NHTSA Seat Belt Testing for Motorcoach Safety

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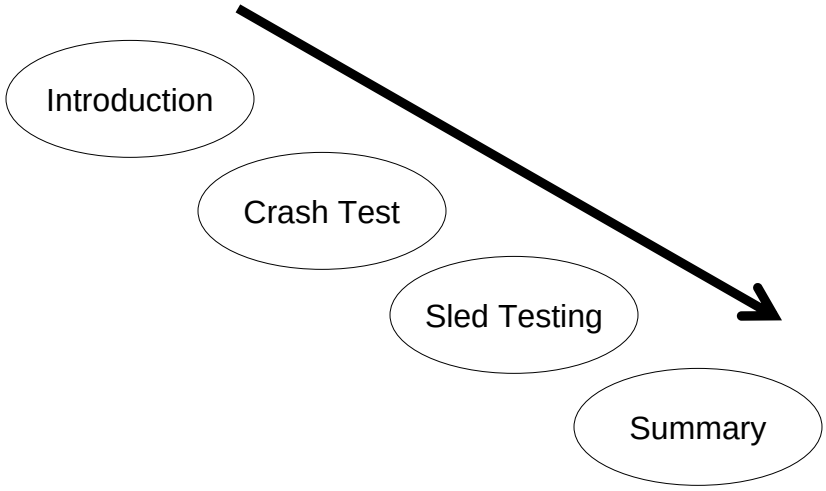
Session G112: Front and Side Impact Crashworthiness

Presentation Overview



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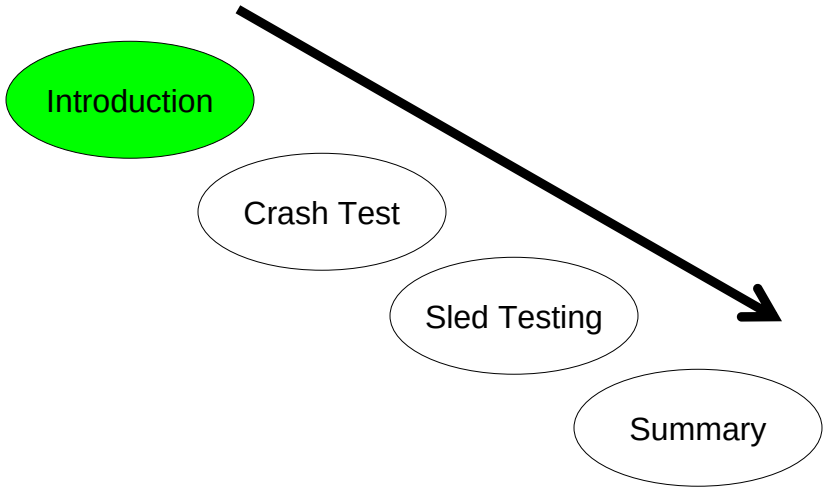
Introduction



Introduction

- In 2007 NHTSA developed a Comprehensive Review of Motorcoach Safety Issues
  - Set Priority Areas
    - Passenger Ejection
    - Roof Strength
    - Fire Safety
    - Emergency Evacuation
- 48 fatal crashes (1996-2005)
  - 31 single vehicle events
  - 14 rollovers

