Presentation to the Committee for a Study of the Feasibility of Wheelchair Restraint Systems in Passenger Aircraft

Introduction

- ***All Wheels Up***
  - Michele Erwin
- ***Calspan***
  - Mike Kulig
  - Jonathon Gondek
- ***Q'Straint***
  - Oli Davalos
- ***Quantum***
  - Brad Meier

Michele Erwin

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Who Is ***All Wheels Up?***

- AWU is a 501(c)(3) not-for-profit organization
- AWU is the ***only*** organization in the world crash-testing wheelchair restraints for in-cabin use
- Twitter: @allwheelsup
- FaceBook: All Wheels Up
- Website: www.allwheelsup.org

AWU Accomplishments

- Most successful petition for wheelchair (WC) spot globally
- Conducted first crash test of WC restraints
- Secured partnerships and nondisclosure agreements (NDAs) with major stakeholders
- Hosted two working groups with major stakeholders
- Conducted first tests of wheelchairs as airplane seats

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AWU Mission and Goal

Mission	Goal
▶ Through research and advocacy, we work to increase awareness and ultimately the feasibility of a wheelchair spot on airplanes	▶ Create a wheelchair spot on planes

AWU Key Areas of Focus

- Crash testing wheelchair tie-down systems for commercial flights at contracted Federal Aviation Administration (FAA)-approved facility
- University research for supporting data
- Data collection (surveys)
- Using AWU research to benefit evacuations during disaster situations
- Urban Elevate
- Funding research that will bring a wheelchair spot to the public

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The First Wheelchair-Accessible Plane: “Sacred Cow,” 1943

- President Roosevelt flew in the first-ever wheelchair-accessible plane
- “The most powerful man in the world being carried like a baby …” —Winston Churchill

Wheelchairs Tied Down On Military Exercises

Image source: Gordon Ratry.

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Wheelchair Tie-Downs

- In 2011, Q'Straint wheelchair tie-down occupant restraint system passed a 20G sled crash test
- This ***surpassed*** the 16G sled test of airplane seats that the FAA has set as the industry standard

Image source: accessed on February 2, 2020, from https://www.qstraint.com/securement-101/

