

NHTSA Research on Improved Restraints in Rollovers

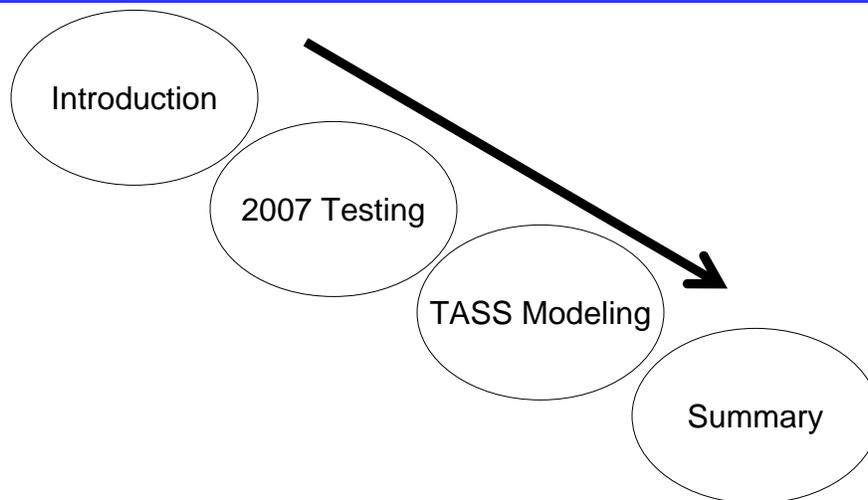
Michael L. Sword
Transportation Research Center, Inc.

SAE Government/Industry Meeting
16 May 2007
Session G8



Introduction

2



Session G8: Belt Use and Restraint Technology
SAE Government/Industry Meeting
16 May 2007

3

Introduction

```
graph LR; A((Introduction)) --> B((2007 Testing)); B --> C((TASS Modeling)); C --> D((Summary));
```

Introduction

2007 Testing

TASS Modeling

Summary

SAE

Session G8: Belt Use and Restraint Technology
SAE Government/Industry Meeting
16 May 2007

Introduction

4

Introduction

- Roof Crush upgrades alone will not eliminate occupant contact with roof
- Previous NHTSA (mid-1990's) research found reduced occupant excursion with improved restraint systems in rollover conditions
- Few studies focused on improved restraint system effectiveness for rollover accident conditions exist

SAE

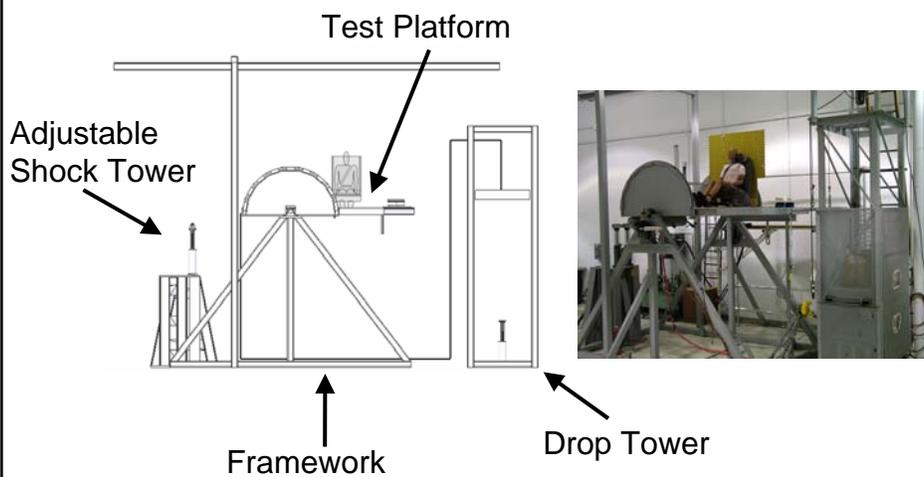
Session G8: Belt Use and Restraint Technology
SAE Government/Industry Meeting
16 May 2007

Objective

- Evaluate the current state-of-the-art of restraint systems in a rollover condition
- Examine occupant head excursion of various restraint configurations
- Build research data for aiding in the potential test procedure development for assessing restraint effectiveness



