

Development of an Automated Wheelchair Tiedown and Occupant Restraint System (AWTORS) for Automated Vehicle Use

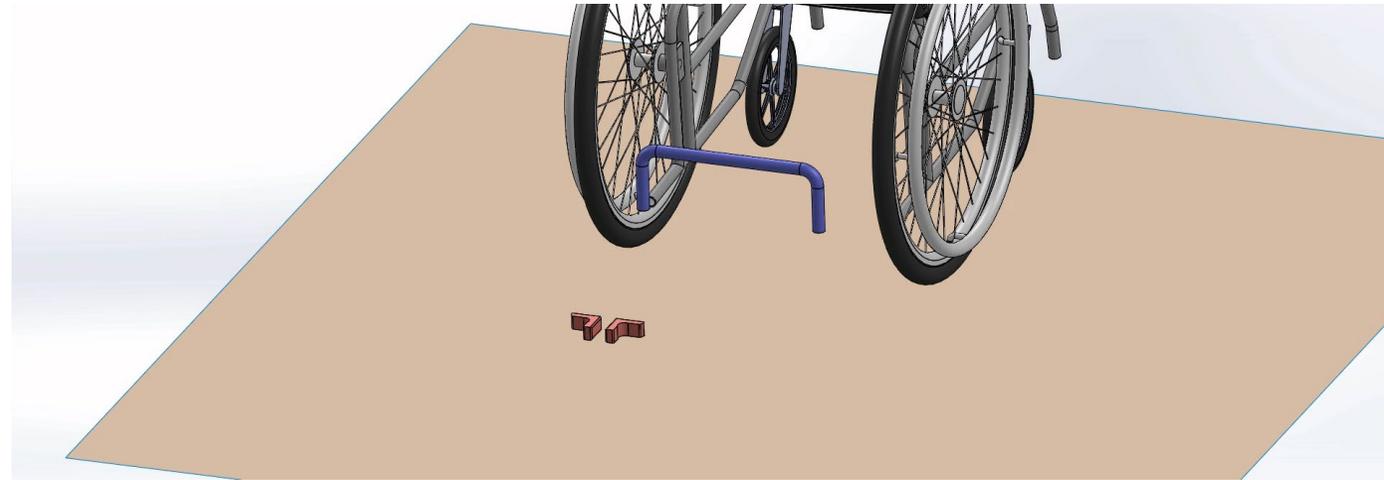
**Kathleen Klinich, Jingwen Hu,
Miriam Manary, Kyle Boyle, Nichole Orton**

January 18, 2022

AWTORS Project

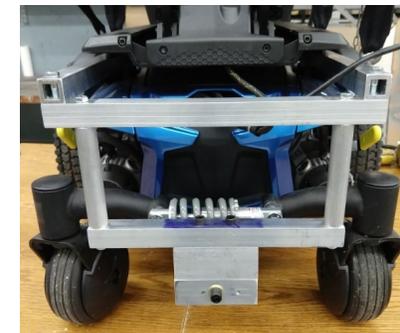
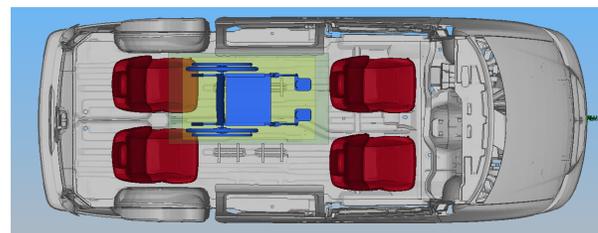
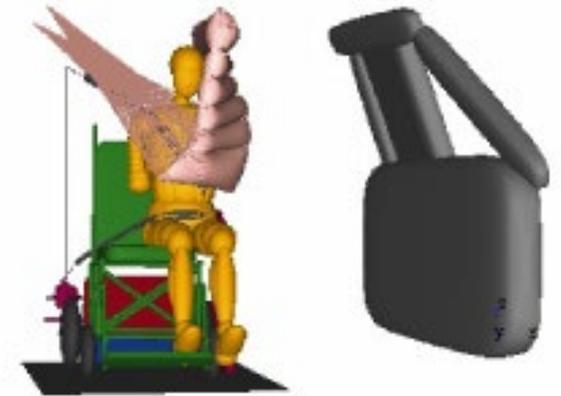
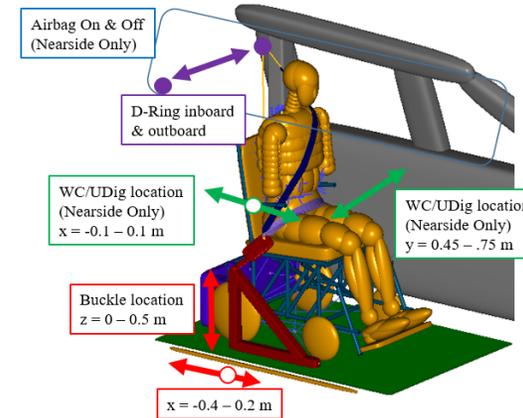
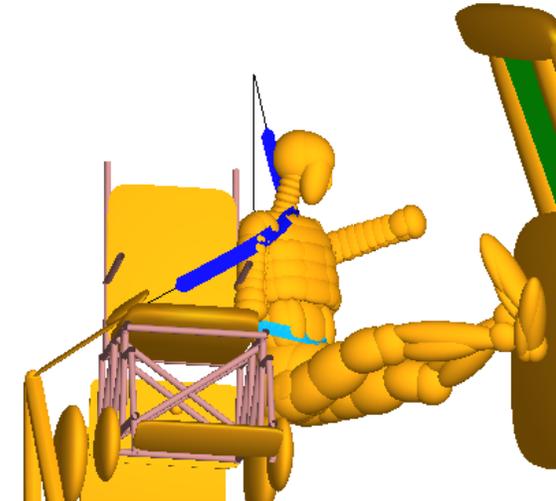
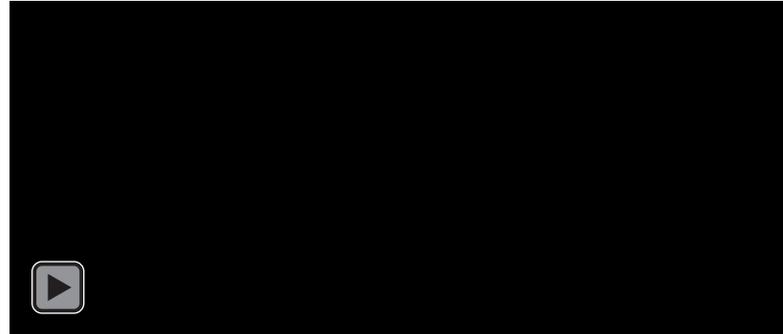
- Develop an automated wheelchair docking station that would allow safe, independent docking of occupants seated in wheelchairs
- Advances and adapts the Universal Docking Interface Geometry (UDIG) concept to the AV environment
- Develop an automated belt-donning system
- Evaluate in front and side impacts

