RESNA's Position on Wheelchairs Used as Seats in Motor Vehicles

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Disclaimer:

The purpose of this document is to share typical clinical applications and to provide evidence from the literature supporting the use of wheelchairs designed to function as a motor vehicle seat that will assist practitioners in decision-making and justification. It is not intended to replace clinical judgment related to specific client needs.

Statement of RESNA's Position

Motor vehicle transportation, whether in private, public, or school-bus vehicles, is vital in today's society. Ready access to transportation is not only essential for most occupations and education, but also for accessing healthcare providers, religious services, recreation and leisure activities, shopping, voting, and many other community activities and services. As reported by the National Council on Disability, the need for transportation is even greater for individuals who use wheelchairs, including those who are unable to transfer out of their wheelchair when traveling (Bureau of Transportation Statistics, 2002; National Council on Disability, 2005). In situations where the wheelchair must function as a motor-vehicle seat, serious concerns arise. Transportation safety and occupant crash-protection studies have shown that a motor vehicle seat is an important part of an occupant-protection system (Digges, Morris, & Malliaris, 1993; Lovsund, Nilson, Thorngren, Haland, & Svensson, 1993; Lundell, Mellander, & Carlsson, 1981; MacLaughlin, Sullivan, & O'Connor, 1988; Severy, Blaisdell, & Kerkoff, 1976; States, 1980). For this reason, wheelchairs that are used as motor vehicle seats must also be designed for this purpose.

It is therefore RESNA's position that wheelchairs prescribed for individuals with the inability to transfer and which will serve as passenger seats in motor vehicles should: (1) demonstrate that they can be effectively secured and provide effective occupant support under the same frontal-impact conditions used to test occupant-restraint systems and seats in passenger cars, and child safety seats used by children, (2) facilitate the proper placement of vehicle-anchored belt restraints, and (3) have design features that reduce user error in securing the wheelchair by four-point, strap-type tiedowns. When seating systems from a second manufacturer are needed, the seating system (i.e., seat, back support and attachment hardware) should also demonstrate the ability to provide effective occupant support during frontal crashes and should not interfere with proper use of belt restraints.

Background

Legislative History

Though wheelchairs have been used within homes, hospitals, and long-term care settings since the late 1800's, their use outside of these environments is clearly linked to the rise of motor-

vehicle transportation in the 20th century as the primary mode of personal transportation throughout the United States. In fact, the increased prevalence of the automobile led Everest and Jennings to develop a folding-frame wheelchair that fit into the trunk of passenger vehicles (Cooper, 1998). Legislation affecting individuals with disabilities has reinforced the importance of transportation for inclusion in education, employment, and community life. In particular, accessible transportation was defined and mandated by the Rehabilitation Act of 1973, the Education for All Handicapped Children Act of 1975 (currently known as the Individuals with Disabilities Education Act, or IDEA), and by the Americans with Disabilities Act (ADA) of 1990 (US Congress, 1972, 1973, 1988, 1997). Each of these laws promotes the full inclusion of persons with disabilities in community life and collectively created changes in physical structures and social expectations throughout American communities. Today there are about 1.7 million individuals who use wheelchairs for all mobility (Kaye, Kang, & LaPlante, 2000). Accessible personal and public vehicles now enable boarding and travel when seated in wheelchairs and create new expectations for the performance of wheelchairs as part of the occupant-protection system in vehicles (Bertocci, Hobson, & Digges, 2000; Bertocci, Manary, & Ha, 2001; Schneider, 1981; Schneider, 1982; Schneider, 1997; Schneider & Manary, 2006; Schneider, Melvin, & Cooney, 1979; Shaw, 2000, 2008). Though individuals often ride standing in large transit vehicles, research has shown that individuals riding seated in wheelchairs are 45 times more likely to be injured in crash than the typical passenger (National Center for Statistics and Analysis, 2009; T. J. Songer, Fitzgerald, & Rotko, 2005).