RRT Rollover Restraint Tester



RRT Overview Video



General Test Matrix

Integrated 3-Point:

No Pretensioner **A**

SWAP No Pretensioner **B**

Other:

4-Point with two lower anchor Pretensioners **J**

Non-Integrated 3-point:

Lower D-Ring (No Pretension) **C**

Upper D- Ring (No Pretension) **D**

Retractor Pretensioner **E**

Buckle Pretensioner **F**

Retractor & Buckle Pretensioner **G**

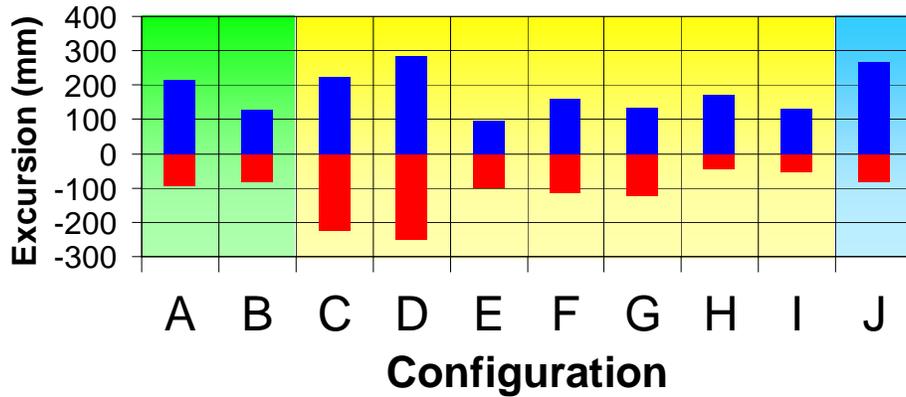
Motorized Pretensioner **H**

Motorized & Buckle Pretensioner **I**



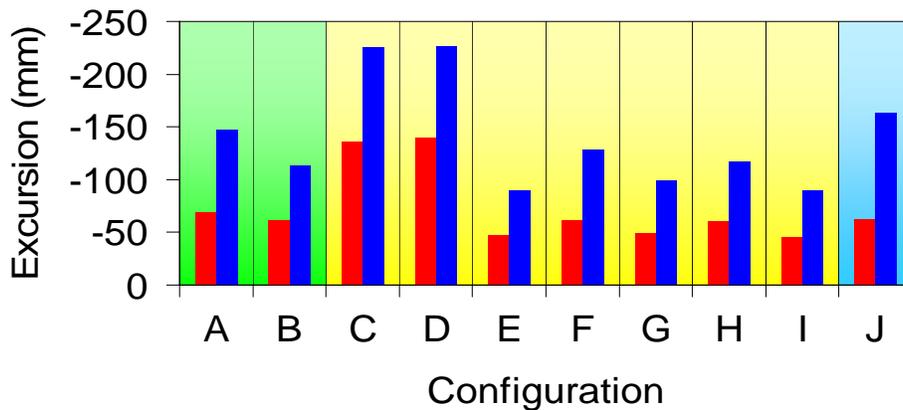
50th Testing Recap

PRE IMPACT Y(IN) AND Y(OUT)



