Development of an Automated Wheelchair Tiedown and Occupant Restraint System: Initial Progress

Kathleen Klinich, Jingwen Hu, Miriam Manary, Kyle Boyle, Nichole Orton, Yushi Wang, Laura Malik, Brian Eby

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UMTRI TRANSPORTATION RESEARCH INSTITUTE UNIVERSITY OF MICHIGAN

Wheelchair Transportation Safety (WTS)*

- Best practice recommendation is to transfer from a wheelchair to a vehicle seat
- Wheelchairs used as motor vehicle seats should be crash tested to verify performance.
- Method to secure the wheelchair to the vehicle. (wheelchair tiedown)
- Method to restrain the occupant.
- Wheelchair Tiedowns and Occupant Restraint Systems (WTORS)
- Goal of equal level of safety for those who remain seated in wheelchairs.

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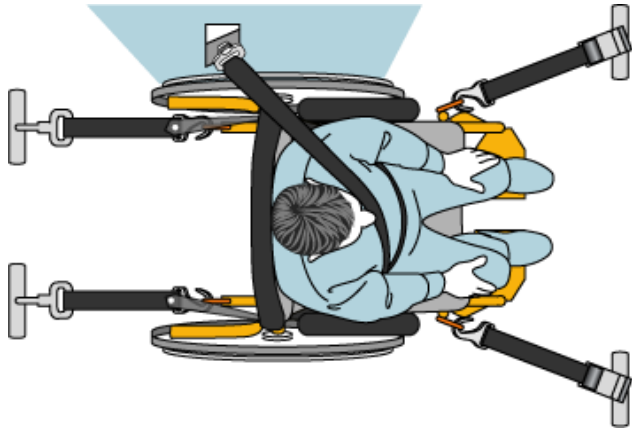
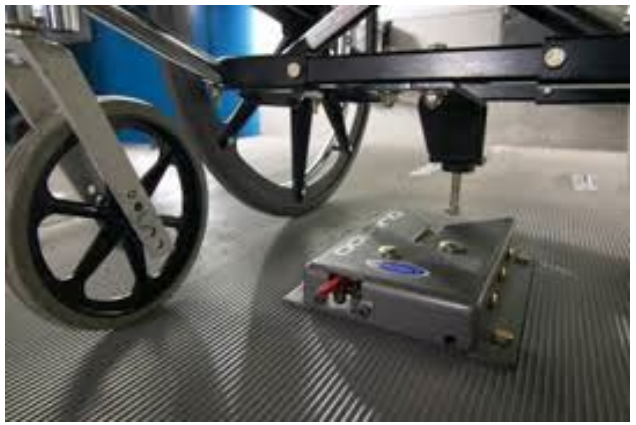
*Buning, Mary Ellen et al. 2012. “RESNA’s Position on Wheelchairs Used as Seats in Motor Vehicles.” *Assistive Technology* 24(2).

Current WTORS Systems

WTORS Type	Independent Use	Protection in High g and Low g crashes	Any combination of wheelchair and vehicle?
4-pt strap tiedown paired with seatbelt	No	Yes	Yes
Docking station paired with seatbelt	Yes	Yes	No
Rear-facing stations	Yes	No	Yes





Universal Docking Interface Geometry

- Common geometry for the connection interface between wheelchairs and vehicles. Based on the idea of truck trailer hitch.
- Allows a wheelchair to use docking in all types of vehicles.
- Geometry defined and field tested.
- Requires both WC and WTORS manufacturers to work together.
- Already implemented in standards, but no commercial use yet.

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Project Goals and Tasks

- Develop an automated wheelchair docking station that would allow safe, independent docking of occupants seated in wheelchairs
- Develop an automated belt-donning system
- Evaluate in front and side impacts

- Computational Modeling
- Volunteer Usability Assessment
- Sled Testing

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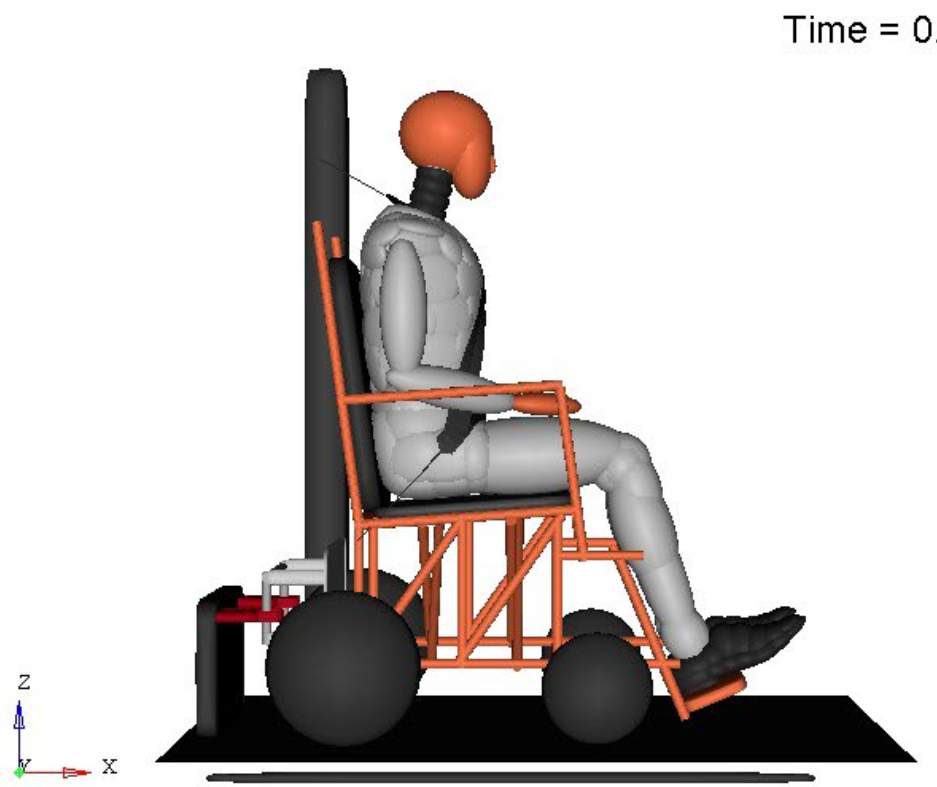
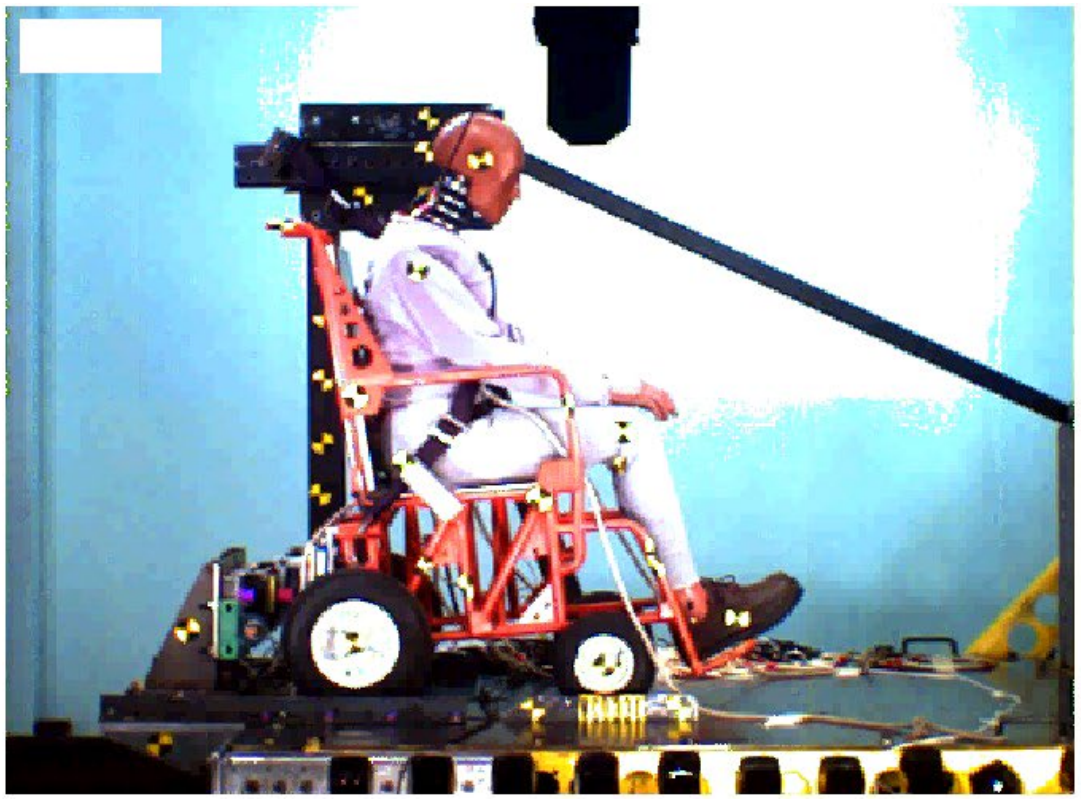
Frontal model validation: surrogate wheelchair fixture





