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Hybrid II and Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy Dynamic Evaluation Test Series

June 2013

Final Report

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16. Abstract

The physical testing of aircraft seating systems is increasingly being replaced by numerical simulation models, thus providing a faster and less expensive way to evaluate design concepts. The principal goal of these efforts is to use numerical models to accurately predict the results of physical tests. In lieu of physical tests, an accurate numerical model could potentially be used to evaluate the seating system, saving both development time and cost. A means of establishing confidence in this predictive ability is needed. Towards that end, the research presented in this document was conducted to provide the baseline test data required to define specifications for numerical occupant models of the Hybrid II and Federal Aviation Administration Hybrid III anthropomorphic test dummies (ATD) suitable for aviation impact test simulations. The research also provides procedures for calibration of both multibody and finite element ATD models, and to convey modeling design guidelines to assist modelers in developing efficient and accurate models. The data presented in this report provides the baseline data required to define Aerospace Recommended Practice (ARP) 5765. ARP 5765 provides the specifications and performance criteria for aviation-specific numerical ATD occupant models. This report defines the minimum set of test parameters and data needed to evaluate the degree of correlation between the model and the physical test, and provide procedures for quantitative comparison of test and modeling results. A separate report will compare the results of the Hybrid II and FAA Hybrid III ATD.

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LIST OF ACRONYMS

AC	Advisory Circular
ARP	Aerospace Recommended Practice
ATD	Anthropomorphic test dummy
c.g.	Center of gravity
CAMI	Civil Aerospace Medical Institute
CFC	Channel frequency class
CFR	Code of Federal Regulation
CMM	Coordinate Measuring Machine
FAA	Federal Aviation Administration
H-point	Intersecting of a line passing through both hip joints and the mid-sagittal plane of the dummy
HIC	Head injury criteria
HII	Hybrid II
HIII	FAA Hybrid III
MTS	Material Testing System
NIAR	National Institute for Aviation Research
S&G	Sprague and Geers
TSO	Technical Standard Order
V-ATD	Virtual anthropomorphic test dummy

EXECUTIVE SUMMARY

Numerical simulation models are increasingly replacing physical testing of aircraft seating systems because they provide a faster and less expensive way to evaluate design concepts. The principal goal of these efforts is to use numerical models to accurately predict the results of physical tests. An accurate numerical model has the potential to evaluate the seating system in lieu of physical tests, saving both development time and cost. A means of establishing confidence in this predictive ability is needed. Toward that end, the research presented in this document was conducted to provide the baseline test data required to define specifications for numerical occupant models of the Hybrid II and Federal Aviation Administration (FAA) Hybrid III anthropomorphic test dummies (ATD) suitable for aviation impact test simulations. The research also provides procedures for validation of both multibody and finite element ATD models, and to convey modeling design guidelines to assist modelers in developing efficient and accurate models.

Advisory Circular (AC) 20-146 provides guidance on how to validate the aircraft seating system numerical model and under what conditions the analytical model may be used in support of certification or Technical Standard Order (TSO) approval/authorization. This AC could be enhanced if more specific data pertaining to the modeling and validation procedures of the Hybrid II and FAA Hybrid III ATD numerical models were defined. Existing ATD specifications and calibration tests do not directly evaluate the ATD's response to all the loading conditions that can occur during aircraft seat dynamic tests. To ensure that numerical ATDs adequately emulate physical ATDs when subjected to these unique loading conditions, comparisons with the results of representative full-scale sled tests are needed. The test parameters specified herein are designed to produce the range of ATD articulation, force application points, and force magnitudes that are typical of those observed during the actual forward-facing aircraft seat tests. To minimize as many variables as possible, rigid seat and restraint systems with fixed anchorages were used. A series of 31 sled tests were conducted in the Crash Dynamics Laboratory of the National Institute for Aviation Research (NIAR) at Wichita State University. A minimum of three repetitions for the following forward-facing configurations were evaluated for the Hybrid II and FAA Hybrid III ATDs:

- Forward-facing test with two-point belt, no toe stop, and a triangular acceleration pulse of 16 g, Δv 44 ft/sec, as described in Title 14 Code of Federal Regulations (CFR) 25.562 for the horizontal test condition.

- Forward-facing test with three-point belt, adjustable shoulder belt to produce 1 inch of initial slack, and a triangular acceleration pulse of 21 g, Δv 42 ft/sec, as described in 14 CFR 23.562 for the horizontal test condition.

- Forward-facing test with four-point belt, adjustable pre-tension of shoulder belt per SAE AS 8049 (about 5 lbf), and a triangular acceleration pulse of 21 g, Δv 42 ft/sec, as described in 14 CFR 23.562 for the horizontal test condition.

- Forward-facing, 60° pitch test with two-point belt and a triangular acceleration pulse of 19 g, Δv 42 ft/sec, as described in 14 CFR 23.562 for the vertical test condition.

The information presented in this report provide the baseline data required to define Aerospace Recommended Practice (ARP) 5765, which provides the specifications and performance criteria for aviation-specific numerical ATD occupant models. This report defines the minimum set of test parameters and data needed to evaluate the degree of correlation between the model and the physical test and provides procedures for quantitative comparison of test and modeling results.

The test results show that, in general, less variability was observed in the FAA Hybrid III ATDs when compared to the Hybrid II ATD. Based on data from this series and the previous series results from the NIAR 06165 series test, a report will be published highlighting the differences between the Hybrid II and the FAA Hybrid III ATDs.

The results also show that, under 14 CFR 23.562 horizontal test conditions, the use of a four-point restraint belt reduced values of Head Injury Criteria (HIC (unlimited)) compared to a three-point restraint belt for both the Hybrid II and the FAA Hybrid III ATD.

1. INTRODUCTION.

The research presented in this document was conducted to provide the baseline test data required to define specifications for numerical occupant models of the Hybrid II and Federal Aviation Administration (FAA) Hybrid III anthropomorphic test dummies (ATD) suitable for aviation impact test simulations. The research also provides procedures for validation of both multibody and finite element ATD models, and to convey modeling design guidelines to assist modelers in developing efficient and accurate models.

Numerical simulation models are increasingly replacing physical testing of aircraft seating systems because they provide a faster and less expensive way to evaluate design concepts. Federal Aviation Administration (FAA) Advisory Circular (AC) 20-146 [1] provides guidance on how to validate the seat numerical model and under what conditions the analytical model may be used in support of certification or Technical Standard Order (TSO) approval/authorization. AC 20-146 relies on the engineering judgment of the applicant and the FAA Aircraft Certification Office to determine compliance. More specific data pertaining to the modeling and validation procedures of the Hybrid II and FAA Hybrid III anthropomorphic test dummy (ATD) numerical models would further enhance this AC.

AC 20-146 [1] sets forth an acceptable means, but not the only means, for demonstrating compliance to the following by computer modeling analysis techniques validated by dynamic tests:

- Title 14 Code of Federal Regulations (CFR) Parts 23, 25, 27, and 29, Sections 23.562, 25.562, 27.562, and 29.562.

- The TSO associated with the above regulation—TSO-C127/C127a.

AC 20-146 provides guidance on how to validate the numerical model and under what conditions the model may be used in support of certification or TSO approval/authorization. This AC applies to several groups:

- Those applicants who include the seat as part of an airplane/rotorcraft type design. In this case, the applicant is not using a TSO-C127/127a seat approved for installation in the aircraft. The applicant would satisfy the requirements of 14 CFR 2x.562 for the baseline seat, using the specific interior configuration of the target aircraft (including attachment hardware and fittings). The applicant can substantiate modifications to this seat design and installation using the guidance presented in this advisory circular [1].

- Seat manufacturers who build seats according to the requirements of TSO-C127/TSO-C127a and who hold either a letter of design approval or a Technical Standard Order Authorization for those seats. In this instance, the manufacturer would demonstrate compliance to the TSO standard by testing for the baseline seat design. Subsequent changes to this seat may show compliance to the TSO by using the analytical techniques and limitations described in this AC [1].

- An airplane/rotorcraft manufacturer or a modifier with intent to install a TSO seat. The baseline seat approval and installation limitations are used to certify the baseline installation approval. Modifications to any of these elements are eligible for certification via the analytical techniques and limitations described in this AC [1].

Analytical computer modeling techniques may be used to do the following, provided that all pass/fail criteria identified in 14 CFR 23.562, 25.562, 27.562, and 29.562 are satisfied.

- Application of computer modeling in support of dynamic testing; for example, determination of a worst-case scenario for seat design, determination of a worst-case scenario for seat installation, and determination of the occupant head-strike envelope [1].

- Application of computer modeling in lieu of dynamic testing; that is, demonstration of compliance to 14 CFR 23.562, 25.562, 27.562, or 29.562 for changes to a baseline seat design, where the baseline seat design has demonstrated compliance to these rules by dynamic tests; for example, to substantiate seat designs or installations that have been modified from a certified configuration. Changes may include geometric or material changes to primary and nonprimary structures [1].

As with any form of analytical modeling, validation of the seat/restraint model is a key requirement in determining whether the model is acceptable for use in certification. The general numerical model validation acceptance criterion includes, but is not limited to, the following:

- The model must be validated against dynamic tests.

- The model should be used for conditions that are similar to the model validation conditions. Similarity should exist between the current seat analysis and the test and analysis used to validate the analysis model, including loading conditions, seat type, and worst-case conditions.

- The general occupant trajectory, verified by time history plots, should correlate with test data.

Defining more specific data pertaining to numerical modeling and validation procedures would further enhance AC 20-146. This report verifies a series of studies conducted at the National Institute for Aviation Research (NIAR) to define the numerical modeling and validation procedure for the Hybrid II and FAA Hybrid III ATDs. This report focuses on experimental studies to develop a standard test database that can be used to validate ATD numerical models. The results and analyses of these tests provide an overview of the ATD test-to-test variability for typical 14 CFR 2x.562 dynamic test conditions. These results will be used by the SAE Aerospace Recommended Practice (ARP) 5765 [2] working group to define the minimum requirements required to validate numerical ATDs.

Existing ATD specifications and calibration tests do not directly evaluate the ATD's response to all loading conditions that can occur during aircraft seat dynamic tests. To ensure that numerical ATDs adequately emulate physical ATDs when subjected to these unique loading conditions, comparisons with the results of representative full-scale sled tests were performed. The test

parameters specified herein were designed to produce the range of ATD articulation, force application points, and force magnitudes that are typical of those observed during tests of actual forward-facing aircraft seats.

To develop the procedures to define and validate numerical models of the seat restraint systems, a series of sled tests were performed. These sled tests allowed the validation of ATD kinematics (head path, chest rotation, pelvis rotation, H-point, pelvis, and shoulder pivot point translation), seat and seat belt reaction forces, as well as the development of a sled and component test documentation standard for model validation purposes. To minimize as many test setup variables as possible, a rigid seat and restraint system with fixed anchorages were used.

2. AEROSPACE ATDs.

Two types of ATDs (per the requirements of 49 CFR Part 572, Subpart B [3]) were used for these experiments: the Hybrid II 50th percentile adult male ATD and the FAA Hybrid III 50th percentile adult male ATD.

2.1 HYBRID II 50th PERCENTILE ATD DESCRIPTION.

The Hybrid II 50th percentile adult male ATD (figure 1) was originally designed by Alderson Research Laboratories, and then modified by General Motors and the National Highway Traffic Safety Administration in 1972 to assess lap/shoulder belt systems. The Hybrid II was the first ATD designed to achieve acceptable repeatability and good durability. Its size and weight represented the average of the adult male population in the United States.

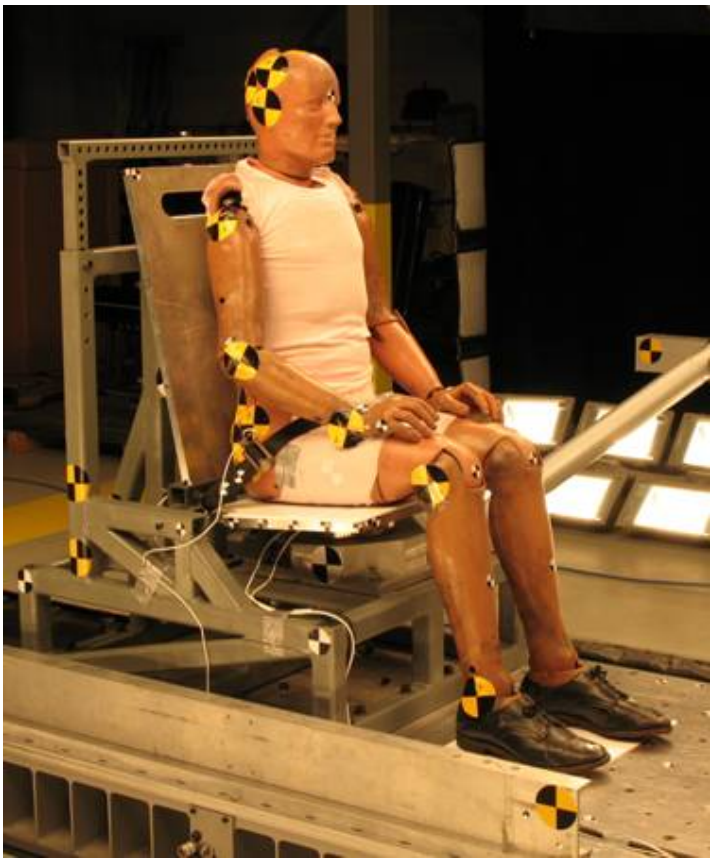


Figure 1. Hybrid II 50th Percentile Adult Male ATD

This design incorporates the range of motion, centers of gravity, and segment masses determined by anthropometric studies to simulate those of human subjects. In 1973, this ATD became the first dummy to be specified in the Federal Motor Vehicle Safety Standard 208 for compliance testing of vehicles equipped with passive restraints. The Hybrid II 50th percentile adult male is constructed of an internal structure made from a variety of materials, including steel, aluminum, brass, Dupont® Delrin™, and a number of complex castings. The outer covering is made of an engineered vinyl or a combination of vinyl and foam materials. A detailed description of the Hybrid II can be found in reference 4. Table 1 lists the weight distribution of the Hybrid II ATD. Figure 2 shows the locations of the measurement points of the Hybrid II ATD, and table 2 lists the external anthropometric dimensions. The assembly of the ATD consists of a three-piece skull weldment with vinyl skin that has a two-piece backplate for access to instrumentation. A cylindrical rubber neck assembly is mounted on a neck bracket with a fixed angle of 15° forward [4].

Table 1. Weight Distribution for Hybrid II ATD

ATD Part	Weight (lbf)
Head	11.2 ±0.1
Upper chest (including lumbar spine)	41.5 ±1.6
Lower chest (including visceral sac and upper thighs)	37.5 ±1.5
Upper arm	4.8 ±0.2
Lower arm	3.4 ±0.1
Hand	1.4 ±0.1
Upper leg	17.6 ±0.7
Lower leg	6.9 ±0.3
Foot	2.8 ±0.1
Total (including instrumentation in head, chest, and femurs)	164.0 ±3.0

Table 2. External Anthropometric Dimensions for Hybrid II ATD

Measurement	Figure 2 Code	Dimension (in.)
Seated height	A	35.7 ±0.1
Shoulder pivot height	B	22.1 ±0.3
Hip pivot height	C	3.9
Hip pivot from back line	D	4.8
Knee pivot from back line	E	20.4 ±0.3
Knee pivot from floor	F	19.6 ±0.3
Head back from back line	G	1.7
Chest depth	H	9.3 ±0.2
Shoulder width	I	18.1 ±0.3
Chest circumference over nipples	K	37.4 ±0.6
Waist circumference at minimum girth	L	32.0 ±0.6
Hip width	M	14.7 ±0.7
Politeal height	N*	17.3 ±0.2
Shoulder-elbow length	Q*	14.1 ±0.3
Elbow rest height	R*	9.5 ±0.5
Head width*	S*	6.1 ±0.2
Head length	T*	7.7 ±0.2
Head segment line	AA	9.3
Shoulder-thorax segment line	BB	25.1

*Measurements not included in 49 CFR Part 572 anthropometric data.

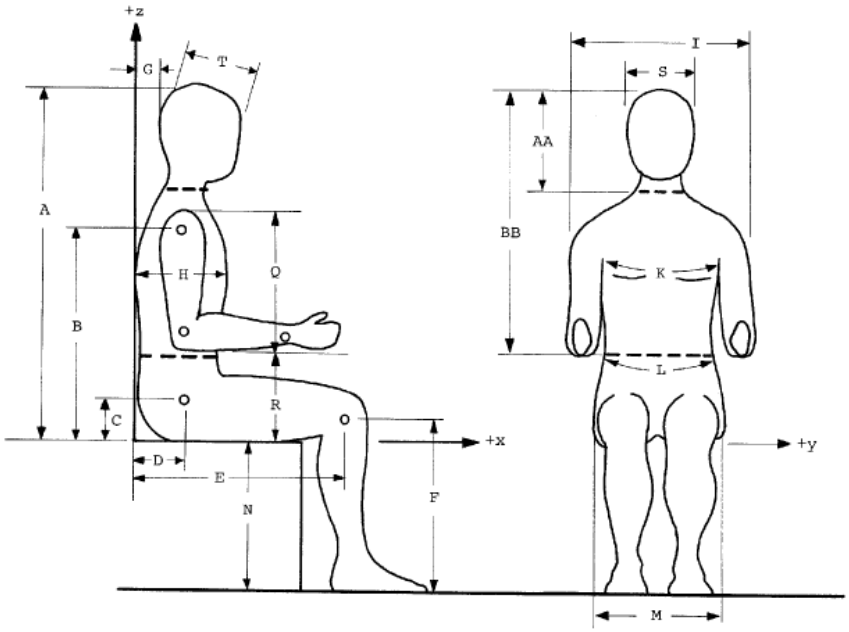


Figure 2. Schematic With Codes of Hybrid II

The chest of the Hybrid II dummy features a steel thoracic spine, cast aluminum clavicles with anatomical scapulae, steel ribs mounted to thorax, and a rear access instrument cavity for accelerometers. Chest flesh with a rear zipper covers the entire assembly and is easily removed. A diaphragm is incorporated above the abdominal cavity. Six pairs of left and right steel ribs have bonded composite damping material, covered with shrink-fit tubing. The ribs are mounted to the thoracic spine and joined by a leather sternum in front. The rib cage accepts a chest displacement transducer. The abdomen has a vinyl skin and foam flesh that removes easily from the area surrounding the lumbar spine. A straight, cylindrical butyl rubber lumbar spine incorporates a cable for strength. The pelvis has ball-and-socket femur joints with friction plungers to control hip ball motion. Cast bronze femurs with slotted balls control the range of motion. The legs are steel skeletons with vinyl skin and foam flesh. The thighs accept femur force load cells for force measurement. The knee and thigh flesh are removable. The locations of the center of gravity (c.g.) and mass moments of inertia for the Hybrid II ATD are listed in tables 3 and 4, respectively.

Table 3. Center of Gravity Locations for the Hybrid II ATD

ATD Part	x and z Reference Origin*	x* (in.)	z* (in.)
Head	Back and top of head	+4.0 ±0.2	-4.7 ±0.1
Upper chest	Backline and top of head	+4.1 ±0.3	-17.2 ±0.3
Lower chest and upper thigh	Backline and top of head	+4.9 ±0.5	+31.0 ±0.5
Upper arm	Shoulder pivot	0.0 ±0.3	-5.0 ±0.3
Lower arm	Elbow pivot	+4.2 ±0.3	0.0 ±0.3
Hand	Wrist pivot	+2.2 ±0.3	0.0 ±0.3
Upper leg	Knee pivot to upper leg rotation center	-6.7 ±0.3	0.0 ±0.3
Lower leg	Knee pivot to ankle pivot	0.0 ±0.3	-8.0 ±0.3
Foot	Ankle pivot	+2.2 ±0.3	-1.7 ±0.3

*Coordinate system is defined in figure 2 (+x forward and +z up).

Table 4. The Locations of the Mass Moments of Inertia for the Hybrid II ATD

ATD Part	Mass Moments of Inertia (in.-lb-sec)		
	Ix	Iy	Iz
Head	0.266	0.275	--
Head/neck	0.310	0.367	0.233
Upper chest (includes lumbar spine)	2.18	1.79	--
Lower abdomen, pelvis, and visceral sac	2.32*	1.73*	--
Right upper arm	0.134	0.132	0.022
Right forearm (no hand)	0.012	0.068	0.071
Right upper leg	0.127	0.873	0.890
Right lower leg (no foot)	0.599	0.575	0.359

*Includes lumbar spine section.
Notes:

- Instrumentation was installed in the head, chest, and femurs during the measurements.
- Estimated accuracy of measurements: ±3%

2.2 THE FAA HYBRID III 50th PERCENTILE ATD DESCRIPTION.

The FAA Hybrid III 50th percentile male ATD (figure 3) was developed under a cooperative effort between the FAA, Civil Aerospace Medical Institute (CAMI), Denton ATD, Inc., and Robert A. Denton, Inc. as an alternative ATD to meet FAA seat certification requirements. The FAA Hybrid III ATD uses standard components from both the Hybrid II [4] and Hybrid III ATDs [5]. The design goal was to create an ATD that would produce lumbar spine responses equivalent to those of the Hybrid II and that could be used as an optional dummy in aviation seat

certification. FAA regulations use pass/fail criteria on lumbar or pelvic loading during vertical test conditions.

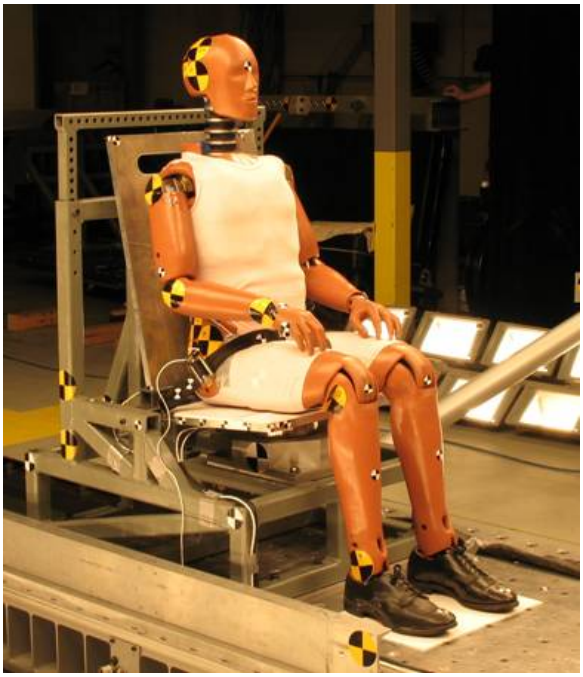
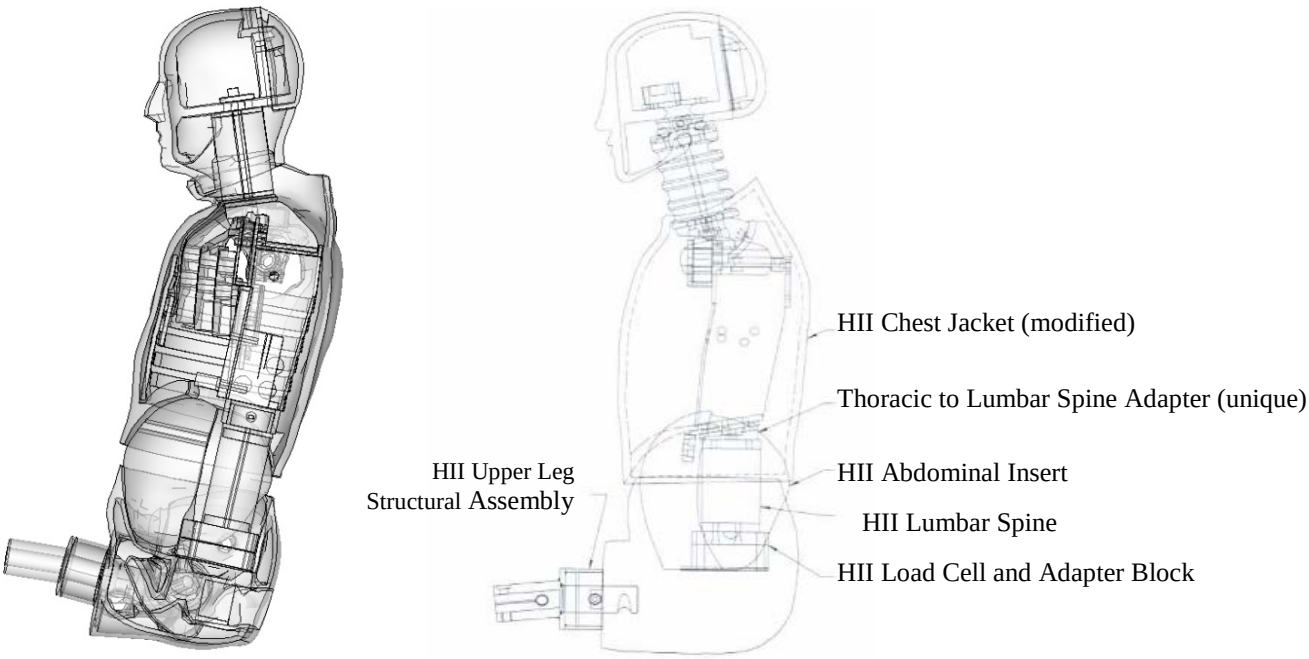


Figure 3. The FAA Hybrid III 50th Percentile Adult Male ATD

The FAA Hybrid III ATD has a number of modifications with respect to the standard Hybrid III ATD (figure 4). The primary difference is the replacement of the Hybrid III lumbar-pelvic adapter block and load cell with a Denton Model 1891 Hybrid II Lumbar Load Cell and mating pelvic adapter block. Another difference is the replacement of the Hybrid III lumbar column with a standard Hybrid II lumbar column, which attaches to the Denton lumbar load cell and pelvic adapter block assembly. The straight lumbar spine of the Hybrid II is important in the certification of aircraft seats because of its ability to reproduce the kinematics of the erect-spine seated posture and the resultant head trajectory, and to measure the compressive axial forces in the spine. The Hybrid III abdominal insert and upper leg elements were replaced with a standard Hybrid II abdominal insert and upper-leg elements. Additionally, the Hybrid III chest flesh jacket was replaced with a modified version of the chest flesh from a Hybrid II. This modified version has a notch cut in the region of the lower neck to prevent interference with the FAA Hybrid III neck flexion. Finally, the Hybrid III upper lumbar-thorax adapter was replaced with a unique adapter. This last modification was the only one that used a nonstandard component of the Hybrid III or Hybrid II. This unique upper lumbar-thorax adapter was required to provide proper alignment for an erect spine seated posture. Also, this adapter was constructed from steel rather than aluminum to provide a slight increase in mass to more closely match the Hybrid II's upper chest weight [6]. The head, neck, thorax, and lower limbs of the FAA Hybrid III are the same as the Hybrid III 50th percentile adult male ATD [6]. The weights and dimensions of the FAA Hybrid III are listed in tables 5 and 6.



(a) (b)

Figure 4. (a) Hybrid II and (b) FAA Hybrid III ATDs

Table 5. Weight Distribution of FAA Hybrid III ATD

ATD Part	Weight (lbf)
Head	10
Neck	3.4
Upper chest	37.9
Lower chest	37.9
Upper arm (each)	4.4
Lower arm (each)	3.75
Hand (each)	1.25
Upper leg (each)	17.0
Lower leg and foot (each)	12.0
Total ATD weight	166.0

Table 6. External Anthropometric Dimensions for FAA Hybrid III ATD

ATD Part	Dimension (in.)
Head circumference	22.5
Head width	6.1
Head length	7.7
Shoulder pivot height	22.1
Buttock to knee pivot	20.4
Knee pivot height	19.6
Sitting height	35.7

3. THE NIAR DYNAMIC SLED TEST SERIES II–SAE ARP 5765 REFERENCE TEST DATA.

Existing ATD specifications and calibration tests do not directly evaluate the dummy's response to all loading conditions that can occur during aircraft seat dynamic tests. To ensure that numerical dummies adequately emulate physical dummies when subjected to these unique loading conditions, comparisons with the results of representative full-scale sled tests are needed.

The test parameters specified herein are designed to produce the range of ATD articulation, force application points, and force magnitudes that are typical of those observed during tests of actual forward-facing aircraft seats. To minimize as many variables as possible, a rigid seat and restraint systems with fixed anchorages were used. In addition, a toe stop was used in the three- and four-point belt configuration to restrain the feet and induce submarining of the lower torso. The toe stop was not present for the two-point belt configuration to allow the legs to flail.

The following test conditions, defined by the SAE ARP 5765 working group, were repeated a minimum of three times (table 7):

- Forward-facing test configuration with two-point belt, no toe stop, and acceleration pulse of 16 g, 44 ft/sec, 14 CFR 25.562 [7] horizontal test condition with no yaw, pitch, or roll. The main purpose of this test was to obtain reference data for the head path, pelvis kinematics, and belt reaction forces.

- Forward-facing test configuration with three-point belt, shoulder belt adjusted to produce 1 inch of initial slack, and acceleration pulse of 21 g, 42 ft/sec, 14 CFR 23.562 [8] horizontal test condition with no yaw, pitch, or roll. The main purpose of this test was to study the upper chest rotation due to the shoulder belt interaction.

- Forward-facing test configuration with four-point belt, pre-tension of shoulder belts adjusted per SAE AS 8049 [9] (about 5 lbf), and acceleration pulse of 21 g, 42 ft/sec, 14 CFR 23.562 horizontal test condition with no yaw, pitch, or roll. The main purpose of this test was to obtain reference data for the belt strap loads.

- A 60° pitch test configuration with two-point belt, and acceleration pulse of 19 g, 42 ft/sec, 14 CFR 23.562 vertical test condition. The main purpose of this test was to obtain reference data for the lumbar spine compression.

Table 7. Test Series 07324 Matrix

Test Number	ATD Serial No.	Belt Type	Test Angle (degrees)	Load (g)	Seat Type	Belt Material	Crash Pulse
07324-1	Hybrid II 698	2	0	16	Rigid	100% nylon	25.562
07324-4	Hybrid II 698	2	0	16	Rigid	100% nylon	25.562
07324-7	Hybrid II 698	2	0	16	Rigid	100% nylon	25.562
07324-10	Hybrid II 698	2	60	19	Rigid	100% nylon	23.562
07324-11	Hybrid II 698	2	60	19	Rigid	100% nylon	23.562
07324-12	Hybrid II 698	2	60	19	Rigid	100% nylon	23.562
07324-2	Hybrid II 698	3	0	21	Rigid	100% nylon	23.562
07324-8	Hybrid II 698	3	0	21	Rigid	100% nylon	23.562
07324-9	Hybrid II 698	3	0	21	Rigid	100% nylon	23.562
07324-3	Hybrid II 698	4	0	21	Rigid	100% nylon	23.562
07324-5	Hybrid II 698	4	0	21	Rigid	100% nylon	23.562
07324-6	Hybrid II 698	4	0	21	Rigid	100% nylon	23.562
07324-16	FAA Hybrid III 289	2	0	16	Rigid	100% nylon	25.562
07324-17	FAA Hybrid III 289	2	0	16	Rigid	100% nylon	25.562
07324-18	FAA Hybrid III 289	2	0	16	Rigid	100% nylon	25.562
07324-13	FAA Hybrid III 289	2	60	19	Rigid	100% nylon	23.562
07324-14	FAA Hybrid III 289	2	60	19	Rigid	100% nylon	23.562
07324-15	FAA Hybrid III 289	2	60	19	Rigid	100% nylon	23.562
07324-19	FAA Hybrid III 289	3	0	21	Rigid	100% nylon	23.562
07324-20	FAA Hybrid III 289	3	0	21	Rigid	100% nylon	23.562
07324-24	FAA Hybrid III 289	3	0	21	Rigid	100% nylon	23.562
07324-21	FAA Hybrid III 289	4	0	21	Rigid	100% nylon	23.562
07324-22	FAA Hybrid III 289	4	0	21	Rigid	100% nylon	23.562
07324-23	FAA Hybrid III 289	4	0	21	Rigid	100% nylon	23.562
07324-25	FAA Hybrid III 289	3	0	21	Rigid	100% nylon	23.562
07324-26	Hybrid II 698	4	0	21	Rigid	100% nylon	23.562
07324-27	Hybrid II 698	4	0	21	Rigid	100% nylon	23.562
07324-28	Hybrid II 698	2	0	16	Rigid	100% nylon	25.562
07324-29	Hybrid II 698	3	0	21	Rigid	100% nylon	23.562
07324-30	Hybrid II 698	2	60	19	Rigid	100% nylon	23.562
07324-31	Hybrid II 698	2	60	19	Rigid	100% nylon	23.562

Each test adhered to the following general test requirements described in ARP 5765 [2]:

- Rigid seat with the specified anchorage geometry, contact surface locations, and load cell locations shall be used.
- Contact surfaces shall be rigid, flat, and smooth.
- Restraint systems shall use 2-inch-wide nylon webbing, and have fixed anchorage points.
- The geometry of the three-point restraint system shall be such that the shoulder belt-to-lap belt attachment point is 4 inches to the right of the dummy centerline.
- The ATD used for these evaluations shall meet its design specifications as defined in 49 CFR Part 572 with clothing per SAE AS 8049, which may be cut away as necessary to avoid obscuring photometric targets.
- Photometric target markers shall be placed as described in section 3.5.1 and SAE J211/2.
- Consistent placement of ATD in the seat per SAE AS 8049.
- Lap belt pretension shall be adjusted per SAE AS 8049 (about 5 lbf).

This report describes the following documentation per ARP 5765 for each test configuration:

- Geometry of the surfaces contacted by ATD and location of the belt anchors and guides.
- Restraint system geometry (length, width, thickness, and location of both rigid and flexible components).
- Restraint system pre-tension or slack values.
- The initial position of significant ATD anthropometry landmarks defined in section 3.5.1 and all photometric target markers used to track those locations. Also, the position of photometric reference targets used for scaling and/or validation per SAE J211/2. The origin for these measurements shall be the intersection of the seat back and seat pan at the seat centerline.

3.1 ANTHROPOMORPHIC TEST DUMMY AND INSTRUMENTATION DESCRIPTION.

Two types of test dummies were used for these experiments: the Hybrid II 50th percentile adult male ATD and the FAA Hybrid III 50th percentile adult male ATD. The Hybrid II ATD was manufactured by First Technology Safety Systems, and the FAA Hybrid III ATD was manufactured by Denton ATD, Inc. All ATDs were calibrated by NIAR's Calibration and Quality Systems Laboratory, following the requirements of 49 CFR, Volume 5, Part 572, Subpart B. The calibration reports are shown in appendix A. The different accelerometers and load cell models used in these ATDs throughout the tests are listed in table 8.

Table 8. The ATD Instrumentation

Head accelerometers	Endevco model 7264C-2KTZ-2-240 Entran EGE-73B-750DF Entran EGE-73B6-500J Endevco model 7264C-500TZ-2
Chest accelerometers	Endevco model 7264C-2KTZ-2-240
Pelvis accelerometers	Endevco model 7264C-2KTZ-2-240 Entran EGE-73B6-500J Endevco model 7264C-500TZ-2 Entran EGE-73B-750DF Entran EGE-73B-750D
Upper neck load cell	Denton model 1716A
Femur load cell	Denton model 2121A
Lumbar load cell	Denton model 1891

3.2 DYNAMIC TEST FACILITY DESCRIPTION.

The NIAR Crash Dynamics Laboratory (figure 5) is housed in a 4500-square-foot, environmentally controlled indoor facility. Temperature and relative humidity are monitored and recorded by a monitoring system that is calibrated semi-annually. The driving force of the laboratory is a Material Testing System (MTS) Model 888.20 crash simulator. The technical specifications of this computer-controlled, servohydraulic accelerator, sled-crash simulator are listed in table 9. The sled travels on a 21-meter-long (69-foot) flat track. Sled platform dimensions are 1.2 meters by 4.0 meters (48 x 156 in.). The maximum test article payload weight is 1500 kg (3300 lbf).

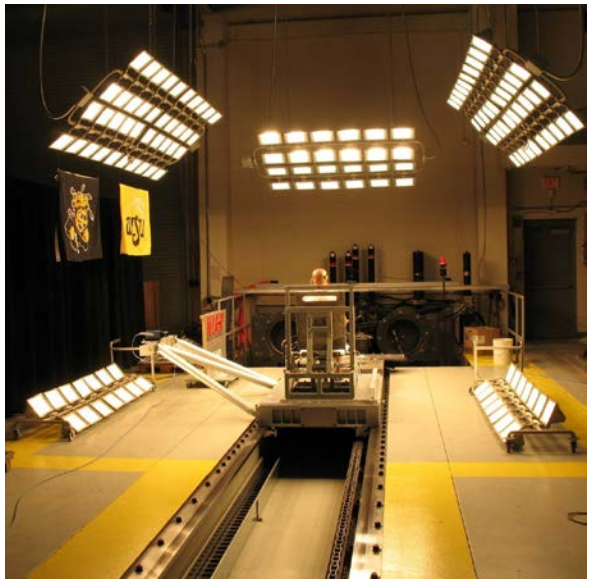


Figure 5. The NIAR Crash Dynamics Laboratory

Table 9. Crash Simulator Specifications

MTS Corporation Crash Simulation Model 888.20	
Nominal force	2,000 kN (450,000 lbf)
Maximum velocity with 1500 kg (3300 lbf)	81 km/h (50 mph)
Dynamic response	>150 Hz
Acceleration with 1500 kg (3300 lbf)	65 g
Acceleration with 1000 kg (2200 lbf)	75 g
Sled travel	21 m (69 ft)
Sled dimensions	1.2 x 4.0 m (48 x 156 in.)
Maximum payload weight	1,500 kg (3,300 lbf)

The laboratory's crash simulator is capable of duplicating 14 CFR 2x.562 crash pulses with a high level of repeatability. This high level of pulse repeatability is illustrated in figure 6, which shows the profiles of the 16-g pulses of six different tests performed in this study.

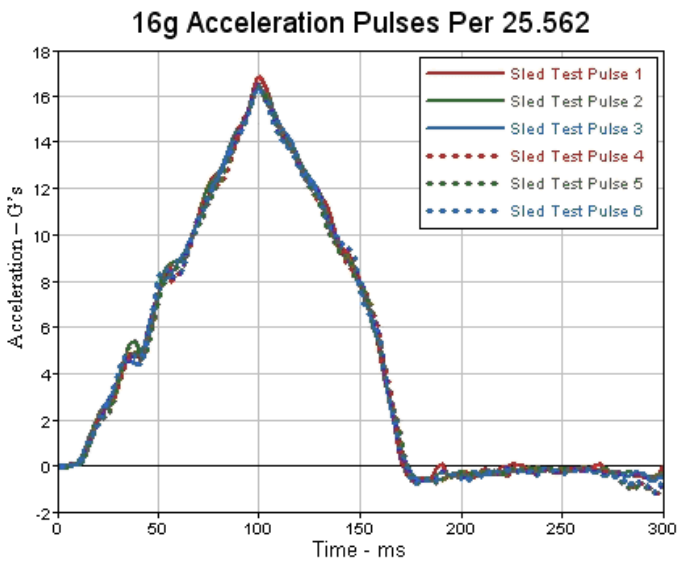


Figure 6. Crash Simulator Acceleration Pulse Repeatability

The ACCEL© Pulse Evaluation Software (developed and used by NIAR) evaluates the sled acceleration pulse for peak g level (Gpk), rise time (Trise), velocity change during rise time (ΔVtrise), and total velocity change (ΔVtotal). The pulse is also graphically evaluated for compliance with AC 2x.562-1A [10] and SAE AS 8049 [9]. Five main requirements must be met in order for a pulse to be considered successful per 14 CFR 2x.562 (b) (1) and (2): pulse shape, Gpk, Trise, ΔVtrise, and ΔVtotal. The initial impact velocity is a function of the sled propulsion system. An accurate evaluation of these pulse parameters is obtained using the digitized data and ACCEL software. Velocity (ΔV) information is determined by integrating the sled acceleration, in accordance with SAE Channel Frequency Class (CFC) 180 requirements, versus time.

