

# NHTSA Research on Occupant Restraint for Wheelchair Seated Drivers

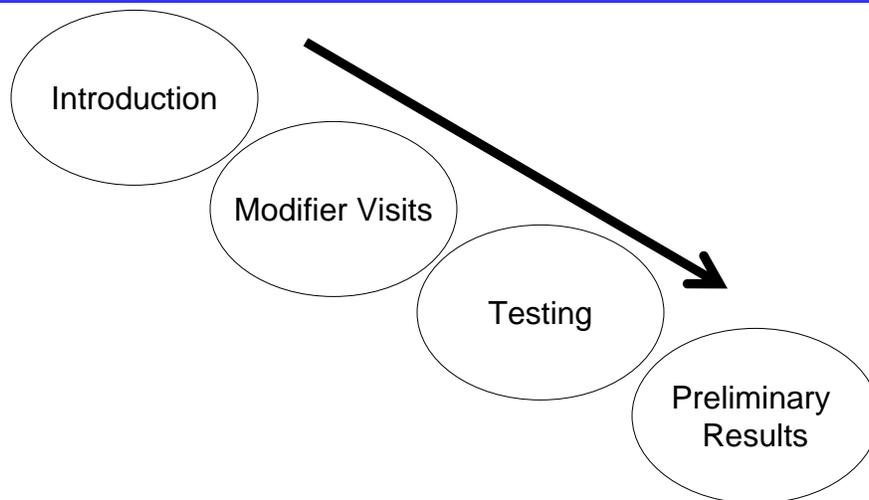
Michael L. Sword  
Transportation Research Center, Inc.

SAE Government/Industry Meeting  
16 May 2007  
Session G8

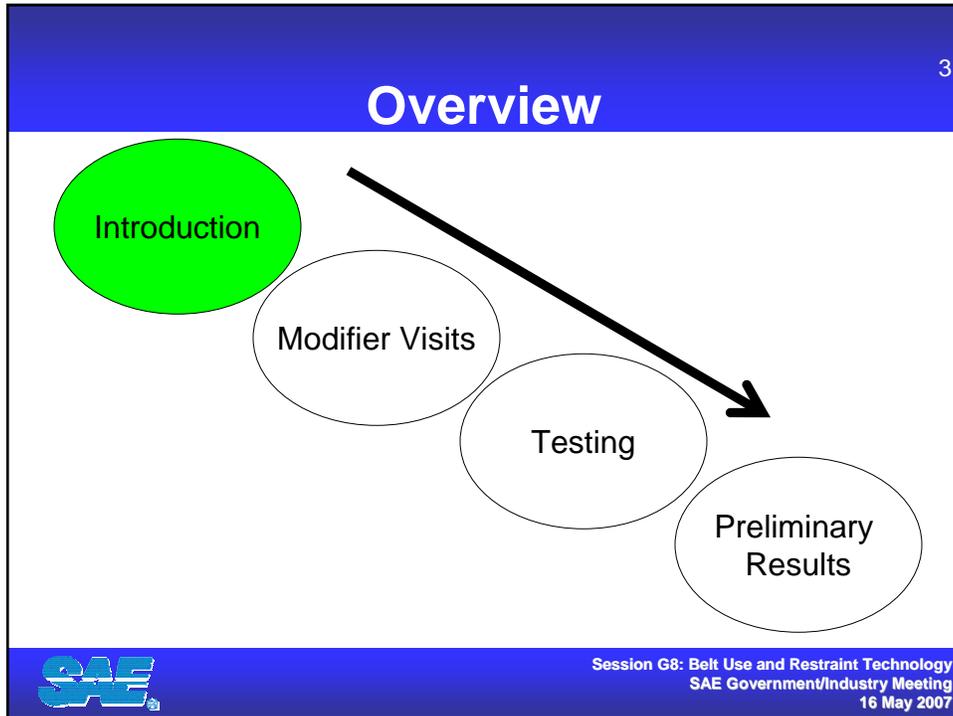


## Overview

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## Introduction

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- Wheelchair users unable to transfer to a OEM vehicle seat, often drive from their wheelchair
- Very little research has been conducted for restraints used for wheelchair seated drivers
  - Research has be conducted for wheelchair seated passengers
  - Chair tie downs, restraints, etc.

