Evaluation of a HIC Component Test Device

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Introduction

Purpose: To develop an approved method for evaluating the Head Injury Criteria (HIC) by means of a component level test; e.g., a method that does not require a full scale sled test using ATDs and complete seat installation representation.

Goals: The HCTD should provide the following benefits:

- Reduce costs of demonstrating compliance with HIC for "562" certified seat/installations
- Provide a method for seat manufacturers to expedite design and testing of HIC-related factors prior to certification, and to use data from the HCTD to support approval for certification.
- Develop materials/structures specifications for items that affect HIC results.

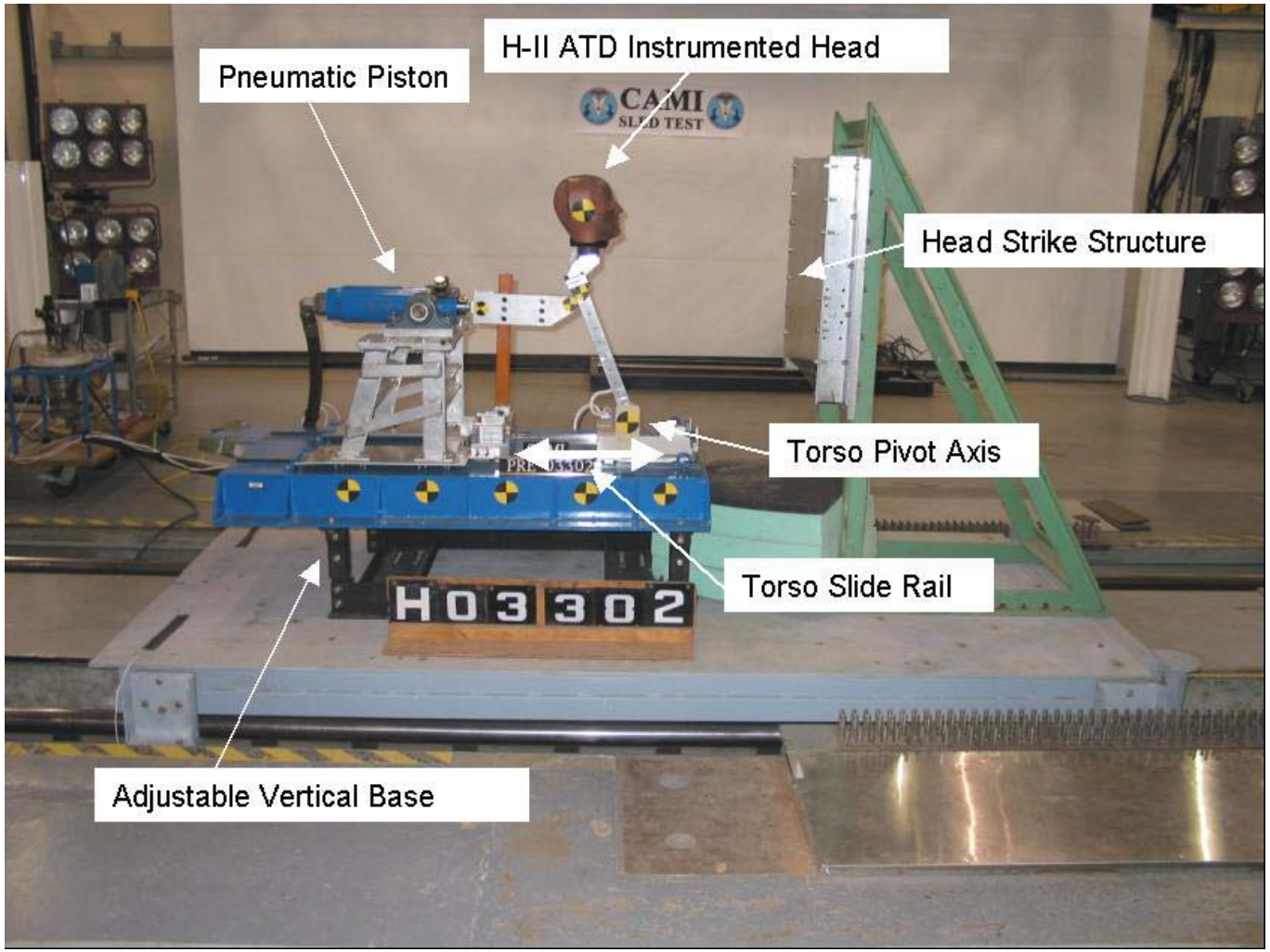
Background

- The HCTD project was initiated under a contract between the FAA Technical Center and National Institute for Aviation Research in 1999.

- The HR-1000 “Streamlining” goals identified the HCTD as a priority. The system hardware was transferred to CAMI in December 2002.

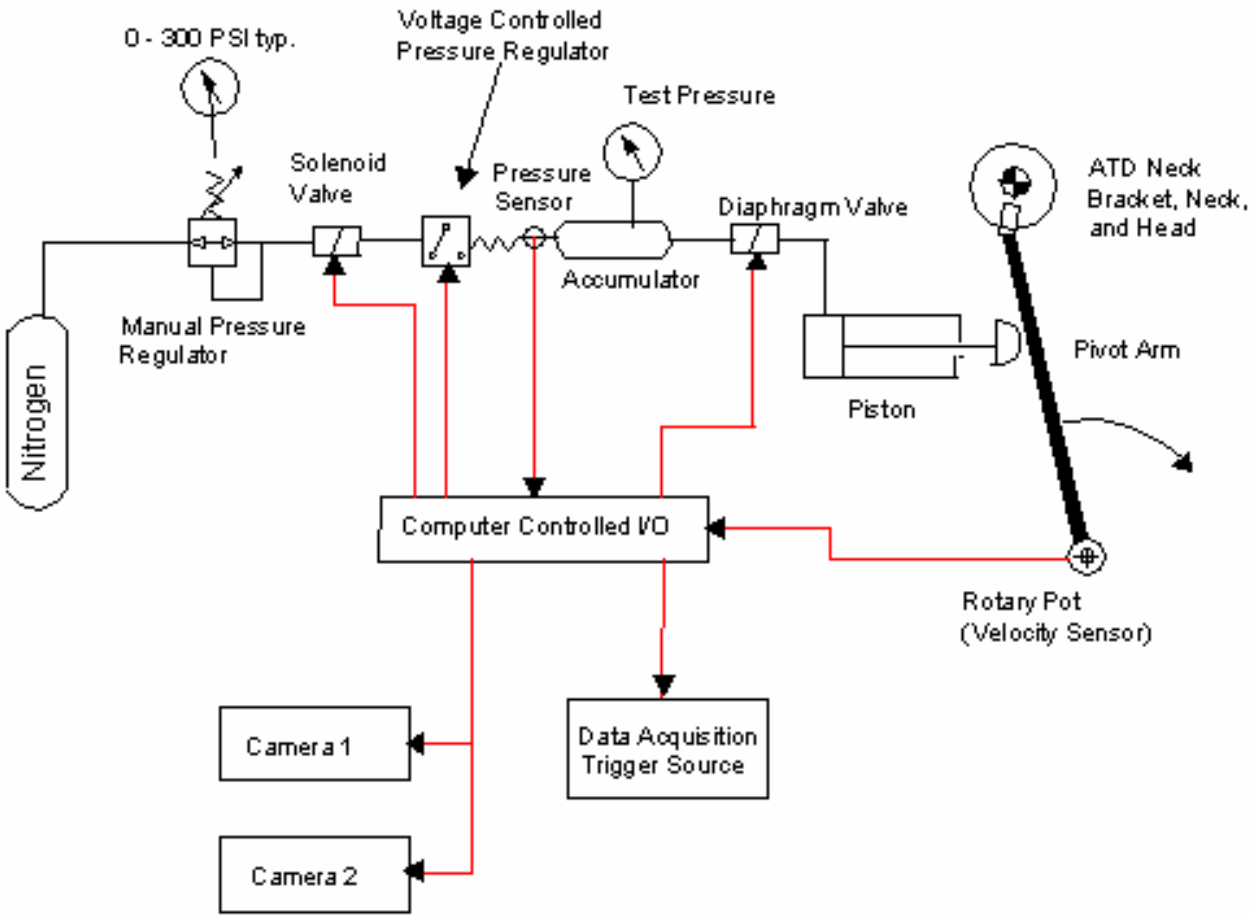
- Research, validation, and refinements to the HCTD have been conducted at CAMI, with cooperative inputs and direction from industry representatives and regulatory authorities.

