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RESEARCH CENTRE FOR INDUSTRIAL MATHEMATICS

ADOPT!VE

Automated Design and Optimisation of Vehicle Ergonomics

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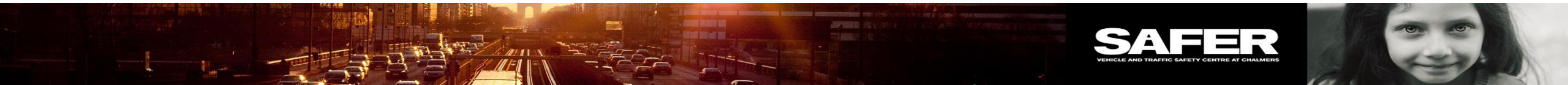
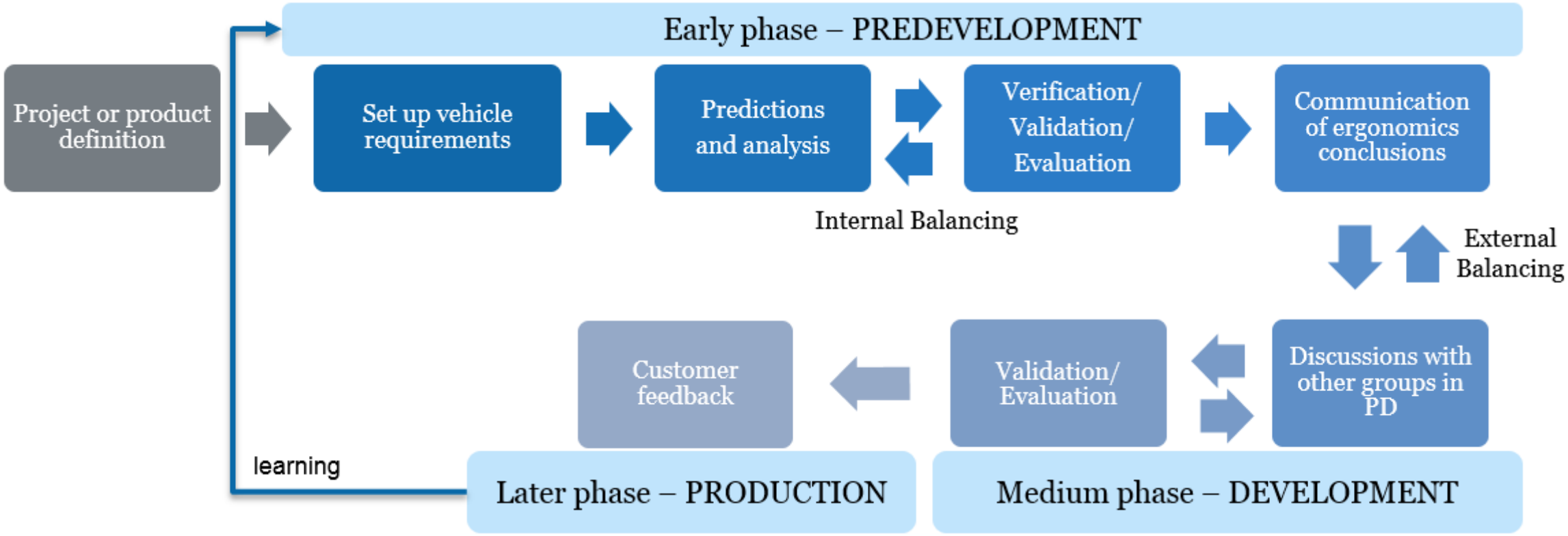
Research group: User Centred Product Design

Research structure of the ADOPTIVE project

	Virtual human models	*Static Posture Simulation*	*Task/Scenario Simulation*	*Ergonomics evaluation*
Data/input	Anthropometry Body shape Joint centre Strength	Constraints Joint angles Statistics …	Motion sequence Behaviour / Strategies Traffic situations …	Simulation results Existing evaluation methods
Functionality	Consider diversity Generic manikin model	H-point to mid-hip Pelvis rotation Subject specific prediction	Fast and easy to set up Repeatable and customisable	Comparing concepts Visualisation of human-system mismatch
Validation	Compare with scanned data Comparison with RAMSIS Comparison with HBMs	Assessment through knowledge and experience Compare with previous and new studies	Assessment through knowledge and experience Compare with previous and new studies	Usefulness for assessing ergonomics in vehicle development processes