- Computational Modeling
- Volunteer Usability Assessment
- Sled Testing

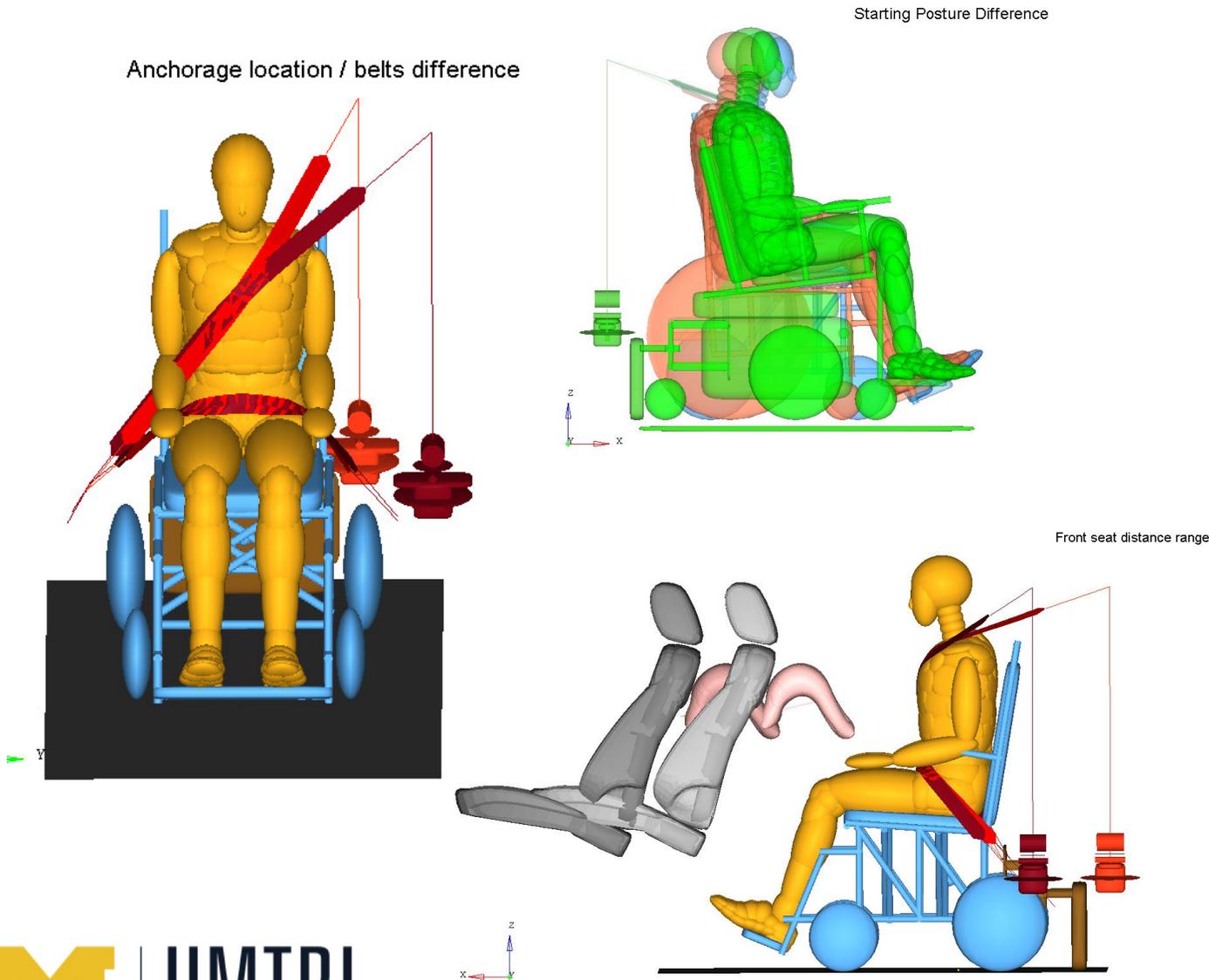


2021 SAE G/I Summary

- Validation of frontal and side impact models
- Optimization of frontal belt geometry with SCARAB
- New concept: Center Airbag To Contain Humans (CATCH)
- Prototype Hardware Development
- Prepare for volunteer evaluation