The Crash Dynamics Laboratory has an aircraft seat 60° pitch fixture (figure 7), a 10° yaw fixture, and a 10° pitch and roll fixture. The seat was either mounted horizontal (0°) or mounted using the 60° pitch fixture. The test description includes the ATD used, the seat belt configuration, and denoted 0° or 60° to indicate the seat pitch angle.

Figure 7. The NIAR Aircraft Seat 60° Pitch Fixture

The high-speed video equipment used for these experiments is shown in figure 8, and the specifications are listed in table 10.

Figure 8. High-Speed Video Cameras and Coordinate Measuring Machine

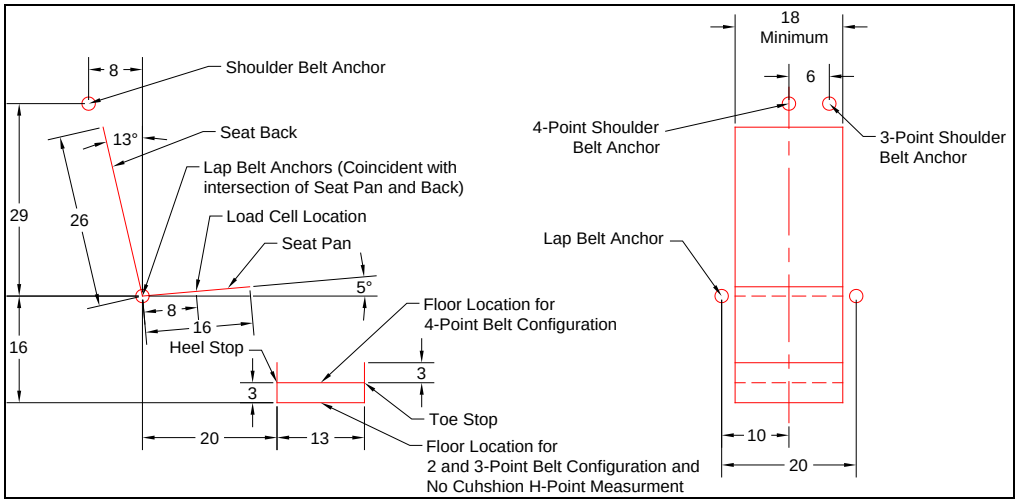
Table 10. High-Speed Video Equipment Specifications

Equipment	Recording Rate	Sled Installation
SpeedCAM VISARIO High-Resolution Color (1536 x 1024 pixels)	1000 frames/sec	On/Off board
5-mm Kinoptik lens high-g	-	On board
9.8-mm Kinoptik lens high-g	-	On board
18-mm Weinberg lens high-g	-	On board
28-mm Kinoptik lens high-g	-	On board
24- and 85-mm Nikon lens	-	Off board

Test data were acquired by a Transient and Signal Acquisition/Processing System (TSAPS), which is capable of recording 96 channels with a programmable sampling rate up to 50,000 samples per second per channel, programmable analog filtering, 16-bit resolution, simultaneous sampling, digital filters (flat pass band, sharp cutoff), and pre- and posttrigger recording. The laboratory used a portable coordinate measuring machine (CMM) to measure and record the initial ATD positions, posttest ATD positions, and permanent structural seat deformations (figure 8).

3.3 SEAT TEST FIXTURE DESCRIPTION.

The dynamic sled tests were conducted with a rigid seat fixture using fixed-belt anchorages (figure 9) to minimize the effects of dynamic loading of the seats (i.e., structural deformations, as well as seat cushion effects) on the response of the ATD. The test setup dimensions for the two-, three-, and four-point belt configurations shown in figure 9 are defined in SAE ARP 5765 [2]. Teflon sheets were used between the ATD and the seat pan/footrest surfaces to maintain a constant coefficient of friction (figure 10).



All dimensiona are in inches.

Figure 9. Rigid Seat and Two-, Three-, and Four-Point Belt Configurations

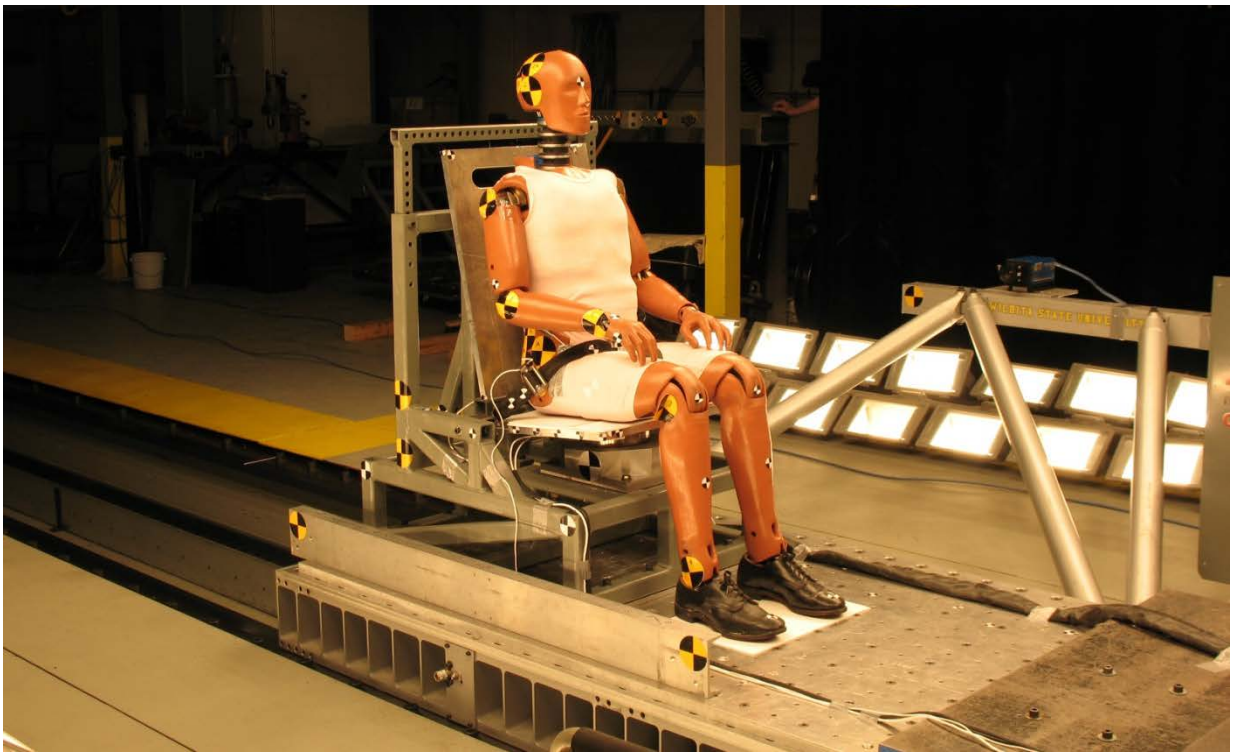
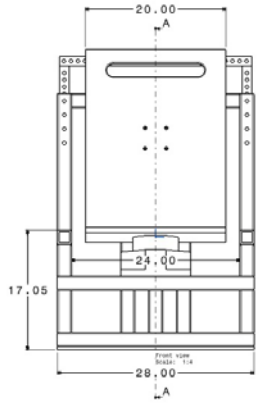


Figure 10. Seat Pan and Footrest Teflon Surfaces

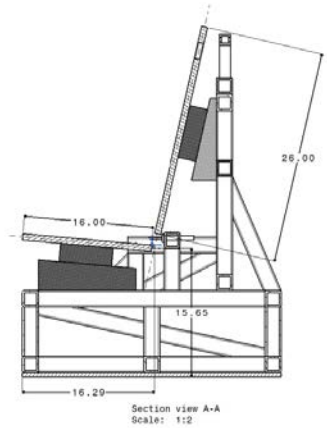
3.3.1 Rigid Seat Fixture Design.

The rigid seat frame (figures 11 through 14) is made of steel with adjustable lap-belt anchor positions at shoulder harness height. The seat has slider bars with holes at 1-inch intervals to provide up and down adjustments for the shoulder anchor height. The seat also has two holes 2 inches apart for each of the lap-belt anchor locations. These can be used to attach the lap-belt or to install an adapter plate that places the lap-belt anchor points at any desired position around the pelvis height.

All tubing used for the assembly of the seat is standard 2- by 2-inch, 0.25-inch-thick steel tubing, except for the slider bars, which are 1.375- by 1.375-inch, 0.25-inch-thick steel tubing and slide into the larger tubing supports. All holes are drilled to fit standard 0.5-inch-diameter bolts. A total of 24, 0.5-inch-diameter bolts are used to assemble the seat. All bolts are threaded 1/2-20 UNF. The seat pan and seat back panels are 0.75-inch-thick aluminum plates, whereas the pan and back spacers are machined from aluminum blocks. The seat pan and seat back are not parallel to the global coordinate system. The global coordinate system is defined by an x axis parallel to the ground and a vertical axis perpendicular to the ground. The seat back is 13° from the vertical global axis, and the seat pan is 5.2° from the global horizontal axis.

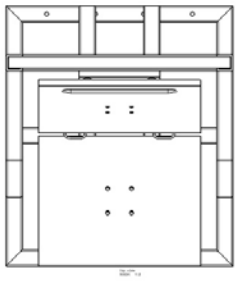


(a) Top

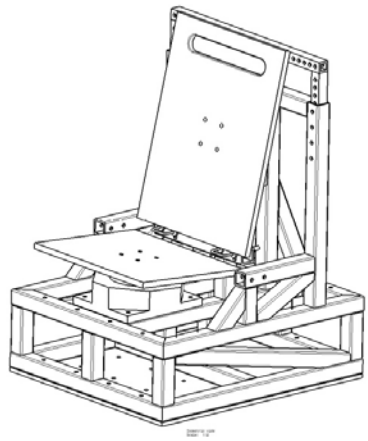


(b) Side

All dimensions are in inches.



(c) Bottom



(d) Angle

Figure 11. Rigid Seat Views

All dimensions are in inches.

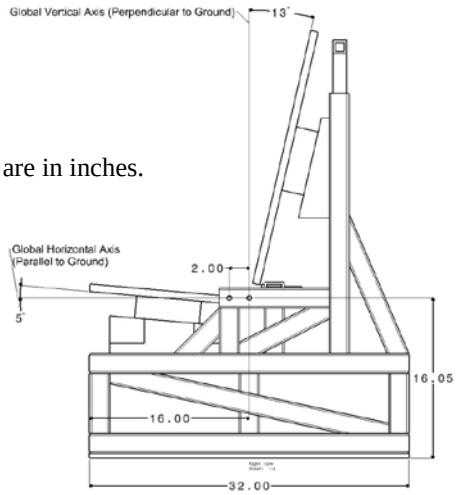


Figure 12. Rigid Seat Pan and Back Angles

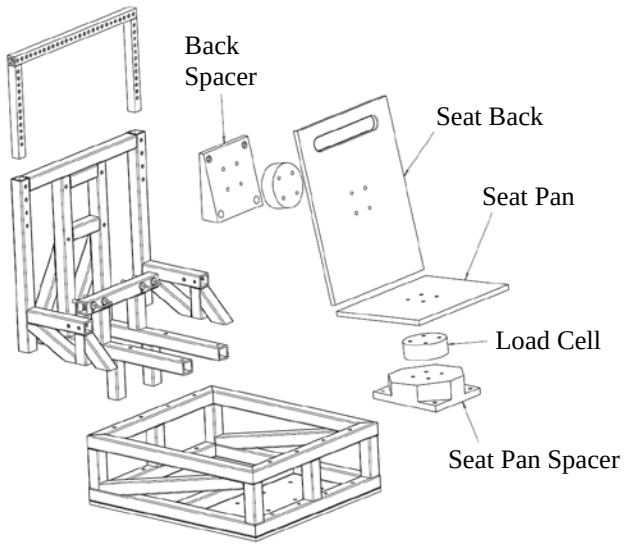


Figure 13. Rigid Seat Exploded View

Figure 14. Rigid Seat Fixture

3.3.2 Rigid Seat Instrumentation.

The rigid seat is instrumented with two load cells: one load cell is located under the seat pan and another behind the seat back (see figure 13). The load cell used for the seat back was a three-channel Denton model 2177 with a load capacity of 10,000 lbf in all three axes. The seat pan load cell was a six-channel Denton model 2513 with a load capacity of 10,000 lbf and moment capacity of 25,000 lb-in. in all three axes. The seat load cell coordinate systems are shown in figure 15.

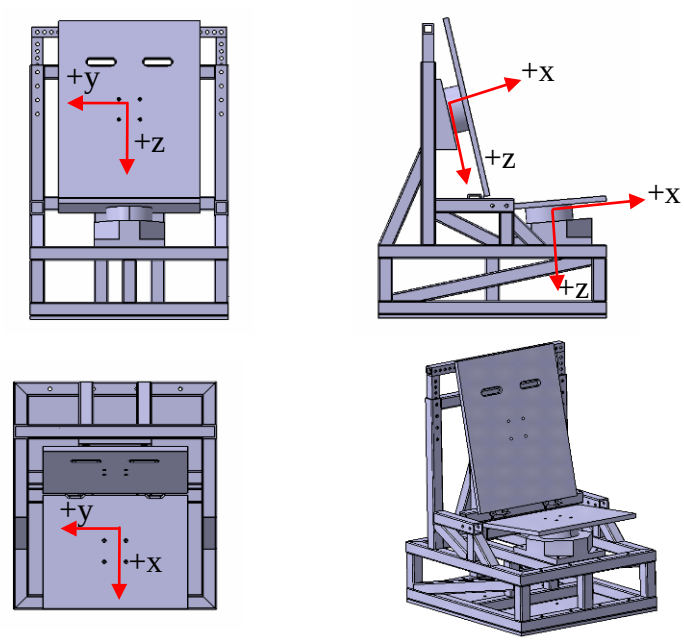


Figure 15. Orientations of Seat Load Cell Coordinate Systems

3.4 RESTRAINT SYSTEMS DESCRIPTION.

Three types of restraint systems were used for the dynamic seat sled tests: a two-point (lap belt), a three-point (lap belt with swivel diagonal shoulder belt), and a four-point (lap belt and two shoulder straps) restraint system configuration.

3.4.1 Belt System Descriptions.

Figures 16 through 19 show the three different types of seat belts used. All configurations used 100% nylon 2-inch-wide webbing with a lift-lever buckle (figure 19). The belt anchors use a steel snap-hook design for the two-point configuration and regular bolt-through fittings for the three- and four-point belt configuration. Note that no d-rings or retractors were used for the three- or four-point configurations (figure 20). A total of ten targets were defined for the two-point restraint system, as shown in figure 16. For the three- and four-point restraint systems, a total of 14 targets were defined, as shown in figures 17 and 18, respectively. The purpose of these targets was to provide x, y, and z coordinates to validate the routing of the numerical finite element belt restraints.

Figure 16. Two-Point Lap Belt Targets

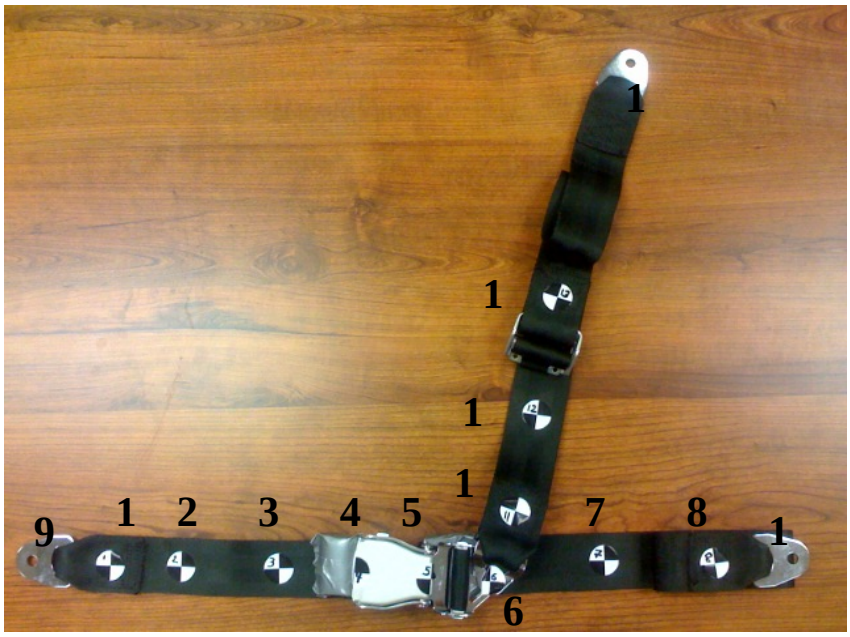


Figure 17. Three-Point Restraint Targets

Figure 18. Four-Point Restraint Targets

(a) Two-point belt buckle

(b) Three-point belt buckle

(c) Four-point belt buckle

Figure 19. (a) Two-, (b) Three-, and (c) Four-Point Belt Buckles

(a) Four-point top anchor point

(b) Three-point top anchor point

(c) Two-point anchor point

(d) Three and four-point bottom anchor point

Figure 20. Belt Anchor Points

3.4.2 Belt Webbing Properties.

The belt webbing material was tested in the Structures Laboratory at NIAR. The test matrix completed for the webbing material characterization is shown in table 11. The webbing coupons were created by cutting 15-inch strips of webbing material from new belts. These webbing strips were then tabbed on both ends with sand paper to avoid grip slipping during the test. Figure 21 shows a typical belt webbing specimen with dimensions before testing. Table 12 lists the pre- and posttest dimensions of the specimens. The end tabs were 2.5 inches long, making the coupon's gage length 10 inches long.

Table 11. Belt Webbing Test Matrix

Test Number	Strain Rate (in/min)	Belt Material	Output	Max Load (lbf)	Sampling Rate (Hz)
1	0.25	100% nylon	Load vs deflection	2600	10
2	0.25	100% nylon	Load vs deflection	2600	10
3	6.00	100% nylon	Load vs deflection	2600	20
4	6.00	100% nylon	Load vs deflection	2600	20

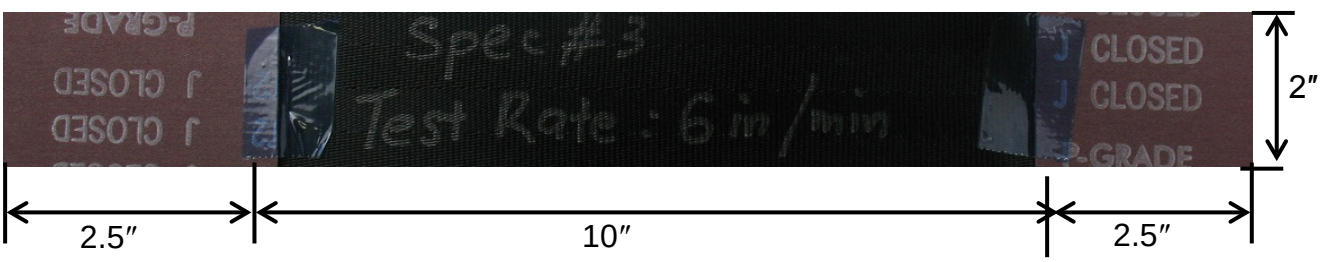


Figure 21. Belt Webbing Specimen

Table 12. Belt Webbing Specimen Dimensions

Pretest Dimensions			
Sample/Test	Gage Length (in.)	Width (in.)	Thickness (in.)
1	10.00	1.915	0.0565
2	10.00	1.910	0.057
3	10.00	1.9	0.0575
4	10.00	1.9	0.0573
Posttest Dimensions			
1	10.15	1.910	0.55
2	10.45	1.905	0.55
3	10.25	1.89	0.55
4	10.30	1.89	0.55

Tests were performed on a 55-kip MTS load frame (figure 22) equipped with a 55-kip servohydraulic actuator instrumented with a ±55-kip piezo-resistive load cell and a linear variable displacement transducer with ±6.0 inches full scale. The loading and unloading phases were conducted with displacement control at two loading rates of 0.25 in/min and 6.0 in/min and as listed in table 11. The load cell force data and actuator displacement data were acquired simultaneously at 20 Hz for the 6.0-in/min loading rate and 10 Hz for the 0.25-in/min loading rate. The test equipment was controlled by an MTS Testar-IIm system. The MTS MultiPurpose TestWare® software was used to program parameters, such as displacement rates and data acquisition intervals for controlling the tests and data acquisition. Typical nylon belt load and elongation experimental data is shown in figure 23. The seat belt webbing experimental data is shown in appendix F.

Figure 22. Sample Belt Webbing Test Setup

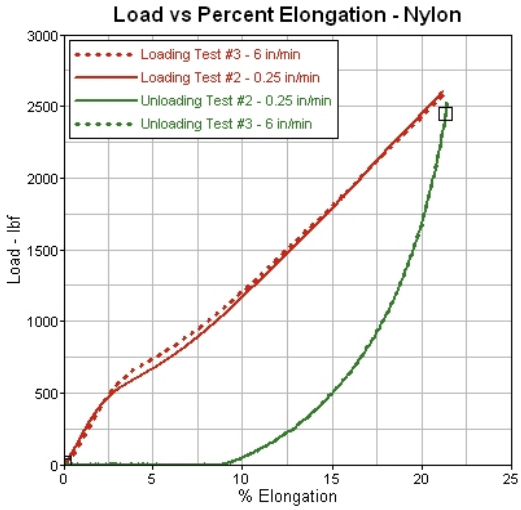
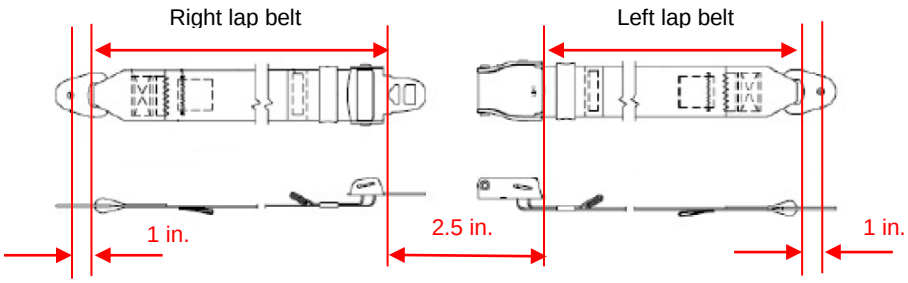


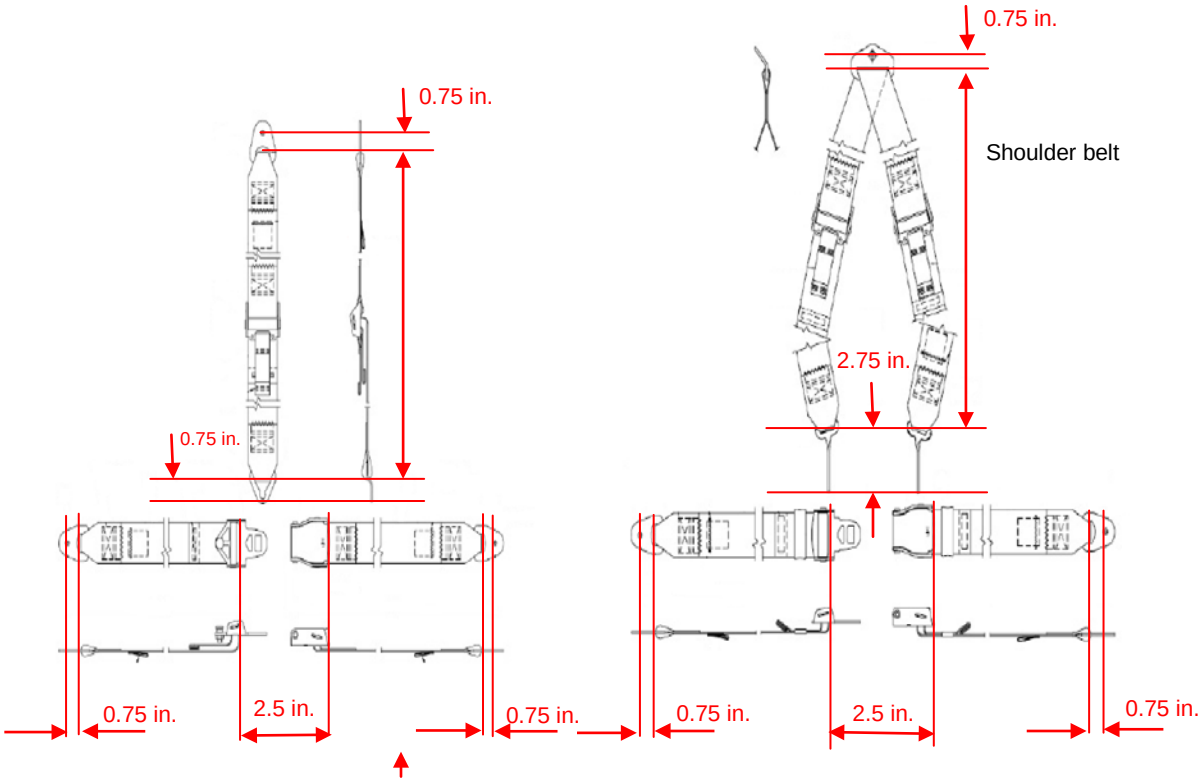
Figure 23. Nylon Belt Webbing Experimental Data

3.4.3 Belt Webbing Dimensions.

Belts were pre-tensioned per SAE AS 8049, and the belt-webbing length was measured and recorded prior to testing. Note that in figure 24, the buckles and anchors were not included in the webbing length measurements. See appendix B for pre- and postmeasurements for each individual test configuration.



(a) Two-point belt configuration



(b) Three-point belt configuration (c) Four-point belt configuration

Figure 24. Belt Length Measurements for (a) Two-, (b) Three-, and (c) Four-Point Belt Configurations

3.5 TEST PROCEDURES.

A protocol similar to SAE AS 8049 was used for this test series. The main objective of this test protocol was to define consistent test setups to minimize the test-to-test ATD positioning

variability. Hybrid II and FAA Hybrid III ATDs representing a 50th percentile adult male, as defined in 49 CFR Part 572, Subpart B, were used to simulate the seat occupant. ATDs used in the tests were calibrated (appendix A) prior to the test series in accordance with the requirements described in 49 CFR Part 572, Subpart B.

3.5.1 Pretest Procedure.

The following steps are part of the pretest procedures.

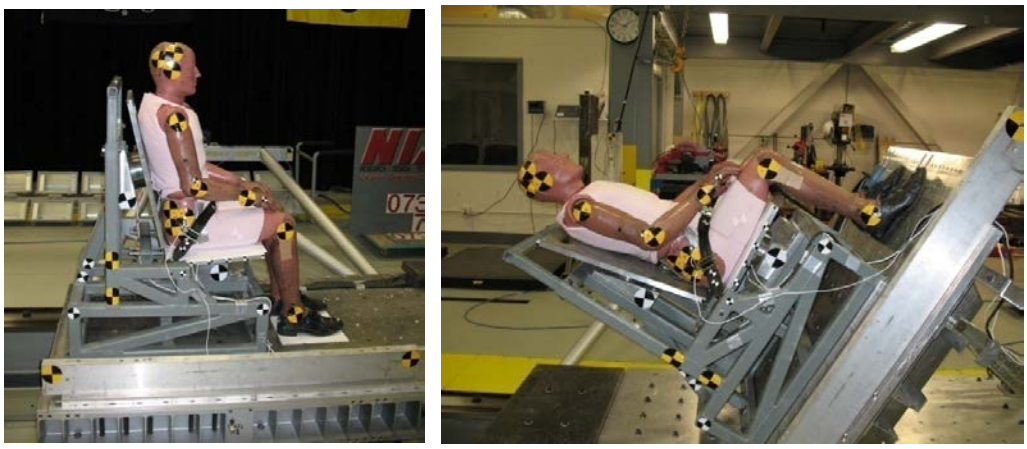
- The ATD (Hybrid II or FAA Hybrid III) was maintained at a temperature range between 19° and 26°C (66° and 78°F) and at a relative humidity from 10% to 70% for a minimum of 4 hours prior to and during the test.

- ATDs were clothed in form-fitting cotton stretch garments with short sleeves, mid-thigh length pants, and size 45 (11E) shoes, weighing about 1.1 kg (2.5 lbf). The color of the clothing selected was in contrast to the color of the restraint system and the background as per SAE AS 8049. The color of the clothing was chosen to avoid overexposing the high-speed photographic images taken during the test.

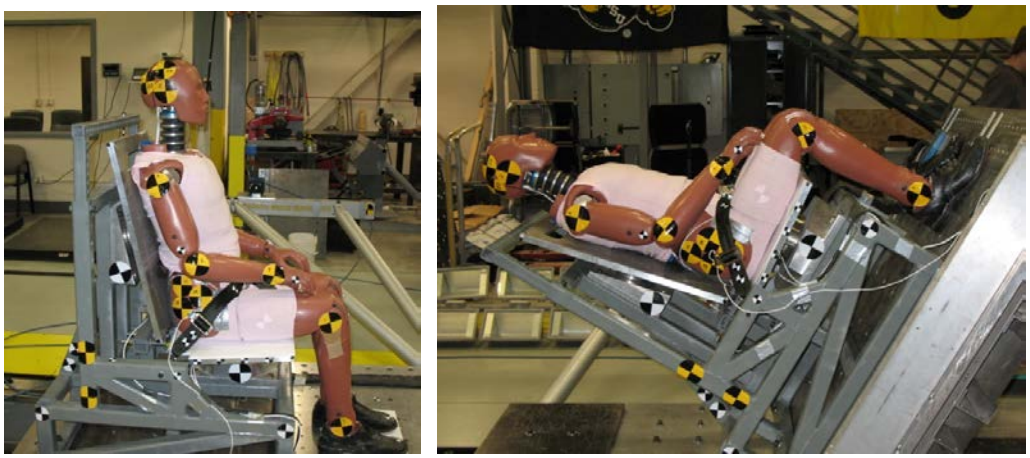
- ATDs were placed on the rigid seat per SAE AS 8049 with the appropriate configuration (0° or 60°), restraint belt system (two, three, or four point), and all sensors connected (accelerometers, load cells), as shown in figures 25 and 26.

- ATD clothing was cut as necessary to avoid obscuring photometric targets and taped around the edges so that it did not move and obscure the targets. Wires were positioned so that none were under belts or within areas that could be hit or pinched, thereby avoiding damage and loss of valuable data. The wires were secured so that they did not move during the test and interfere with imaging-tracking software. Belt ends were also secured so they did not move in front of photometric targets during the tests. The belt load cells were installed so that their wires exited from the top and were high enough to avoid hitting the seat pan during the test.

- Targets were placed in the ATD, belt system, and seat structure (table 13). Note that some of these targets were only recorded to establish dummy initial positioning, while others were also used to measure dummy excursions during the test per SAE J211/2 [11]; the latter are referred to as anthropometric landmarks. These anthropometric landmarks used 3-inch-diameter, black and yellow position targets, as described in table 14 and shown in figures 27 through 30. The reference coordinate system for these measurements was the aft center of the seat pan, as shown in figures 27 and 28. Targets on the rigid seat and the belt system were also defined; the number of targets and locations varied, depending on the restraint system used (i.e., more targets were necessary to define the location of a three- or four-point restraint system than to define a two-point restraint system). A total of ten targets were defined for the two-point restraint system (lap belt only). For the three-point restraint system, a total of 16 targets were defined, and for the four-point restraint system, 19 targets were defined. The individual test data sheets are located in appendix B, an illustration of target placement is shown in appendix C, and ATD initial position data is shown in appendix D.



(a) Hybrid II ATD with two-point belt at 0° pitch (left) and 60° pitch (right)



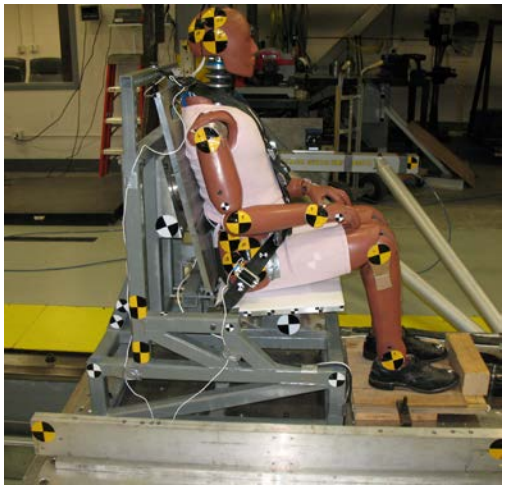
(b) FAA Hybrid III ATD with two-point belt at 0° pitch (left) and 60° pitch (right)

Figure 25. (a) Hybrid II and (b) FAA Hybrid III ATD Vertical Test Configurations

(a) Hybrid II ATD with three-point belt at 0° pitch

(b) FAA Hybrid III ATD with three-point belt at 0° pitch

(c) Hybrid II ATD with four-point belt at 0° pitch



(d) FAA Hybrid III ATD with four-point belt at 0° pitch

Figure 26. Hybrid II and FAA Hybrid III Longitudinal Test Configurations

Table 13. Placement of ATD Targets

Identifier	Name
1	H-point
1a	H-point vertical auxiliary
1b	H-point horizontal auxiliary
1c	H-point auxiliary
2	Head c.g.
2a	Head c.g. vertical auxiliary
2b	Head c.g. horizontal auxiliary
3	Knee R
4	Ankle R
5	Femur R
6	Shoulder R
7	Elbow 1 R
8	Elbow 2 R
9	Wrist R
10	Hand R
11	Top hand wrist R
12	Top hand wrist L
13	Knee R
14	Knee L
15	Tibia L
16	Tibia R
17	Shoe tip top R
18	Shoe tip top L
19	Shoe back L
20	Shoe back R
21	Shoulder L
22	Elbow L
23	Wrist L
24	Top Head
25	Forehead
26	Femur L
27	Knee L
28	Ankle L

Table 14. The ATD Anthropometric Landmark Targets

Identifier	Name	Definition	Measured Point
1	H-point	Intersection of a line passing though both hip joints and the mid-sagittal plane of the dummy	Measured at the surface of the hip flesh
2	Head c.g.	Intersection of a line along the y axis passing though the head c.g. and the mid-sagittal plane of the dummy	Measured at the surface of the head flesh
3 and 27	Knee	Intersection of the centerline of the knee pivot and the mid-sagittal plane knee	Measured at the surface of the knee pivot bolt head
4 and 28	Ankle	Intersection of the centerline of the ankle pivot and the mid-sagittal plane of the ankle	Measured at the surface of the ankle pivot bolt head
6 and 21	Shoulder	Intersection of the centerlines of the shoulder horizontal pivot and the fore-aft pivot	Measured at the surface of the shoulder flesh.
8 and 22	Elbow	Intersection of the centerline of the elbow pivot and the mid-sagittal plane of the elbow	Measured at the surface of the elbow pivot bolt head for the Hybrid II or the outboard surface of the elbow flesh for the FAA Hybrid III
9 and 23	Wrist	Intersection of the centerline of the wrist pivot and the mid-sagittal plane of the wrist	Measured at the surface of the wrist pivot bolt head
1a,1b, and 1c	Pelvic angle	The angle that the x axis of the lumbar spine load cell makes with the seat x axis	Measured using auxiliary markers placed at known locations relative to the pelvis coordinate system
2a, 2b, and 2c	Head angle	The angle that the x axis of the head accelerometer array makes with the seat x axis	Measured using auxiliary markers placed at known locations relative to the head coordinate system

