Parametric Seat Modeling in Rear Impacts

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Seat Performance in Rear Impacts

Currently assessed through…

- Low-speed tests
  - IIHS (IIWPG pulse): 16 km/h, 10g
  - EuroNCAP: 16 km/h, 5 g; 16 km/h, 10 g; 24 km/h, 7.5 g
- Geometric assessment
- Quasistatic tests (e.g., FMVSS 207 seatback pull tests)

Question

- How do these assessments relate to seat performance in higher speed rear impact?
  - FMVSS 301R fuel system integrity tests (e.g., 36.5 km/h, 15 g; Edwards et al. 2019)

Parametric Rear Impact Seat Modeling

Goal: Use a parametrically modifiable seat model to study…

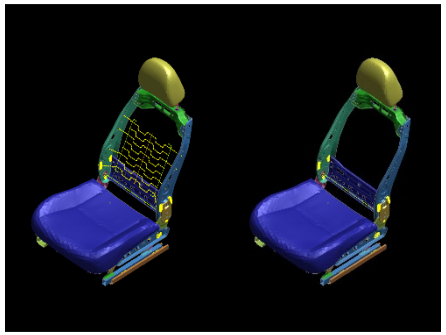
- The influence of various seat design characteristics (geometry stiffness) on rear impact response
- The relationship between quasistatic and dynamic assessment, and low-speed vs. high-speed response

Parametric Model

Geometry

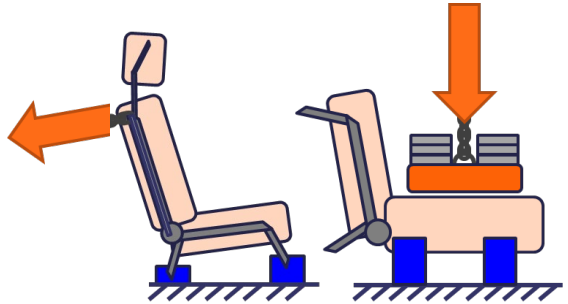
Stiffness

Structure

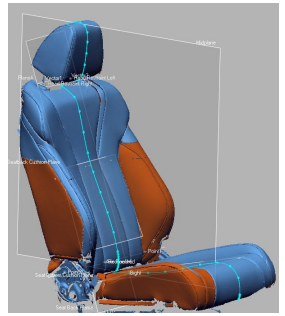


Informed by Real Seat Characteristics

Component Testing



Digitization



Comparison to Sled Tests

Loading & Occupant Parameters to Investigate

Severity (low vs. high speed)

Occupant (BioRID, THOR-50M, GHBMC-50M)

Static vs. Dynamic Assessment

Occupants \ Crash	IIWPG	FMVSS301R
BioRID	X	
THOR-50M		X
GHBMC-50M	X	X

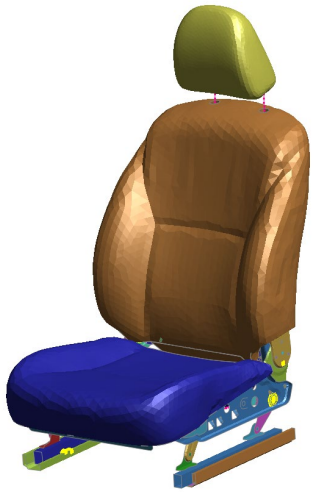
Parametric Modeling

Goal: Use a parametrically modifiable seat model to study…

- The influence of **various seat design characteristics** (geometry stiffness) on rear impact response
- The relationship between quasistatic and dynamic assessment, and low-speed vs. high-speed response

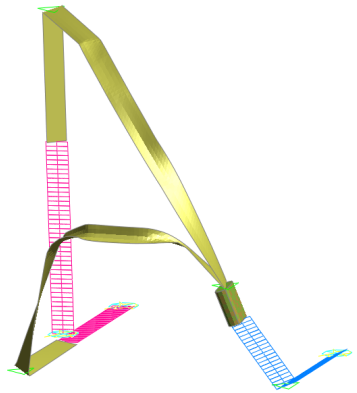
Parameters/Variables

Seat



- Head restraint
- Seatback Foam
- Internal Support
- Upper Seatback Frame
- Lower Seatback Frame
- Seatpan

Belt (Pretensioner)