Basic Principles of Transportation Safety and Occupant Crash Protection

Motor-vehicle crashes are the leading cause of death for Americans ages 3 through 33 (Subramanian, 2005). Research has shown that pelvic/shoulder safety belts provided by vehicle manufacturers and regulated by federal motor vehicle safety standards (FMVSS), when used properly, reduce the risk of crash-related fatalities to front-seat occupants of passenger cars (age 5 and older) by about 45% and the risk of disabling injuries by about 50% (National Center for Statistics and Analysis, 2003). Reducing the risk of death and injury in motor vehicle crashes uses a systems approach to occupant protection in which the vehicle, the vehicle seat, and the occupant restraint system (e.g., pelvic/shoulder belts, airbags) each contribute to the safety *system*. Federal Motor Vehicle Safety Standards have been established by the National Highway Traffic Safety Administration (NHTSA) to regulate each of these components for passengers and drivers who use the seats provided by the vehicle manufacturer. However, there are *no* federal safety standards that apply to wheelchairs used as seats in vehicles, or to aftermarket wheelchair tiedown and occupant restraint systems (US Department of Transportation, 1999). In fact, many functional features of wheelchairs can potentially create an unsafe vehicle seat.

In the absence of federal regulations, transportation safety experts have applied the principles of occupant protection to develop voluntary standards for wheelchair tiedown and occupant restraint systems (WTORS) and for wheelchairs designed for use as seats in motor vehicles (Schneider, Manary, Hobson, & Bertocci, 2008). Since frontal collisions account for more than 50% of all disabling and fatal injuries the wheelchair and WTORS standards require frontal-impact sled testing of WTORS and wheelchairs using a 30-mph, 20-*g* crash pulse. This crash pulse is comparable to that used in FMVSS, such as FMVSS 213 *Child Restraint Systems*. Standards also address only forward facing since facing the front of the vehicle enables the

occupant restraint system to work effectively in frontal crashes. The WTORS standard requires provision of shoulder- and pelvic-belt restraints designed to distribute crash-generated forces to the skeletal parts of the passenger. This prevents injurious contact with the vehicle interior, ejection from the vehicle, and reduces the risk of injury by the seat belt to soft regions of the body, such as the abdomen.

Evidence of Injuries and Injury Scenarios for Wheelchair-Seated Travelers

In the field of motor-vehicle safety, the need for safety standards and regulations, and guidelines for transportation policy and "best practice," are generally driven by an understanding of the real-world patterns and risks of injuries sustained by vehicle occupants in relationship to crash, vehicle, occupant, and restraint factors. Unfortunately, significant limitations in crash/injury data collection prevent reliable estimates of the patterns and risks of disabling and fatal injuries to people traveling while seated in wheelchairs. Commonly used national motor vehicle crash/injury and crash/fatality databases, such as the National Automotive Sampling System (NASS) and the Fatal Accident Reporting System (FARS), enable researchers and policy makers to estimate the magnitudes and risks of fatalities and specific injuries for the general population as functions of crash type and severity, and occupant restraint usage. The lack of adequate data collection prevents this kind of analysis for wheelchair-seated passengers. (NHTSA, 2006, 2008). Additionally, state directors of pupil transportation do not collect data on the number of students in their states who ride in wheelchairs on school buses, and there are no known databases of injuries to wheelchair-seated students on school buses.

However, there are some data that provide insight into the magnitude and nature of wheelchair-occupant injury issues and that people seated in wheelchairs are at significantly greater risk of serious injury or death in motor-vehicle crashes than are properly restrained occupants who are using the vehicle manufacturers' seats (Fitzgerald, Songer, Rotko, & Karg, 2007; Frost & Bertocci, 2007; T. Songer, Fitzgerald, & Rotko, 2004). Ten years ago, the NHTSA's National Center for Statistics and Analysis (NCSA) examined data from the Consumer Product Safety Commission's (CPSC) National Electronic Injury Surveillance System (NEISS) database, which is a representative sample of emergency department visits. The NCSA's analysis estimated that about 2,294 injuries/deaths occurred to wheelchair-seated occupant as a result of improper securement of occupied wheelchairs between 1991 and 1995, where, in most cases, proper securement implies attachment of all four tiedown straps to the structural areas on the wheelchair or seat frame. (NHTSA), 1997).