System Description



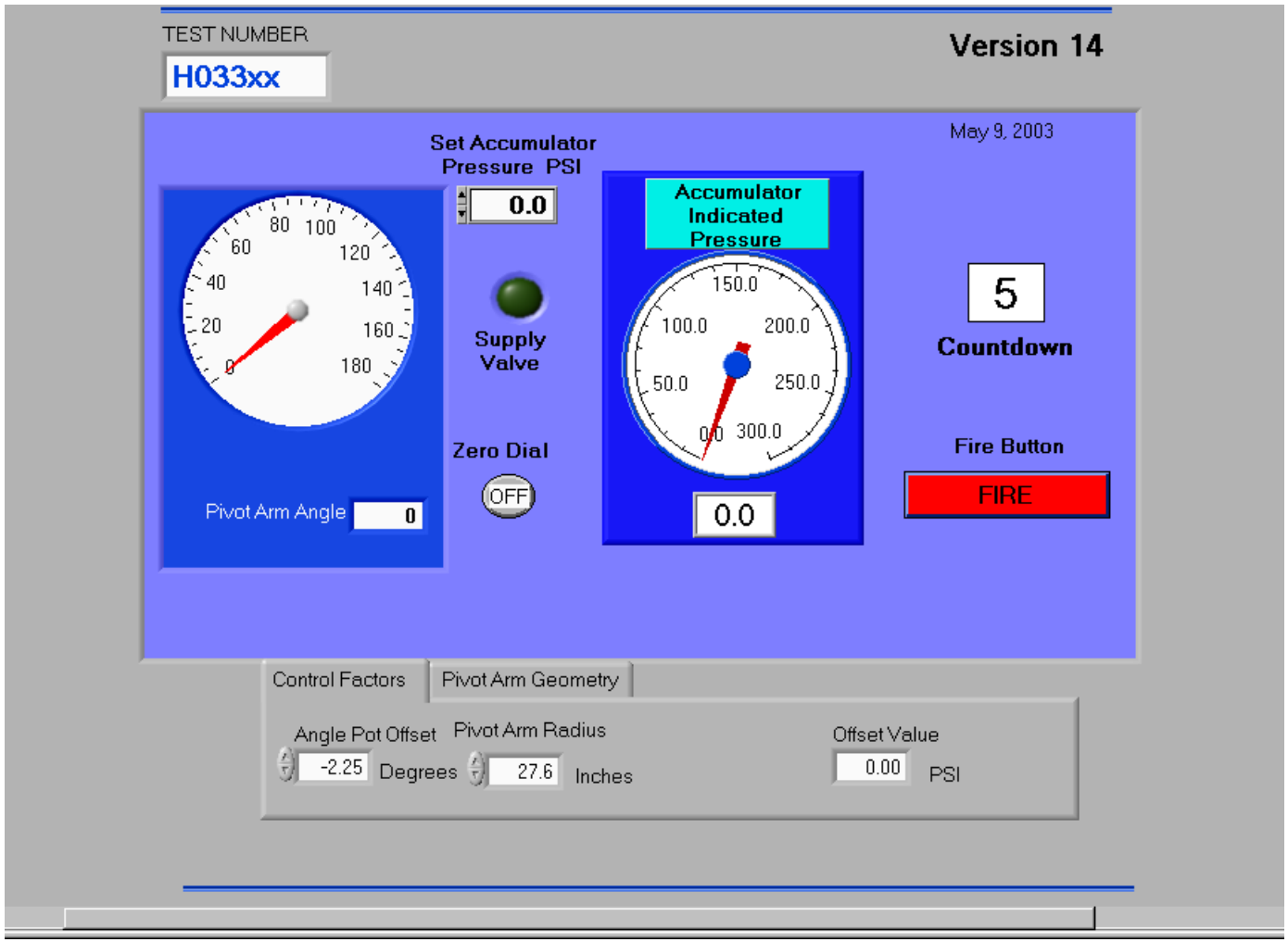
System Description

System Schematic



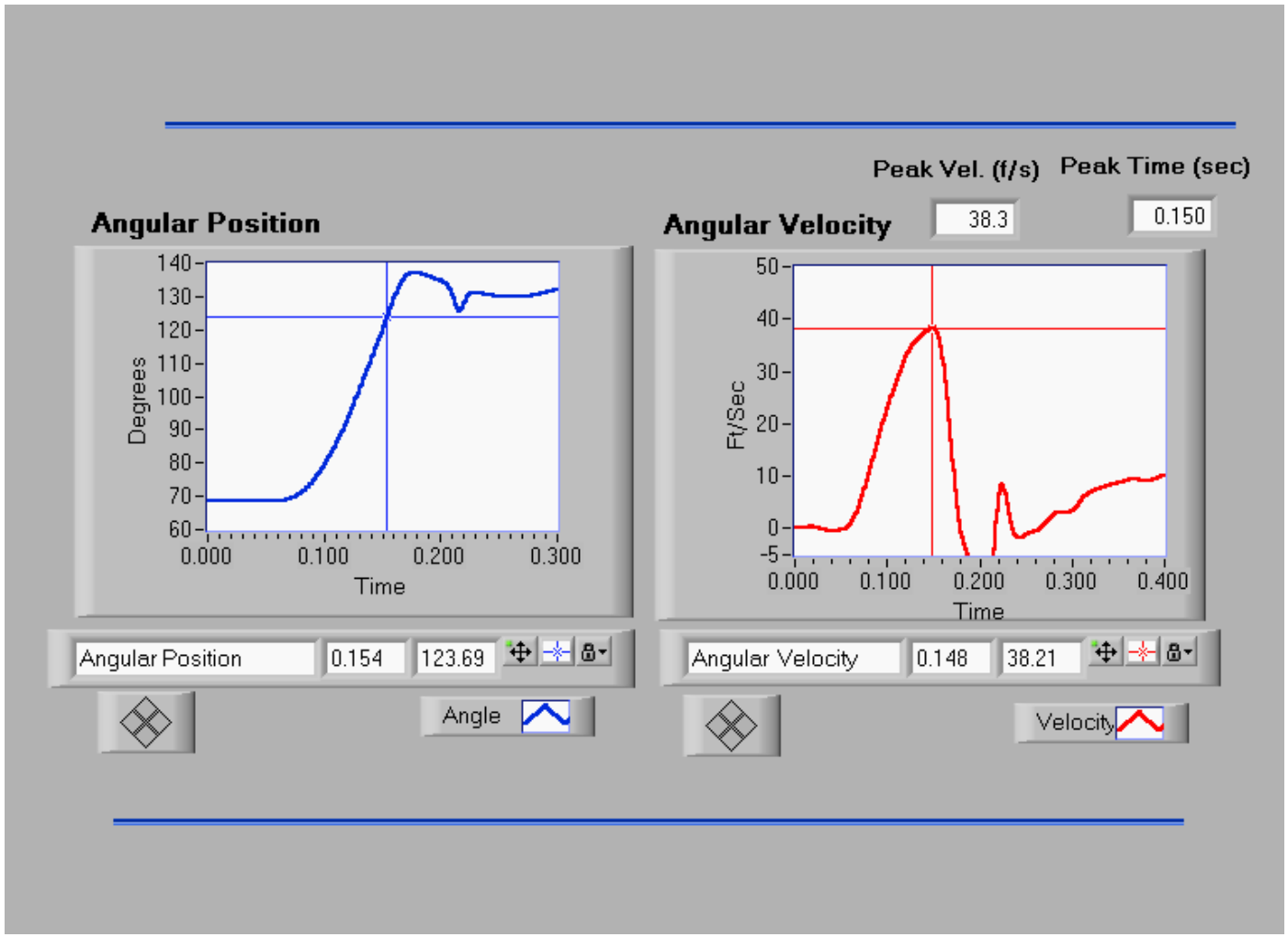
System Description

Data Acquisition – Control Software HCTD Control Software Screen 1



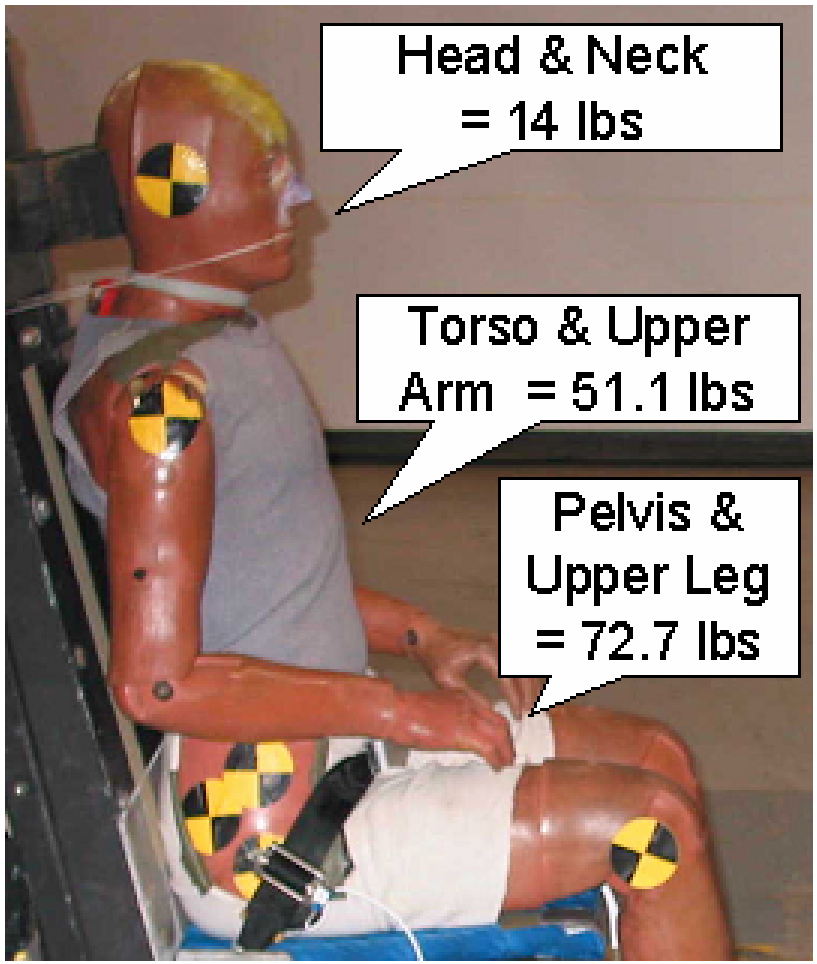
System Description

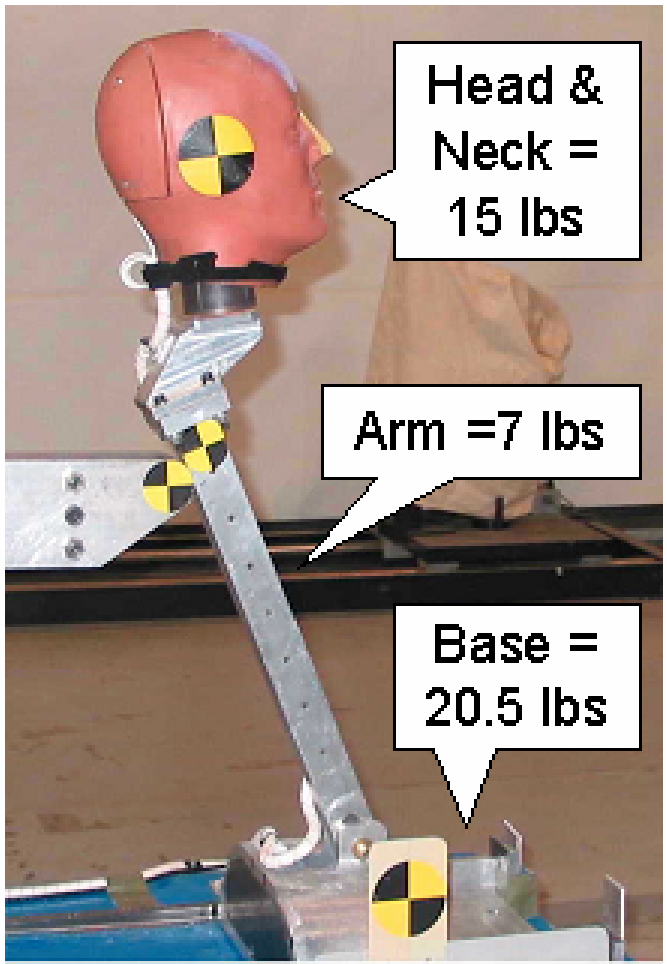
Data Acquisition – Control Software HCTD Control Software Screen 2