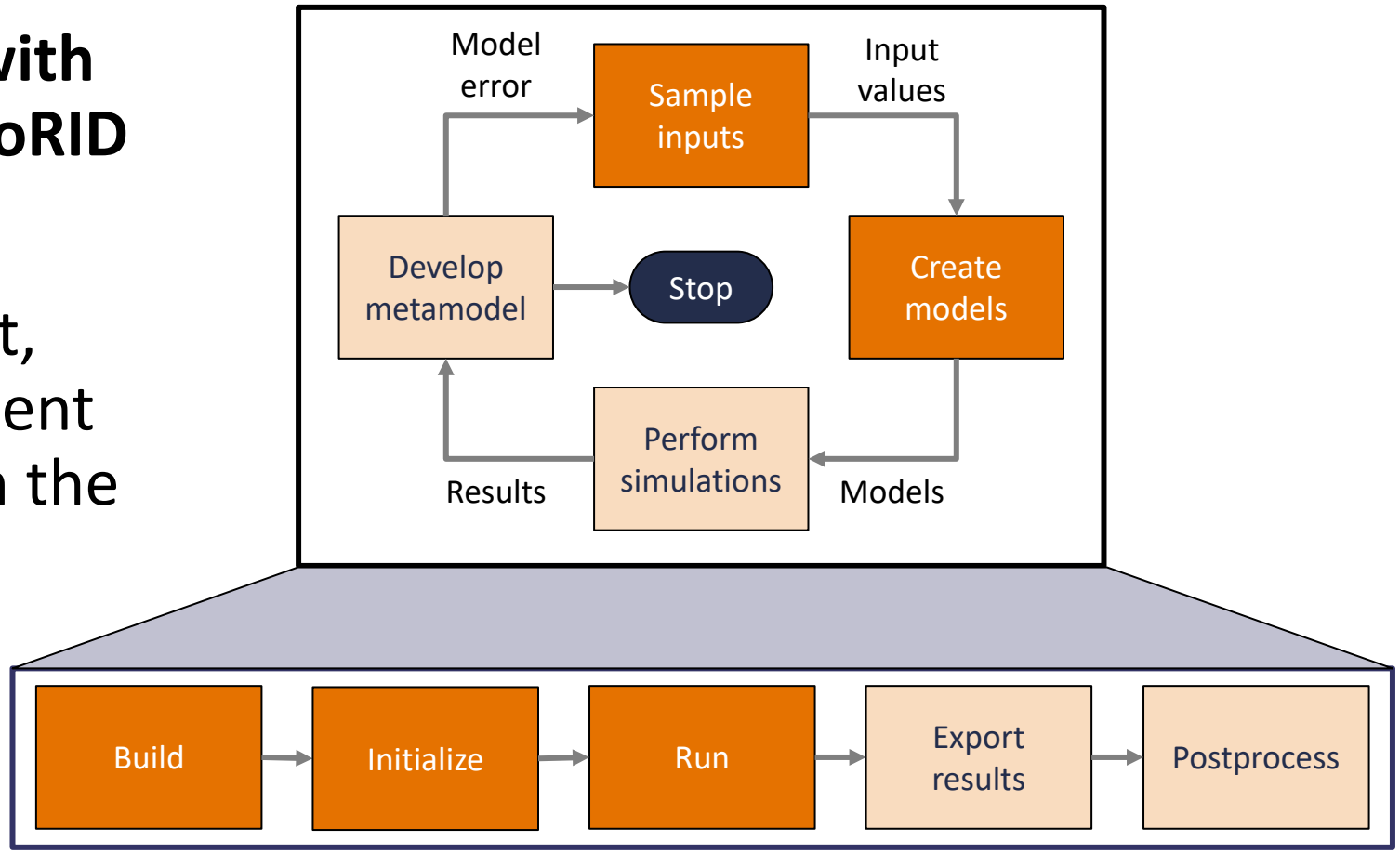
Occupant and Crash Pulse

Occupants \ Crash	IIWPG	FMVSS301R
BioRID	X	
THOR-50M	X	X
GHBMC-50M	X	X

Simulation Automation Summary

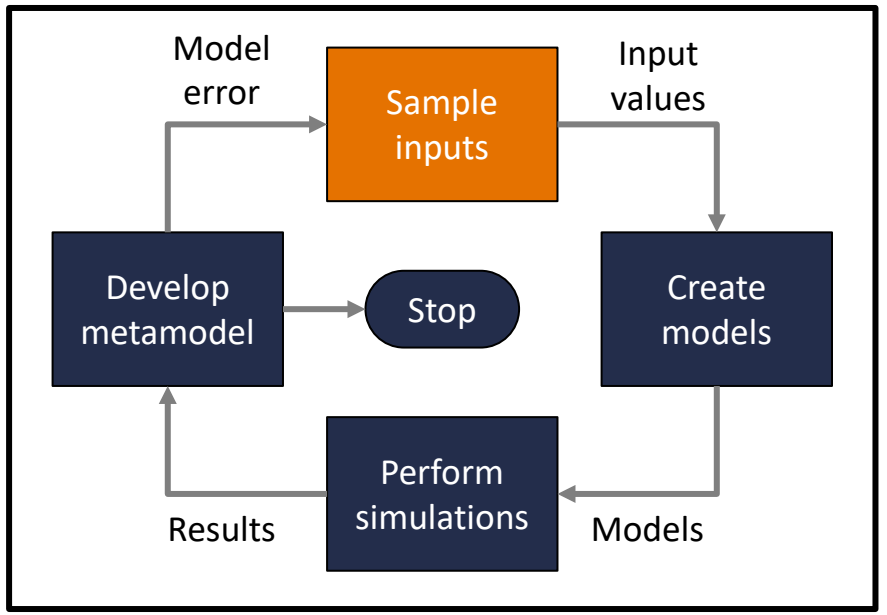
Fully Automated Workflow with THOR-50M, GHBMC-50M, BioRID