Initial Proposed Solution

Source: retrieved on January 27, 2020, from https://youtu.be/mGQmrXEo9Rc

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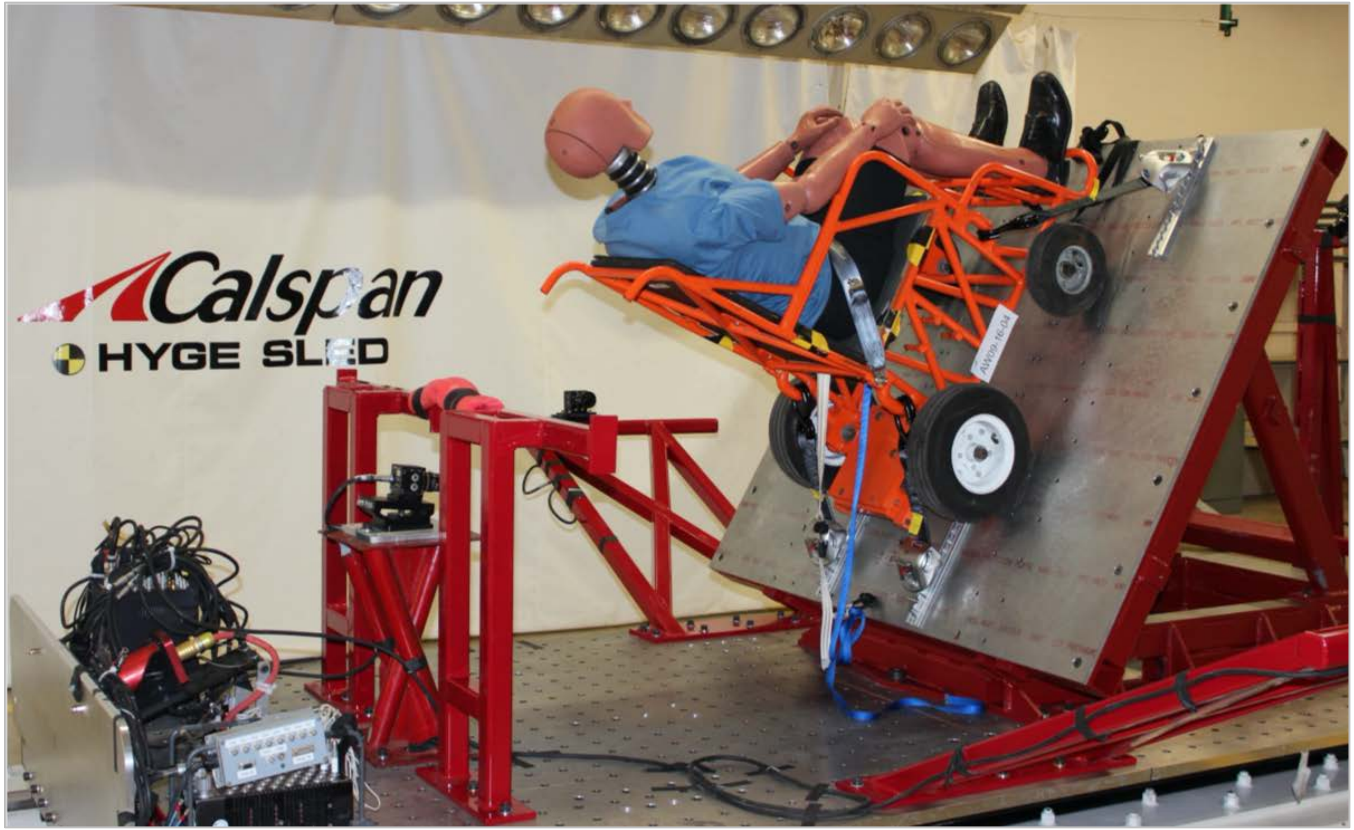
2016 - AWU Makes History: 14 CFR 25.562



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Aerospace Testing Standards

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

- **14 CFR 25.561 and 14 CFR 25.561.562**
  - Title 14: aeronautics and space
  - CFR: Code of Federal Regulations
  - Part 25: airworthiness standards
  - .561: general aviation
  - .562: emergency landing dynamic conditions

FAA/DOT's Test Criteria

- Will the wheelchair fly out of the plane?
  - AWU results = **NO**
- Will the wheelchair fall over on its side?
  - AWU results = **NO**
- Will the tie-downs rip away from the floor?
  - AWU results = **NO**
- Will the straps tear during crash test?
  - AWU results = **NO**

What Was Tested

- Wheelchair Tiedown and Occupant Restraint Systems (WTORS) – QRT-360
- A surrogate wheelchair
- "L" track
  - Airplane floors have the same "L" track as accessible vans and buses

16G Pulse Test

Airplane seat crash test—16G	All Wheels Up crash test—16G

Proposed Solution after Working with Stakeholders

Source: retrieved on January 27, 2020, from https://youtu.be/mGQmrXEo9Rc

2019 Benchmarking for a WC Spot on Airplanes

- QLK—150
- QRT—360
- Power wheelchairs (PWC)

14 CFR 25.562 with QLK-150 and Wheelchair

14 CFR 25.562 with QLK-150 and Wheelchair Test Video

Mike Kulig
Jonathon Gondek

Initial Testing of Wheelchair and Restraints—1

- Initial testing began in September of 2016
- There are no test standards for a wheelchair on an aircraft

Initial Testing of Wheelchair and Restraints—2

- Calspan ran tests on the surrogate wheelchair and two restraint systems to standards that are required for aircraft seats
  - 14 CFR 23.562 (private/small planes)
  - 14 CFR 25.562 (commercial planes)

