Volunteer Evaluation of Prototype Integrated Wheelchair Seating Stations with UDIG-Compatible Docking Systems and Automated Belt Donning

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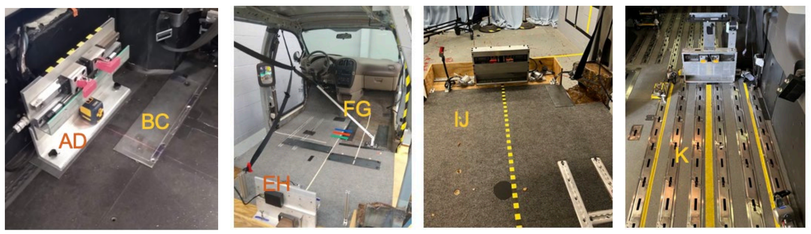
INTRODUCTION

The advent of automated vehicles (AVs) holds great promise for improving independent transportation options for people with disabilities. As vehicle manufacturers work to design integrated wheelchair seating stations, they have sought solutions that could allow people who travel in their wheelchairs to dock independently in AVs that also can provide the crash protection needed for smaller vehicles. As a result, there has been renewed interest in the Universal Docking Interface Geometry specified in current voluntary wheelchair transportation safety standards. With the UDIG concept, any wheelchair with UDIG-compatible hardware should be able to dock in any vehicle with a UDIG-compatible anchor.

Recent research projects conducted by the University of Michigan Transportation Research Institute have developed multiple versions of prototype UDIG-compatible anchors and wheelchair attachments. These systems, paired with automated belt donning systems, have been installed in a variety of wheelchair station configurations to allow assessment of their usability by volunteers. This paper summarizes key findings that can used to inform design of integrated wheelchair seating stations in automated and other vehicles.

TEST CONDITIONS

Condition	Vehicle	Station location	Station width (in)	Station length (in)	Seatbelt	Lap Belt	Donning
A	Caravan	2nd row center	30	60+ or 48	Optimal	Best feasible	A1
B	Caravan	2nd row, left	30	60+ or 54	Above Optimal	45 deg, manual	A1
C	Caravan	2nd row, left	30	60+ or 54	Below Optimal	45 deg, power	A1
D	Caravan	2nd row center	30	60+ or 48	Practical	Best feasible	A1
E	BIW	2nd row, right	34	60+	IB of Optimal	45 deg, power	A2
F	BIW	1st row, right	30	48	Forward of optimal	45 deg, power, (IB), higher OB	A2
G	BIW	1st row, right	30	48	Rearward of optimal	45 deg, manual (IB), higher OB	A2
H	BIW	2nd row, right	34	60+	OB of Optimal	45 deg, manual	A2
I	BIW	2nd, Center	34	60	Optimal	Best feasible (same as D)	A3
J	BIW	2nd, Center	34	60	Optimal		M
K	Transit	3rd, Left	30	60	Optimal	Optimal	A4



AD and BC were in a modified Dodge Caravan. For AD conditions, the anchor was located rearward and inboard of the wheel well, while BC (shown by mounting plate) placed the anchor more outboard and forward of the wheel well. Conditions E, H, I, and J simulated a second-row center position, while K was in a third-row outboard position. Conditions FG were in the front row right; the experimenter installed the UDIG anchor in place after they entered the vehicle.

MORE INFORMATION

- Travelsafer.org
- https://deepblue.lib.umich.edu/
- Umtri.umich.edu
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WHEELCHAIR ATTACHMENTS

UDIG-compatible attachments for Ki Mobility Catalyst 5, Quantum Rehab Q6 Edge 2.0, Sunrise Quickie 2, Permobil F3 Corpus, and Motion Concepts Helios.

AUTOMATED DONNING ARMS

Donning arms used in conditions A-D, I, and K

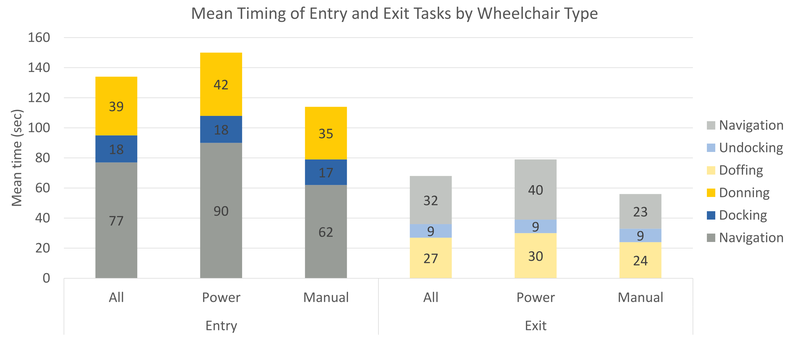
DISCUSSION

This study demonstrated the feasibility of using UDIG wheelchair securement systems in accessible minivans and vans. The volunteers successfully docked the study wheelchairs using UDIG after viewing a demonstration video. Participants tended to have faster trials when they were using the same type of wheelchair (manual/power) that they used daily. Familiarity with using a particular type of wheelchair complicated identifying how other factors, such as wheelchair station space and location and additional marking, affected ease of use. However, the number of fore-aft movements required to align the wheelchair with the UDIG anchor directly correlated to the amount of fore-aft space provided in the WC passenger area. Stations located closer to the center of the vehicle were generally easier to dock, but had poorer shoulder belt fit if the upper shoulder belt anchor was located on the vehicle C-pillar. Testing one front-row condition showed that with current vehicle dimensions, a shoulder belt upper anchor located on the B-pillar using the minimal required space for a wheelchair station of 48”x30” does not allow acceptable belt fit. Trials also demonstrated the feasibility of using an automated donning arm that may be necessary if passengers cannot don a traditional seatbelt system by themselves and a driver is not available. Participants were able to navigate around the donning hardware and seatbelts, although sometimes they caught on wheelchair components.

RESULTS

We had 33 unique volunteers across our studies, including 16 men, 16 women, and 1 not reported. The mean age was 50 years, with a range from 19 to 75. Mean stature was 164 cm, with a range from 107 to 191, while mean BMI was 28.9, with a range from 18 to 56.

Across all studies, all volunteers were able to successfully secure the study wheelchairs in every trial. Times were longer for trials in power wheelchairs compared to manual, likely because they were longer than the manual wheelchairs and more challenging to maneuver, and because more of our participants were regular manual wheelchair users and less familiar with operating a power wheelchair.



- Volunteer faced away from the vehicle during entry in 2% of ramp trials and in 88% of trials with the lift.
- In about half of trials, the volunteer moved the seatbelt out of the way while entering, or had it catch on part of the wheelchair. The seatbelt caught on part of the wheelchair while donning in 21% of trials.
- 37% of participants took 3 or more attempts to align, and 37% required realignment after the first engagement attempt.
- For exit, 27% had the belt caught on the armrest or push handle while doffing, and the seatbelt caught on the wheelchair or volunteer in 18% of trials as they navigated to exit.
- In 83% of the trials for second or third row positions, volunteers steered directly out of the station to exit without changing direction.