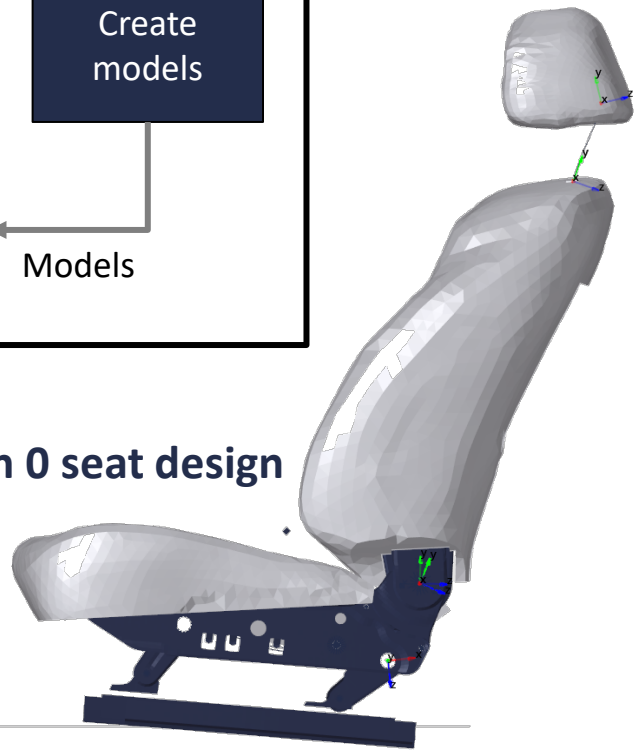
- **200 sampled seat designs** morphed from OpenVT seat, based on Principal Component Analysis of scanned seats in the fleet



Simulation Automation Workflow

- **200 sampled seat designs** morphed from OpenVT seat selected using Sobol Sampling method
  - Each seat design is one Batch
- Within each Batch are scenarios
  - 0 – BioRID – No Pretensioner – IIWPG
  - 1 – BioRID – Pretensioner – IIWPG
  - 2 – THOR-50M – No Pretensioner – IIWPG
  - 3 – THOR-50M – No pretensioner – 301R
  - 4 – THOR-50M – Pretensioner – IIWPG
  - 5 – THOR-50M – Pretensioner – 301R
  - 6-9 – GBHMC-50M cases in similar pattern to THOR





