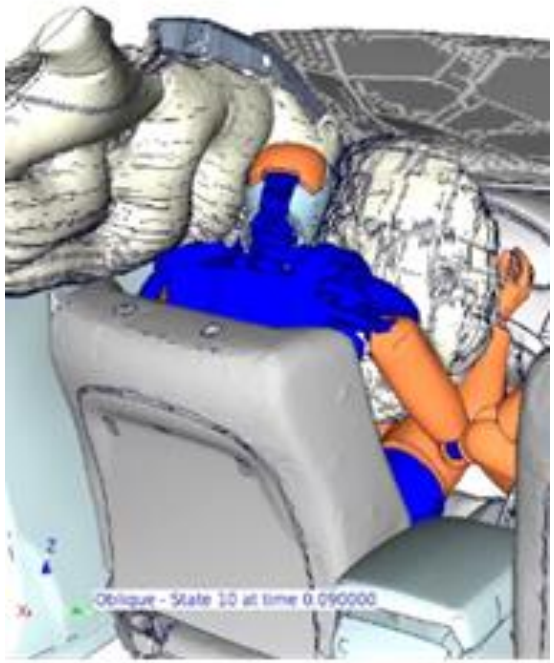


Knee-to-knee
BL/+30/+60mm

Results – THOR Position Repeatability Study Driver

Changing seating position of near-side occupant within defined test tolerances showed good repeatability:

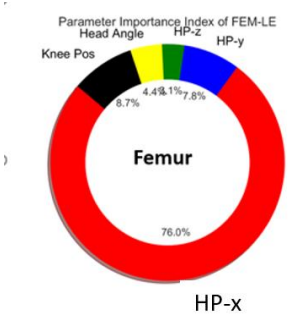
- Small variance in occupant kinematics
- “GOOD” correlation of time history data (CORA ratings between 0.81 and 0.94)
- Tibia loads most sensitive due to interaction with gas pedal

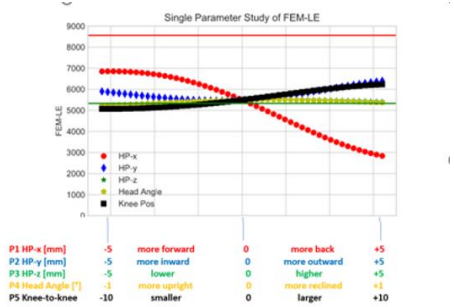


Results – THOR Position Sensitivity Passenger

Changing seating position of the far-side occupant beyond defined test tolerances resulted in more significant differences:

- Differences in occupant kinematics
- HP-x most important (76%) for Femur
- Time history data with larger variance (CORA ratings between 0.7 and 0.9)



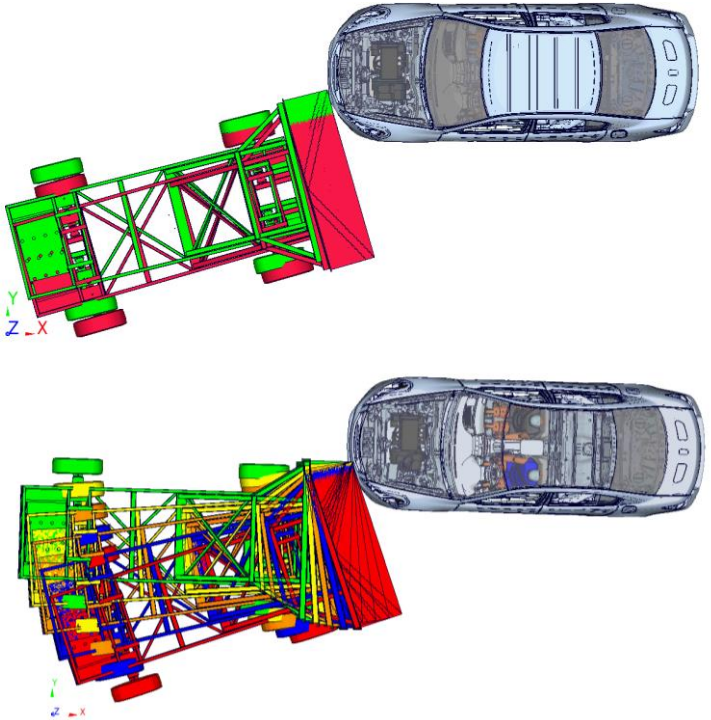


Conclusion

NHTSA's oblique test showed good overall repeatability when relevant parameters were changed within defined tolerances

Far-side occupant results were more sensitive to parameter variations than the near-side occupant

More oblique impact scenarios tended to produce higher overall injury risk for the far-side occupant



Limitations

- Study has been conducted using a specific mid-size sedan vehicle model which was validated using NHTSA test #8789 (2014 Honda Accord 4-door sedan)

- Effect of individual and combination of parameters was determined using DOE surrogate models

Acknowledgment

- Baseline FE vehicle model with restraints developed by EDAG and Key Safety Systems
- THOR occupant FE model developed by UVA
- Project has been sponsored and directed by NHTSA

Thank You

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