50th Testing Recap

PRE AND POST IMPACT Z

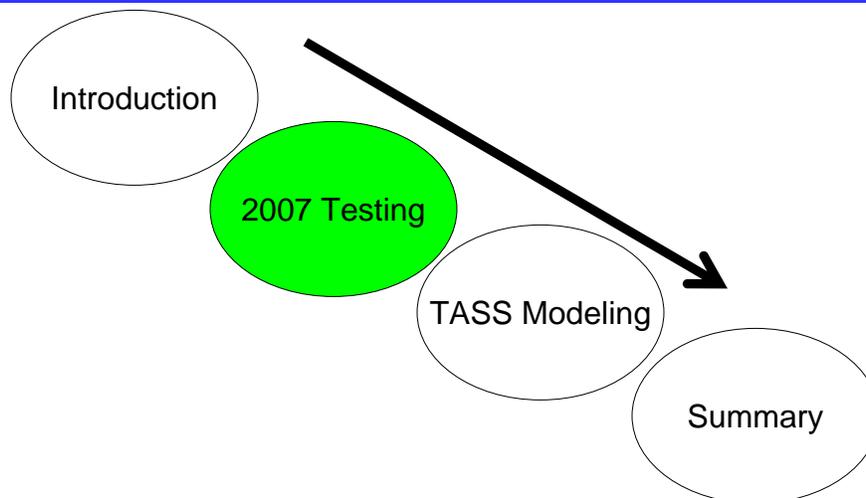


50th Testing Recap

- Integrated seats, when compared to the baseline (C), reduced both Y and Z head excursions up to 54% in the pre and post impacts
- Motorized retractor pretensioners (H, I) reduced pre-impact excursion in the Y-direction by up to 76% and Z-direction head excursion up to 66%



Introduction



2007 Testing

- 5th female Hybrid III (instrumented head, neck and chest)
- Use video analysis to evaluate occupant head excursion