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## Introduction

- Securing the wheelchair to the vehicle is a problem
  - Must be an autonomous system
  - Driver has a limited range of motion
- Restraint use problems exist too
  - Obstacle problems with adaptive equipment
  - Wheelchair obstructions



## Introduction

- Vehicles are most often modified by small independent dealers
  - Modifier must be registered under CFM part 595
  - Must provide a FMVSS 209 certified belt and FMVSS 210 certified anchor.
  - Originally thought that this would alleviate occupant restraint issues
  - Problems still exist



## Introduction

- Industry is rapidly and constantly changing
  - Manufacturing Consolidation
  - Dealer Expansion
  - NMEDA (National Mobility Equipment Dealers Association)
  - Modifiers looking for guidance on safety issues



## Objective

- Evaluate the current state of technology and practice of restraints for wheelchair seated drivers
- Discover restraint characteristics needed to accommodate the occupant and wheelchair.
- Determine the driver use needs for a restraint.

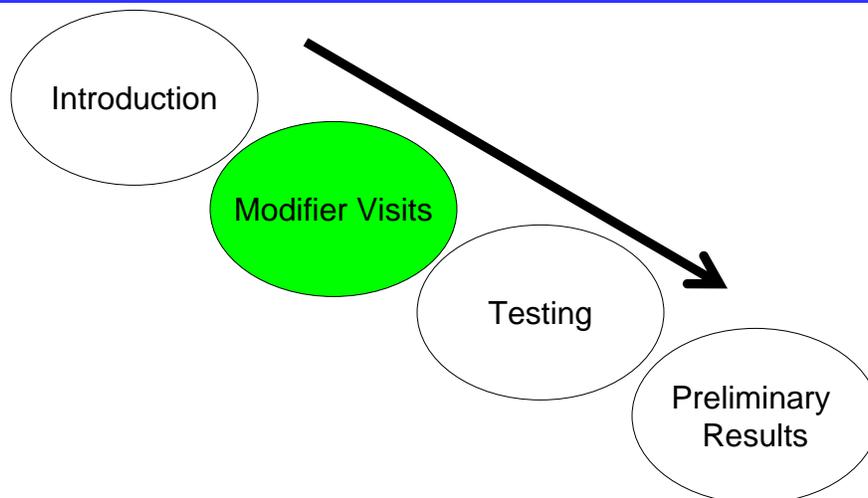


## Objective

- Visit with modifiers/installers who work with wheelchair seated drivers looking at:
  - Restraint use and applications
  - Common practices
  - Regional differences
- Conduct VRTC sled testing to recreate common practices.



## Overview



## Visit Overview

- Conducted visits throughout 2006
  - Various regions in the U.S.
- Visited with large and small modifiers
- Observed ‘fitting’ appointments with actual customers
- Attempted to grasp the overall dynamics of the industry



## Base Van

- Base Modified Van
  - 3 main manufacturers
  - Floor lowered (~6 in)
  - Installed ramps and removable seats



## Installed Options

- Dealer/Modifier Installed Options
  - Custom fit (hours of time)
  - Operation controls
  - Wheelchair securement
  - Occupant restraints



## Other Vehicles

- Honda Element



Photo Courtesy of Freedom Motors, Battle Creek MI



## Other Vehicles

- PT Cruiser



## Wheelchair Driver Scenario

- Quadriplegic: very limited range of motion
- Requires high tech driving equipment
- Shoulder restraint only
- This customer's 2<sup>nd</sup> van



## Vehicle Control



- Steering control
- Direction control
- Seat belt



## Wheelchair Restraint

### EZ-Lock

- Common device
- Can be operated autonomously
- Brackets unique for each wheelchair



