



## Project P3

Improved Design and Performance of Vehicle Restraint Systems for Frontal and Rear Impact Protection of Wheelchair-Seated Drivers and Passengers in Vans and Minivans

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**Investigators:** N Ritchie, M Manary, N Madura

**Students:** I de Jongh, S Elahi

**Collaborators:** Amy Lane (driver trainer), Jong Bae Kim (consumer)

**Duration:** 5 years, 1 year of research, 4 years of development



## Background/Need

- Wheelchair-seated drivers typically must use:
  - docking-type securement
  - passive belt restraints (often modifications of OEM systems)
- There is anecdotal evidence that wheelchair structures often interfere with proper positioning and fit of belt restraints



## Background/Need

- Wheelchair-seated drivers typically must use:
  - docking-type securement
  - passive belt restraints (often modifications of OEM systems)
- There is anecdotal evidence that wheelchair structures often interfere with proper positioning and fit of belt restraints
- Modifications to steering wheel and other controls often:
  - result in removal/disconnection of frontal-impact airbags
  - present driver with increased hazards from interaction with controls
- Back and head support for rear-impact protection must not interfere with entry into driver space and are usually non-existent



## P3 Objectives

- Understand/quantify the problems of providing effective occupant restraint for wheelchair-seated drivers.
- Improve wheelchair/armrest designs to remove interference with passive seatbelt fit when driver moves into space.
- Improve designs of occupant (belt) restraints.
- Develop/evaluate deployable back and head support systems.





## Organization

**Task P3.1** - Investigation of WTORS availability and usage in personal vehicles

**Task P3.2** - Development and demonstration of WTORS and wheelchair solutions for improved wheelchair driver protection in front and rear impacts:

- Part 1 - frontal impacts - Years 2 and 3
- Part 2 - rear impacts - Years 4 and 5



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## P3.1 - Objective

- Determine and document the issues and problems of effective seatbelt use for wheelchair-seated drivers and RF passengers in vans and minivans



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## P3.1- Methods

- Subjects
  - 25+ wheelchair users who travel seated in their wheelchair in the front row of their personal vehicle
  - at least 20 drivers
  - male or female
  - > 18 years old



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## P3.1- Methods

- Test Protocol
  - Digital videos of subject entering/exiting vehicle and moving in/out of securement/restraint system
  - Digital photos of subject in vehicle ready for travel
  - Measurements (manual and 3D coordinates) of subject in vehicle ready for travel:
    - Seatbelt/occupant/wheelchair physical relationships
    - Distances to vehicle interior/controls
  - Interview of subject



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## P3.1- Methods

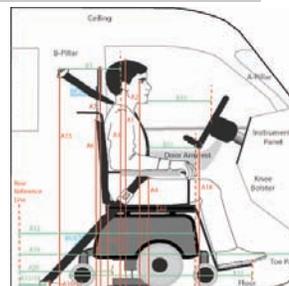
- Data collection:
  - Video recordings:
    - ingress/egress from vehicle
    - moving to/from wheelchair station
    - donning and doffing occupant restraint
  - Interview protocol:
    - experience using equipment
    - sense of safety, usability, and independence
  - Measurement protocol and digital images:
    - quantify and illustrate seatbelt fit and interference issues
    - Document vehicle interior and safety system positioning



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## Methods

- Manual measurements
- Digital (3D) measurements
  - FARO Arm (UMTRI only)



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## Methods

- Measurements taken in unoccupied vehicle



- Measurements taken in occupied vehicle



- Measurements taken of wheelchair outside vehicle



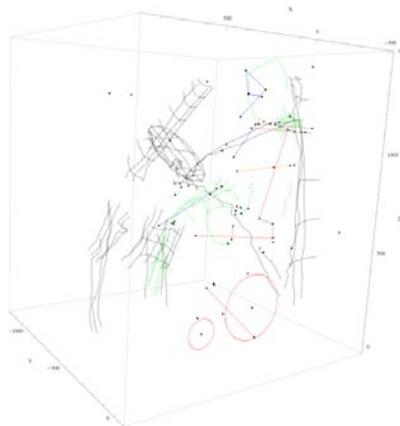
- Measurements taken of subject outside vehicle