- Each test standard requires two tests
  1. 14G: 60° pitch (down) test
  2. 16G: 10° yaw test

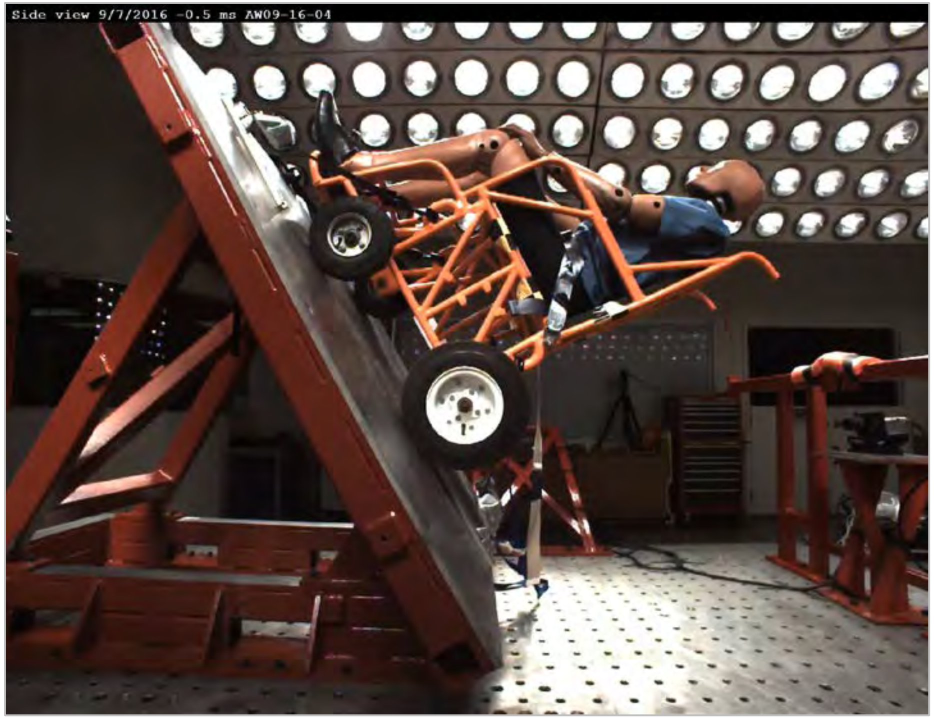
- Goal: to get an understanding how current restraint systems would perform to such test methods

- Calspan performed a total of six tests on the surrogate wheelchair with Q'Straint restraint systems (two models)

Initial Testing of Wheelchair and Restraints—3

	10° yaw test	60° pitch test
Pretest		
Posttest		

Initial Testing of Wheelchair and Restraints—4



Second Round of Wheelchair and Restraint Testing: January, 2019

- Using actual wheelchair models (not rigidized) with actual restraint systems
- Same dynamic test methods were performed as would be required for an aircraft seat
  - 14 CFR 23.562
    - Private/small planes
  - 14 CFR 25.562
    - Commercial planes

Second Round

- Goal: see how actual wheelchairs and restraint systems would perform together under these test standards
- Calspan performed a total of five tests over three different wheelchair models using Q'Straint restraint systems