## Alternate Scenario

- Lower level quadriplegic
- Modified OEM belt with Lap
- Different control environment
- Utilizes steering wheel



## Visit Review

- Customers have various levels of ability
  - Hand controls range from basic to high tech
- EZ-Lock is the most common device for securing the wheelchair
  - Provide custom brackets for many models of wheelchairs
- Belt application and use is wide ranging

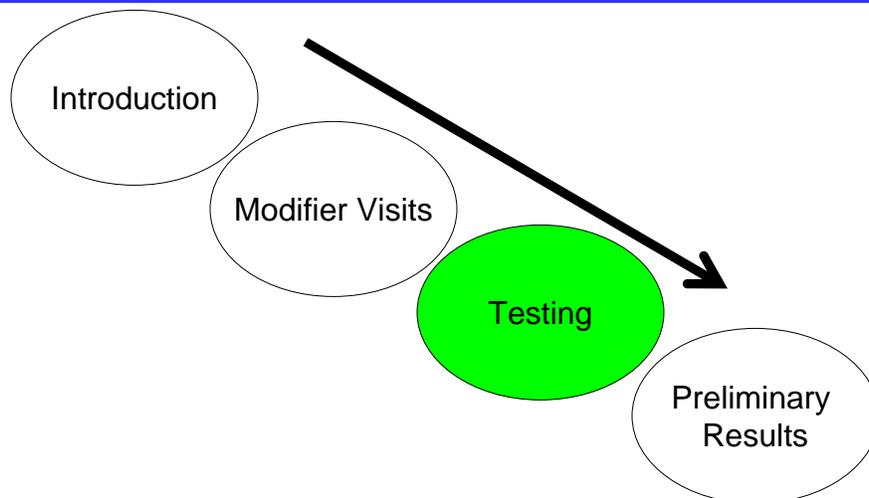


## Visit Review

- Restraints are often an afterthought in the modification process
  - Often last consideration prior to the customer driving off the dealer lot
- Belt fit can vary widely with different wheelchairs
  - Dozens of wheelchair models/options available



## Overview



## Sled Buck



- 2003 Braun Entervan
  - Modified Dodge Caravan
  - Very common vehicle for Wheelchair seated occupants.
- Retrofitted for sled testing



## Devices



- Invacare wheelchairs
  - Pronto
  - TDX 3
- Q-Strait floor anchor tracking and restraints
- 50<sup>th</sup> Hybrid III male for testing



## Devices



- EZ-Lock
  - Wheelchair lock
  - Front Stabilizer
- Q-Stem
  - Buckle
  - Cable
  - Track Mounted



## Objective

- GOAL: Recreate restraint configurations observed from modifier visits
- Conduct sled tests with these configurations to develop a baseline for understanding restraint performance
- Demonstrate the challenges faced for effectively restraint wheelchair seated drivers

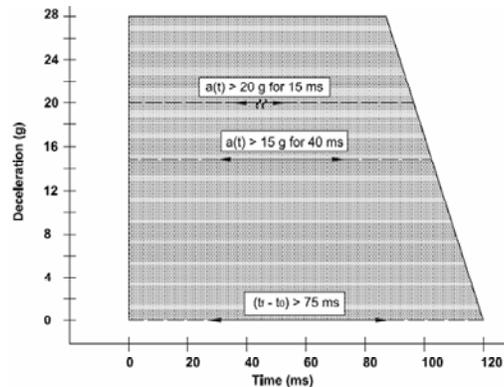


## Test Condition

### WC-19 (ANSI/RESNA)

Wheelchairs used as Seats in Motor Vehicles

- Delta V 48 km/h (+2/0)
- $a(t) > 20 \text{ g}$  for 15 ms
- $a(t) > 15 \text{ g}$  for 40 ms
- $(t_f - t_0) > 75 \text{ ms}$