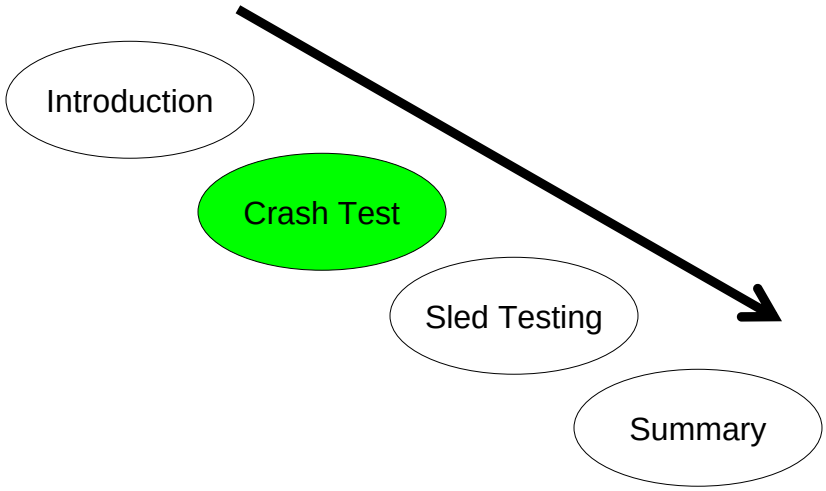
Introduction

- 14 annual fatalities (1996-2005)
  - 2 drivers annually
  - 56% are ejections
- Single events with high fatalities can dramatically affect a particular years data.
- A single crash event has a large potential for occupant injury causing elevated concern.

Objective

- Obtain crash pulse from severe frontal crash event
- Obtain dummy readings for
  - Different dummy sizes
  - Different seat types
    - No belts
    - Lap and shoulder belts (3 – point belts)
    - Lap belts (2 – point belts)
    - Different seat manufacturers
- Study seat and seat attachment strength for different dummy sizes and rear occupant loading

Motorcoach Crash Test



Motorcoach Details

- 2000 MCI 102EL3 Renaissance
- Series 60 diesel engine
- B500 Allison Automatic transmission
- 54 seats
- 45 ft long, 12 ft 6 inches tall
- Weight (including dummies and equipment):42,720 lbs

Motorcoach Seats

- Baseline seats
  - No belts
  - American Seating
- Seats with Belts
  - Amaya/FAINSA
    - 3 point belts – 4 rows (dual seats)
    - 2 point belts – 1 row (dual seats)
  - Freedman Seating
    - 3 point belts – 1 row (dual seats)

Test Conditions

- Speed: 30 mph (48.3 kph)
- Frontal impact: 0 degrees; full overlap
- Fixed Rigid Barrier
- Data channels: 381
  - 355 dummy
  - 26 vehicle
  - 12500 samples/sec

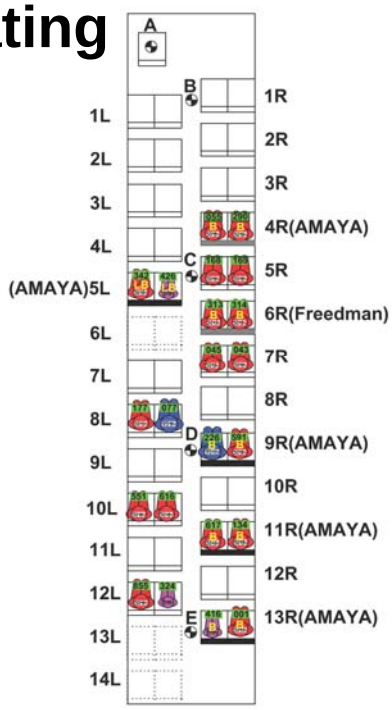
Occupants

- Hybrid III 50th percentile male – 17 dummies
  175 cm (5 ft 9 in) tall and 77 kg (170 lb)
- Hybrid III 5th percentile female – 3 dummies
  150 cm (5 ft) tall and 50 kg (110 lb)
- Hybrid III 95th percentile male** – 2 dummies
  188 cm (6 ft 2 in) and 100 kg (220 lb)
- Dummy Instrumentation
  - Accelerometers in head and chest
  - Load cells in upper neck and femur
  - Chest displacement potentiometer