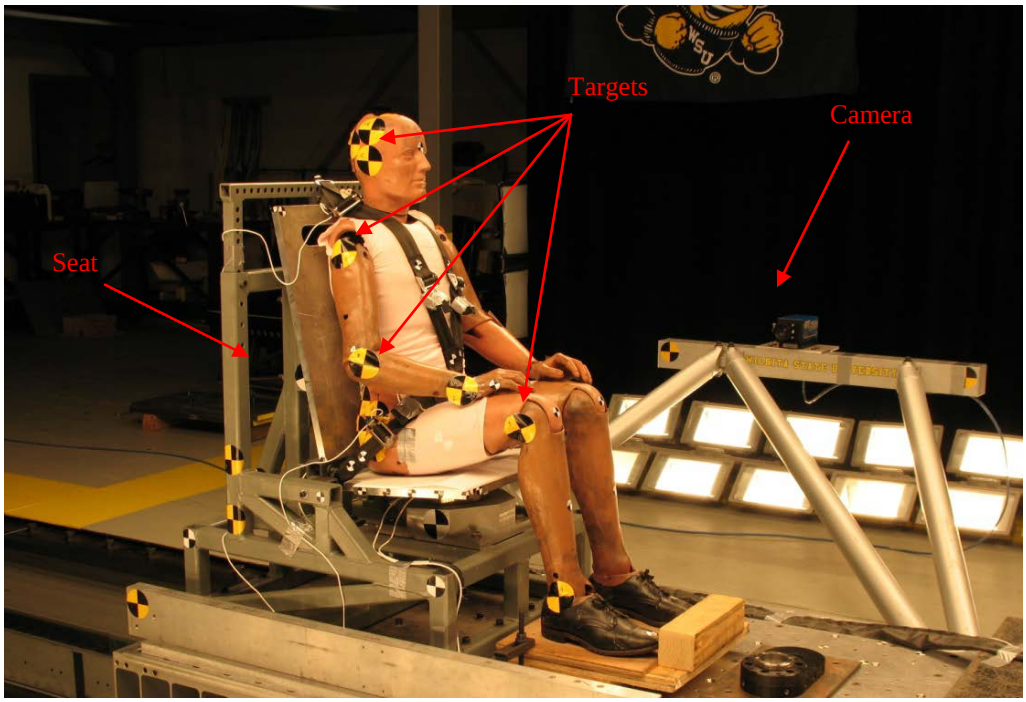


Figure 27. The ATD Targets

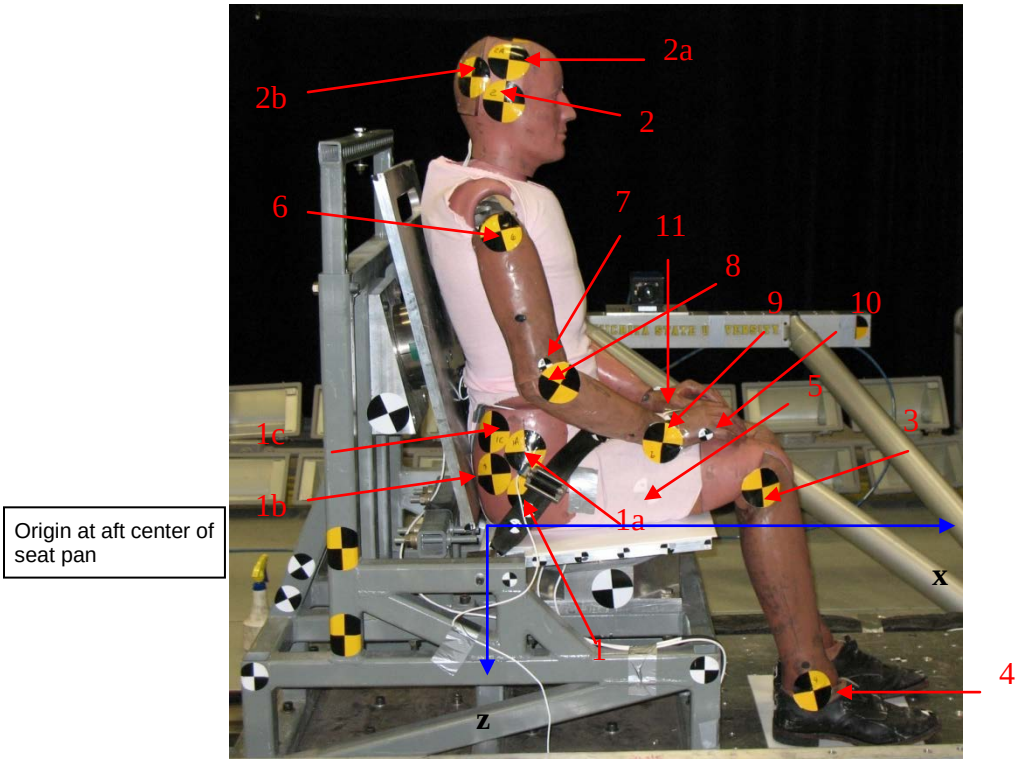


Figure 28. Right Side ATD Targets

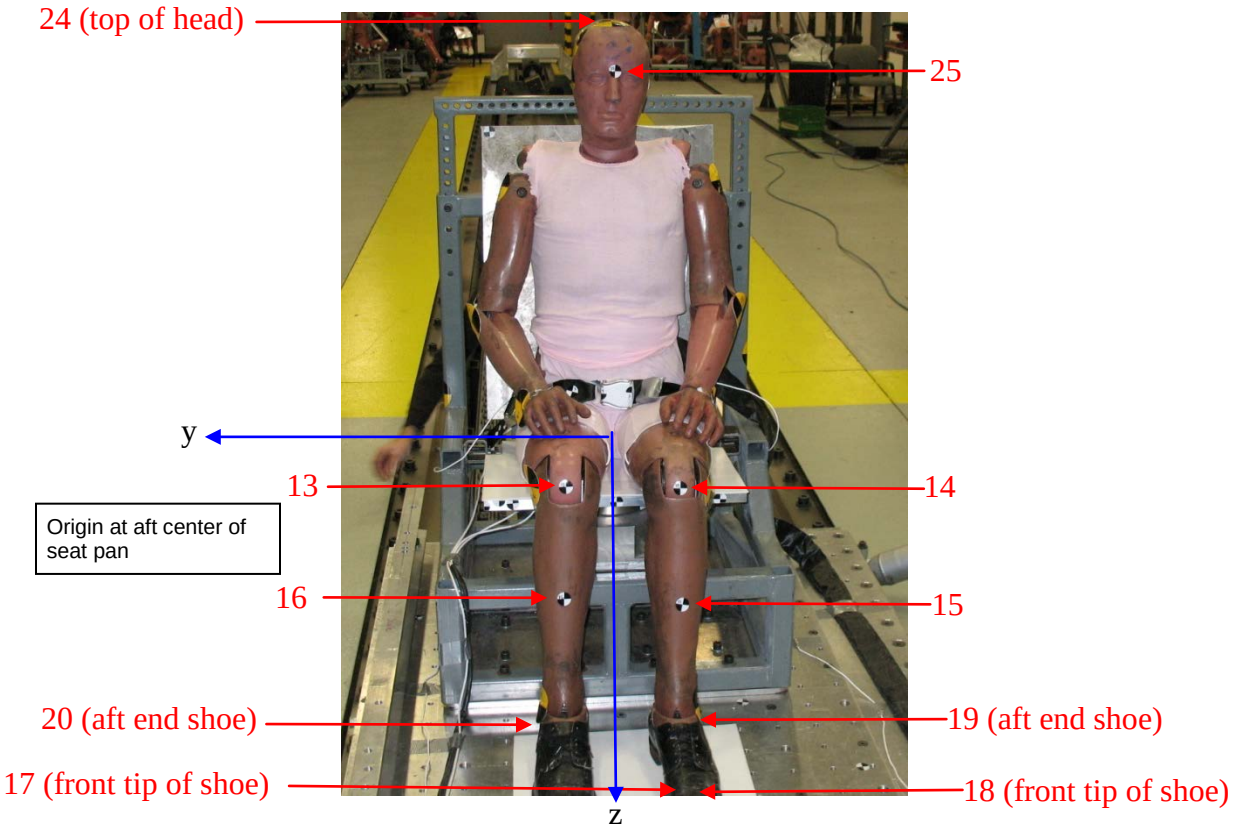


Figure 29. Front ATD Targets

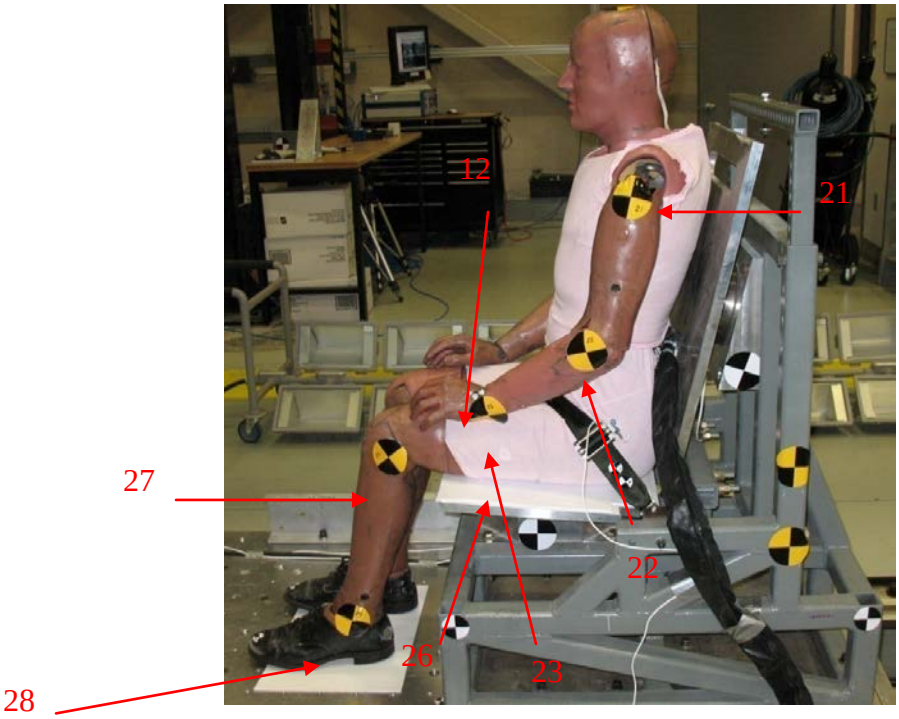


Figure 30. Left Side ATD Targets

Furthermore, a two-dimensional profile of the head and chest of the ATD pretest was recorded. Figure 31 shows the measurements taken for the ATD profile, where each dot represents a profile data point recorded on the dummy prior to testing. Once all ATD target measurements were recorded, the setup was photographed with a digital camera from several angles for additional reference.

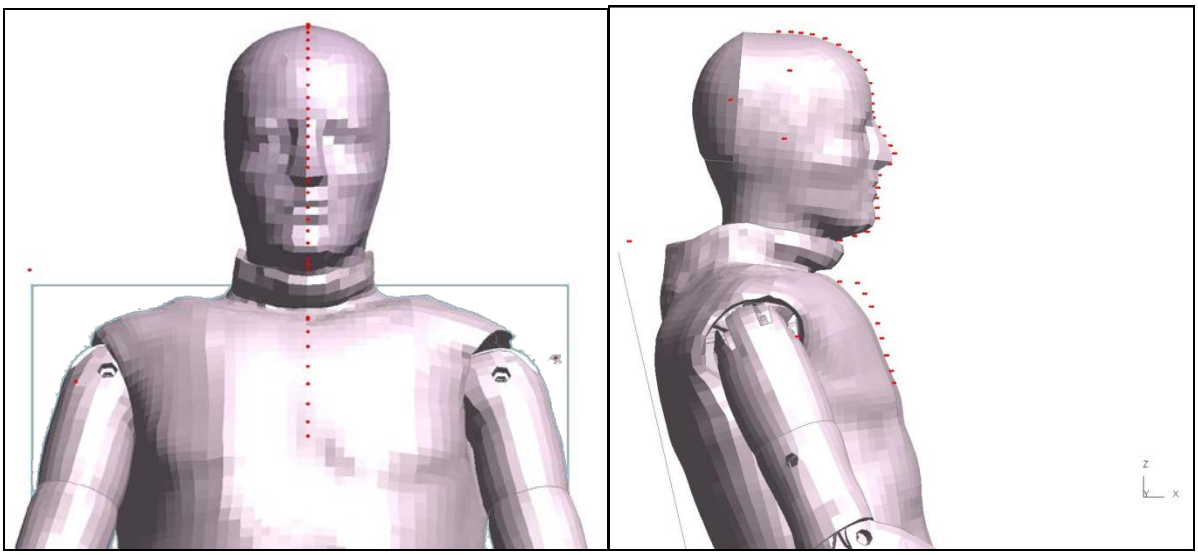
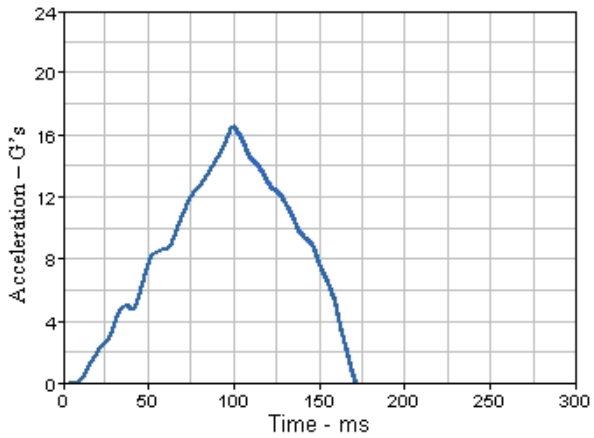


Figure 31. The ATD Head and Torso Profile

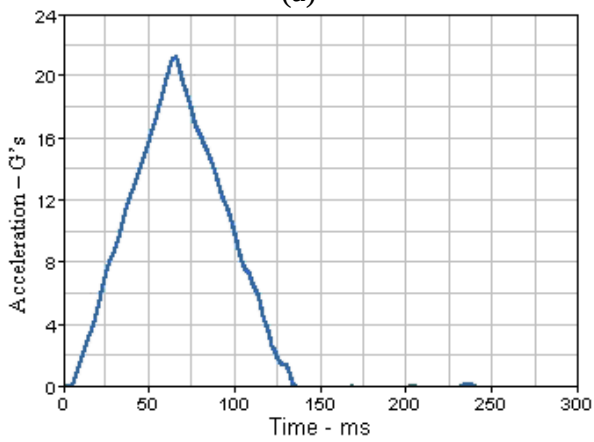
- Pretest measurements (x, y, and z coordinates) of various target locations in the seat and ATD were recorded with the CMM. A pretest data sheet was filled out with the locations of all targets, and a record of angles (using a digital protractor) was kept, measured from different planes of reference, such as the ground or the base of the rigid seat to a number of different areas of the ATD or restraint system (femur, tibia, or chest). In addition, the length of belt segments was recorded. All pretest data sheets are documented in appendix B.

3.5.2 Dynamic Test Acceleration Profiles and Data Channels Overview.

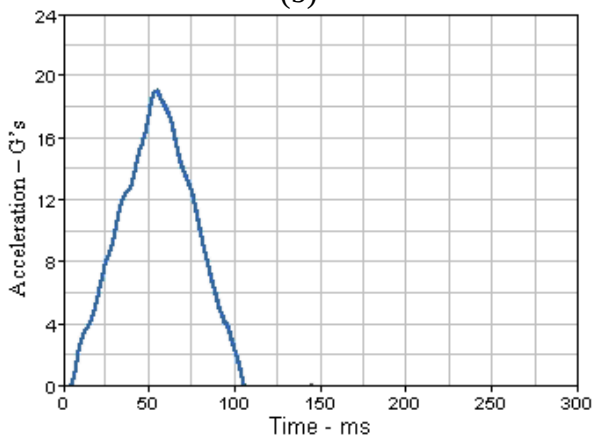
Three types of pulses were used for this study (figure 32). One pulse represents a change in forward longitudinal velocity of not less than 44 ft/second, with the airplane's longitudinal axis horizontal (no 10° yaw, pitch, and roll). Peak floor deceleration must occur in no more than 0.09 second after impact and must reach a minimum of 16 g's. The second pulse was very similar to the first. This pulse also represents a change in forward longitudinal velocity of not less than 42 ft/second, with the airplane's longitudinal axis horizontal (no 10° yaw, pitch, and roll). Peak floor deceleration must occur in no more than 0.06 second after impact and must reach a minimum of 21 g's. Also, where floor rails or floor fittings were used to attach the seating devices to the test fixture, the rails or fittings were not misaligned (no 10° yaw and no 10° roll). The final pulse represents a change in downward vertical velocity of no less than 31 ft/second, with the airplane's longitudinal axis canted downward 30° with respect to the horizontal plane and with the wings level. Peak floor deceleration must occur in not more than 0.05 second after impact and must reach a minimum of 19 g's.



(a)



(b)



(c)

Figure 32. Acceleration Pulses ((a) 16, (b) 21, and (c) 19 g's) vs Time

The sampling rate of the ATD and seat sensors was set to 10 kHz (table 15). The recording speed of the video camera was 1000 frames per second.

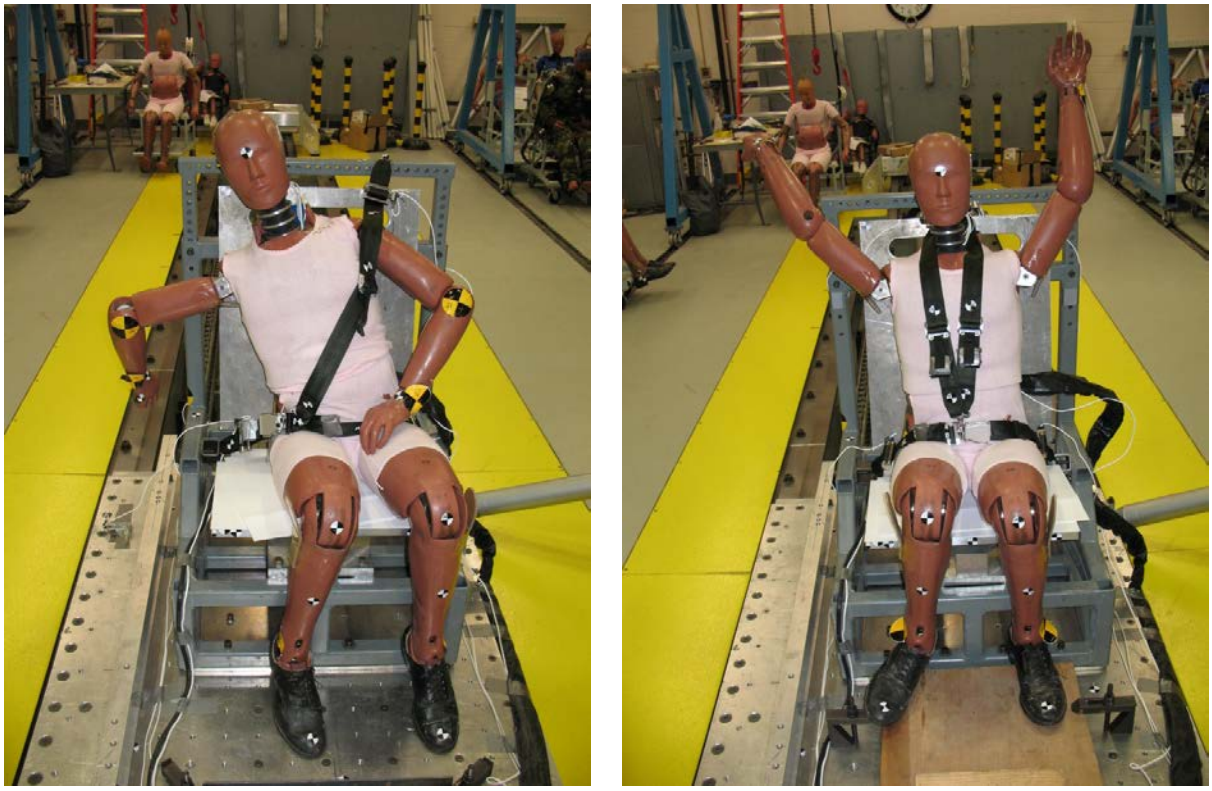
Table 15. Test Data Channels

Channel Description	Channel Units	Hybrid II	FAA Hybrid III
Sled acceleration	g's vs second	√	√
Head x acceleration	g's vs second	√	√
Head y acceleration	g's vs second	√	√
Head z acceleration	g's vs second	√	√
Upper neck force x direction	lbf vs second	N/A	√
Upper neck force y direction	lbf vs second	N/A	√
Upper neck force z direction	lbf vs second	N/A	√
Upper neck moment about x axis	in-lb vs second	N/A	√
Upper neck moment about y axis	in-lb vs second	N/A	√
Upper neck moment about z axis	in-lb vs second	N/A	√
Chest x acceleration	g vs second	√	√
Chest y acceleration	g vs second	√	√
Chest z acceleration	g vs second	√	√
Lumbar load x direction	lbf vs second	√	√
Lumbar load z direction	lbf vs second	√	√
Lumbar moment about x axis	in-lb vs second	√	√
Pelvis x acceleration	g's vs second	√	√
Pelvis y acceleration	g's vs second	√	√
Pelvis z acceleration	g's vs second	√	√
Left femur compression load	lbf vs second	√	√
Right femur compression load	lbf vs second	√	√
Lap strap left side tension load	lbf vs second	√	√
Lap strap right side tension load	lbf vs second	√	√
Shoulder left strap tension load	lbf vs second	√	√
Shoulder right strap tension load	lbf vs second	√	√
Joint shoulder straps tension load	lbf vs second	√	√
Seat back x reaction force	lbf vs second	√	√
Seat back y reaction force	lbf vs second	√	√
Seat back z reaction force	lbf vs second	√	√
Seat pan x reaction force	lbf vs second	√	√
Seat pan y reaction force	lbf vs second	√	√
Seat pan z reaction force	lbf vs second	√	√
Seat pan x reaction moment	in-lb vs second	√	√
Seat pan y reaction moment	in-lb vs second	√	√
Seat pan z reaction moment	in-lb vs second	√	√
Head trajectory in the x-z plane	inch vs inch	√	√
Chest trajectory in the x-z plane	inch vs inch	√	√
Chest trajectory in the x-z plane	inch vs inch	√	√
Knee trajectory in the x-z plane	inch vs inch	√	√

3.5.3 Posttest Procedure.

A number of steps were performed after the completion of each test to provide a consistent and reliable record of the final configuration of the test article (ATD and restraint system) so that later numerical model simulations could be validated using these tests.

The first step was to ensure that all data from the different sensors and camera was recorded successfully. During this particular study, one test (07324-19) had a sensor failure and was repeated to ensure that there were three complete data sets for each test condition. The ATD was photographed with a digital camera from several angles and different close-ups for additional reference. Figure 33 shows typical ATD posttest positions.



(a) FAA Hybrid III three-point belt at 0° pitch (b) FAA Hybrid III four-point belt at 0° pitch

Figure 33. Typical ATD Posttest Positions

3.6 TEST DATA PROCESSING.

This section provides an overview of channels, filters, and load correction factors for data collected during the dynamic sled tests.

3.6.1 Channel Filters.

The positive orientations of a standardized dummy coordinate system [8] are shown in figures 34 and 35, which are consistent with the positive recorded outputs on each channel. The sampling rate was 10 kHz, and the CFC filters are listed in table 16. The orientations and CFC for each channel are consistent with SAE recommended practices outlined in SAE AS 8049 [8]. The seat pan and seat back are not parallel to the global coordinate system. The seat back is 13° from the vertical global axis, and the seat pan is 5.2° from the global horizontal axis, as described in section 3.3.1. Note that loads and moments obtained from the seat pan and seat back load cells align with this local coordinate system.

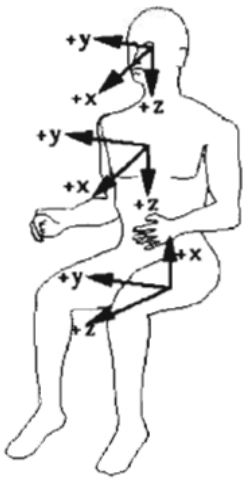


Figure 34. Seating Posture Orientations of Standardized Dummy Coordinate Systems

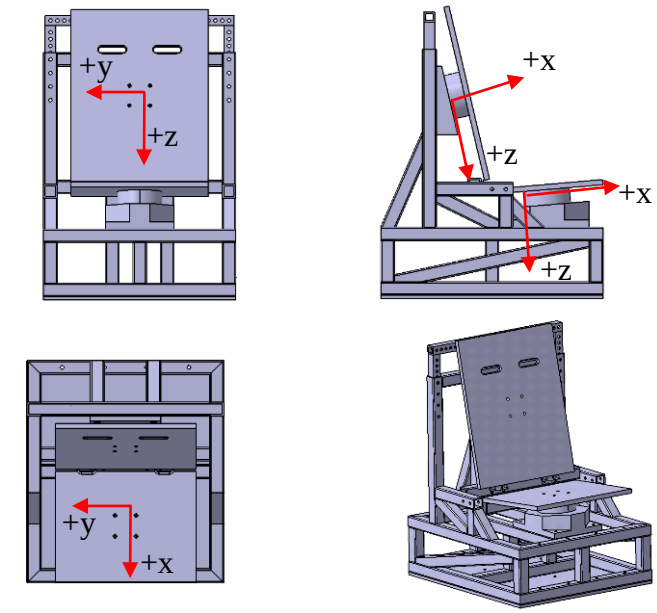


Figure 35. Orientations of Seat Load Cell Coordinate Systems

Table 16. Data Channel Filters

Channel	Manufacturer	Model Number	Range	CFC
Sled accelerations	Endevco	Endevco 7290A-100	500 g's	1000
Head accelerations	Endevco	Endevco 7264C	500 g's	1000
Upper neck forces	Endevco	Denton 1716A	2,000 lbf	1000
Upper neck moments	Endevco	Denton 1716A	2,500 lb-in	600
Chest accelerations	Endevco	Endevco 7264C	2,000 g's	180
Lumbar forces	Denton	Denton 1891	3,500 lbf	600
Lumbar moments	Denton	Denton 1891	5,000 lb-in	600
Pelvic accelerations	Entran	Entran 7264C	500 g's	1000
Femur forces	Denton	Denton 2121A	3,000 lbf	600
Belt system loads	Denton	Denton 1910/3255	3,000 lbf	60
Seat back forces	Denton	Denton 2177A	10,000 lbf	60
Seat pan forces	Denton	Denton 2513	10,000 lbf	60
Seat pan moments	Denton	Denton 2513	25,000 lb-in	60

3.6.2 Mass Effects on Seat Back and Seat Pan Forces.

The seat pan and seat back forces obtained from the load cells also measure the inertia loads of the 23.7-lbf seat pan and 36-lbf seat back during the test. These inertia loads must be subtracted from the recorded loads to obtain seat back and seat pan loads caused by ATD contact. In addition, the load cell itself is also under acceleration on the sled, and part of its own accelerated mass (i.e., 6 lbf) is picked up by the load cell as applied load; therefore, this load is also subtracted. The 0.3-lbf hardware used to attach the load cell to the seat also loads the load cell, and its inertia load must be subtracted. The calculated seat pan and seat back inertia loads were obtained by multiplying the 16-g acceleration pulse (two-point belt, 0° only, figure 36) to the weight of the seat pan/back load cell (6 lbf only) and hardware:

$$\text{Maximum Seat Pan Inertia Load} = (16\ g)\ (23.7\ lbf + 6\ lbf + 0.3\ lbf) = 480\ lbf$$

$$\text{Maximum Seat Back Inertia Load} = (16\ g)\ (36\ lbf + 6\ lbf + 0.3\ lbf) = 677\ lbf$$

The resulting seat back and seat pan loads were subtracted from the respective loads recorded in the tests. This was done to isolate the response of the ATD. Figure 36 presents the seat pan and seat back inertia loads. Note that the two top plots of figure 36 are loads from the test in load cell local coordinates, while the two bottom plots show the loads in global coordinates (i.e., horizontal x-force parallel to the ground, and z-force perpendicular to the ground). The maximum inertia loads calculated for the 21-g test conditions (three- and four-point belts) were calculated as follows:

$$\text{Maximum Seat Pan Inertia Load} = (21\ g)\ (23.7\ lbf + 6\ lbf + 0.3\ lbf) = 630\ lbf$$

$$\text{Maximum Seat Back Inertia Load} = (21g)\ (36\ lbf + 6\ lbf + 0.3\ lbf) = 888\ lbf$$

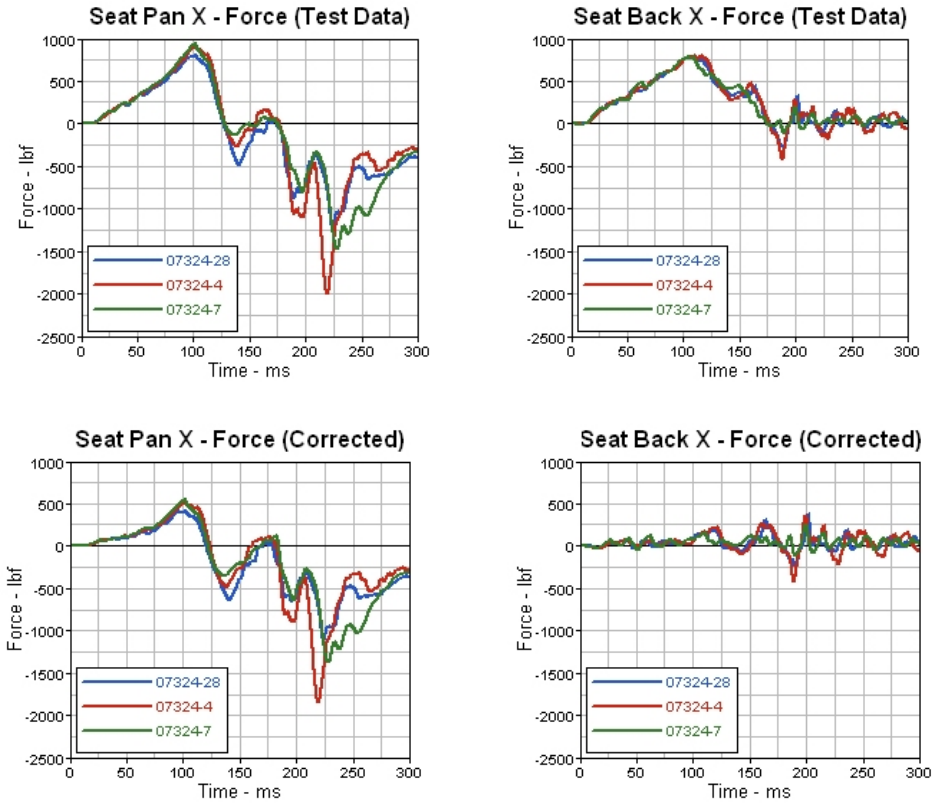


Figure 36. Seat Pan and Seat Back Inertia Loads

The same type of correction was performed on the 19-g test conditions, taking into account that the seat had a pitch of 60° up with respect to the horizontal acceleration. The maximum inertia loads calculated for the 19-g test conditions were calculated as follows:

Maximum Seat Pan Inertia Load = (19 g) (23.7 lbf + 6 lbf + 0.3 lbf) = 570 lbf

Maximum Seat Back Inertia Load = (19 g) (36 lbf + 6 lbf + 0.3 lbf) = 804 lbf

3.6.3 The ATD Kinematic Analysis.

CAMI provided the software and methodology for the photometric analysis. CAMI also provided a Microsoft® Excel® macro that computes smooth trajectories for all tracked targets. This macro can also track hidden targets using a triangulation-interpolation method. This technique is particularly useful for triangulating the location of the H-point, which is almost always hidden under the seat belt, as shown in figure 37. It is also used for tracking the head c.g. location when the arms cover it during the forward excursion of the chest. The Microsoft Excel macro uses the positioning data collected on the pretest data sheets (appendix B), which list target locations and important distances (camera lens to sled, etc.). Combining this data with the video recorded from the test allows calculation of smooth trajectories for all visible and hidden targets.

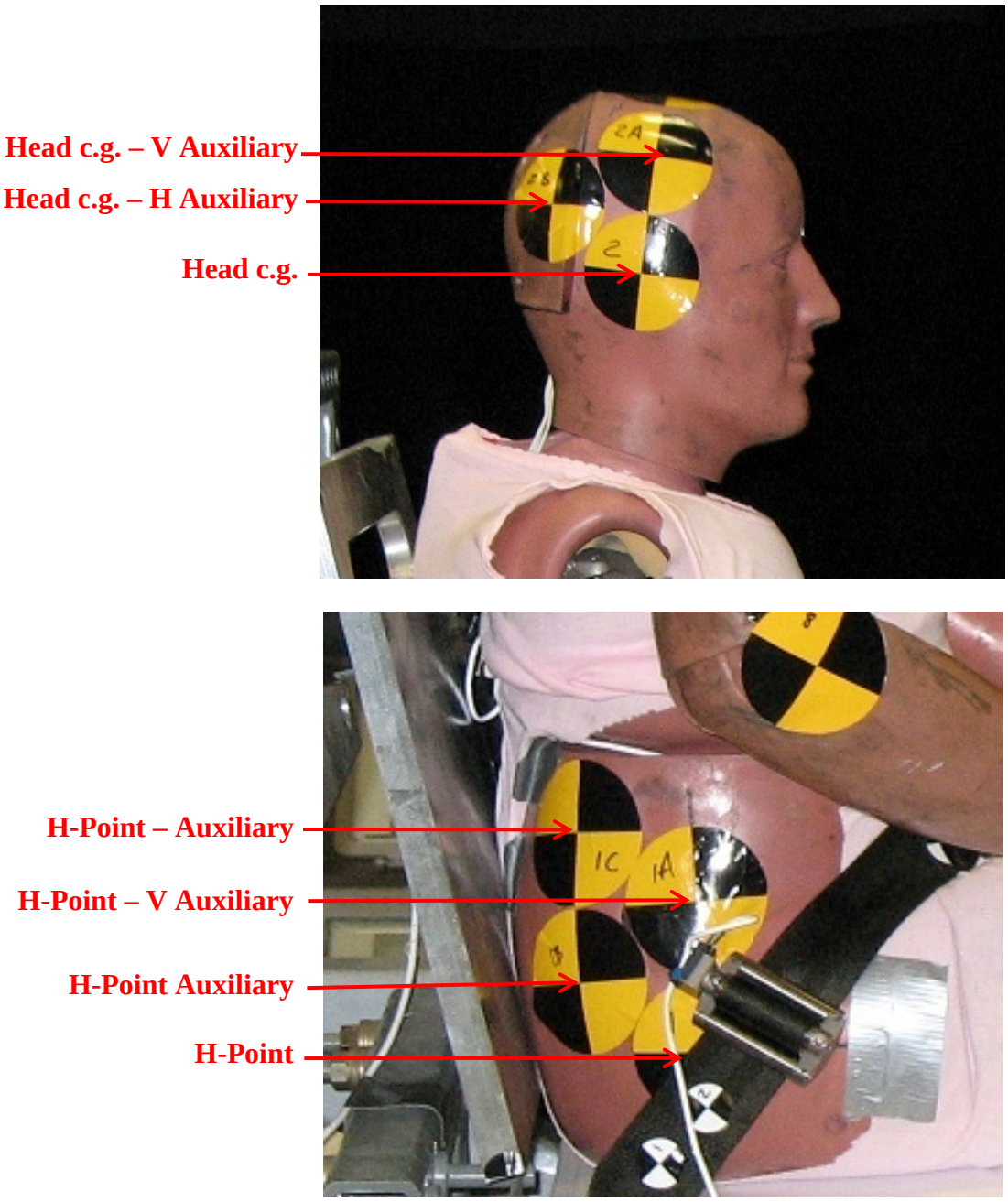


Figure 37. The ATD Head and H-Point Target Placement

Position data was derived from sled test videos in a multistep process that involved three software codes and several Microsoft Excel macros. A commercially available target tracking package was used to find the location of the targets of interest in each video frame. A Microsoft Excel spreadsheet was used to correct the raw pixel locations to remove image distortions. The spreadsheet then processed the corrected pixel locations into real space coordinates. A curve-fitting routine was used to fit a polynomial spline to the derived target locations. This curve-fitting process simultaneously smoothed the position data while deriving the velocity and acceleration. The output of this program was then imported into another Microsoft Excel

spreadsheet that summarized the data and provided graphing utilities. When needed, the position of virtual points or the angular position of rigid items could be derived from tracked data positions.

The software used for tracking was TEMA Automotive, version 2.4-011. Points of interest that are marked with yellow/black quadrant targets were automatically located using the quadrant symmetry tracking routine. Other target shapes could be tracked if required. Tracking parameters were adjusted as necessary to compensate for target size, lighting conditions, and partial obscurities. If the tracking algorithm was unable to find the center of the target, then it was manually entered. Tracking could be paused whenever a target was completely obscured and resumed if it reappeared. The raw pixel location of each target tracked was output in a text file for further processing.

Cameras typically distort the image produced to some degree. To quantify the amount of distortion produced by each camera and lens combination, a target pattern of known dimensions was imaged and the apparent location of the targets compared to the actual measured locations. The target pattern used was the SAE J211/2 pattern, sized to fit the camera's aspect ratio. Additional targets were added to the standard pattern at interstitial points. Also, an additional circular pattern of 12 targets was added. The target pattern was imaged, and distortion error parameters were calculated per SAE J211 procedures. To correct for distortions, a mathematical model for predicting target displacements was derived. Since lens distortion effects are relative to the center of the image, the distortion model was expressed in polar coordinates.

The symmetrical radial distortion present was modeled by a function that relates the displacement along a radial line (Δr_s) to the measured radius (r) using the coefficients of radial distortion K_0, K_1, K_2, and K_3. The coefficients of this function vary from lens to lens, and a number of terms needed are dependent on the complexity of the lens distortion. The function used to model this effect is

$$\Delta r_s = (K_0 r + K_1 r^3 + K_2 r^5 + K_3 r^7) \tag{1}$$

A second type of lens distortion, referred to as decentering distortion, has both a radial and tangential component. This distortion effect is symmetrical about the axis of zero tangential distortion (φ_0). The orientation of this line of symmetry is dependent on the direction of lens misalignment. The radial and tangential components both vary as a function of the radius from the center of the image and the angle. The radial effect was modeled by the following function that relates the displacement along a radial line (Δr_{dc}) to the measured radius (r) and angle (φ), and decentering parameters (J_1, J_2, and φ_0) as

$$\Delta r_{dc} = 3(J_1 r^2 + J_2 r^4)\sin(\varphi - \varphi_0) \tag{2}$$

The tangential effect was modeled by the following function that relates the displacement along a tangent line (Δr_t) to the measured radius (r), angle (φ), and decentering parameters (J_1, J_2, and φ_0) as

$$\Delta r_t = (J_1 r^2 + J_2 r^4)\cos(\varphi - \varphi_0) \tag{3}$$

The angular displacement with respect to the center of the image can be related to this tangential displacement using the following trigonometric identity:

$$\Delta\varphi = ATAN(\Delta r_t / r) \tag{4}$$

Therefore, the angular displacement with respect to the center of the image was modeled by the following function that relates the change in angle ($\Delta\varphi$) to the measured radius (r), angle (φ), and decentering parameters (J_1, J_2, and φ_0)

$$\Delta\varphi = ATAN\left[\left(J_1 r^2 + J_2 r^4\right)\cos(\varphi - \varphi_0) / r\right] \tag{5}$$

The total radial displacement is modeled by the summation of the radial portion of the two distortion effects as follows:

$$\Delta r = \Delta r_s + \Delta r_{dc} \tag{6}$$

The coefficients for these equations (K_0, K_1, K_2, K_3, φ_0, J_1, and J_2) were derived by comparing the model output to the observed target displacements.

The resulting correction formulae were implemented in an Microsoft Excel spreadsheet that, in a stepwise fashion, converted the raw pixel locations output by the tracking software to polar coordinates (with the origin at the center of the image), adjusted the radial distance and angle of each point using the correction model, and then converted the locations back to rectangular coordinates for further processing.

The position of the points in real space coordinates were derived from the corrected pixel locations by using the geometric relationship between the tracked targets and the camera. This method was only applicable when the following applied:

- The motion of all objects was planar, and those planes were parallel to each other.
- The camera recording the event was perpendicular to the object motion planes.
- The orthogonal distance from the camera object plane to each of the motion planes was known.
- The distance between two coplanar objects was known.

Figures 38 and 39 show the geometric relationship between the various points of a typical sled test setup. These geometric relationships were used to derive formulas for calculating the orthogonal x and z distance between the fixed marker, which was assumed to be securely fixed on the sled, and the target markers, which may be moving with respect to the sled.

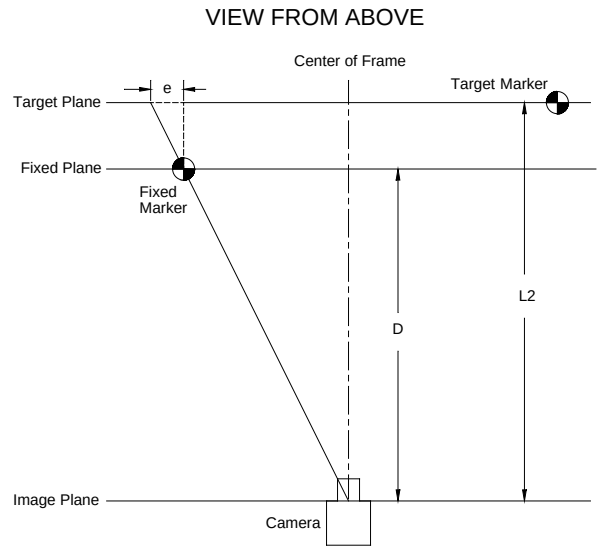


Figure 38. Relationship Between Fixed and Target Marker Locations

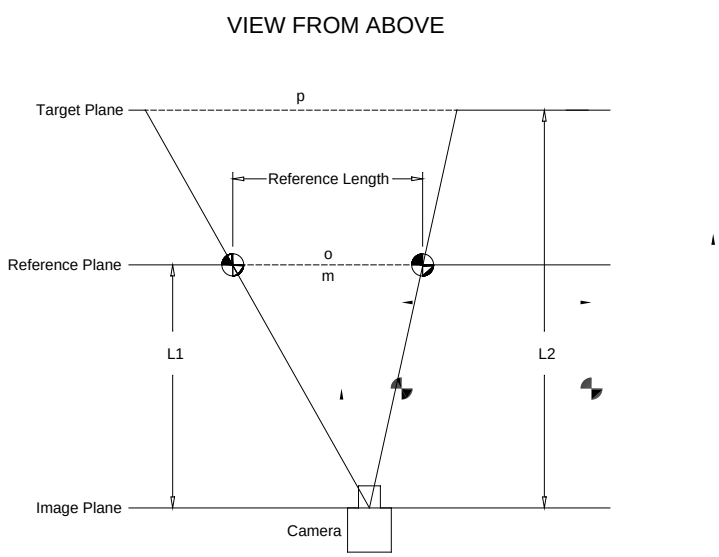


Figure 39. Relationship Between Reference and Target Planes

The formula for calculating the x coordinate of the target marker with respect to the fixed marker in real coordinate space is

$$X = \left\{ U_t - U_c + D\left[\left(U_c - U_f \right) / L2 \right] \right\} (m / o)(L2 / L1) \tag{7}$$

where:

U_t = x coordinate of the target marker
U_f = x coordinate of the fixed marker
U_c = x coordinate at the center of the frame
D = orthogonal distance from camera image plane to fixed target plane
$L1$ = orthogonal distance from camera image plane to reference plane
$L2$ = orthogonal distance from camera image plane to target plane
m = the measured reference length
o = the observed reference length
p = target plane

The formula for the z coordinate of the target marker with respect to the fixed marker in real coordinate space is

$$Z = \left\{ V_t - V_c + D\left[\left(V_c - V_f \right) / L2 \right] \right\} (m / o)(L2 / L1) \tag{8}$$

where:

V_t = z coordinate of the target marker
V_f = z coordinate of the fixed marker
V_c = z coordinate at the center of the frame

These formulas were implemented in an Microsoft Excel spreadsheet. The camera image coordinate system, in which the target positions were derived, was rotated to align it with the seat coordinate system. This compensated for any rotational misalignment between the camera and sled, and simplified interpretation of the 60° pitch tests. The origin of the derived target positions was also translated to a useful location, such as the defined seat reference point.