- Upgraded cameras to high speed on board
- Each configuration repeated 3 times



5th Female Test Matrix

Integrated 3-Point:

No Pretensioner **A**

SWAP No Pretensioner **B**

Other:

4-Point with two lower anchor Pretensioners **J**

Non-Integrated 3-point:

Lower D-Ring (No Pretension) **C**

Upper D- Ring (No Pretension) **D**

Retractor Pretensioner **E**

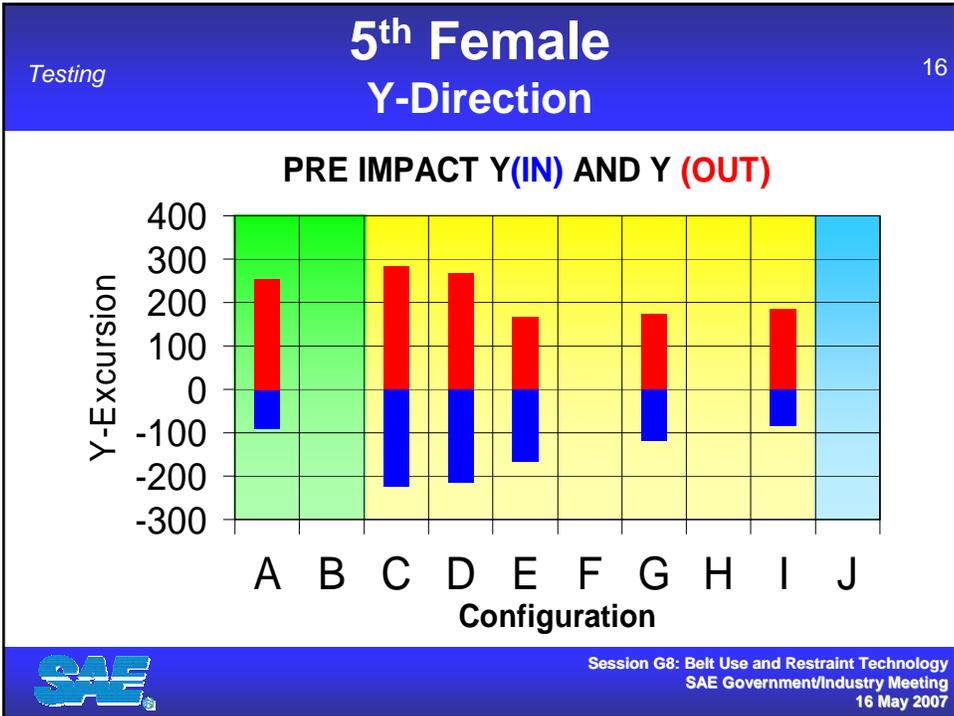
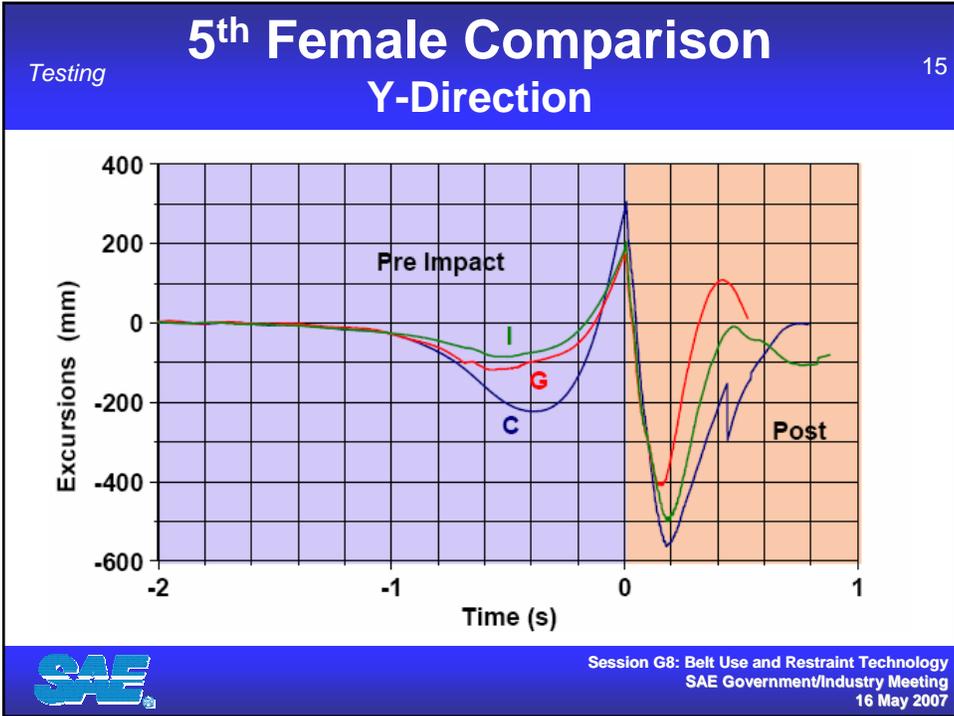
Buckle Pretensioner **F**