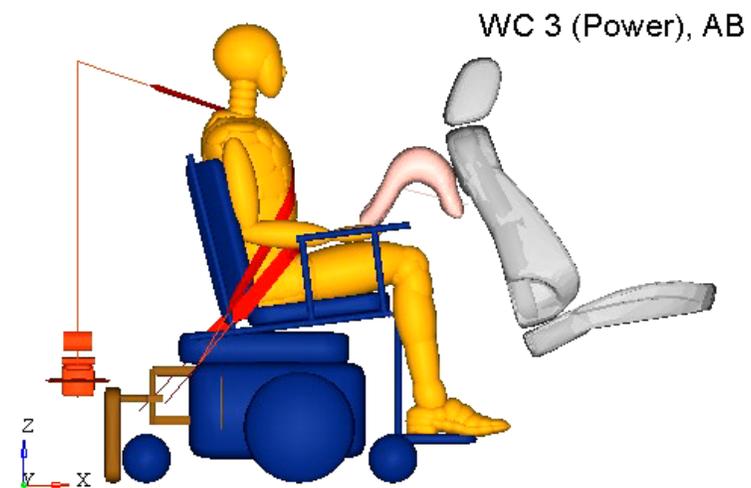
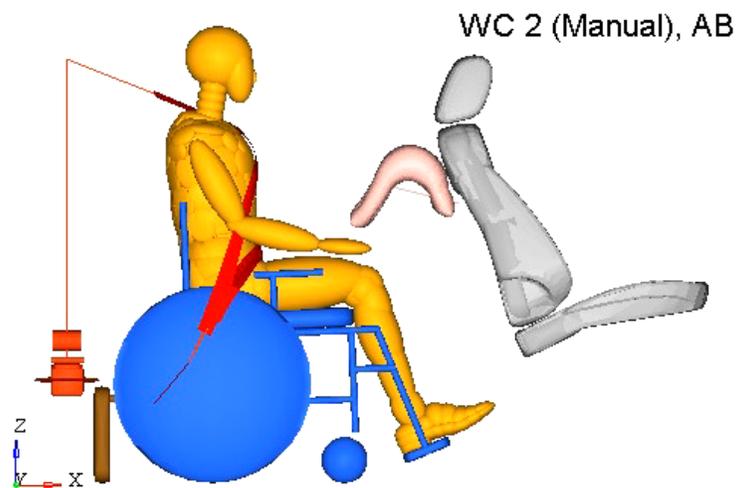
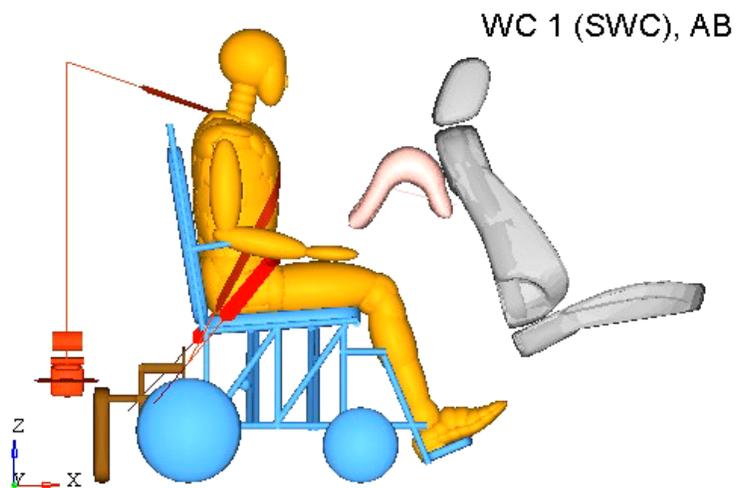
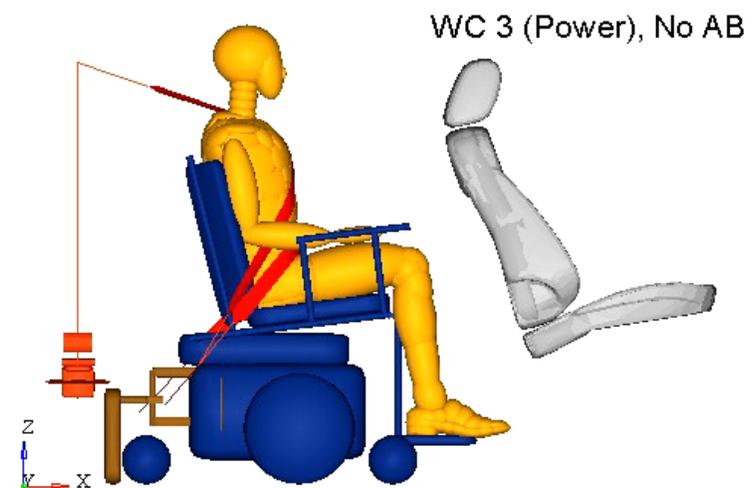
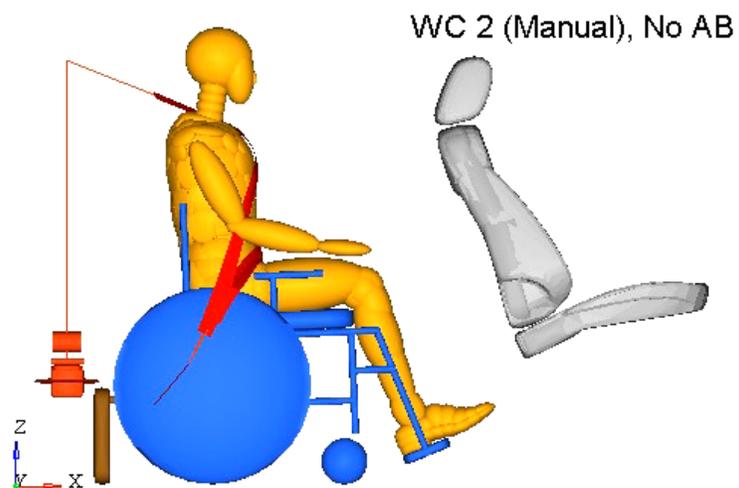
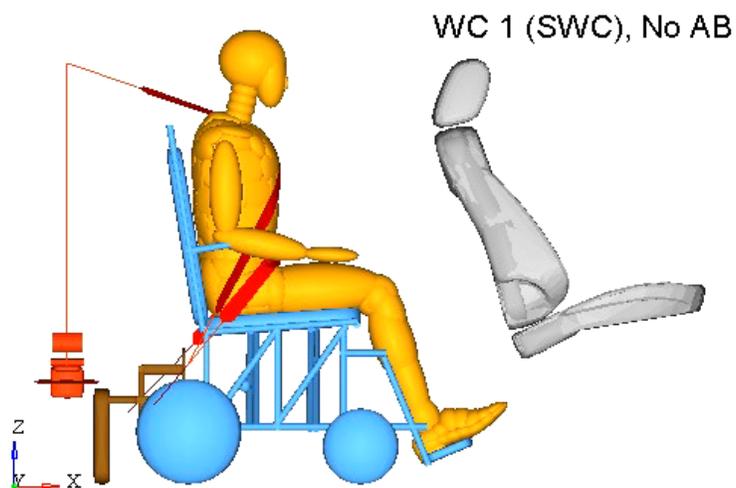


Simulations of Feasible Geometry



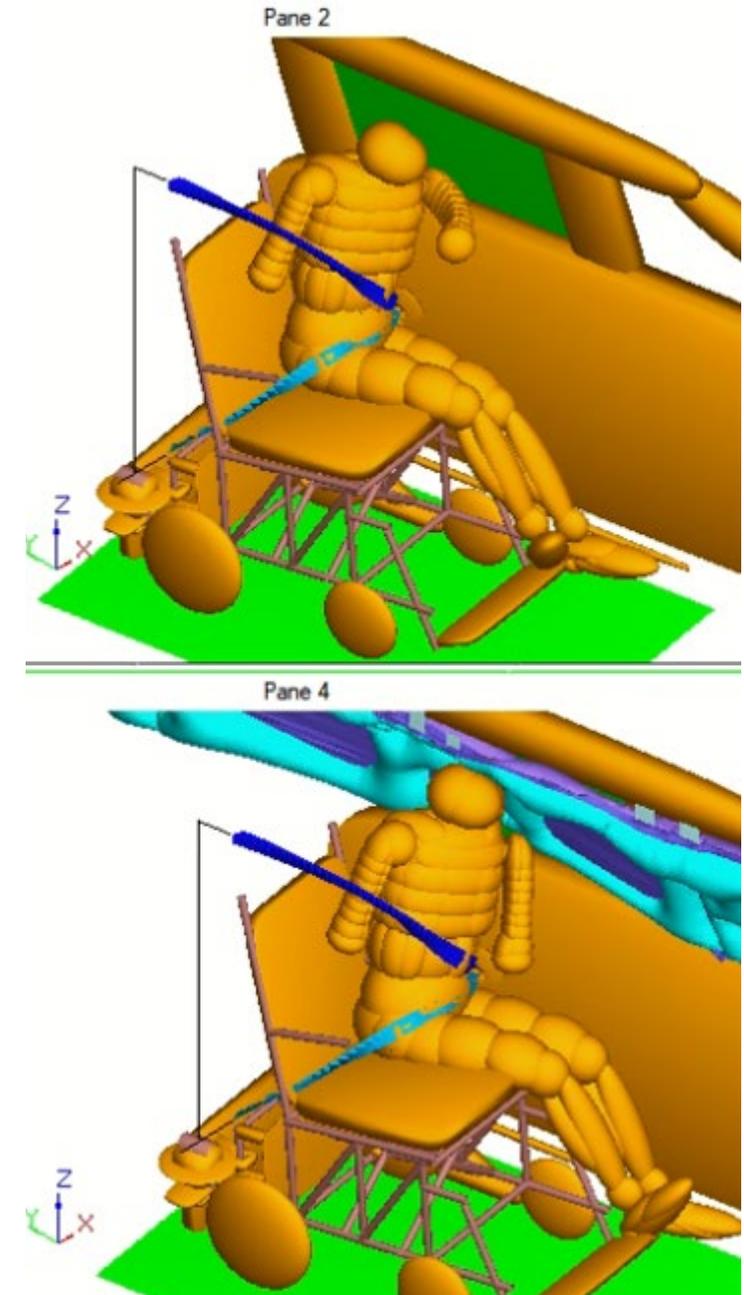
- Two belt geometries (B & D)
- With and without SCaRAB
- Three wheelchairs
 - Manual, power, surrogate
- Location of forward structure (0-250 mm)
- Seatbelt torsion bar / load limit
- Airbag venting