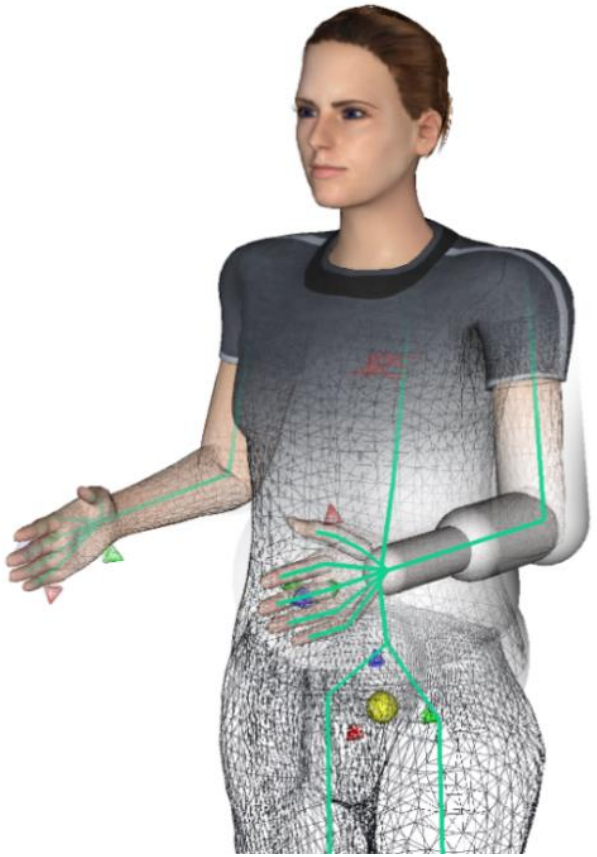
Ergonomics designers' work



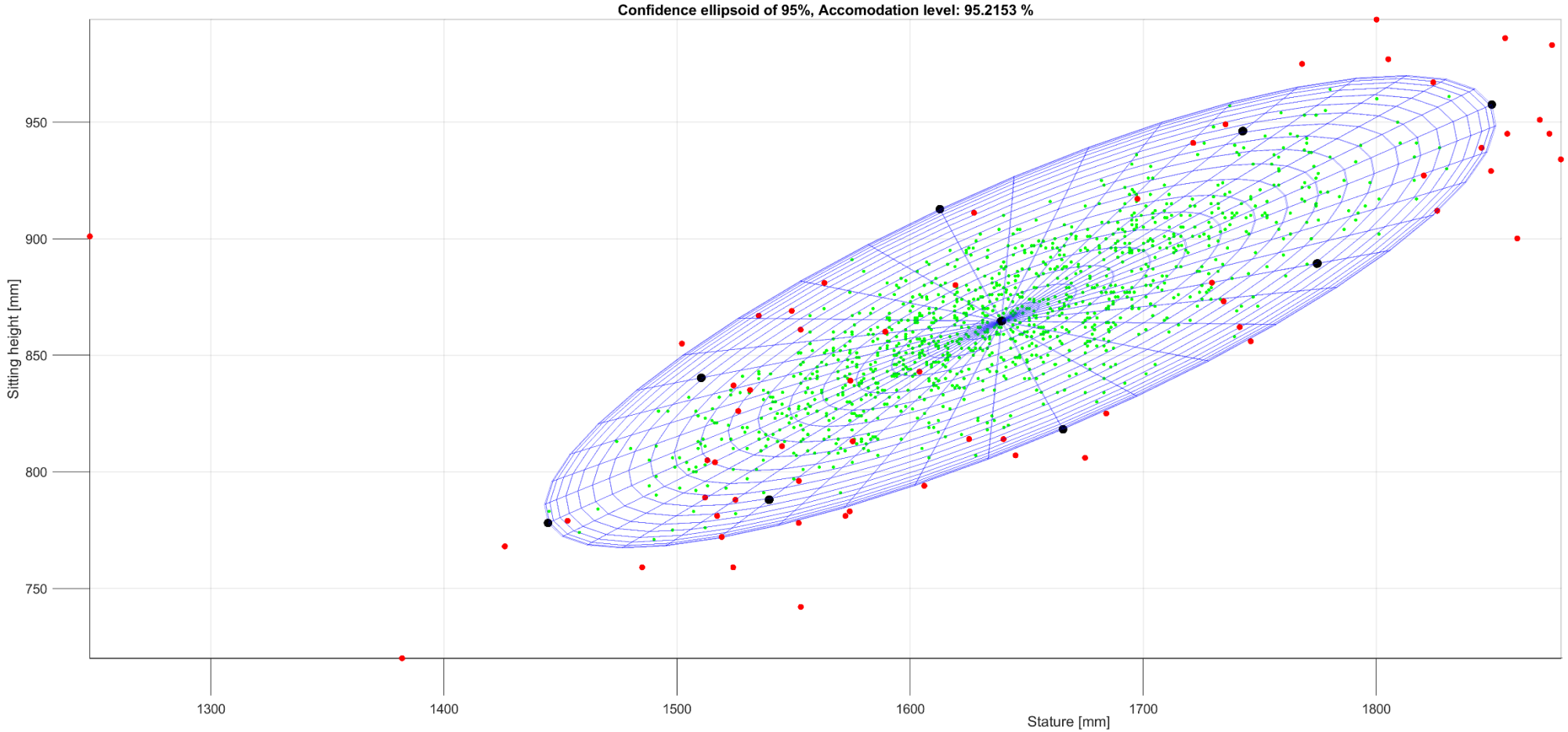
Luque, E. P., Lamb, M., Brolin, E., & Högberg, D. (2022) Challenges for the consideration of ergonomics in product development in the Swedish automotive industry - an interview study. In *Proceedings of International Design Conference – Design 2022* (doi.org/10.1017/dsd.2022.000).