** The 95th percentile male dummy is not in any FMVSS

Dummy Seating Locations

KEY

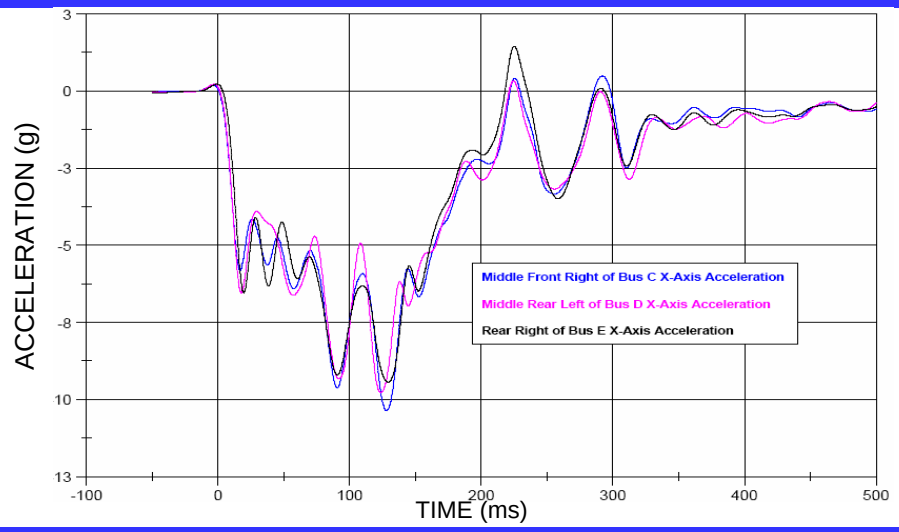


Results

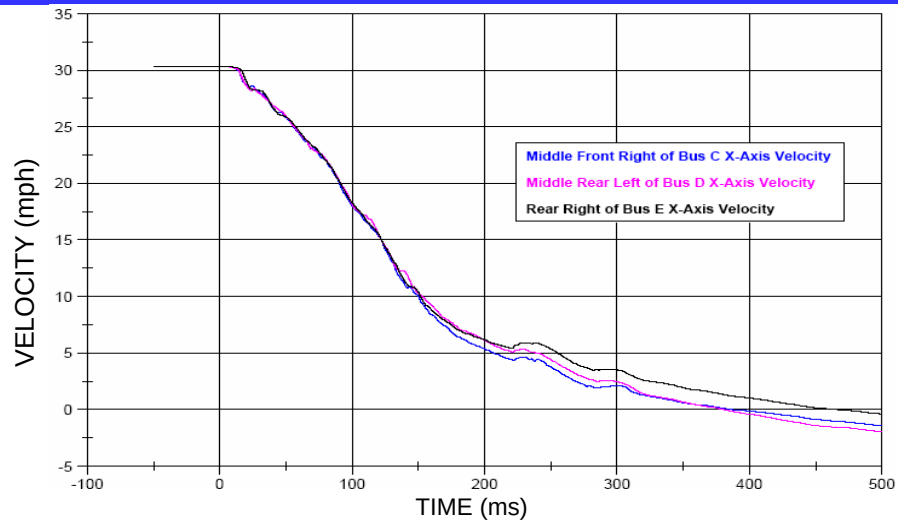
- Speed = 30.36 mph
- Dynamic crush of 6.5 feet
- Peak deceleration 10 g at 125 msec.

Post Test Pictures

Crash Test Pulse – X (CFC 30)



Velocity – X



Typical Dummy Kinematics

Head Injuries - HIC

Notes:

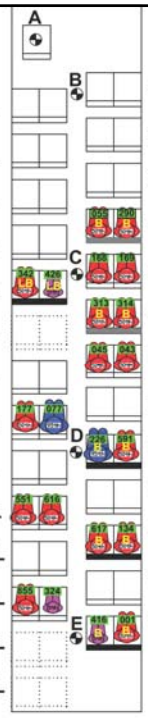
Unbelted dummies typically make head contact with seatback in front within 150 – 180 msec