SCaRAB Effects



Simulation findings

- Symmetric lap belt anchors prevents twisting and excessive head excursion
- Restraints designed for surrogate wheelchair work well with power and manual wheelchairs
- Modeling results defined geometries for sled tests to demonstrate benefits of airbags and better belt geometry
- Review of models and sled tests shows excellent agreement
 - Airbag helps make up for suboptimal belt fit
 - May be needed given belt fit of volunteers



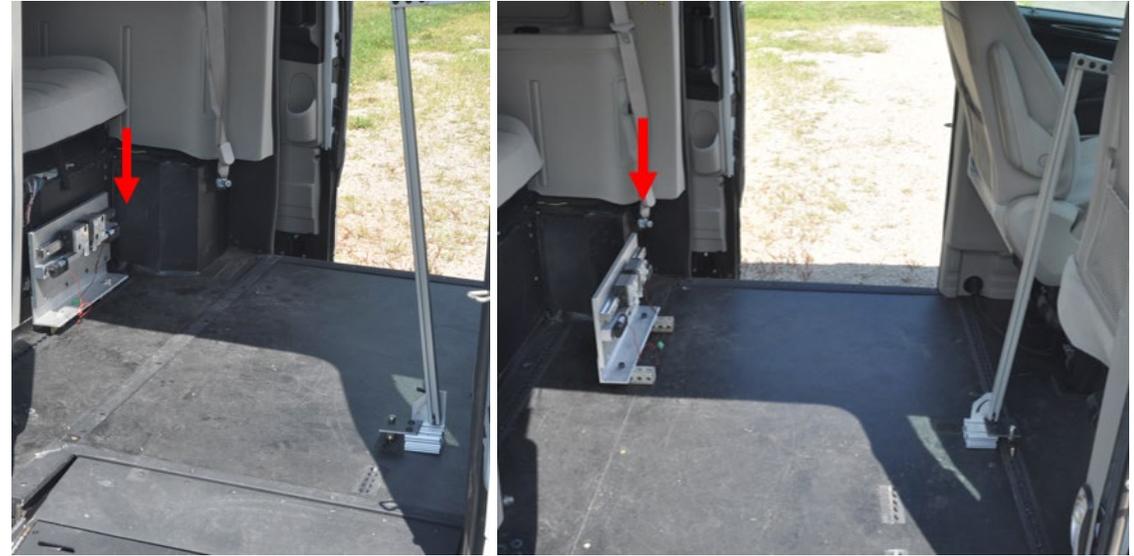
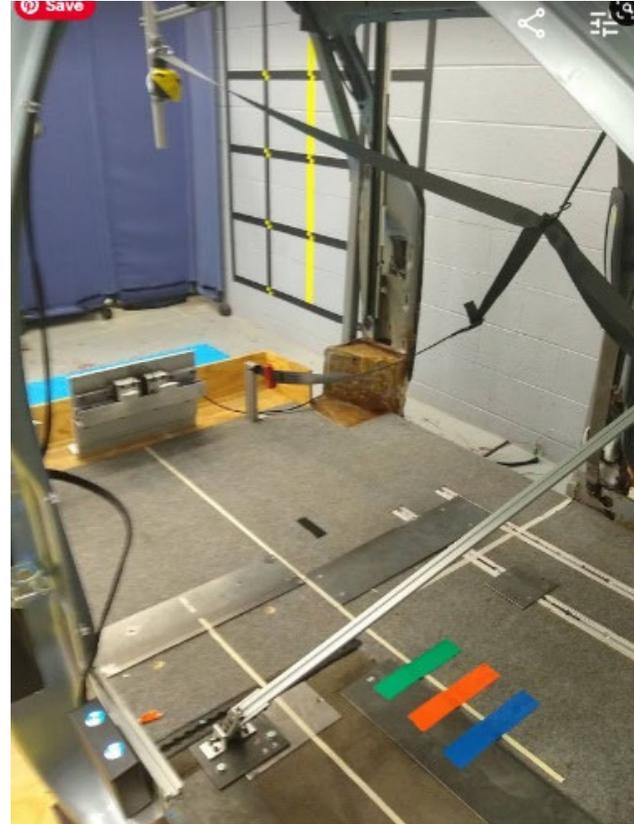
UDIG Docking



