INVESTIGATION OF MOTOR-VEHICLE CRASHES INVOLVING WHEELCHAIR-SEATED OCCUPANTS

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ABSTRACT
As part of its program to determine the extent and nature of injuries occurring to wheelchair-seated occupants of motor vehicles, the RERC on Wheelchair Transportation Safety is conducting in-depth investigations of crashes and other moving-vehicle incidents that result in the potential for injury to wheelchair occupants. Summaries of two real-world crashes are described to illustrate the value of these investigations to understanding injury scenarios that are unique to wheelchair travelers, and to assessing the performance of equipment that complies with newly developed safety standards.

BACKGROUND
One of the research priorities of the Rehabilitation Engineering and Research Center on Wheelchair Transportation Safety (RERC on WTS) being conducted as a partnership between the University of Pittsburgh and the University of Michigan Transportation Research Institute (UMTRI) is to "investigate and report on the incidence, extent, and nature of injuries to wheelchair riders" due to motor-vehicle accidents and other moving-vehicle incidents. One of the RERC tasks in this priority is to conduct in-depth investigations of moving-vehicle incidents and crashes involving wheelchair-seated occupants. This paper describes the results of two investigations that illustrate the value of these data to revealing injury scenarios that are unique to the wheelchair-seated traveler, and to assessing the crash performance of equipment that complies with recently developed voluntary standards.

METHODS
To facilitate the timely identification of crashes involving wheelchair-seated occupants, a notification network has been established, whereby manufacturers of adaptive equipment, van modifiers, transit providers, and other crash-investigation programs have been made aware of this project. If, after being notified of the program by a representative of one of these organizations, the involved wheelchair user or family member agrees to participate in the study, they are contacted for a phone interview by an UMTRI crash investigator. If a full investigation is warranted, an effort is made to inspect, measure, and photograph the damaged case vehicle, the accident site, the case wheelchair and WTORS, and the other involved vehicle, if any, to obtain relevant medical records, and to interview the occupant and/or witnesses. Vehicle crush measurements are used in available computer programs to estimate the severity of the impact based on equations of energy and momentum. The results are analyzed to determine the most likely occupant kinematics and source of injuries, and to assess the crashworthiness performance of equipment used.

EXAMPLE CASES
Case 1 – Offset-Frontal Crash of Full-Size Van with Adult Passenger in a Power Wheelchair
In this crash, the right front of a 1998 Ford Econoline van struck the box of a 1997 Chevy dump truck after the truck entered a four-way intersection from the north. Figure 1 shows the damage to the van, which was estimated to correspond to a 20-mph delta-V offset-frontal

impact. A 28-year-old male passenger was seated in a 300-lb powerbase wheelchair that was equipped with four securement points that had been crash tested as specified in Section 19 of ANSI/RESNA WC/Volume 1 (1), and secured facing forward just behind the front seats using an SAE J2249-compliant (2) four-point strap-type tiedown, as shown in Figure 2.

Figure 1 - Damage to front of Econoline van carrying a wheelchair-seated passenger.

Figure 2 - Powerbase wheelchair secured by four-point strap-type tiedown behind front van seats.

Figure 3 - Postural lap belt torn at attachment to wheelchair.

Prior to the crash, the wheelchair occupant was restrained in the wheelchair by lap and chest postural belts that were attached to the wheelchair frame using sheet-metal screws through webbing grommets. As indicated in Figure 3, the lap belt failed first due to occupant loading at the right attachment point, followed by failure of the chest belt at the left attachment point to the seatback (not shown). These failures allowed the wheelchair occupant to slide out of the wheelchair during the impact, resulting in a laceration to the back of the head from contact with the wheelchair and a fracture to the second finger of the right hand, probably from contact with the right-front passenger seat.

Although the wheelchair rider was not using an available vehicle-anchored three-point belt, this case is considered to be a transit-wheelchair/tiedown success story because the wheelchair occupant sustained only minor injuries in a moderate offset-frontal crash due to the fact that his heavy wheelchair was effectively secured by a J2249-compliant tiedown system attached to crash-tested securement points. Although the postural belts offered nearly sufficient restraint in this 20-mph frontal crash, it is likely that the wheelchair occupant would have been seriously or fatally injured if the crash had been more severe. Had the wheelchair rider been using the available three-point belt restraint, he probably would not have sustained the head laceration or fractured finger in this crash.

Case 2 – Ejection of Belt-Restrained Wheelchair-Seated Occupant in a Rollover Crash
This case involves a paratransit van that was transporting a manual-wheelchair user in the center-rear position using an SAE J2249-compliant four-point strap-type tiedown system to secure the wheelchair. The van was struck from behind by another vehicle, which caused it to swerve and rollover multiple 1/4 turns with the passenger side leading. During the rollover sequence, the wheelchair occupant was ejected through the right-rear passenger-side window, resulting in fractures to both legs, but the wheelchair was still secured in an upright position when the vehicle came to rest. The driver of the vehicle reported that she had restrained the occupant using the available SAE J2249-compliant vehicle-anchored three-point belt.

Figures 4 and 5 show the case occupant's wheelchair secured in an exemplar van with an adult occupant restrained by the three-point belt. Figure 6 shows the location of the lap-belt buckle

receptacle with end-release button relative to the wheelchair side frame and large right wheel, and shows the reason that this belt-restrained wheelchair user was ejected in a rollover crash. As the vehicle rolled to the right, the wheelchair and occupant leaned to the right, causing the buckle receptacle to move downward relative to the large wheel rim. As the vehicle completed the first 360-degree roll, the wheelchair and occupant leaned back to the left, causing the buckle receptacle to move up into contact with the large wheel rim, depressing the end-release button and releasing the buckle tongue from the buckle receptacle. Because the shoulder belt attaches to a pin-bushing connector on this restraint system, release of the lap belt buckle also released the shoulder belt, and the occupant became completely unrestrained, thereby allowing his ejection from the vehicle.

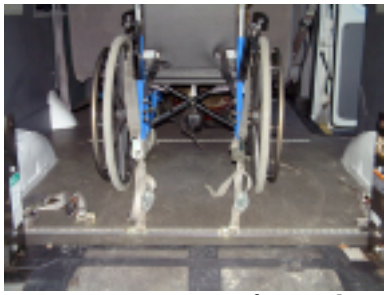

Figure 4 – Rear view of manual wheelchair secured by four-point strap tiedown at rear of van.

Figure 5 – View of three-point belt showing location of end-release button on receptacle.

Figure 6 – Closer view of buckle receptacle between large wheel and armrest.

DISCUSSION

In-depth crash investigations of motor-vehicle crashes provide accurate information on real-world injury scenarios that are unique to wheelchair-seated occupant, and can reveal problems that have not yet been addressed by existing standards and transportation procedures. This is illustrated by the two cases presented in this paper. Case 1 is primarily a success story that illustrates the value of using a crash-tested *transit* wheelchair. While this case illustrates how postural belts can provide some restraint in frontal crashes, it also points out the potential limitations of postural restraints in more severe crashes. Case 2 illustrates the problems that current wheelchair structures present to effective performance of vehicle-anchored belt restraints that comply with SAE J2249 and federal safety standards.

REFERENCES

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