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## Test Matrix

Test #	Description	Wheelchair
W_001	OEM belt	Pronto
W_002	OEM belt over armrests	Pronto
W_003	OEM belt	TDX 3
W_004	Modified Shoulder/EZ-Lock Lap	TDX 3
W_005	OEM belt over armrests	TDX 3
W_006	Modified Shoulder Belt/NO Lap	TDX 3
W_007	W_003 with reinforced Chair	TDX 3
W_008	Modified EZ lap and Q-Strait	TDX 3



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## Test Matrix

Test #	Description	Wheelchair
W_001	OEM belt	Pronto
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W_003	<b>OEM belt</b>	TDX 3
W_004	<b>Modified Shoulder/EZ-Lock Lap</b>	TDX 3
W_005	<b>OEM belt over armrests</b>	TDX 3
W_006	<b>Modified Shoulder Belt/NO Lap</b>	TDX 3
W_007	W_003 with reinforced Chair	TDX 3
W_008	Modified EZ lap and Q-Strait	TDX 3



## Tested Configurations

- W\_003
- OEM lap and shoulder belt w/o armrest interference
- Wheelchair position belt
- TDX3



## Tested Configurations

- W\_004
- Modified shoulder belt over armrest
- Lap belt anchored to bottom of chair at EZ-Lock bracket
- TDX3



## Tested Configurations

- W\_005
- OEM lap and shoulder belt with armrest interference
- Wheelchair position belt
- TDX3

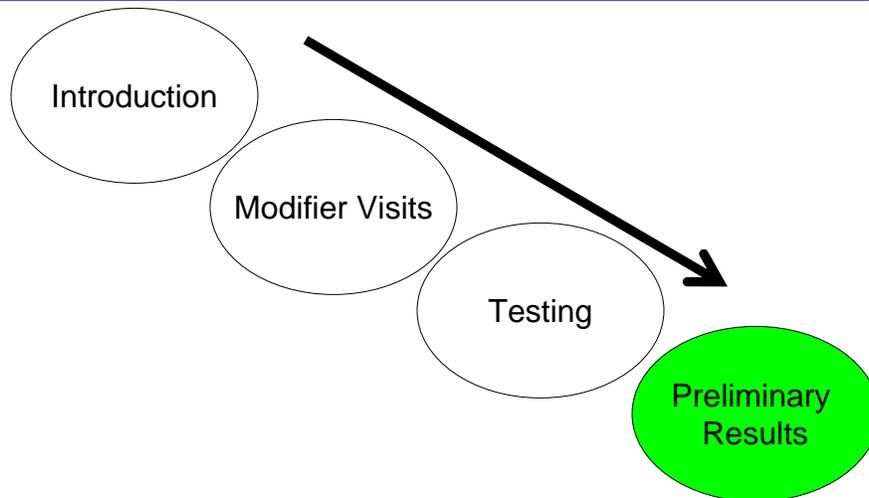


# Tested Configurations

- W\_006
- Modified shoulder belt over armrest
- No Lap belt
- Wheelchair position belt
- TDX3



# Overview



## W\_004

Results

35

### Modified shoulder w/lap belt

- Lap belt is cut from routing
- Dummy submarines after belt breaks
- Wheelchair rotates up



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## W\_005

Results

36

### OEM belt over arm rests

- Lap Belt over armrests cut into upper abdomen
- Q-stem damaged
- Significant neck extension during rebound



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## W\_006

Results

37

### Modified shoulder belt

- Dummy separates from the wheelchair
- Wheelchair position belt does not hold
- Dummy impacts the IP and steering wheel



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## Summary

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- Investigated how restraints are utilized for those who drive seated in a wheelchair
- Conducted 8 sled tests to recreate restraint used for wheelchair seated drivers
- Although rules apply, the unique and custom application of driving from the wheelchair presents many challenges for effective occupant restraint



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## Thank You

# NHTSA Research on Occupant Restraint for Wheelchair Seated Drivers

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