Belt Donning System



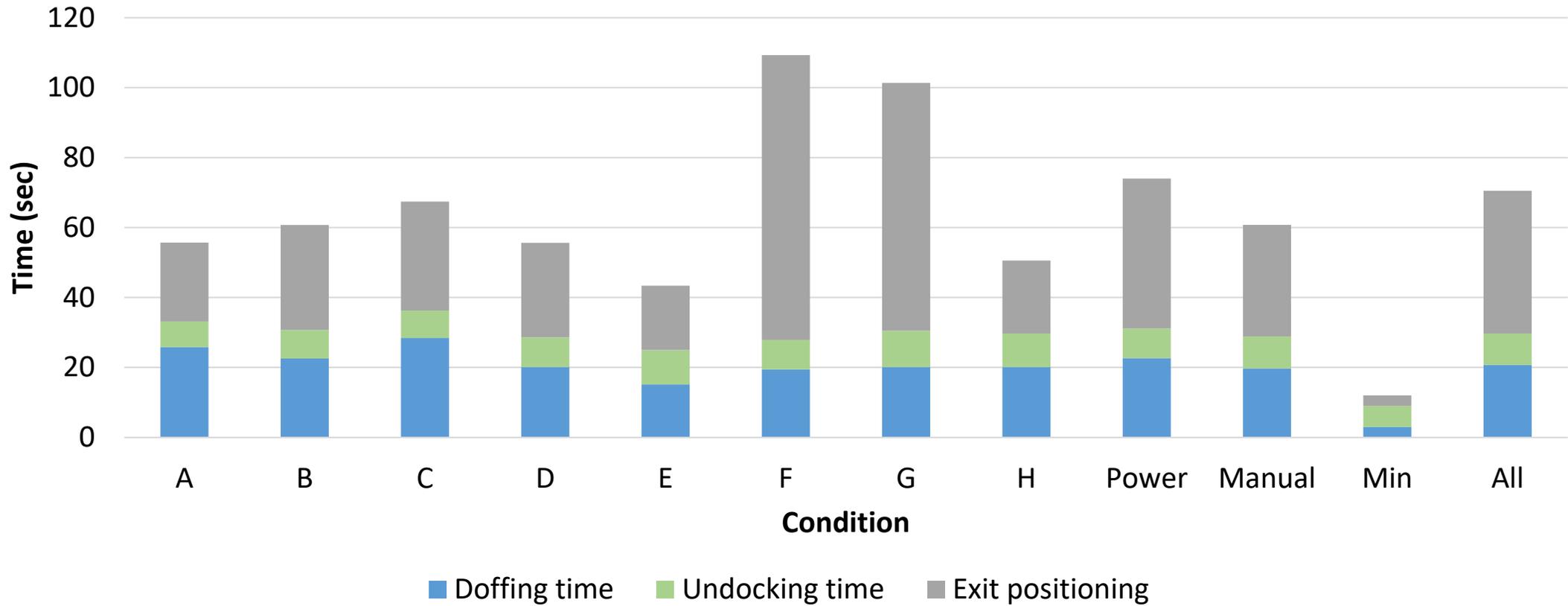
Implementation



Belt Fit Variations: Condition D



Exit Timings



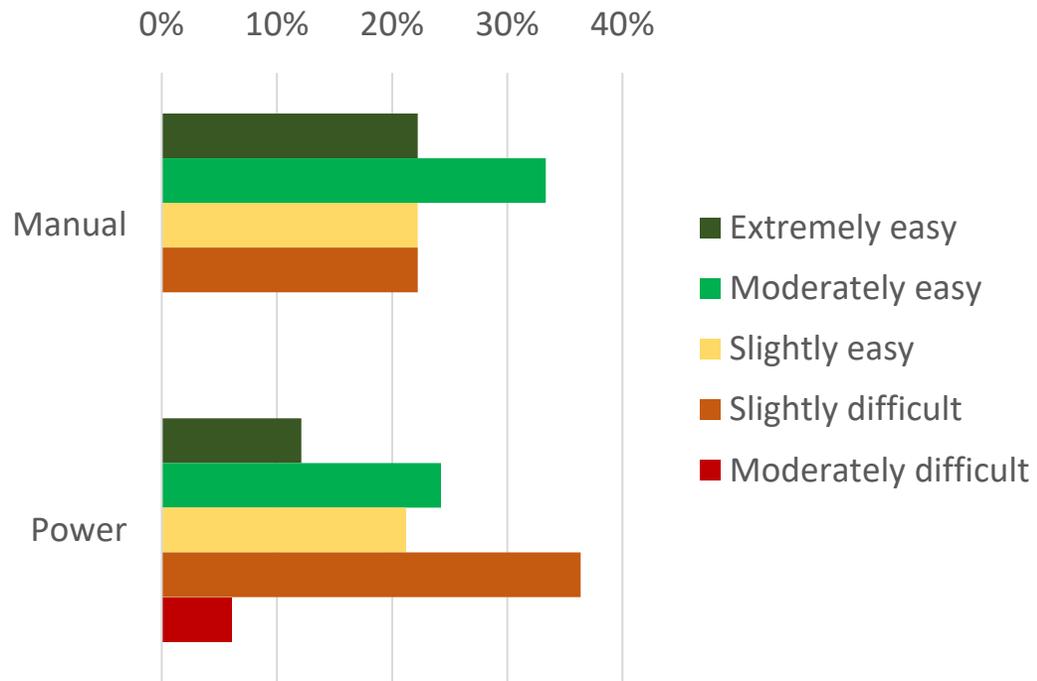
Max: Doffing 66 Undocking 18 Positioning 140

Ingress/Egress Docking/Donning/Doffing

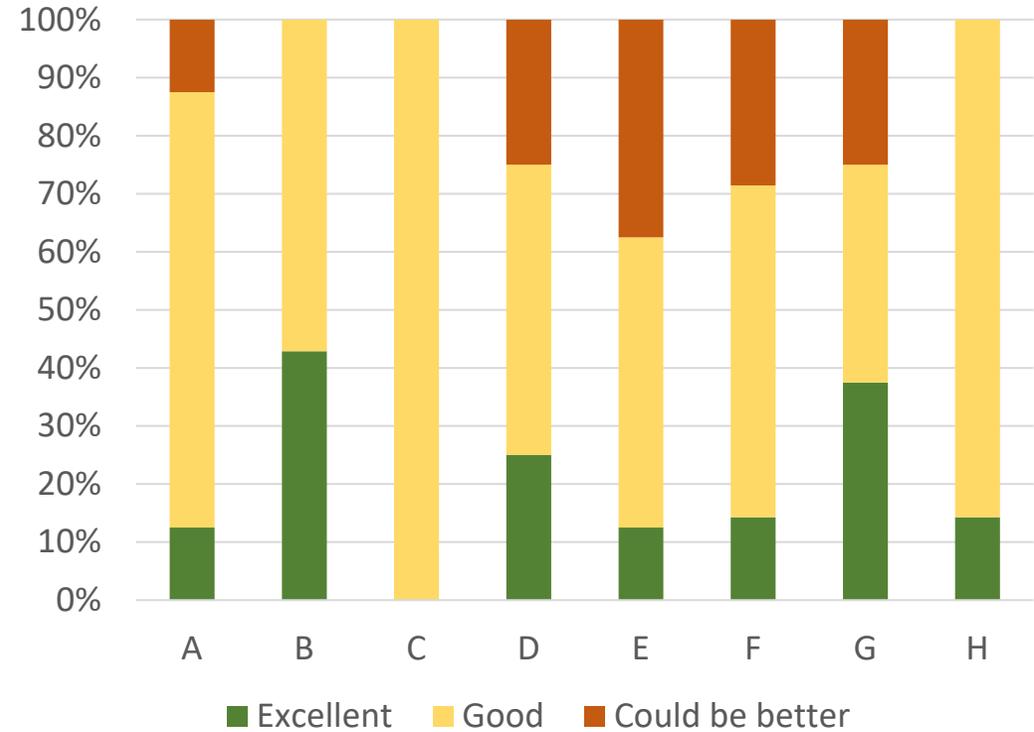
	% all trials
Traveled in forward position during entry	95%
Problems maneuvering around seatbelt during docking	8%
Took 3 or more attempts to align	20%
Realignment required after first engagement attempt	28%
Steered directly out of station on exit without changing direction	72%
Problems maneuvering around seatbelt on exit	15%

