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

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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.

## Current WTORS Systems

<table>
<thead>
<tr>
<th>WTORS Type</th>
<th>Independent Use</th>
<th>Protection in High g and Low g crashes</th>
<th>Any combination of wheelchair and vehicle?</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-pt strap tiedown paired with seatbelt</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Docking station paired with seatbelt</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Rear-facing stations</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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</tbody>
</table>
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.
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
Frontal model validation: surrogate wheelchair fixture
Side impact validation tests

Test conditions based on proposed 213 NPRM conditions
Side model validation

Time = 0.000000
Frontal optimization parameter ranges
Optimum lap belt anchorage zones

Second row

Front row
SCARAB airbag

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

Airbag On & Off (Nearside Only)

D-Ring inboard & outboard

WC/UDig location (Nearside Only)
\[ x = -0.1 - 0.1 \text{ m} \]

WC/UDig location (Nearside Only)
\[ y = 0.45 - 0.75 \text{ m} \]

Buckle location
\[ z = 0 - 0.5 \text{ m} \]

\[ x = -0.4 - 0.2 \text{ m} \]
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)
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
Wheelchair UDIG attachments
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.
Pilot testing
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.

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