Rear Seat Occupant Protection: Addressing the Different Needs of A Diverse Population

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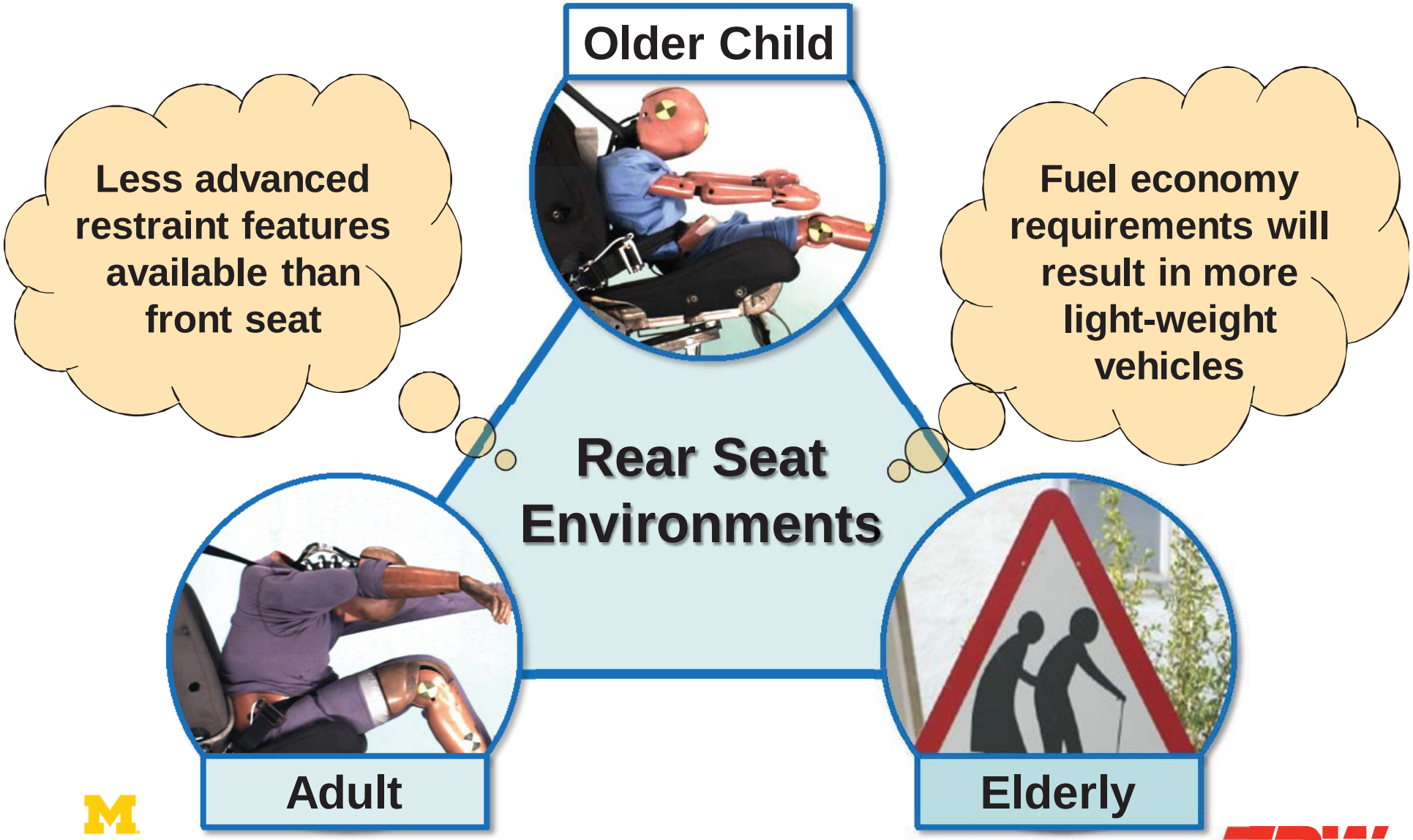
Research Motivation



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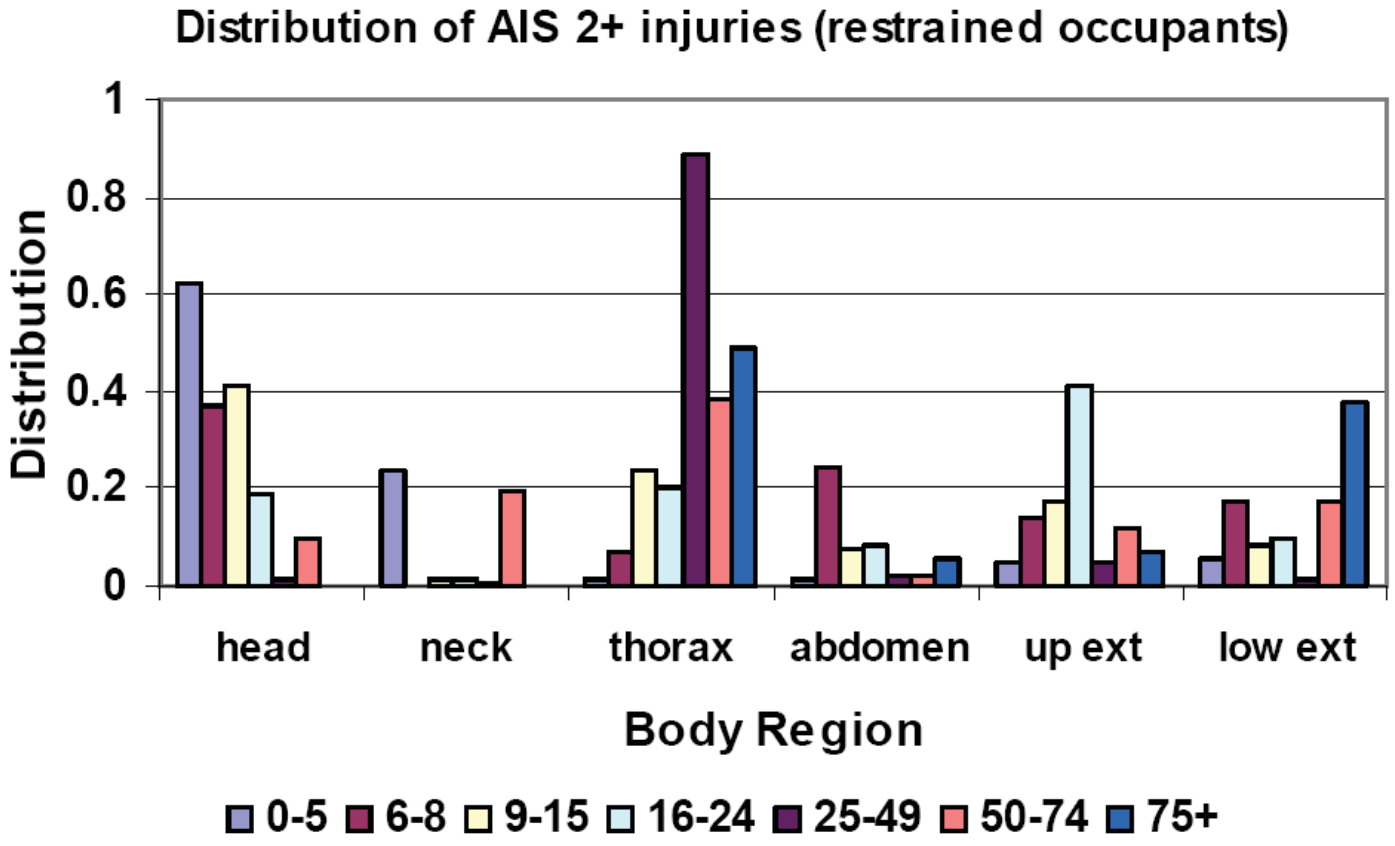
Background

- **What are the leading injuries in rear seat?**



Data based on Kuppa et al. 2005

Background

- **What are the leading injuries in rear seat?**
  - For belted children, the most frequently injured body region is the head, and the main source of these head injuries is the back of the front seat and B-pillar.
  - For adults, especially the elderly, the most frequently injured body region is the chest, and the major source of these chest injuries is the seatbelt.
  - These results suggest that the restraint system types and characteristics that provide optimal protection to children may be different than those that provide optimal protection to either elderly or young adults.

Data based on Kuppa et al. 2005 and Arbogast et al. 2012

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Objectives

- **Rear Seat Advanced Restraint Program**
  - To identify, design, optimize, and fabricate a prototype advanced restraint system for rear seat occupants.
  - To provide protection for rear seat occupants in frontal crashes with different crash pulses and directions of impact and to different occupant size, age and gender.
  - To establish the baseline performance of a non-advanced system and show the occupant safety improvements of various advanced restraint systems.