A polynomial function was fitted to the derived target locations to smooth data collection errors and interpolate during periods of target obscurity. A publicly available code, SMOOTH.EXE, was then used to fit a spline to the derived target locations using a generalized cross-validation routine. This routine created a polynomial in such a way that the first and second derivatives were continuous. The amount of smoothing provided could be controlled by specifying the order of the polynomial function and how far the function could vary from the original data. This curve-fitting process simultaneously smoothed the position data while deriving the velocity and acceleration. This smoothing process was implemented using a Microsoft Visual Basic® macro that sent the spreadsheet data to an executable file and then imported the results into a Microsoft Excel spreadsheet that summarized the data and provided graphing utilities. This summary file also documented all geometric and smoothing parameters used throughout the entire process.

When needed, the positions of virtual points were determined using known geometric relationships between tracked points and virtual points. The angular position of rigid items that exhibited rotation in a plane perpendicular to the camera, such as the pelvis or head of the ATD, could be determined from the position of at least two points attached to that item.

The ATD's head movement during the test was recorded by a stationary camera. This displacement was measured in x-z coordinates and plotted, as shown in figure 40.

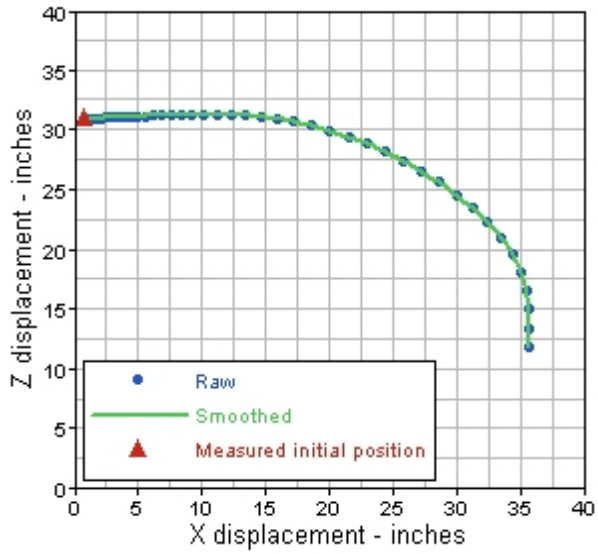


Figure 40. The ATD Head Path During the Test

This head trajectory, also shown in figure 41, corresponds to the head movement from its original position at rest to the end of the forward and down movement, before it starts bouncing back. The series II test procedure used a length of 55 inches in the x axis for scaling, and 6 inches in the z axis to track the error along the lens field of view. The larger distance between scaling targets allowed for a smaller scaling error, and the two vertical targets gave a measure of error throughout the tracking of the event.

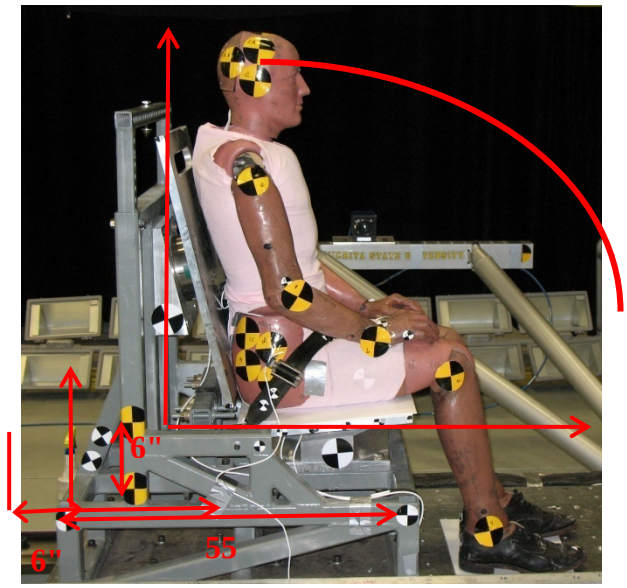


Figure 41. The ATD Head Path Target and Coordinate System

Table 17 lists all camera and lens combinations that were used for these tests.

Table 17. Camera and Lens Settings

Camera Serial Number	Lens Serial Number	Camera Name	Lens Setting (mm)
20010128	1	Nikon - F2.8	25
20010128	1	Nikon - F2.8	31
20010128	1	Nikon - F2.8	24
20010127	117181	Kinoptik - F1.8	12.5
20010128	1	Nikon - F2.8	26

3.7 TEST RESULTS.

The data presented in the following sections have been trimmed to 300 ms. Each plot presents the data of a single channel (e.g., x acceleration) for a particular test configuration. Each test configuration was repeated three times except for tests 1, 2, 3, 6, and 19, which were repeated in tests 28, 29, 26, 27, and 25, respectively, as well as test 10, which was repeated in tests 30 and 31. These plots allow the evaluation of the repeatability of the signal's experimental data using the error metrics discussed in section 4. The corrected seat pan moments for all test conditions are shown in appendix H.

3.7.1 Hybrid II ATD Test Data.

This section contains a summary of the Hybrid II ATD dynamic test results.

3.7.1.1 Hybrid II ATD With Two-Point Belt at 0° Pitch.

A series of tests of the Hybrid II ATD with two-point belt at 0° included test numbers 07324-4, 073247, and 07324-28. The dynamic test setup is shown in table 18, and the significant peak values for reference are shown in table 19. The configuration consisted of a rigid seat, a two-point belt restraint, and 0° pitch (figure 42). The tests were performed using the 14 CFR 25.562 16-g acceleration pulse. For the calibration report and test data, refer to appendices A and B, respectively. The channel data, derived data (from video), calculated data (from channel data), shown in figures 43 to 51, and a series of images showing the ATD kinematics are shown in figure 52. A review of the data indicates that the head of the ATD in test 07324-4 impacted the shin of the left leg. This is indicated by the observed spike occurring in the head data at approximately 185 msec.

Table 18. Dynamic Test Configuration for Hybrid II ATD With Two-Point Belt at 0° Pitch

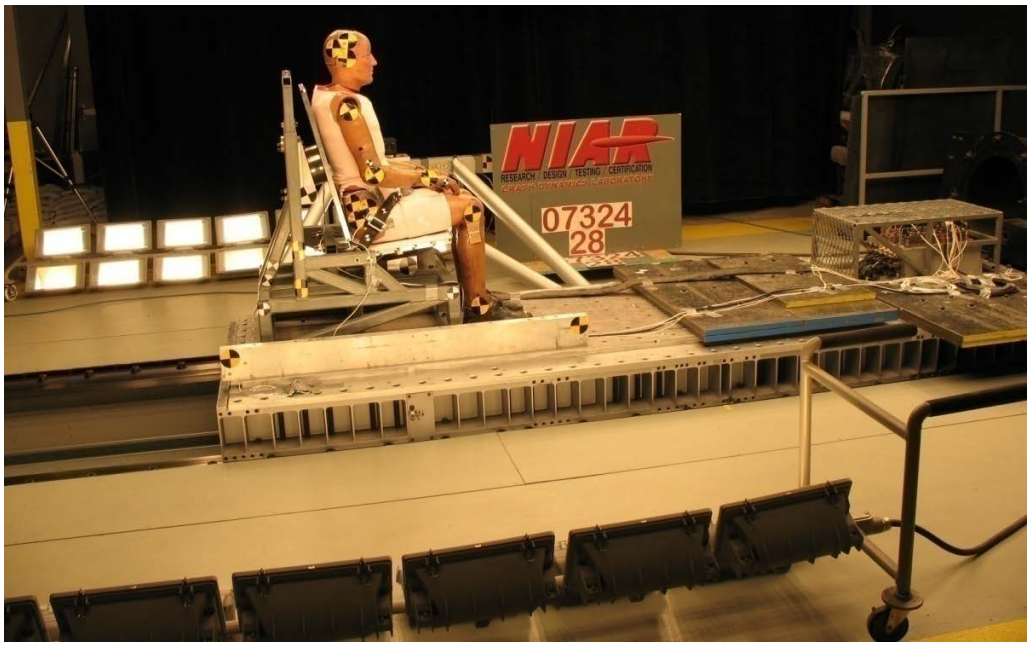
Test Number	ATD Serial Number	Belt Point Type	Pitch Angle (degrees)	Load (g)	Seat Type	Belt Material	Acceleration Pulse	Test Data (page)
07324-7	Hybrid II 698	2	0	16	Rigid	100% Nylon	25.562	B-5
07324-4	Hybrid II 698	2	0	16	Rigid	100% Nylon	25.562	B-1
07324-28	Hybrid II 698	2	0	16	Rigid	100% Nylon	25.562	B-45

Table 19. Significant Peak Values for Hybrid II ATD With Two-Point Belt at 0° Pitch

Channel Description	Injury Criteria	Hybrid II Test 07324-4	Hybrid II Test 07324-7	Hybrid II Test 07324-28
HIC (unlimited)*	1000	825	689	703
T1-ms	-	149	145	147
T2-ms	-	185	181	183
Head xz velocity (ft/s)	Not required	47.9	46.9	47.0
Head xz excursion (in.)	Not required	35.2	35.7	36.2
Lumbar Fz load (lbf) (compression)	1500	59	78	72
Seat pan resultant force (lbf)	Not required	3688	3528	4282
Left lap belt load (lbf) (tension)	Not required	1887	2002	1989
Right lap belt load (lbf) (tension)	Not required	1870	1952	1976
Left strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A
Right strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A

N/A = not applicable
*Unlimited head injury criteria (HIC) is calculated until 300 ms for this test configuration.
[1]Individual shoulder strap
[2]Dual shoulder strap

(a) Front view



(b) Side view

Figure 42. Front (a) and Side (b) Views of Hybrid II ATD With Two-Point Belt at 0° Pitch

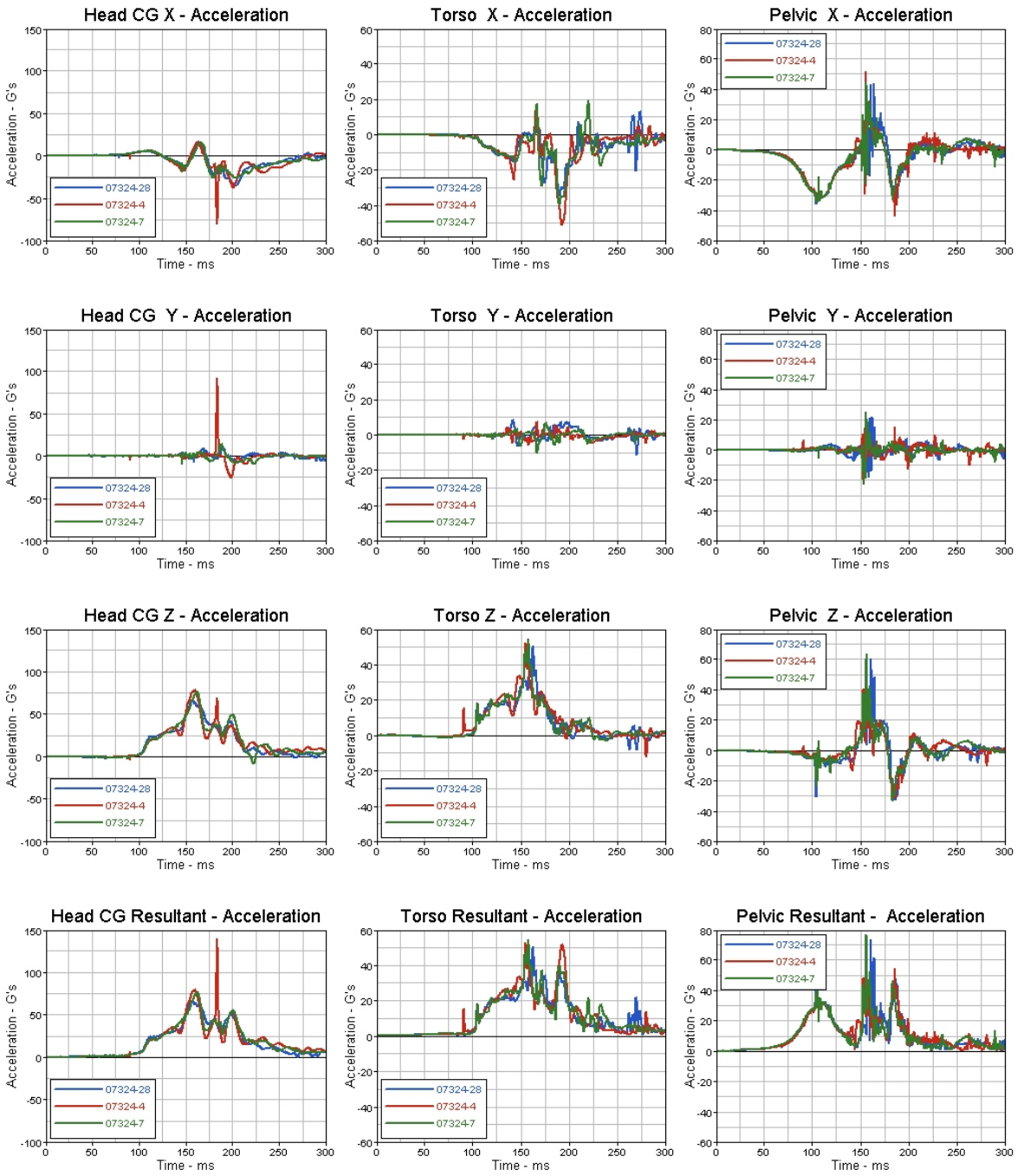


Figure 43. Head, Torso, and Pelvis Accelerations of Hybrid II ATD With Two-Point Belt at 0° Pitch

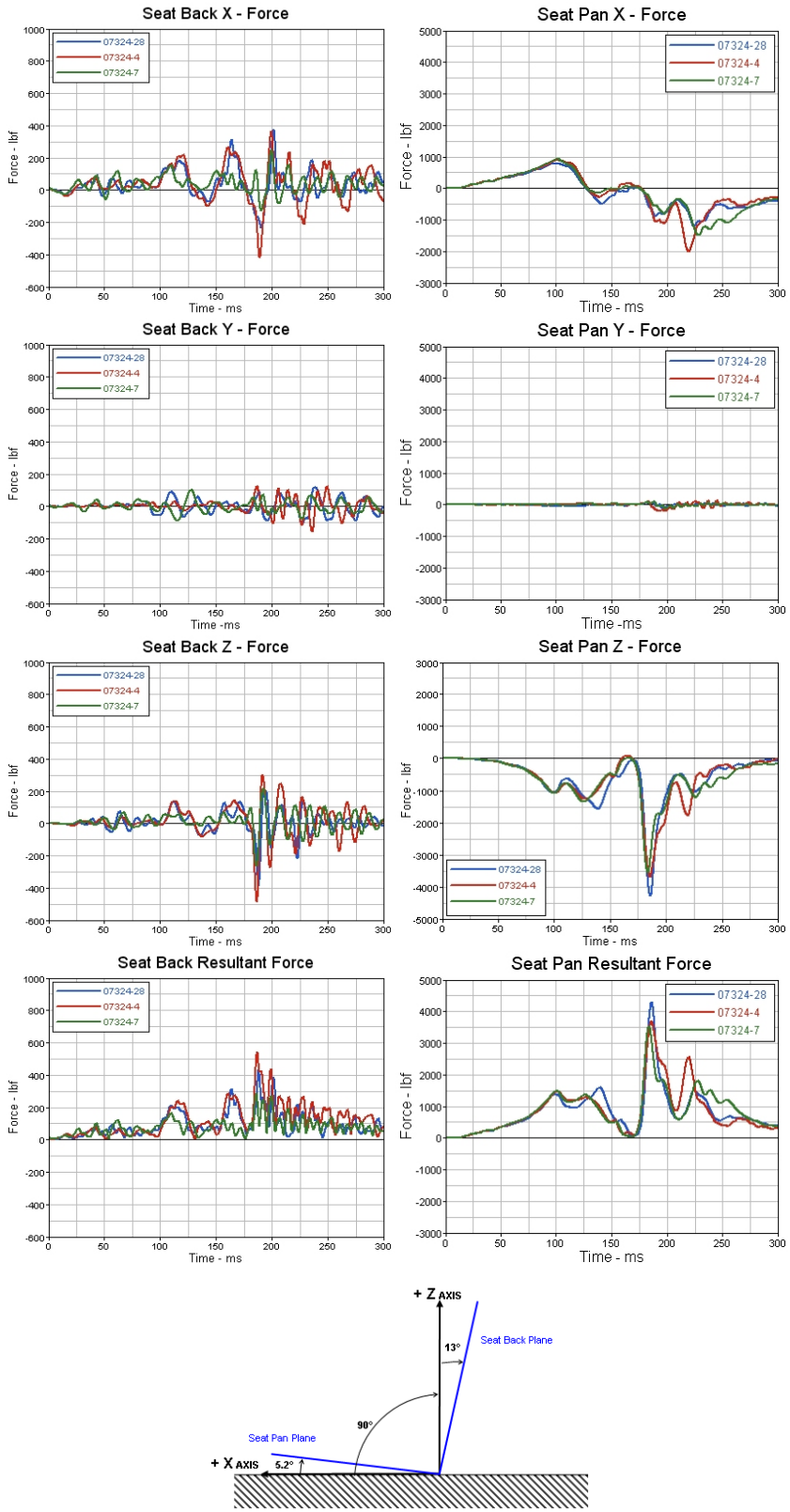


Figure 44. Seat Pan and Back Loads (Tare Compensation and Global Coordinates) of Hybrid II ATD With Two-Point Belt at 0° Pitch

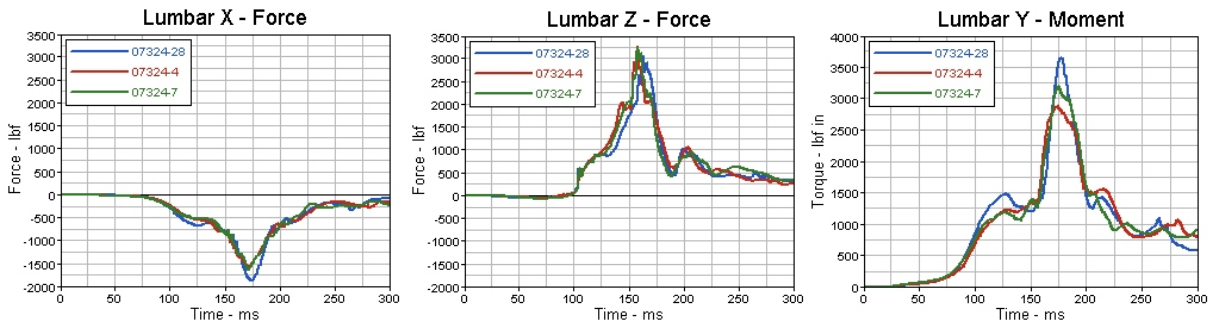


Figure 45. Lumbar Loads and Moments of Hybrid II ATD With Two-Point Belt at 0° Pitch

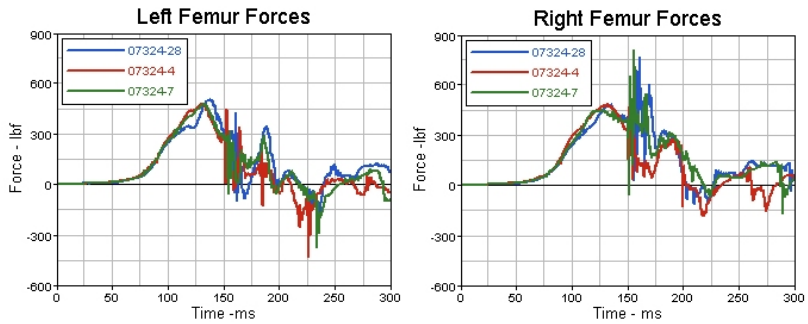


Figure 46. Femur Forces of Hybrid II ATD With Two-Point Belt at 0° Pitch

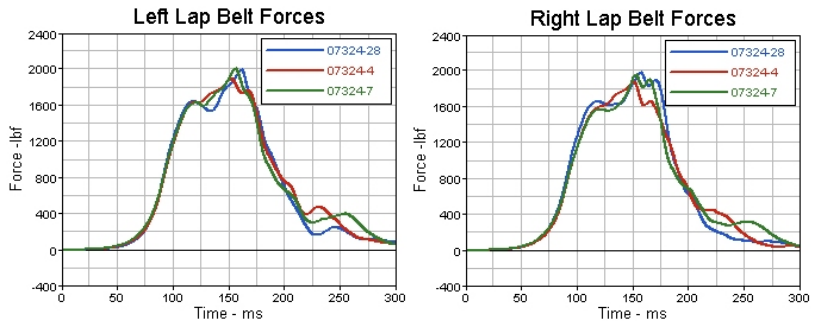


Figure 47. Lap Belt Forces of Hybrid II ATD With Two-Point Belt at 0° Pitch

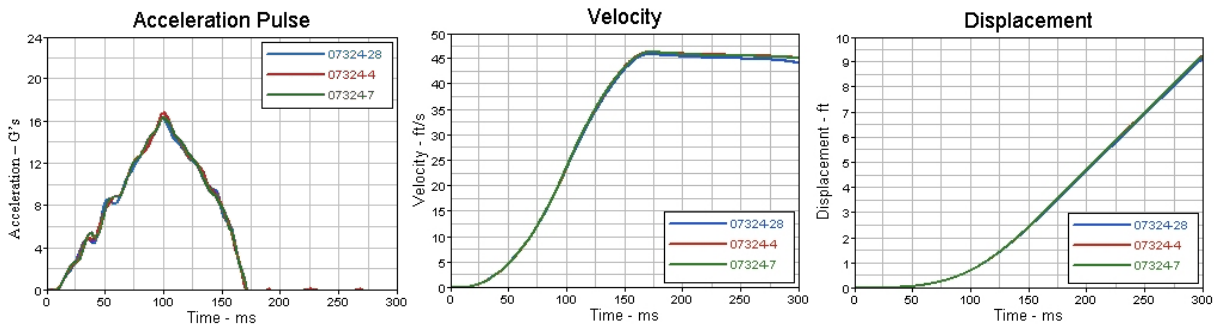


Figure 48. Acceleration Pulses of Hybrid II ATD With Two-Point Belt at 0° Pitch

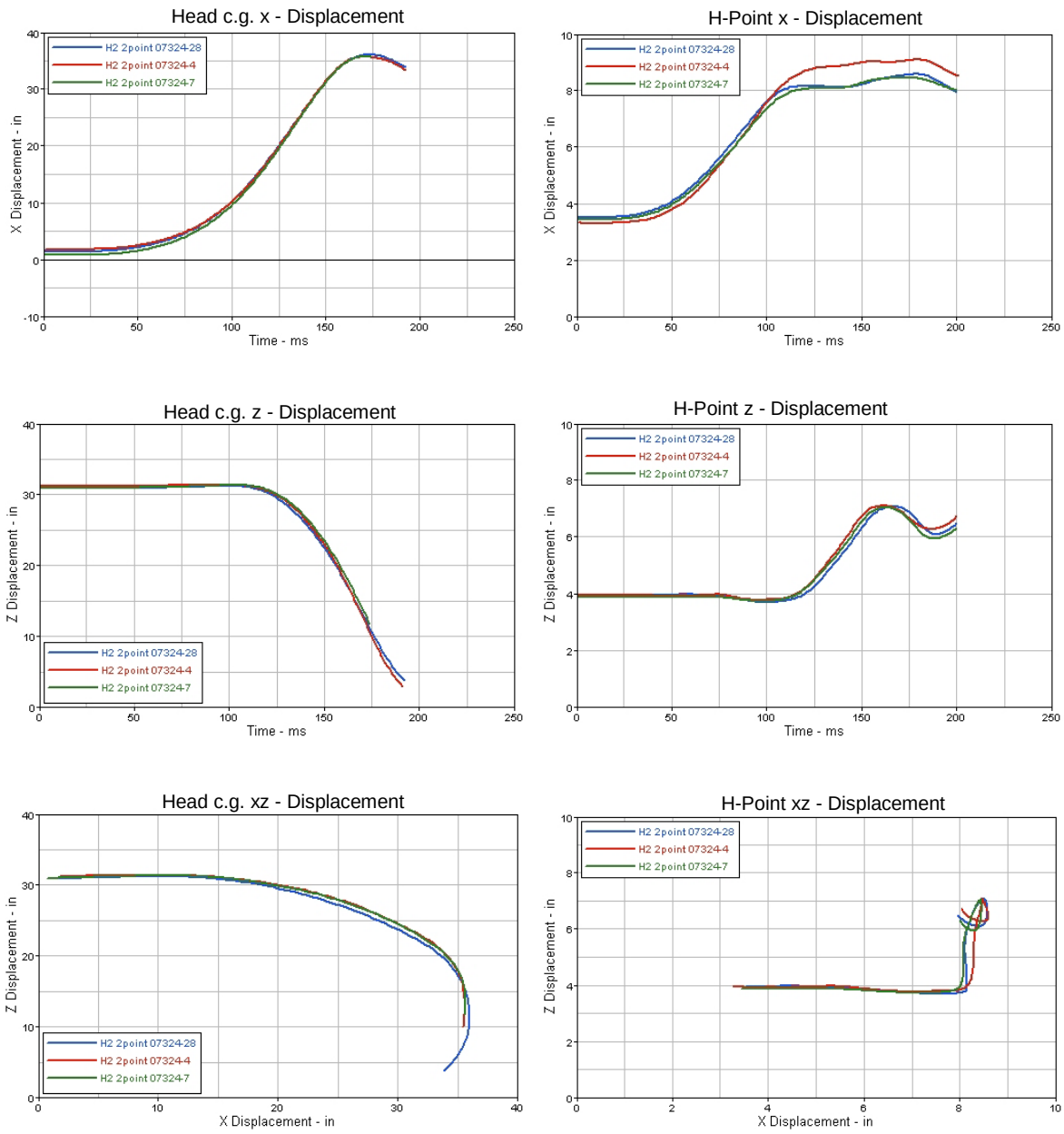


Figure 49. Head and H-Point Displacements of Hybrid II ATD With Two-Point Belt at 0° Pitch

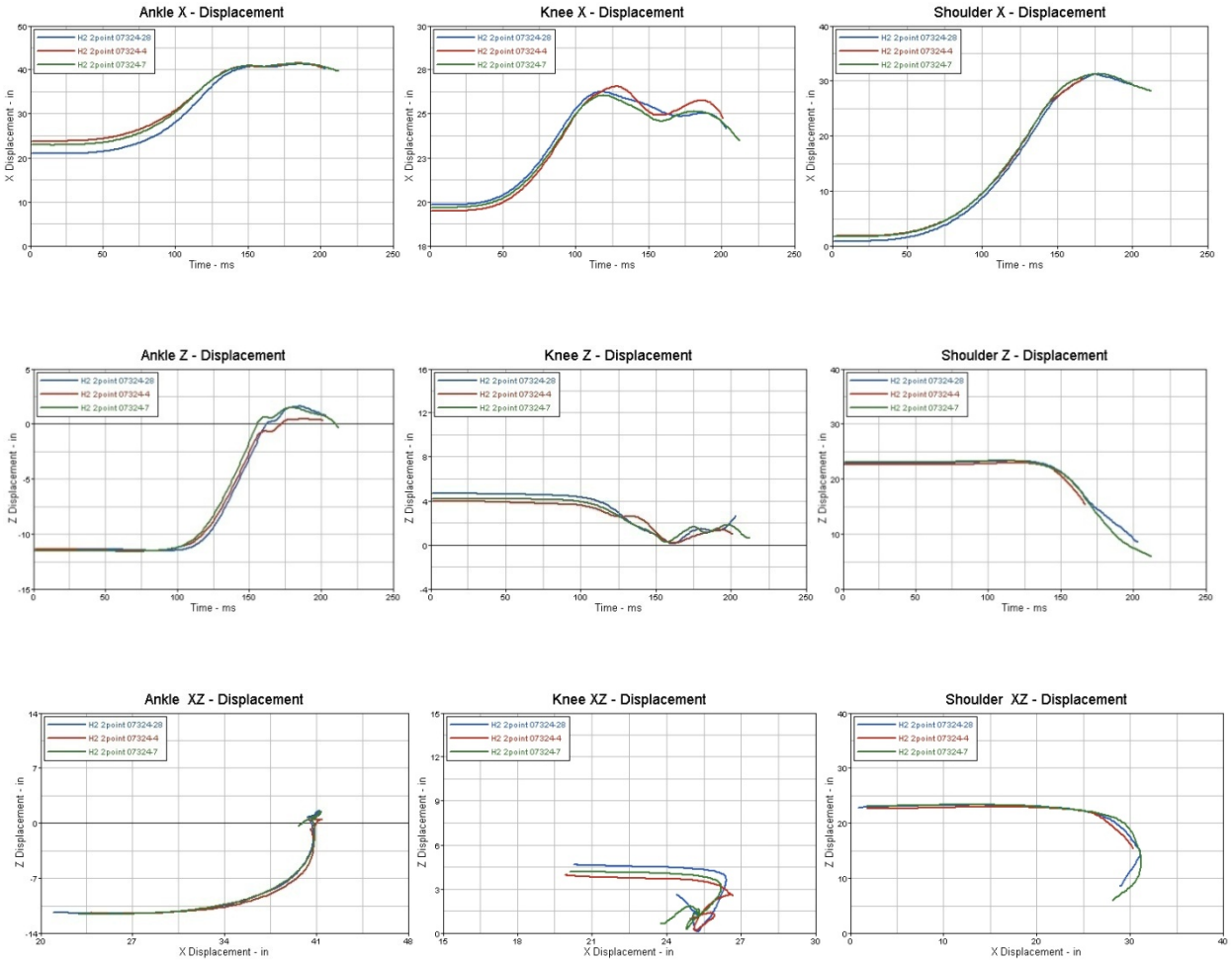


Figure 50. Ankle, Knee, and Shoulder Displacements of Hybrid II ATD With Two-Point Belt at 0° Pitch

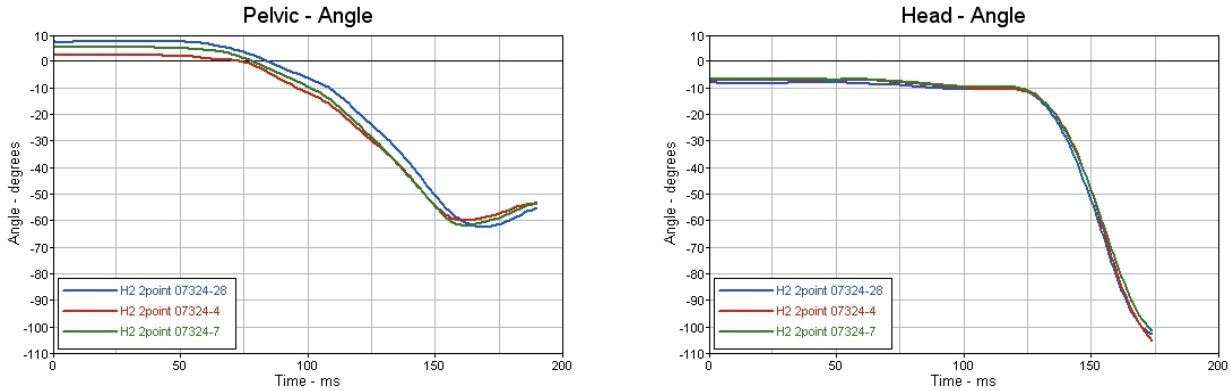


Figure 51. Pelvis and Head Angles of Hybrid II ATD With Two-Point Belt at 0° Pitch

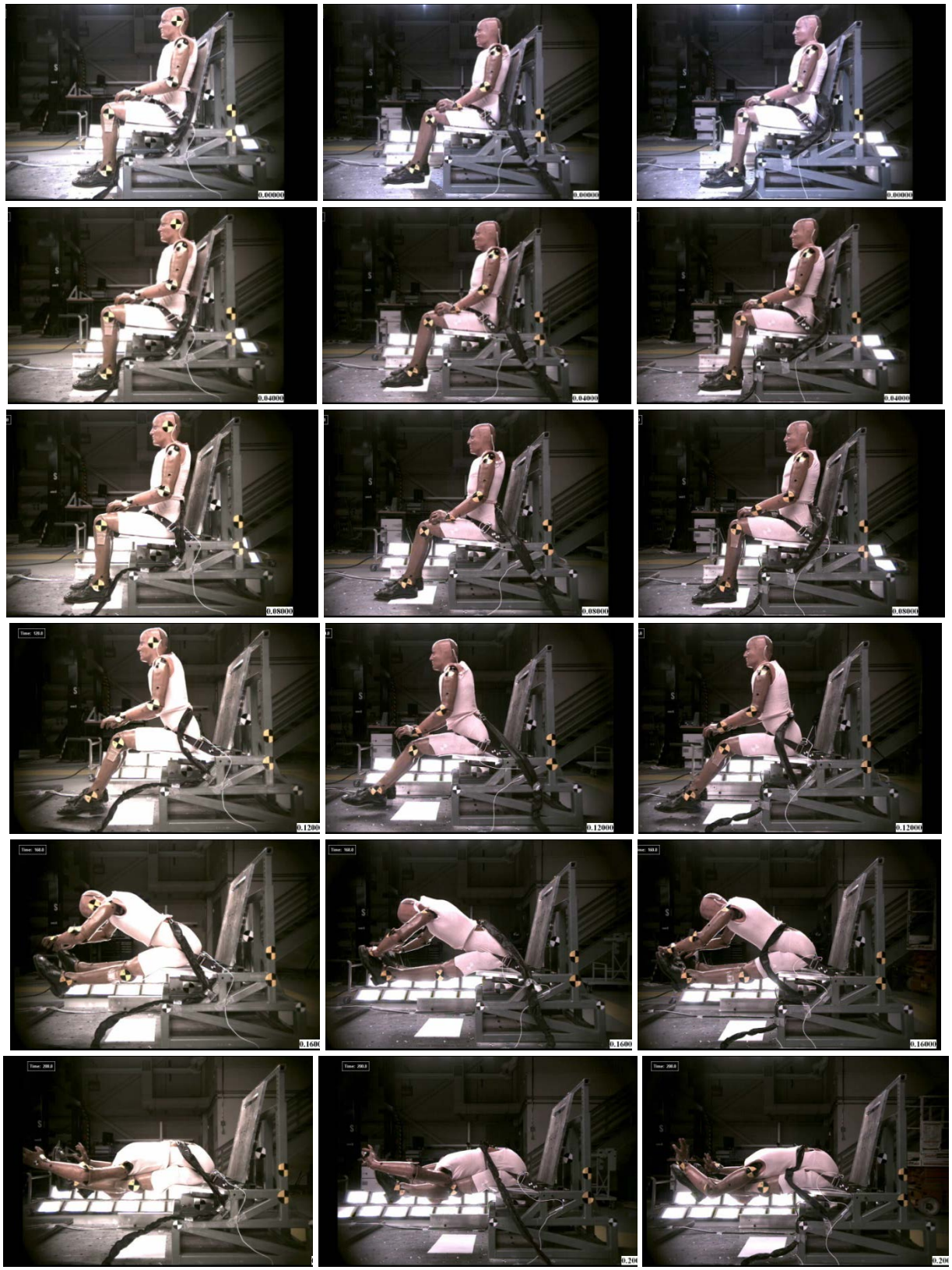


Figure 52. Test Kinematics 07324-28 (left), 07324-4 (middle), and 07324-7 (right) of Hybrid II ATD With Two-Point Belt at 0° Pitch

3.7.1.2 Hybrid II ATD With Two-Point Belt at 60° Pitch.

A series of tests of the Hybrid II ATD with two-point belt at 60° included test numbers 07324-10, 07324-11, 07324-12, 07324-30, and 07324-31. The dynamic test setup is shown in table 20, and the significant peak reference values are shown in table 21. The configuration consisted of a rigid seat, a two-point belt restraint, and 60° pitch (figure 53). The tests were performed using the 14 CFR 23.562 19-g acceleration pulse. This test configuration was performed more than three times because the maximum compression lumbar load recorded for the first three tests showed a significant difference for one of the tests; therefore, more tests were performed to investigate this variability, which is discussed in detail in section 5. The channel data, derived data (from video), calculated data (from channel data) are shown in figures 54 through 62, and images showing the ATD kinematics are shown in figures 63 and 64.