System Description

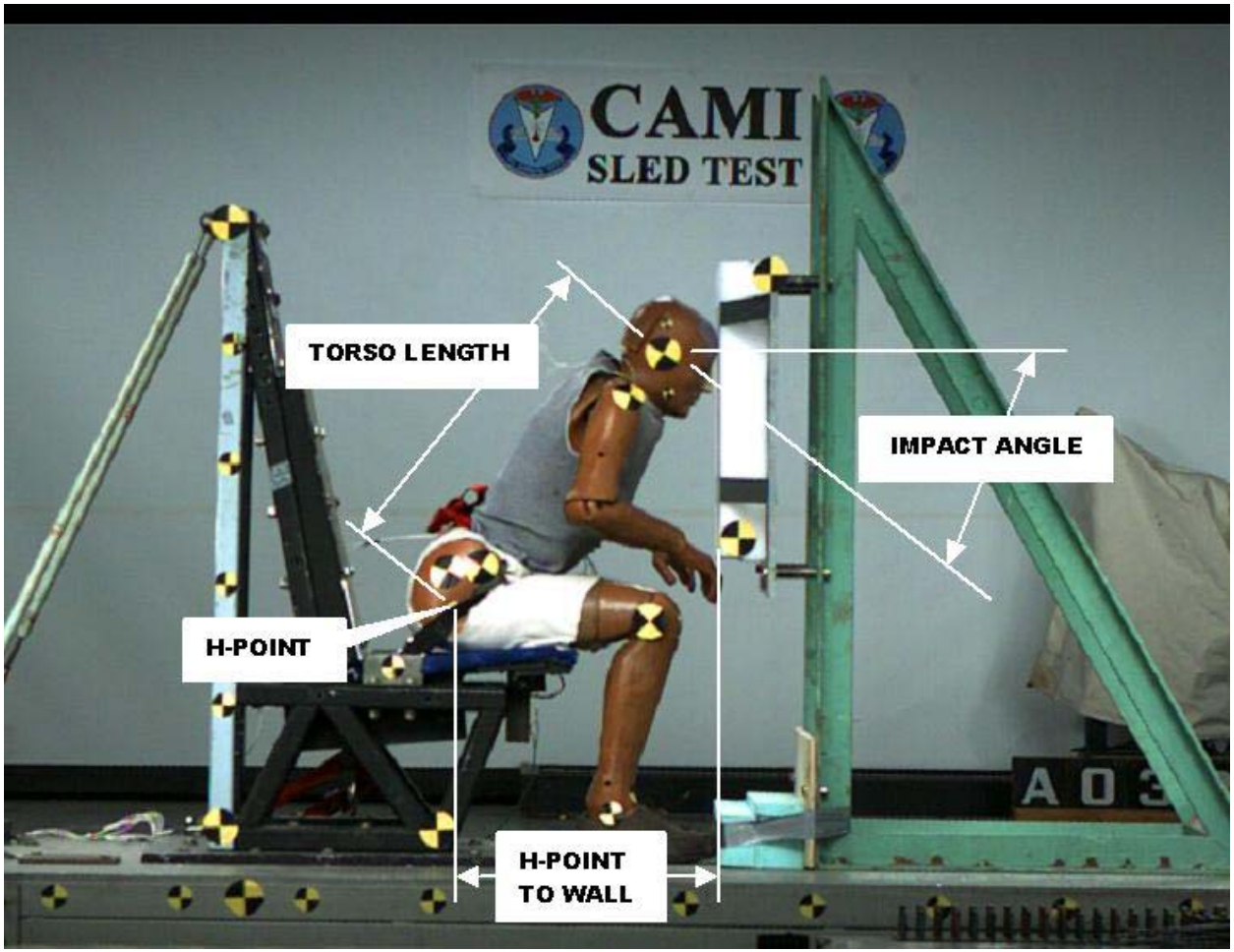
Mass Distribution Comparison





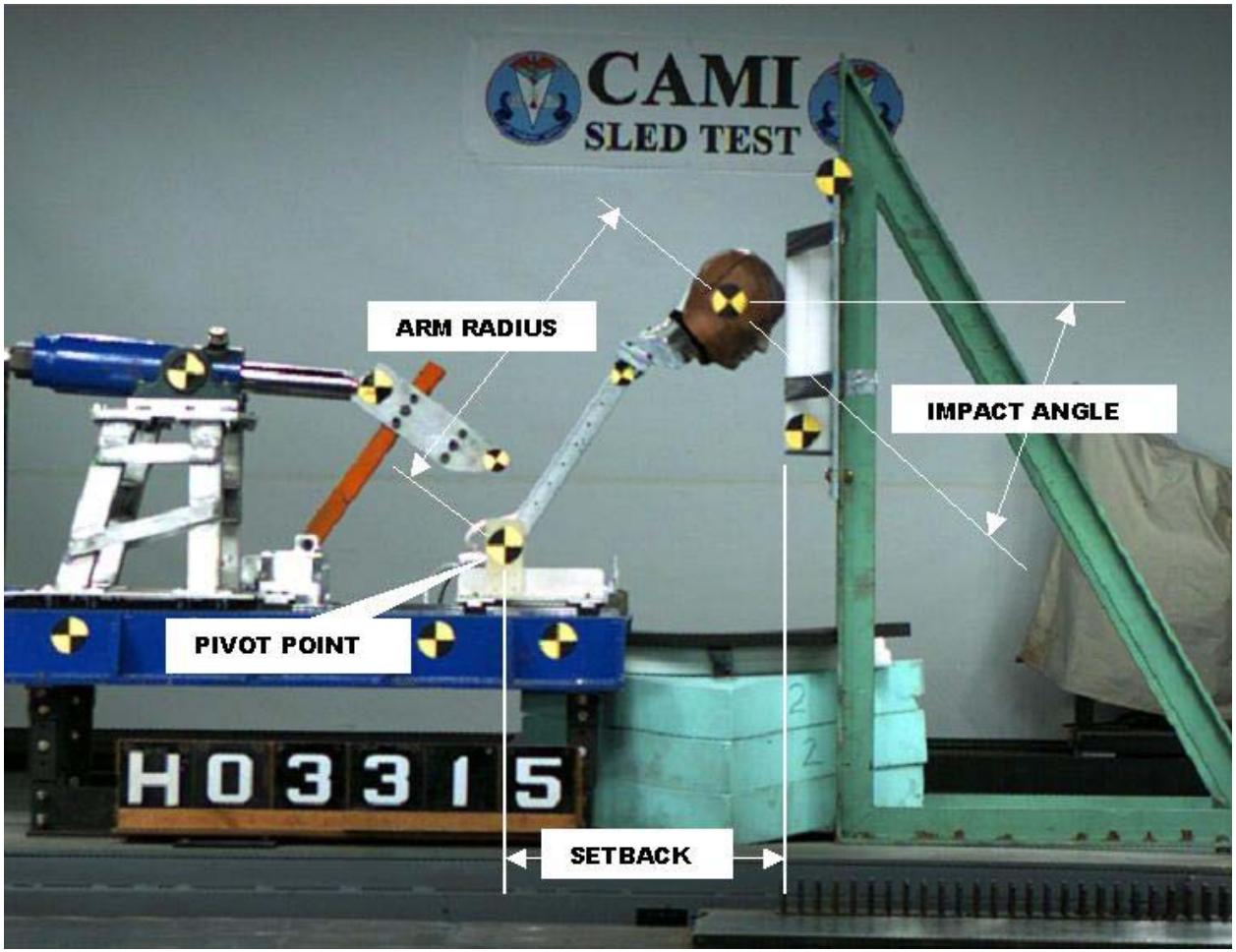
System Description

Sled Test Dimensional Parameters



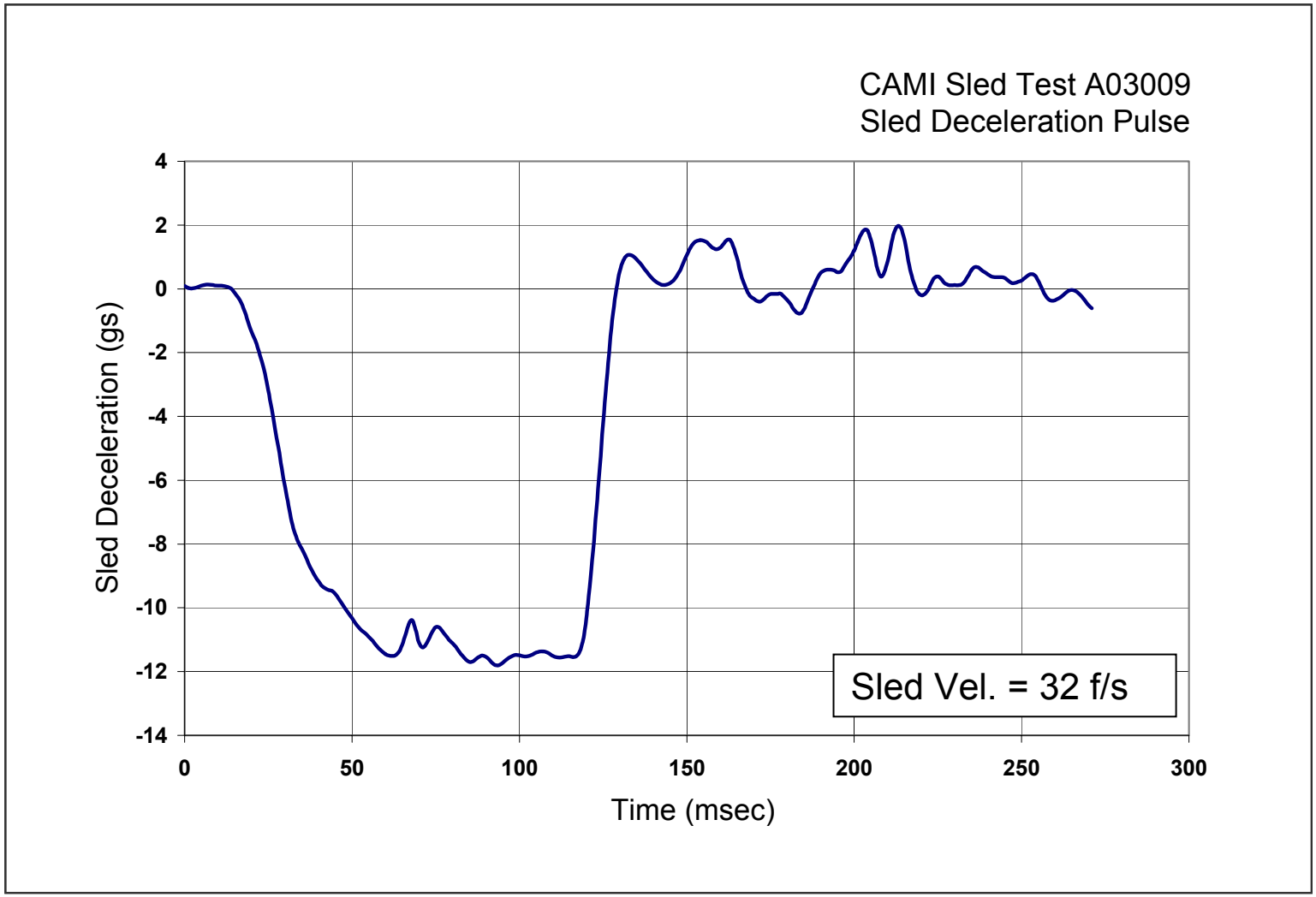
System Description

HCTD Test Dimensional Parameters



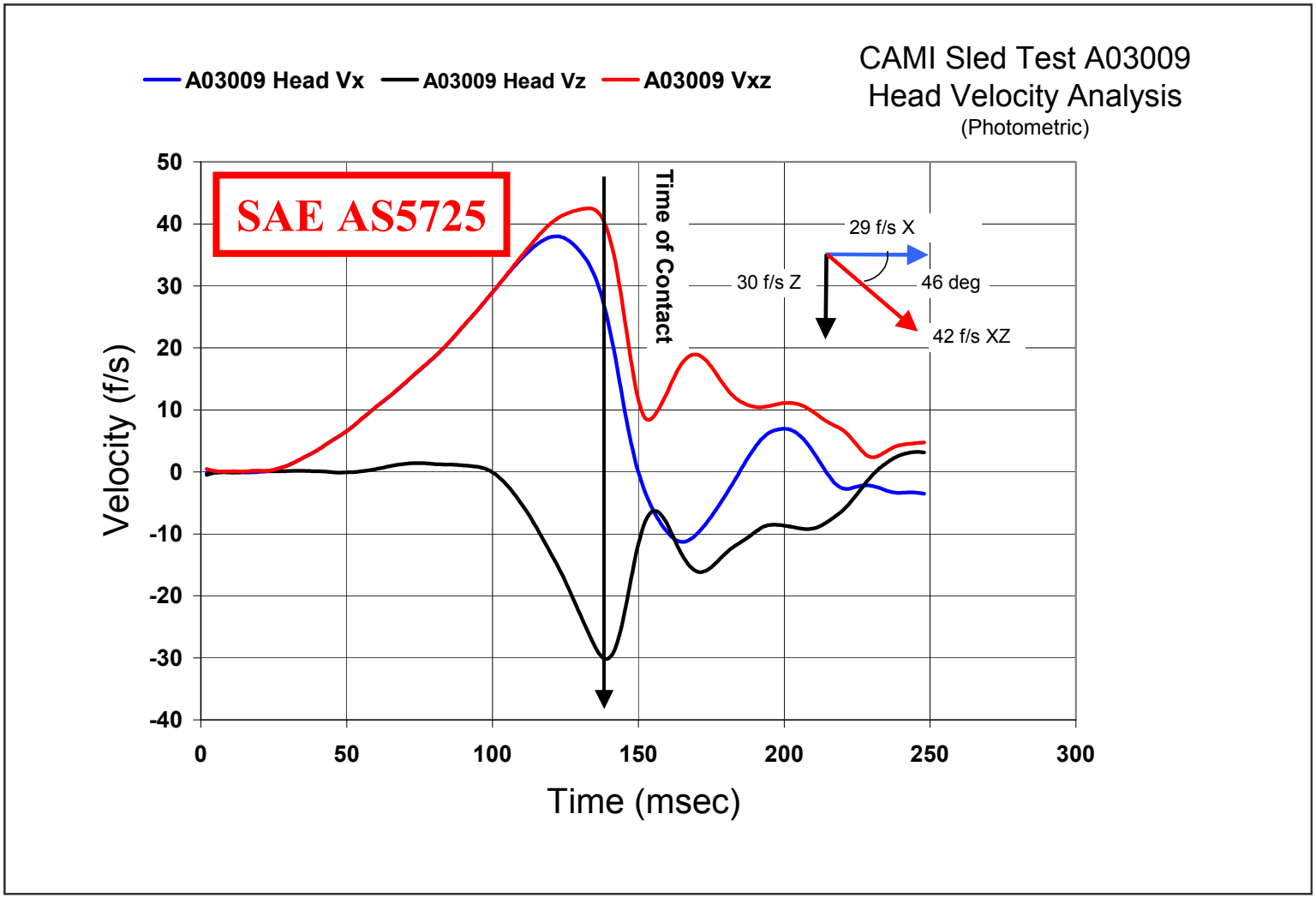
Test Methods

Example sled impact pulse designed to achieve a head impact velocity of ~ 41 f/s



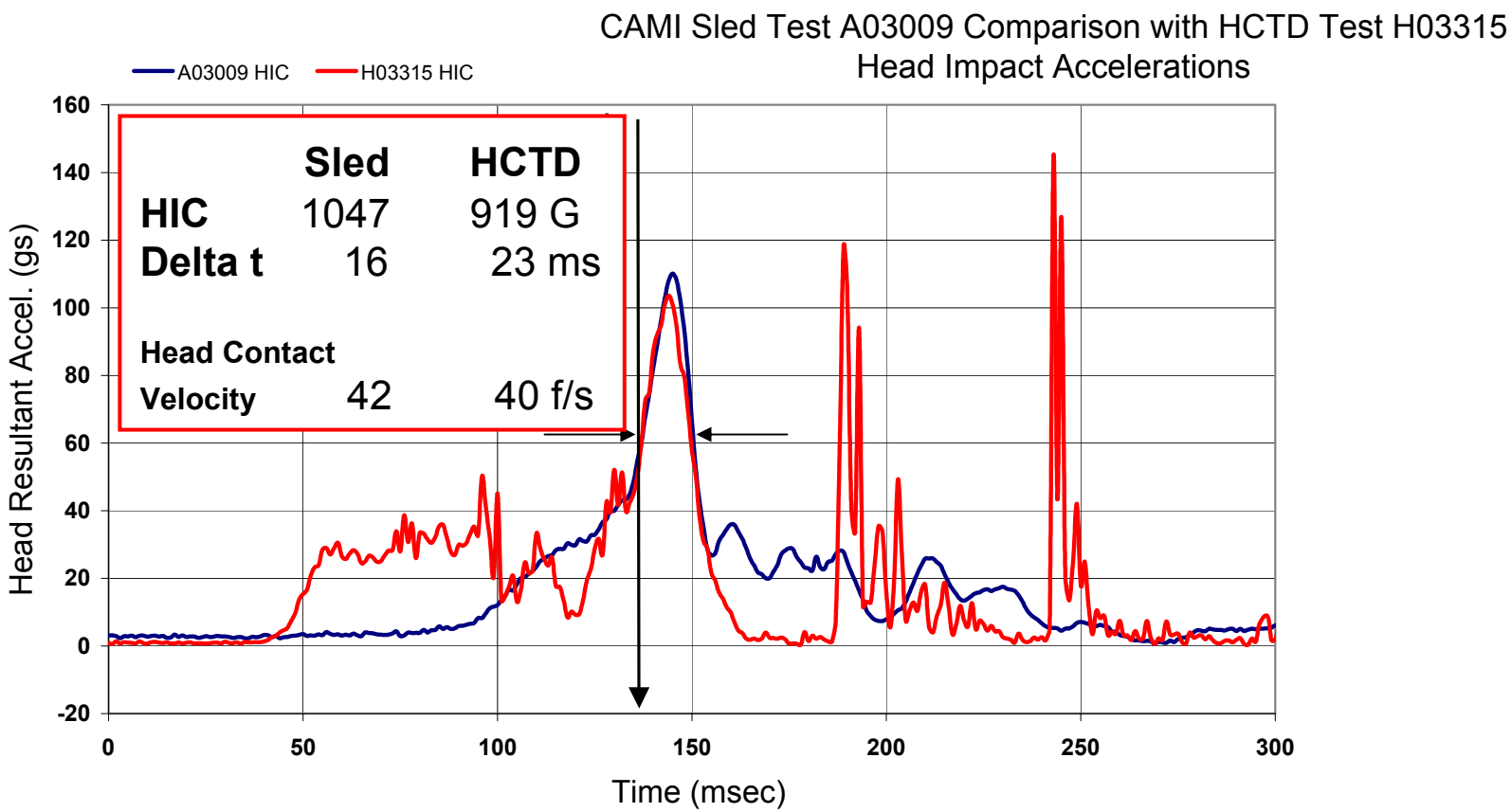
Test Methods

Example (cont'd) Photometric analysis of head velocity

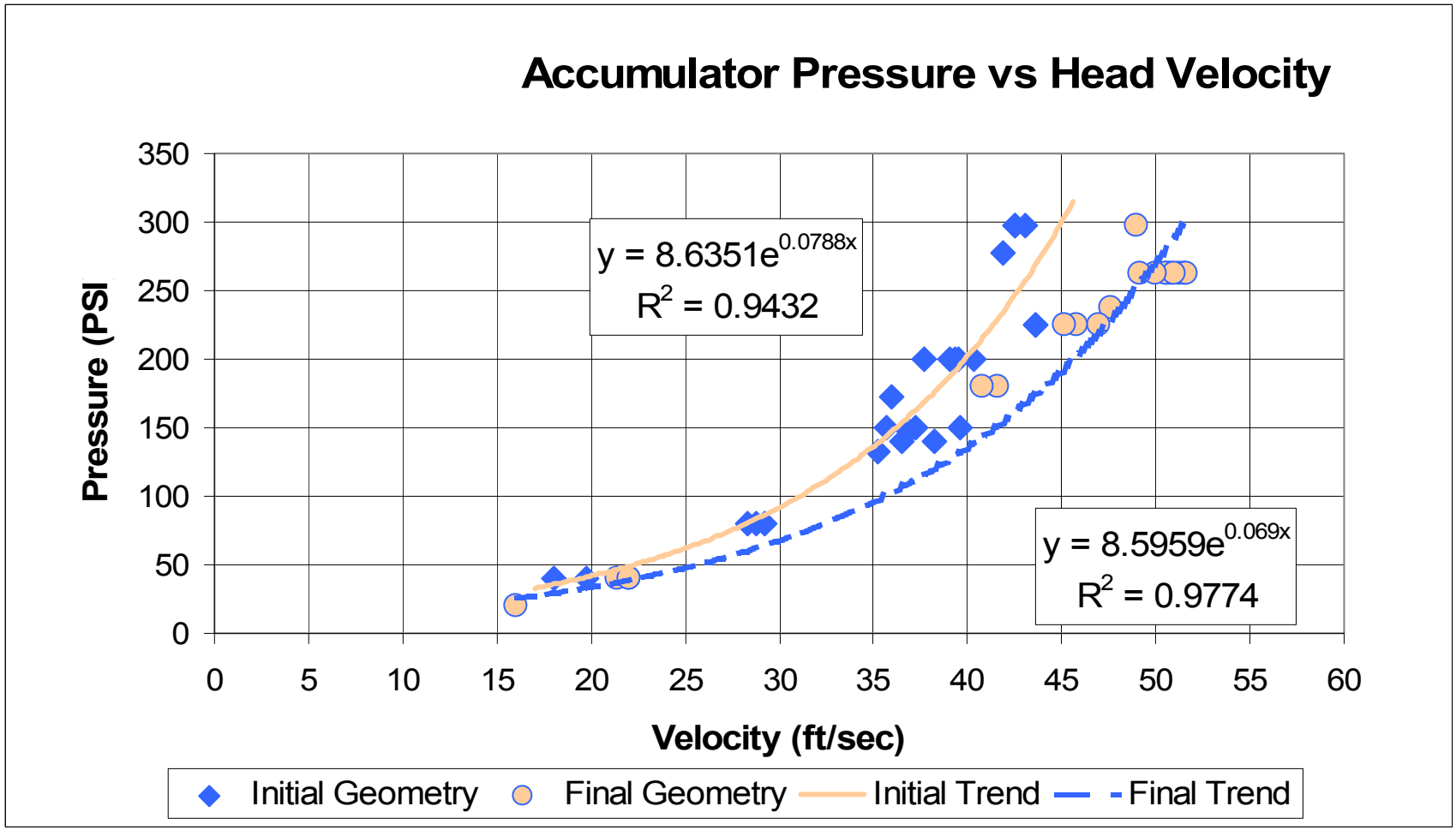


Test Methods