Docking ease of use

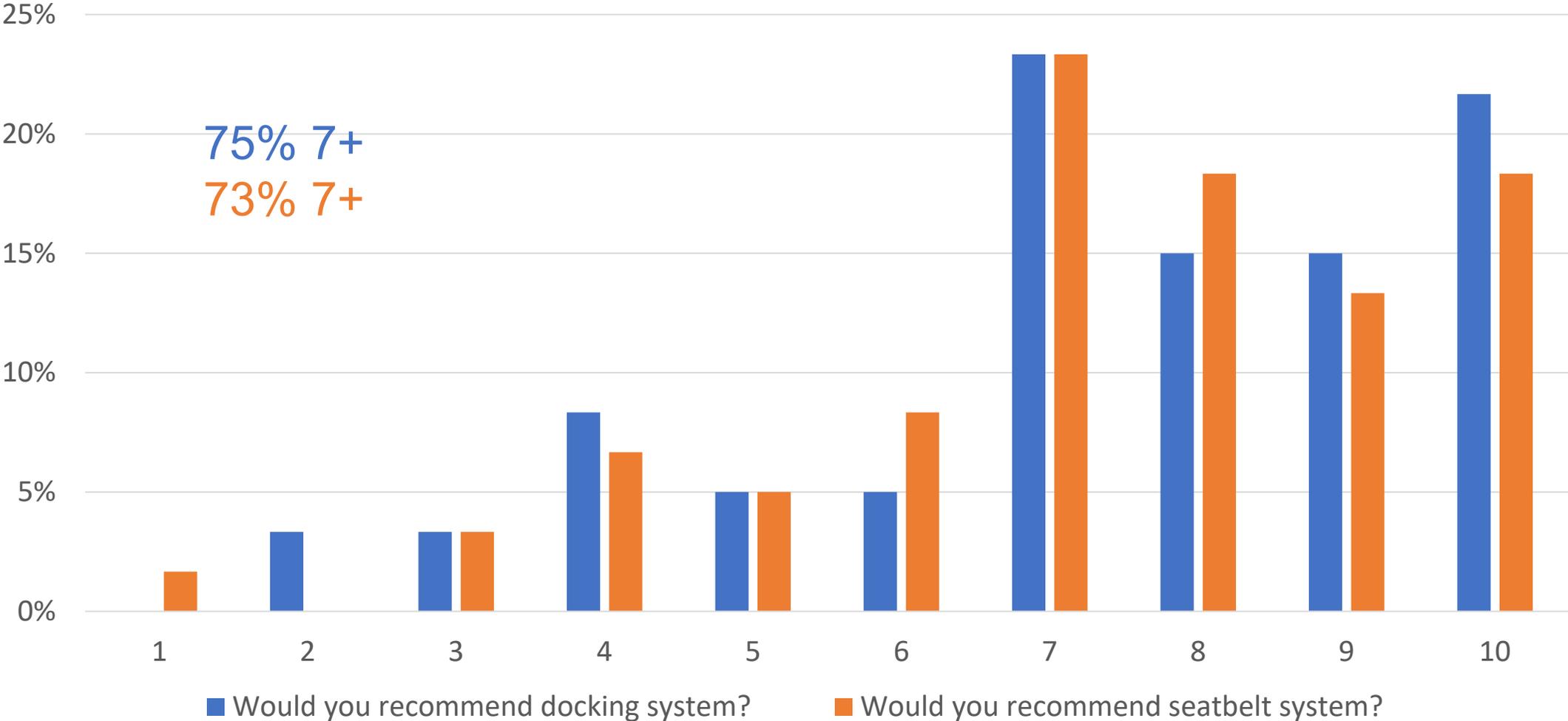
Level of Difficulty Maneuvering the Test Wheelchair vs Personal WC



Ease of Lining Up WC with UDIG Anchors

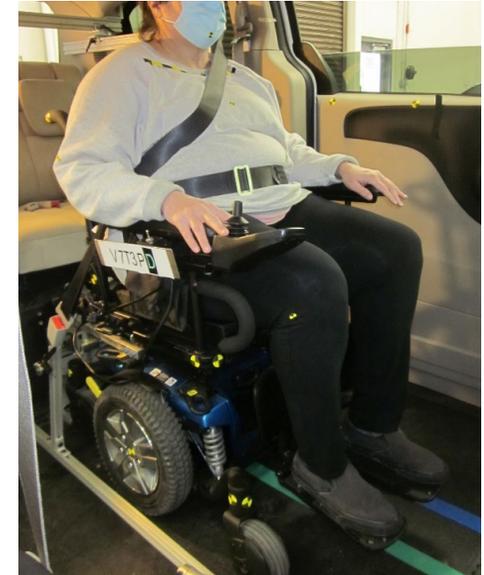


Acceptance

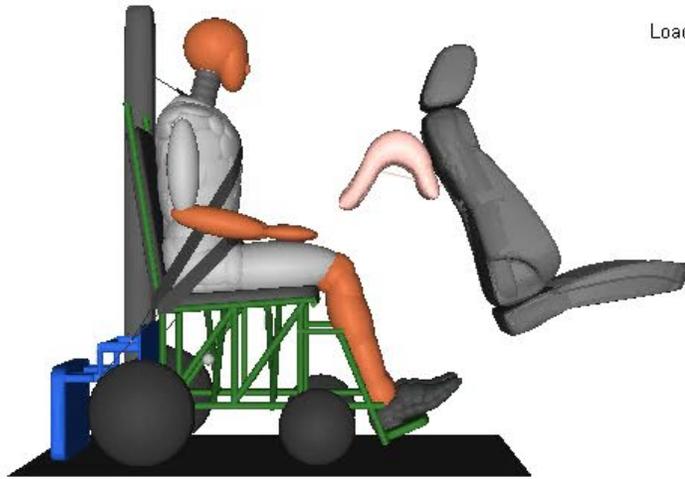


Belt Fit

- Belt fit generally better than in our previous study of participants in their own vehicles
- Range of belt fit in this study comparable to volunteers in vehicle seats in past studies
- People in vehicle seats have secondary restraint from knee bolsters to make up for poor lap belt fit that are not available for wheelchair stations with adequate maneuverability space