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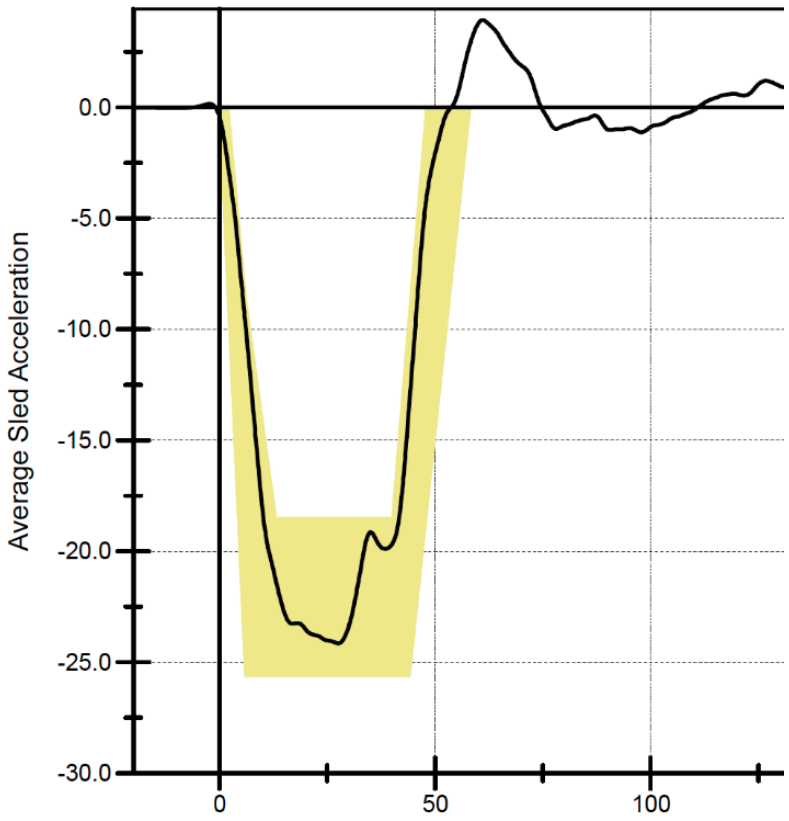
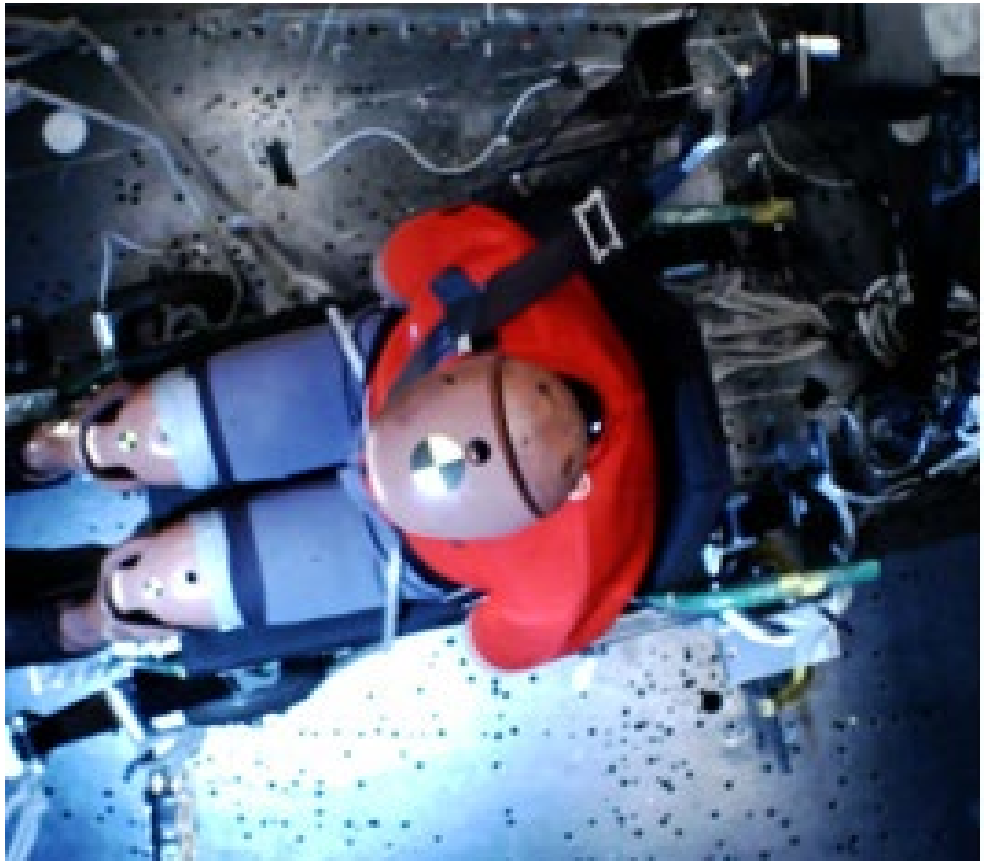
Side impact validation tests