Batch 0 seat design

Example simulations – IIWPG (16 km/h), No Pretensioner, Batch_1

- BioRid

- THOR-50M

- GHBMC-50M

Example simulations – Pulse severities, No Pretensioner, Batch_1

- IIWPG: 16 km/h

- 301R: 36.5 km/h

Example simulations – Pulse severities and Pretensioner, GHBMC, Batch_1

- IIWPG, no Pre-T

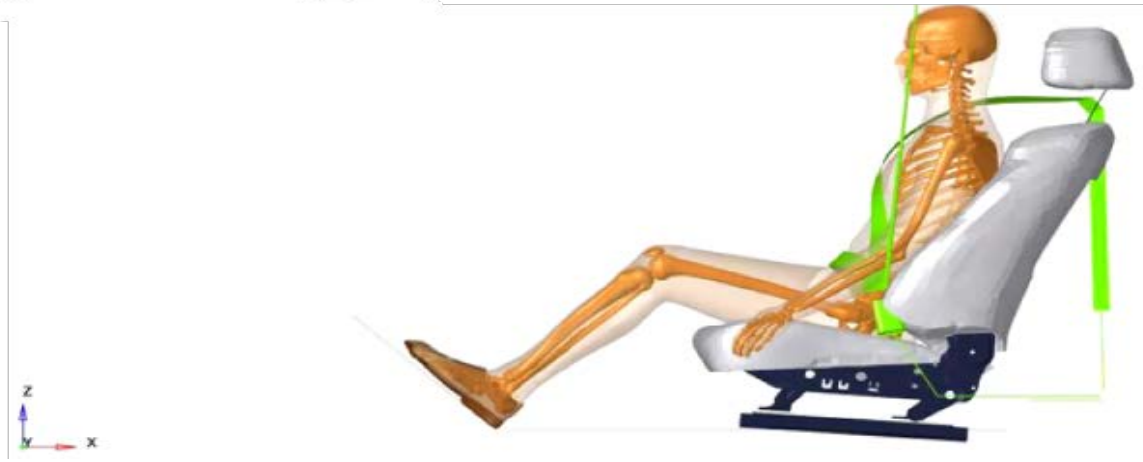
Pre-tensioner

Example simulations – Seat design variation, IIWPG, No PT, GHBMC-M50

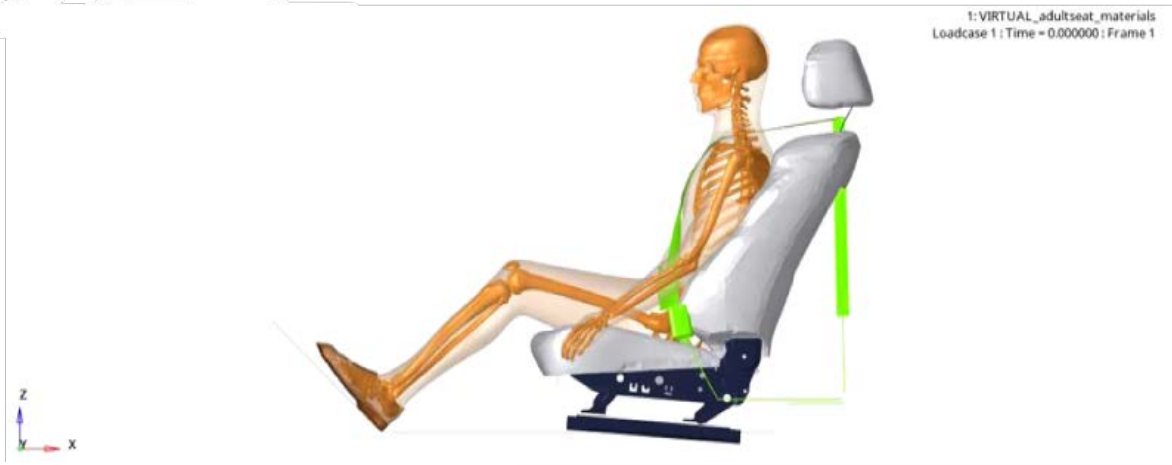
- Batch_5

- Batch_1

- Batch_6



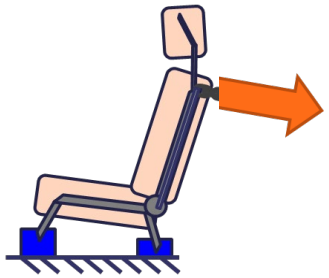
- Batch_9

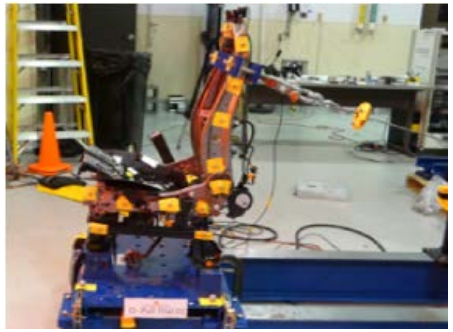


Example simulations – Seatback collapse with 301R pulse (36.5 km/h)

Batch 2 seat model

Reminder – seat stiffness parameters are informed by tests of real seats





Note: Does not represent a specific seat, but the stiffness is in the range of tested seats

Parallel Work: Detailed Seat Modeling

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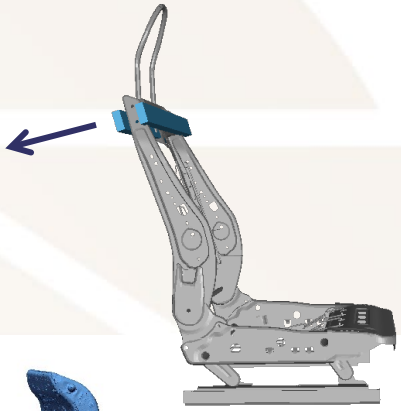
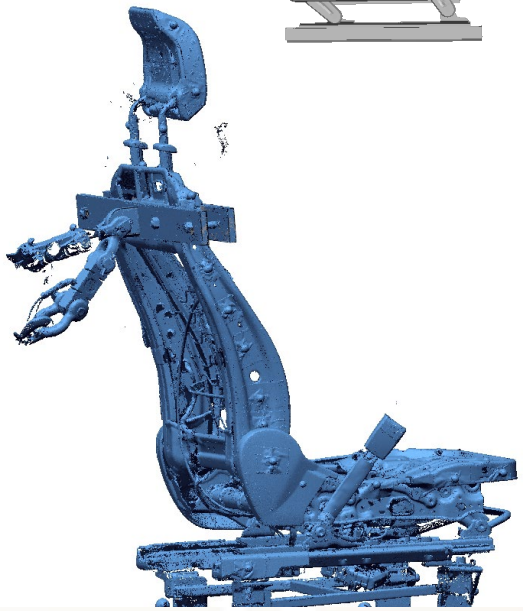
Goal: Develop detailed FE models of two seats for open distribution (for research)

- Detailed tear down & scanning
- Component testing with deformation tracking (compression, pull to failure)
- Material testing
- Meshing & assembly
- Validation with low & moderate rear impact speed sled tests