A few recent studies have focused directly on injuries to individuals who use wheelchairs as seats in motor vehicles. In one cross-sectional study, 596 wheelchair users were interviewed about their involvements in motor-vehicle crashes and injuries they may have sustained (T. Songer et al., 2004). The screening interviews for the 596 subjects were followed by more in-depth surveys of 336 participants who used their wheelchair as a seat in a public or private vehicle, or both (Songer et al., 2005). More than one-quarter of the respondents (28.7%) reported sustaining at least one injury while using motor-vehicle transportation in the previous three years. Crash involvement was reported by 14.9% of the study population at an estimated rate of 10.6 events per 100,000 miles traveled. Of 65 respondents who reported being involved in at least one crash, 55 provided further details about their crash experience. Of these, 38% reported being injured in a crash, and two-thirds of the injured occupants required medical attention.

Thus, 6% of the 336 occupants reported being injured while traveling seated in their wheelchair, which amounts to 3.6 injury events per 100,000 miles traveled. This is 45 times higher than the injury rate for the general automotive population of 0.08 injuries per 100,000 miles traveled (NHTSA, 2009)

Recent studies provide increasing evidence that a large percentage of injuries and fatalities to wheelchair-seated travelers are being caused in non-collision events, such as abrupt vehicle turning maneuvers and hard braking (Frost & Bertocci, 2007, 2009a). The evidence further indicates that these injuries are due to the lack of proper wheelchair securement that result in the wheelchair moving within the vehicle or tipping over, and/or non-use or improper use of belt restraints by wheelchair passengers that result in the wheelchair occupant coming out of the wheelchair seat, resulting in injuries from contact with the vehicle interior (Frost & Bertocci, 2009b). Most wheelchair users have limited ability to stabilize their wheelchair or their position in the wheelchair by bracing or by grabbing vehicle components with their hands during these low-*g*, non-collision events, and therefore often sustain serious or fatal injuries in events where other passengers are uninjured (Fitzgerald et al., 2007). Songer et al. (2005) reported that non-crash injuries were most frequently reported to have occurred during entering and exiting vehicles (15.8% of respondents; 43.1 events per 100,000 miles traveled). However, injuries resulting from sudden vehicle maneuvers were reported with a similar frequency by 15.7% of respondents or at a rate of 31.8 events per 100,000 miles traveled. Most non-crash injuries arose from sudden braking (50%) or sharp turning (33.3%), which resulted in the wheelchair tipping over (33%), securement failure (22%), or the occupant falling out of the wheelchair seat (15.3%). While these studies are some of the first to report on frequencies and causes of injuries sustained by wheelchair users in motor vehicle transportation, the study populations represents a convenience sample and selection bias and the ability of participants to accurately report on past events may influence the results. However, the results document the general types and characteristics of injury events that are occurring to wheelchair-seated travelers, and raise concerns about the relatively high risk of injuries to occupants seated in wheelchairs.

In another recent and ongoing study, in-depth investigations of crash and non-crash events involving wheelchair-seated occupants are being performed (Schneider, Klinich, Moore, & MacWilliams, 2010). In these investigations, interviews are conducted with the wheelchair occupant and/or vehicle driver (if other than the wheelchair occupant) and detailed inspections of the case vehicle, accident site, wheelchair, and wheelchair tiedown and occupant restraint systems, are conducted when appropriate. As of 2009, in 39 crash and non-crash evens involving 42 wheelchair-seated occupants, 34 of the 42 wheelchairs were effectively secured during the crash or non-crash event. However, only 12 of these occupants were properly restrained using a crash-tested pelvic/shoulder belt restraint. Many wheelchair-seated occupants failed to use shoulder belts or wore the belt restraints loosely or improperly positioned. Wheelchair components frequently interfere with the routing of lap/shoulder belts, or individuals assume that a postural or positioning belt will provide effective restraint in crash situations. Ten of the 42 occupants died and ten others sustained serious injuries, and many of these occurred in low-to-moderate severity crash events that would not be expected to result in serious or fatal injuries to properly restrained occupants sitting in vehicle seats.