Test conditions based on proposed 213 NPRM conditions

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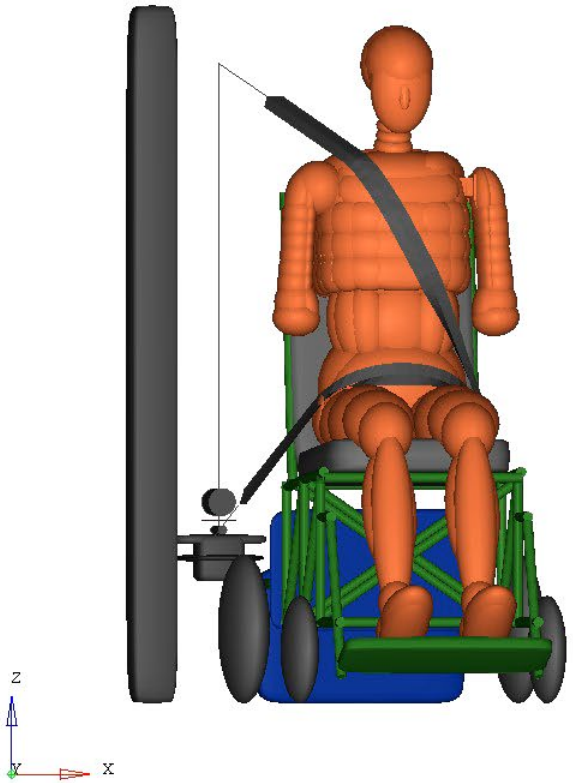
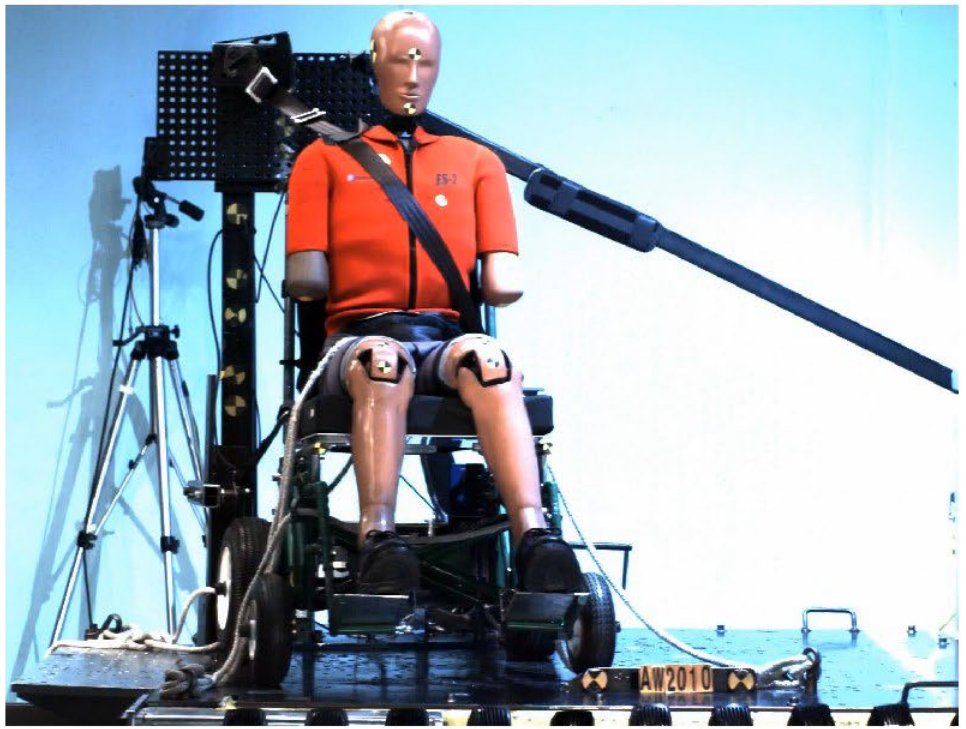
Side model validation