IMMA

Intelligently Moving Manikins



Virtual Human Models – Diversity consideration



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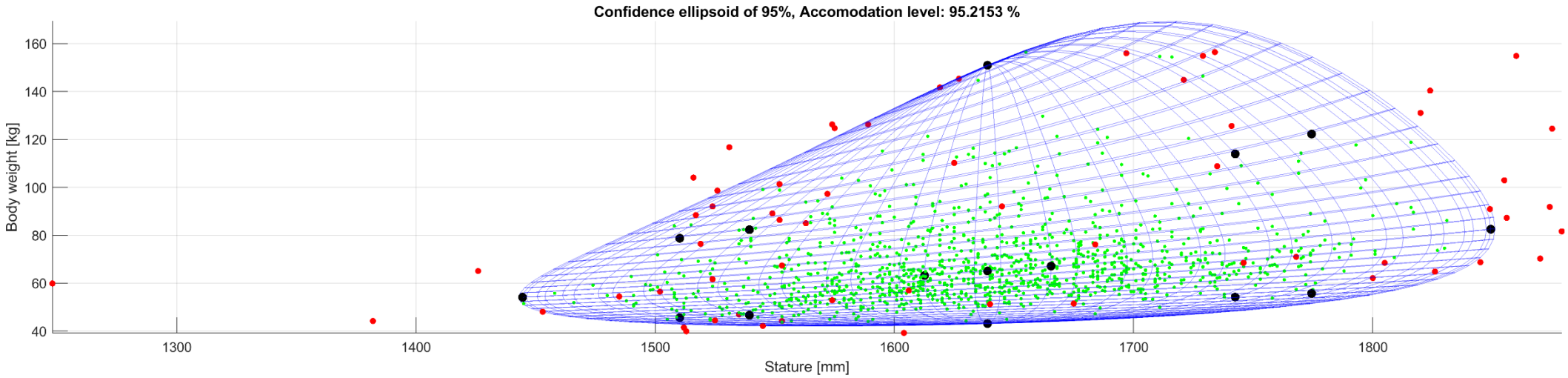
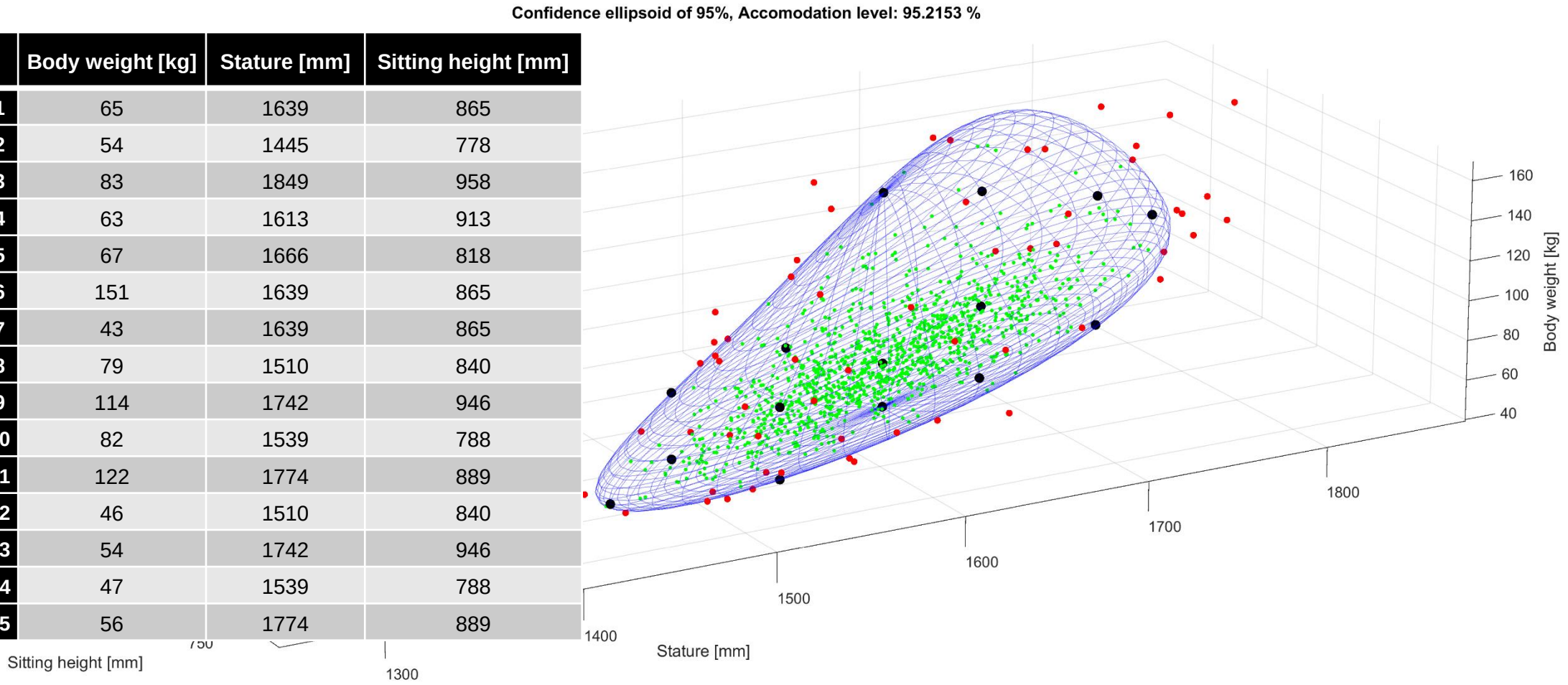
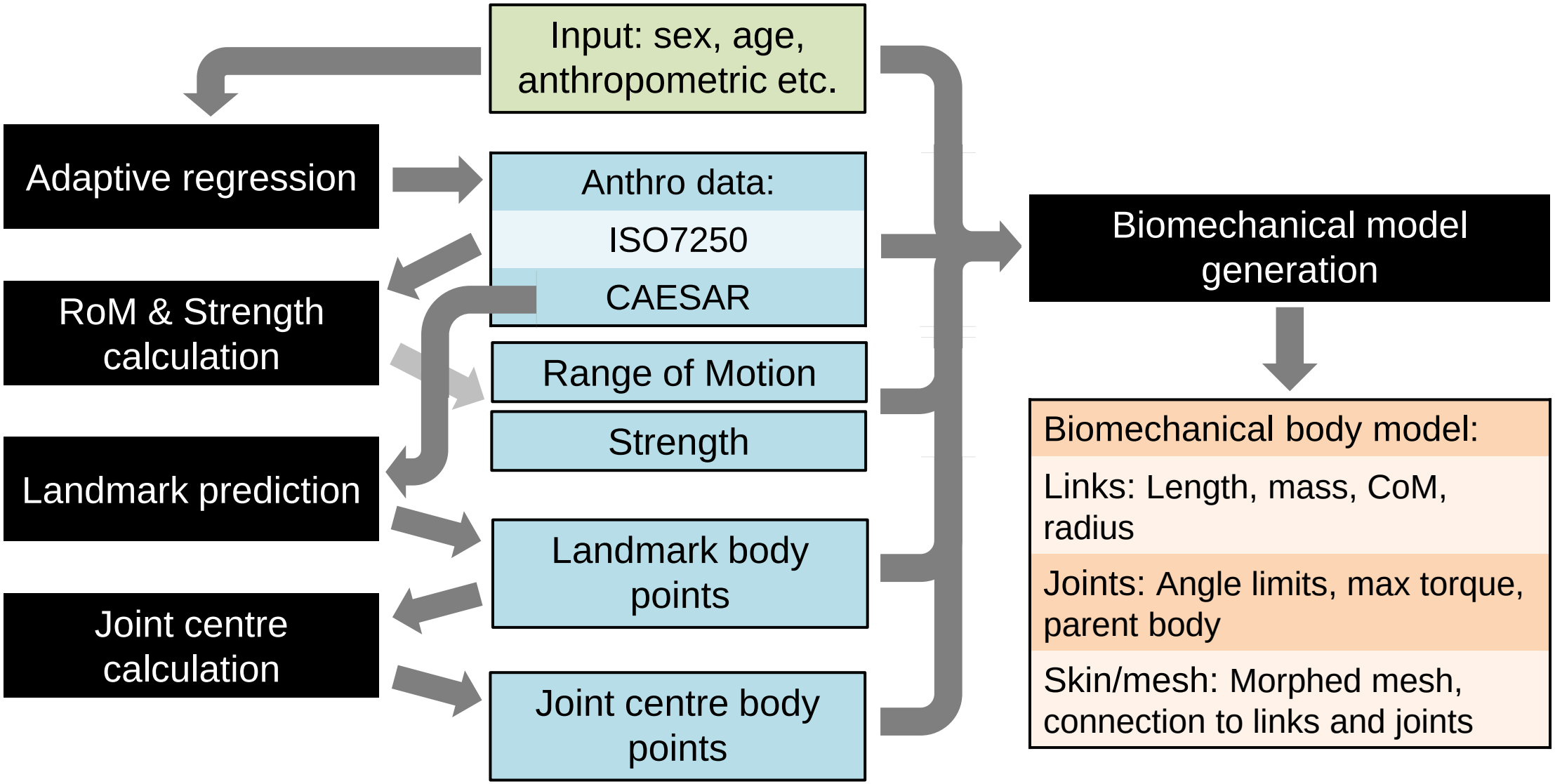


Virtual Human Models – Diversity consideration

	Body weight [kg]	Stature [mm]	Sitting height [mm]
Case 1	65	1639	865
Case 2	54	1445	778
Case 3	83	1849	958
Case 4	63	1613	913
Case 5	67	1666	818
Case 6	151	1639	865
Case 7	43	1639	865
Case 8	79	1510	840
Case 9	114	1742	946
Case 10	82	1539	788
Case 11	122	1774	889
Case 12	46	1510	840
Case 13	54	1742	946
Case 14	47	1539	788
Case 15	56	1774	889



