

Project Title: Evaluation of Wheelchairs and wheelchair tie downs, occupant restraint systems and occupant protection on transport airplanes.

Explanation: All Wheels Up is researching and crash test worthiness of wheelchair tie down systems and wheelchairs for commercial and private flight. We are proposing physical, biological, medical, psychological, mathematical, and engineering sciences for our crash test project. We will need to collaborate with aircraft designers and manufacturers, Universities, Universal Design experts, and the standard organizations to just name a few for true accessible air travel.

All Wheels Up, Inc. (AWU) was created with the intent on proving wheelchair tie downs can pass and with stand the FAA standards for safety. There are approximately 4 million Americans, 15 years and older who use a wheelchair. (Census, 2010) This excludes the approximately 100,000 children under the age of 15 who also rely on wheelchairs for mobility. Currently, there are no commercial air carriers or private aircraft that are wheelchair accessible.

Those who use Wheelchairs should be able to travel via airplane in the safety of their chair without the risk of harm to self or damage to the wheel chair while traveling. This can only be accomplished if the traveler is not transferred from his/her wheelchair to fly and the wheelchair is not stowed. In 2008, one major air carrier spent one million dollars on wheelchair repairs due to the inept way the chairs are handled by cargo handlers and in 2016 that same airline spent \$2.5 million. There is already a nationwide movement toward coordinated transportation planning, mobility management, and universal design for public transportation. AWU is looking to facilitate the same safety and ease for the wheelchair community in air carrier travel.

According to a study done by The Open Doors organization and Society for Accessible Travel and hospitality (SATH) showed the following results: (Horn, 2002)

- If incidence rate by age remains same; by 2030 nearly 24% of the total population will be disabled. With 15% severely disabled
- The severely disabled population will increase by 21 million, when compared to 1997

Through interviews from the same study the following was determined:

- Specific to Air travel – 30% of the people with disabilities had traveled by air in the past 2 years (9.4 Million in total). This amounts to 2 trips in the last 2 years.

- They will take 2 more trips if their needs are met. This translates into 18.8 million flights which would be double the current revenue in the airline industry.
- The accommodations needed to capture this potential revenue do not seem to be cost-prohibitive or unattainable.

Our study will show the demographic and potential for increased revenue to support this project. With Air carriers losing revenue, and cutting cost, this initiative could go a long way in helping the air carrier business rebound fiscally. The Aviation industry could expect long-term financial growth by not discounting those in wheelchairs.

In More recent studies done by the Muscular Dystrophy Association (MDA), 80% of the wheelchair users survey said they would prefer to remain in their own chair when flying.

AWU is working with government and non-government agencies to conduct crash tests for wheelchairs and use of wheelchair tie down and occupant restraint wheelchair systems (WTORS) in air carriers. A WTORS is a complete set of safety equipment for use by wheelchair-seated occupants of motor vehicles comprised of equipment for securing the wheelchair to the vehicle and equipment for keeping the wheelchair occupant in the wheelchair seat and limiting occupant movement during emergency vehicle maneuvers and crash events, (RESNA, 2010). In May of 2011 Q'Straint published a report that their personal wheelchair restraint systems used for in personal vehicles and buses passed as 20 G Crash Test. (Q'Straint, 30mph/20G testing: Its Not Just the Speed, But the Force that Matters, 2011) Q'Straint is a global leader in innovation. Their research demonstrated that wheelchair passengers have very unique safety needs, and led them to develop the world's first fully integrated 4-point wheelchair passenger securement system. Q'Straint was the first to introduce this innovative system to the global transportation industry (Q'Straint). Q'Straint develops the world's highest quality, most progressive wheelchair passenger safety solutions for public and private transportation. AWU approached Q'Straint regarding our initiative and Q'Straint is on board with donating the restraints for crash test purposes.

The reason the Q'Straint study is so significant is that the FAA's own standards for crash tests for aircraft seats is only 16 G (Bahrami, 2006). According to the AC25.562-1B "A single 16g

longitudinal or 14g vertical test is sufficient to substantiate the attachment between structural members with a different design philosophy or variations within the same design philosophy, provided it can be determined which test condition is critical for the attachment. (Bahrami, 2006)

AWU believes this report is clear evidence that wheelchair and the personal wheelchair restraint systems surpass the Federal Aviation Administration's 16 G parameters. Based on this test report AWU crash tested wheelchair restraints under the FAA Advisory Circulars suggested the FAA.

AWU tested according the FAA standards for in-cabin use - the same test for airplanes seats, drink carts etc.

14CFR25.561 and 562

Title 14 = Aeronautics and space

CFR = Code of federal Regulations

Part 25 = Airworthiness standards

.561 = General Aviation

.562 = emergency landing dynamic conditions

. The following was conducted and reviewed:

- Biomechanical properties and injury tolerance of the human body related to occupant injury in impact environments
- Anthropometry of children and adults, particularly as it relates to restraint systems and aircraft interior design for occupant protection and accommodation
- In-depth investigations of aircraft crashed with a focus on causes and mechanisms of injury
- Biomechanics of occupant positioning and posture in the aircraft environment
- Development of advanced Anthropomorphic Test Dummies
- Development of test methods, performance criteria, and standards for improved cash protection of disabled travelers seated in wheelchairs
- Understanding of the need for using transit safety technologies and procedures that are appropriate to the travel environment by translating research findings into reasons for changing transportation practices.
- That wheelchairs provide four easily accessible securement points (or tie down points) with very specific geometry – does the geometry change for aviation purposes?
- That the wheelchair is successfully crash tested at 30 mph when secured by a four-point strap-type tie down, and loaded with an appropriate size anthropomorphic test dummy representing the intended size and mass of wheelchair user

- What are the challenges for existing seat Track fittings and anchorages– do new anchorages need to be developed or can existing ones be used?
- What are the challenges regarding injury criteria especially the Head Injury Criterion. Specific head rests and/or special back support will need to be determined?

