Rear-Facing Reclined Testing
Sled Buck Design & ATD Tests

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Automated Vehicle Occupant Safety Workshop
11. 27. 2018
AGENDA

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1. Sled Buck Design Evolution
2. Sled Tests with Instrumented ATDs
3. Plans for PMHS Sled Tests
A rear impact sled buck design was fabricated and tested for durability and feasibility using ballast dummies.
Sled Buck Design

- 2 occupant design

- Adjustable configurations
  - Recline angles
  - Seatback rotation limits
  - Loading directions
  - Various seats
  - Integrated or standard belts
Seat Selection

Honda Odyssey

- Integrated seatbelt
- 2\textsuperscript{nd} row seating
- Readily available
- Used throughout test series
Seatback Support Bracket

- Intended to create “fixed” scenario and/or limit seatback rotation
- Adjustable to align with seatback angle
Sled Buck Shakedown Tests

Ballast dummies used to check durability and feasibility of sled buck

25°/ 45° recline free back
25°/ 45° recline fixed back
25°/ 45° recline with 20° allowable rotation
Test Pulses

- **24 kph**
  - Consistent with previous low/moderate speed rear impact testing

- **56 kph avg. NCAP pulse**
Sled Buck Issues

Solution

• Eliminate free back configuration from future tests for better repeatability
Sled Buck Issues

- Seatback support bracket height allows seatback bending
- Rotation of the bracket during seatback contact

25 Deg Recline with 20 Deg Allowable Seatback Rotation

45 Deg Recline with No Allowable Seatback Rotation
Sled Buck Issues

- Solutions

• Extended seatback support bracket height to encompass seatback

• Additional reinforcement to center to prevent bracket rotation
Sled Buck Issues
- Solutions

• Increase height of seatback support bracket to cover entire seatback frame
Sled Tests with Instrumented ATDs

Two sled test series with THOR-50M and HIII-50th performed at 24 kph and 56 kph
Instrumented ATD Sled Tests

25°/ 45° recline fixed back
25°/ 45° recline with 20° allowable rotation
Addition of Seat Anchor Load Cells

- Load cells added to the anchor points to measure reaction forces
- For model validation
56 kph Tests: THOR-50M

25 Deg Recline

45 Deg Recline

Fixed Seatback

Seatback Allowed to Rotate 20 Deg

This test not conducted due to ATD instrumentation issues
Sled Buck Issues

• Head restraint bent, broke, or pulled out due to head interaction

• Undesirable for repeatability & model validation

• SOLUTION: Fix both head restraint and seatback
ATD Issues

- Pinched cables, data channel loss
- Associated with cable bundle interacting with seatback
- **SOLUTION:** Reroute cables for next series
ATD Issues

• HYIII head far from head restraint in 45° recline

• THOR lumbar spine set to erect to better fit 45° recline
Instrumented ATD Series: Findings

• Fix all seatbacks for next series
  • No allowable seatback rotation
  • Pulse, recline angle, and ATD only variables for repeatability

• Cable rerouting needed to limit cable bundle interacting with seatback

• Head restraint needs to be supported
Instrumented ATD Sled Tests – Round 2

25° / 45° recline fixed back
New Head Restraint Support

• Fully supports head restraint

• Posts have set screw “clamps” to keep headrest from being pulled out
Reroute Cables

- Reconfigured to prevent compression of cables on the back
56 kph: THOR-50M & HIII-50th

25 Deg Recline

45 Deg Recline
Rerouting instrumentation cables was effective.

Fixed seatback + fixed head restraint appears to exhibit a repeatable configuration.
- Allows for PMHS vs. ATD comparison of seatback/head restraint interaction.
Seatback/Head Restraint Loads

- 8 load cells per seatback:
  - 1 on head restraint
  - 1 to measure head restraint post load
  - 6 to measure seatback loads (in groups of 2)
Rear-Facing Reclined Testing
PMHS Instrumentation Plan

Yun-Seok Kang, PhD

Automated Vehicle Occupant Safety Workshop
11.27.2018
Preliminary Results
THOR-50M 56kph

This chart is NOT intended to assess injury but to use as a guide for PMHS instrumentation