Virtual Human Models – Improved biomechanical model

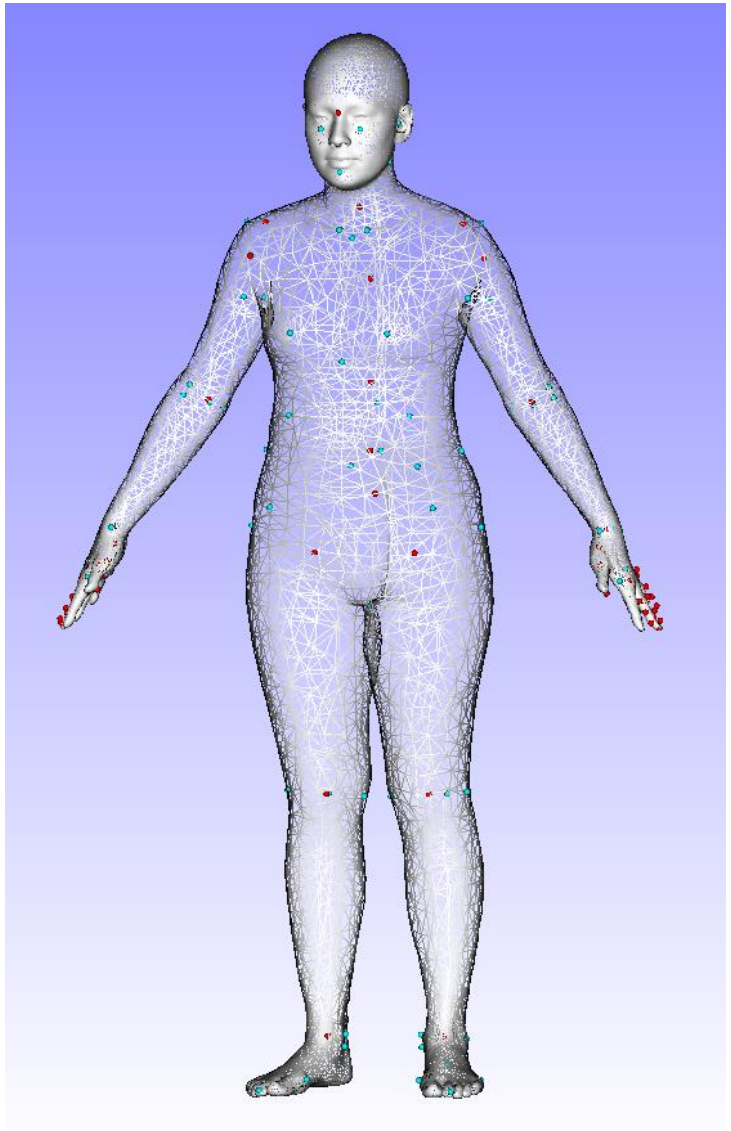


Virtual Human Models – Improved biomechanical model

Biomechanical body model:
Links: Length, mass, CoM, radius
Joints: Angle limits, max torque, parent body
Skin/mesh: Morphed mesh, connected to LM and JC

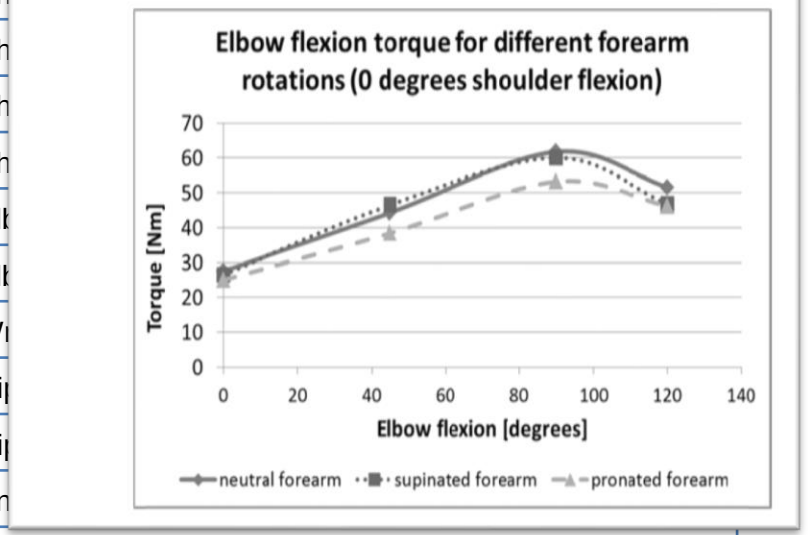
Medium Mary	
Sex	Female
Age	30 year
Weight	68.48 kg
Stature	1634 mm

Joint	Angle [degrees]
Hip extension	12.38
Hip flexion	121.94
Knee flexion	125.77
Knee extension	-0.33
Knee hyperextension	0.37
Shoulder flexion	166.42
Elbow flexion	138.45
Elbow extension	-1.34
Elbow hyperextension	-0.28
Elbow pronation	78.55
Elbow supination	79.96
Ankle dorsiflexion	10.64
Ankle plantarflexion	48.92



Joint	Max torque [Nm]
Sh	
Sh	
Sh	
Sh	
Sh	
Elb	
Elb	
Wr	
Hip	
Hip	
Kn	
Knee extension	126.39
Ar	
El	
El	
Ar	
Ar	
Ar	
…	

Figure 5 Elbow flexion torque for different forearm rotations at a shoulder flexion angle of 0 degrees



Next step:
Implementation in IPS-IMMA!

Virtual Human Models – Diversity consideration

	Body weight [kg]	Stature [mm]	Sitting height [mm]
Case 1	65	1639	865
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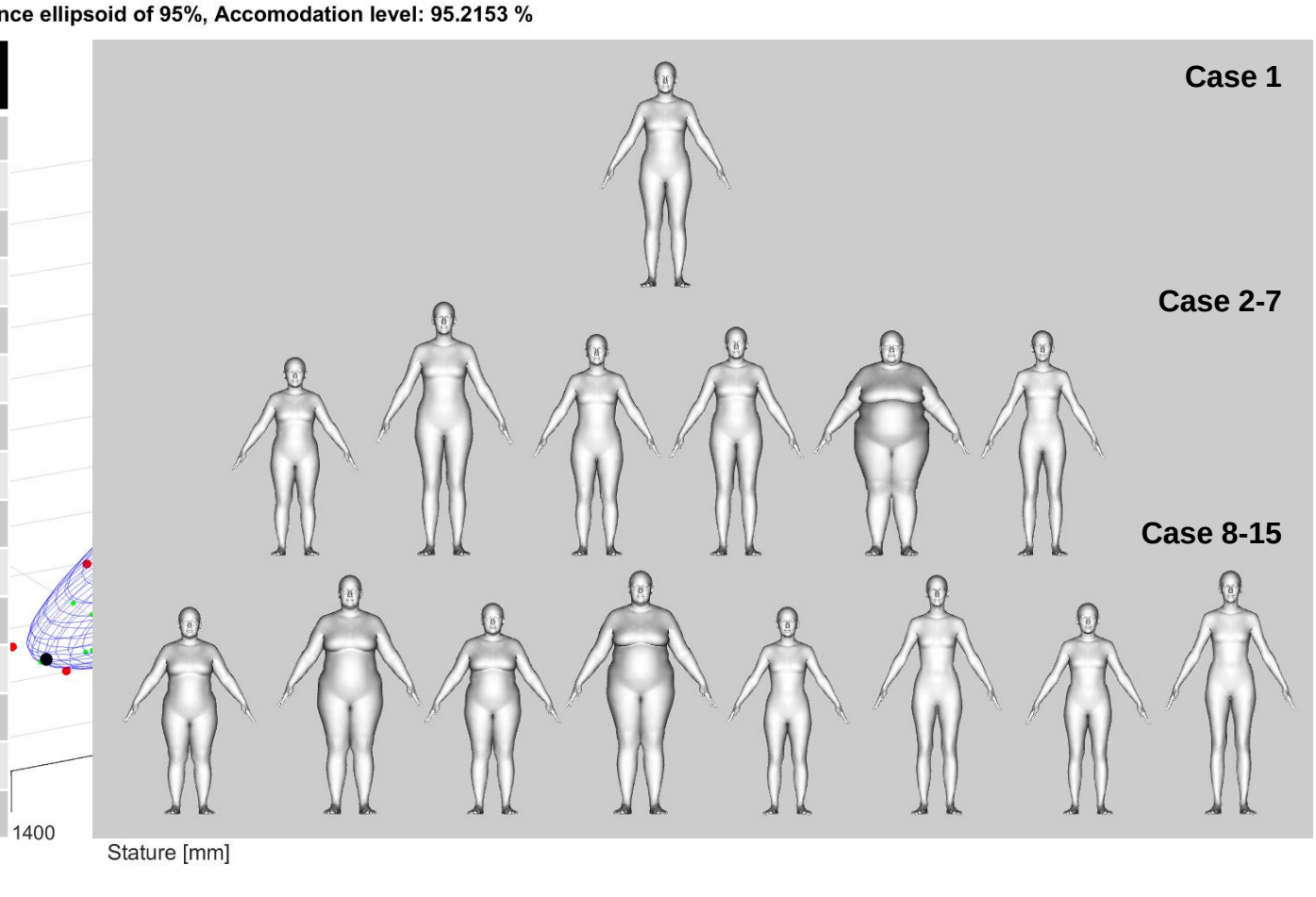
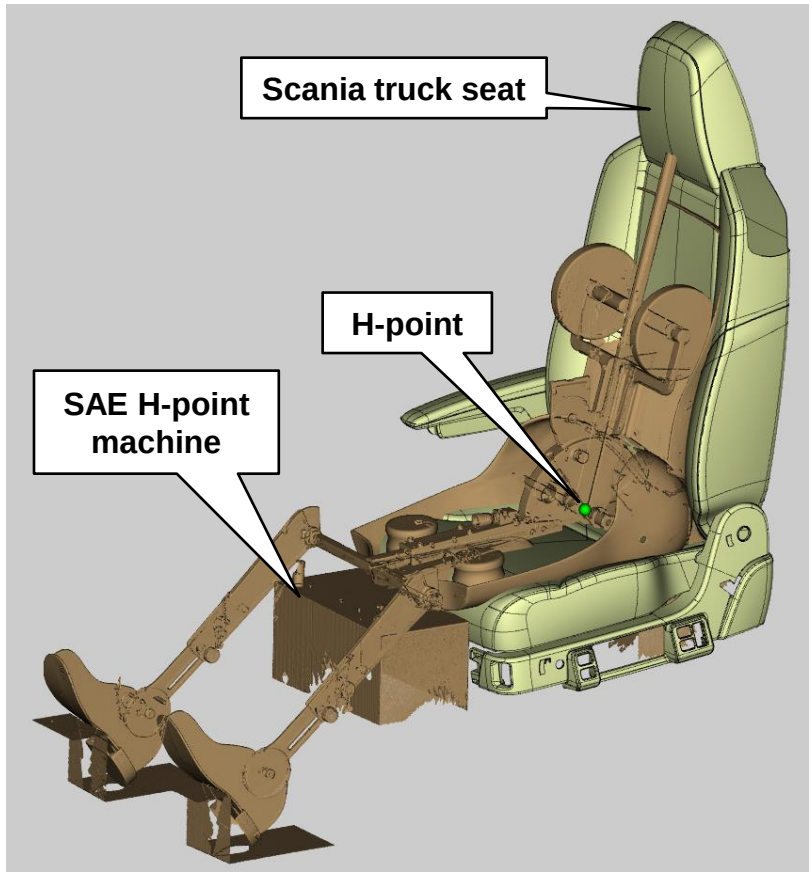