*- Head strike with camera stand

•Unbelted dummies in the aisle seat ended up on the floor in the aisle

•Belted dummies stayed in their seats

785	1356	(AMAYA)	5L
700*	754		8L
336	570		10L
210	1959		12L

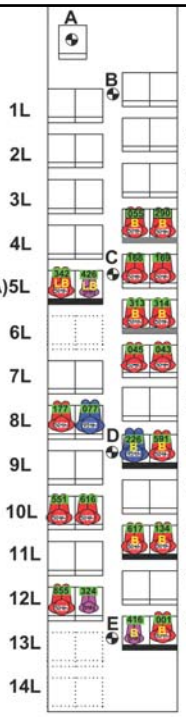


4R(AMAYA)	439	77
5R	1308	843
6R(Freedman)	204	157
7R	613	728
8R		
9R(AMAYA)	349	118
10R		
11R(AMAYA)	195	38
12R		
13R(AMAYA)	14	27

Neck Injuries - Nij

Notes:

Dummies with high neck loads were either unbelted or in 2-pt belts



			4R(AMAYA)	.83 CF	---
.40 TE	4.75 CE	(AMAYA)	5R	.97 CE	.56 CF
			6R(Freedman)	.65 CF	.68 CF
			7R	.53 CE	.50 CF
1.35 CE	.57 CE		8R		
			9R(AMAYA)	.51 CF	.72 CF
.45 CE	---		10R		
			11R(AMAYA)	.31 CF	.25 TE
.36 CF	2.05 CF		12R		
			13R(AMAYA)	.20 CF	.28 TF

Observations - Restraints

- Unbelted dummies
  - High head accelerations, Nij
- Dummies with 2-pt. belts
  - High head accelerations, Nij
- Dummies with 3-pt belts
  - Low head and neck loads
- All dummies had low chest accelerations, chest displacements, femur loads

Observations – Unbelted Dummies

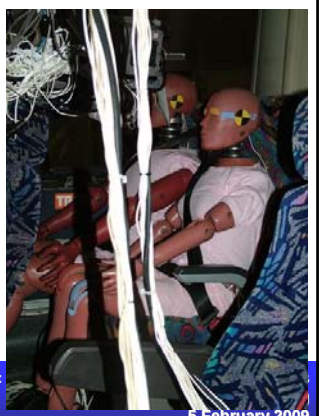
- Typically make head contact with seatback in front within 150 – 180 msec
- In aisle seat end up in the aisle; in window seat end up in the row in front or on floor



Observations – Belted Dummies

- Head/knee contact with seatback in front for 95th M
- Dummies stay in the seat





Observations – Seat Hardware

- All seat attachments (including baseline) intact.
- One failure of the seat frame at the floor attachment (baseline seat – not designed for belts)
- This unoccupied seat had unbelted 50th M and 95th M in the row behind it

Observations – Seat Hardware

- Baseline seats and Freedman seat back bent/broken when impacted by unbelted dummies in the seat behind it

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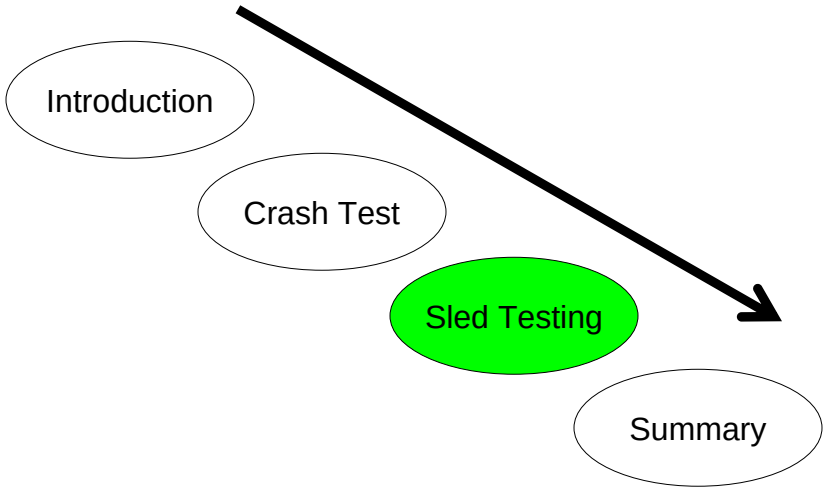
Motorcoach Sled Testing