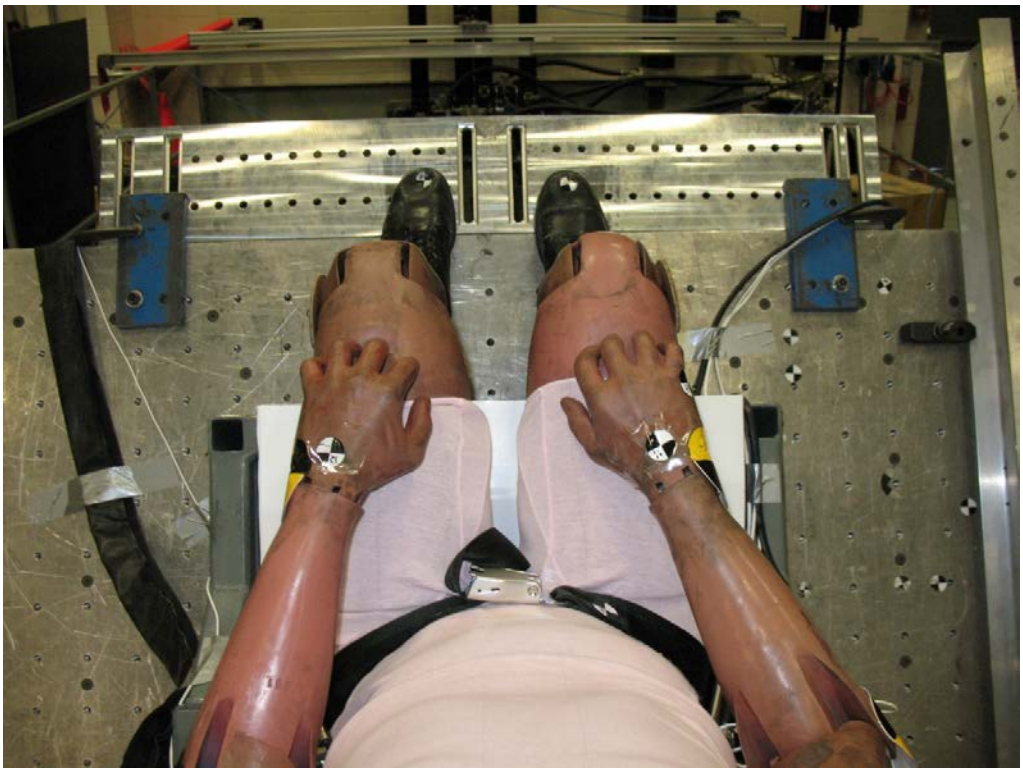
Table 20. Dynamic Test Configuration for Hybrid II ATD With Two-Point Belt at 60° Pitch

Test Number	ATD Serial Number	Belt Point Type	Pitch Angle (degrees)	Load (g)	Seat Type	Belt Material	Acceleration Pulse	Test Data (page)
07324-10	Hybrid II 698	2	60	19	Rigid	100% Nylon	23.562	B-11
07324-11	Hybrid II 698	2	60	19	Rigid	100% Nylon	23.562	B-13
07324-12	Hybrid II 698	2	60	19	Rigid	100% Nylon	23.562	B-15
07324-30	Hybrid II 698	2	60	19	Rigid	100% Nylon	23.562	B-49
07324-31	Hybrid II 698	2	60	19	Rigid	100% Nylon	23.562	B-51

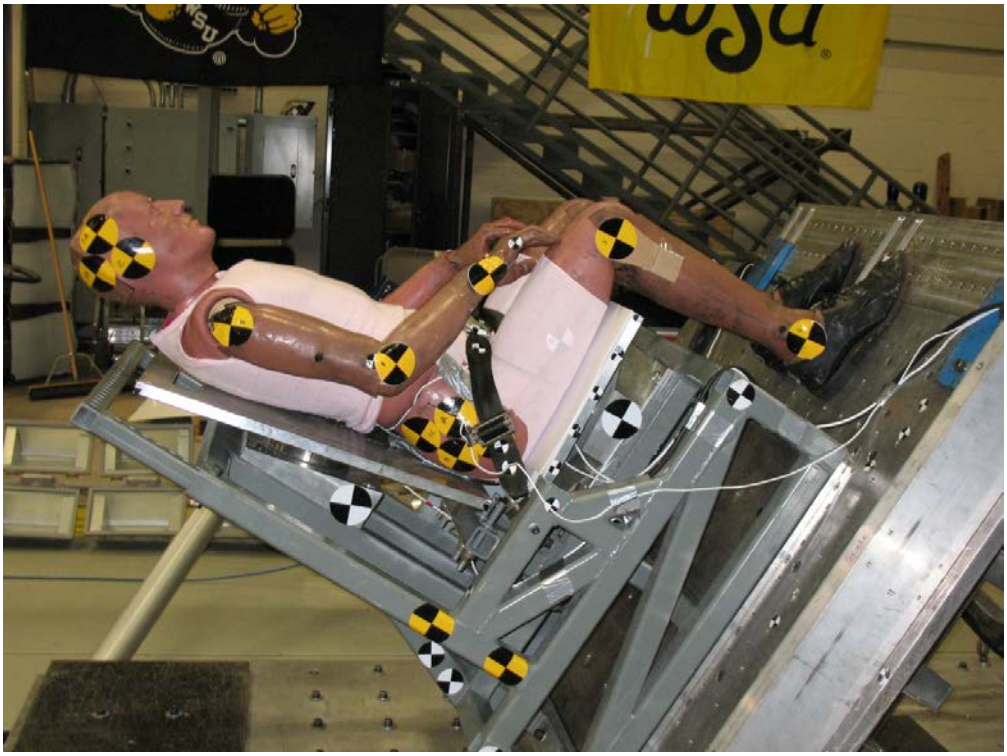
Table 21. Significant Peak Reference Values for the Hybrid II ATD With Two-Point Belt at 60° Pitch

Channel Description	Injury Criteria	Hybrid II Test 07324-10	Hybrid II Test 07324-11	Hybrid II Test 07324-12	Hybrid II Test 07324-30	Hybrid II Test 07324-31
HIC (unlimited)*	1000	41	63	57	26	31
T1-ms	-	38	40	40	35	38
T2-ms	-	74	74	74	71	74
Head velocity (ft/s)	Not required	19.6	18.0	18.5	20.6	19.7
Head x excursion (in.)	Not required	23.0	22.2	23.3	22.7	21.9
Lumbar Fz load (lbf) (compression)	1500	1410	1757	1693	1120	1161
Seat pan resultant force (lbf)	Not required	2644	3067	2923	2335	2485
Left lap belt load (lbf) (tension)	Not required	157	146	152	202	187
Right lap belt load (lbf) (tension)	Not required	146	134	145	138	154
Left strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A	N/A	N/A
Right strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A	N/A	N/A

*Unlimited HIC is calculated according to the evaluation period (125 ms) for this test configuration.
N/A = Not applicable
[1]Individual shoulder strap
[2]Dual shoulder strap



(a)



(b)

Figure 53. Front (a) and Side (b) Views of Hybrid II ATD With Two-Point Belt at 60° Pitch

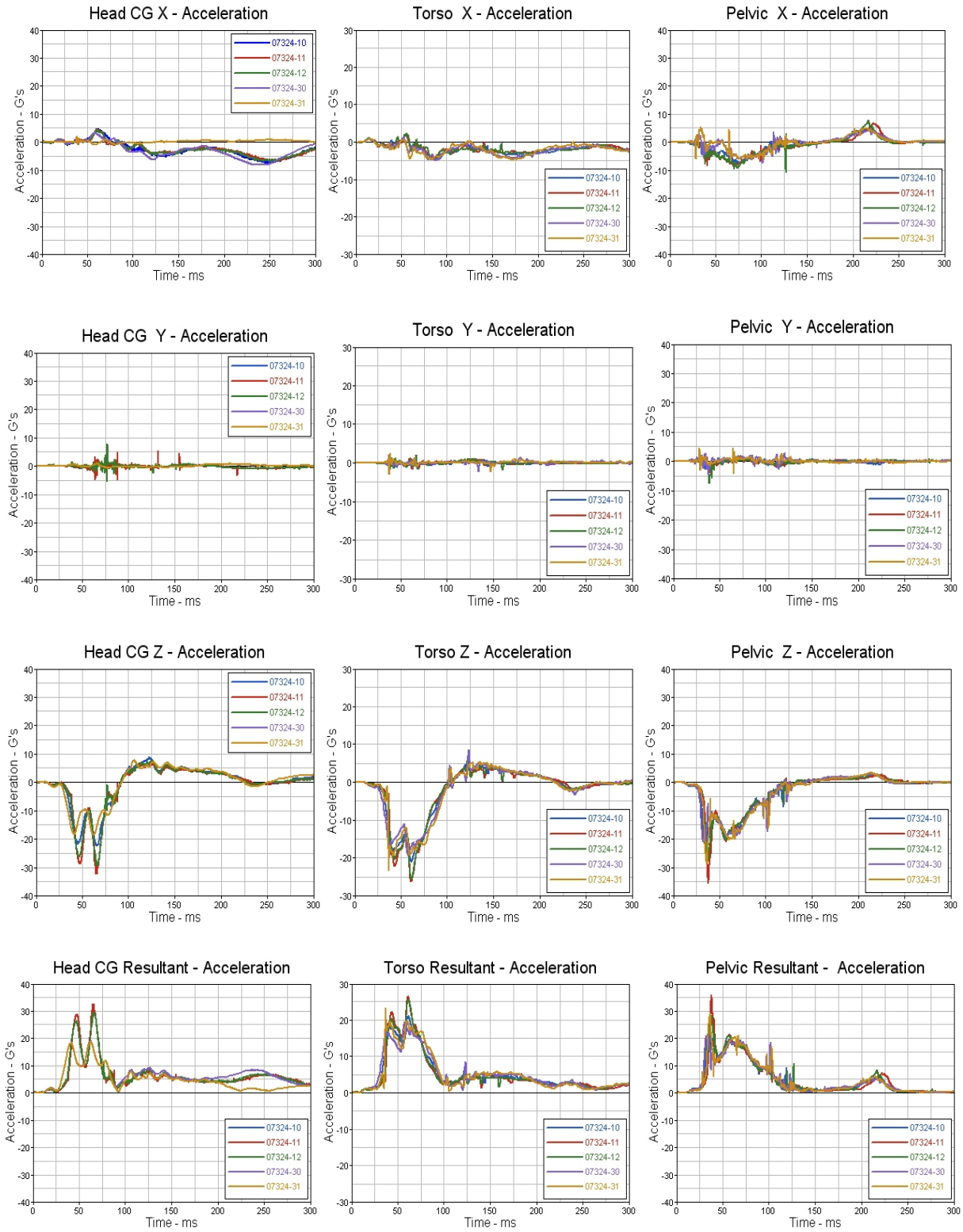


Figure 54. Head, Torso, and Pelvis Accelerations of Hybrid II ATD With Two-Point Belt at 60° Pitch

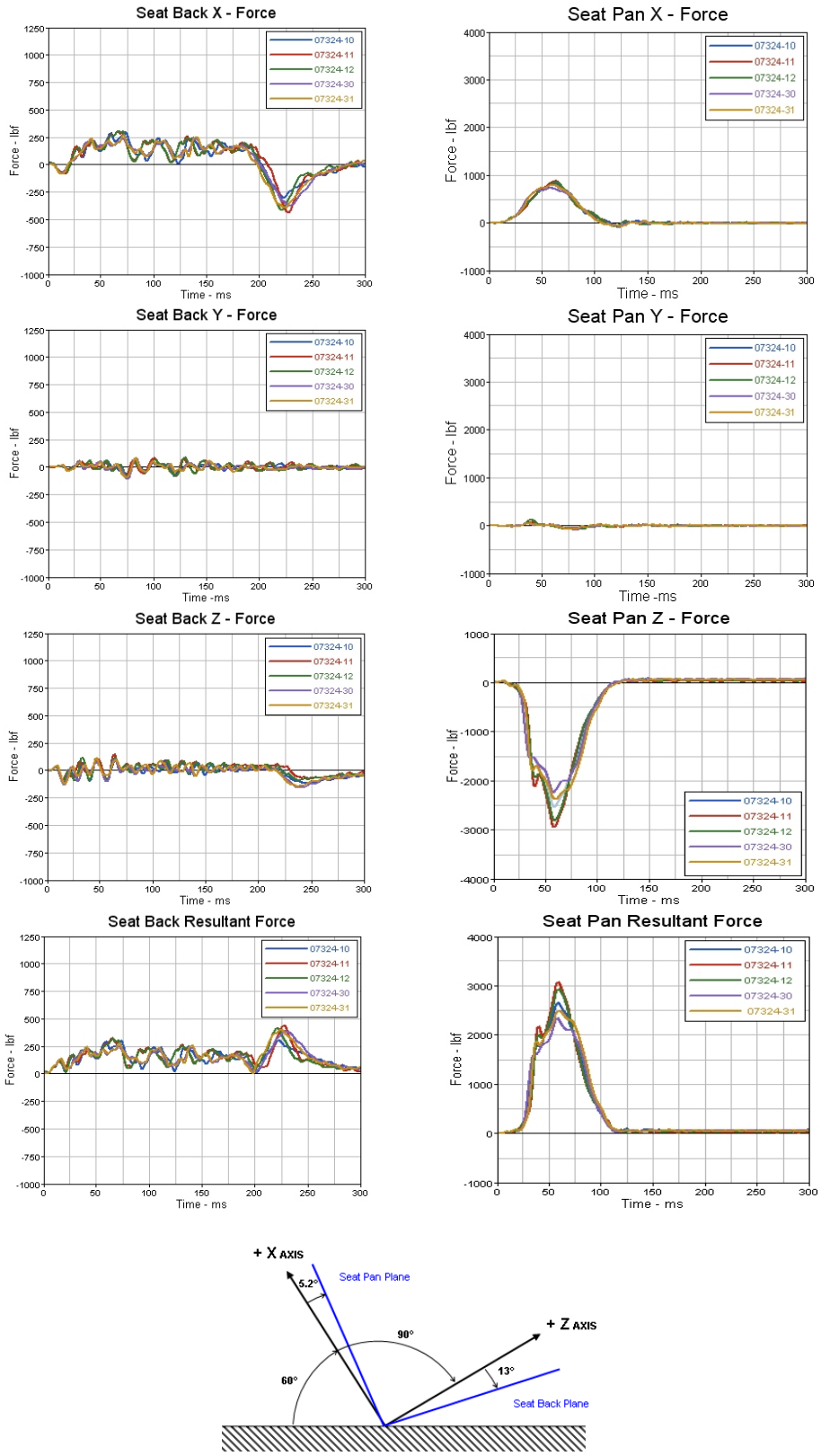


Figure 55. Seat Pan and Back Loads (Tare Compensation and Global Coordinates) of Hybrid II ATD With Two-Point Belt at 60° Pitch

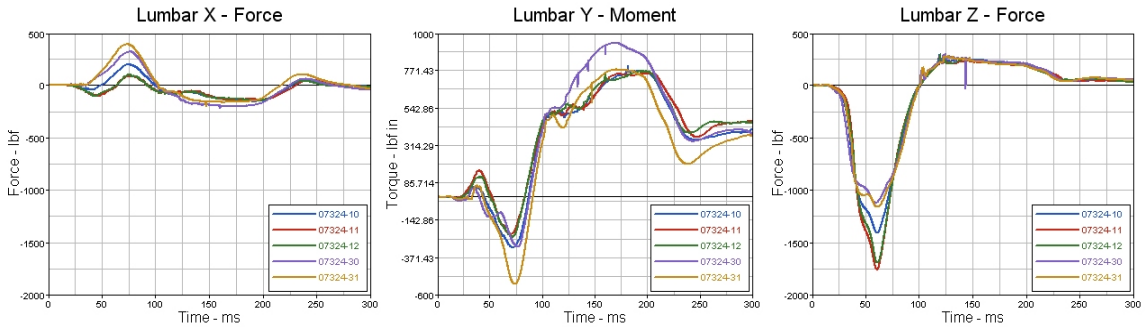
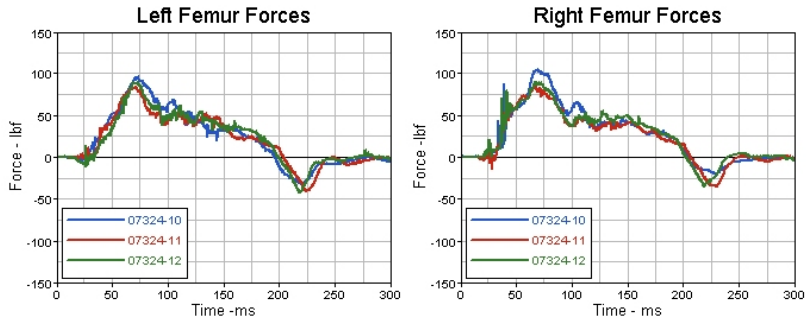


Figure 56. Lumbar Loads and Moments of Hybrid II ATD With Two-Point Belt at 60° Pitch



Note: Left and right femur forces were not recorded in tests 07324-30 and 07324-31

Figure 57. Femur Forces of Hybrid II ATD With Two-Point Belt at 60° Pitch

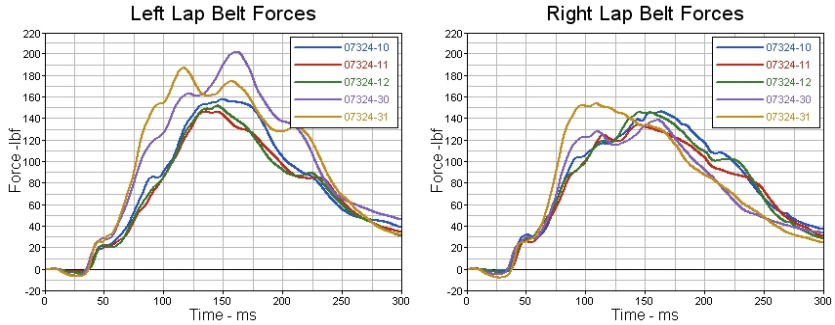


Figure 58. Lap Belt Forces of Hybrid II ATD With Two-Point Belt at 60° Pitch

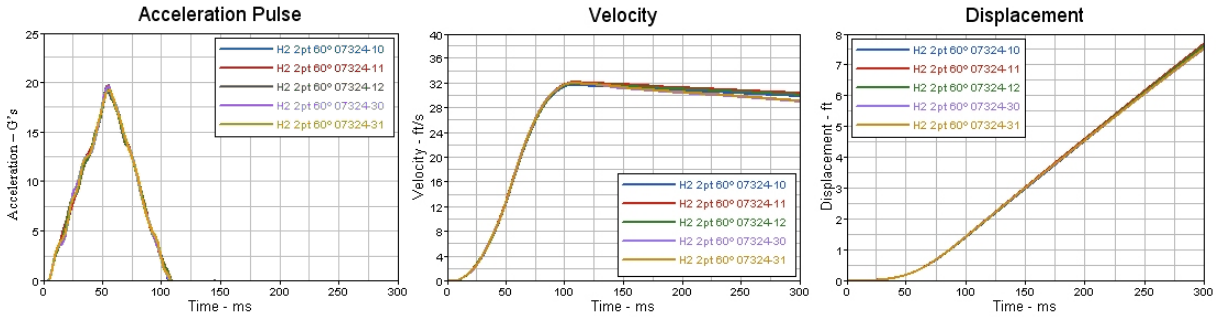


Figure 59. Acceleration Pulses of Hybrid II ATD With Two-Point Belt at 60° Pitch

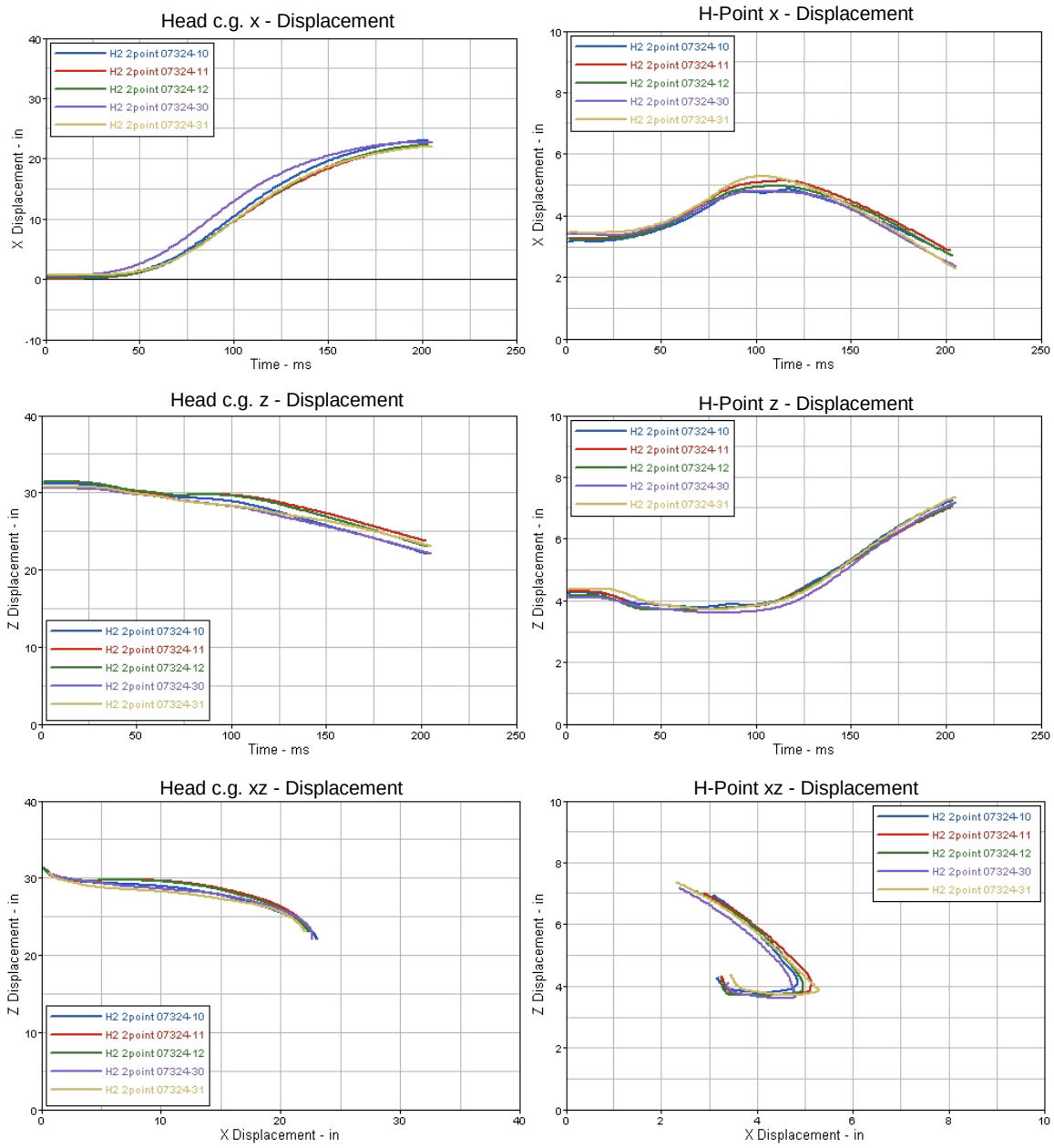


Figure 60. Head and H-Point Displacements of Hybrid II ATD With Two-Point Belt at 60° Pitch

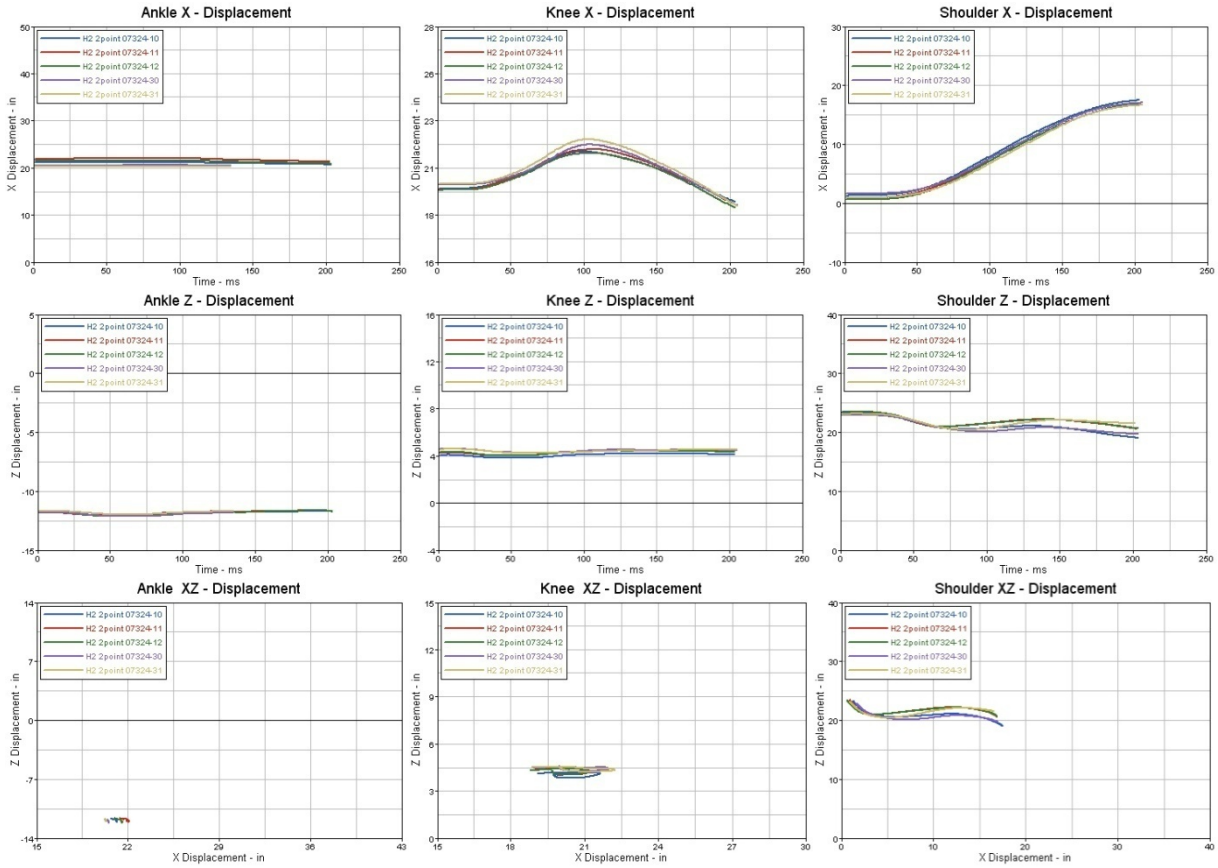


Figure 61. Ankle, Knee, and Shoulder Displacements of Hybrid II ATD With Two-Point Belt at 60° Pitch

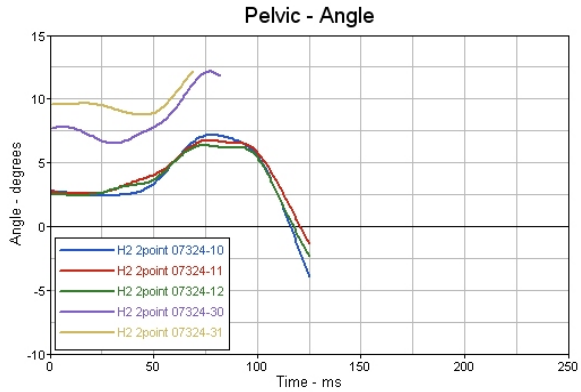


Figure 62. Pelvis Angles of Hybrid II ATD With Two-Point Belt at 60° Pitch

Figure 63. Test Kinematics 07324-10 (left), 07324-11 (middle), and 07324-12 (right) of Hybrid II ATD With Two-Point Belt at 60° Pitch

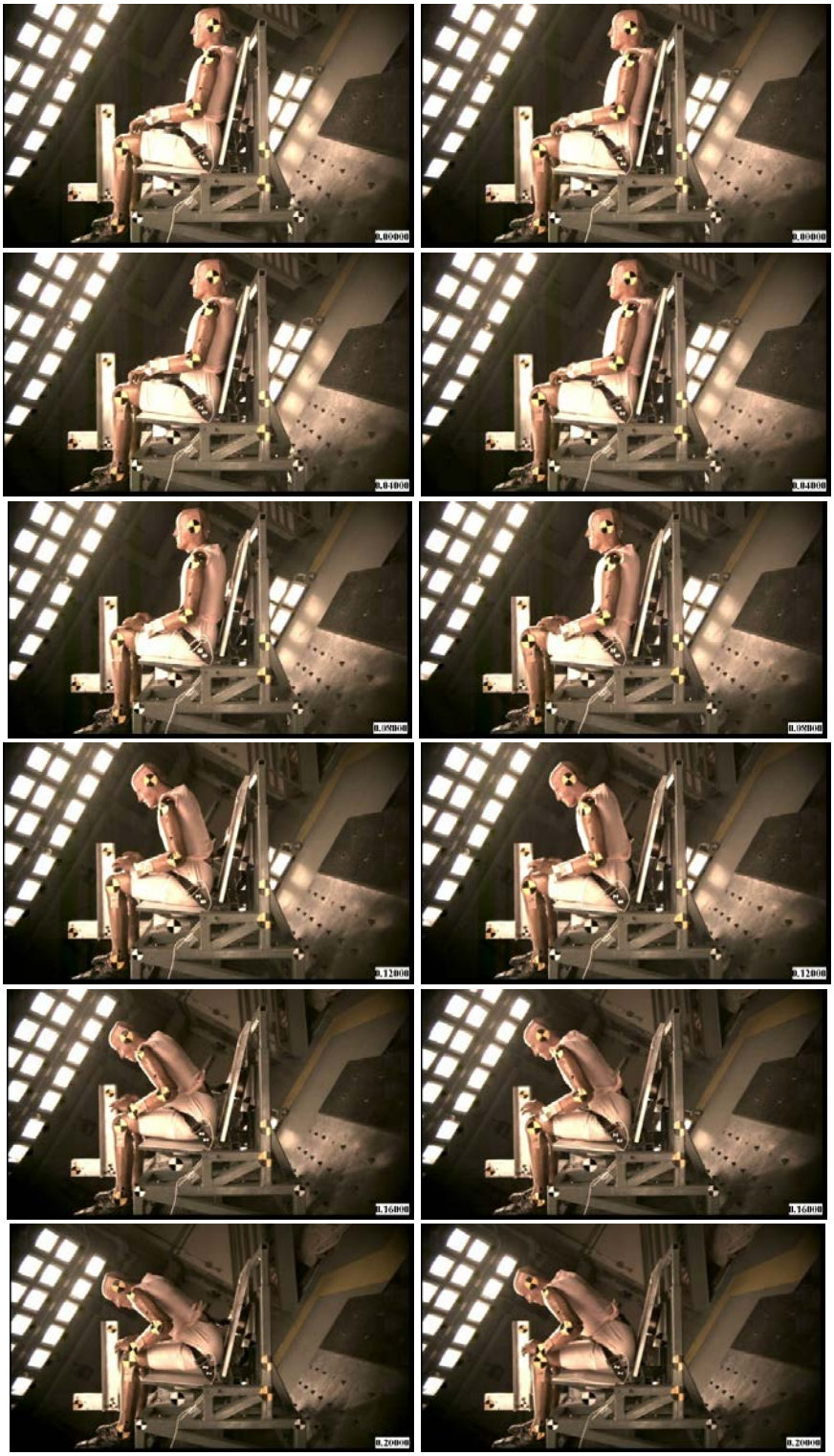


Figure 64. Test Kinematics 07324-30 (left) and 07324-31 (right) of Hybrid II ATD With Two-Point Belt at 60° Pitch

3.7.1.3 Hybrid II ATD With Three-Point Belt at 0° Pitch.

A series of tests of the Hybrid II ATD with three-point belt at 0° pitch included test numbers 07324-8, 07324-9, and 07324-29. The dynamic test setup is summarized in table 22, and the significant peak values for reference are shown in table 23. The configuration consisted of a rigid seat, a three-point belt restraint, and 0° pitch (figure 65). The tests were performed using the 14 CFR 23.562 21-g acceleration pulse. For the calibration report and test data, please refer to appendices A and B, respectively. The channel data, derived data (from video), calculated data (from channel data), and images showing the ATD kinematics are shown in figures 66 through 75.

Table 22. Dynamic Test Configuration for Hybrid II ATD With Three-Point Belt at 0° Pitch

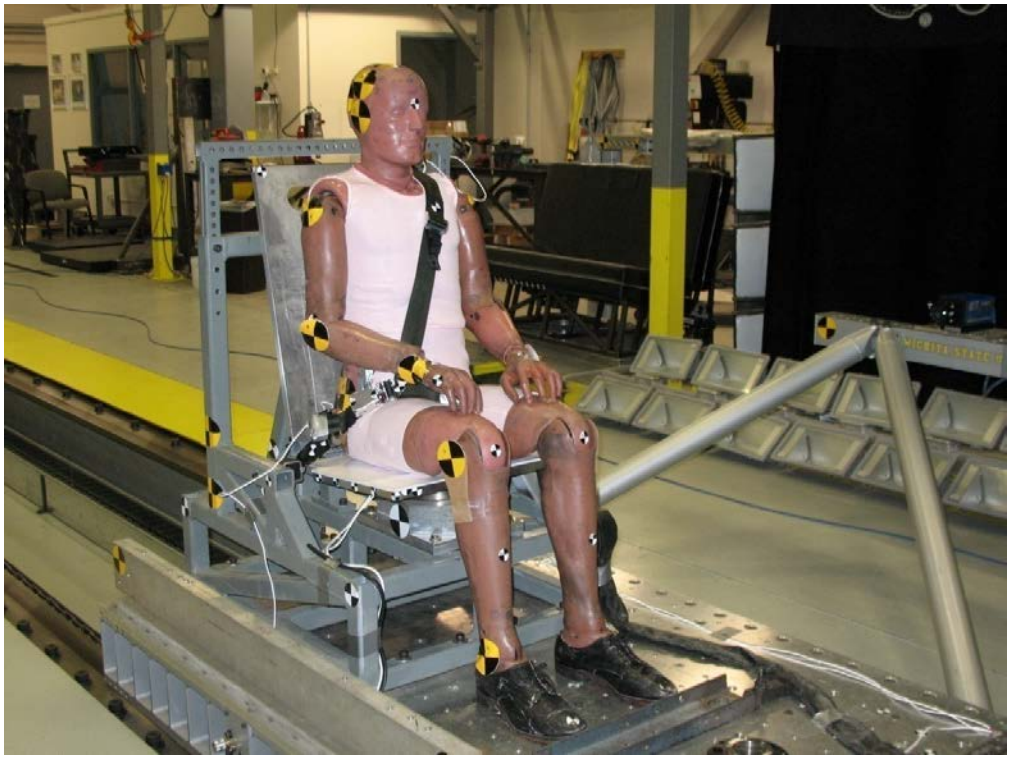
Test Number	ATD Serial Number	Belt Point Type	Pitch Angle (degrees)	Load (g)	Seat Type	Belt Material	Acceleration Pulse	Test Data (page)
07324-8	Hybrid II 698	3	0	21	Rigid	100% Nylon	23.562	B-7
07324-9	Hybrid II 698	3	0	21	Rigid	100% Nylon	23.562	B-9
07324-29	Hybrid II 698	3	0	21	Rigid	100% Nylon	23.562	B-47

Table 23. Significant Peak Values for Hybrid II ATD With Three-Point Belt at 0° Pitch

Channel Description	Injury Criteria	Hybrid II Test 07324-8	Hybrid II Test 07324-9	Hybrid II Test 07324-29
HIC (unlimited)*	1000	178	182	182
T1-ms	-	87	84	88
T2-ms	-	123	120	124
Head velocity (ft/s)	Not required	27.4	27.3	27.5
Head excursion (in.)	Not required	18.9	18.9	19.1
Lumbar Fz load (lbf) (compression)	1500	336	283	378
Seat pan resultant force (lbf)	Not required	1471	1363	1621
Left lap belt load (lbf) (tension)	Not required	1724	1720	1599
Right lap belt load (lbf) (tension)	Not required	2475	2509	2474
Left strap load (lbf) (tension)	1750[1]/2000[2]	1606	1641	1574
Right strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A

N/A = Not applicable
*Unlimited HIC is calculated according to the evaluation period (180 ms) for this test configuration.
[1]Individual shoulder strap
[2]Dual shoulder strap

(a)



(b)

Figure 65. Front (a) and Side (b) Views of Hybrid II ATD With Three-Point Belt at 0° Pitch

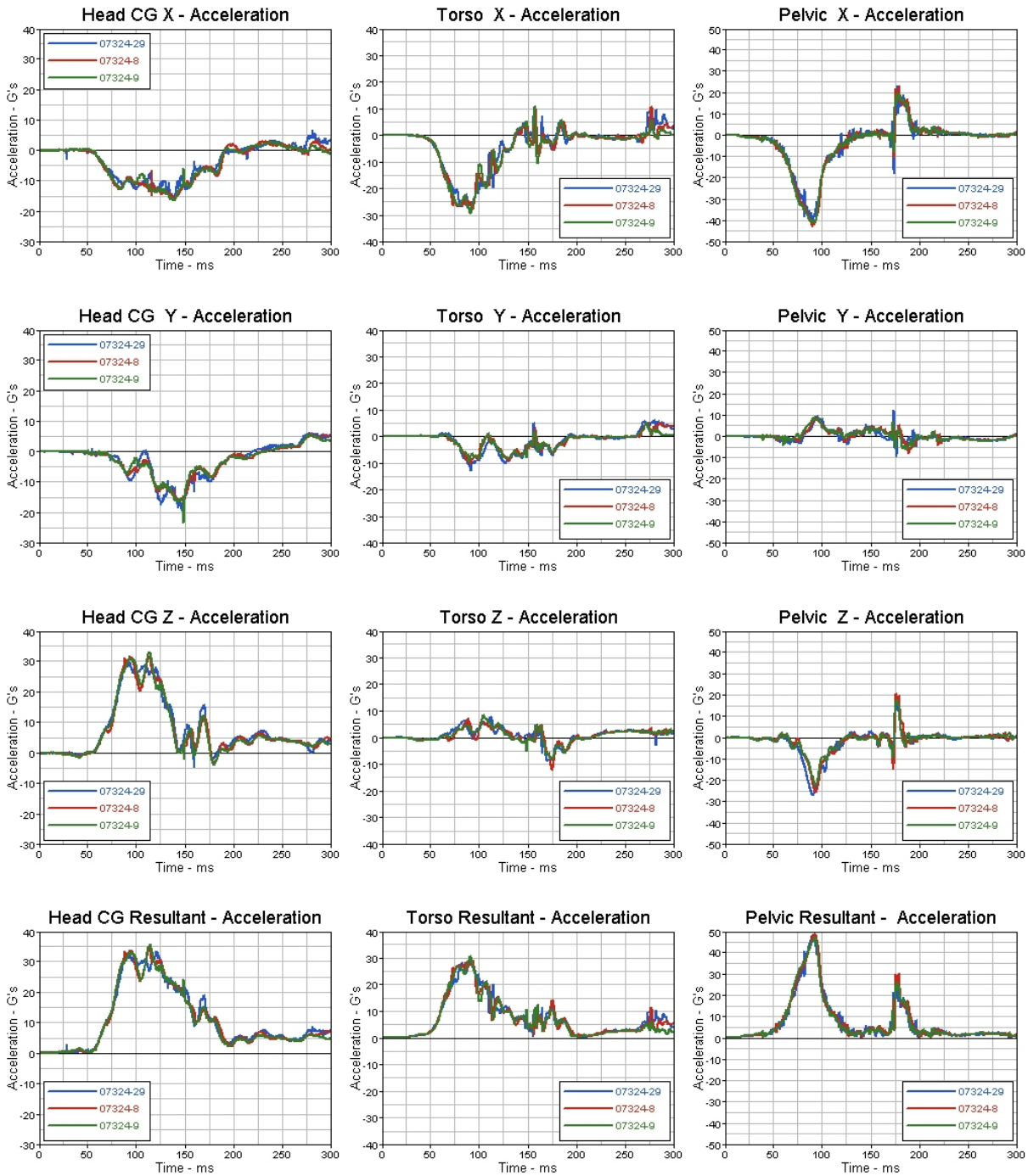


Figure 66. Head, Torso, and Pelvis Accelerations of Hybrid II ATD With Three-Point Belt at 0° Pitch

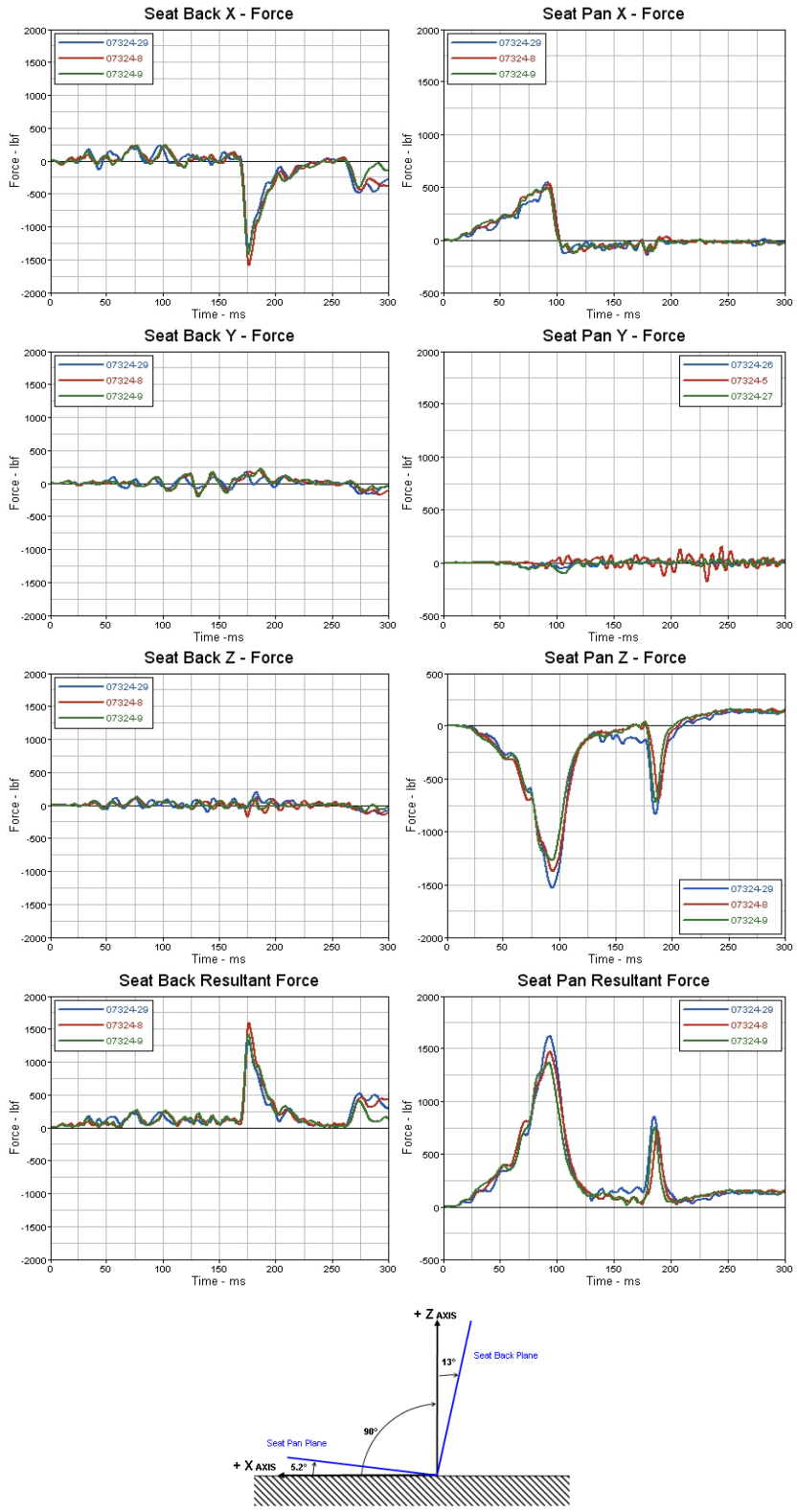


Figure 67. Seat Pan and Back Loads (Tare Compensation and Global Coordinates) of Hybrid II ATD With Three-Point Belt at 0° Pitch