Time = 0.000000





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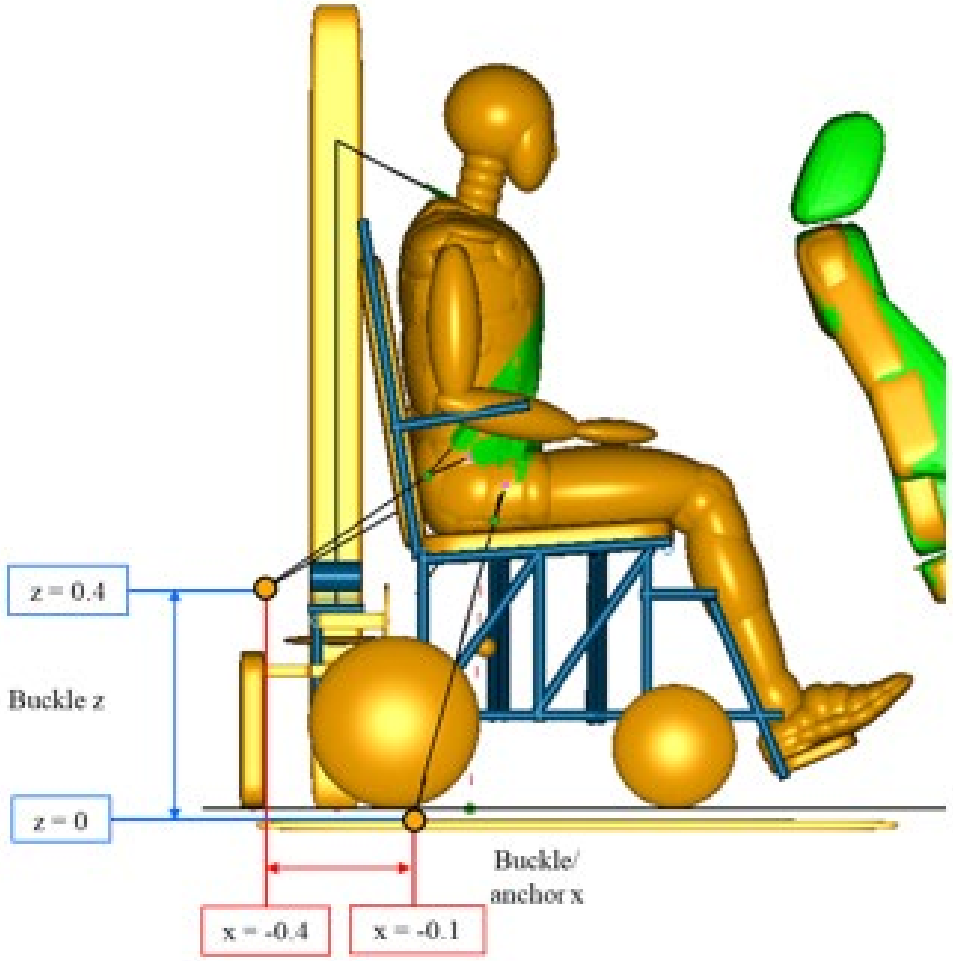
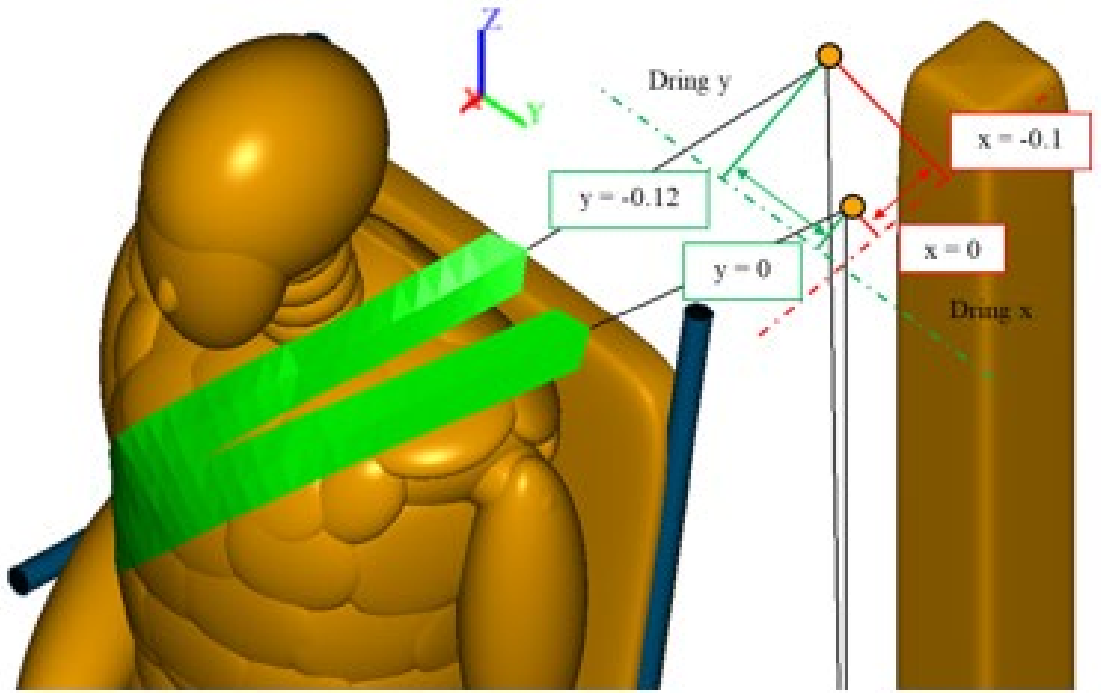
Frontal optimization parameter ranges