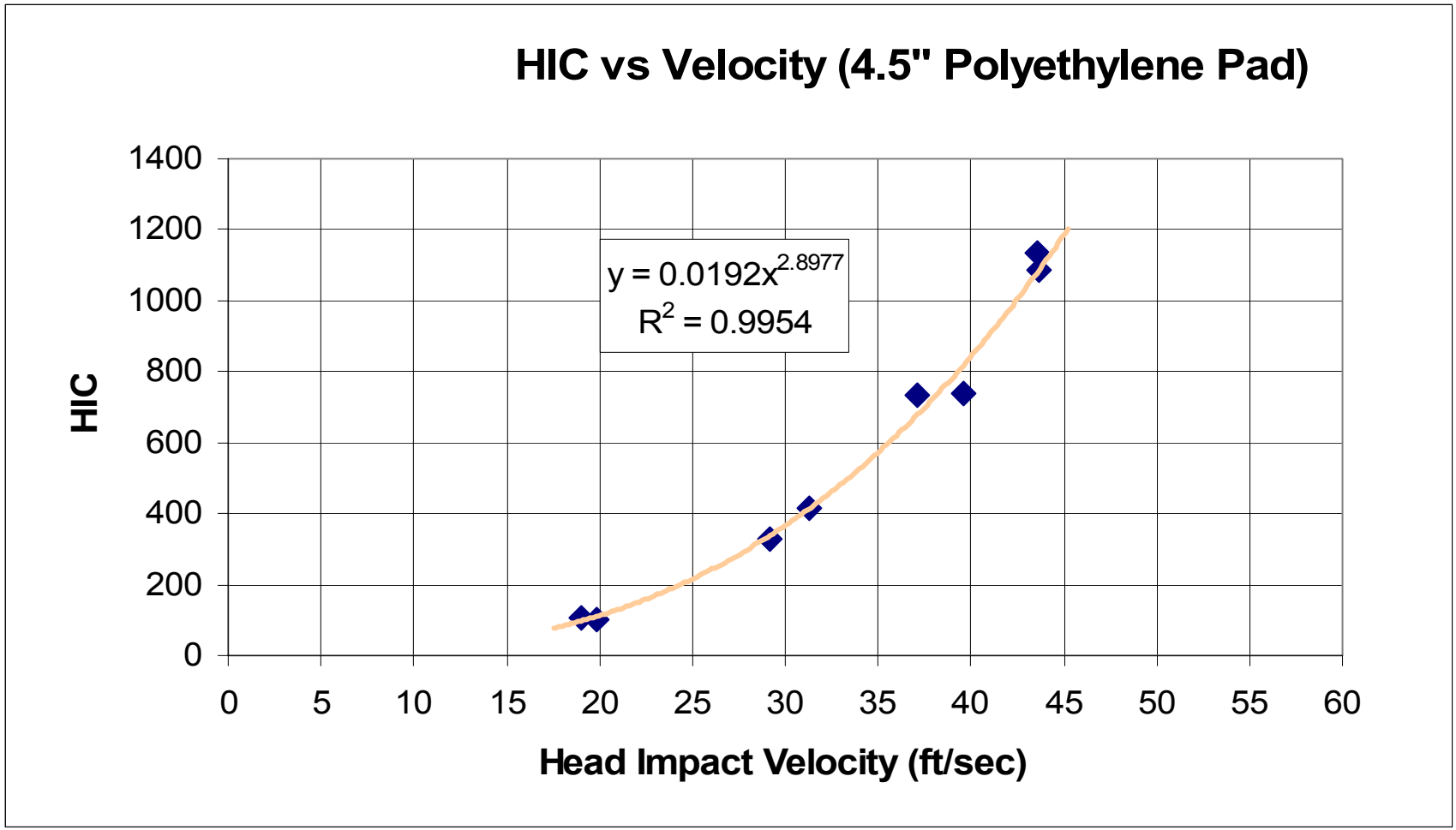
Example (cont'd) Comparison of sled test and HCTD head impacts



Predictability and Repeatability Tests



Predictability and Repeatability Tests



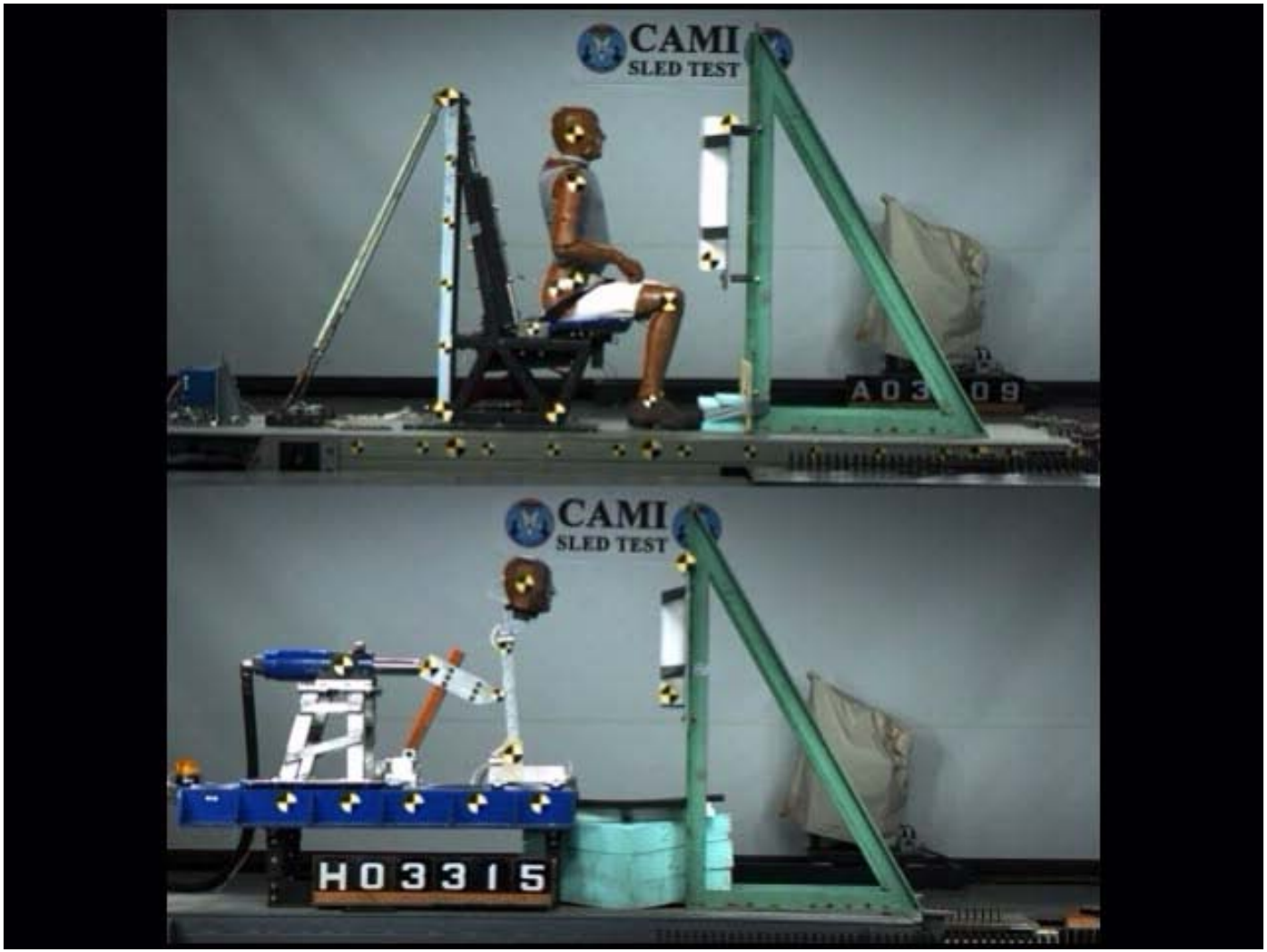
Representative Aircraft Interior Surface Tests

Polyethylene Foam Pad

4” Thick

A03009

H03315



Representative Aircraft Interior Surface Tests

Polyethylene Foam Pad (4” Thick)				
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)
A03007	32.2	45.7 °	304	28
A03008	32.6	46.7 °	302	29
H03316	28.3	43.0 °	401	19
A03011	38.7	40.6 °	668	17
A03013	38.7	40.6 °	699	21