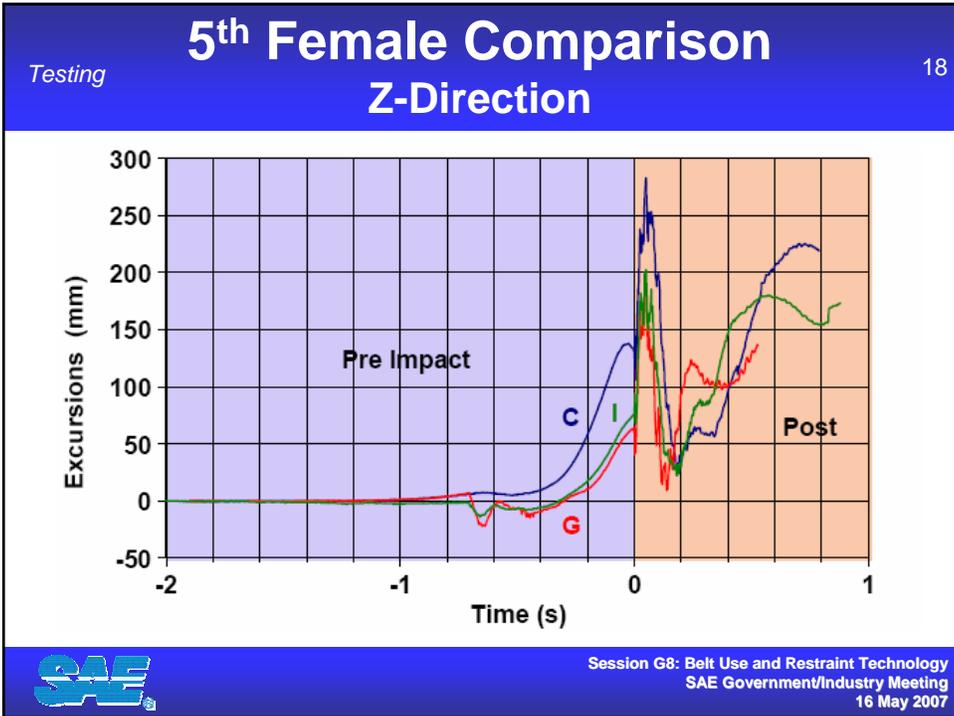
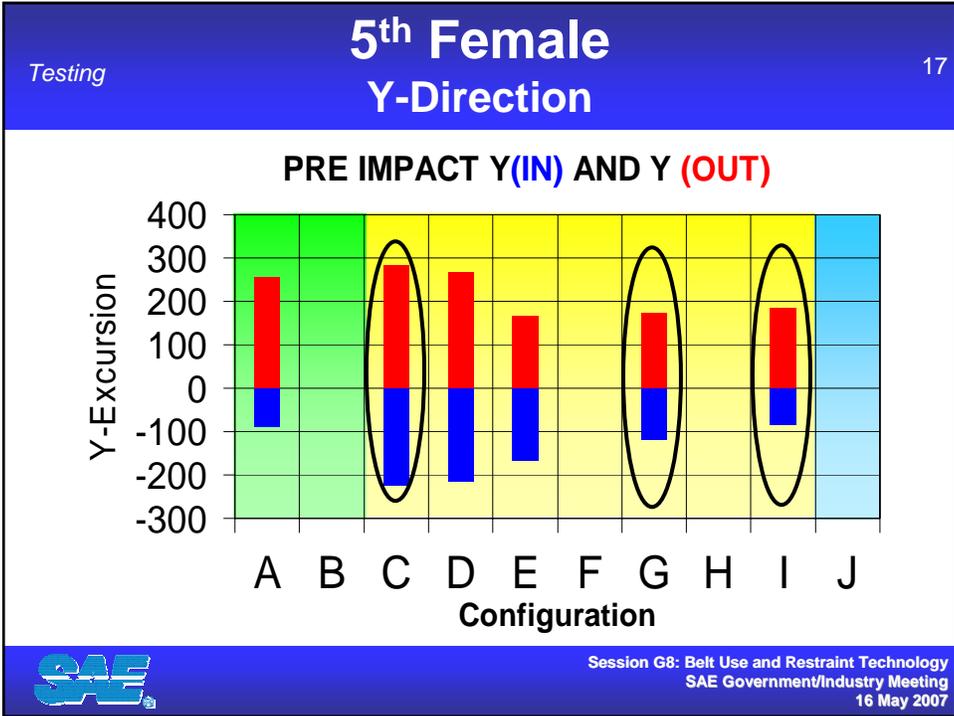
Retractor & Buckle Pretensioner **G**