Second Round

	10° yaw test	60° pitch test
Pretest		
Posttest		

Second Round

Oli Davalos

Q'STRAINT®

THINKING **BEYOND** SAFETY

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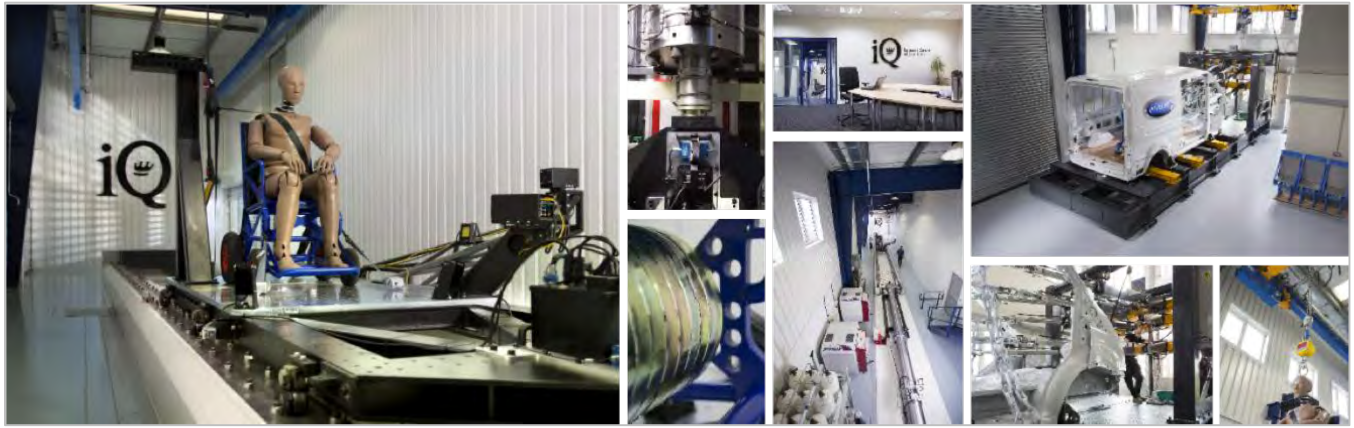
Who We Are

- Our mission: making safety accessible—we believe all mobility passengers deserve access to the same level of safety as those around them
  - Through research and development, engineering and support, to providing innovative solutions, we are making safety accessible

iQ Research Center of Excellence Launched in 2014

- Our research and development facility has its sole focus on mobility passenger safety; certified by several major testing authorities worldwide
  - Full static testing center and dynamic crash simulator
  - State-of-the-art HYGE system is accompanied with an equivalent list of technologies—phantom cameras, DTS data acquisition, and Humanetics crash test dummies



Q'Straint Markets

TRANSIT	PARA-TRANSIT	PUPIL	MOBILITY
City Bus	Community Transport	School Bus	Mini Van
Coach Bus			Taxi
Rail			

WC-18/WC-19 Overview: ANSI and RESNA Work to Publish Standards for Stronger, Safer, Transport Ready Wheelchairs

ANSI American National Standards Institute

RESNA

2000

WC-19
- Voluntary Standard for WC Manufacturers
- Regulates the design and crash testing of wheelchairs to be used in vehicles
- Main Provision: 4 Crash Tested Securement Points

2010

Slow Acceptance
- Challenges: added expense in wheelchair design, engineering and testing
- Added operational cost
- Added need for awareness and training

2011

Gaining Momentum
- Efforts by ANSI/RESNA
- Attention from Lawsuits
- US Dep. Veteran Affairs only funding WC-19 Chairs

2012

WC-19 Revised
- Wheelchairs require integrated lap belt that is crash tested, attached to chair, and adaptable with shoulder belt

2015

WC-18 Revised
- Tie-Downs must now secure wheelchairs with an integrated lap belt
- Increase in loads on tie-downs by 60%

Innovation to Meet Transportation Needs

QRT-360

The first automatic retractor built to meet WC18 requirements.

Benefits:

- Compatible with all mobility device types
- RESNA WC-4 & WC-18

Challenges:

- Footprint
- Not Autonomous

QLK-150

The most advanced docking system.

Benefits:

- Adaptable to most WCs
- RESNA WC-4
- Autonomous

Challenges:

- Requires mating bracket
- Passenger restraint is not autonomous

QUANTUM

The first fully independent securement system

Benefits:

- Compatible with all mobility device types
- RESNA WC-4
- Autonomous

Challenges:

- Station is rear facing
- Relatively expensive for private transportation
- 30 lb.