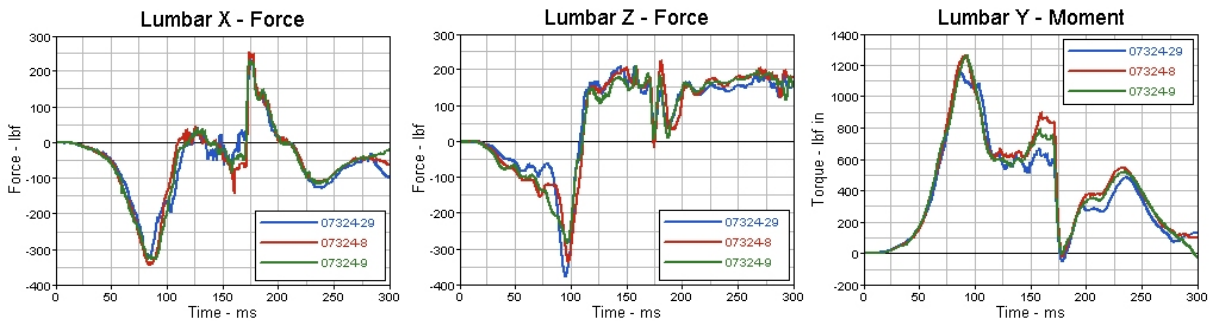


Figure 68. Lumbar Loads and Moments of Hybrid II ATD With Three-Point Belt at 0° Pitch

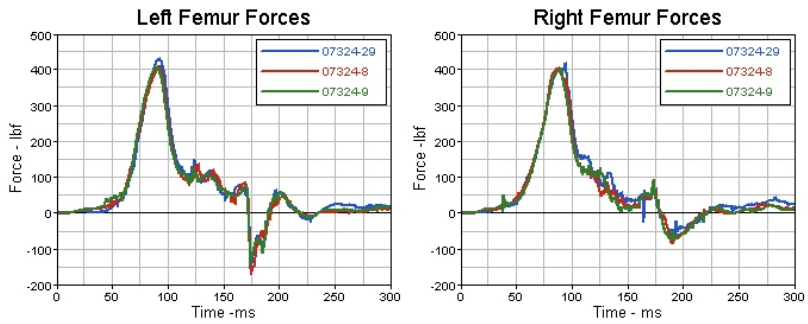


Figure 69. Femur Forces of Hybrid II ATD With Three-Point Belt at 0° Pitch

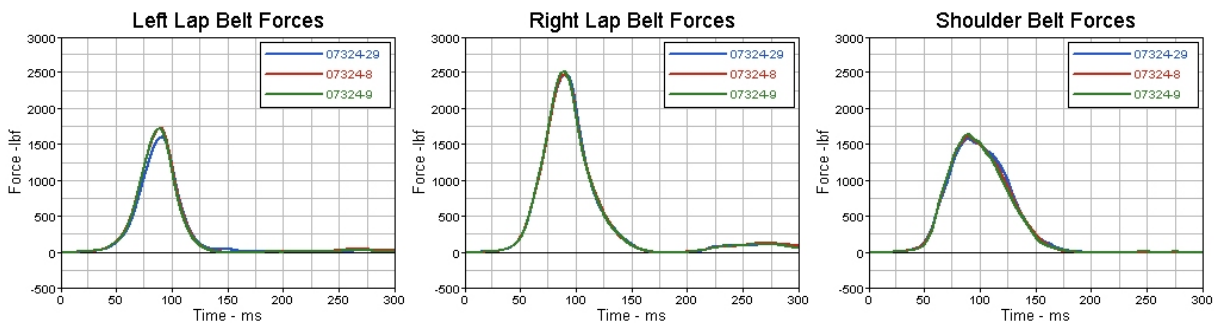


Figure 70. Lap and Shoulder Belt Forces of Hybrid II ATD With Three-Point Belt at 0° Pitch

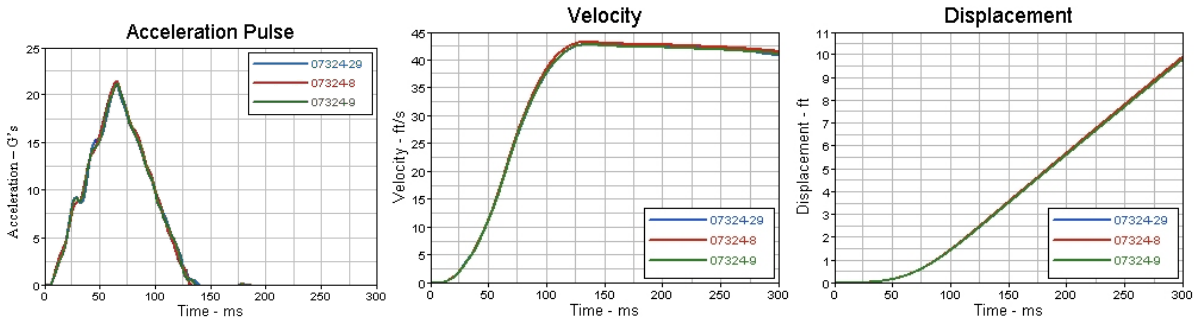


Figure 71. Acceleration Pulses of Hybrid II ATD With Three-Point Belt at 0° Pitch

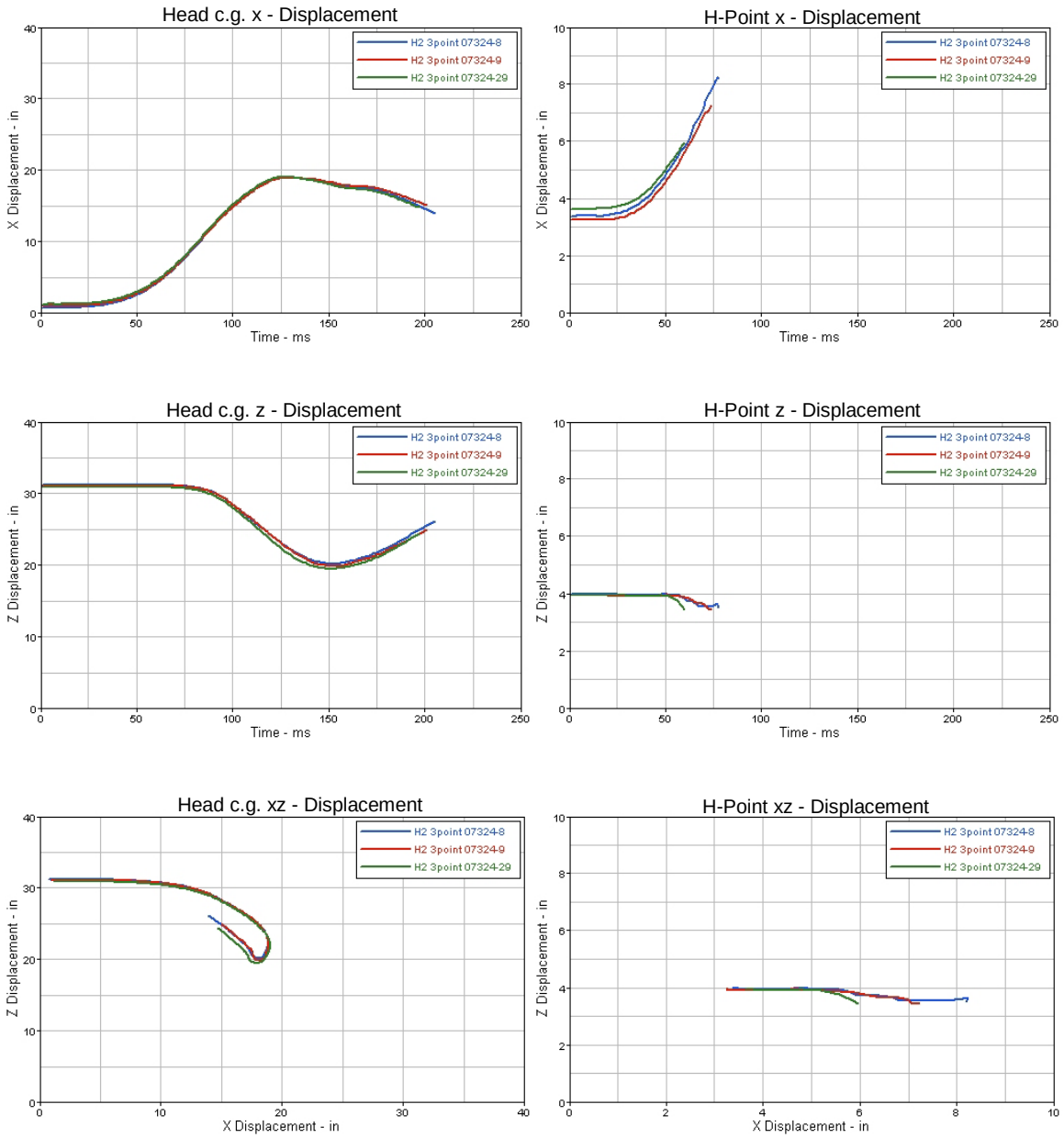


Figure 72. Head and H-Point Displacements of Hybrid II ATD With Three-Point Belt at 0° Pitch

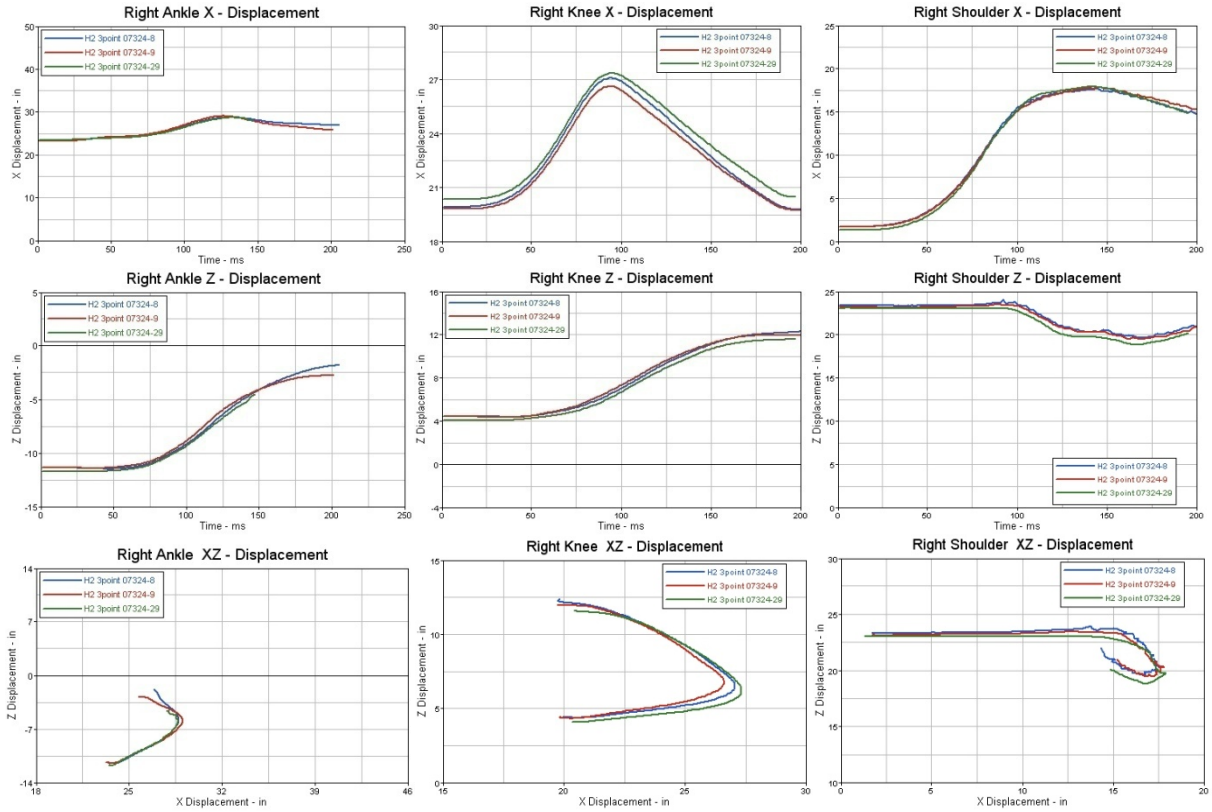


Figure 73. Right Ankle, Knee, and Shoulder Displacements of Hybrid II ATD With Three-Point Belt at 0° Pitch

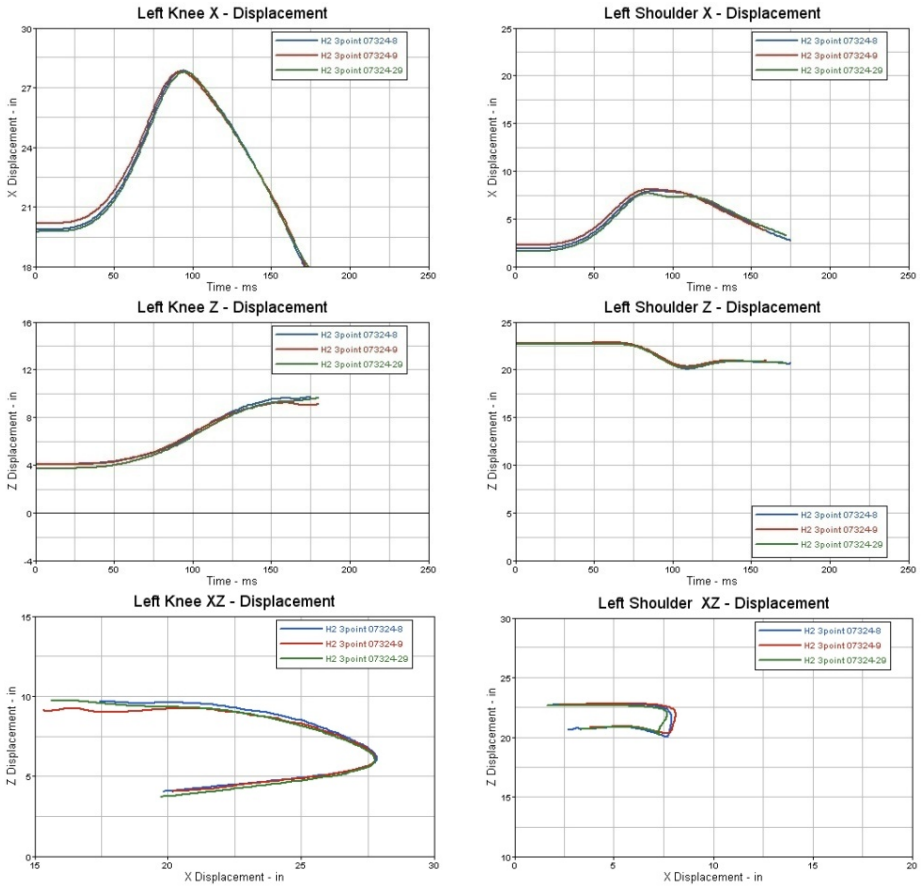


Figure 74. Left Knee and Left Shoulder Displacements

Figure 75. Test Kinematics 07324-8 (left), 07324-9 (middle), and 07324-29 (right) of Hybrid II ATD With Three-Point Belt at 0° Pitch

3.7.1.4 Hybrid II ATD With Four-Point Belt at 0° Pitch.

A series of tests of the Hybrid II ATD with four-point belt at 0° pitch included test numbers 07324-5, 07324-26, and 07324-27. The dynamic test setup is summarized in table 24, and the significant peak values for reference are shown in table 25. The configuration consisted of a rigid seat, a four-point belt restrain, and 0° pitch (figure76). The tests were performed using 14 CFR 23.562 21-g acceleration pulse. For the calibration report and test data, please refer to appendices A and B, respectively. The channel data, derived data (from video), calculated data (from channel data), and images showing the ATD kinematics are shown in figures 77 to 87.

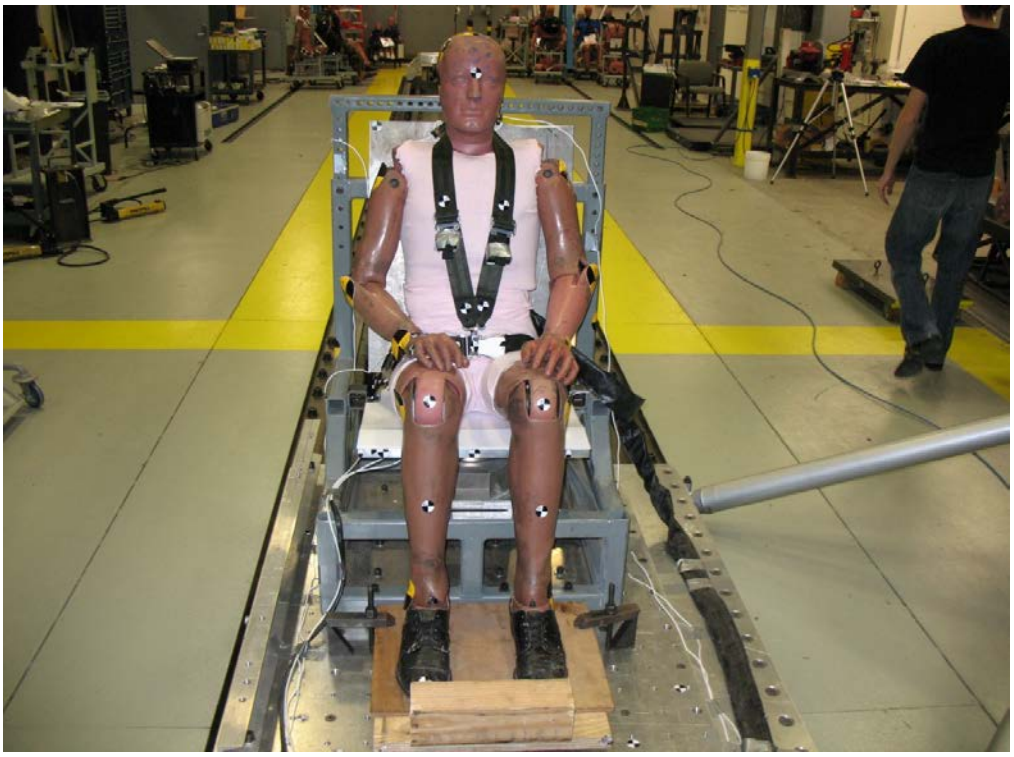
Table 24. Dynamic Test Configuration for Hybrid II ATD With Four-Point Belt at 0° Pitch

Test Number	ATD Serial Number	Belt Point Type	Pitch Angle (degrees)	Load (g)	Seat Type	Belt Material	Acceleration Pulse	Test Data (page)
07324-5	Hybrid II 698	4	0	21	Rigid	100% Nylon	23.562	B-3
07324-26	Hybrid II 698	4	0	21	Rigid	100% Nylon	23.562	B-41
07324-27	Hybrid II 698	4	0	21	Rigid	100% Nylon	23.562	B-43

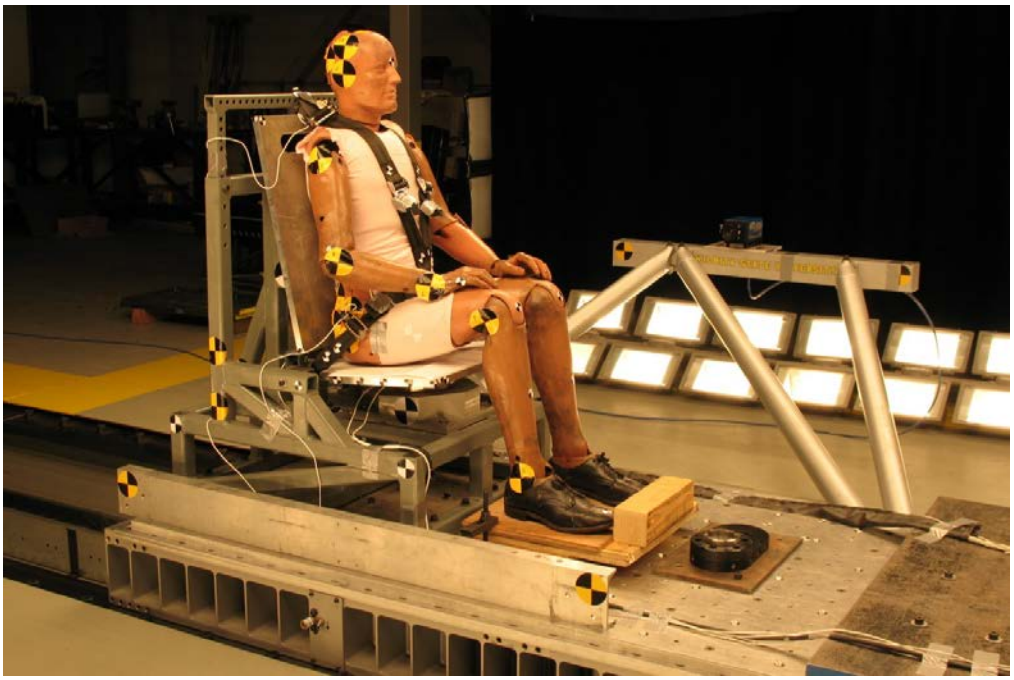
Table 25. Significant Peak Values for Hybrid II ATD With Four-Point Belt at 0° Pitch

Channel Description	Injury Criteria	Hybrid II Test 07324-5	Hybrid II Test 07324-26	Hybrid II Test 07324-27
HIC (unlimited)*	1000	153	168	177
T1-ms		81	71	90
T2-ms		117	107	125
Head velocity (ft/s)	Not required	20.7	18.4	18.4
Head excursion (in.)	Not required	14.7	13.4	13.5
Lumbar Fz load (lbf) (compression)	1500	432	337	295
Seat pan resultant force (lbf)	Not required	1495	1742	1616
Left lap belt load (lbf) (tension)	Not required	1904	2024	2042
Right lap belt load (lbf) (tension)	Not required	1858	1958	1941
Left strap load (lbf) (tension)	1750[1]/2000[2]	990	920	874
Right strap load (lbf) (tension)	1750[1]/2000[2]	935	995	973

*Unlimited HIC is calculated according to the evaluation period (150 ms) for this test configuration.
N/A = Not applicable
[1]Individual shoulder strap
[2]Dual shoulder strap



(a)



(b)

Figure 76. Front (a) and Side (b) Views of Hybrid II ATD With Four-Point Belt at 0° Pitch

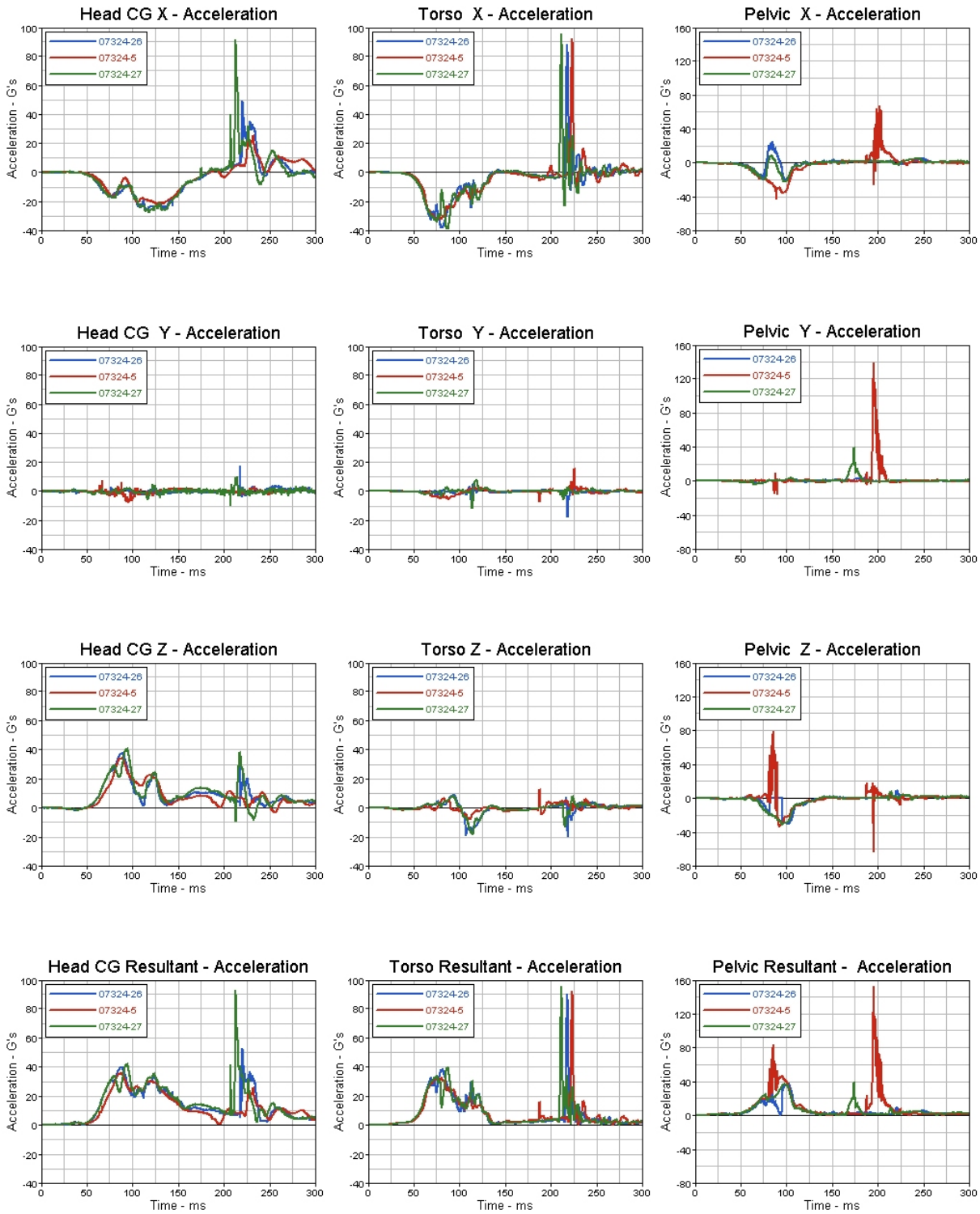


Figure 77. Head, Torso, and Pelvis Accelerations of Hybrid II ATD With Four-Point Belt at 0° Pitch

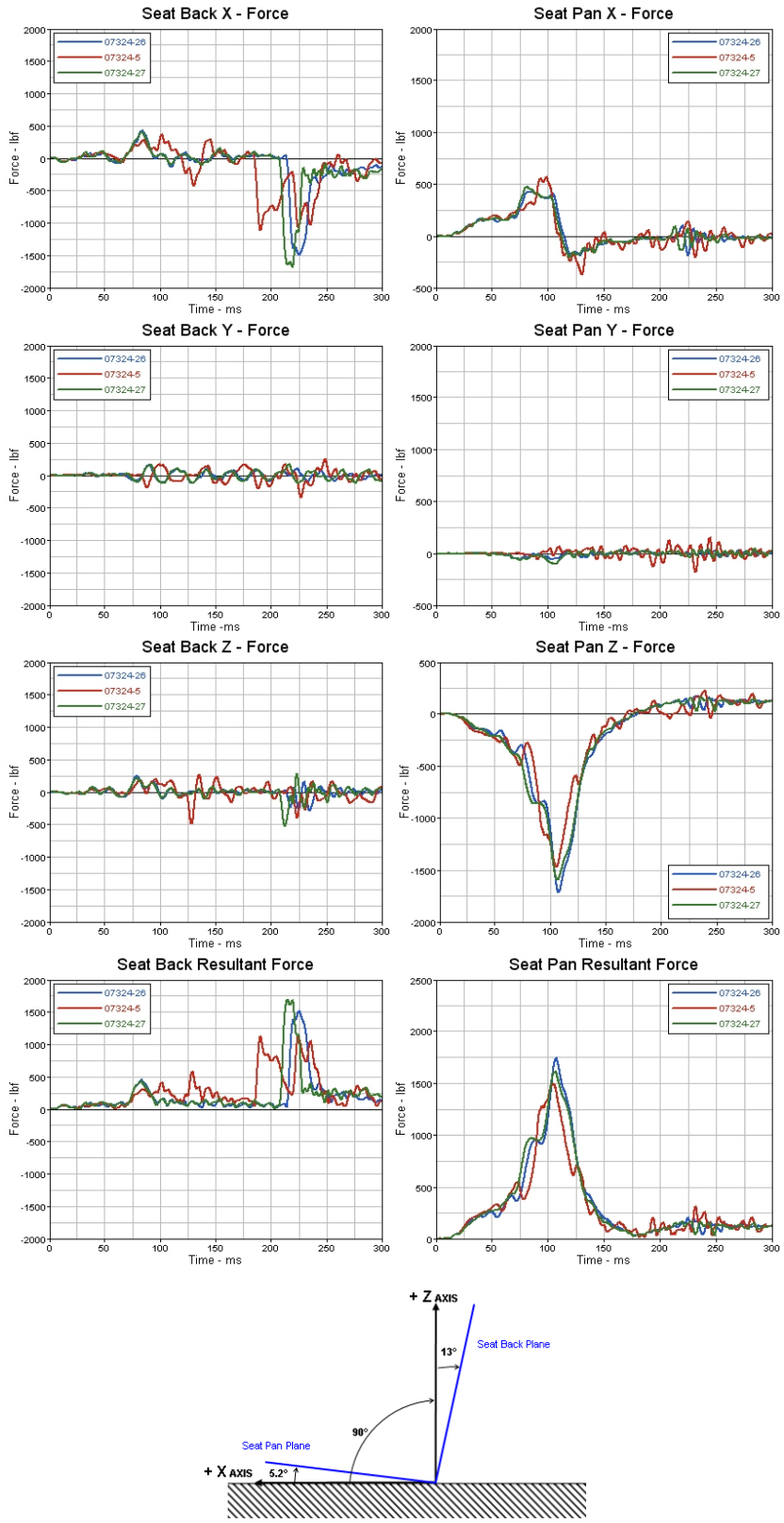


Figure 78. Seat Pan and Back Loads (Tare Compensation and Global Coordinates) of Hybrid II ATD With Four-Point Belt at 0° Pitch

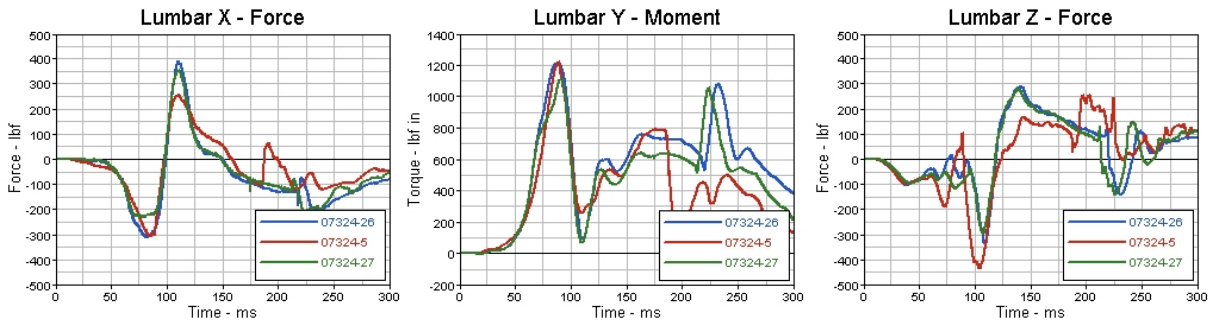


Figure 79. Lumbar Loads and Moments of Hybrid II ATD With Four-Point Belt at 0° Pitch

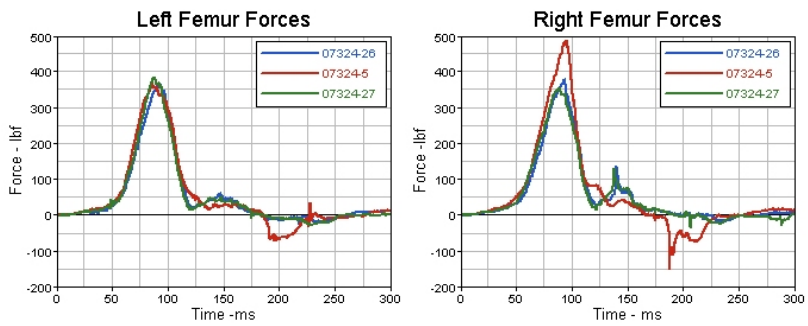


Figure 80. Femur Forces of Hybrid II ATD With Four-Point Belt at 0°

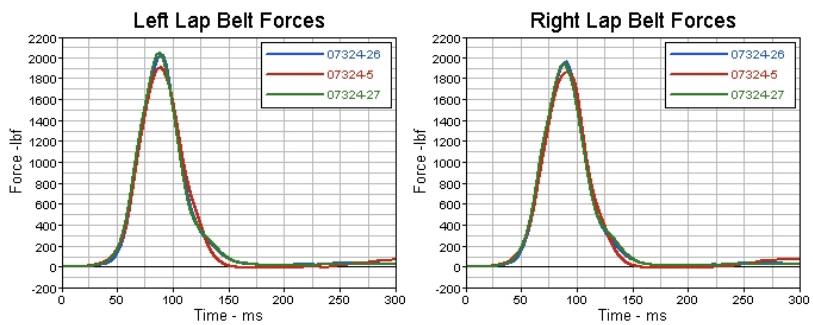


Figure 81. Lap Belt Forces of Hybrid II ATD With Four-Point Belt at 0° Pitch

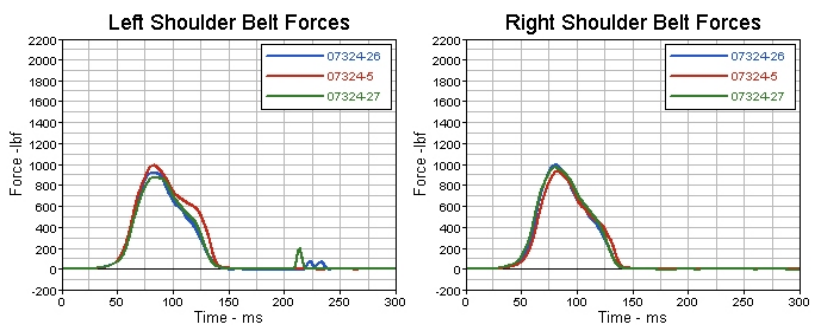


Figure 82. Shoulder Belt Forces of Hybrid II ATD With Four-Point Belt at 0° Pitch

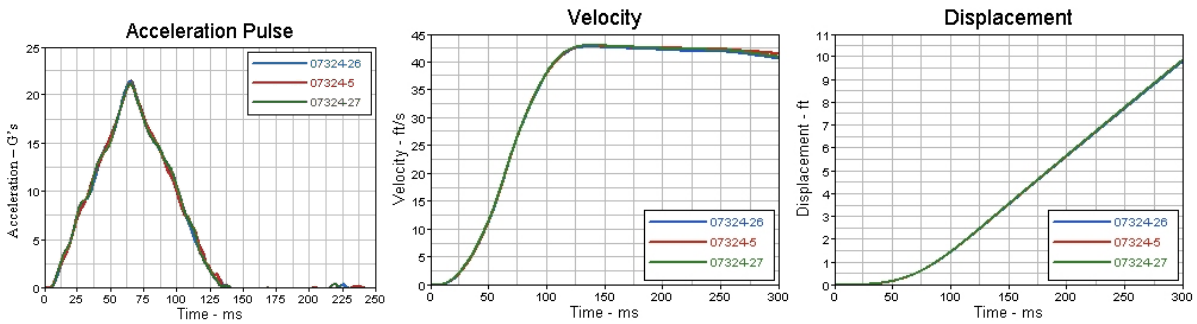


Figure 83. Acceleration Pulses of Hybrid II ATD With Four-Point Belt at 0° Pitch

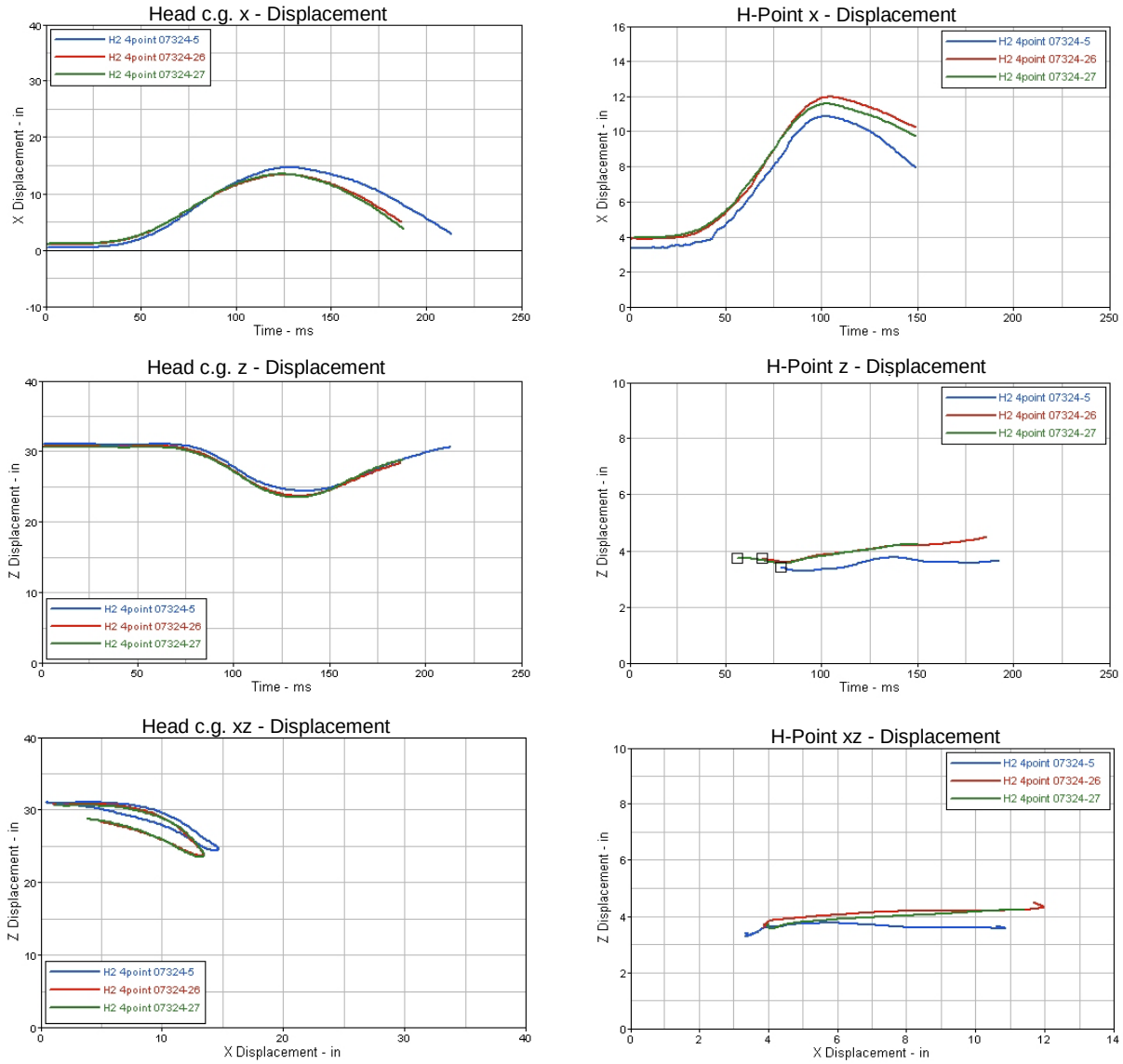


Figure 84. Head and H-Point Displacements of Hybrid II ATD With Four-Point Belt at 0° Pitch

