

EFFECT OF UNIVERSAL DOCKING INTERFACE GEOMETRY (UDIG) PLACEMENT ON WHEELCHAIR AND OCCUPANT KINEMATICS

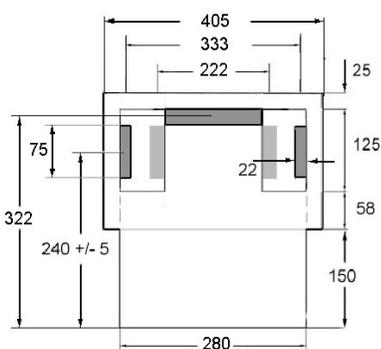
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ABSTRACT

A Universal Docking Interface Geometry (UDIG) has been under development to enable independent wheelchair securement (docking) for all WMD users traveling in motor vehicles [1]. Wheelchair and occupant kinematics during frontal (30mph/20g) and side (15mph/12g) impact were investigated for various attachment locations of the UDIG. Computer simulations were conducted with a manual wheelchair model and a 50th percentile Anthropomorphic Test Dummy (ATD). Wheelchair center of gravity (CG) and UDIG placement were systematically altered and their effect on horizontal (fore/aft), vertical and lateral displacement of the wheelchair (at the P-point) and occupant (head and knee) were measured. Simulation results show that occupant and wheelchair excursions stayed well within ISO excursion limits. Excursions were minimized when the UDIG was mounted wide and forward on a low-CG wheelchair, and when the UDIG was grasped high.

BACKGROUND

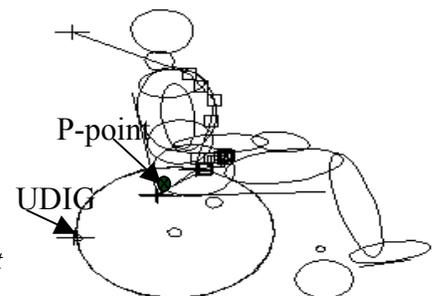
Wheelchair securement is a safety concern for individuals using WMDs when traveling in motor vehicles. WMDs include manual and power wheelchairs, scooters, and specialized seating bases (e.g. tilt-in-space seating system). Currently, the four-point strap type tie-down systems are commonly used, because they fit a wide range of WMDs. However, four point tiedowns can be difficult to use and very time consuming, especially when used in public transportation with drivers that may not be familiar with the securement system or the WMD being secured [2]. Automated docking has been proposed to enable individuals to independently secure their WMDs [3]. Docking type securement devices can be permanently mounted to the vehicle floor and engage with a compatible adapter that is attached to the rear of a WMD. The agreement on a geometry of the compatible adapter or UDIG (see figure 1) is key to the success of automated



docking [1]. The objective of this study was to determine the impact of UDIG placement on ISO-10542 requirements for wheelchair and occupant excursions [4].

Figure 1 (left): Rear view of proposed UDIG geometry and clearance zone (mm).

Figure 2(right): Simulation model of a manual wheelchair with P-point and UDIG.



RESEARCH METHOD

Computer simulations were conducted using Dynamax version 4.0 and a validated model of a standard manual wheelchair (46 lb.). A 50th percentile male Hybrid III ATD was used to represent the wheelchair occupant [5]. The occupant was restrained with a wheelchair mounted pelvic belt and a vehicle mounted shoulder belt. Figure 2 shows the wheelchair model and figure

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3 the ranges of location of the UDIG adaptor, i.e. fore/aft position, height position (w.r.t. the floor of the vehicle), and width along the centerline.