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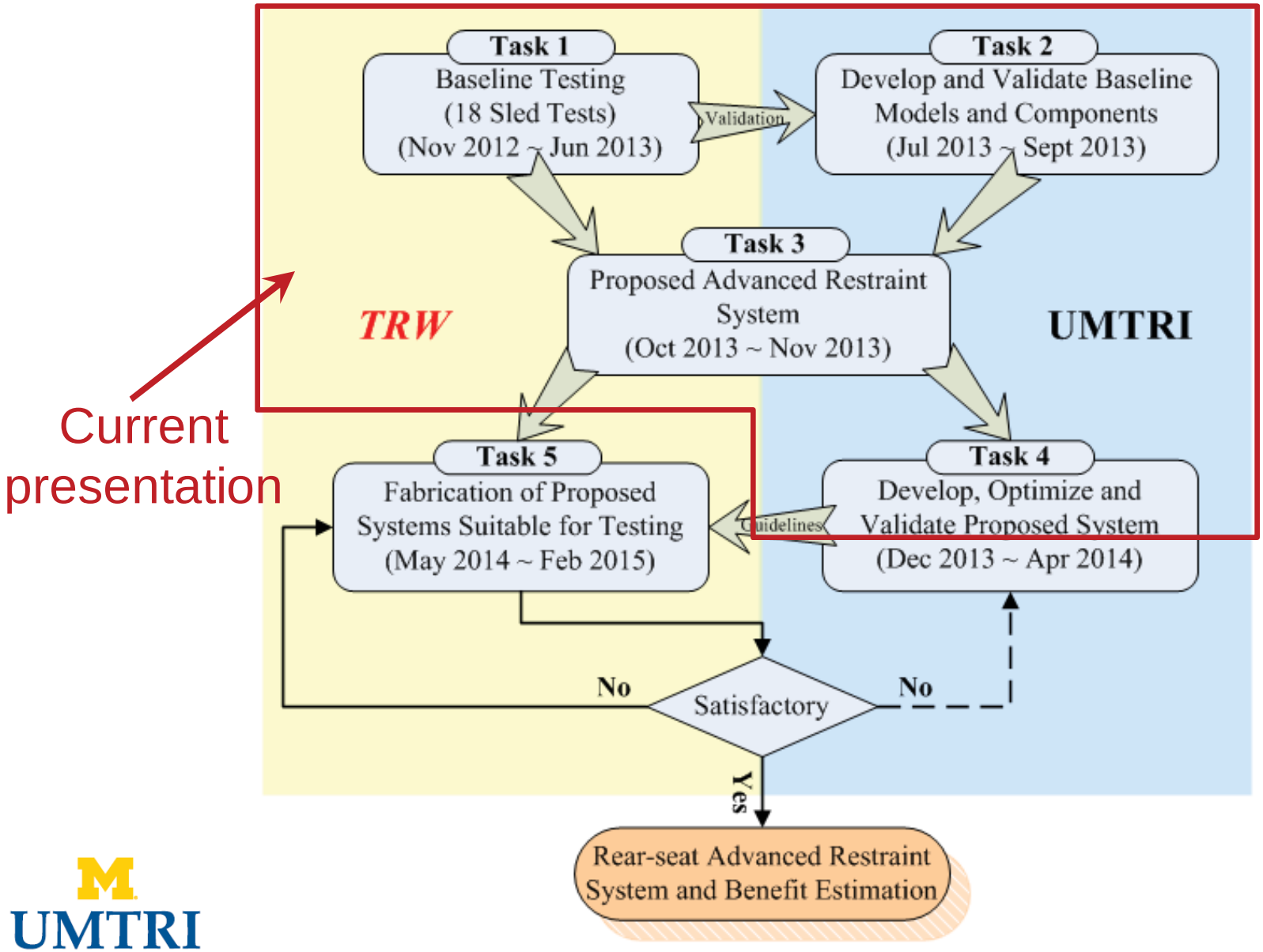
Research Tasks



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Baseline Tests

Sled No.	Sled Angle	Sled Pulse	Left Passenger	Right Passenger
1	0	Soft	HIII 95th	HIII 6YO
2	0	Severe	HIII 95th	HIII 6YO
3	0	Soft	HIII 6YO	HIII 95th
4	0	Severe	HIII 6YO	HIII 95th
5	0	Soft	THOR-Mod Kit	HIII 5th
6	0	Severe	THOR-Mod Kit	HIII 5th
7	0	Soft	HIII 5th	THOR-Mod Kit
8	0	Severe	HIII 5th	THOR-Mod Kit
9	15	Soft	THOR-Mod Kit	HIII 5th
10	15	Severe	THOR-Mod Kit	HIII 5th
11	15	Soft	HIII 5th	THOR-Mod Kit
12	15	Severe	HIII 5th	THOR-Mod Kit
13	15	Soft	HIII 95th	HIII 6YO
14	15	Severe	HIII 95th	HIII 6YO
15	15	Soft	HIII 6YO	HIII 95th
16	15	Severe	HIII 6YO	HIII 95th

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Front Seat Location

`	Driver		Passenger	
	Seat Back Angle	Seat Position (Knee/Seat Offset)	Seat Back Angle	Knee/Seat Offset
6 Year Old	12 deg	Mid	3 deg	150 mm
Small Female (5^{th})	12 deg	Mid (110 mm)	3 deg	150 mm (Mid seat track)
Mid Size Male (50^{th})	12 deg	Mid (70 mm)	3 deg	150 mm
Large Male (95^{th})	12 deg	2 notches FWD of MID (20 mm)	3 deg	150 mm (Approx full fwd)

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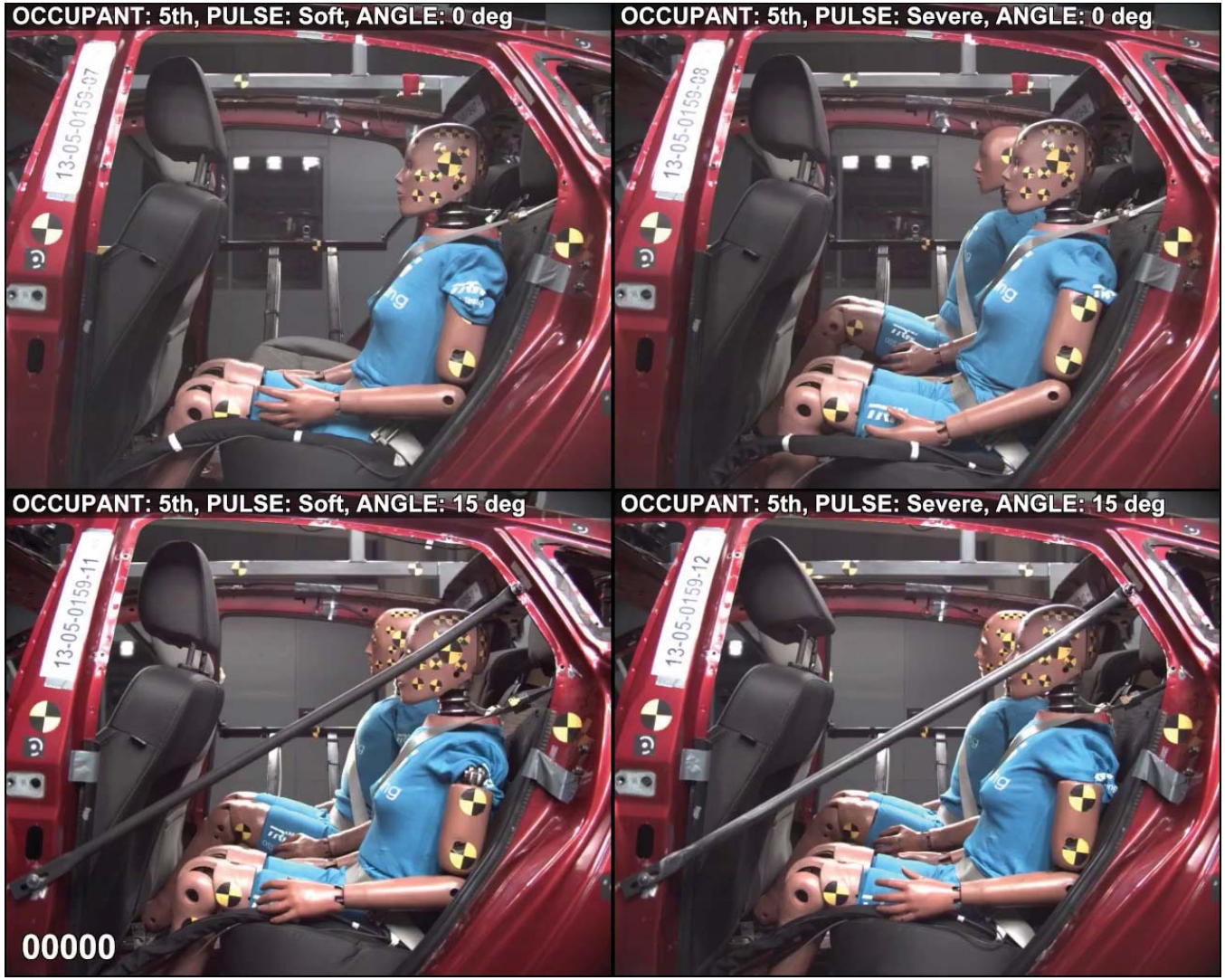
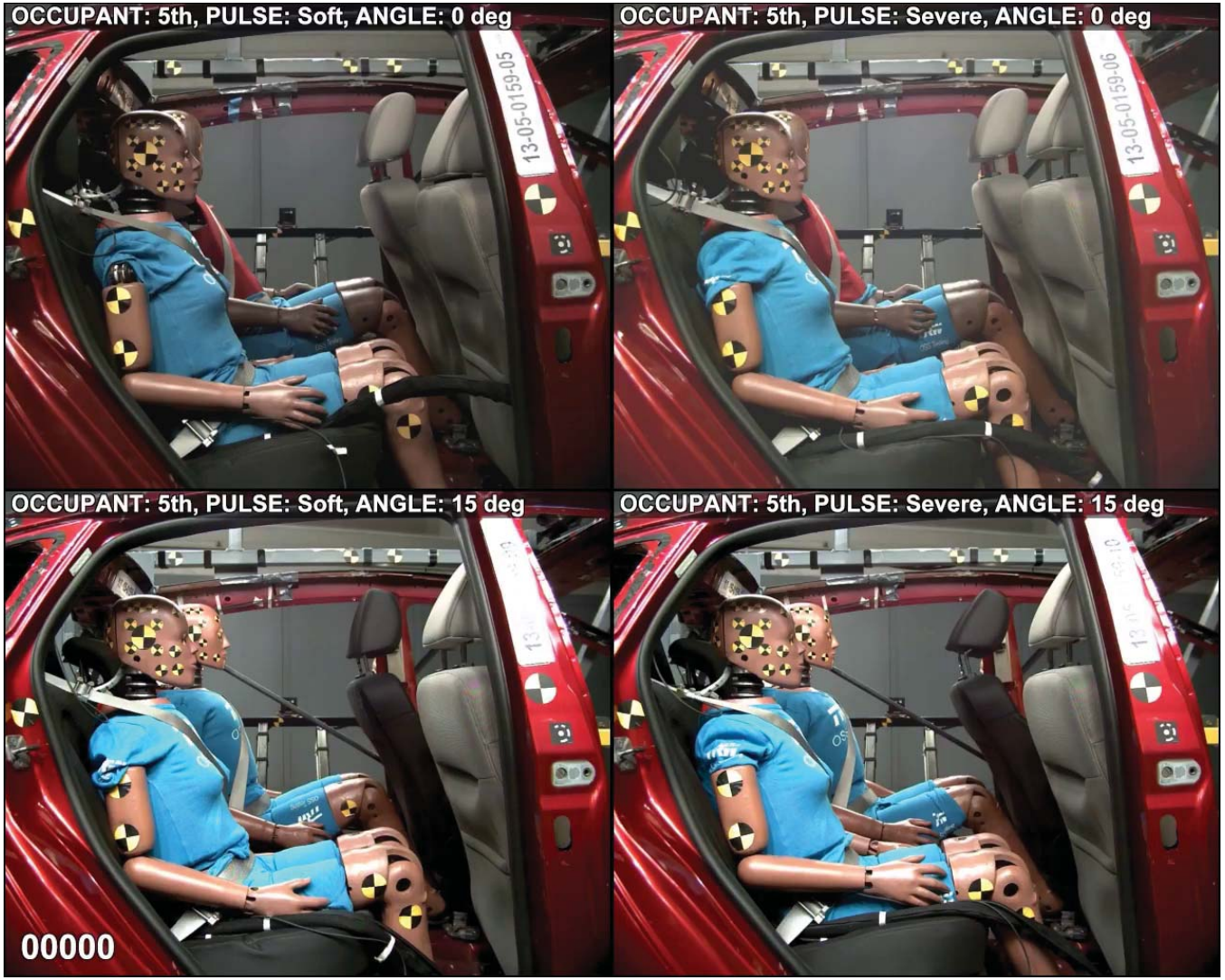
Results – Baseline Testing