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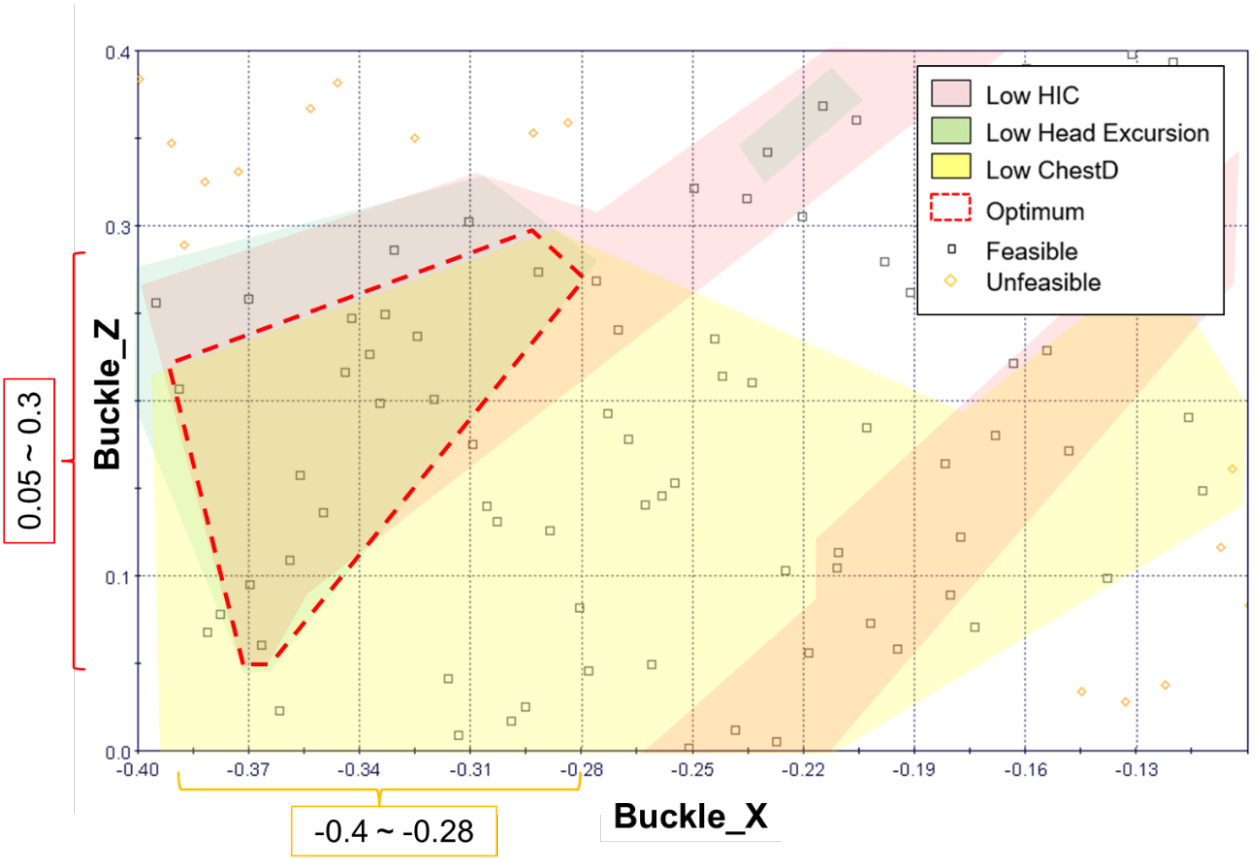
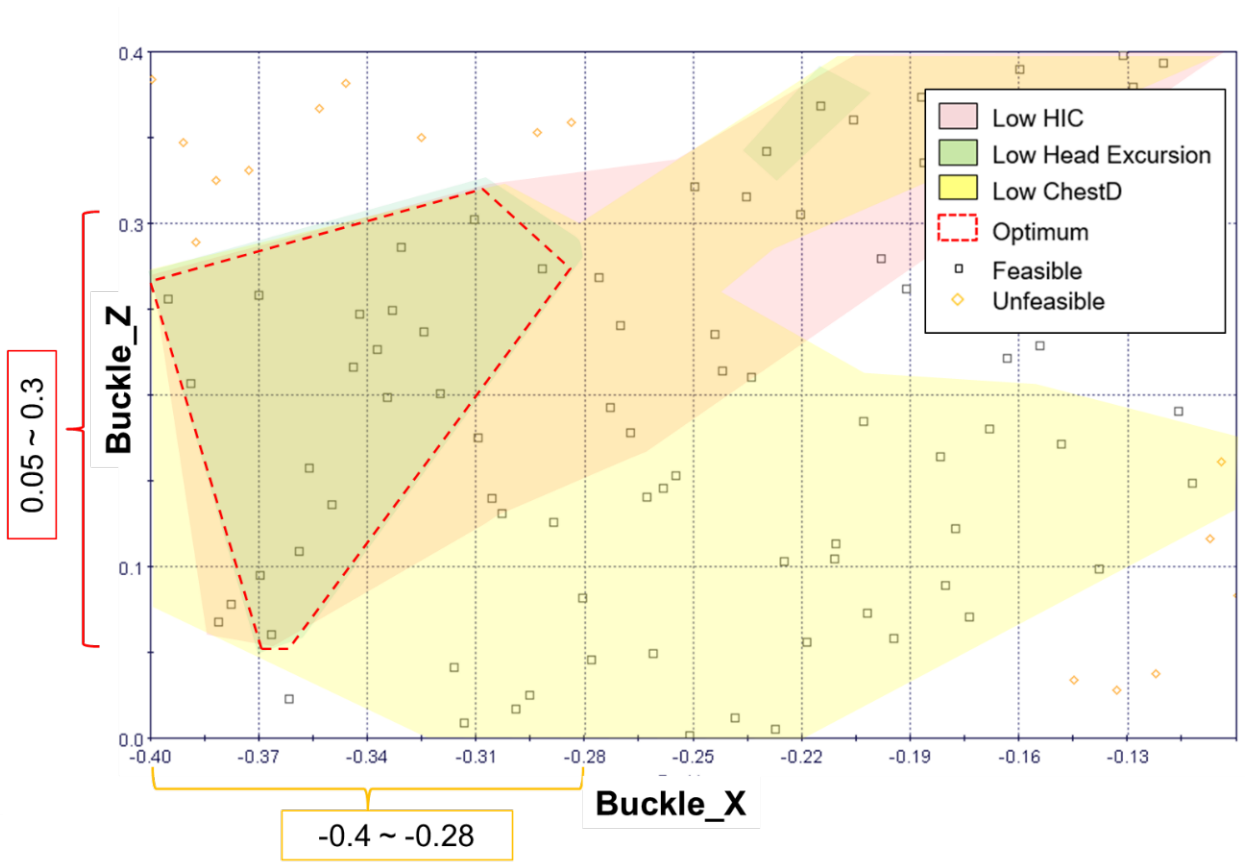
Optimum lap belt anchorage zones



Second row



Front row

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SCARAB airbag

- Airbag provides benefit for suboptimal geometry
- Providing sufficient space to maneuver wheelchair may reduce potential for head contact

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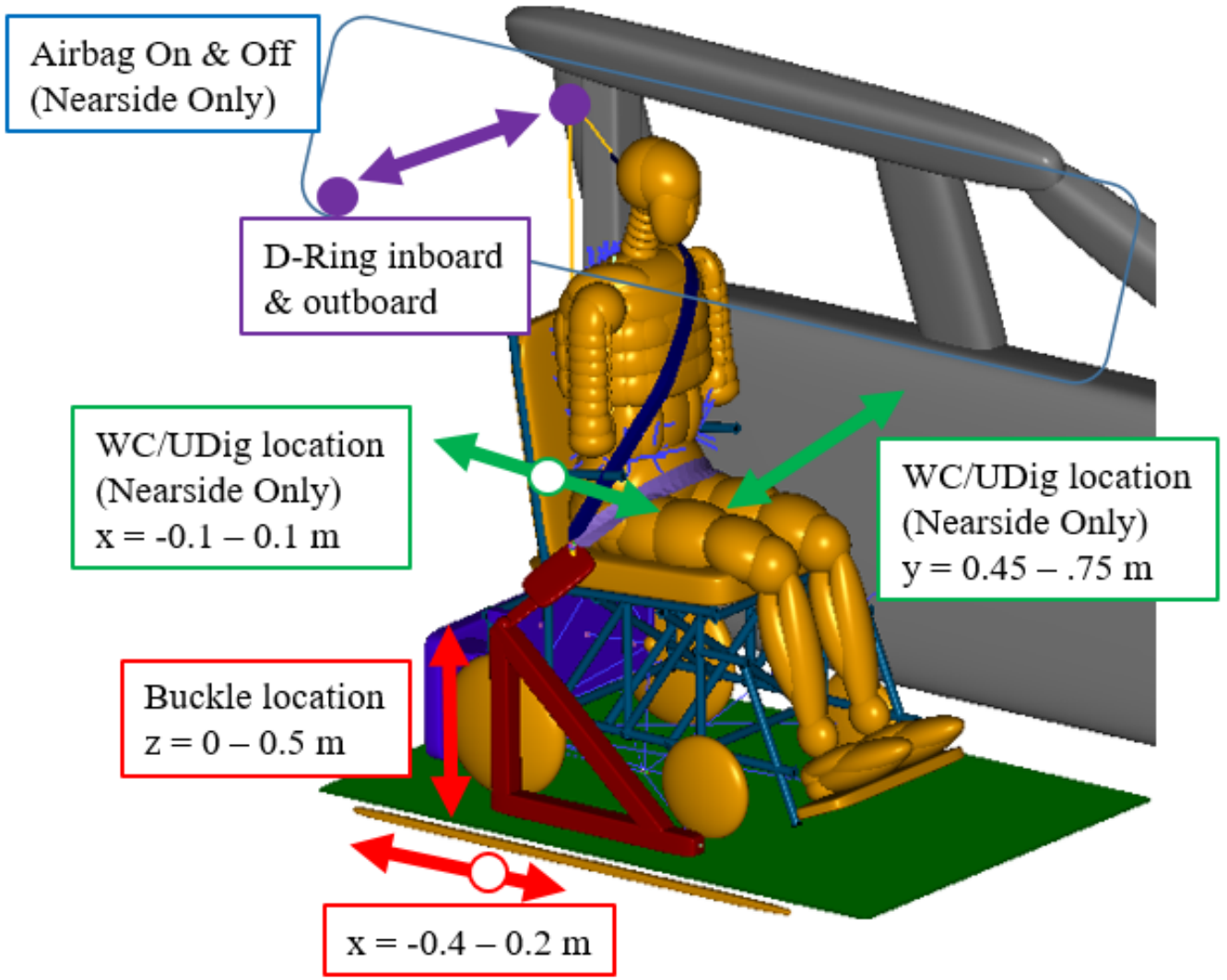
Side impact optimization