Detailed Seat Modeling

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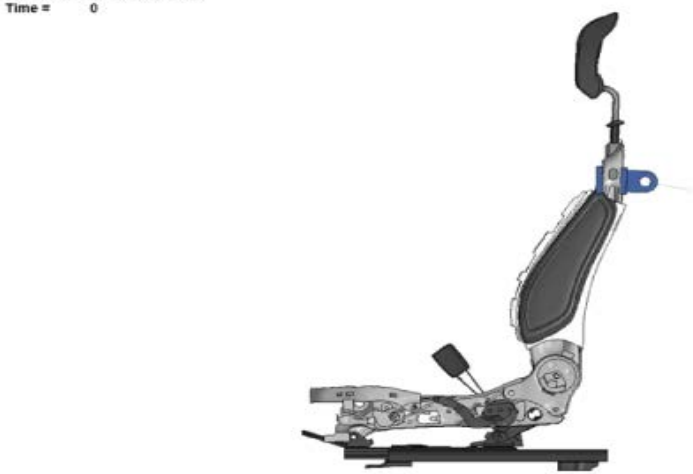
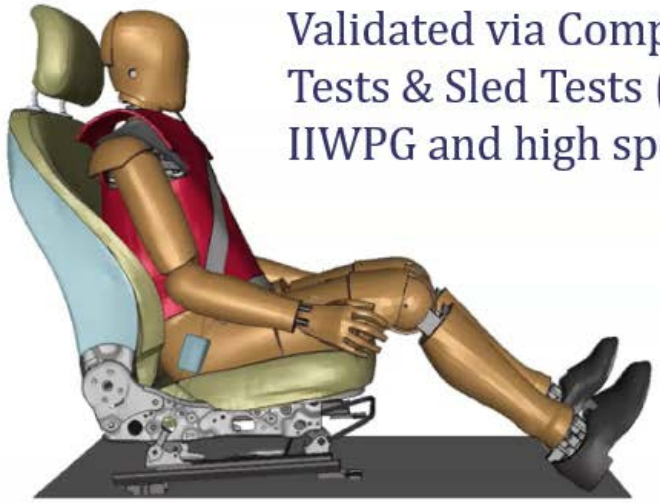
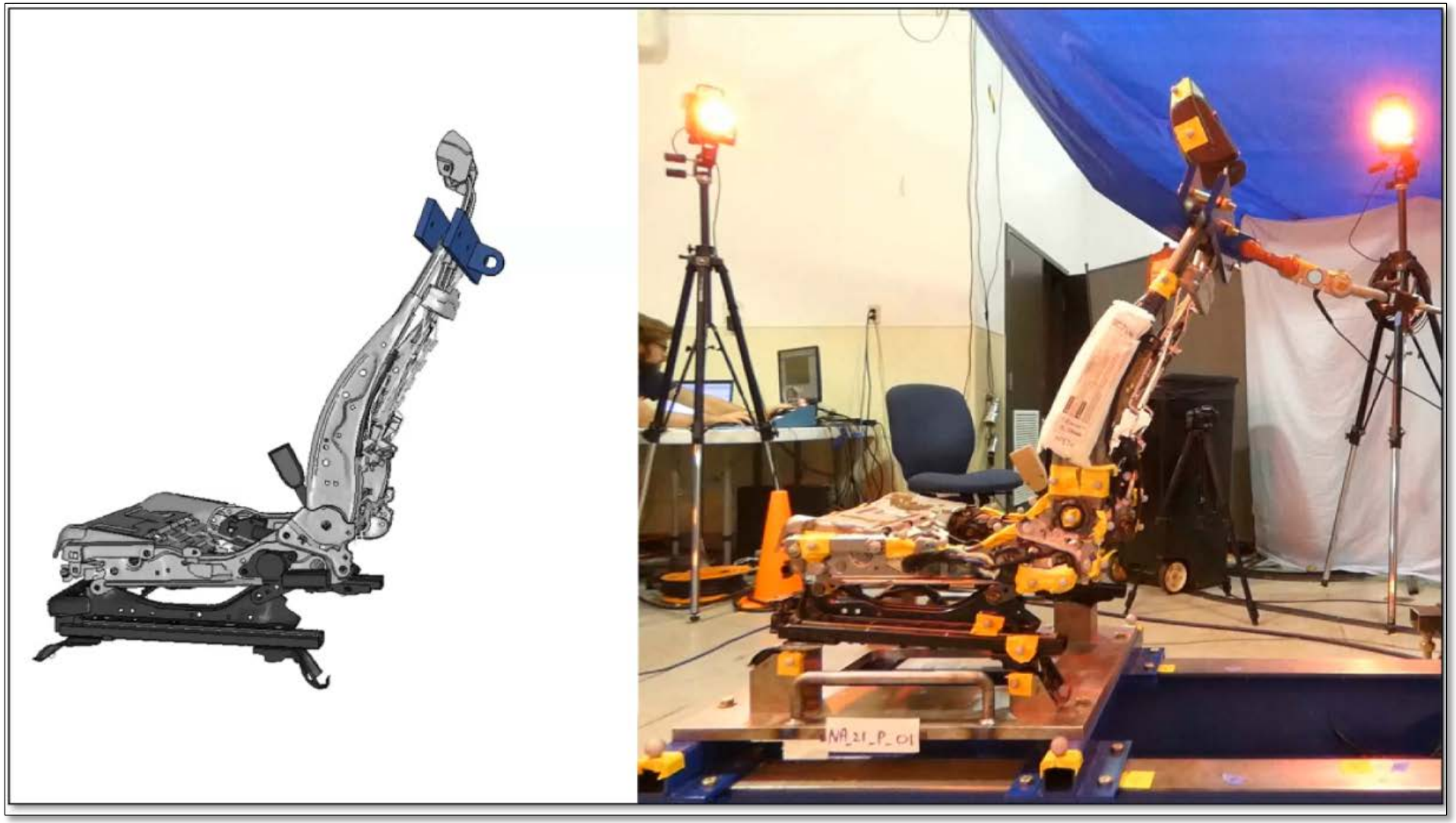
Bottom-Up Development
(from detailed geometry
& material properties)



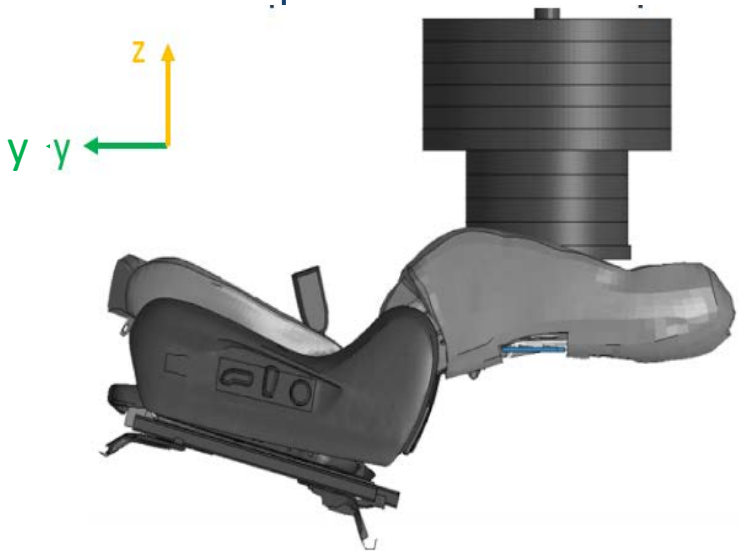


Validated via Component Tests & Sled Tests (low speed IIWPG and high speed 301R)