Static Posture Prediction – H-point to Mid-hip

Statistical prediction

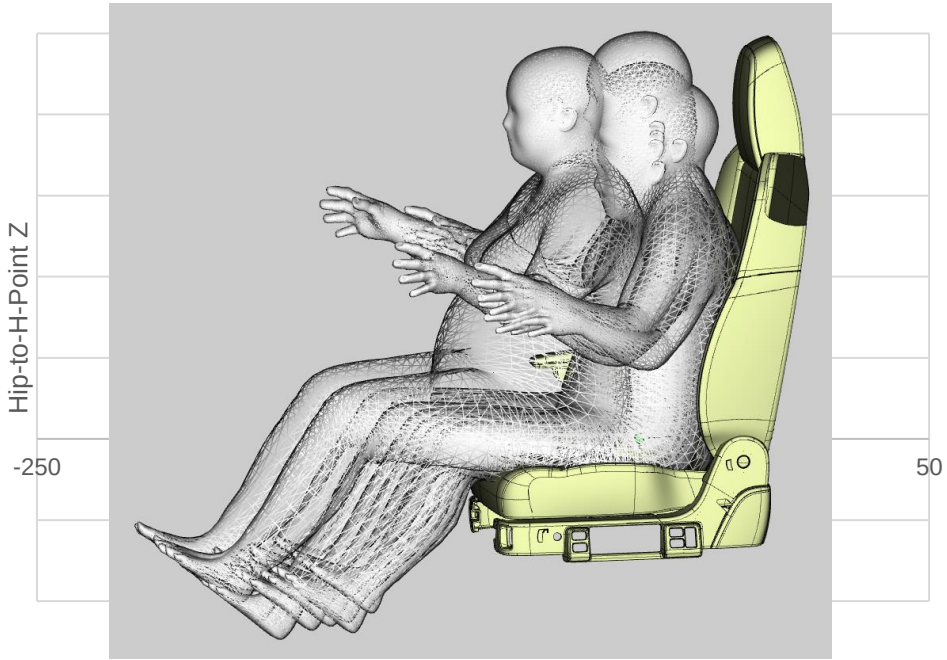


Reed, M. (2001). *Preliminary Driver Posture Prediction Models for Trucks and Buses*. University of Michigan, Transportation Research Institute, February 2001

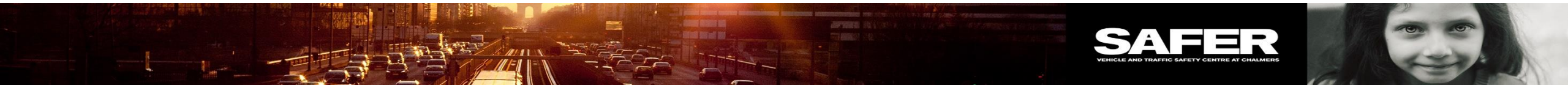
Hip-to-H-Point X = 90.2 – 5.27 × BMI

Hip-to-H-Point Z = -109.9 + 1.51 × BMI + 0.0813 × SittingHt

	Hip-to-H-Point X	Hip-to-H-Point Z
Case 1	-37.32	-3.04
Case 2	-46.09	-7.60
Case 3	-37.74	4.64
Case 4	-37.41	0.89
Case 5	-37.01	-6.95
Case 6	-206.03	45.30
Case 7	5.84	-15.40