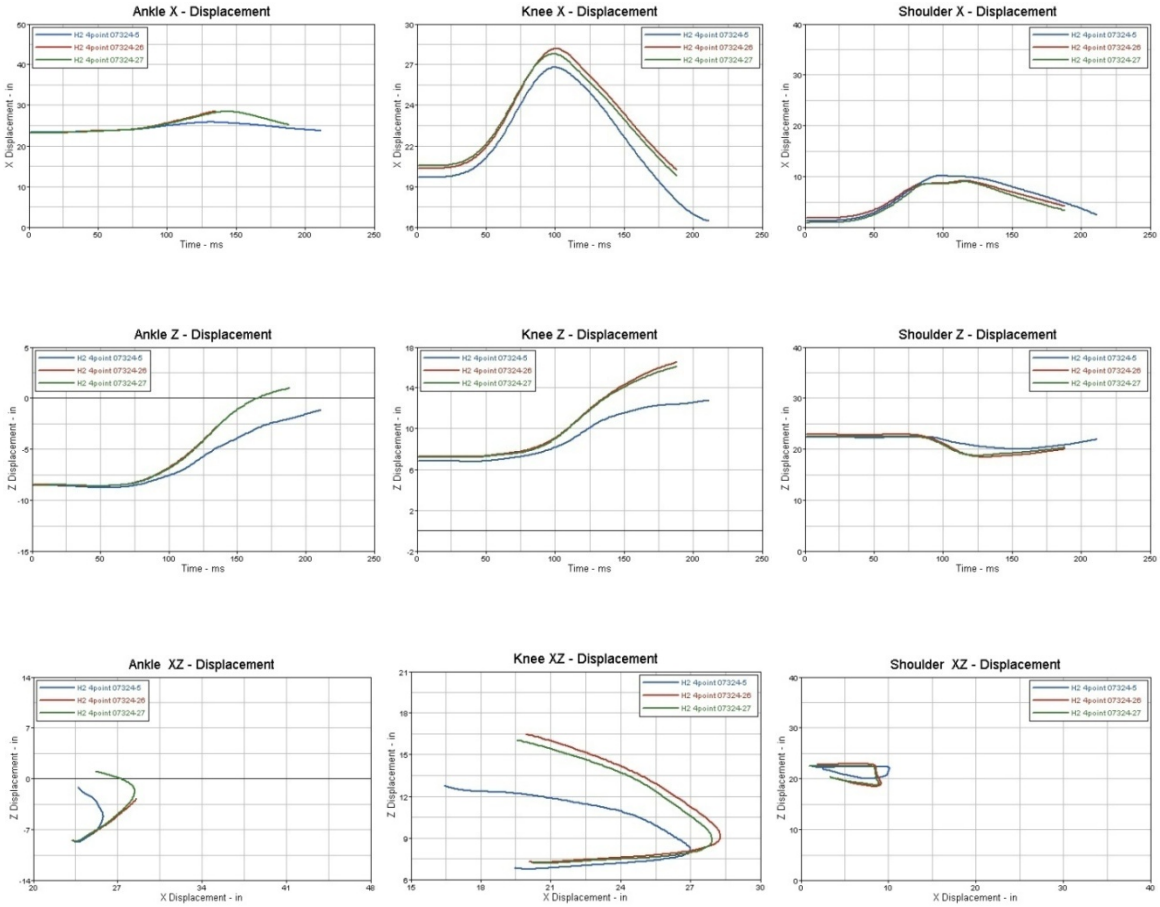


Figure 85. Ankle, Knee, and Shoulder Displacements of Hybrid II ATD With Four-Point Belt at 0° Pitch

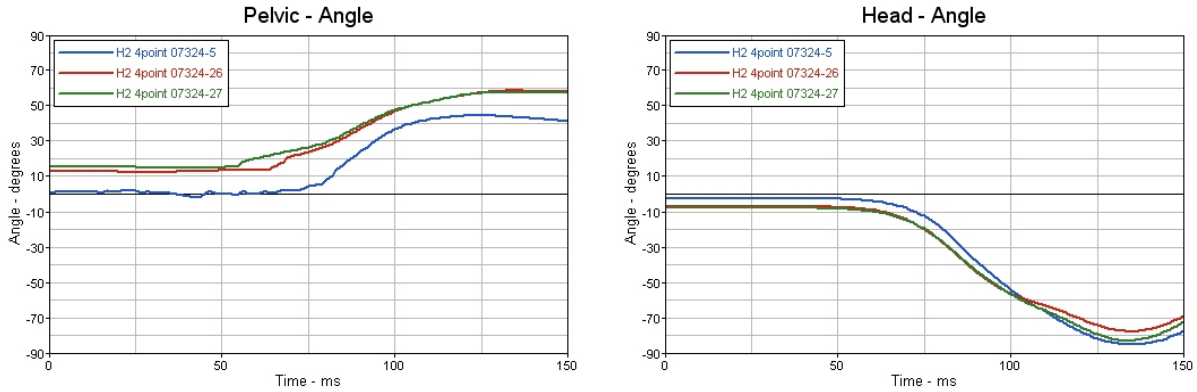


Figure 86. Pelvis and Head Angles of Hybrid II ATD With Four-Point Belt at 0° Pitch

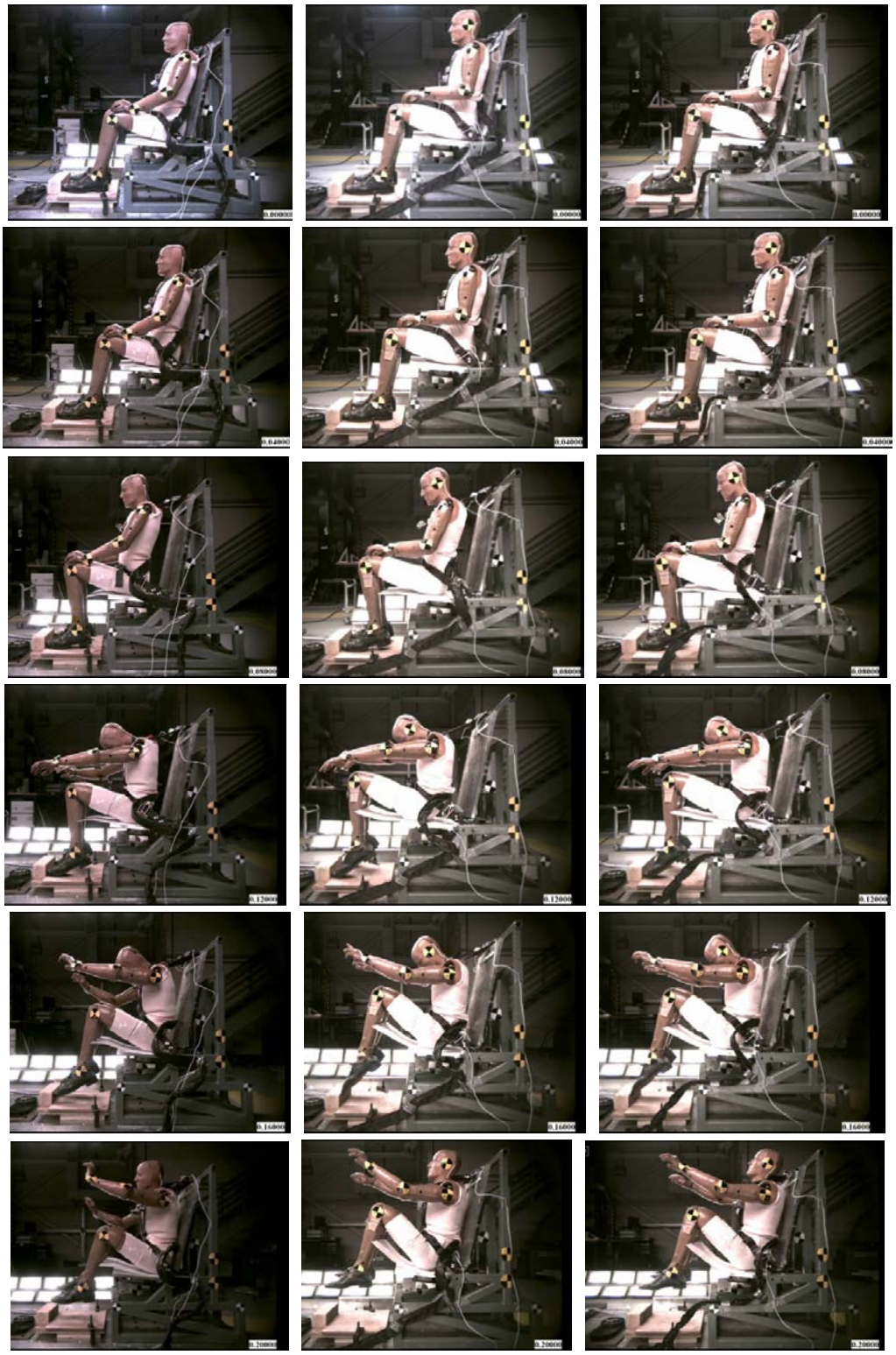


Figure 87. Test Kinematics 07324-5 (left), 07324-26 (middle), and 07324-27 (right) of Hybrid II ATD With Four-Point Belt at 0° Pitch

3.7.2 The FAA Hybrid III ATD Test Data.

3.7.2.1 The FAA Hybrid III ATD Two-Point Belt at 0° Pitch.

A series of tests of the FAA Hybrid III ATD with two-point belt at 0° pitch included test numbers 07324-16, 07324-17, and 07324-18. The dynamic setup for these tests is summarized in table 26, and the significant peak values for reference are shown in table 27. The configuration consists of a rigid seat, a two-point belt restraint, and 0° pitch (figure 88). The tests were performed using the 14 CFR 25.562 16-g acceleration pulse. For the calibration report and test data, refer to appendices A and B, respectively. The channel data, derived data (from video), calculated data (from channel data), and images showing the ATD kinematics are shown in figures 89 to 99.

Table 26. Dynamic Test Configuration for FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

Test Number	ATD Serial Number	Belt Point Type	Pitch Angle (degrees)	Load (g)	Seat Type	Belt Material	Acceleration Pulse	Test Data (page)
07324-16	FAA Hybrid III 289	2	0	16	Rigid	100% Nylon	25.562	B-23
07324-17	FAA Hybrid III 289	2	0	16	Rigid	100% Nylon	25.562	B-25
07324-18	FAA Hybrid III 289	2	0	16	Rigid	100% Nylon	25.562	B-27

Table 27. Significant Peak Values for FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

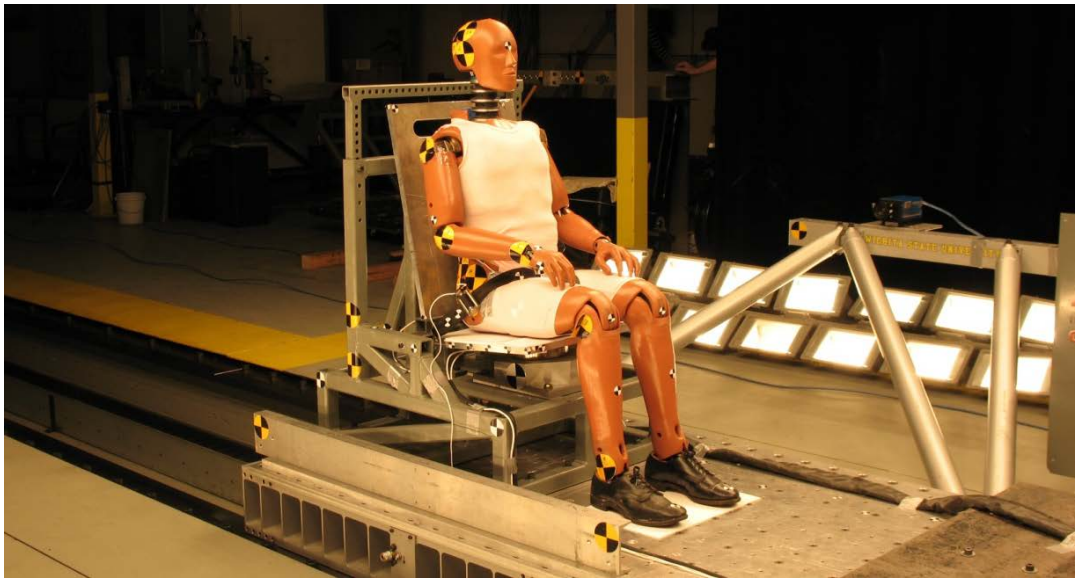
Channel Description	Injury Criteria	FAA Hybrid III Test 07324-16	FAA Hybrid III Test 07324-17	FAA Hybrid III Test 07324-18
HIC (unlimited)*	1000	1666	1695	1578
T1-ms		167	170	172
T2-ms		202	206	208
Head xz velocity (ft/s)	Not required	55.6	55.3	59.8
Head xz excursion (in.)	Not required	36.9	37.1	37.4
Lumbar Fz load (lbf) (compression)	1500	86	60	65
Seat pan resultant force (lbf)	Not required	5588	5439	4694
Left lap belt load (lbf) (tension)	Not required	1852	1839	1817
Right lap belt load (lbf) (tension)	Not required	1777	1813	1784
Left strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A
Right strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A

N/A = not applicable

*Unlimited HIC is calculated until 300 ms for this test configuration.

[1]Individual shoulder strap

[2]Dual shoulder strap



(a)

(b)

Figure 88. Front (a) and Side (b) Views of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

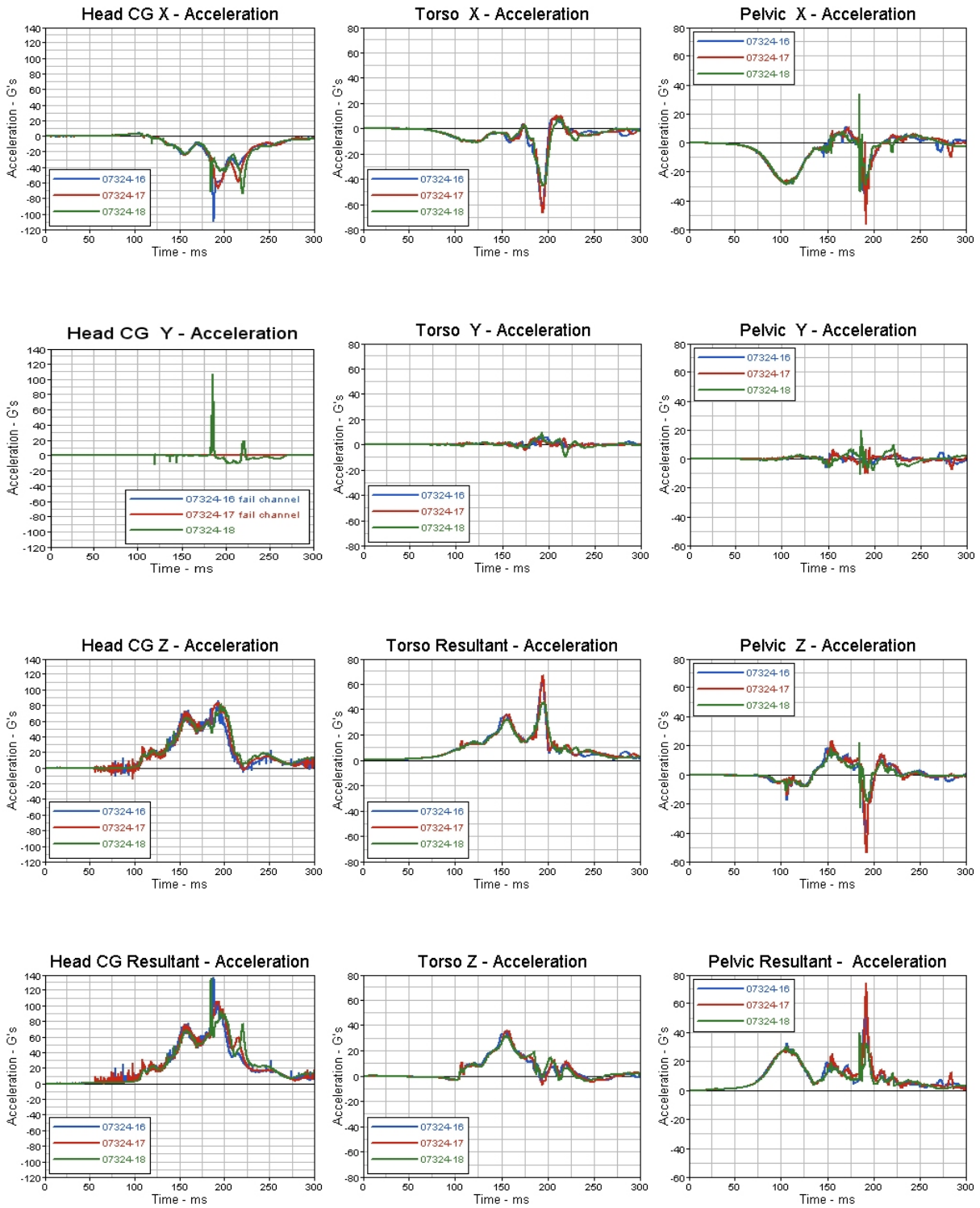


Figure 89. Head, Torso, and Pelvis Accelerations of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

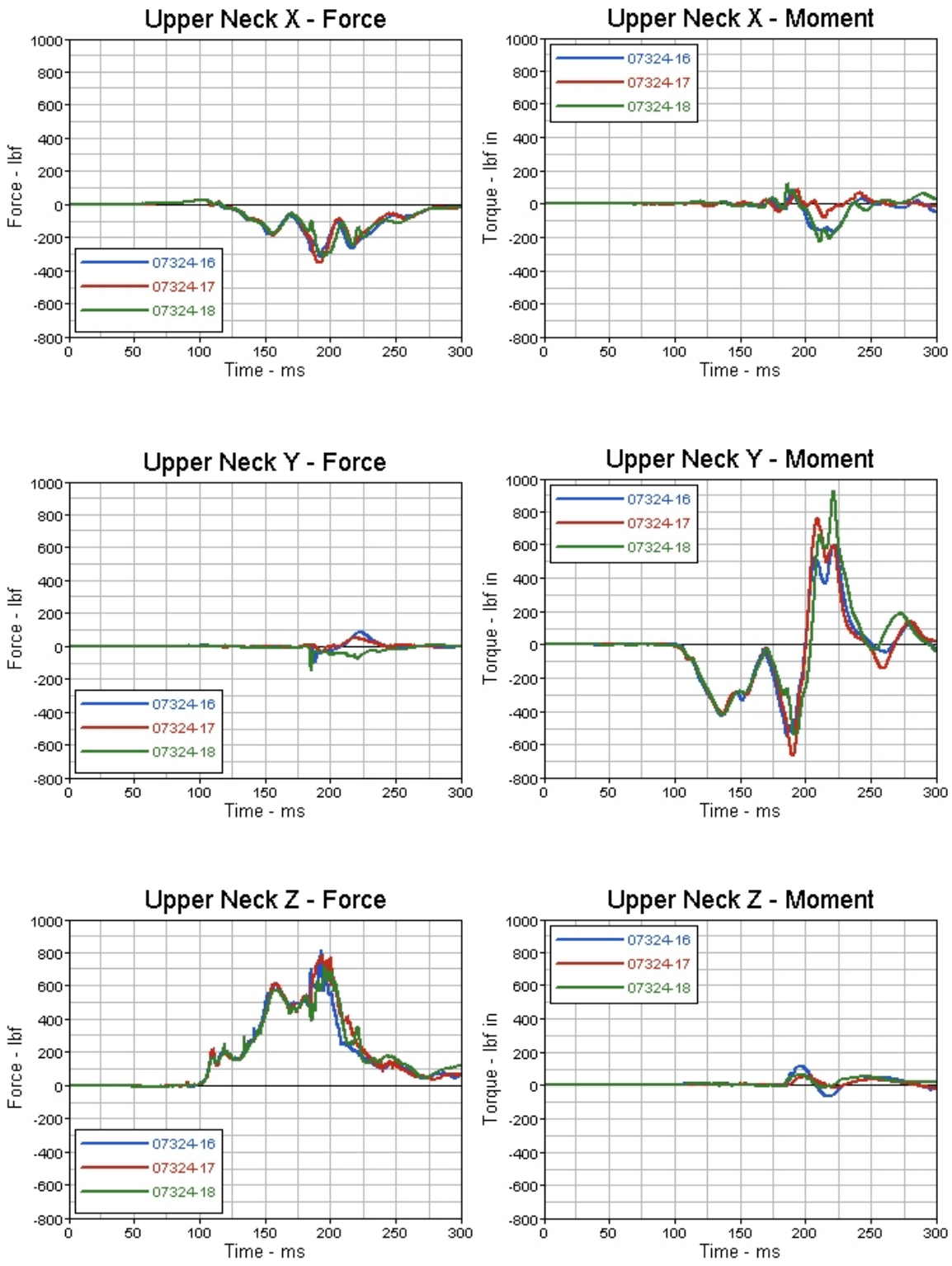


Figure 90. Upper Neck Forces and Moments of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

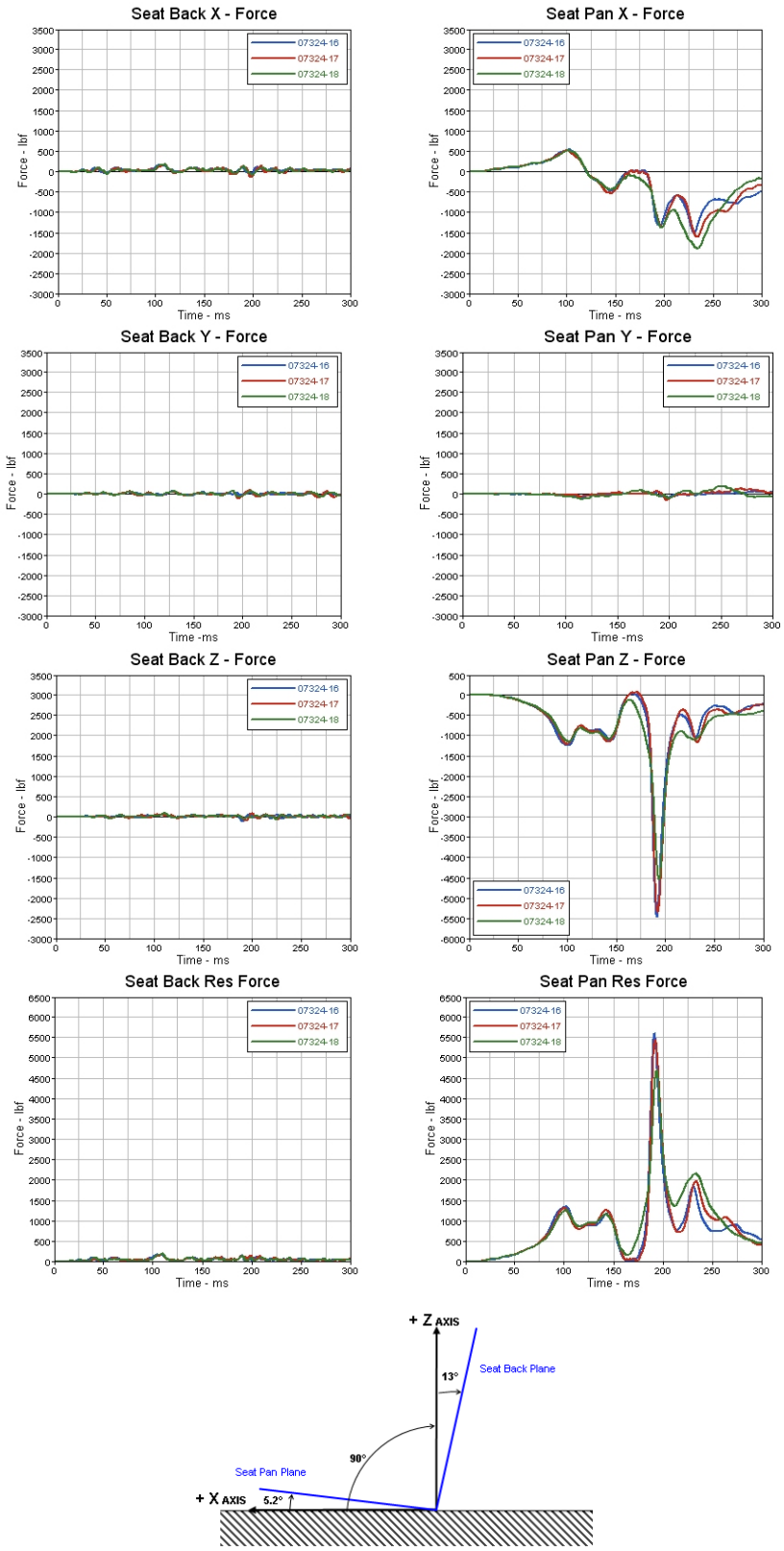


Figure 91. Seat Pan and Back Loads (Tare Compensation and Global Coordinates) of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

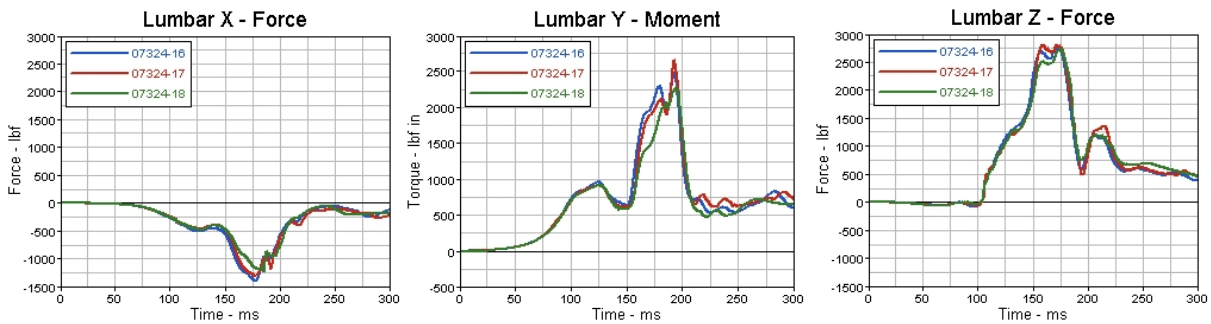


Figure 92. Lumbar Loads and Moments of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

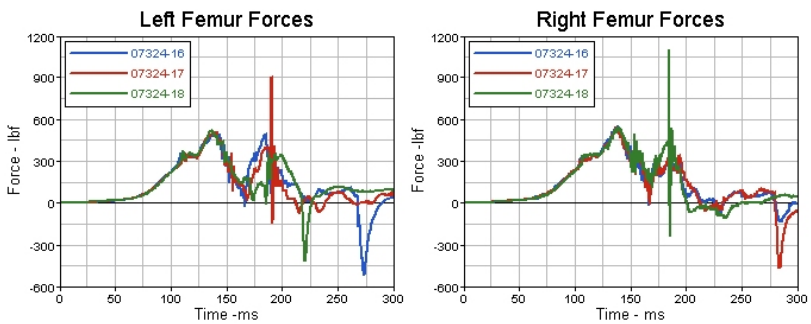


Figure 93. Femur Forces of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

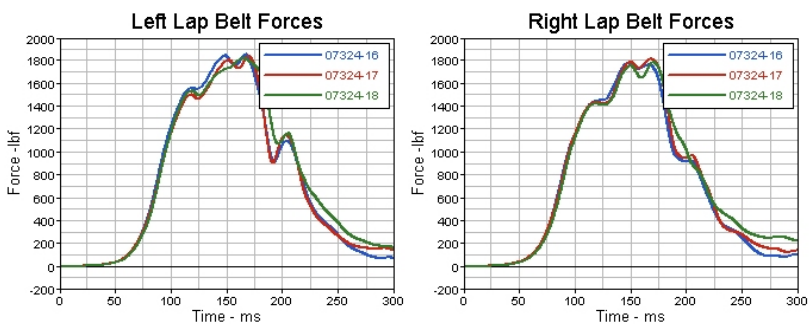


Figure 94. Lap Belt Forces of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

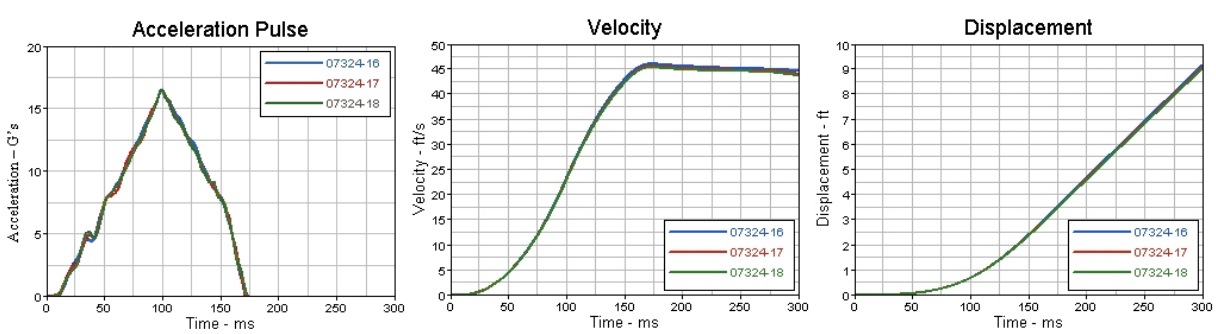


Figure 95. Acceleration Pulses of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

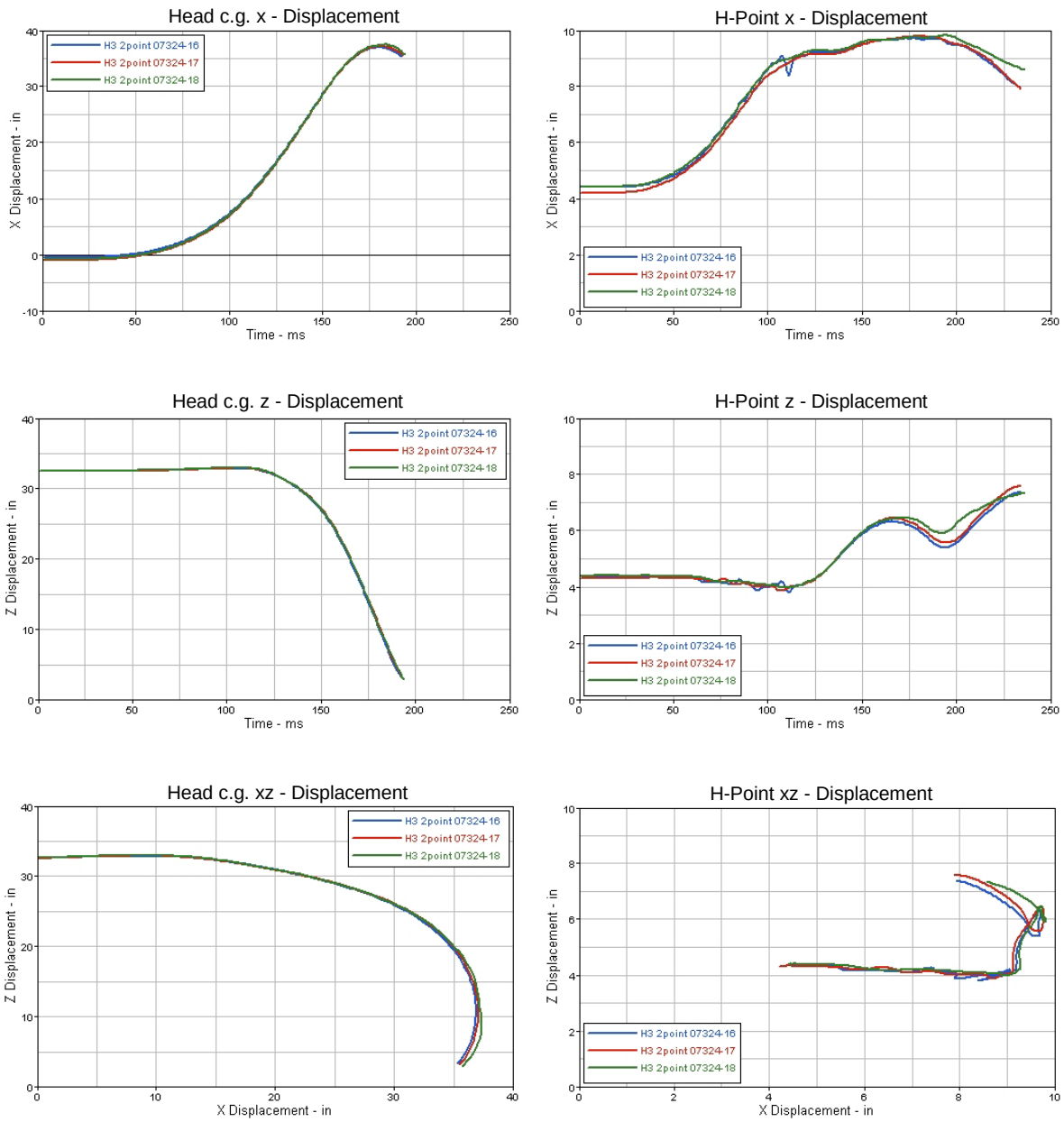


Figure 96. Head and H-Point Displacements of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

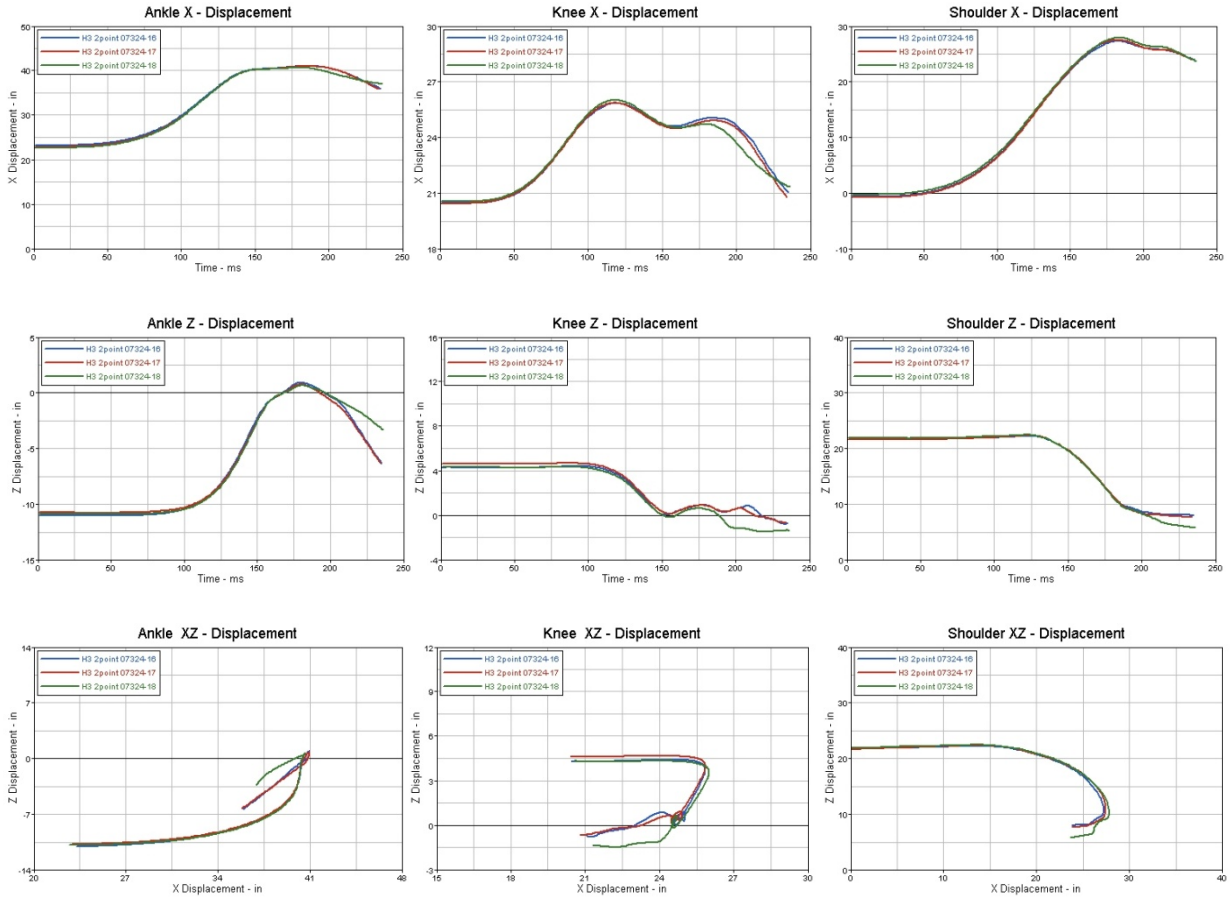


Figure 97. Ankle, Knee, and Shoulder Displacements of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

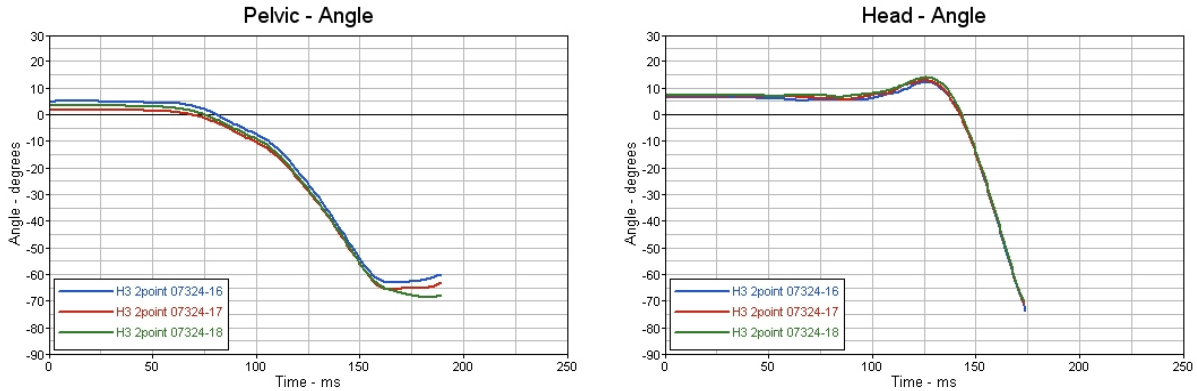


Figure 98. Pelvis and Head Angles of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

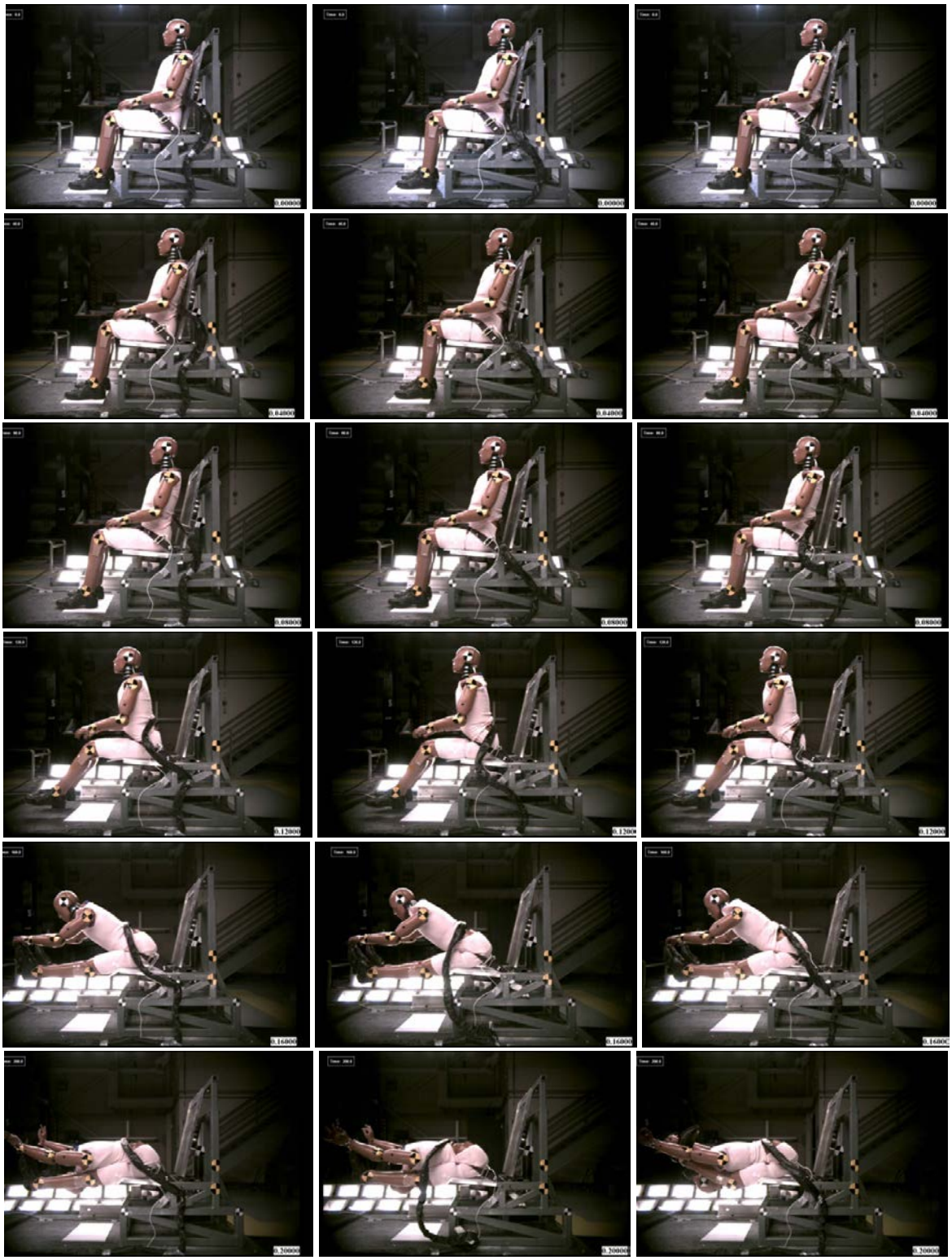


Figure 99. Test Kinematics 07324-16 (left), 07324-17 (middle), and 07324-18 (right) of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

3.7.2.2 FAA Hybrid III ATD With Two-Point Belt at 60° Pitch.

A series of tests of the FAA Hybrid III ATD with two-point belt at 60° pitch included test numbers 07324-13, 07324-14, and 07324-15. The dynamic test setup for these tests is summarized in table 28, and the significant peak values for reference are shown in table 29. The configuration consisted of a rigid seat, a two-point belt restraint, and 60° pitch (figure 100). The tests were performed using 14 CFR 23.562 19-g acceleration pulse. For the calibration report and test data, refer to appendices A and B, respectively. The channel data, derived data (from video), calculated data (from channel data), and images showing the ATD kinematics are shown in figures 101 to 111.