5th female – Left Side



Results – Baseline Testing

5th female – Right Side



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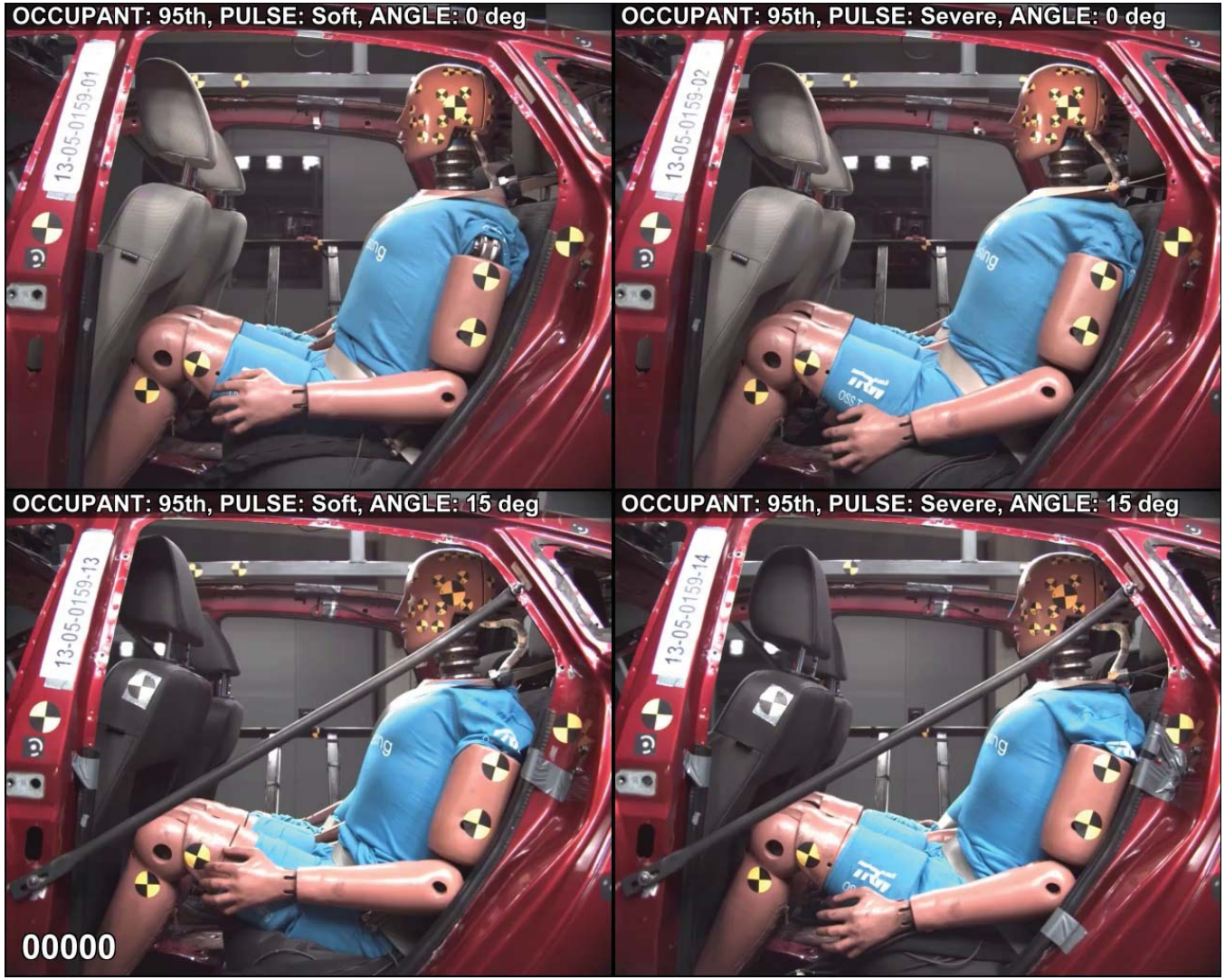
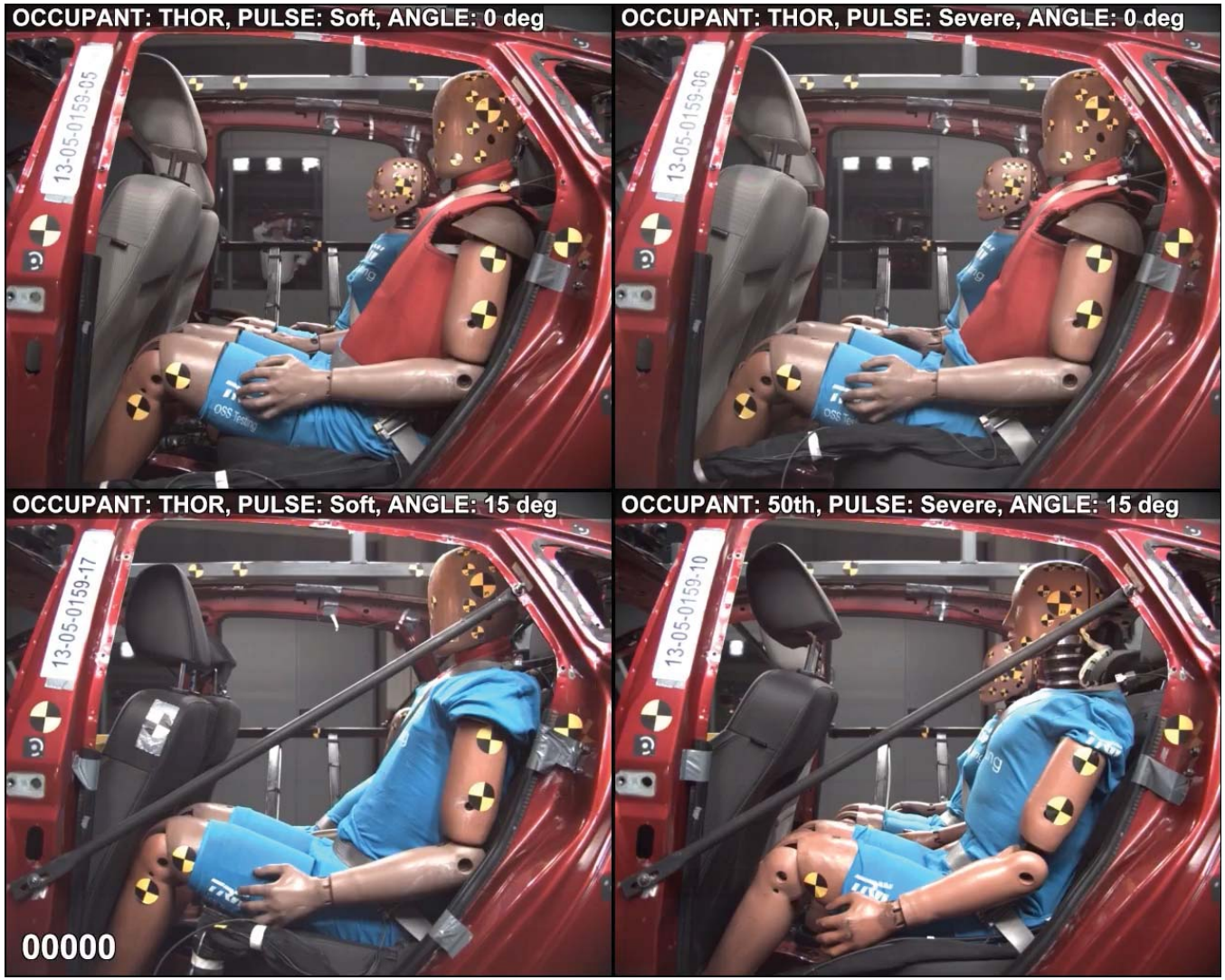
Results – Baseline Testing