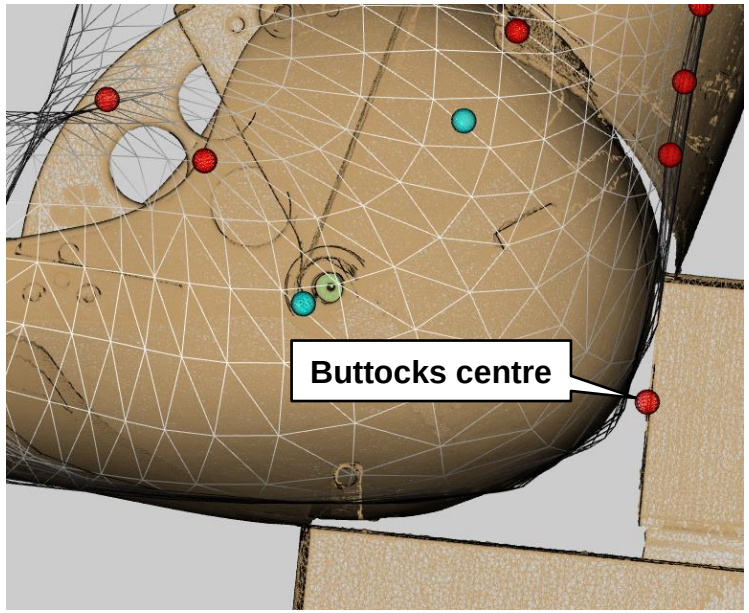


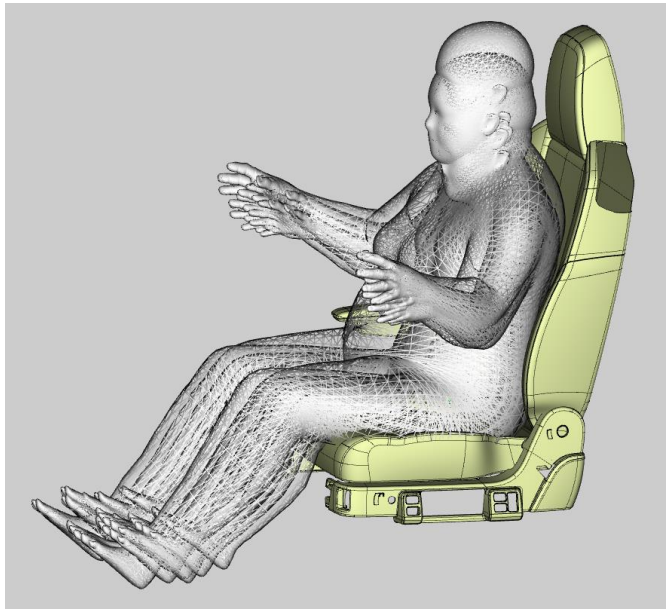
humanshape.org

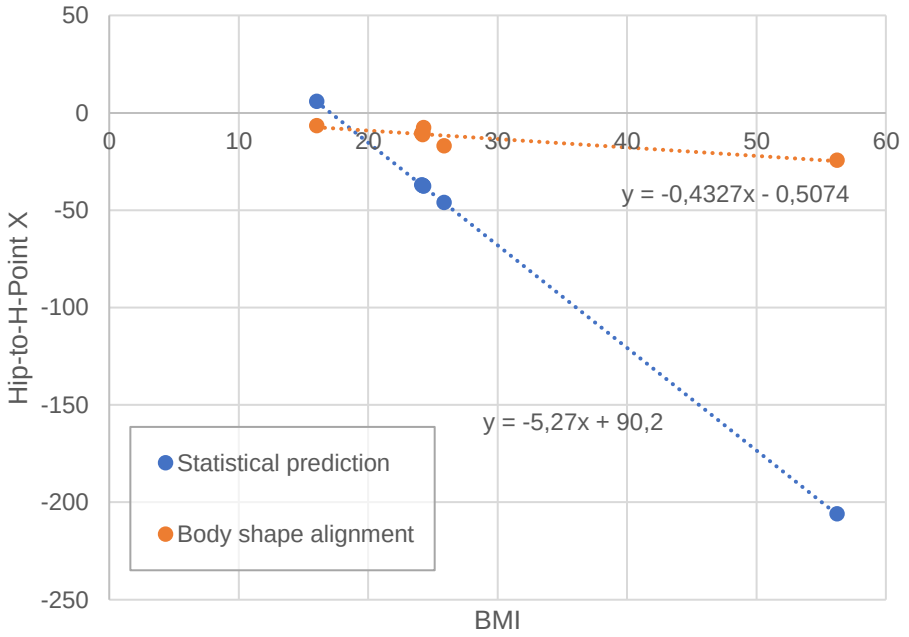


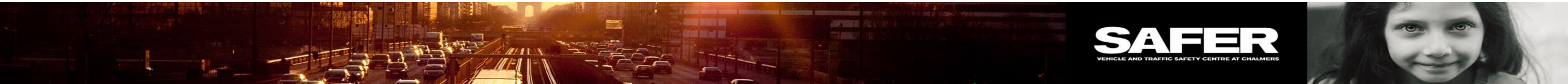
Static Posture Prediction – H-point to Mid-hip