Motorized Pretensioner **H**

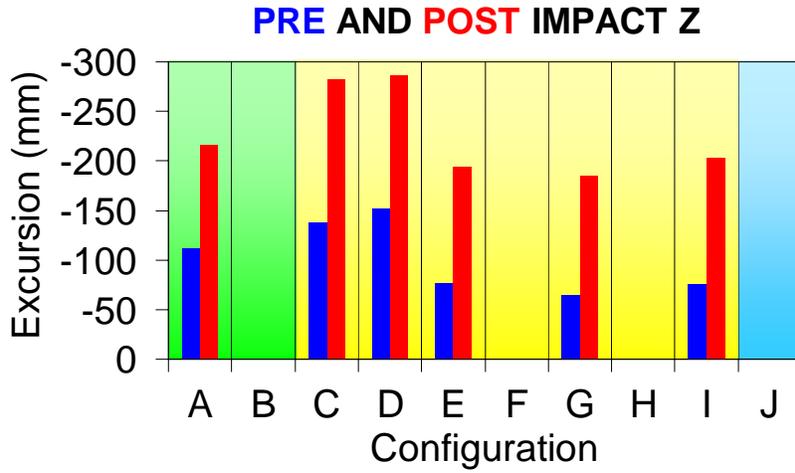
Motorized & Buckle Pretensioner **I**



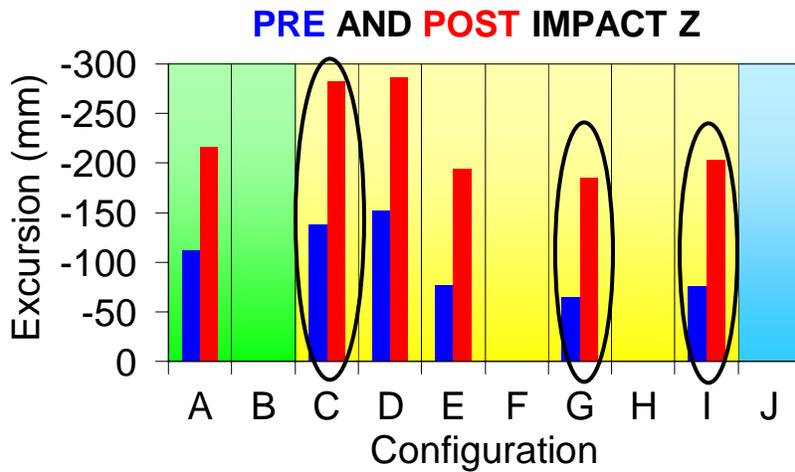




5th Female Z-Direction



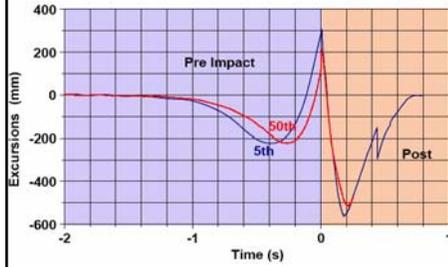
5th Female Z-Direction



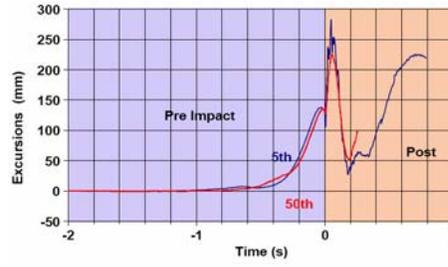
5th Female vs. 50th Male Configuration C

No Pretensioning

Y-Direction



Z-Direction



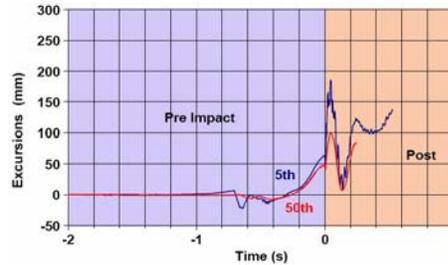
5th Female vs. 50th Male Configuration G

Retractor/Pyro Pretensioner

Y-Direction



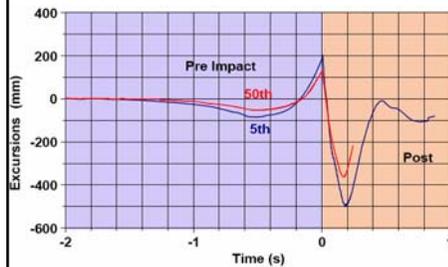
Z-Direction



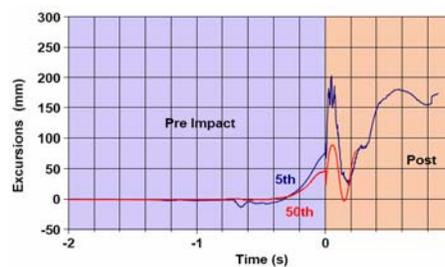
5th Female vs. 50th Male Configuration I