95th Male – Left Side



Results – Baseline Testing

50th Male – Left Side



Results – Baseline Testing

6 Year Old – Right Side

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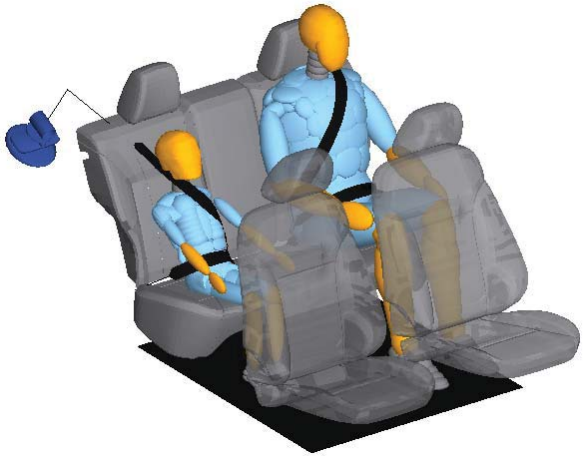
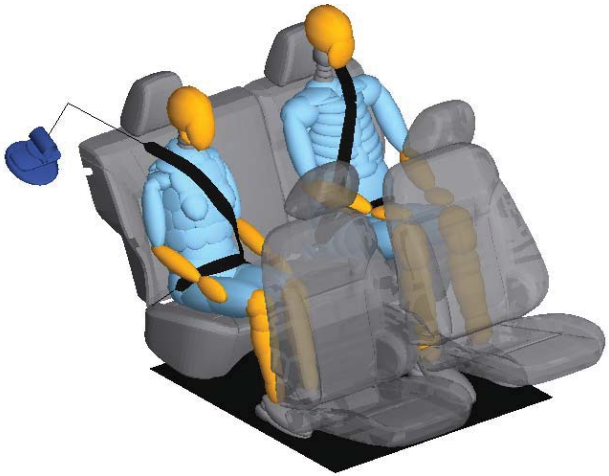
Model Validation

- 95th & 6YO

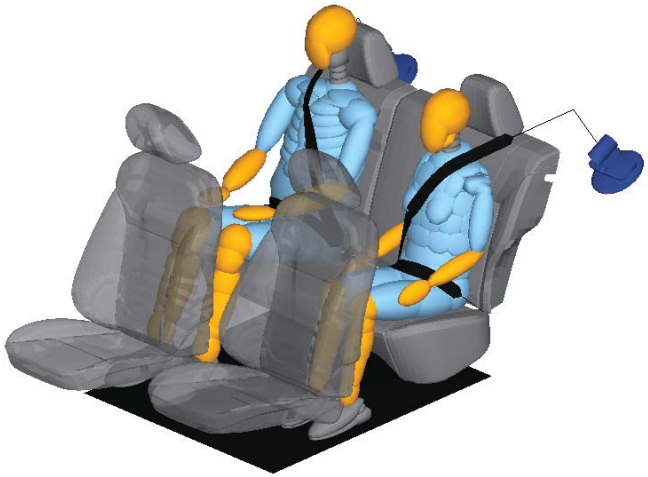


- 6YO & 95th

- THOR & 5th



- 5th & THOR



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Validation Example

- 0°-Soft-05F-Pa. (after optimization)

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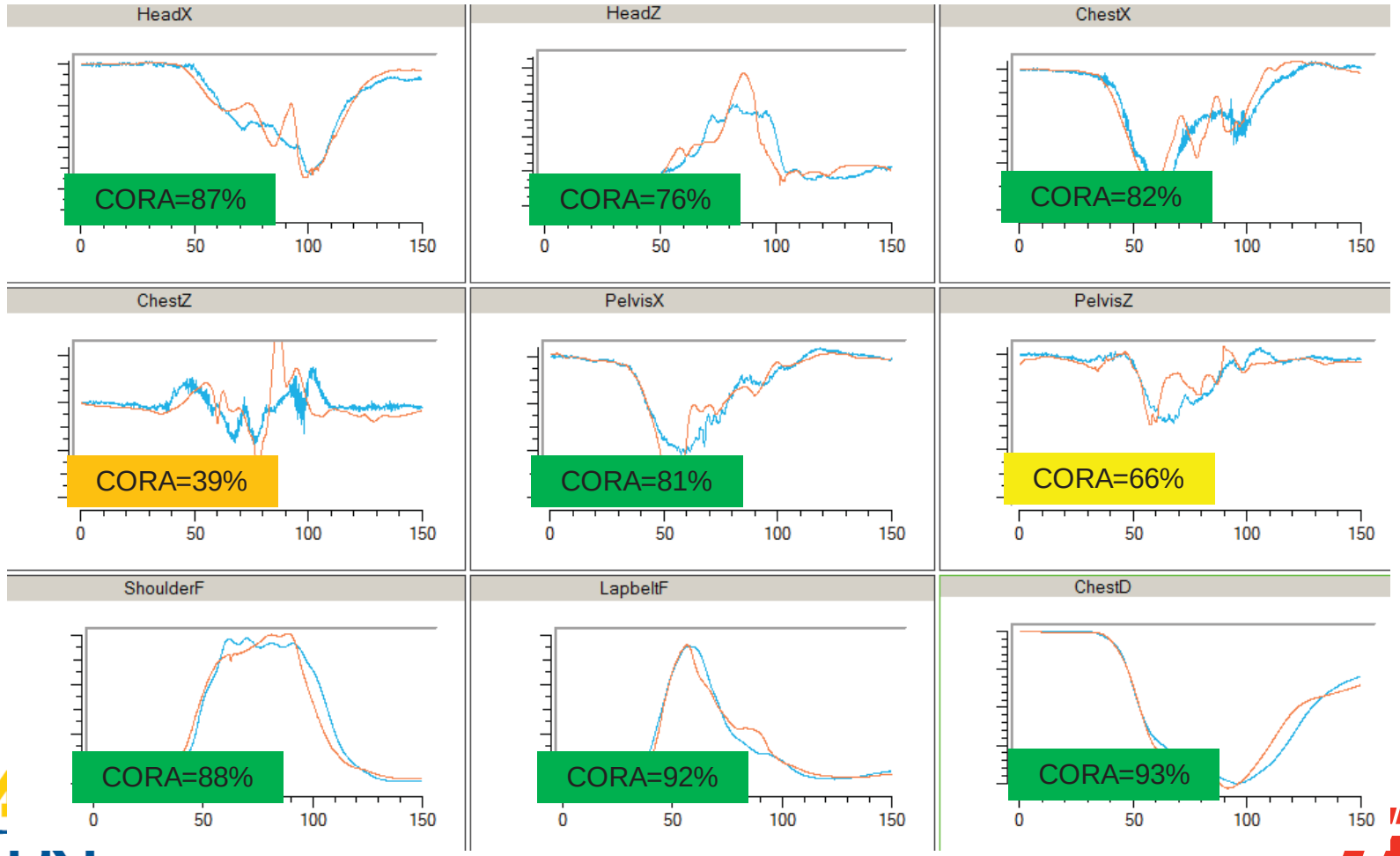
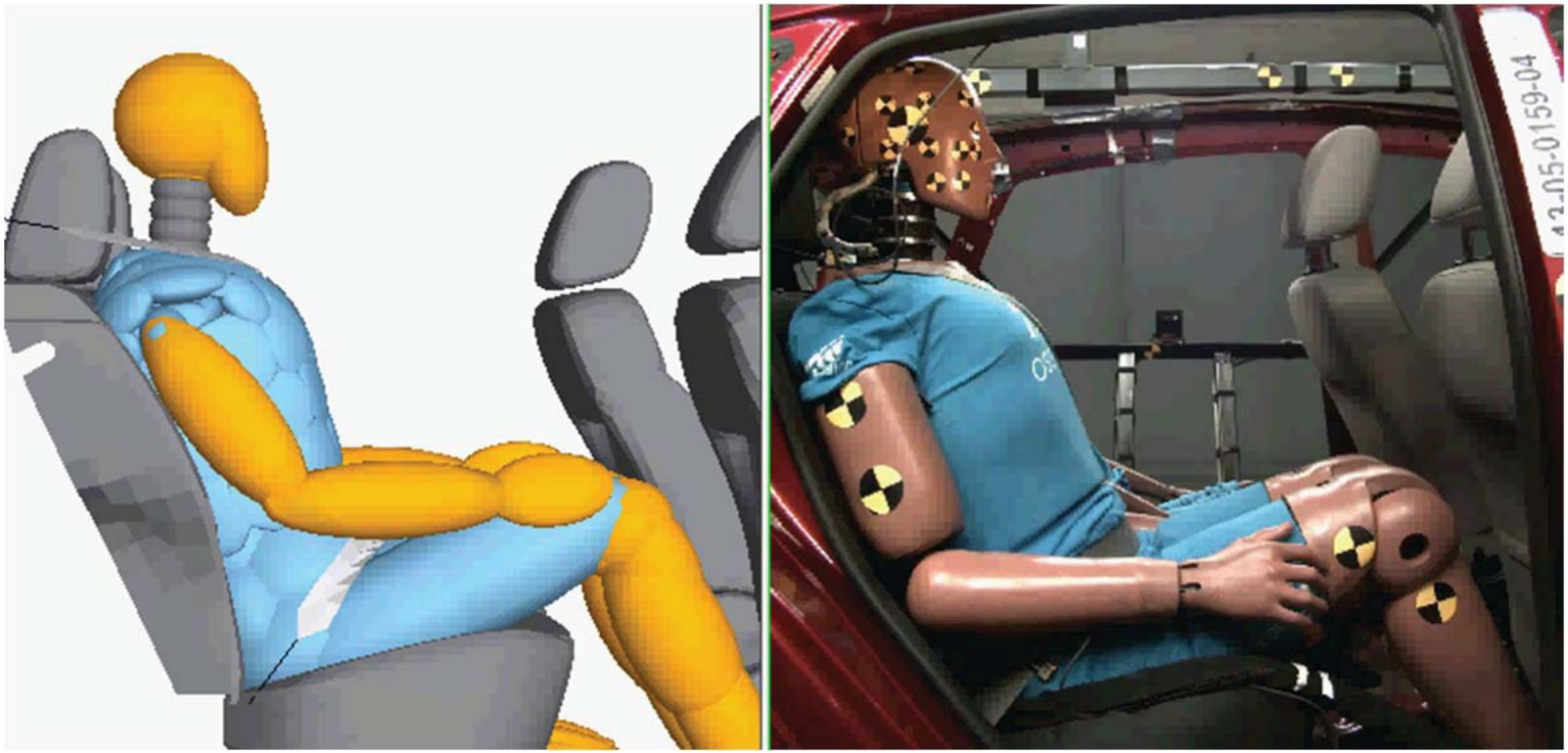
Validation Example

- 0°-Soft-05F-Pa.