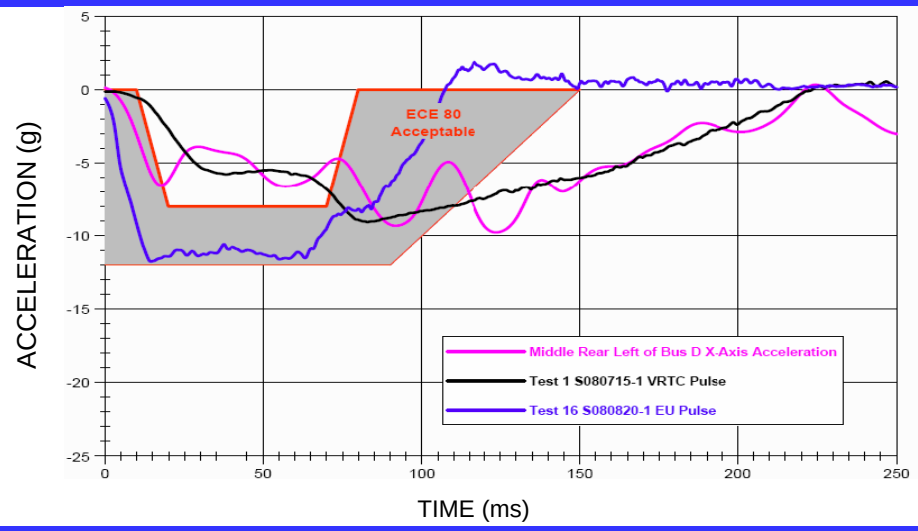
Sled Test Program

- Conducted 20 sled tests
- 2 crash pulses
  - VRTC Motorcoach Pulse (15 tests)
  - ECE 80 Pulse (5 tests)
- Tested 5th, 50th and 95th in various seating arrangements
  - Replicated some Crash Test seating scenarios
  - Tested other types of dummy seating setups

Sled Test Program

- Collected Force Data at Seat Anchors
- Collected Seatbelt Force Load Data
- Examined affect of rear dummy loading onto subject seat
- Tested at 2 buck angles (0 and 15 degrees)

Sled Test Pulses



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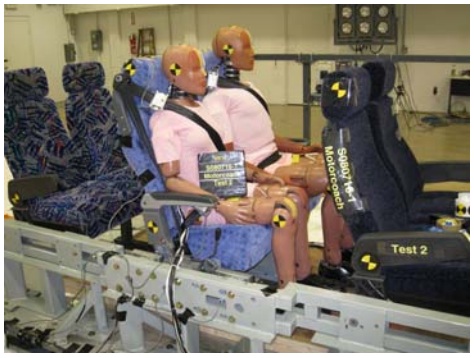
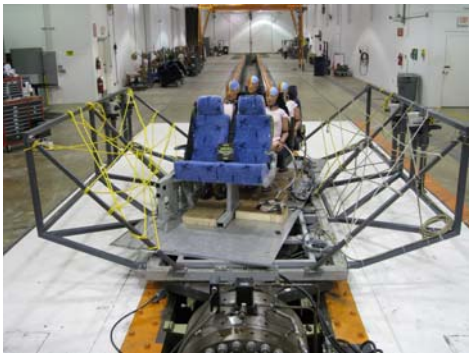
Pre-Test Pictures



Center Subject Seat



Sled Buck at 15° angle

Sled Test Seats

- Baseline (no belts) American Seating seats
- M3 seats (belted seats from Amaya)
  - with 2-point belts
  - with 3-point belts
- M2 seats (belted seats from Amaya)
  - with 3-point belts