Elemance | Pull Test – Example Validation

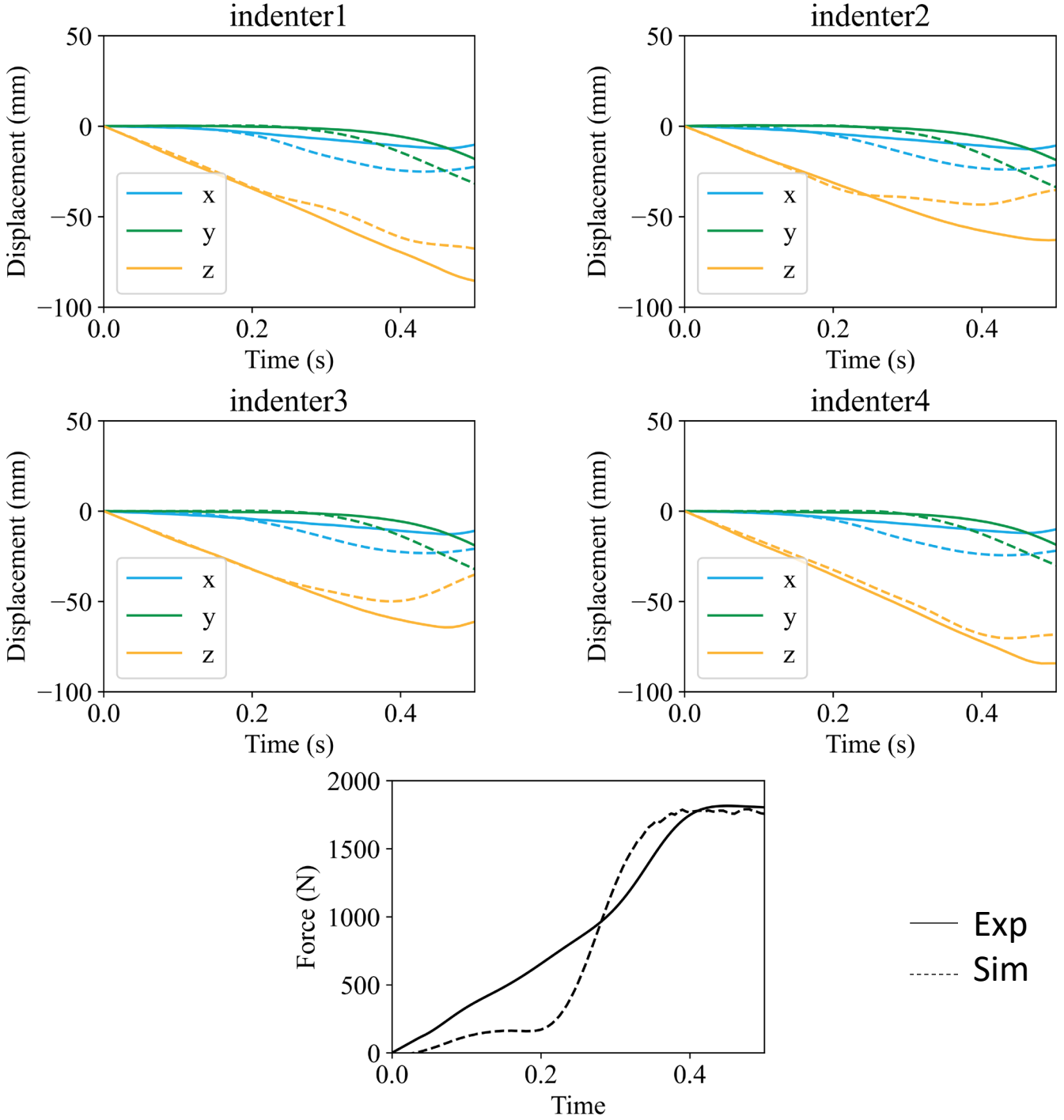


Elemance | Push Tests – Example Validation



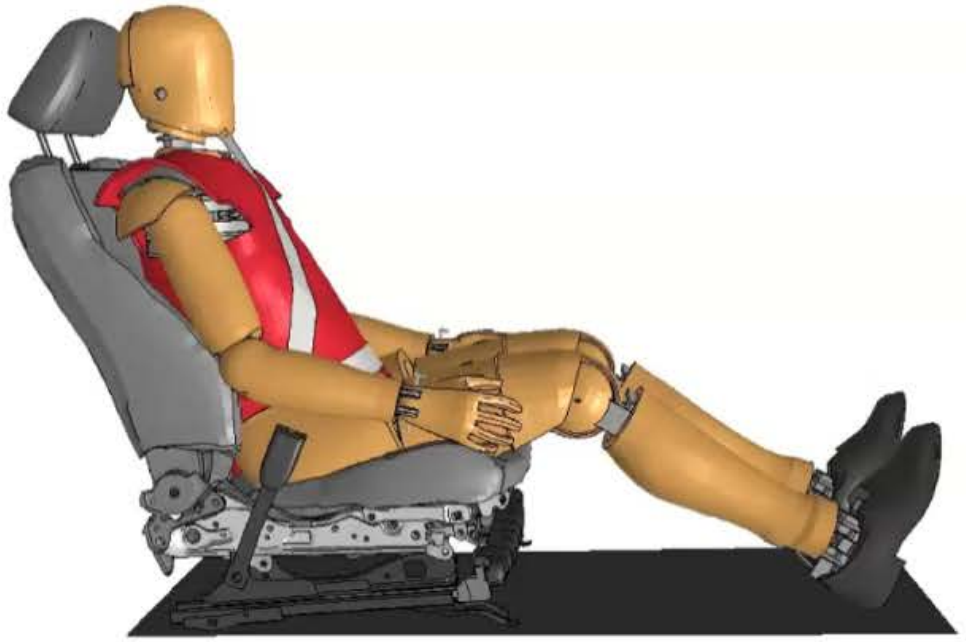
Subaru NA02							
		Corridor	Shape	Size	Phase	XC	Total
Indenter 1	X	0.436	0.973	0.218	1.000	0.730	0.613
	Y	0.667	0.966	0.227	1.000	0.731	0.705
	Z	0.878	0.992	0.752	1.000	0.915	0.900
Indenter 2	X	0.449	0.955	0.255	1.000	0.737	0.622
	Y	0.651	0.964	0.212	1.000	0.725	0.696
	Z	0.727	0.918	0.631	1.000	0.850	0.801