H03314	36.9	43.0 °	756	18
A03009	42.4	41.6 °	1047	16
A03010	43.8	42.9 °	1045	16
H03315	40.3	43.0 °	919	23
H03317	39.5	43.0 °	943	15
H03318	39.0	43.0 °	874	17
H03319	39.3	43.0 °	923	17

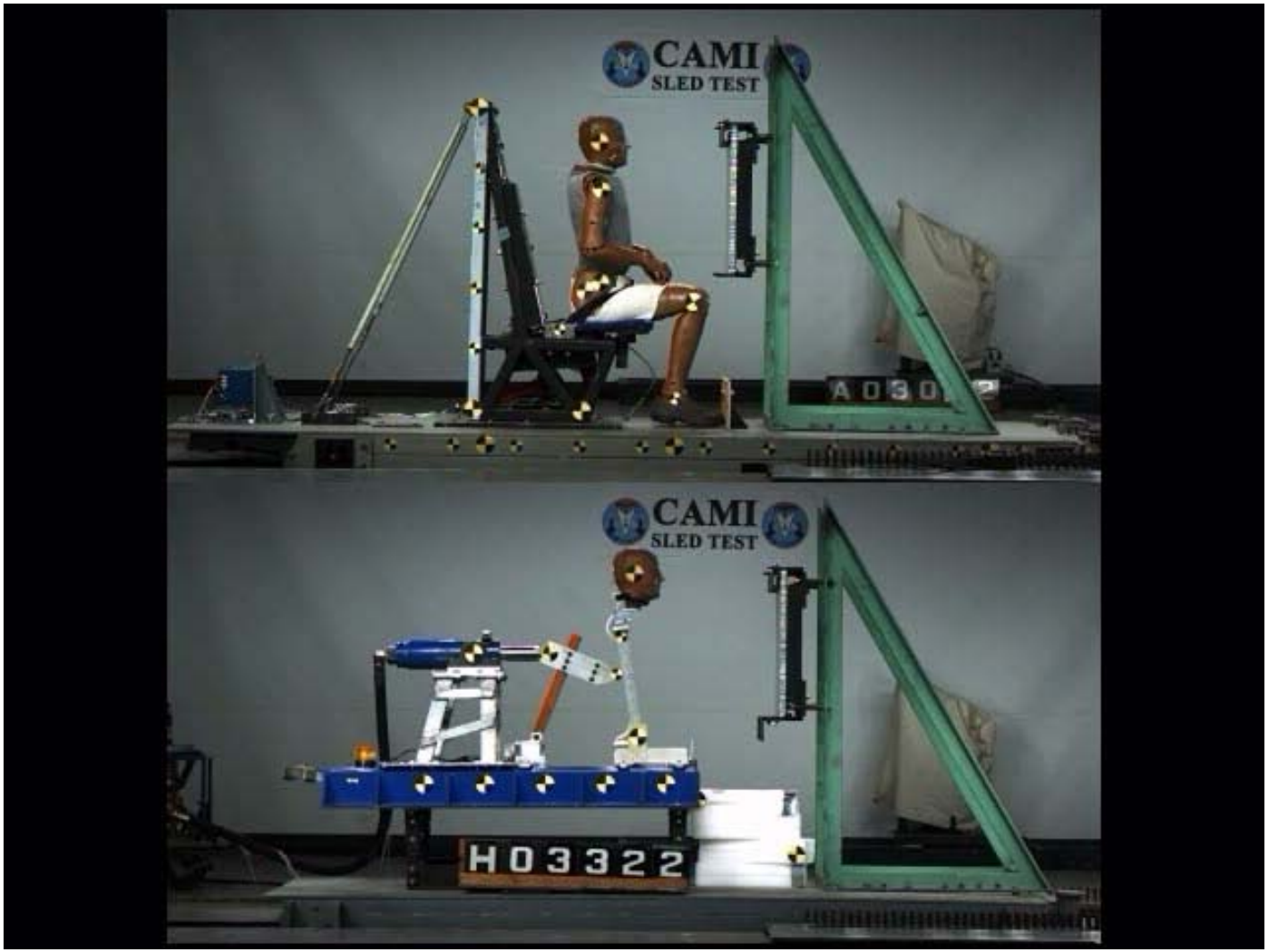
Representative Aircraft Interior Surface Tests

Fiberglass Faced Aluminum Honeycomb

24” x 24” Panel

A03022

H03322



Representative Aircraft Interior Surface Tests

Aluminum Honeycomb Panel (24” x 24”) – Framed Support				
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)
A03022	42.1	42.4 °	773	20
H03322	41.9	42.4 °	727	26
A03023	46.3	38.4 °	1010	21
H03329	45.8	37.9 °	803	26