With this background on significance of the problem in place, we will now describe how wheelchairs and seating systems that meet the requirements listed in the RESNA position

statement, in addition to applicable Food and Drug Administration requirements, are essential for the health and safety of an individual that will use his/her wheelchair as a seat in a motor vehicle.

Wheelchair Transportation Safety Standards

Wheelchair Tiedowns and Occupant Restraint Systems (WTORS)

The ideal safety practice for people who use wheelchairs is to transfer into a manufacturer-installed vehicle seat and use the vehicle's crash-tested occupant restraint system. However, the inability to transfer, the increased risk for falls during transfer, and/or the need to rely on the external support provided by specialized wheelchair seating should not prevent people who must remain seated in their wheelchairs from traveling and having equivalent transportation safety and occupant restraint in the event of a crash or sudden vehicle maneuver.

A minimal level of crash safety for wheelchair-seated passengers requires the use of an effective wheelchair securement system and a properly positioned, crash-tested pelvic and shoulder belt restraint or WTORS. The current WTORS standard in the U.S. was published in 1996 and revised in 1999. The Restraint System Task Force of the Society of Automotive Engineers (SAE) Adaptive Devices Subcommittee developed the standard, known as *SAE Recommended Practice J2249 Wheelchair Tiedowns and Occupant Restraints for Use in Motor Vehicles* (Society of Automotive Engineers, 1996).

This standard will be part of a new volume of wheelchair standards (nearing completion) that focus on wheelchair performance in transportation environments. It will be known as Section 18 of RESNA Wheelchair Standards, Volume 4, *Wheelchairs and Transportation*, and commonly called WC18. WTORS equipment that complies with this standard is dynamically strength tested to the FMVSS test pulse of 30mph/20g. The WC18 standard describes the required performance of a WTORS and allows compliance by four-point, strap-type tiedowns, docking systems and potential future systems.

Compliant WTORS are a critical part of a wheelchair transportation safety system as they anchor the wheelchair to the floor and keep passengers seated in their wheelchairs. Private vehicles use either docking systems or four point tiedowns, and public, paratransit, and school bus vehicles (where the same wheelchair station is used by many different passengers) primarily use the four-point tiedown system.

Four-point, strap-type WTORS can adapt to a wide range of wheelchair models and sizes, however, in practice they are difficult to use properly and completely (Buning, Getchell, Bertocci, & Fitzgerald, 2007; Klinich, Moore, Manary, & Schneider, 2006; National Highway Traffic Safety Administration (NHTSA), 1997; Rotko, Karg, Songer, & Fitzgerald, 2006; T. Songer et al., 2004). Difficulty arises because of factors common to wheelchairs, such as:

- Frames and wheels are not designed to withstand the high forces generated in many crash situations.
- Poor access to the structural frame, where tiedown securement points should be located, to attach tiedown hooks and straps.
- Components that interfere with the routing of belt restraints for proper placement on the body and require intrusion into the personal space of the wheelchair-seated passenger to apply.

- Varying structural designs that result in transportation personnel and caregivers being unable to select the best locations to attach tiedown straps and hooks on wheelchairs and not knowing how to successfully route occupant safety belts.

Standards for Wheelchairs Used as Seats in Motor Vehicles

In the mid 1990s, problems arising with the proper use of four-point strap-type WTORS led to development of a standard for wheelchairs designed for use as a seat in a motor vehicle. Wheelchairs that comply with *RESNA Wheelchair Standards Volume 1 Section 19: Wheelchairs Used As Seats In Motor Vehicles*, are commonly referred to as WC19-compliant. The standard was developed by a Working Group of the RESNA Wheelchair Standards Committee and finally published in May 2000 (American National Standards Institute (ANSI)/Rehabilitation Engineering and Assistive Technology Society of North America (RESNA), 2000). (This standard will also be updated in RESNA Wheelchair Standards, Volume 4, *Wheelchairs and Transportation.*)

WC19-compliant or transportation ready wheelchairs have design features that reduce user error in securing four-point, strap-type tiedowns. Under simulated crash conditions they demonstrate that they can be effectively secured and provide effective occupant support for the same frontal-impact conditions that are used to test occupant-restraint systems and seats in passenger cars, and child safety seats used by children. In addition, these wheelchairs include manufacturer instructions and are labeled so they can be readily identified.