Motorized Retractor w/Buckle Pretensioner

Y-Direction



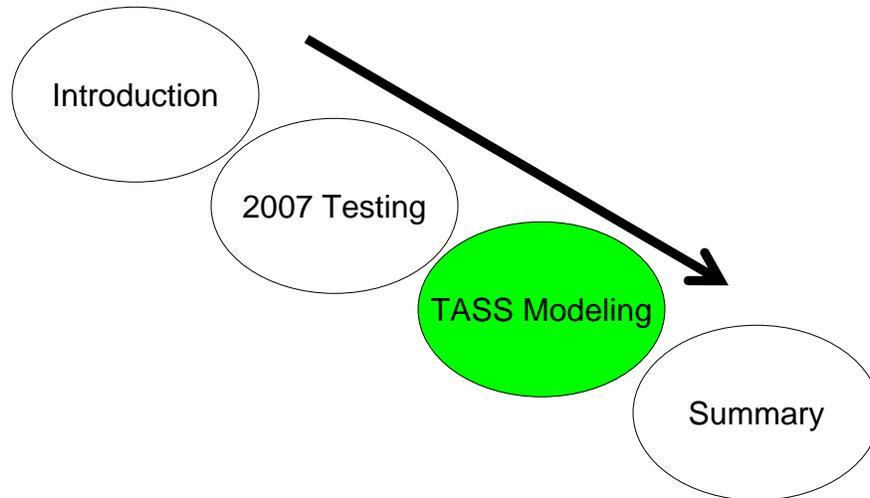
Z-Direction



2007 Testing Summary

- Pretensioning appears to reduce head excursion in both the Y and Z direction of the 5th female (Similar to the 50th male)
- 5th female appears to demonstrate more excursion when compared to equivalent 50th male tests (particularly in Z direction)
- Immediate testing to include the 4-point seat belt and Inflatable air belt of the 5th female





TASS-TNO

- NHTSA started a rollover study with the RRT
- NHTSA asked TASS to create MADYMO models based on the tests
- TASS created the model and validated it with data generated from the RRT testing.
- 50th male test data were used (2006 tests)



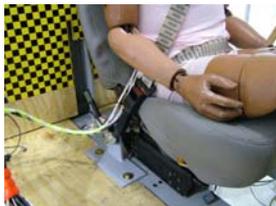
TASS-TNO

Configurations Modeled

- C Configuration
 - 3-point without pretensioners
- G Configuration
 - 3-point with buckle and retractor pyro pretensioners
- I Configuration without pretensioners
 - 3-point with electric resettable and buckle pyro



3-point Belt Model Setup



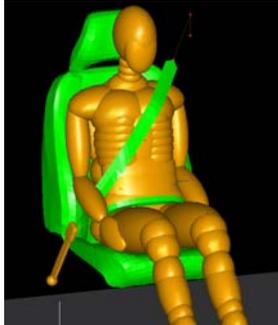
Buckle Anchor Point			D-ring Anchor		
X	521	mm	X	717.5	mm
Y	171.5	mm	Y	774.7	mm
Z	146	mm	Z (upper)	1120	mm
			Z (lower)	1030	mm

Top of Buckle Receiver			Lap Anchor		
X	406.5	mm	X	650	mm
Y	203	mm	Y	800	mm
Z	355.5	mm	Z	190	mm



3-point Belt Model Setup

- Dummy positioning with pre-simulation



- Belt routing



3-point Belt Model Setup

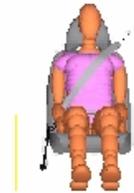
Pretensioner Prescriptions

	Configuration C	Configuration G	Configuration I
Prescribed rotation	pitch_C function	pitch_G function	pitch_I function
End time simulation	2.87 seconds	2.92 seconds	2.77 seconds
Retractor trigger time	-	1.958 seconds	0 seconds
Amount of retractor pretension	-	0.05 meters	120 Newton
Buckle trigger time	-	1.958 seconds	1.802 seconds
Amount of buckle pretension	-	0.006 meters	0.01 meters