Validation Example

- 0°-Severe-95M-Pa. (after optimization)



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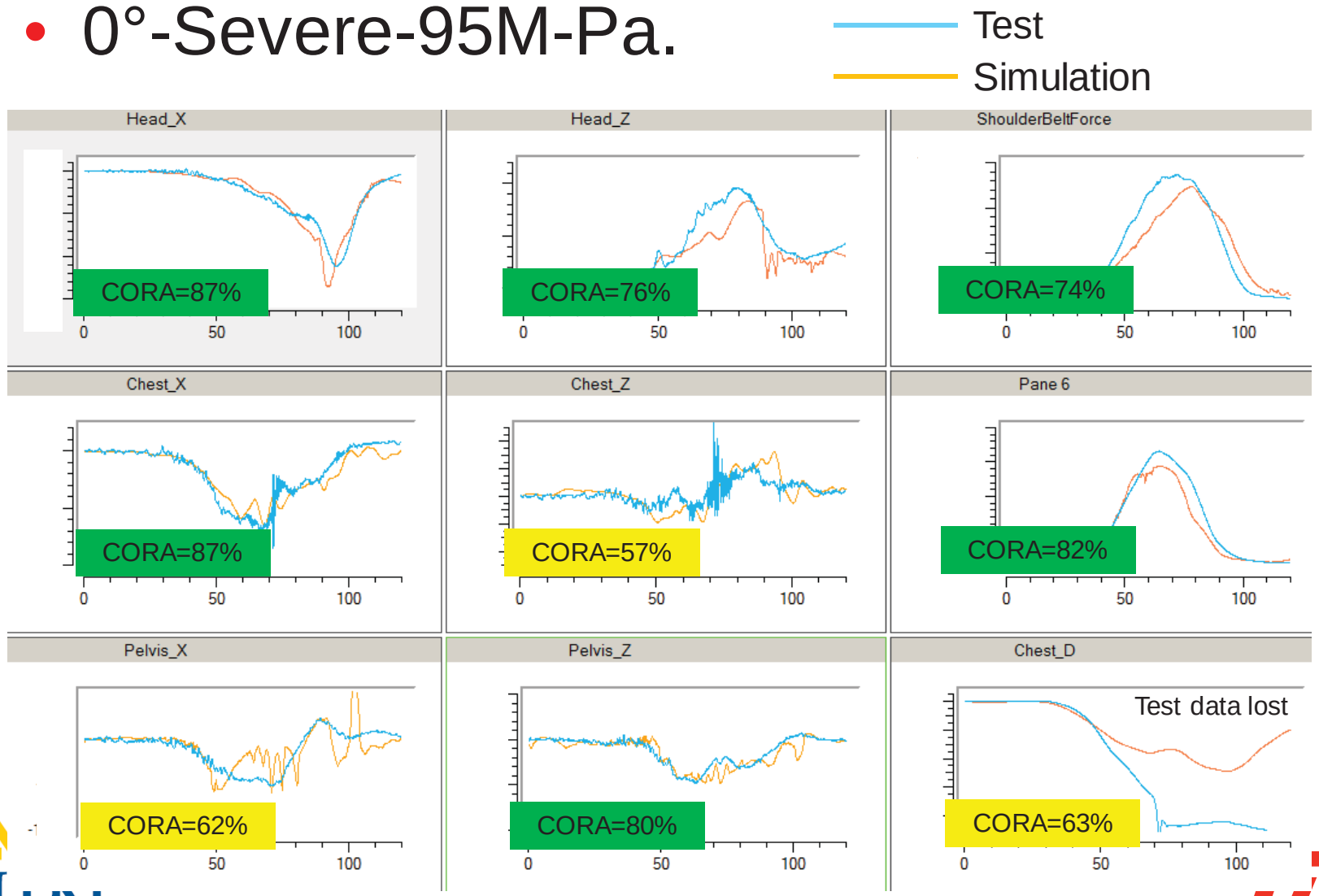
Validation Example

- 0°-Severe-95M-Pa.



Validation Example

- 0°-Soft-THOR-Dr. (after optimization)

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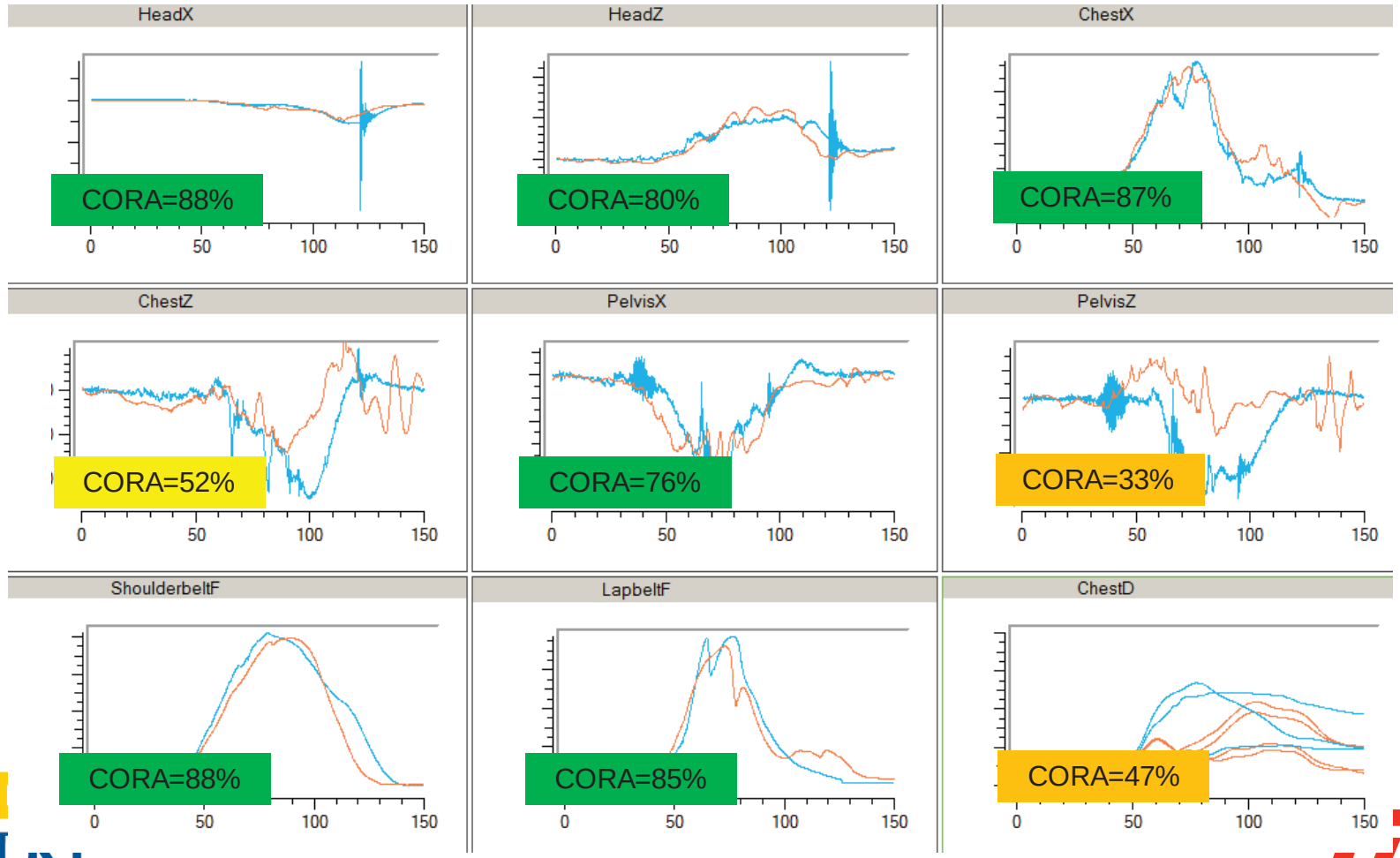
Validation Example

- 0°-Soft-THOR-Dr.