A wheelchair that complies with the transportation standard has the following features:

- Four permanently labeled, easily accessible securement-point brackets with specific geometry that allows for one-hand attachment of one or two tiedown hooks from tiedown-strap assemblies by a driver or caregiver reaching from one side of the wheelchair,
- A base frame and seating system that, along with the four securement points, have been successfully crash tested in a 30-mph, 20-*g* frontal impact when loaded by an appropriate-size crash-test dummy with the wheelchair secured facing forward by a surrogate four-point, strap-type tiedown,
- Tiedown-strap clear paths between the securement points on the wheelchair and typical anchor points on the vehicle floor, such that tiedown straps will not be in close proximity to sharp edges that could cause failure of webbing material when loaded in a frontal crash,
- Anchor points that enable the wheelchair occupant to use a wheelchair-anchored crashworthy pelvic/lap belt to which the lower end of a vehicle-anchored shoulder belt can be readily connected near the occupant's hip,
- A manufacturer-disclosed rating of poor, acceptable, good, or excellent for the wheelchair's accommodation of properly using and positioning a vehicle-anchored belt-restraint,
- A measure of wheelchair lateral stability when secured facing forward by a four-point, strap-type tiedown,

- Reduction of sharp points and edges that could damage belt restraints or injure passengers, and
- Provision for crashworthy retention of wheelchair batteries and motors, and use of gel-cell or sealed batteries to eliminate the potential for acid spills.

In addition to the RESNA WC19 standard, a similar, but less stringent, international standard, ISO 7176 Part 19, also establishes requirements for wheelchairs used as seats in motor vehicles. A wheelchair that complies with RESNA WC19 meets all of the key requirements of ISO 7176-19 but the reverse is not true. However, a wheelchair that complies with ISO 7176-19 will be more suitable for use as a seat in a motor vehicle than a wheelchair that doesn't comply with either standard. The primary differences are that RESNA WC19 requires:

- wheelchairs to be crash tested with the crash-test dummy restrained by a three-point lap/shoulder-belt restraint that includes a commercial wheelchair-anchored lap belt, thereby providing the wheelchair user with the option of using a wheelchair-anchored pelvic-belt restraint to which a vehicle-anchored shoulder belt can be connected,
- specific closed-loop geometry for securement-points that facilities one-hand attachment of hook-type tiedown strap end fittings, and that helps retain the tiedown hook on the securement point during crash loading,
- testing of tiedown clear paths and securement-point accessibility, and
- testing to measure wheelchair lateral stability when the wheelchair is secured by a four-point, strap-type tiedown.

Standards for Wheelchair Seating Systems Used on Transportation-Ready Wheelchair Bases

One issue that has complicated wheelchair transportation safety is that many individuals who remain in their wheelchairs during travel have a level of impairment that require using second-party or after-market wheelchair seats, power seating components, back support surfaces, etc. to customize their wheelchair's fit and function. Wheelchair manufacturers, realizing that this often happens, have been reluctant to label their products suitable for occupancy during transportation in motor vehicles. The RESNA WC19 standard only tests the performance of manufacturer's mobility base with a specific seat, power seat or back support option.

A third standard, *RESNA Wheelchair Standards Volume 4 Section 20: Seating Systems for Use in Motor Vehicles*, (nearing completion) provides for the independent testing of wheelchair seating systems (seats and back support with attachment hardware) on a surrogate wheelchair base (a representative base designed for repeated 30mph/20g crash tests). Thus, a second-party seating system that complies with the WC20 standard could be used with a WC19-compliant base. As with the transportation compliant wheelchair, seating system manufacturers will be given a period of time to redesign, crash test and label their products for transportation.