50M, SWCB, D, SCaRAB



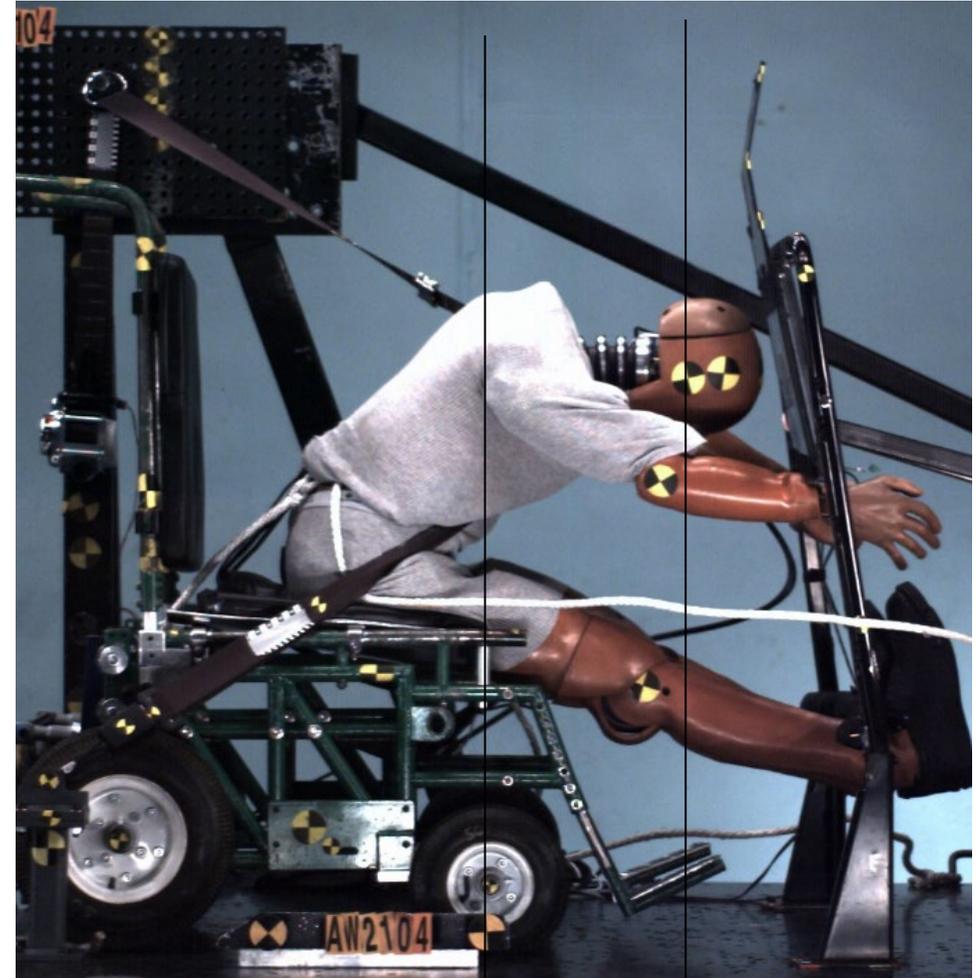
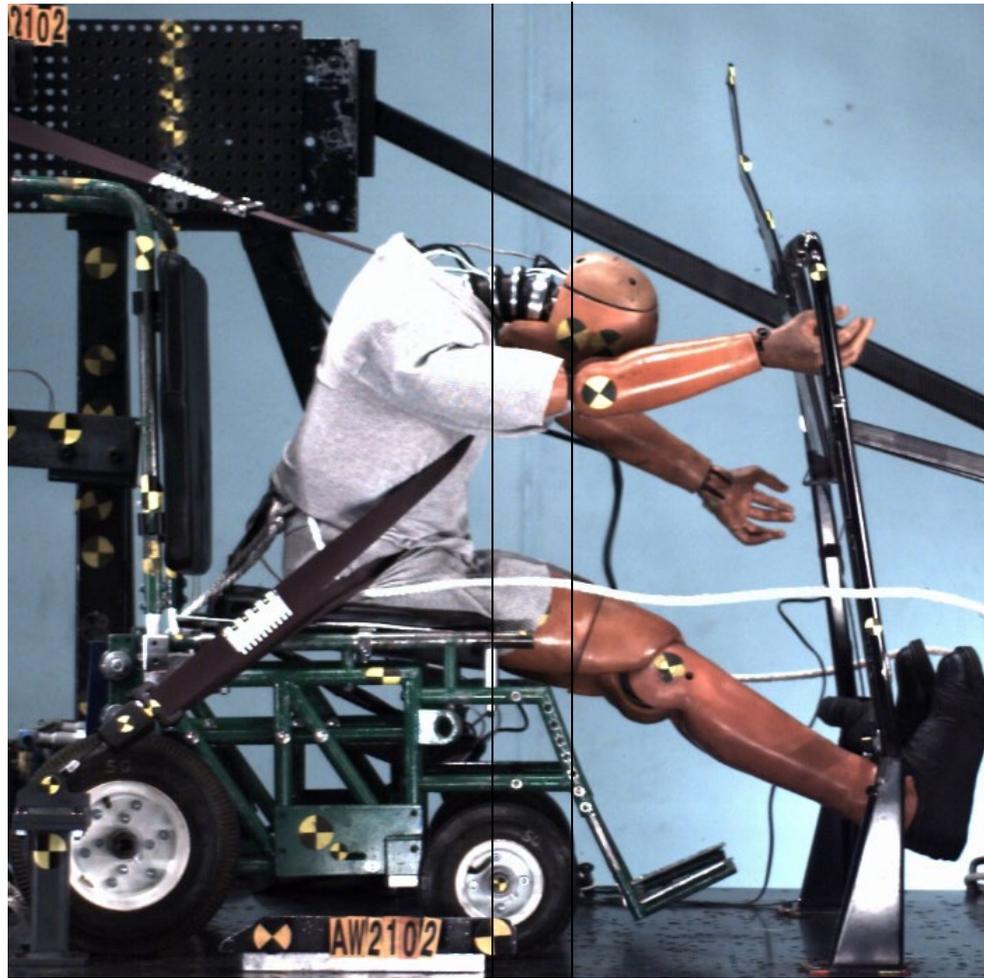
H350, Geo 2, With AB
Loadcase 1 : Time = 0.000000
Frame 1



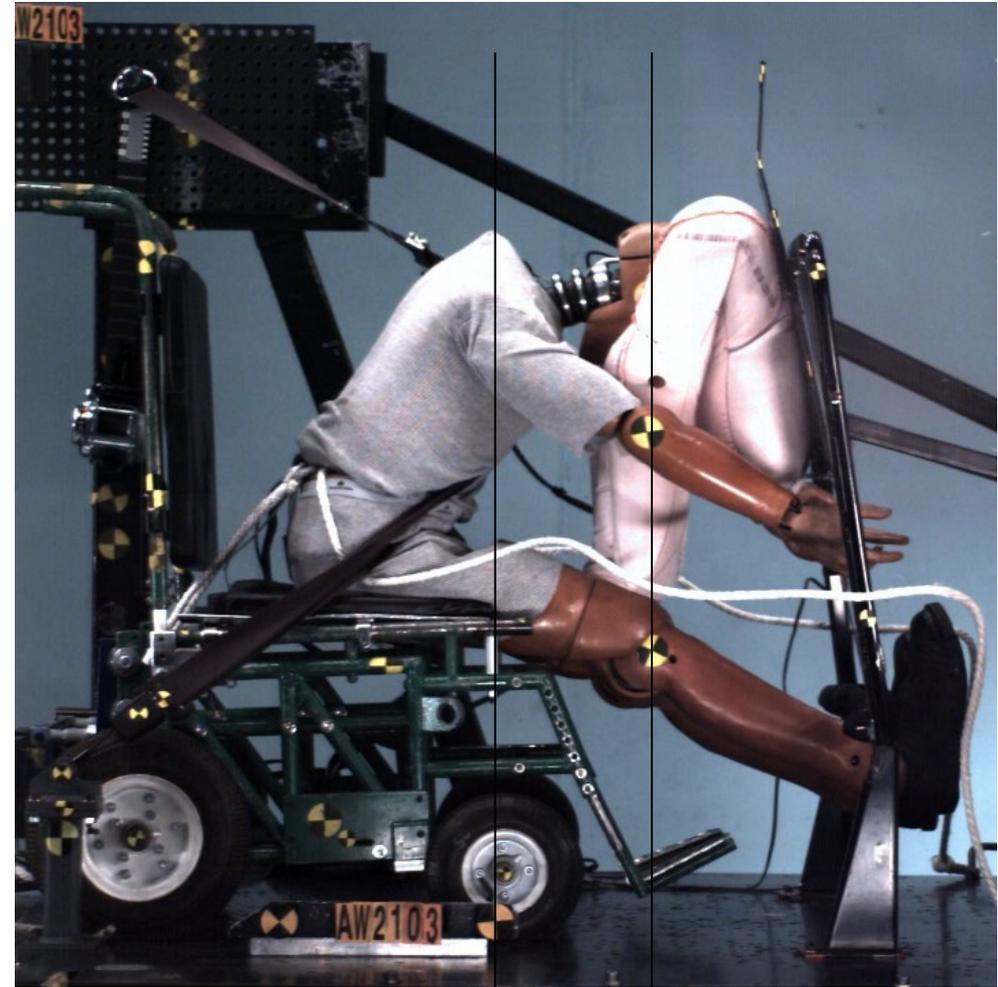
H350, Geo 2, With AB
Loadcase 1 : Time = 0.000000
Frame 1