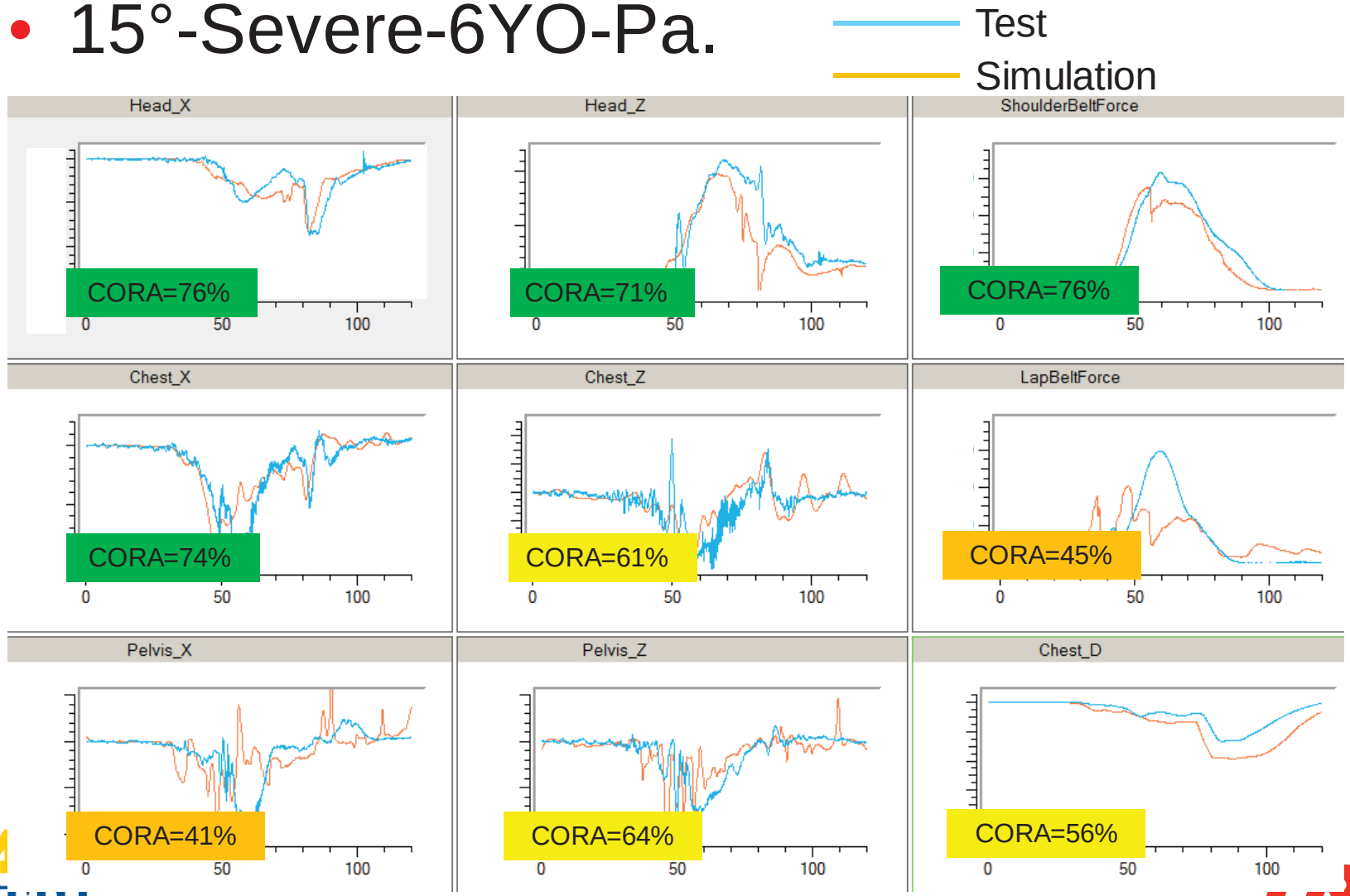


Validation Example

- 15°-Severe-6YO-Pa. (after optimization)

Validation Example

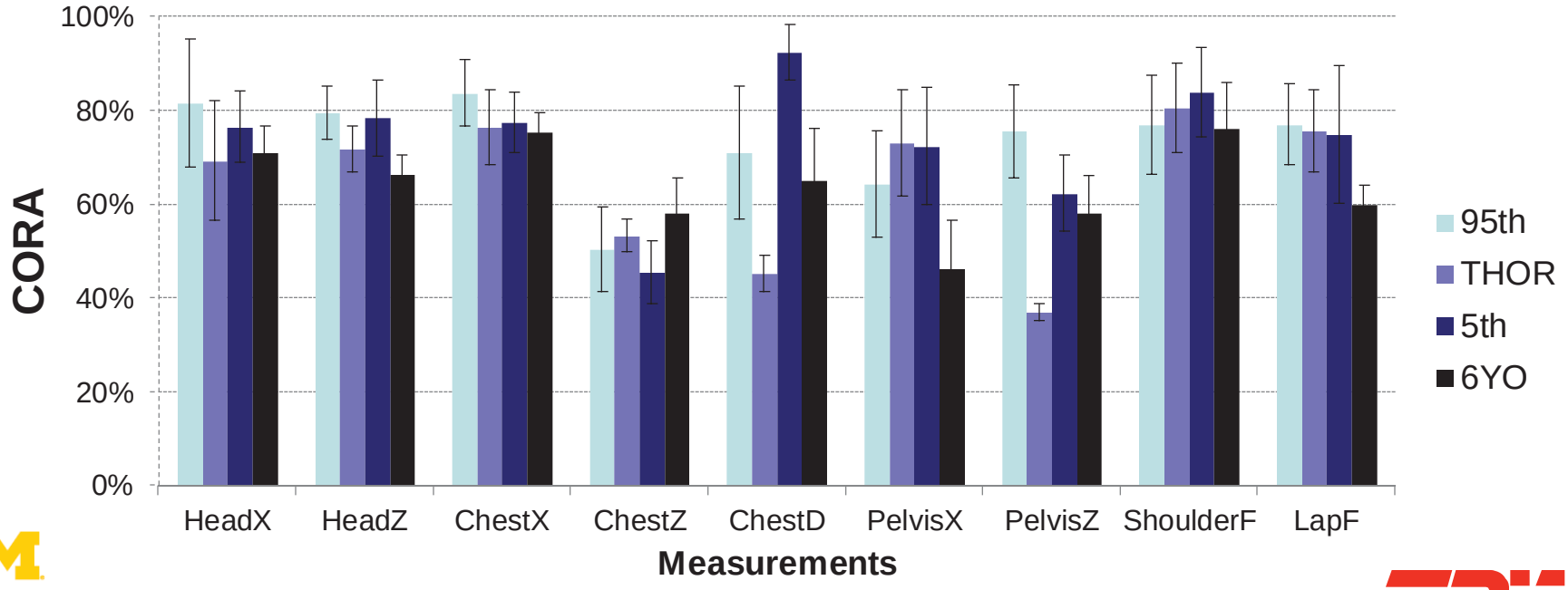
- 15°-Severe-6YO-Pa.



Quantitative Model Assessment

- CORA

Occupant	HeadX	HeadZ	ChestX	ChestZ	ChestD	PelvisX	PelvisZ	ShoulderF	LapF
95th	81.49%	79.45%	83.74%	50.35%	70.94%	64.20%	75.50%	76.89%	76.99%
THOR	69.29%	71.78%	76.48%	53.27%	45.24%	73.08%	36.96%	80.50%	75.64%
5th	76.52%	78.42%	77.48%	45.43%	92.36%	72.37%	62.34%	83.91%	74.89%
6YO	70.90%	66.33%	75.41%	58.16%	64.95%	46.34%	58.01%	76.10%	59.84%



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Advanced Restraint Features

Restraint Technology	Minimize Excursion	Reduce Chest Loading	Reduce Head/Neck Loading	Minimize Belt Rollout	Adaptability Occupant Size
Constant Load Limiter	--	+	0	0	0
Declining Load Limiter	--	+	0	0	0
Progressive Load Limiter	-	+	0	0	+
Self-Adaptive Load Limiter	0	++	0	0	++
Switchable Load Limiter	0	++	0	0	++
Retractor Pre-tensioner	+	+	0	0	0
Anchor Pre-tensioner	+	+	0	0	0
Buckle Pre-tensioner	+	+	0	0	0
Wider Webbing	0	+	0	0	0
Four Point Mounting	0	+	0	++	0
Locking Tongue	+	+	0	0	0
Inflatable Belt	+	0	+	0	0
Air Bag in Rear-seat Area	++	0	++	0	0
Seat Cushion Length	+	0	+	0	0

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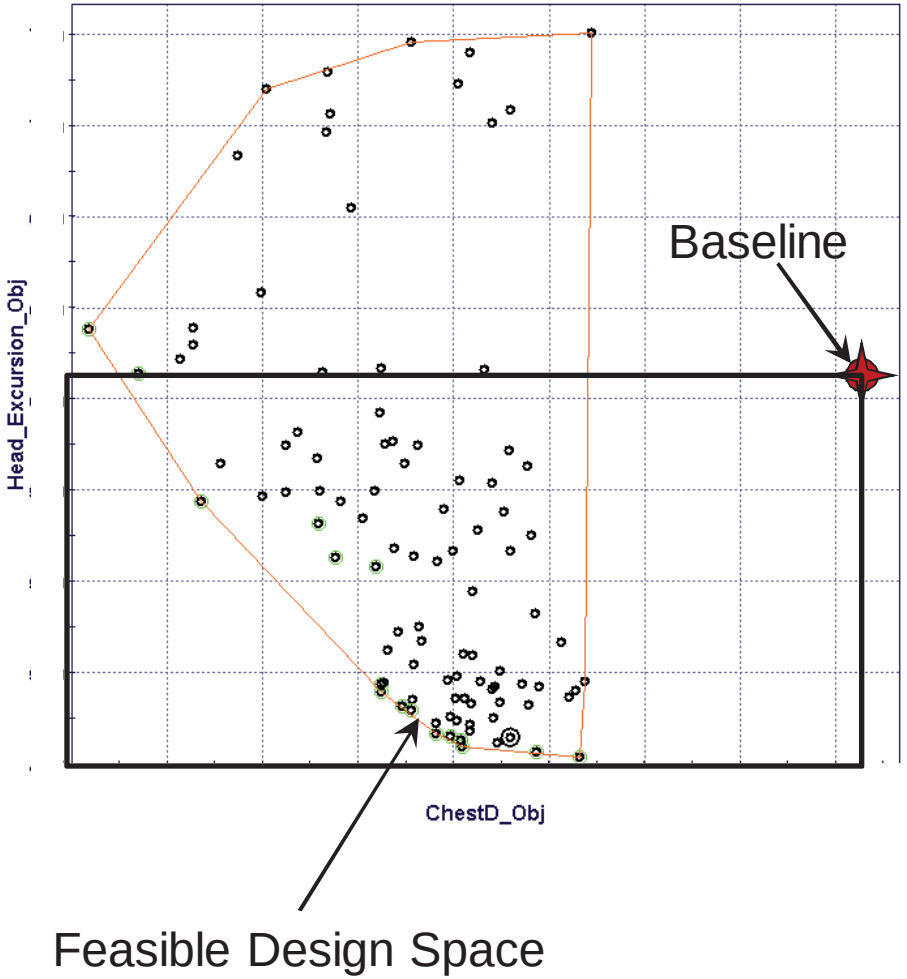
Optimization Simulations

- 95M-severe-dri

Parameters		Range
Retractor	Retr_Torque	9-12mm
	SLL_Switch	50-90ms
	SLL_level	1.0-2.5kN
	Webbing	500-1200mm
Buckle_PT	PT_time	Yes/No
Anchor_PT	PT_time	Yes/No
DLT	DLT_force	Yes/No