Conclusion

The increased safety provided by wheelchairs designed for use as a motor vehicle seat should lead therapists, suppliers and third-party payers to recognize the value this affords consumers. Individuals with these wheelchairs are ready for travel in all modes of transportation. These improvements should prompt therapists and suppliers to make prescribing wheelchairs designed

for use a vehicle seat a priority for children traveling in school buses and for adults with a level of impairment or a progressive diagnosis that will require using a wheelchair as a vehicle seat. Compliance with voluntary transportation standards also indicates that a wheelchair is suitable for use in *all types* of accessible motor vehicles both large and small and their use provides a reasonable level of occupant protection in a motor-vehicle crash.

Using a wheelchair and seating system designed and tested for use as a motor-vehicle seat will:

- greatly facilitate the proper and effective securement of wheelchairs using four-point, strap-type tiedowns,
- provide a wheelchair that is structurally sound and able to withstand crash-level forces when secured by a four-point, strap-type tiedown or other securement method, such as automatic docking devices, for which the wheelchair has been successfully crash tested,
- provide stable seated support for the wheelchair user during crash conditions, thereby reducing the likelihood of injuries from seatbelt loading,
- facilitate the proper placement of vehicle-anchored belt restraints for wheelchairs that are rated "good" to "excellent" in seatbelt accommodation, and
- provide wheelchair-seated travelers with the option of using a wheelchair-anchored pelvic-belt restraint to which a vehicle-anchored shoulder belt can be connected to comprise a three-point belt restraint system, thereby reducing intrusion into the wheelchair users personal space by a driver or attendant, eliminating wheelchair interference with proper belt positioning, improving restraint effectiveness, and reducing the time required to provide the wheelchair user with a complete belt restraint system. (This feature is not required by the ISO 7176-19 standard)

When individuals travel seated in wheelchairs with seating components that promote proper use of WTORS, they will have a robust systems approach to their transportation safety.

Restatement of RESNA's Position

RESNA is an interdisciplinary association of people with a common interest in technology and disability. RESNA's purpose is to improve the potential of people with disabilities to achieve their goals through the use of technology. RESNA serves that purpose by promoting research, development, education, advocacy, and provision of technology, and it does this by supporting the people engaged in these activities.

Recognizing the important contribution that a wheelchair designed for use as a seat in a motor vehicle makes to health and safety, it is RESNA's position that:

- Consumers should be able to expect that rehabilitation professionals will be knowledgeable about best practices in transportation safety, will discuss and include transportation safety issues in their evaluations, and, when needed, will recommend a suitable wheelchair. In addition they will provide the justification needed to support payment for the additional cost of transportation-related features of these products.

- Manufacturers who produce products designed for individuals with significant impairments who are less likely to be able to safely transfer to a vehicle seat should be proactive in marketing products that are designed for use as a vehicle seat.
- In keeping with ethical practice, consumers should expect RESNA-credentialed professionals to inform and educate the public about the use of wheelchairs designed for use in a motor vehicle. In addition to building safety awareness, this will help to increase the demand for such wheelchairs for children and adults, and thereby increase their prevalence in the marketplace.
- Third-party payers should recognize the risk reduction and cost-saving benefits of transportation safety products. They have significant potential to reduce injuries and fatalities to wheelchair-seated occupants of motor vehicles. The moderate increase in cost for such products in worthwhile when compared to the high cost of emergency medical care, and the lifetime cost of greater disability or death. The Food and Drug Administration should incorporate compliance with wheelchair transportation standards into requirements for specific products. In particular, the Centers for Medicare & Medicaid Services (CMS) Healthcare Common Procedure Coding System (HCPCS) for most categories of pediatric and adult wheelchair products should include the design and performance requirements for wheelchairs that may be used as a motor vehicle seat.
- Transportation providers should encourage the purchase of wheelchairs designed for use as a motor vehicle seat by regular users of their services to increase driver efficiency and to reduce driver effort, errors, and injury potential. These wheelchairs will facilitate ease and proper use of WTORS, which will improve best practice and reduce overall liability.