THOR Injury Criteria Report
NHTSA (unpublished)
Preliminary Results
THOR-50M 56kph

THOR Injury Criteria Report
NHTSA (unpublished)
Head, neck, spine and pelvis kinematics

THOR Injury Criteria Report
NHTSA (unpublished)
THOR-50M BioRID II HIII-50th PMHS

Head, Neck, Spine, and Pelvis

ATD vs. PMHS

Kang et al., 2017

Coplanar 6a°
### Head, Neck, Spine, and Pelvis

#### ATD vs. PMHS

![THOR-50M](image1)

![BioRID II](image2)

![HIII-50th](image3)

![PMHS](image4)

<table>
<thead>
<tr>
<th></th>
<th>THOR-50M</th>
<th>BioRID II</th>
<th>HIII-50th</th>
<th>PMHS</th>
</tr>
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<td><strong>Head</strong></td>
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<td><img src="image6" alt="Green" /></td>
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<td><strong>Pelvis</strong></td>
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<td><img src="image24" alt="Green" /></td>
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**Notes:**
- **Green** indicates coplanar 6 axes.
- **3aω** indicates specific axes.
- **ARS** indicates regional axes of significance.
### Head, Neck, Spine, and Pelvis

#### ATD vs. PMHS

**THOR-50M** | **BioRID II** | **HIII-50th** | **PMHS**
---|---|---|---
**Head** | ![THOR-50M](image1) | ![BioRID II](image2) | ![HIII-50th](image3) | ![PMHS](image4)
**C2/4/6** | N/A | ![HIII-50th](image3) | ![PMHS](image4) | ![PMHS](image4)
**T1** | ![THOR-50M](image1) | ![THOR-50M](image1) | ![PMHS](image4) | ![PMHS](image4)
**T4** | N/A | N/A | ![PMHS](image4) | ![PMHS](image4)
**T8** | N/A | ![PMHS](image4) | ![PMHS](image4) | ![PMHS](image4)
**T12** | ![THOR-50M](image1) | ![THOR-50M](image1) | ![PMHS](image4) | ![PMHS](image4)
**L1** | N/A | N/A | ![PMHS](image4) | ![PMHS](image4)
**Pelvis** | ![THOR-50M](image1) | ![BioRID II](image2) | ![HIII-50th](image3) | ![PMHS](image4)

- Green: Coplanar 6aω
- Red: 3aω
- Blue: ARS
- Green with a yellow dot: Biaxial accelerometers (x, z) and one ARS (y)
### Head, Neck, Spine, and Pelvis

#### ATD vs. PMHS

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- **Coplanar 6a_ω**
- **3a_ω**
- **ARS**
- **Biaxial accelerometers (x, z) and one ARS (y)**
- **Biaxial accelerometers (x, z)**

Biaxial accelerometers (x, z)
### Head, Neck, Spine, and Pelvis

**ATD vs. PMHS**

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**Pelvis**

- Coplanar 6\(\omega\)
- 3\(\omega\)
- ARS
- Biaxial accelerometers (x, z) and one ARS (y)
- Biaxial accelerometers (x, z)
Head, Neck, Spine, and Pelvis
ATD vs. PMHS

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- ▶️: Coplanar 6a₀
- 3a₀
- ARS
- Biaxial accelerometers (x, z) and one ARS (y)
- Biaxial accelerometers (x, z)
Instrumentation Plan

Chest deflection

- 25 deg recline
- 45 deg recline

THOR Injury Criteria Report
NHTSA (unpublished)
Thorax
Chest Deflection

45.0

24.2 mm @ 45.00 ms

50.0

45.7 mm @ 50.10 ms
Thorax
Instrumentation

: Chest band
Thorax
Instrumentation

- Chest band
- Strain Gage

Rib 3 - 9

Rib 3 - 10
**Instrumentation Plan**

**Femur and tibia**

![Graph showing normalized forces for different conditions](image)


- The graph compares forces under 25 deg recline (red bars) and 45 deg recline (gray bars).

- The THOR Injury Criteria Report by NHTSA (unpublished) is referenced.
Seat Pan Interaction with Tibia
Femur and Tibia
Instrumentation

\[ 3a_\omega \]

Strain Gage