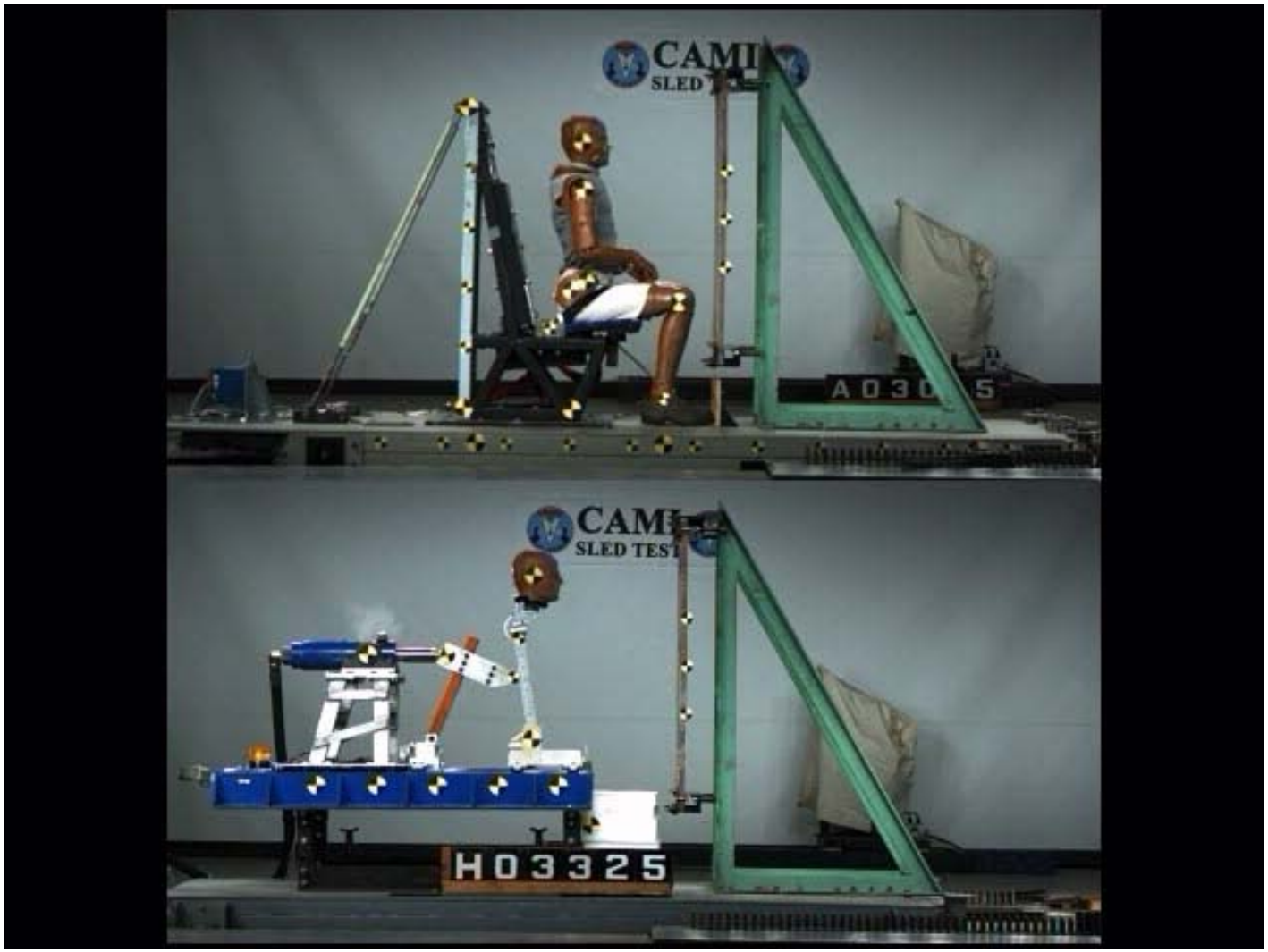
Representative Aircraft Interior Surface Tests

Narrow Fiberglass Faced Nomex Honeycomb

24” x 48” Panel

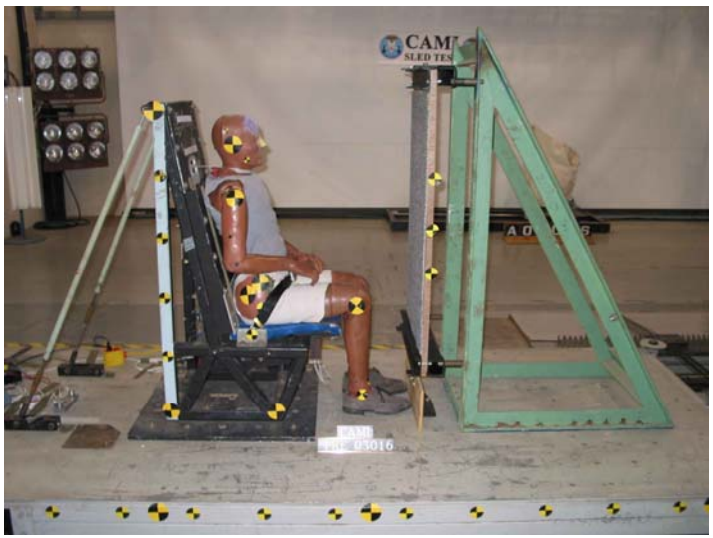
A03015

H03325



Representative Aircraft Interior Surface Tests

Narrow, Nomex Honeycomb Panel (24” x 48”) Top and Bottom Support				
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)
A03015	38.0	44.6 °	1110	17
A03018	37.9	44.1 °	944	16
H03325	37.7	44.9 °	389	5



Representative Aircraft Interior Surface Tests

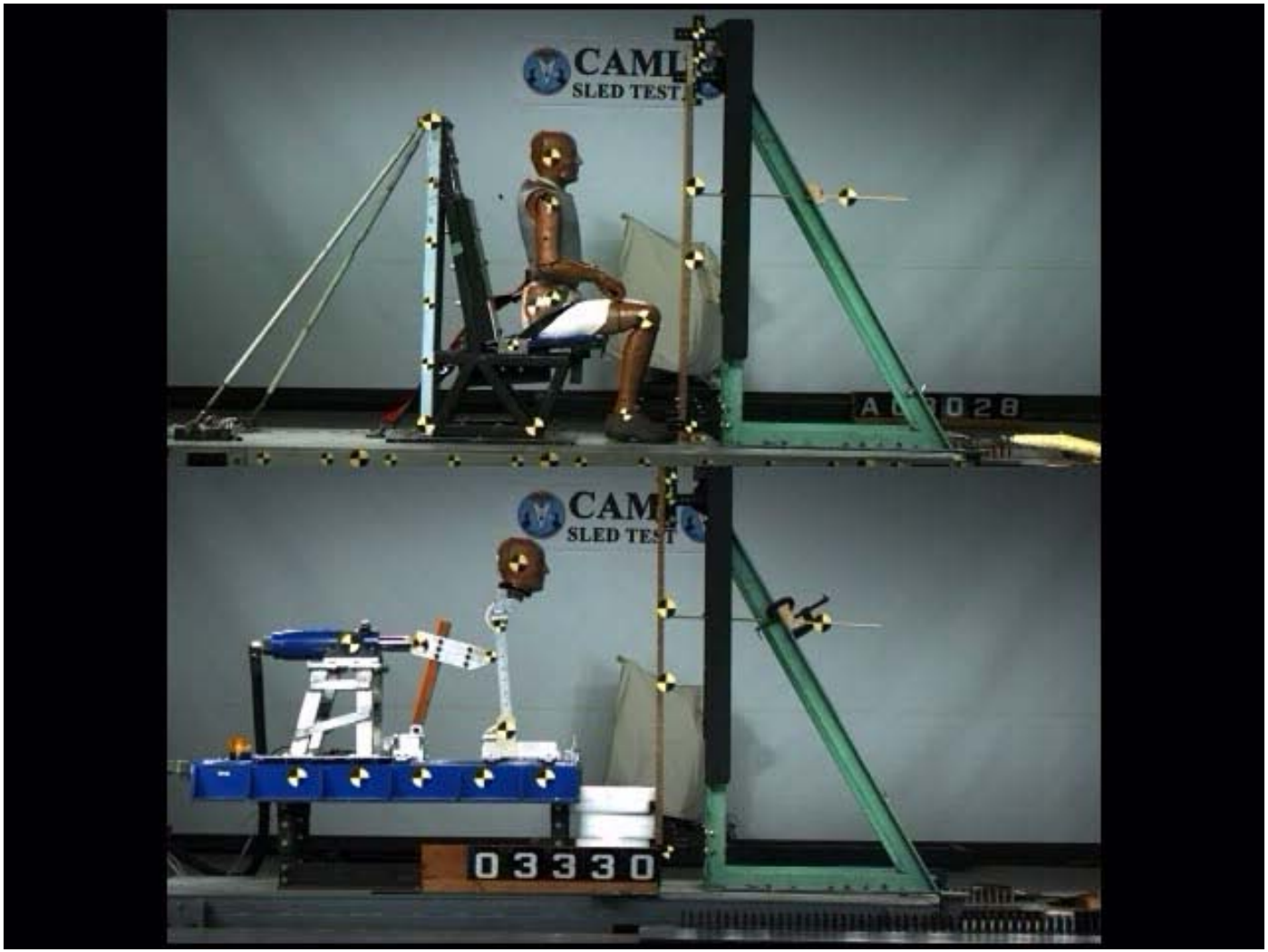
Wide, Nomex Honeycomb Panel (48” x 48”) Supported at Corners				
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)
A03004	44.7	53.2 °	1084	7
H03320	47.6	53.0 °	1421	23