The Benefits of Supporting the Use of Wheelchairs Designed to Function as a Motor Vehicle Seats

Recognizing the value of using and paying for wheelchair designed to function as a motor vehicle seat requires greater knowledge among many stakeholders: consumers, rehabilitation/seating clinicians, rehabilitation counselors, suppliers, manufacturers, driver educators, payers and policy makers. Creating equivalent safety for individuals who ride seated in wheelchairs extends to them the “equal protection” demanded by law, reduces human suffering and loss of life that may result from not exercising reasonable caution, and promulgates best practice supported by peer-reviewed research. It amounts to using RESNA’s leadership role to *do the right thing*. As an organization of professionals involved in rehabilitation engineering and assistive technology, RESNA is in a unique position to influence the broader recognition and use of products designed to improve safety for those who use wheelchairs as seats during transportation

Case Studies

Beth: Riding a School Bus in a Manual Wheelchair Designed for Use as a Motor Vehicle Seat With a Wheelchair-Anchored Pelvic-Belt Restraint

Beth is a 7-year old child with Spastic Quadriplegia who is transported to school each day in a lift-equipped school bus. The bus aide brings Beth in her wheelchair that meets the RESNA

WC19 standard to the first wheelchair securement station on the left side of the bus. The aide positions Beth facing forward in the center of the designated wheelchair space and engages the wheelchair brakes. She grabs the hook end fittings of the front tiedowns straps from the floor-anchored retractors and attaches them to the securement brackets on the front of Beth's wheelchair frame. She repeats the process with the rear tiedown strap assemblies by grabbing the hooks from the retractors and attaching them to the two clearly marked wheelchair securement brackets just below the back of her wheelchair seat. Once Beth's wheelchair is securely anchored to the bus floor, the aide adjusts the height of the shoulder-belt anchor point on the bus wall to a few inches above Beth's left shoulder, brings the belt over her left shoulder, and attaches the metal fitting to the pin bushing located on the right side of her wheelchair-anchored pelvic-belt restraint. The belt restraints are routed over a butterfly harness, which is part of her wheelchair seating system and helps to keep Beth sitting more upright. Beth is ready for a safe trip to school with all parts of the system safely in place.

Dan: Riding on an Urban Fixed-Route Bus in a Powered Wheelchair Designed for Use as a Motor Vehicle Seat and Equipped with a Crash-Tested Wheelchair-Anchored Pelvic-Belt Restraint

Dan is an accountant and rides an urban mass-transit bus to work each day. He sustained a C5-C6 Spinal Cord Injury in a diving accident several years ago and, as a result, is paralyzed with limited use of his arms and hands. It is therefore necessary for Dan to remain in his wheelchair when he travels in motor vehicles. Each weekday morning, the bus stops at the corner of his street, where the bus driver activates the kneeling feature to lower the bus floor and then deploys the ramp from the side door of the bus to allow Dan to safely enter the bus in his wheelchair. When the other regular bus passengers see Dan coming up the ramp, they move out of the designated wheelchair station on the left side of the bus so that the bus driver can raise the seats necessary to provide Dan with access to the station. Dan then maneuvers his powered wheelchair to face forward in the center of the wheelchair space and turns off the power to his wheelchair. Since Dan recently obtained a wheelchair that complies with the RESNA WC19 standard, the driver is able to attach the four tiedown hooks to the designated securement-point brackets on Dan's wheelchair in less than a minute. Dan's wheelchair is equipped with a crash-tested wheelchair-anchored pelvic restraint belt that his wife buckled low and snug across his pelvis before he left home. Dan asks the bus driver to attach the standard connector of the vehicle-anchored shoulder belt to the pin-bushing connector on the aisle side of his wheelchair-anchored lap belt near Dan's hip, thereby providing him with an effective three-point belt-restraint system. Dan is now confident that he will have a safe ride to work if the bus should swerve or stop suddenly, or even in the rare event that the bus is involved in a collision.

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