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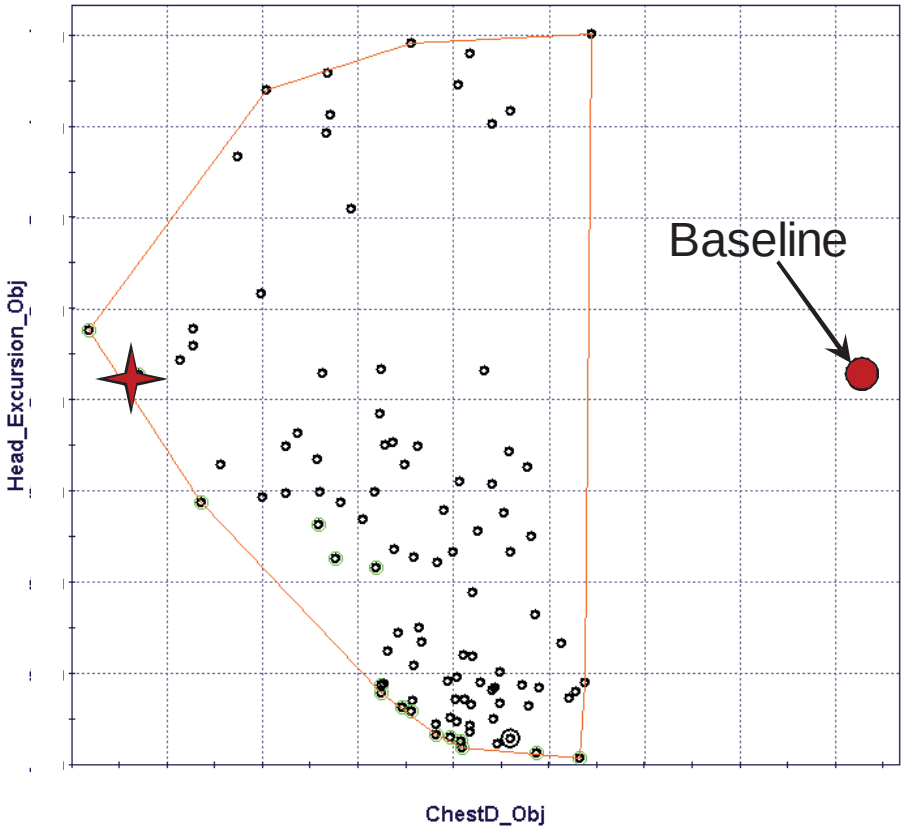
Optimization Simulations

- 95M-severe-dri –No.21

Parameters		Range
Retractor	Retr_Torque	10mm
	SLL_Switch	80ms
	SLL_level	1.0kN
	Webbing	900mm
Buckle_PT	PT_time	No
Anchor_PT	PT_time	Yes
DLT	DLT_force	Yes



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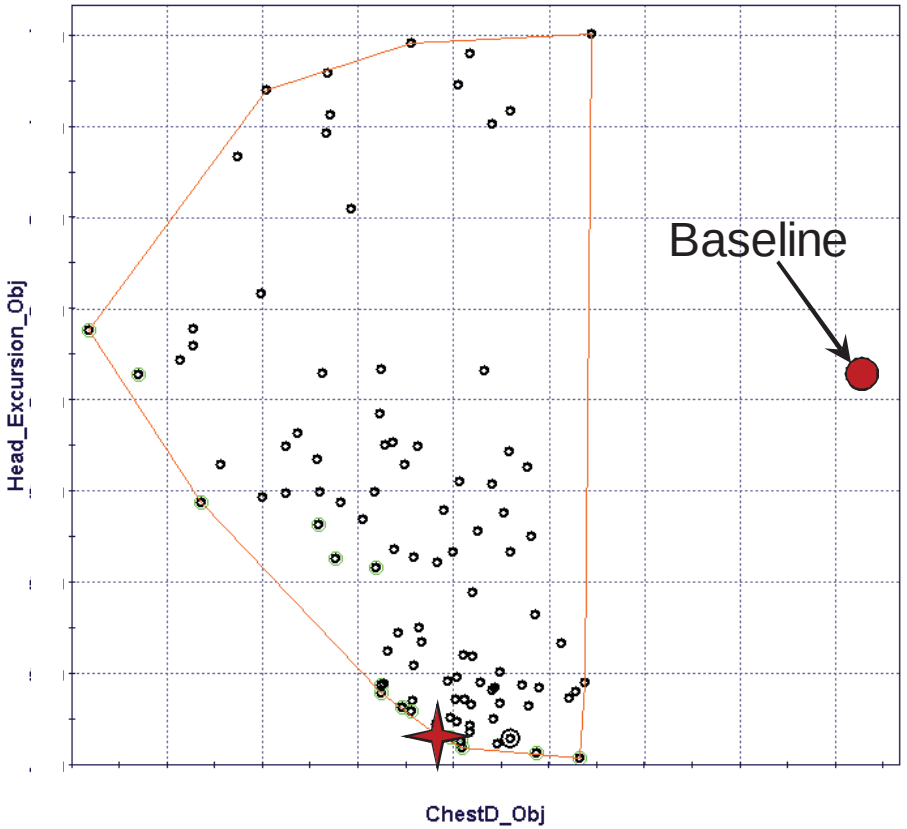
Optimization Simulations

- 95M-severe-dri –No.79

Parameters		Range
Retractor	Retr_Torque	11.5mm
	SLL_Switch	50ms
	SLL_level	1.0kN
	Webbing	600mm
Buckle_PT	PT_time	Yes
Anchor_PT	PT_time	No
DLT	DLT_force	No



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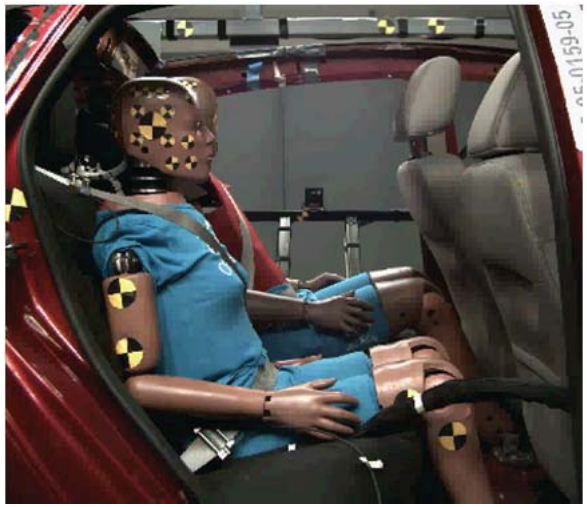
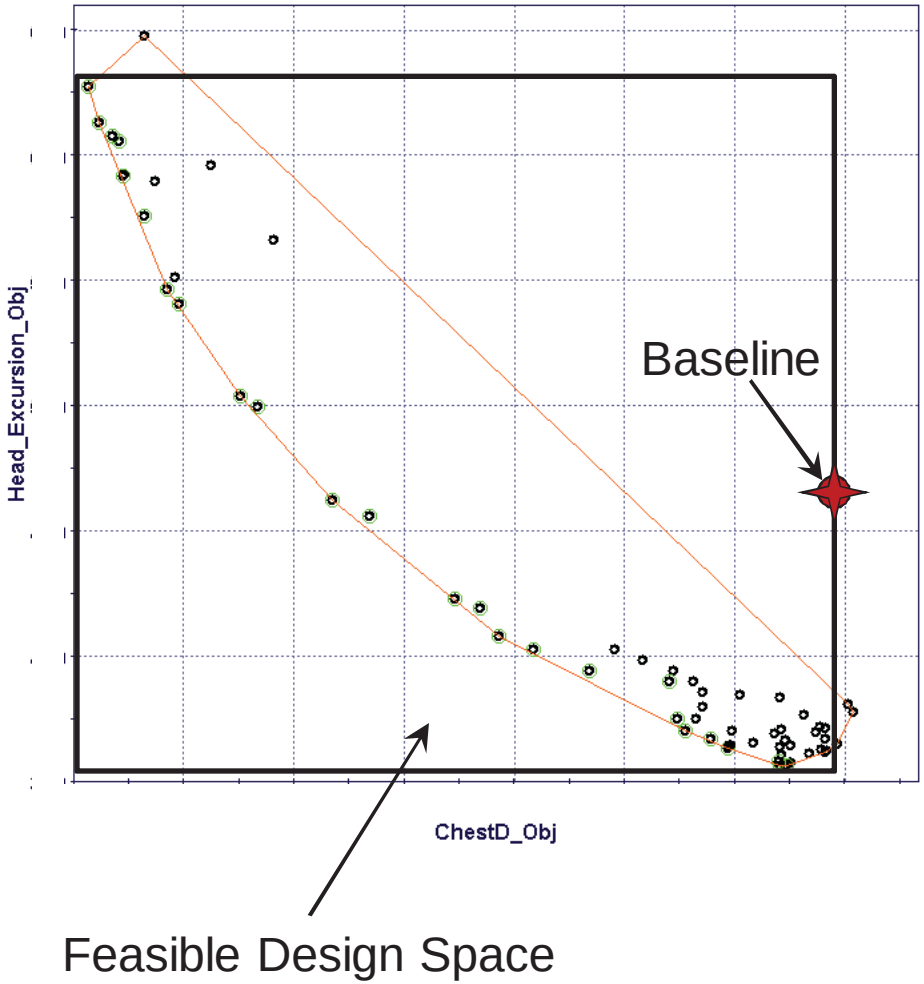
Optimization Simulations

- 05F-soft-pas

Parameters		Range
Retractor	Retr_Torque	7.5-9.5mm
	SLL_Switch	20-50ms
	SLL_level	0.0-2.0kN
	Webbing	500-1200mm
Buckle_PT	PT_time	Yes/No
Anchor_PT	PT_time	Yes/No
DLT	DLT_force	Yes/No