Indenter 3	X	0.444	0.943	0.278	1.000	0.740	0.622
	Y	0.697	0.961	0.250	1.000	0.737	0.721
	Z	0.797	0.941	0.696	1.000	0.879	0.846
Indenter 4	X	0.439	0.968	0.225	1.000	0.731	0.614
	Y	0.711	0.954	0.279	1.000	0.744	0.731
	Z	0.939	0.993	0.815	1.000	0.936	0.937
Force		0.755	0.887	0.990	1.000	0.959	0.877

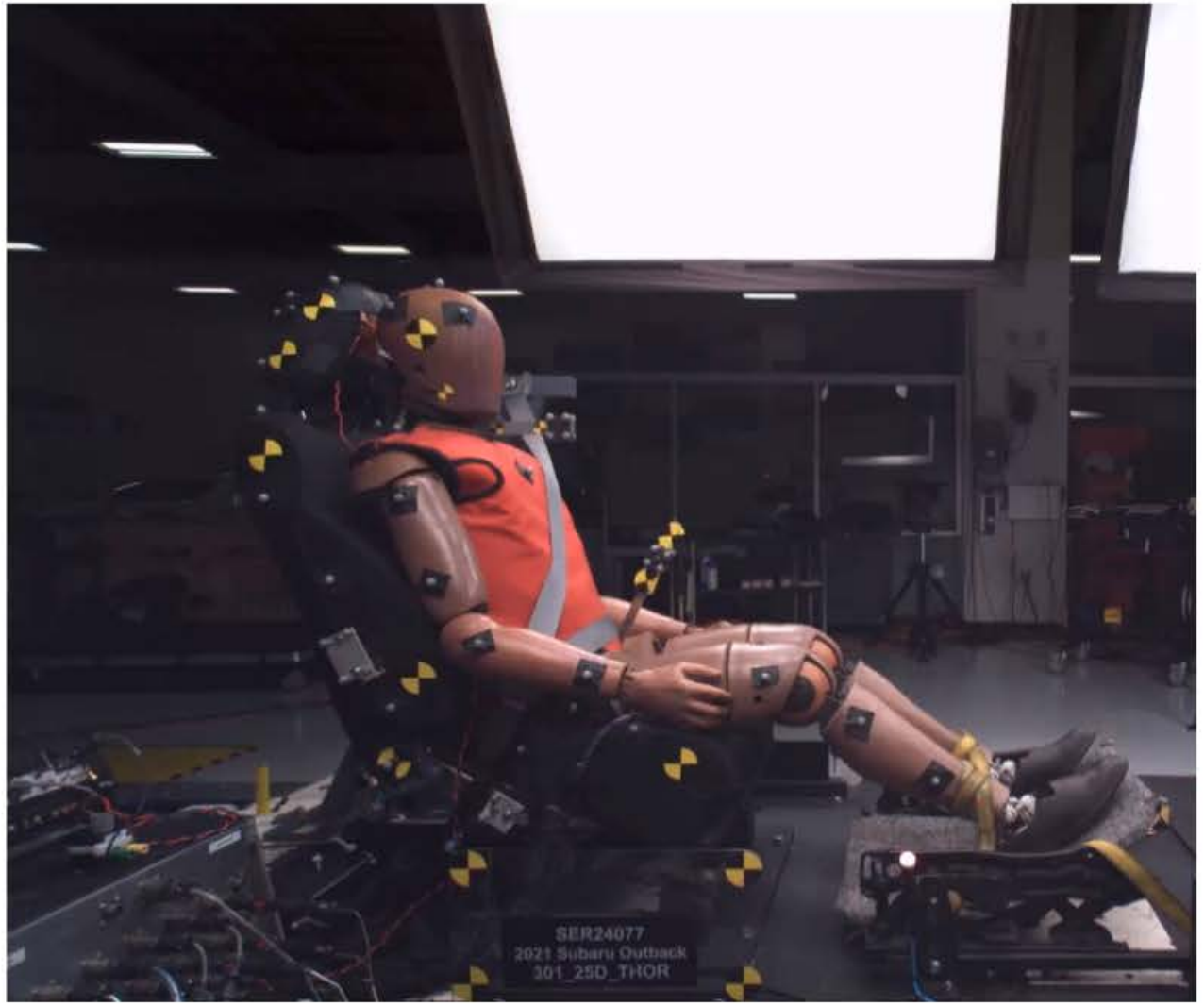
0.745±0.116



High Speed Rear Impact – Example Validation

301R Pulse: 36.5 km/h





Also validated with IIWPG low-speed pulse (with BioRID)