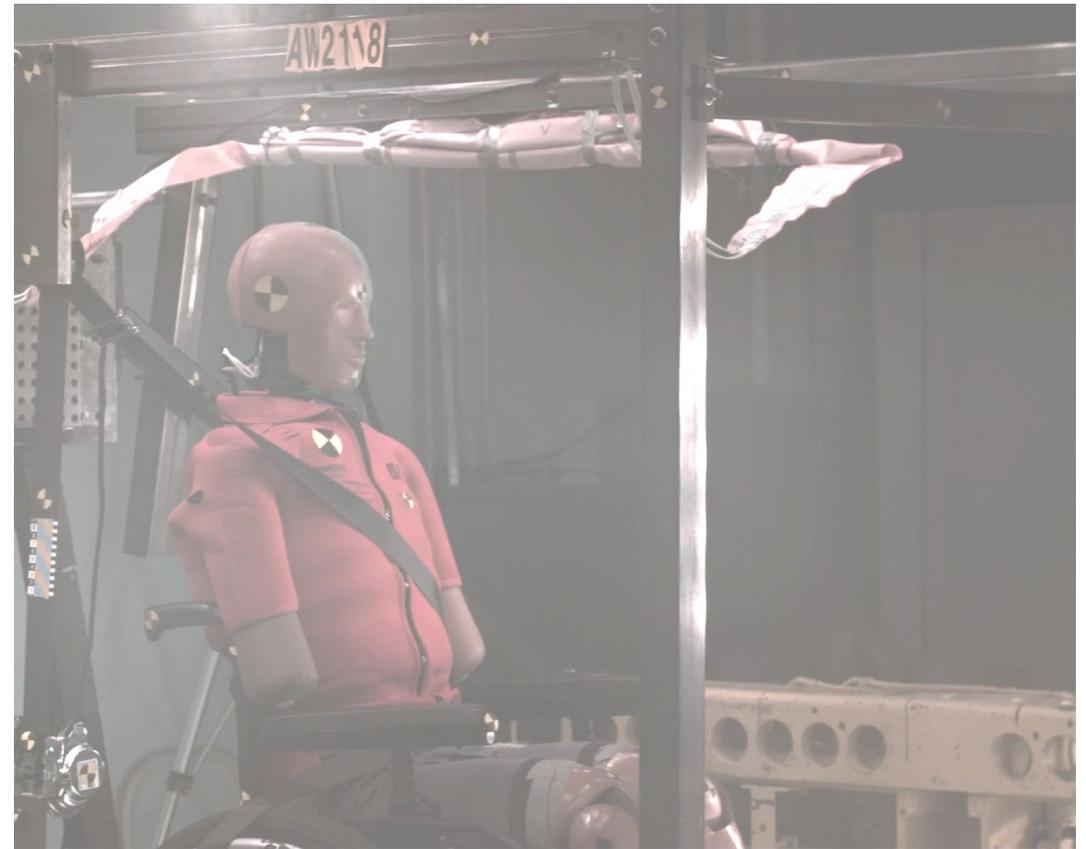
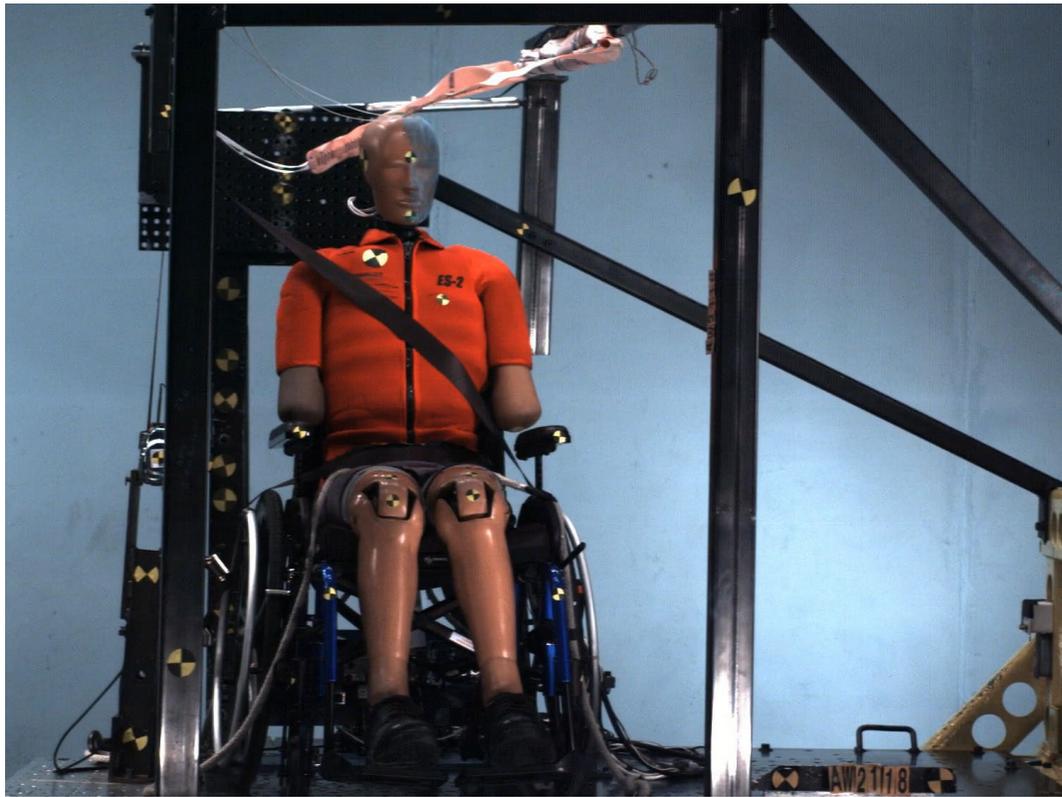
Peak Comparison: Belt Geometry



Peak Comparison: Belt Geometry



18: 50M, Manual WC, CATCH-V', tether loc 2



Summary

- Identified feasible good belt geometry for wheelchair seating stations
- Demonstrated benefit of SCARAB, particularly for suboptimal belt geometry
- Developed new CATCH airbag for farside impacts
- Demonstrated feasibility of UDIG-compatible docking system and automated belt-donning arm with volunteers
- Identified challenges of implementing integrated wheelchair seating stations in AVs

More information & research

- Presentation from public open house on AWTORS project available at umtri.umich.edu
- Final technical report will be posted there when approved, and also at <https://deepblue.lib.umich.edu/>
- Participating in USDOT Inclusive Design Challenge with May Mobility (and others) to evaluate an iteration of the prototypes on road in an electric vehicle; public Design Charette January 24, 2022.
- Developing procedure to test wheelchairs in side impact (NHTSA, 2023)
- Design Guidelines for Accessible AVs: Mobility Focus (Mcity, June 2022)
- Updated website on Wheelchair Transportation Safety at travelsafer.org coming in February

**Thank you to the National Traffic Safety Administration
for sponsoring this project.**

Thank you for your attention!

Kathleen Klinich kklinich@umich.edu

Jingwen Hu jwhu@umich.edu

Miriam Manary mmanary@umich.edu

Kyle Boyle kjboyle@umich.edu

Nichole Orton nritchier@umich.edu