Body shape alignment



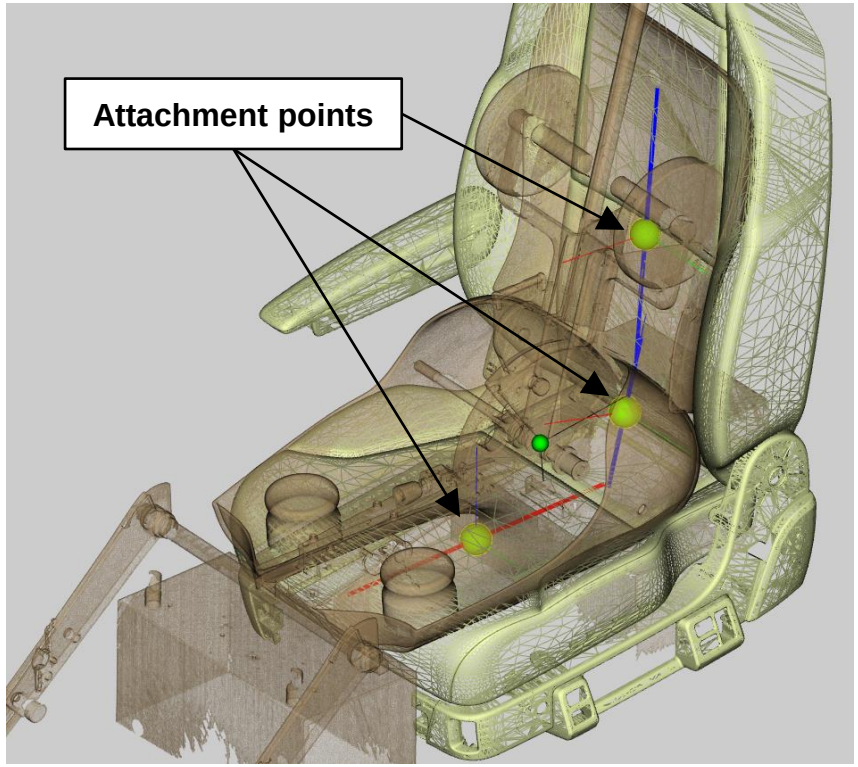






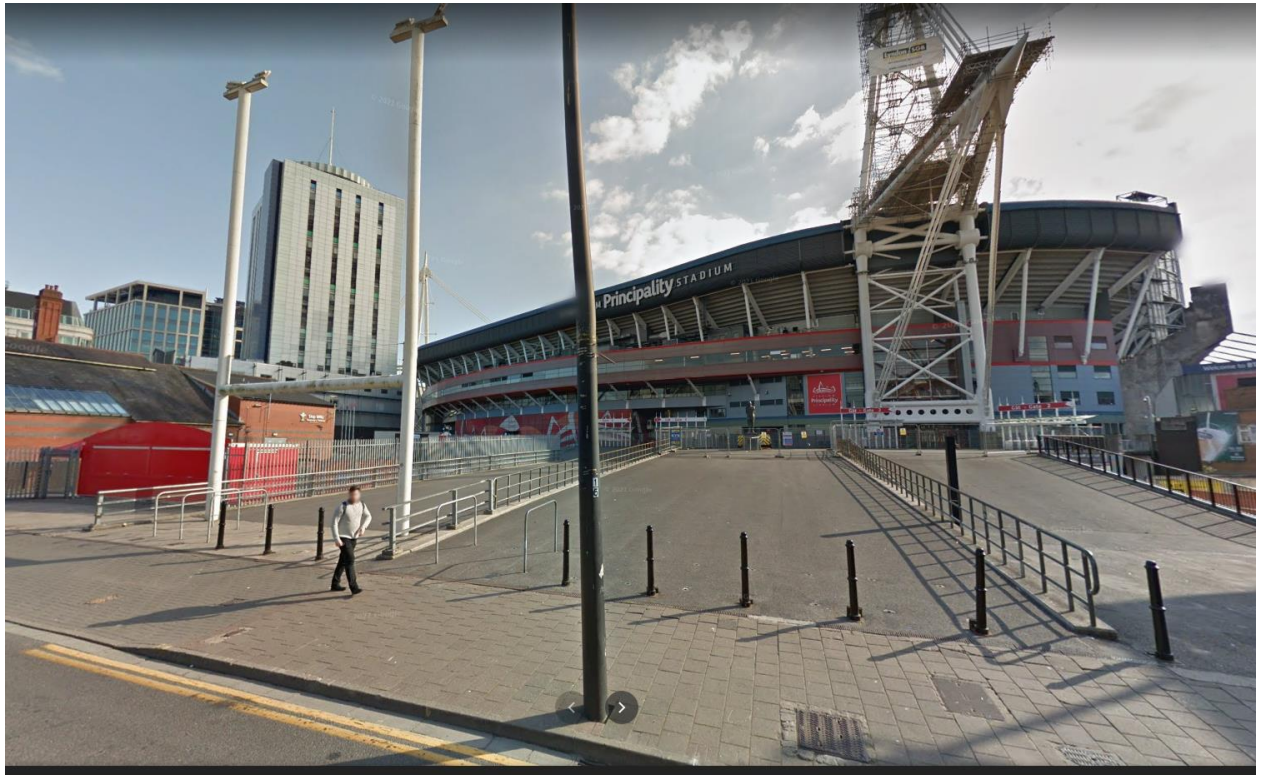
Static Posture Prediction – H-point to Mid-hip