Representative Aircraft Interior Surface Tests

Narrow-Body Class Divider Panel

A03028

H03330



Representative Aircraft Interior Surface Tests

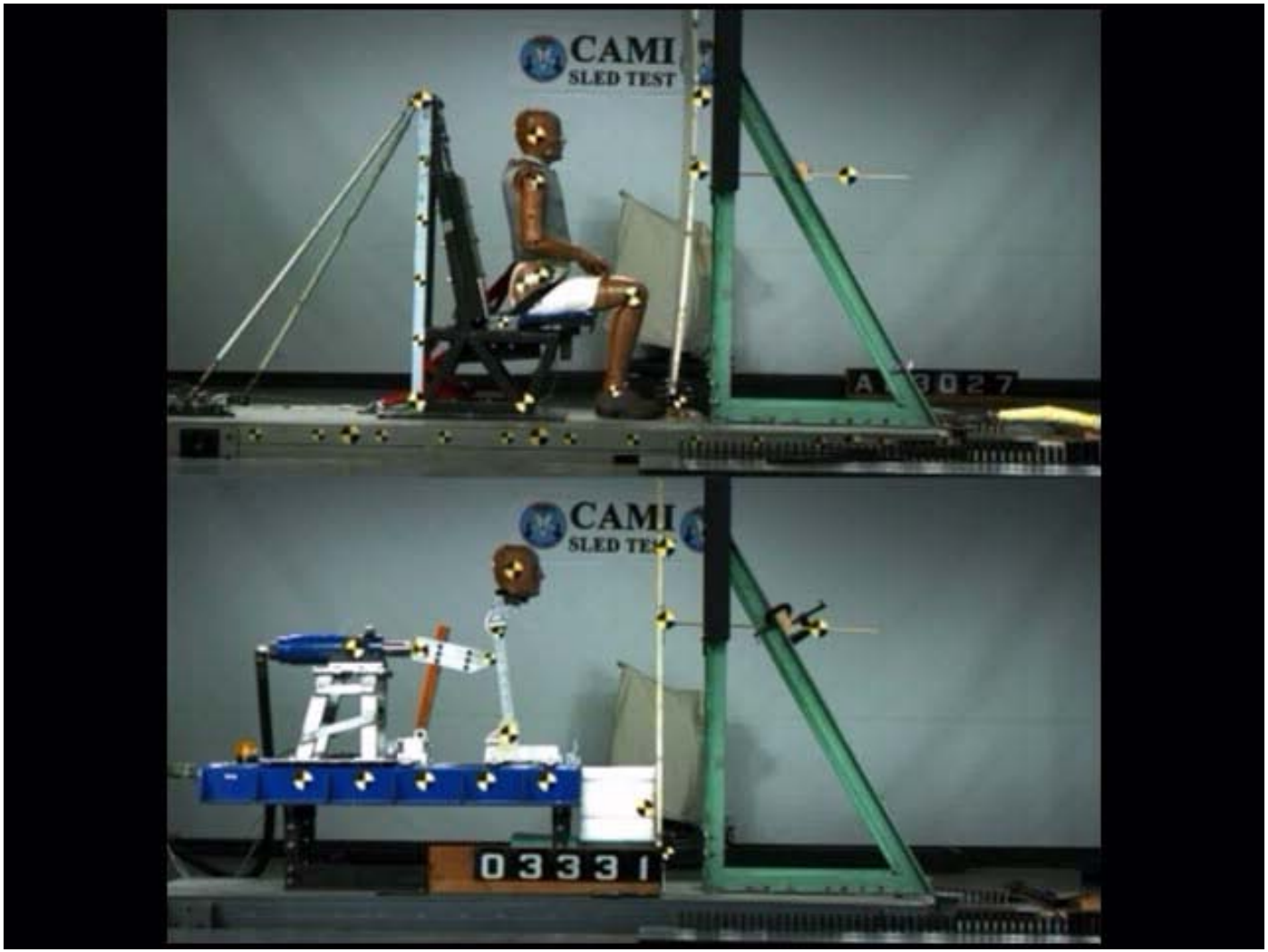
Narrow-Body Class Divider Panel Top and Bottom Attachments				
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)
A03028	41.6	43.8 °	458	34
H03330	41.6	44.0 °	286	36

Representative Aircraft Interior Surface Tests

Wide-Body Class Divider Panel

A03027

H03331



Representative Aircraft Interior Surface Tests

Wide-Body Class Divider Panel Top and Bottom Attachments				
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)
A03027	40.5	45.8 °	1547	5
A03034	41.3	49.5 °	1598	11
H03331	40.8	44.0 °	671	9

Representative Aircraft Interior Surface Tests

Energy Absorbing Seatback

Without Video/Phone

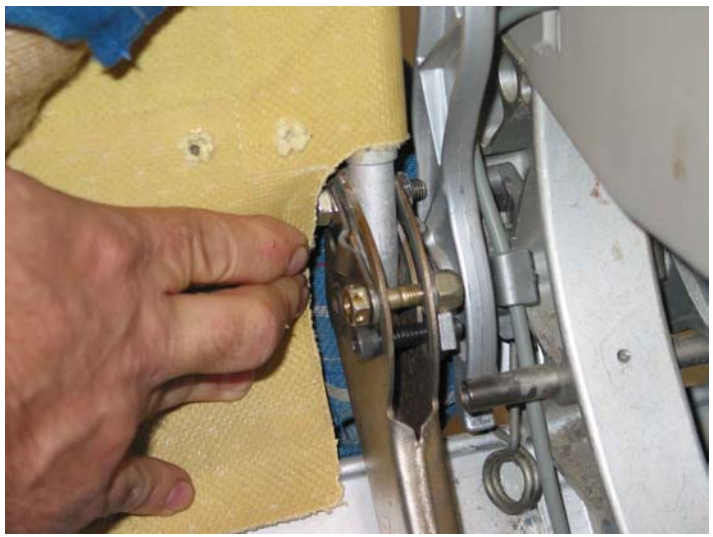
A03030

H03332

Representative Aircraft Interior Surface Tests

Seat to Seat (Head Contact with Seatback) Energy Absorbing Seatback (No Video/Phone)					
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)	HCTD Seatback Pre-Load
A03030	48.6	30.6 °	639	30	
H03332	49.0[1]	33.3 °	325	10	68 lbs – 4.4 inches

(1) HCTD velocity goal was 4.0 Ft/Sec greater than the sled test to account for aftward seatback motion at time of impact



Representative Aircraft Interior Surface Tests

Energy Absorbing Seatback

With Video/Phone Mock-up

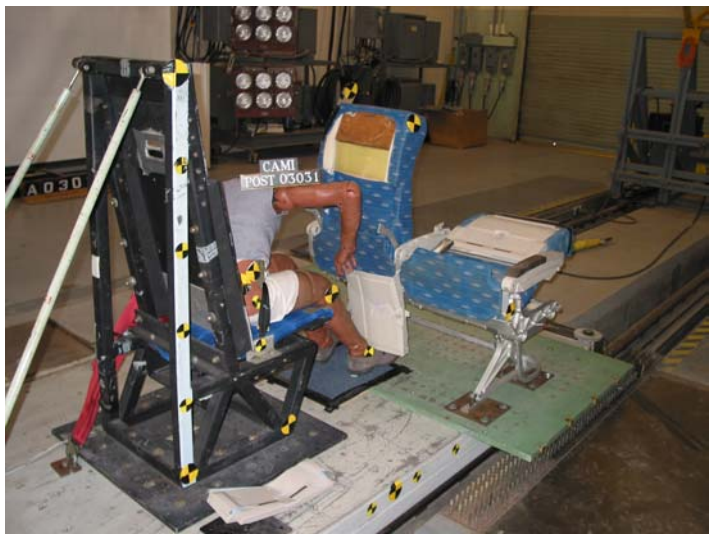
A03032

H03333

Representative Aircraft Interior Surface Tests

Seat to Seat (Head Contact with Seatback) Energy Absorbing Seatback (With Video/Phone Mockup)					
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)	HCTD Seatback Pre-Load
A03032	49.2	35.2 °	789	5	
H03333	45.2[1]	37.2 °	753	6	148 lbs – 12.1 inches

(1) HCTD velocity goal was 3.7 Ft/Sec less than the sled test to account for forward seatback motion at time of impact



Representative Aircraft Interior Surface Tests

Centered Impact Point

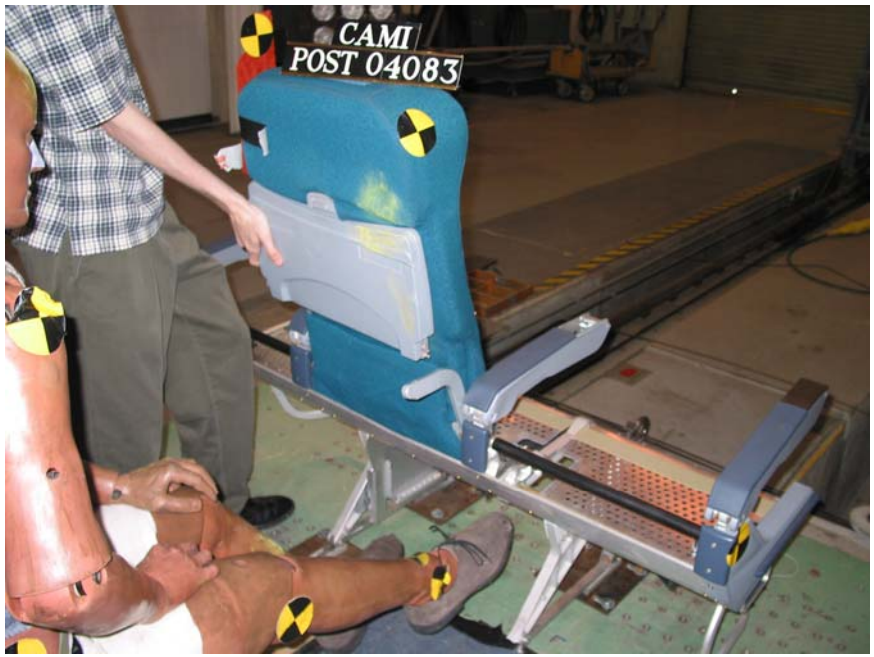
On Centerline

3” Above Tray Table

Offset Impact Point

6” Right of Centerline

1” Above Tray Table



Representative Aircraft Interior Surface Tests

Non-Energy Absorbing Seatback

Centered Impact

A04075

H04304

Representative Aircraft Interior Surface Tests

Seat to Seat (Head Contact with Seatback) Non-Energy Absorbing Seatback (Centered Impact Point)					
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)	HCTD Seatback Pre-Load
A04075	47.4	38.5 °	1207	29	
A04076	48.0	38.7 °	1179	25	
A04077	47.4	38.9 °	1255	10	
H04304	51.5[1]	40.0 °	820	12	92 lbs – 1.9 inches
H04305	51.6[1]	40.0 °	805	12	88 lbs – 1.9 inches
H04306	50.5[1]	40.0 °	818	12	98 lbs – 1.9 inches

(1) HCTD velocity goal was 3.4 Ft/Sec greater than the sled test to account for aftward seatback motion at time of impact

Representative Aircraft Interior Surface Tests

Non-Energy Absorbing Seatback

Offset Impact

A04081

H04307

Representative Aircraft Interior Surface Tests

Seat to Seat (Head Contact with Seatback) Non-Energy Absorbing Seatback (Offset Impact Point)					
Test IDs	Head Vel. Ft/Sec	Contact Angle °	HIC	HIC Duration (ms)	HCTD Seatback Pre-Load
A04081	49.2	41.4 °	867	7	
A04082	48.1	42.9 °	907	7	
A04083	48.8	42.8 °	802	11	
H04307	51.0[1]	42.6 °	738	17	110 lbs – 1.9 inches
H04308	50.0[1]	42.6 °	882	19	115 lbs – 1.9 inches
H04309	49.2[1]	42.6 °	674	7	122 lbs – 1.9 inches

(1) HCTD velocity goal was 1.8 Ft/Sec greater than the sled test to account for aftward seatback motion at time of impact