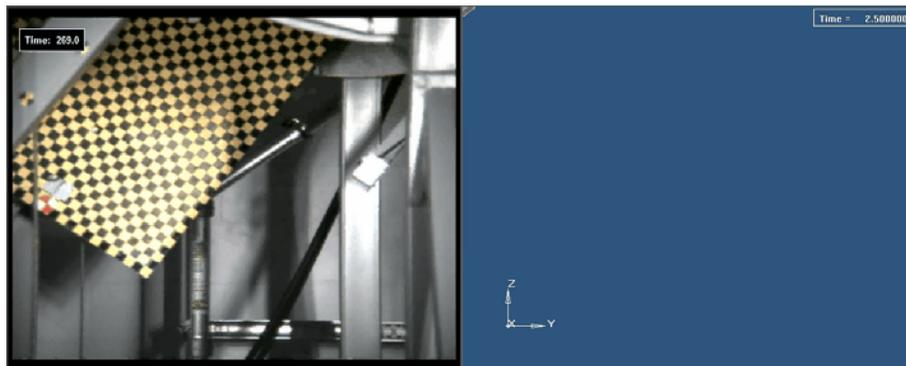
3-point Belt Model Setup

Overview of 3-pt



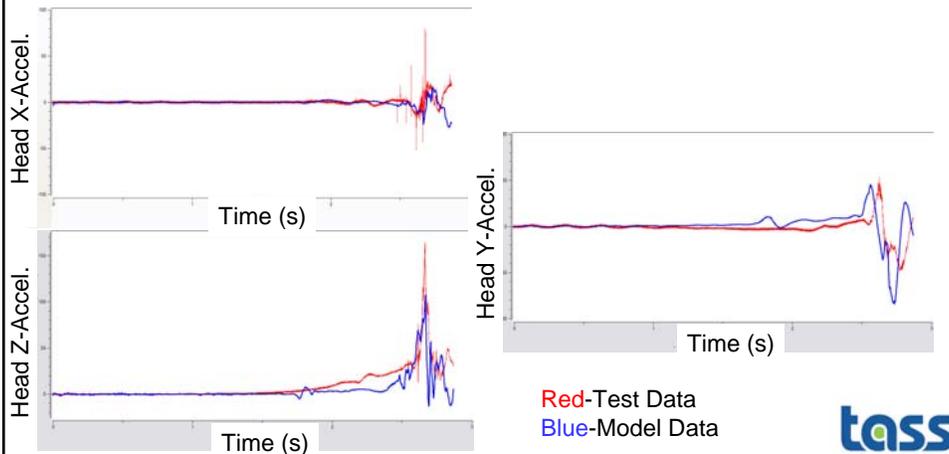
C Configuration

Post Impact Simulation



C Configuration

Correlation Head Acceleration Data

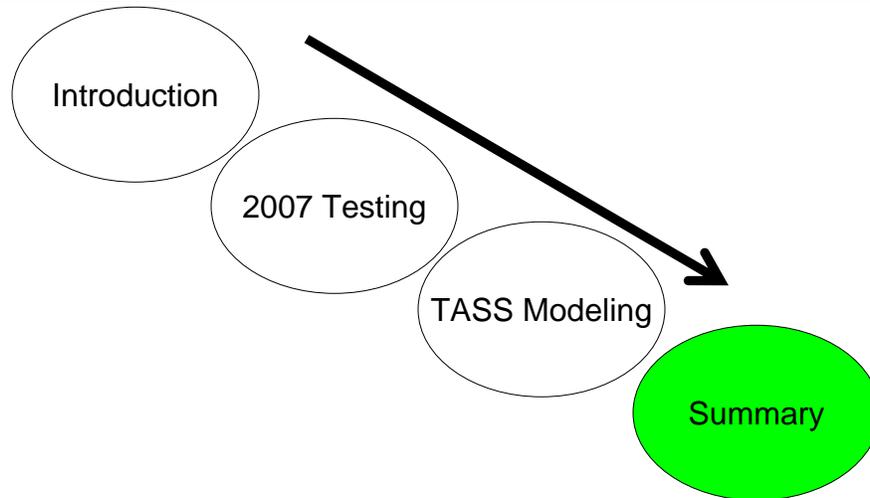


TASS-TNO Simulation Summary

- Reasonable good correlating models
 - Spike in belt forces at impact needs improvement
 - Kinematics are satisfactory
 - Head y-direction needs improvement
- Recommendations
 - Improve seat geometry replication
 - More detailed stiffness of belts, retractors, buckles and seat
 - Clear pretension stroke modeling



Introduction



Summary

- Testing to continue at VRTC
- Future testing to include incorporation of a reaction surface to replicate the roof interior
- Simulation modeling of the RRT can be very useful for future research
 - Pretensioner fire timing
 - Various occupant sizes
 - Other physical limitations of RRT



Thank You

NHTSA Research on Improved Restraints in Rollovers

Michael L. Sword
Research Engineer
Transportation Research Center, Inc.
937-666-4511



Session G8: Belt Use and Restraint Technology
SAE Government/Industry Meeting
16 May 2007