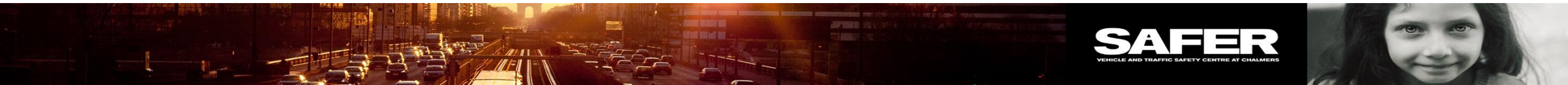
Body shape alignment



Scenario simulation

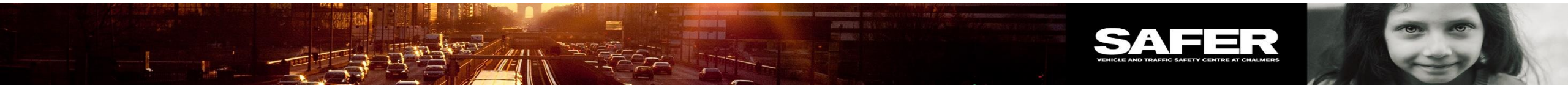
Google maps



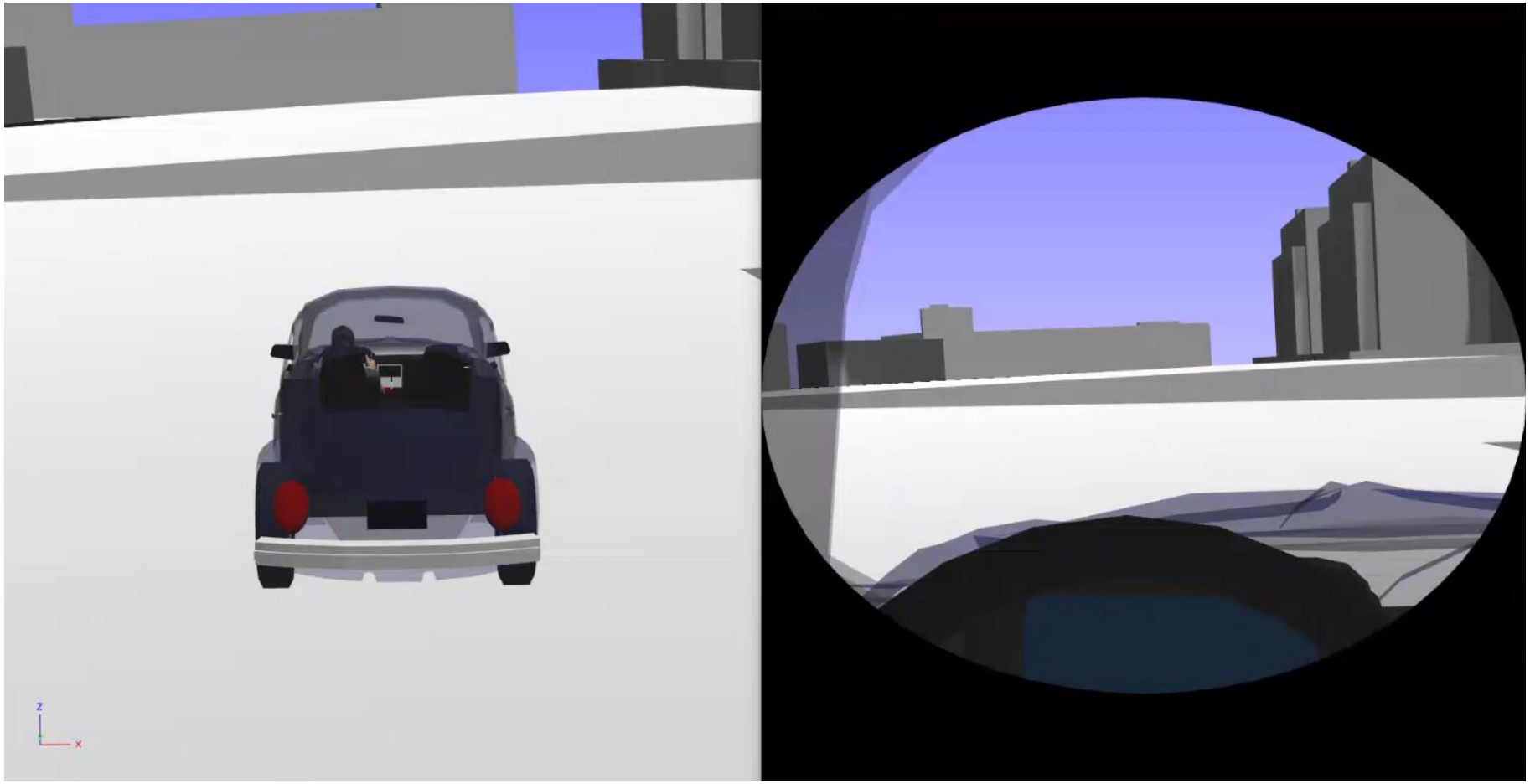


Scenario simulation

Free 3D Model of Cardiff by AccuCities



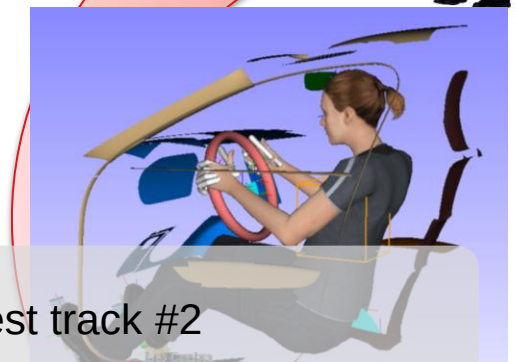
Scenario simulation



Scenario simulation

Standardized test groups

Standardized test tasks



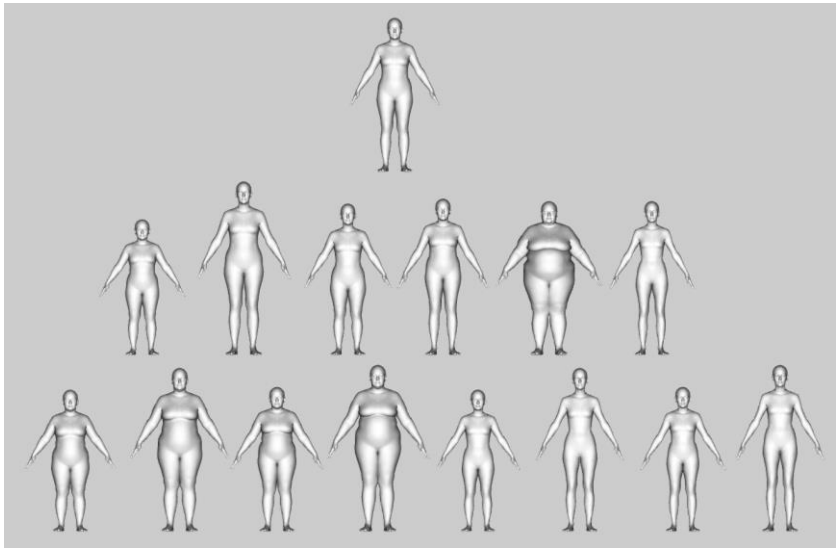
High: Run test track #2

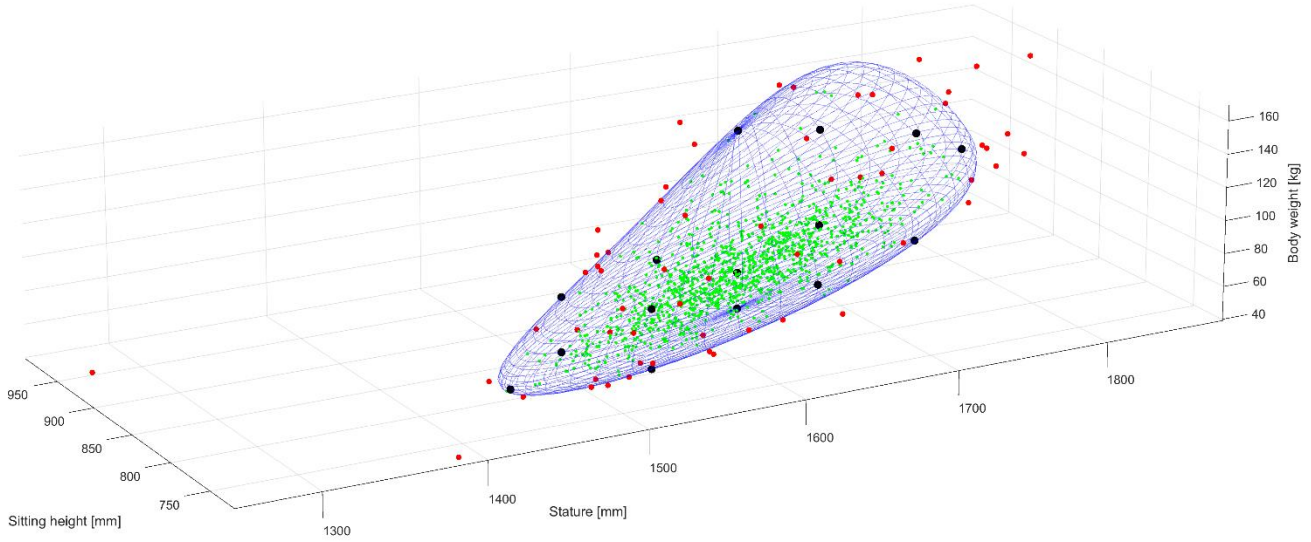
Medium: Start vehicle, back out of parking, take left, go straight, right in the roundabout…

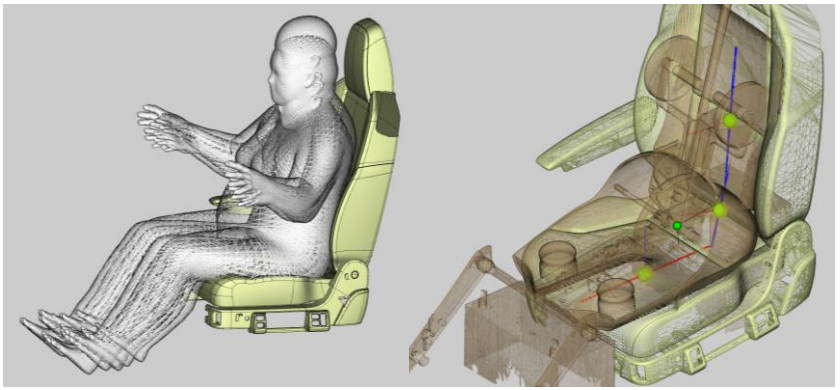
Low level: Grasp grip points, follow eye point, release, move hand...

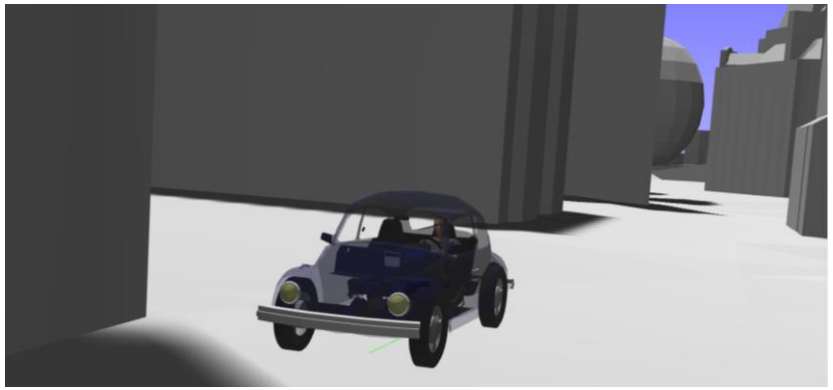
Standardized test criteria

Criteria 1√
Criteria 2 ⑦
Criteria 3 X
Criteria 4 √
Criteria 5 ③
⋮
Criteria n









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