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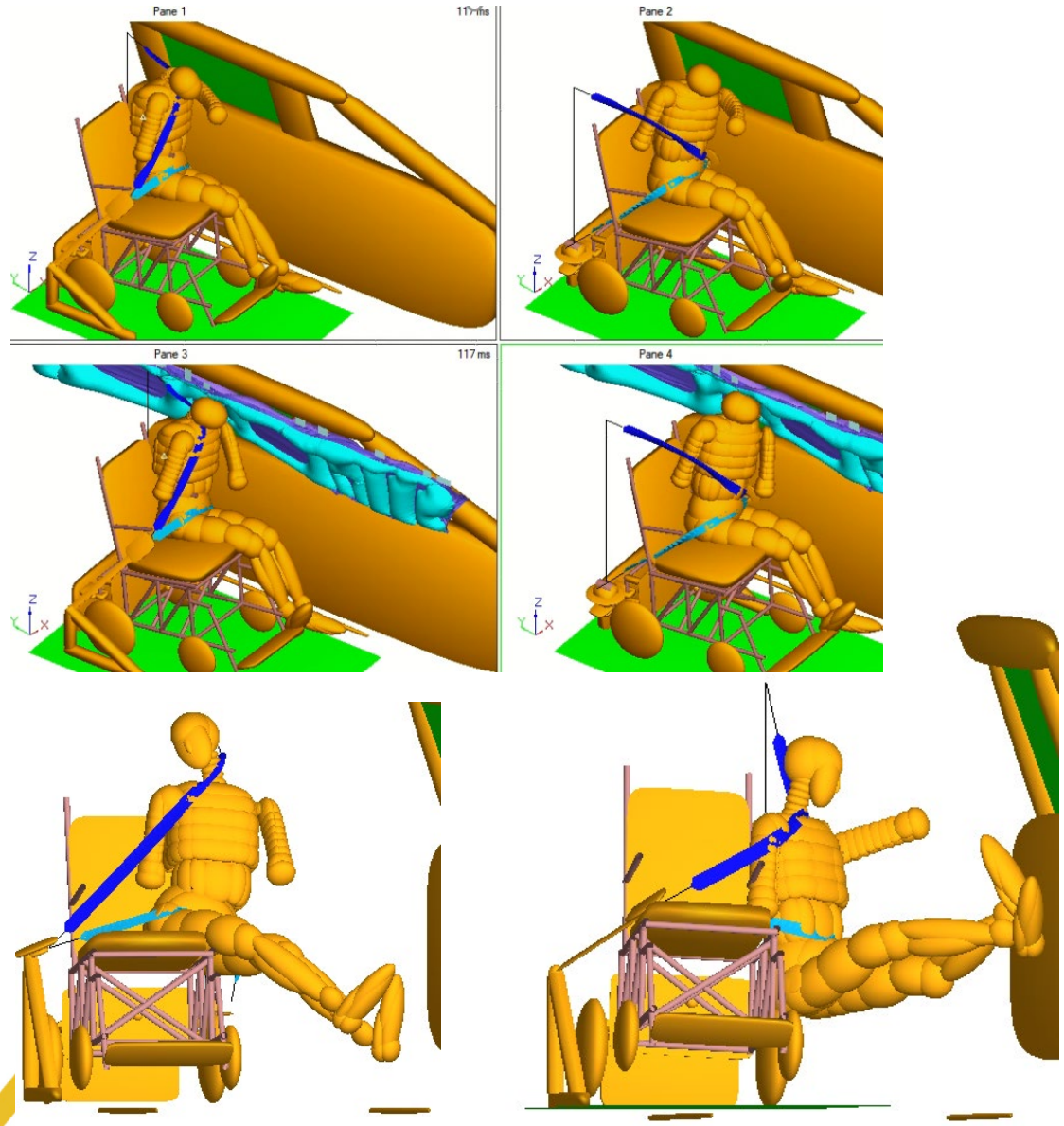
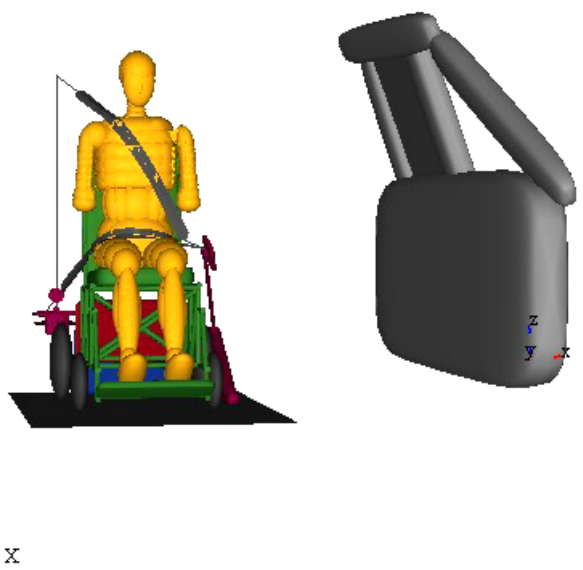
Inboard/outboard D-ring locations