Belted Seats

- Supplied by Amaya/FAINSA
- ECE Regulation 14,TRANS/WP.29/78/Rev.1/Amend2
  - M3: For vehicles > 8 seats (plus driver), mass > 5 tonnes (11,023 lbs). This uses a load equivalent to 6.6g. Referred to as “7G seats” in results.
  - M2: For vehicles > 8 seats (plus driver), mass < 5 tonnes (11,023 lbs). This uses a load equivalent to 10g. Referred to as “10G seats” in results

Load Cells Mounts

3-axis load cells at 4 seat mounting locations of the center seat.

Sled Test Observations

- Dummy injuries were mostly limited to HIC and Nij
  - Similar to the VRTC Bus Crash observations
  - Unbelted 5th females often recorded high Femur loads
- 3-point belted seats prevented critical injury values in almost all configurations with VRTC crash pulse
  - No 3pt belted dummy recorded a critical Nij across all test conditions
- Unbelted dummies rear loading the target seat often lead to increased injury values of the 3-point mounted dummy when compared to tests that had no rear dummy loading.

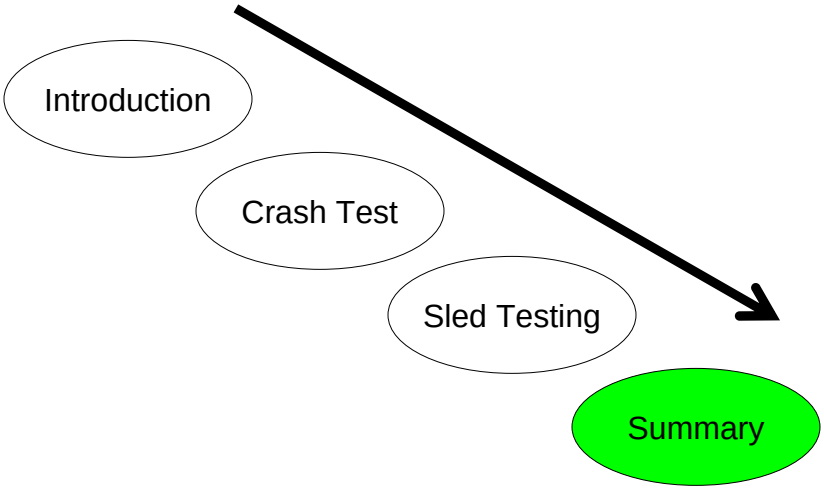
Sled Test Observations

- EU pulse tests resulted in higher HIC when compared to VRTC crash test pulse.
  - 3 pt belted dummies with the EU pulse reached critical (IARV) injury values
  - The pulse has a shorter duration and higher peak G than the VRTC
- Dummy injuries (HIC and Nij) reached critical thresholds with 2-point (lap only) belt tests.
  - Head Contact with seat in front
  - Nij values reached critical (IARV) value for all 2-point belted occupants and many unbelted ones.

Sled Test Observations

- The 5th female consistently recorded higher injury numbers when compared to the larger occupants in 2-point and unbelted conditions.
- Low injury numbers were recorded for 15 degree angled testing however unbelted dummies were not contained between the seats and often fell into the 'aisle'
- When compared the Amaya 7g and 10g seats injury values were relatively similar.

Summary



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Summary

- NHTSA conducted a Crash Test of a Motorcoach to obtain a crash pulse and examine the affects of belted seats.
- Unbelted Dummies had higher HIC and NIJ readings in both Crash and Sled Test when compared to belted dummies
- Seat anchor force load data collected in sled testing used to develop static pull test

Next Steps

- Static pull tests
  - Somewhat like FMVSS-210
  - Achieve similar belt tension and forces at seat mounts as in sled tests

Thank You

NHTSA Seat Belt Testing for Motorcoach Safety

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