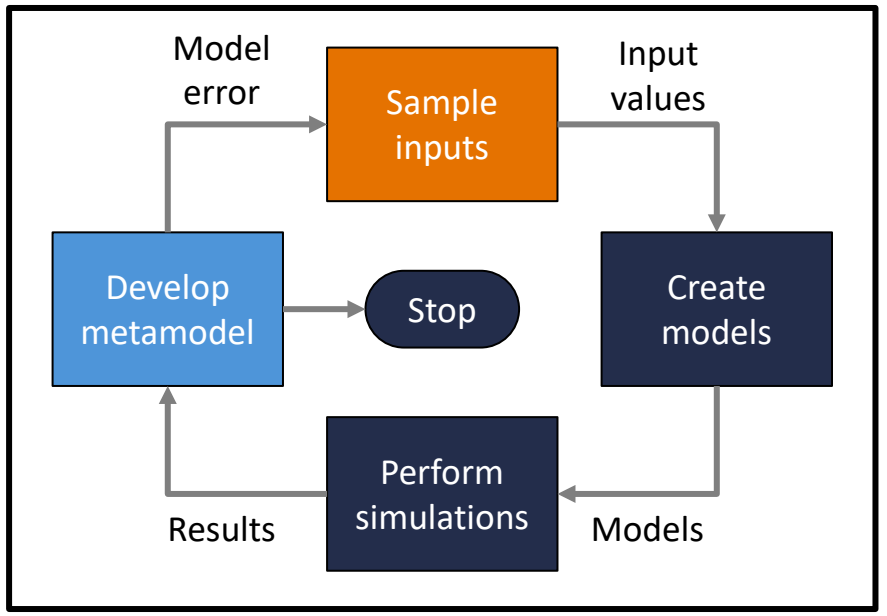
Performed in collaboration with IIHS (Thank You!)

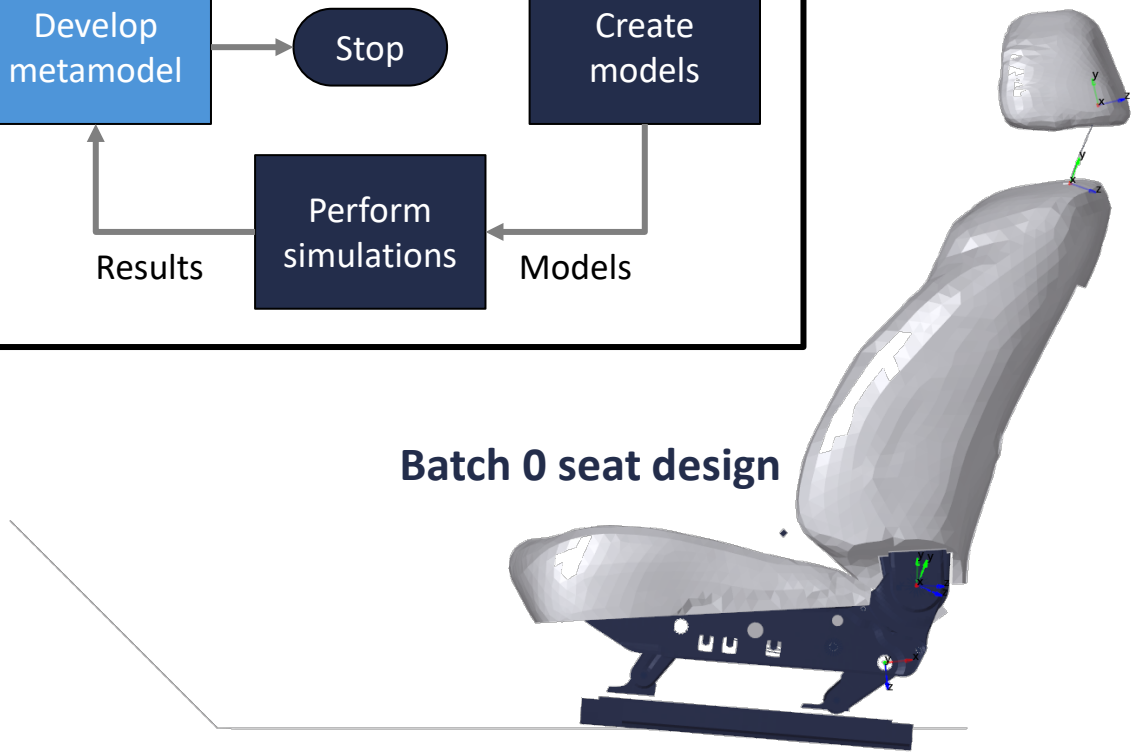
Next Steps

Parametric Modeling: Finalize Metamodels Describing Effect of Seat Characteristics on Occupant Responses

- Effects of seat characteristics in low-speed vs. high-speed impacts
  - Relationship between component evaluations and system-level response

Detailed Seat Models: Deliver for review and distribution





Batch 0 seat design

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Thank You!

Questions?

Email: jlf3m@virginia.edu

Special thanks to IIHS, Humanetics!

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