Correlation Results

Key Observations

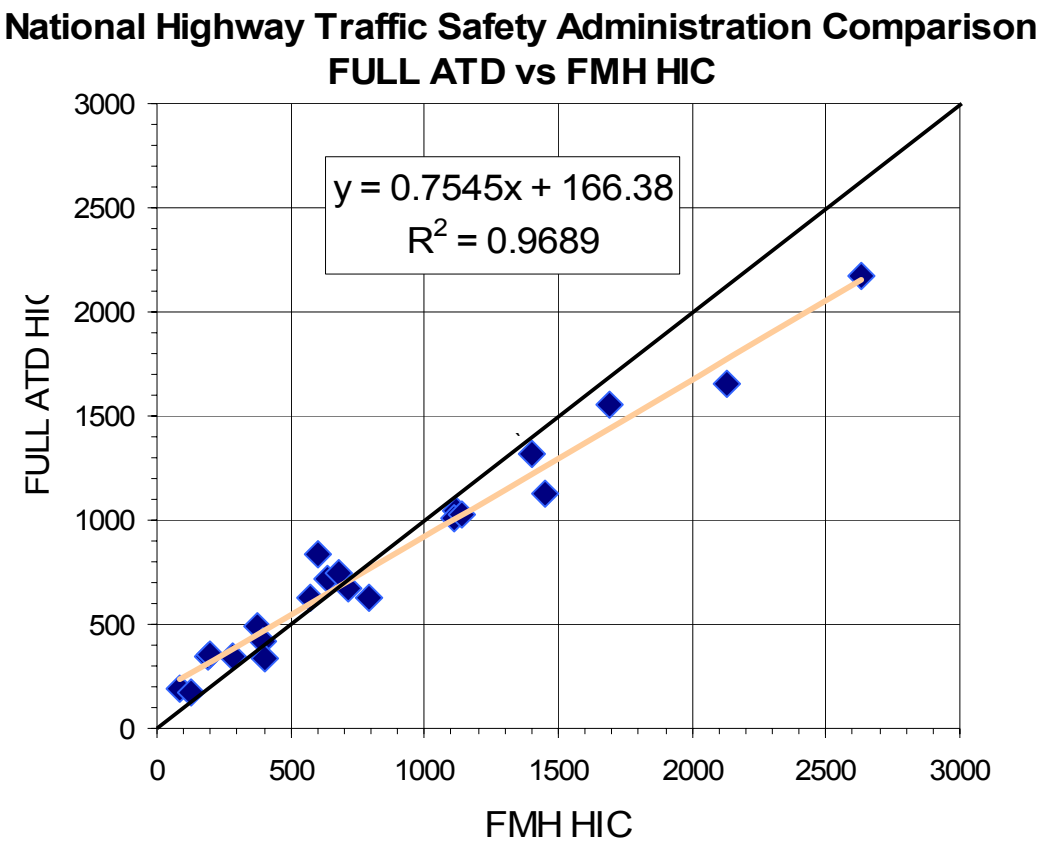
- Not all of the head contact examples tested show a consistent relationship between the HCTD and sled tests results.
- Items with “softer” force / deflection characteristics such as padded rigid walls and energy absorbing seat backs showed good correlation.
- Items that had high initial stiffness such as large panels and non-energy absorbing seat backs did not correlate as well.

Factors Potentially Affecting Correlation

- All of the tests presented in this summary were conducted with a rigid neck connecting the ATD head to the pivot arm.
- The mass distribution of the HCTD is significantly different from the ATD.
- In some test, all of the HCTD test parameters did not exactly match the sled test parameters.

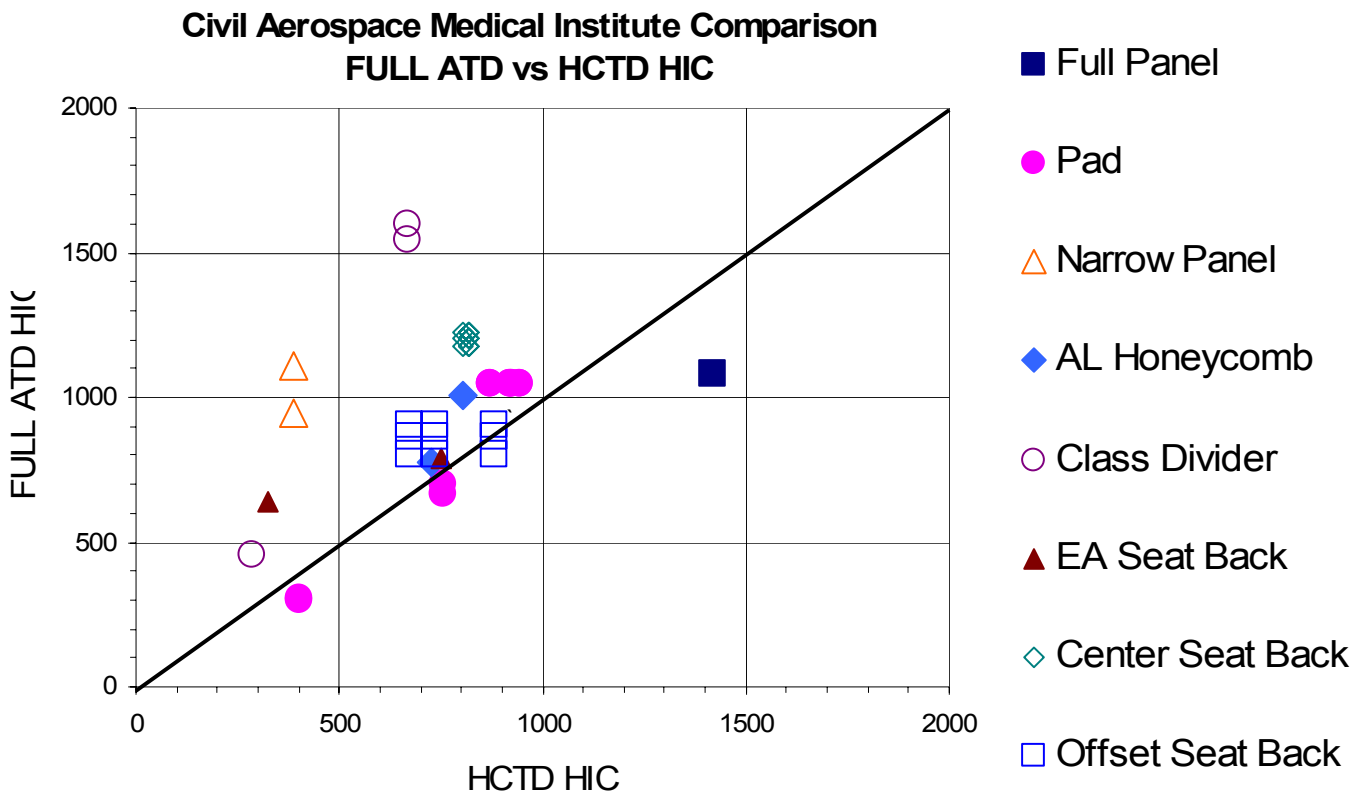
Correlation Results

Free-Motion Head Form Example



Correlation Results

HCTD Data



Validation Criteria Development

Sled Test HIC Repeatability				
Surface	Samples	Sled Decel. (Avg. Peak)	HIC Avg.	HIC Variation
Polyethylene Foam Pad	2	8.9	303	1.1
	2	10.5	684	15.6
	2	11.8	1046	1.4
Narrow Nomex Panel	2	10.0	1027	82.8
Wide-body Class Divider	2	11.3	1573	25.2
Seatback Centered	3	16.3	1204	23.0
Seatback Offset	3	16.6	859	52.9

- HIC repeatability is related to the complexity of the item being struck.
- The degree of correlation that can be achieved between any two test methods is related to the data spread of each method.

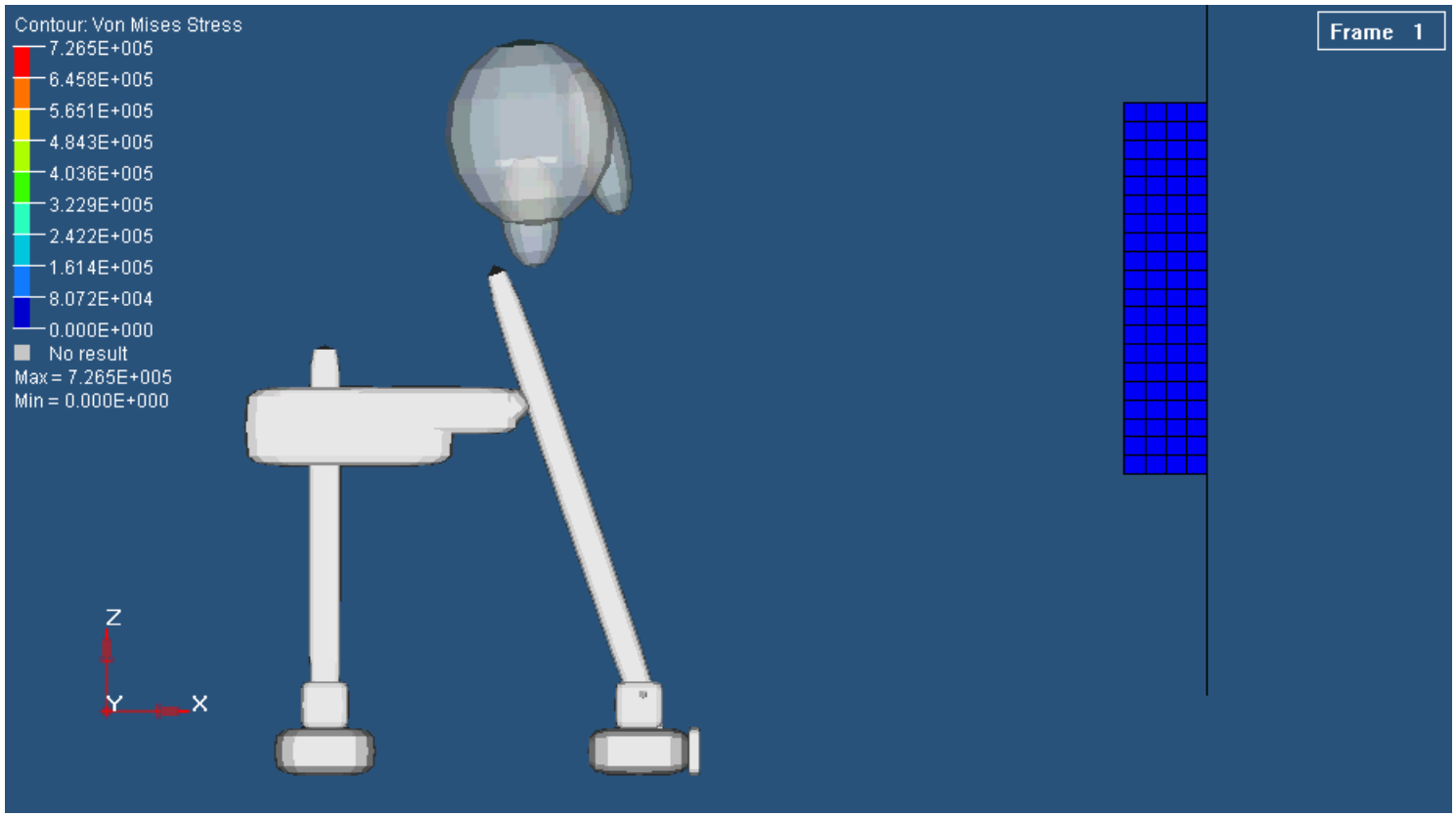
Evaluation of Potential Modifications

Investigate the Factors Affecting Correlation Using a MADYMO Model.

- HCTD model was developed to simulate impacts with polyethylene foam pads for three velocities. Chosen primarily because the consistent test results yielded by this surface would simplify validation of the model.
- Used to parametrically study how a flexible neck, neck initial position, and mass distribution of the HCTD could affect results.
- None of the configurations showed an improvement over the baseline for all three velocities, however, the combination of a rigid neck and increased torso mass had a definite negative affect.
- Model yielded insight into the complex nature of the interaction between the HCTD and even a relatively simple surface like a foam pad.

Evaluation of Potential Modifications

MADYMO Model of the HCTD impacting a 4” Thick Polyethylene Foam Pad



Conclusions and Recommendations

- At its current stage of development the HCTD does not always produce results that correlate with similar full-scale sled tests.
- The HCTD in its current form may be useful for conducting parametric studies limited to specific surface types.
- Further investigation is necessary to determine if modifications to the HCTD can improve its degree of correlation.
- Achieving overall correlation may require a specific device configuration for each type of surface impacted.
- Any modifications made to the device would need to be evaluated by a series of tests to establish the new level of correlation.