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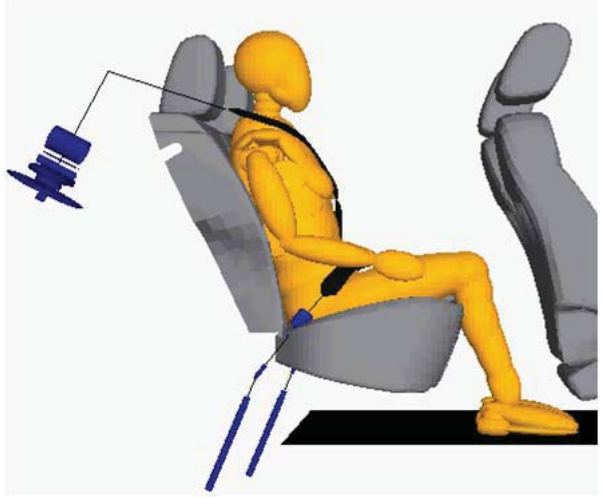
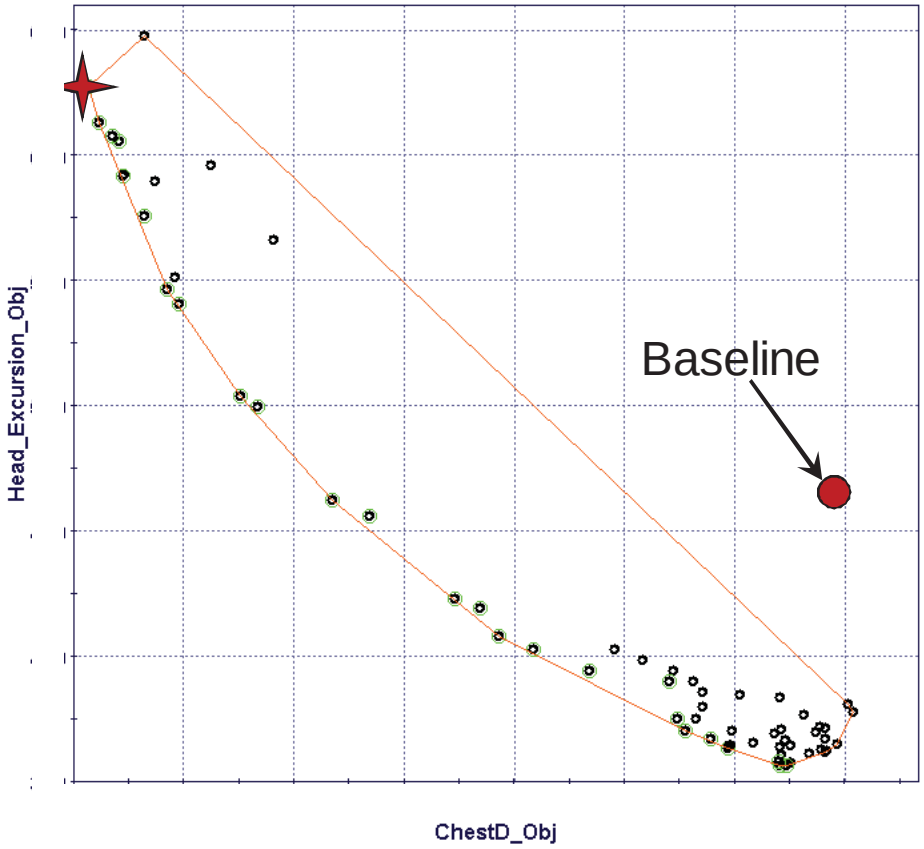
Optimization Simulations

- 05F-soft-pas –No.06

Parameters		Range
Retractor	Retr_Torque	8mm
	SLL_Switch	50ms
	SLL_level	0.0kN
	Webbing	1200mm
Buckle_PT	PT_time	No
Anchor_PT	PT_time	Yes
DLT	DLT_force	Yes





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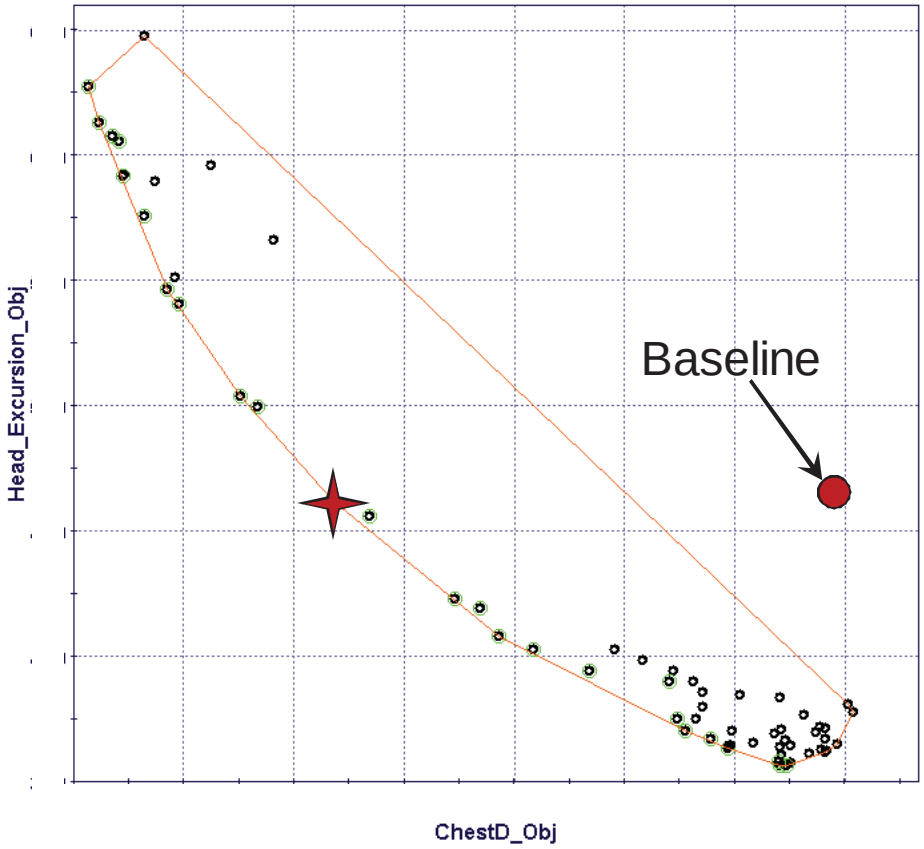
Optimization Simulations

- 05F-soft-pas –No.75

Parameters		Range
Retractor	Retr_Torque	9mm
	SLL_Switch	50ms
	SLL_level	1.0kN
	Webbing	1000mm
Buckle_PT	PT_time	No
Anchor_PT	PT_time	Yes
DLT	DLT_force	Yes



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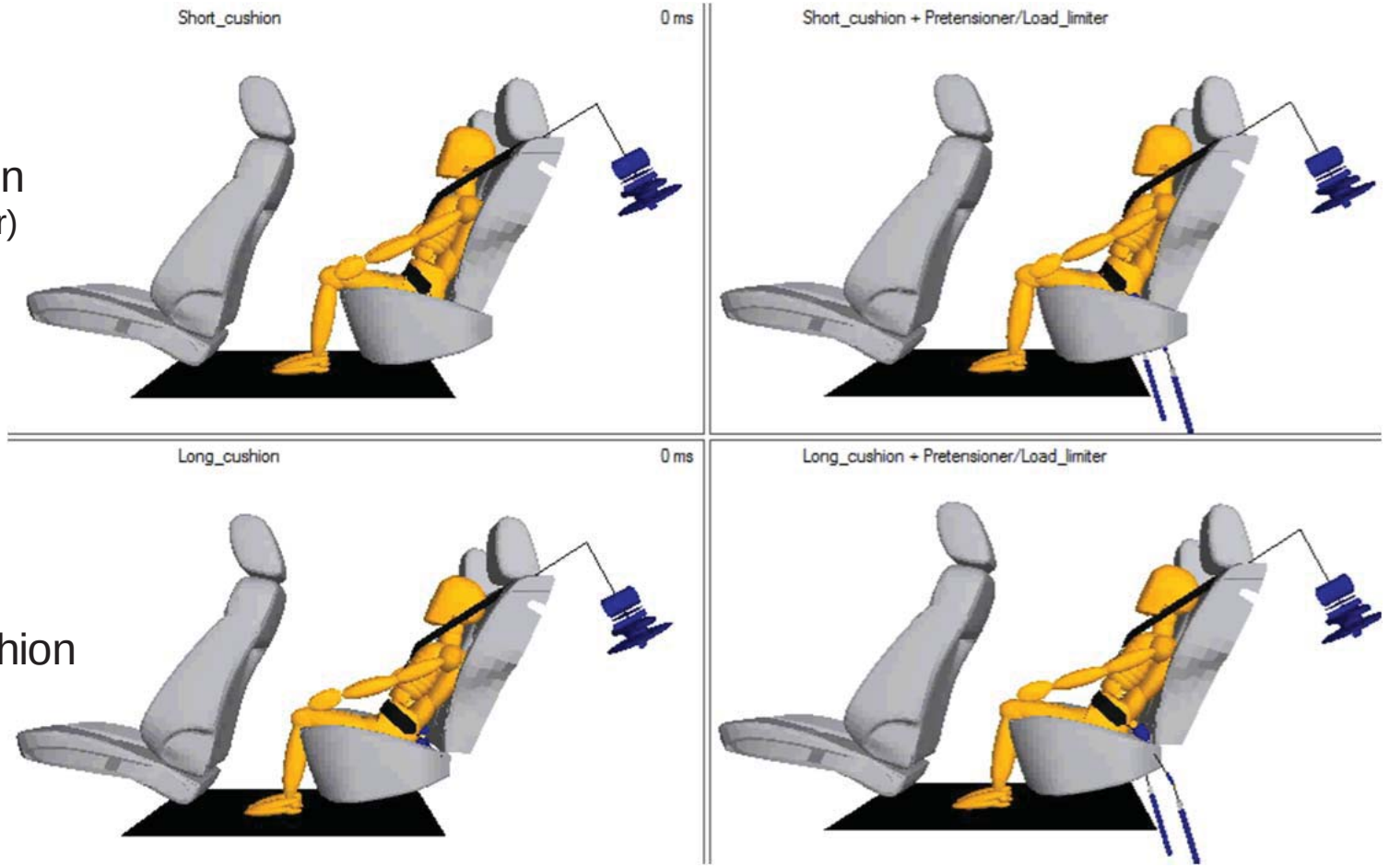
Optimization Simulations

Baseline belt

Belt with pretensioner and load limiter

Short cushion
(100mm shorter)

Baseline cushion



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Summary

- Baseline tests show significant effects from crash pulse and occupant size on occupant kinematics and injury outcomes.
- Model validation results show generally good correlation between tests and simulations.
- Preliminary simulations show direct conflict between head and chest objectives.
- Seat belt pretensioners and load limiters show great potential to reduce head and chest objectives at the same time.
- Shorter seat cushion reduce submarining risk for 6YO ATD.

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Thanks! Questions?

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