QRT-360 and QLK-150 systems tested to FAA Standards (14CFR25.561 and 14CFR25.562)

Autonomous Vehicles, an Accessibility Game Changer

- Closely monitored by:
  - Government transit authorities (VA, hospitals)
  - Retirement communities, university campuses, airport shuttles, private transit
  - Ride share (Uber)
- Q’straint
  - Working with OEMs to help ensure that new design paradigms include accessible vehicle necessities

Different Industries, Different Stakeholders, Different Needs, Common Goal: ***Accessibility***

Transit, Paratransit, Pupil, Personal Mobility

Autonomous

Commercial Flight

- Challenges to overcome:
  - Thousands of different mobility device designs
  - Absence of safety testing standards
  - Industry specific space and weight requirements
  - Urgent need for training and awareness
  - Evidence shows that socio-demographic factors are impacting transportation industries

Brad Meier

QUANTUM®

Power Wheelchair

- Four Q6 Edge 2.0 units with TruBalance 3 seating
- Each unit had tilt, recline, lift, articulating foot platform (AFP)
- These units are fully adjustable to meet a patient's needs

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Q6 Edge 2.0 Specs

- Base length: 35.5” without riggings
- Base width: 24.4”
- Turning radius: 20.5”
- Drive tires: 14”
- Caster tires: 6”

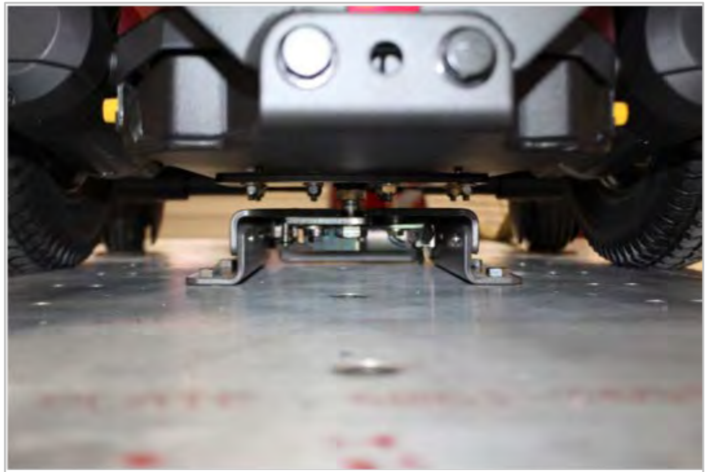
- Batteries: two 22NF
- Total system weight with seating system is approximately 432 pounds
- Ground clearance: 2.7”

System Specs Based on 18"Wx20" Seating System

- Approximate:
  - Overall width 25.5" arm to arm
  - Overall length 42.5" AFP to rear caster wheel
  - Overall weight 432 pounds
  - Overall height 52"
  - Overall length when reclined 67" from headrest to AFP
  - Length when tilted from center of drive wheel to headrest 28.5"

Securement Systems—1

- Two tests were run with the QLK-150 docking station
- The entire system secured by one 11/16 docking bolt