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## FARO Output

- Able to recreate driver space in vehicle with 3D plots



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## Progress

- Test/measurement protocol and interview questionnaire developed
- Approval by PITT and UMTRI IRBs
- 10+ subjects have been tested
  - 3 passengers
  - 7 drivers
- Preliminary results compiled
- Draft problem overview - flowchart
- Preliminary brainstorm session



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## Progress

- Problem focus

Functions	Maneuver into vehicle and driver station	Secure wheelchair	Don/doff occupant restraint	Unsecure wheelchair	Exit vehicle
Interaction Vehicle	Limited space	Location	Mounting Location	Manual release	Limited space
Wheelchair	Size and maneuverability	Design Structure	Design Structure	Interference	Size and maneuverability
Person	Skill	Vision Accuracy	Reach Dexterity	Reach Vision	Skill



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## Favorites

- \* Toyota Sienna
- \* Chevrolet Ventura
- \* Dodge Grand Caravan
- \* Ford Econoline

EZ-Lock (drivers)  
4-point tiedown (passengers)

Sliding or folding ramps  
Kneeling function and 10" drop



## User Characteristics

- Variety of abilities, postures and postural needs



## Variation in Head and Back Supports



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## Passenger WC-Securement

Misuse of 4-point tiedown systems



3 points only



Misplaced floor track

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## Passenger Restraints



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## Driver Observations



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## Driver Observations

Use of shoulder  
belt portion only



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## Driver Observations

Tight shoulder belt  
Loose pelvic belt  
"Sown" together



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## Preliminary Findings

- Parts of the wheelchair interfere with occupant restraint fit
- Occupant restraint setup and belt-fit
- Seatbelt buckles are difficult to reach and use
- Misuse of seat belts and tie-down systems
- Drivers are often restricted in the driver's area (controls and limited space)
- Securing wheelchair in docking system often requires multiple attempts
- Perception of personal safety level is often inaccurate



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## Additional User Input

- I lose my balance during turns
- I need more support than the shoulder belt
- The shoulder belt doesn't keep me upright
- I have difficulty "driving into" the belt system



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## User Input

- Emergency Egress
  - I can't unhook my docking system when the power fails
  - When power fails I use my cell-phone to call for help
  - I would be stuck without power
  - I can't open the window
- Secondary controls
  - I need a third hand to activate the radio or wipers.
  - Both my hands are always occupied with the steering and gas/brake control
  - Voice control is too slow



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## Completed Outputs

- ADED May '07 newsletter (LvR/LWS)
- ADED 2007 general session (LvR)
- ADED 2007 workshop (LWS)
- Student poster presentation
  - PITT Int'l week, Sep '07 (IdJ)
- ISS 2008 paper presentation (LvR)



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## Planned Outputs

- RESNA conference paper/presentation
- Journal articles on study methods and results
- Collaboration with van modifiers/driver trainers
- Design requirements for passive belt restraints
- Prototypes of new hardware concepts for WC, WTORS, and vehicle features
- WTORS standards related to rear-impact protection features



## Plans for Year 2

- Task P3.1:
  - Recruit additional subjects
  - Compile/analyze results of subject testing
  - Interpret results using computer simulations
  - Identify & design countermeasures
- Task P3.2 Part 1: Frontal Crash Protection
  - Develop design concepts for improved passive seatbelt designs
  - Develop design improvements for wheelchairs to enhance passive seatbelt fit
  - Work with wheelchair and WTORS manufacturers and van modifiers to implement new design approaches
  - Use selection of subjects to evaluate new designs



## Questions/Discussion

- Does anyone have knowledge of innovative modifications to wheelchairs, passive/active occupant restraints, or head/back supports that have the potential to improve crash protection for wheelchair-seated drivers?
- Does function follow safety?



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## Questions about this presentation?

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