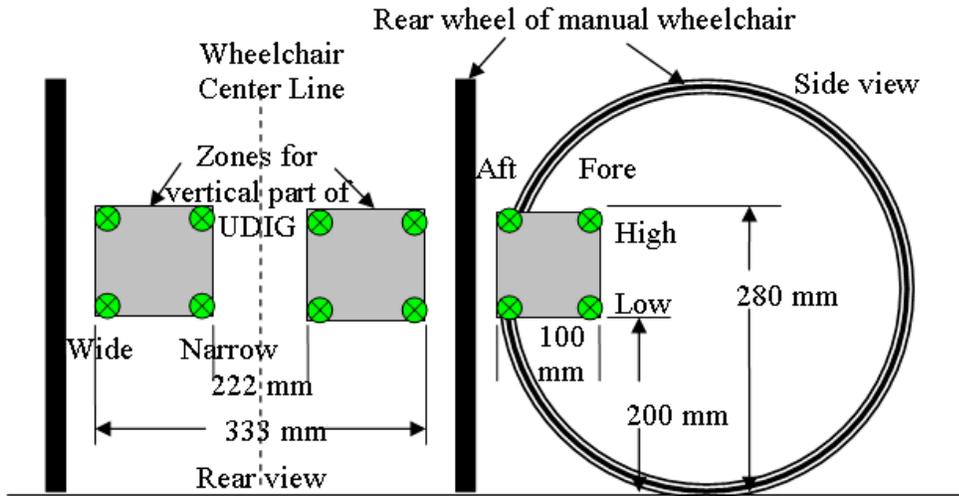


Figure 3: Diagram of UDIG placement on a manual wheelchair in fore/aft, high/low and wide/narrow position

Frontal impact was simulated using a 30mph/20g, and side impact was simulated using a 15mph/12g sled pulse [6, 7]. Since wheelchair CG can affect wheelchair and occupant kinematics, the CG was systematically altered from a 12 in. (low) to 17.5 in. (high) above the vehicle floor for the various simulation trials [8, 9]. The variables measured were horizontal (X) displacement, vertical (Z) displacement, and lateral (Y) displacement of the ATD’s head, knee and wheelchair P-point (see Figure 2). Lateral displacement of the wheelchair (@ the P-point) was measured during side impact trials only. Excursion measurements during frontal impact were recorded during forward motion only.

RESULTS

Simulation results of wheelchair and occupant forward (X-dir) and vertical (Z-dir) excursions due to frontal impact for the various UDIG locations are listed in Table 1. Table 1 also lists the excursion limits from ISO-10542 for wheelchair, head and knee for frontal impact. Simulation results of lateral (Y-dir) and vertical (Z-dir) excursions due to side impact are listed in Table 2. Excursion limits for side impact are yet not available in current wheelchair standards.

Table 1: Peak forward and vertical excursions during frontal impact (mm)

	Wheelchair CG and UDIG setup	Forward Excursion (mm)	ISO 10542 Excursion limit (mm)		Wheelchair CG and UDIG setup	Vertical Excursion (mm)	ISO 10542 Excursion limit (mm)
WC	Low CG UDIG: High, wide, fore	26 (min)	200	WC	High CG UDIG: Low, wide, aft	4 (min)	No limits available
	High CG UDIG: Low, wide, fore	32 (max)	200		High CG UDIG: High, narrow, aft	38 (max)	No limits available
Head	Low CG UDIG: High, wide, fore	475 (min)	650	Head	High CG UDIG: Low, wide, aft	8 (min)	No limits available
	High CG UDIG: Low, wide, aft	529 (max)	650		Low CG UDIG: High, narrow, aft	9 (max)	No limits available
Knee	Low CG UDIG: High, wide, aft	169 (min)	375	Knee	Low CG UDIG: High, wide, aft	86 (min)	No limits available
	High CG UDIG: Low, wide, fore	184 (max)	375		High CG UDIG: Low, wide, fore	117 (max)	No limits available

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Table 2: Peak lateral and vertical wheelchair excursions during side impact (mm)

Wheelchair excursion @ P-point	Wheelchair CG and UDIG setup	Peak Excursion (mm)	ISO excursion limits for side impact
Min. lateral excursion	High CG UDIG: High, wide, fore	20 (min)	No limits available
Max. lateral excursion	High CG UDIG: Low, narrow, aft	63 (max)	No limits available
Min. vertical excursion	High CG UDIG: Low, wide, fore	35 (min)	No limits available
Max. vertical excursion	High CG UDIG: High, wide, aft	70 (max)	No limits available

CONCLUSIONS

For all proposed UDIG adapter placements, forward wheelchair and occupant excursions remained within the ISO limits. Wheelchair and occupant kinematics stayed well within the excursion limits for frontal impact when placing the UDIG on a manual wheelchair. During frontal impact the configuration to minimize wheelchair head and knee excursions is a high, wide and forward mounted UDIG adapter for wheelchairs having a low CG. A wide mounted UDIG adapter is necessary to minimize vertical and lateral wheelchair excursions during side impact. Fore and aft UDIG adapter locations did not show large differences in wheelchair, head or knee excursions. Future research will evaluate wheelchair and occupant excursions due to UDIG placement on power wheelchairs and scooters.

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