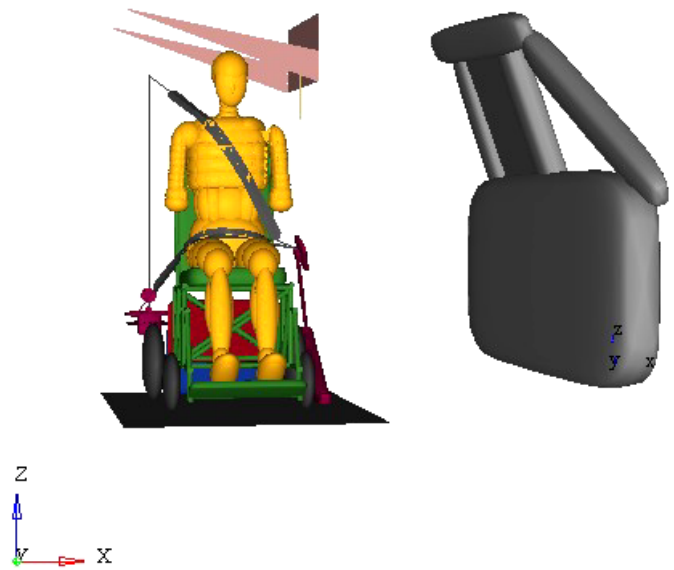
- Considered inboard D-ring location as a potential benefit for farside conditions
- Injury risk increases in nearside loading with inboard D-ring
- Inboard D-ring insufficient to keep farside occupant in wheelchair without excessive neck loads

Concept: Center Airbag To Contain Humans (CATCH)

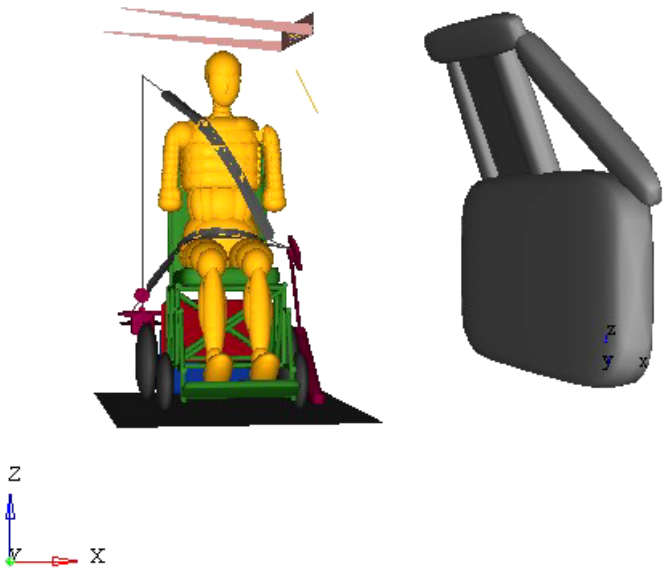
Belt Only
Time = 0.000000 : Frame 1



Roof Airbag 1
Time = 0.000000 : Frame 1



Roof Airbag 2
Time = 0.000000 : Frame 1



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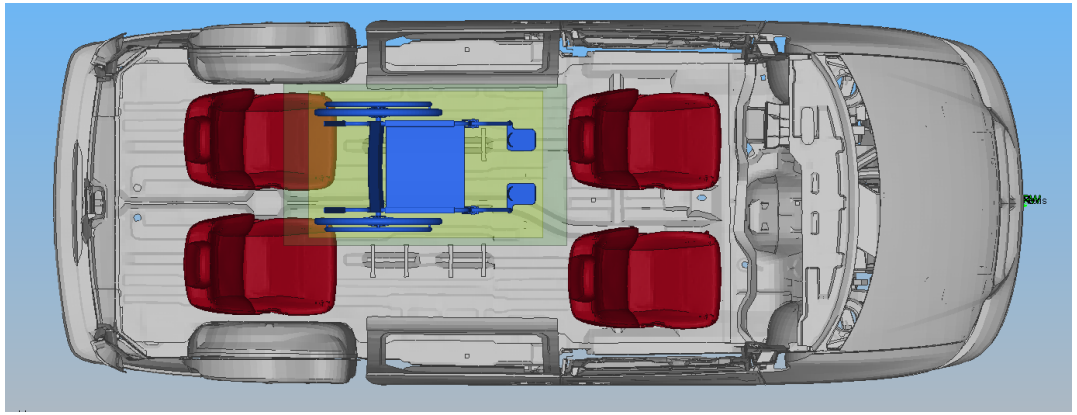
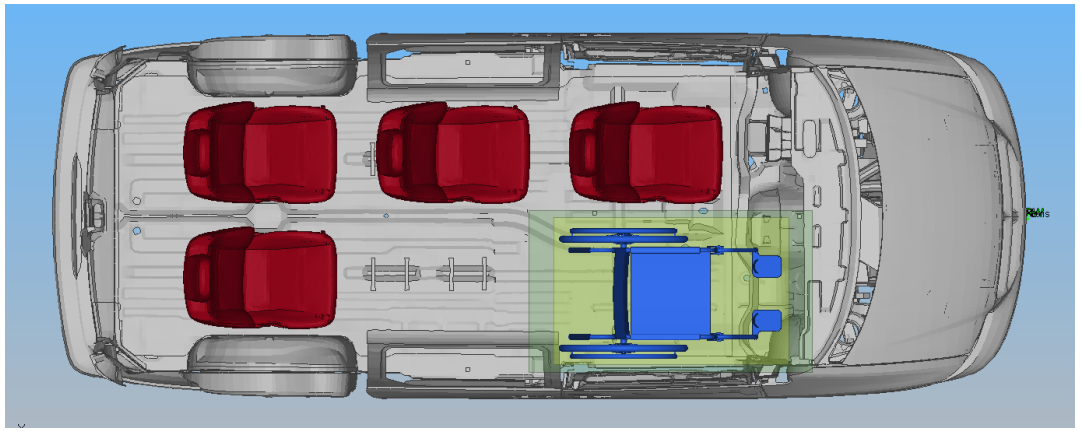
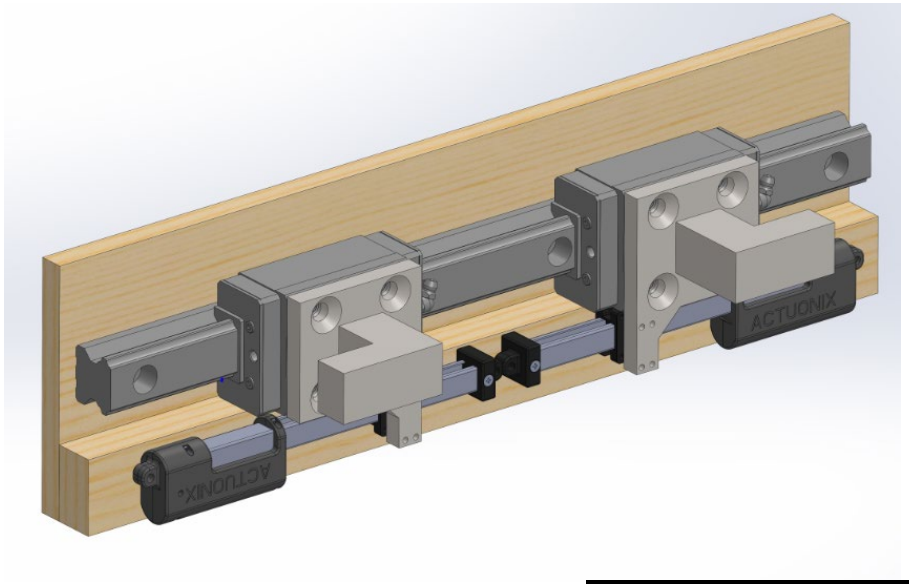
Seating Position