Securement Systems—2

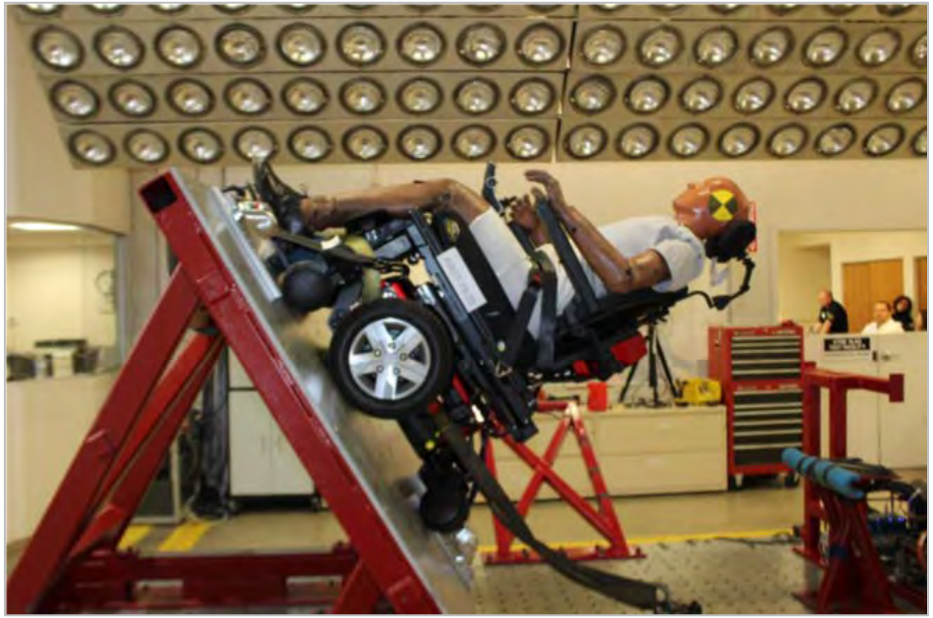
- Two tests were run with the Q'Straint's tie-down system
- Six- and four-point systems were used
- The tie-downs for this system are installed during production