In addition to with working with the FAA, we are regular dialog with leaders in the industry for accessible travel such as Qstraint, UMTRI, Rehabilitation Engineering and Assistive Technology Society of North America (RESNA), and the University of Buffalo, School of Architecture and Planning Center of Inclusive Design and Environment Access. We continue to expand our working group base to make true accessible air travel a reality. These organizations would need to be involved to help create and or expand upon the standards already established for wheelchair transport and safety. Existing research and published documents already have established the standards of safety for wheelchairs and their occupants. They are: WC18, Wheelchair Tie down and Occupant Restraint Systems for Use in Motor Vehicles, WC19 Wheelchairs used as seats in motor vehicles, and WC20- Crash-tested seating systems for wheelchairs. These three documents are a culmination of over 20 years of dedicated research and tested crash test information pertaining to wheelchair safety in moving vehicles. In addition to finding the actual crash test standards you can also find on the RESNA website www.ercwts.org "A description of the Crash Testing Process at UMTRI". Many standards, methods, specifications, and engineering drawings are already in place. These documents are a great spring board for how to crash test of wheelchairs in transport planes.

Such tests already in place are the Method for frontal-impact test, Methods for testing wheelchair lateral stability, and methods for measuring geometry and adjustment of belt restraints, to just name a few. Just as the Advisory Circular is the established standard for aviation crash testing – these three documents are the same Holy Grail to the motor vehicle community pertaining to the wheelchairs and their occupants.

AWU is requesting a new category to be tested at FAA crash test facilities funded by the FAA to fully develop understand how the tests outlined in the Advisory Circular and the Impact as we work towards FAA approved Wheelchairs and Wheelchair tie downs. The tests requested by the FAA are the following:

25.562 = emergency Landing dynamic conditions

25.785 = seats, berths, safety belts, harnesses

121.311 = Seats, safety belts, and shoulder harnesses

In addition, what additional tests would need to be created for the purposes for transport planes. For example, taking the test standards from the WC18 and WC19 and creating them for aviation purposes such as the following Instrumentation used will include, but will not be limited to:

- 1) Electronic instrumentation should measure the test environment and measure and record data required for comparison of performance to pass/fail criteria
- 2) Photographic instrumentation should be used to document the overall results of tests.
- 3) Crash test sleds or Surrogate Wheelchair (SWC): rigid reusable frame and seating system supported on pneumatic ties used to evaluate the dynamic strength of production wheelchair tie downs and securement devices by simulating the inertial loads generated by typical powered wheelchairs in a simulated frontal crash test. (RESNA, 2010)
- 4) crash test facilities and towers
- 5) Anthropomorphic test Devices (ATD)
- 6) Wheelchair tie down and occupant restraint system (WTORS)
- 7) Test Wheelchair: production or surrogate wheelchair used to conduct tests specified in performance standards (RESNA, 2010)
- 8) Seat Track fittings and Restraint anchors

The AWU initiative is a very complex project. There are many key players from government Agencies, Universities, and private sector organizations that all play an integral role in this project being a success. Due to the enormity of the project we needed to break out this project into 4 parts.

Phase I – Communication: Organizing the coalition. (completed)

Phase II –Creating and Standardizing test procedures (completed)

Phase III- Actual Crash Test (Completed several Crash Tests with a surrogate wheelchair and wheelchair tie down systems) - first proof of concept study completed.

Phase IV – Data Analysis (Post-test observations, measurements and calculations and Report) -
(Pending Review and discussion)

Examine the WTORS, ATD, and the wheelchair, and analyze the test films or video to determine measure and calculate:

- a) Whether the ATD remained in the wheelchair
- b) Whether the test wheelchair remained upright on the test platform
- c) Any evidence of damage to, or failure of, structural or load-carrying components or the WTORS or wheelchair securement adaptors,
- d) Whether any securement points on a production wheelchair showed signs of failure,
- e) Whether the seat or back support of a production wheelchair broke free at any attachment points,

** These are just a few of the results that would need to observe.....

The FAA has advised the guidelines for Acceptable test procedures for crash testing wheelchairs as well as acceptable means of compliance and Pass/fail criteria. All Wheels Up has already conducted several tests and working on the initial reports. These crash test documents will be extremely lengthy and complete with technical information. The guidance provided in this document will direct airplane manufactures, modifiers, foreign regulatory authorities, Federal Aviation Administration (FAA), transport airplane type certification engineers, and FAA designees. However, what we can tell you from the initial crash tests is the L-track system does not pull away from the airplane floor at 16G with a wheelchair tie down system at 16G. The Surrogate wheelchair does not tip over at 16G. The WTORS did not break or come up from the L-track. Nor did the wheelchair become a projectile. Based on these points providing a wheelchair spot on planes is feasible. While more testing is needed and we are working securing funding to proceed with additional testing wheelchair restraint systems do initially pass a crash test. It is our job to create a safer and more user-friendly model for air carriers to agree to installing such a system.

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