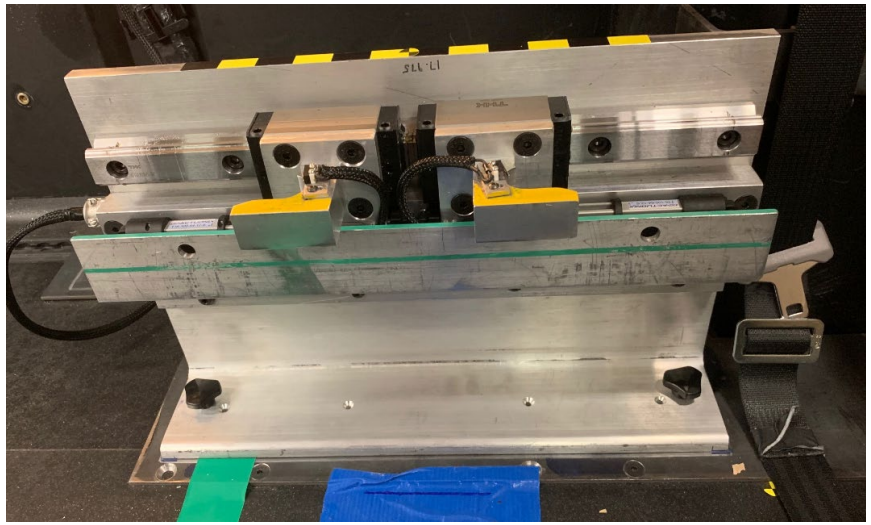
- Access through side door
- Maximize seats for other occupants
- Provide reaction surface for frontal airbags
- Adequate space to maneuver
- Include side airbag protection





UDIG Anchorages





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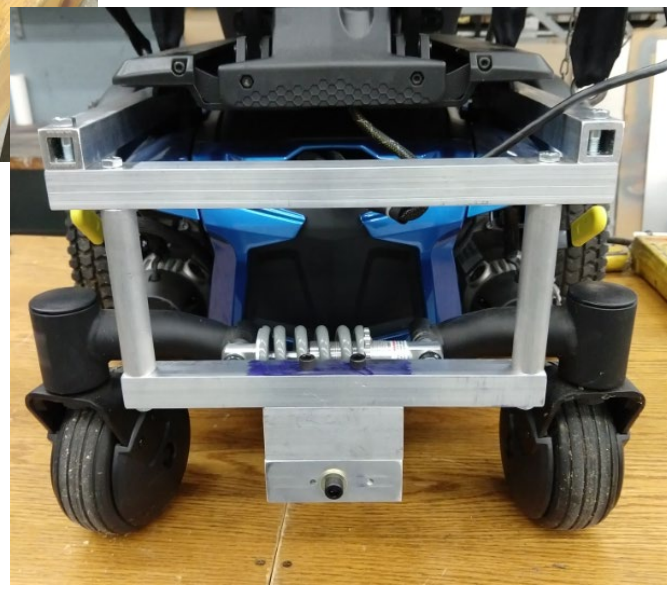
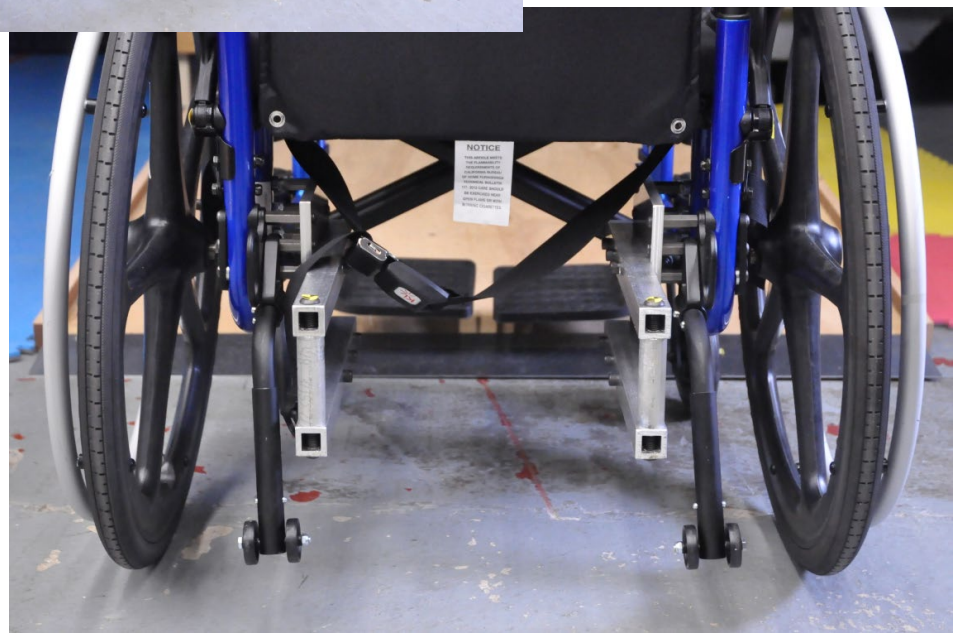
Wheelchair UDIG attachments





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Key goals of volunteer testing

- How do different seating station configurations affect accessibility?
- How do different belt geometries affect fit, comfort, and usability?
- How much variation in belt fit do we get between power and manual wheelchairs in the same condition?
- Feedback from regular wheelchair users on usability.

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Pilot testing

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Upcoming tasks

- Volunteer evaluation of usability
- Modeling of feasible belt geometries
- Sled testing belt and airbag restraint systems

We would like to thank the National Highway Traffic Safety Administration for sponsoring this project.

Thank you for your attention.

Kathleen D. Klinich kklinich@Umich.edu