Rear tie down

Front tie down

Four-Point Securement System

Front tie-downs in a simulated crash setting

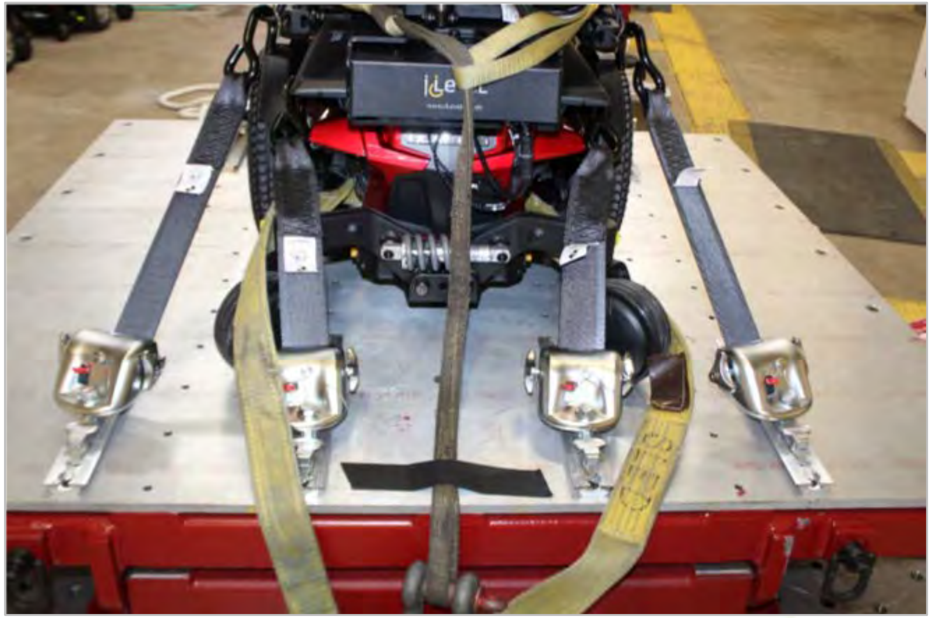


Rear tie-downs in a simulated crash setting

Six-Point Securement System

Front tie-downs in simulated taxiing setting

Rear tie-downs in simulated taxiing setting

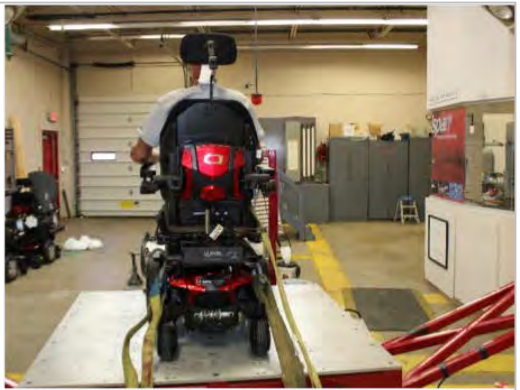


Test 1: Taxiing on a Runway

- The first test was conducted with QLK-150 docking station
- The base performed well and could still be driven or pushed
- No objects of significant mass were detached from the unit
- The rear of the seating became detached from the base due to damage to the rear brackets, but the front bracket held—which kept the entire seating system on the base

Test 1: Taxiing on a Runway images

Pretest



Posttest

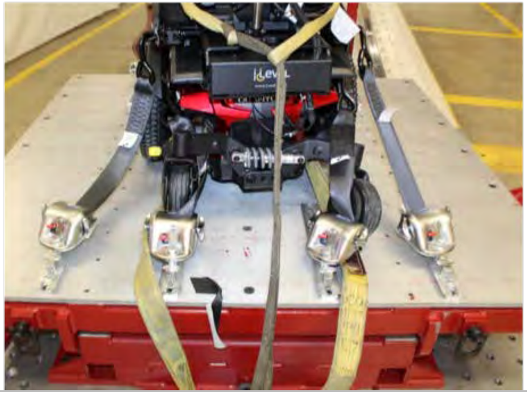
Test 2: Taxiing on a Runway

- The second test was conducted with six-point tie-down system
  - The base performed well and could still be driven or pushed
- No objects of significant mass were detached from the unit
- Due to a six-point tie-down system force of the test was distributed better
  - The additional two points on the seating system aided in keeping the seating system in place
  - The system remained intact
- Recline actuator was damaged but back still anchored in place
- Excursion of the test dummy and damage to the back may have been mitigated by addition of a three-point shoulder harness

Test 2: Taxiing on a Runway images

Pretest

Posttest



Test 3: Simulated Crash Landing

- The third test was conducted with QLK-150 docking station with the entire system at angle to mimic a crash landing
- The base performed well and could still be driven or pushed
- No objects of significant mass were detached from the unit
- Being at angle reduced the amount of front caster articulation, which caused the unit not to pitch forward
- The system remained intact

Test 3: Simulated Crash Landing images

Pretest

Posttest

Test 4: Simulated Crash Landing—1

- The fourth test was conducted with a four-point tie-down system with the entire system at angle to mimic a crash landing
- The base performed well and could still be driven or pushed
- No objects of significant mass were detached from the unit
- Being at angle reduced the amount of front caster articulation, which caused the unit not to pitch forward
- Due to a four-point tie-down system force of the test was distributed better

Test 4: Simulated Crash Landing—2

- The base of the seating system was secured to the L brackets with the tie-downs
- The system remained intact
- Excursion of the test dummy and damage to the back may have been mitigated by the addition of a three-point shoulder harness

Test 4: Simulated Crash Landing—3

Conclusions

- The four- and six-point tie-down systems worked best with our PWC systems

- The addition of a three-point shoulder harness may help mitigate test dummy excursion and will help secure the PWC system

Michele Erwin, Moving Forward

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Additional Research and Development Is Needed

- Roadmap will be created by National Institute for Aviation Research (NIAR)

- Determine standards for:
  - Wheelchair Securement Systems
  - Wheelchairs

- Additional Benchmarking
  - Additional market securement systems
  - Manual wheelchairs

- Development of commercial aviation wheelchair securement systems and Wheelchairs

- Testing for FAA approval
  - Developed Wheelchair Securement systems and Wheelchairs
  - Batteries (batteries have been tested for transit flight)
  - Structure of the airplane floor
  - Flammability

Questions?

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www.AllWheelsUp.org

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References

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