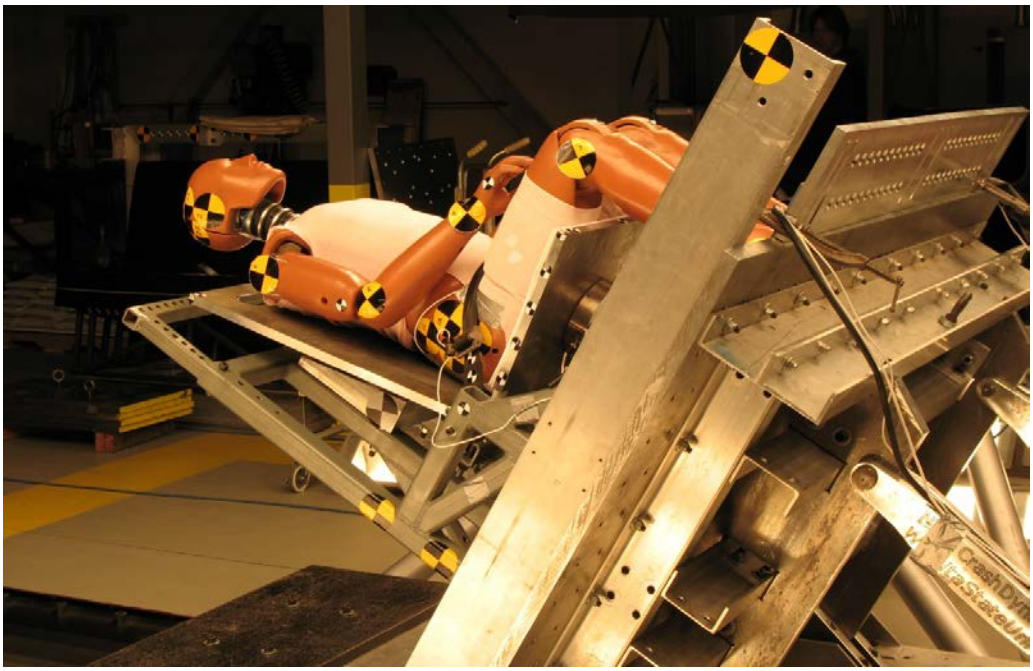
Table 28. Dynamic Test Configuration for FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

Test Number	ATD Serial Number	Belt Point Type	Pitch Angle (degrees)	Load (g)	Seat Type	Belt Material	Acceleration Pulse	Test Data (page)
07324-13	FAA Hybrid III 289	2	60	19	Rigid	100% nylon	23.562	B-17
07324-14	FAA Hybrid III 289	2	60	19	Rigid	100% nylon	23.562	B-19
07324-15	FAA Hybrid III 289	2	60	19	Rigid	100% nylon	23.562	B-21

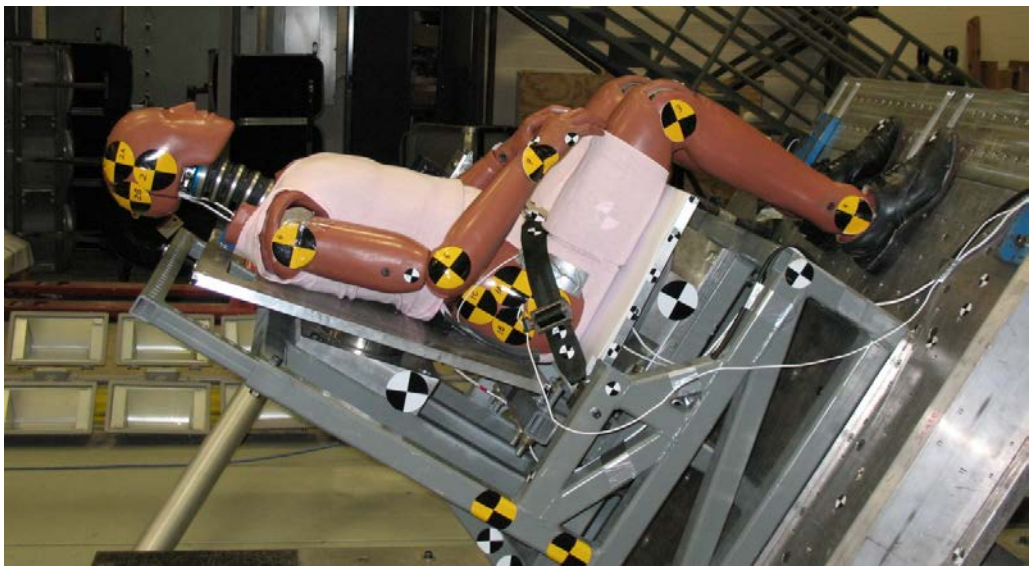
Table 29. Significant Peak Values for FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

Channel Description	Injury Criteria	FAA Hybrid III Test 07324-13	FAA Hybrid III Test 07324-14	FAA Hybrid III Test 07324-15
HIC (unlimited)*	1000	52	56	59
T1-ms		40	41	41
T2-ms		76	77	77
Head velocity (ft/s)	Not required	14.2	14.0	13.8
Head x excursion (in.)	Not required	16.6	16.8	16.9
Lumbar Fz load (lbf) (compression)	1500	1713	1736	1798
Seat pan resultant force (lbf)	Not required	3189	3268	3306
Left lap belt load (lbf) (tension)	Not required	175	192	176
Right lap belt load (lbf) (tension)	Not required	168	175	168
Left strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A
Right strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A

N/A = not applicable
*Unlimited HIC is calculated according to the evaluation period (125 ms) for this test configuration
[1]Individual shoulder strap
[2]Dual shoulder strap



(a)



(b)

Figure 100. Front Angle (a) and Side View (b) of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

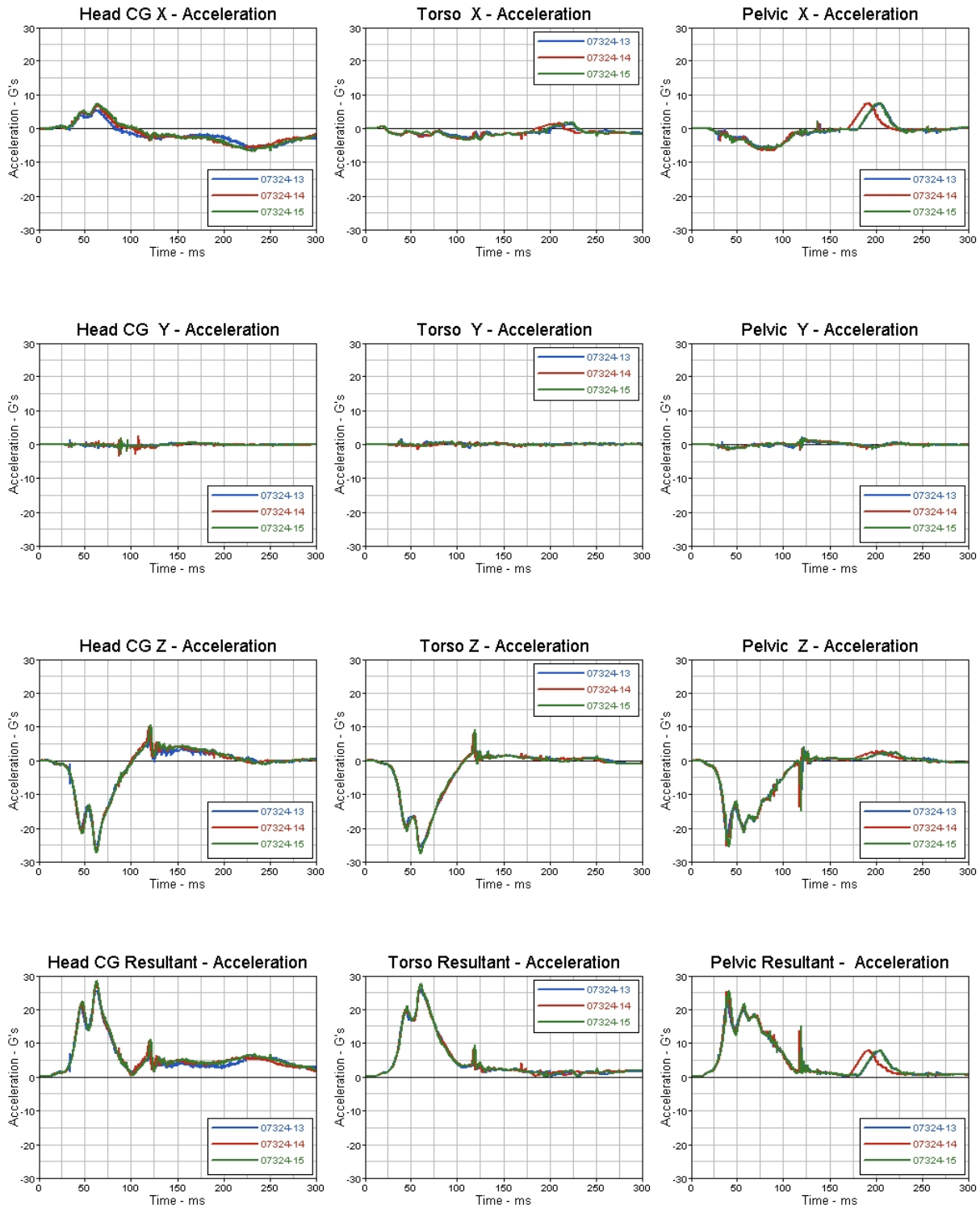


Figure 101. Head, Torso, and Pelvis Accelerations of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

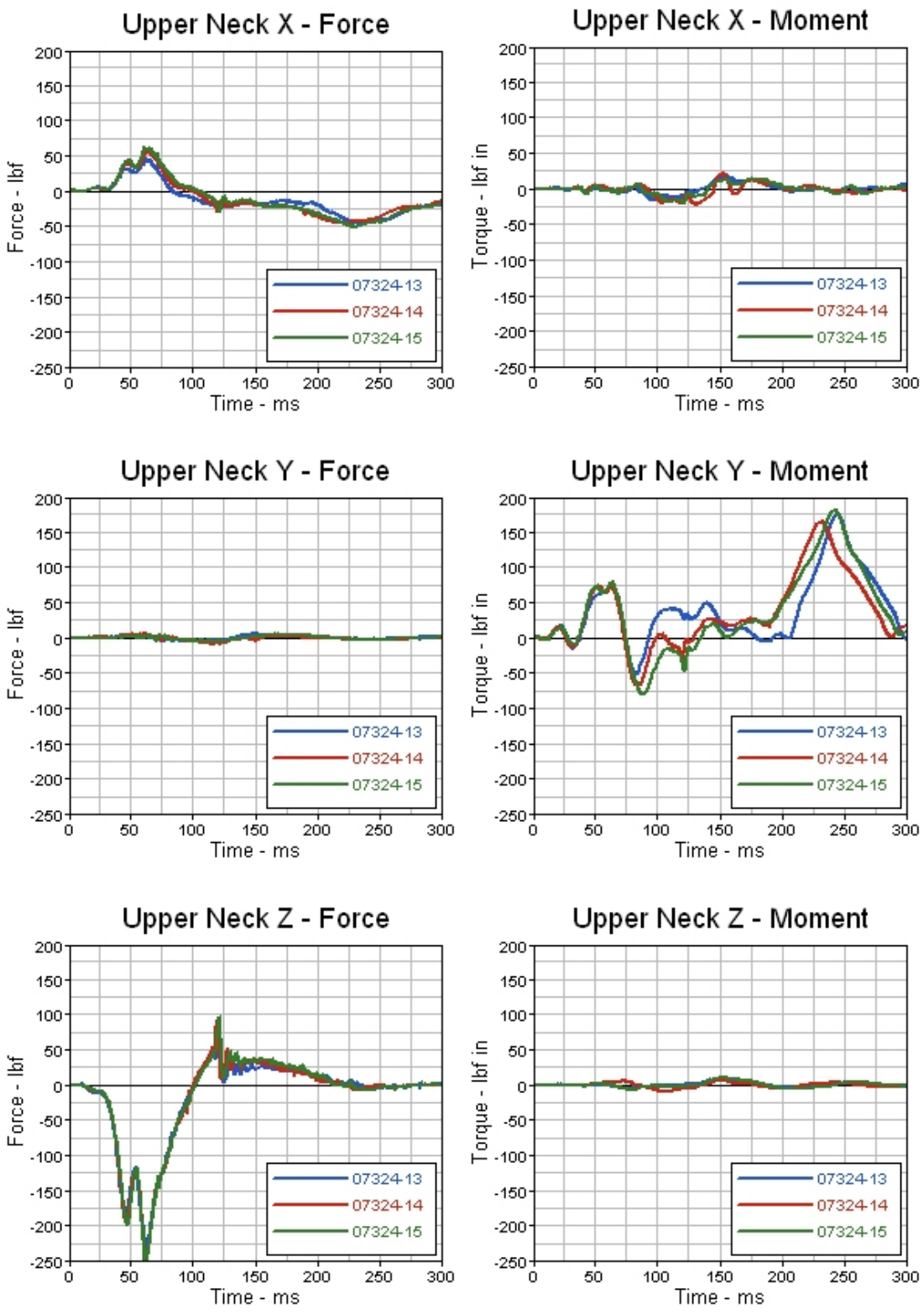


Figure 102. Upper Neck Forces and Moments of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

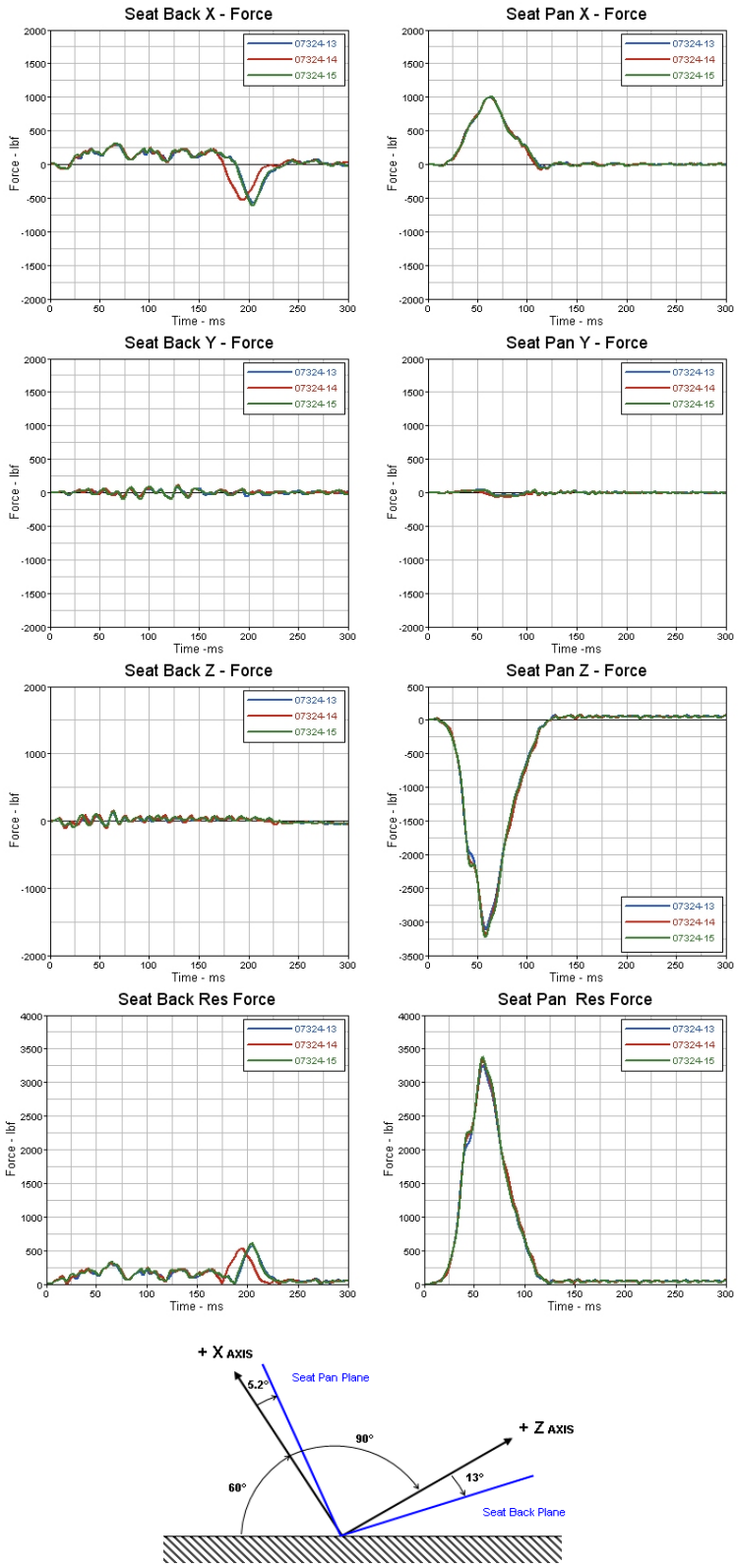


Figure 103. Seat Pan and Back Loads (Tare Compensation and Global Coordinates) of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

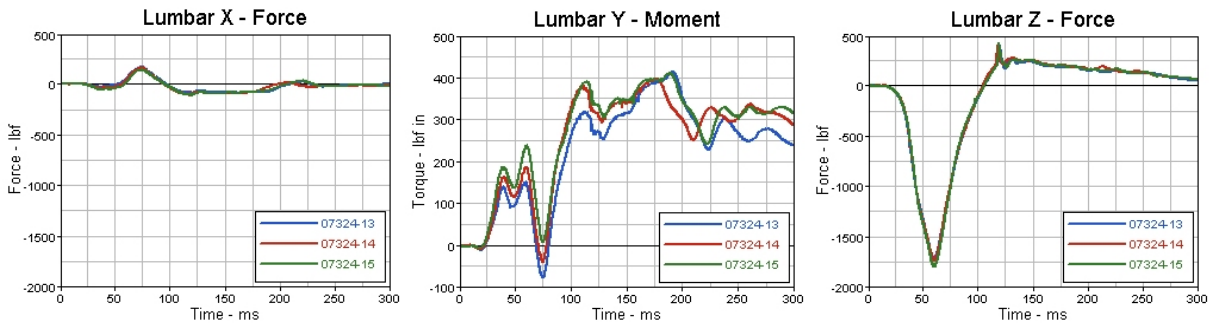


Figure 104. Lumbar Loads and Moments of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

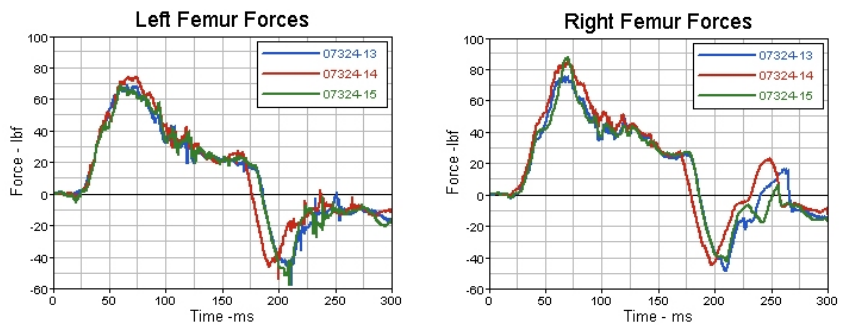


Figure 105. Femur Forces of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

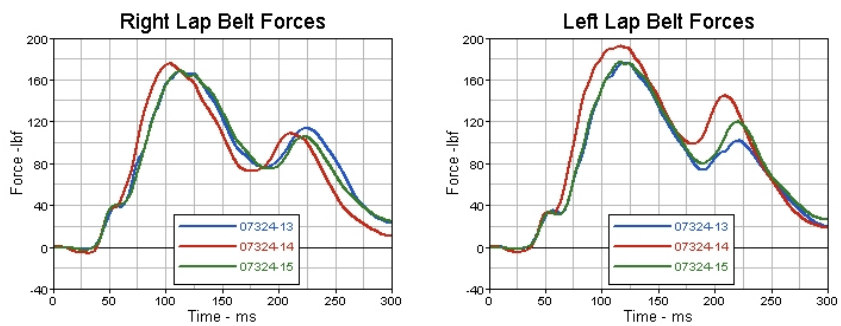


Figure 106. Lap Belt Forces of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

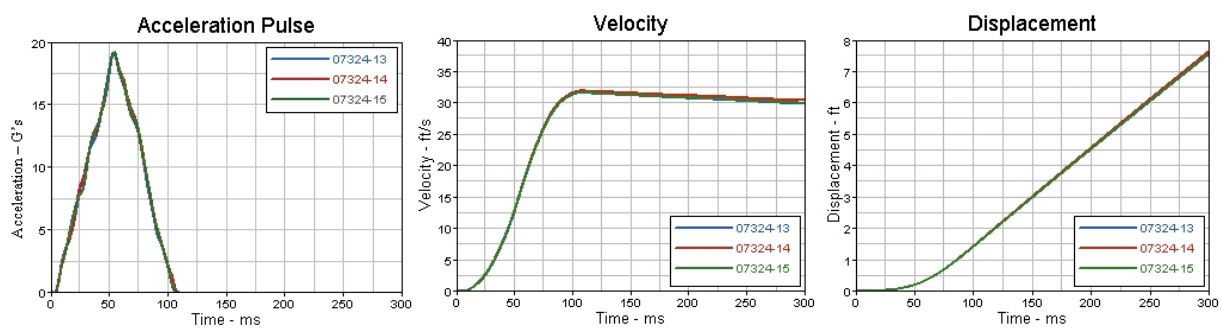


Figure 107. Acceleration Pulses of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

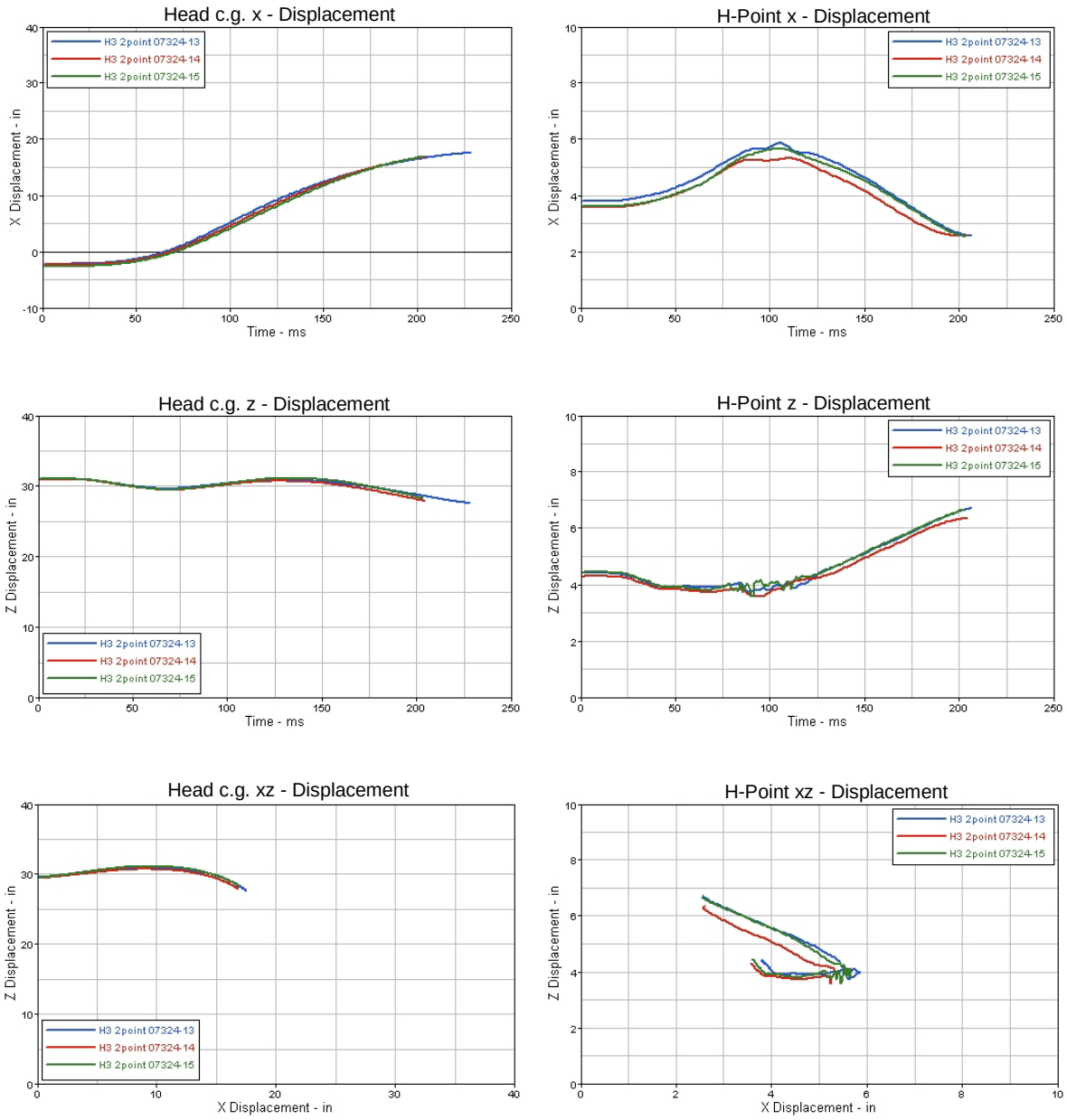


Figure 108. Head and H-Point Displacements of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

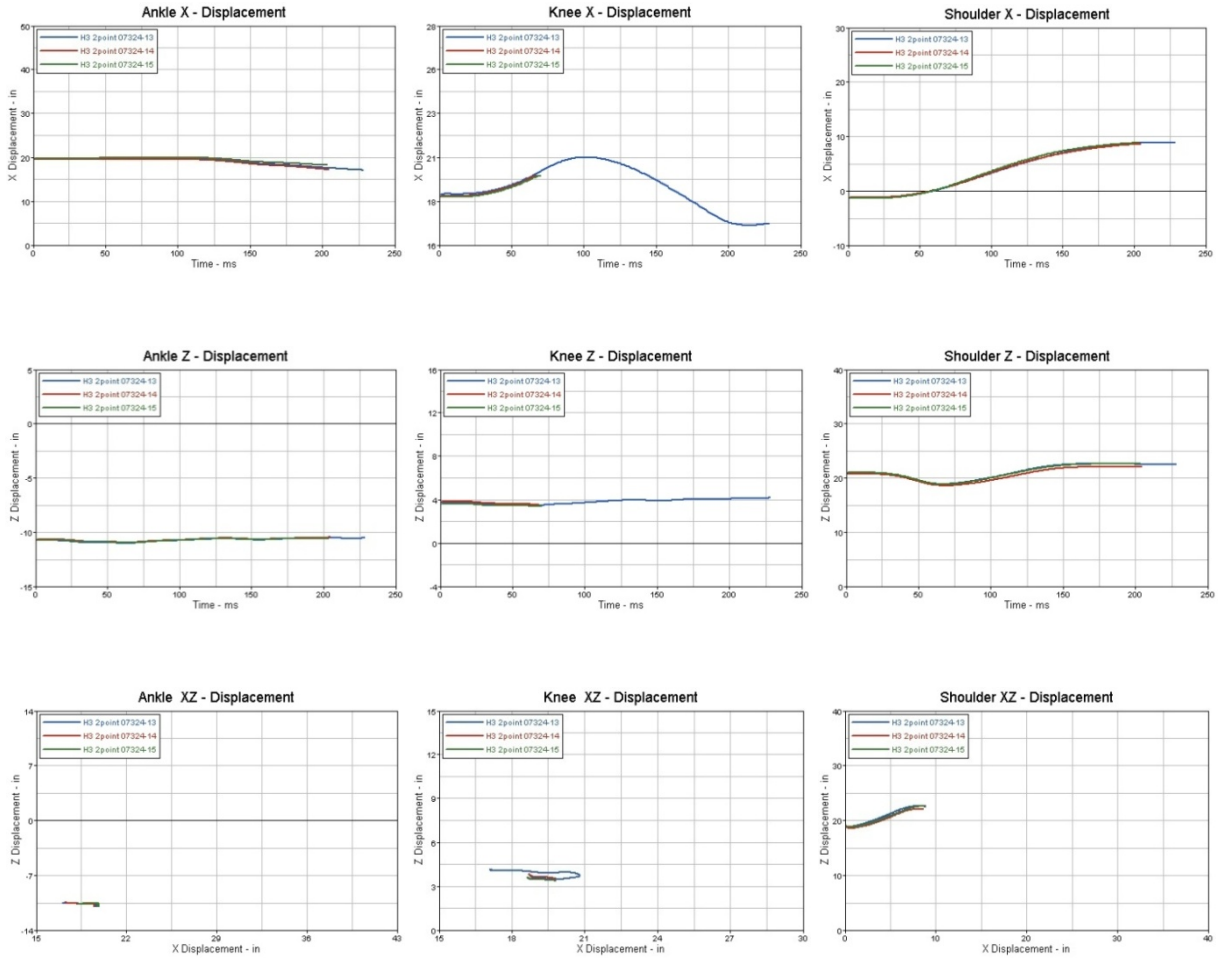


Figure 109. Ankle, Knee, and Shoulder Displacements of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

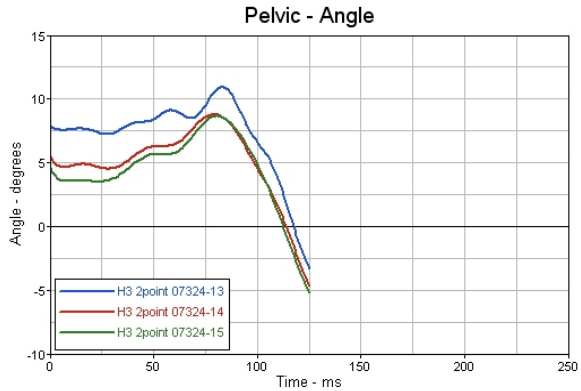


Figure 110. Pelvis Angles of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

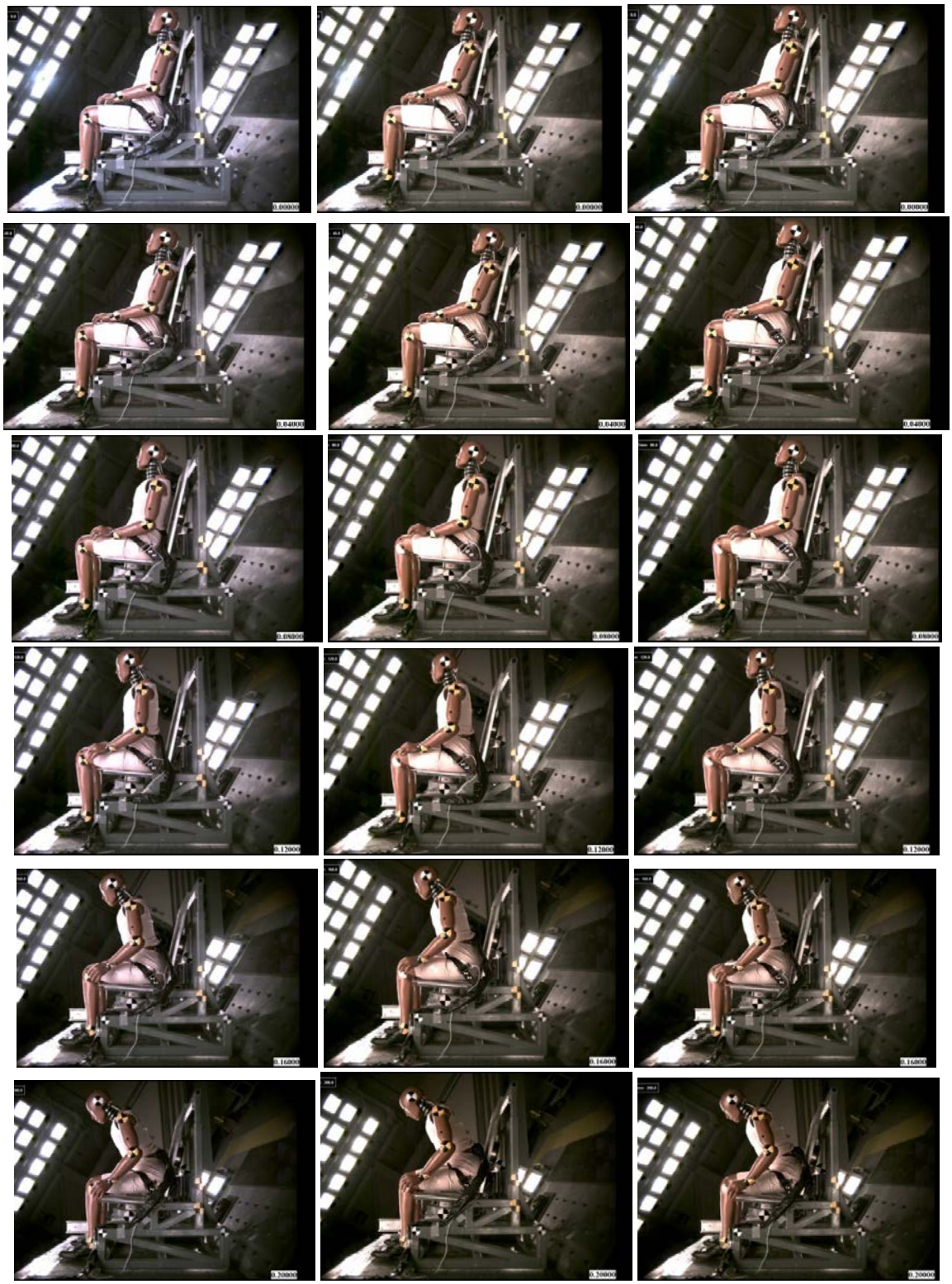


Figure 111. Test Kinematics 07324-13 (left), 07324-14 (middle), and 07324-15 (right) of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

3.7.2.3 The FAA Hybrid III ATD Three-Point Belt at 0° Pitch.

A series of tests of the FAA Hybrid III ATD with three-point belt at 0° pitch included test numbers 07324-20, 07324-24, and 07324-25. The dynamic test setup for these tests is shown in table 30, and the significant peak values for reference are shown in table 31. The configuration consisted of a rigid seat, a three-point belt, and 0° pitch (figure 112). The tests were performed using the 14 CFR 23.562 21-g acceleration pulse. For the calibration report and test data, please refer to appendices A and B, respectively. The channel data, derived data (from video), calculated data (from channel data), and images showing the ATD kinematics are shown in figures 113 to 122.

Table 30. Dynamic Test Configuration

Test Number	ATD Serial Number	Belt Point Type	Pitch Angle (degrees)	Load (g)	Seat Type	Belt Material	Acceleration Pulse	Test Data (page)
07324-20	FAA Hybrid III 289	3	0	21	Rigid	100% nylon	23.562	B-29
07324-24	FAA Hybrid III 289	3	0	21	Rigid	100% nylon	23.562	B-37
07324-25	FAA Hybrid III 289	3	0	21	Rigid	100% nylon	23.562	B-39

Table 31. Significant Peak Values for Reference

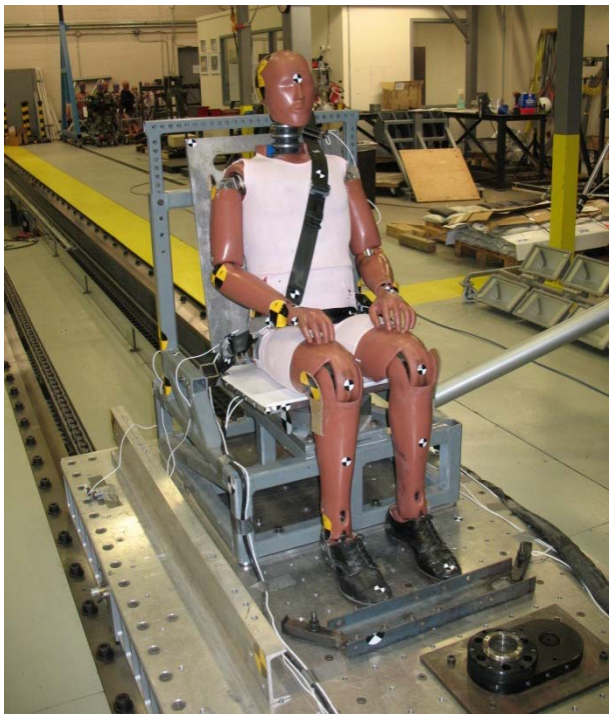
Channel Description	Injury Criteria	FAA Hybrid III Test 07324-20	FAA Hybrid III Test 07324-24	FAA Hybrid III Test 07324-25
HIC (unlimited)*	1000	305	356	339
T1-ms		96	97	97
T2-ms		132	133	133
Head velocity (ft/s)	Not required	30.9	33.8	33
Head excursion (in.)	Not required	19.5	21.1	20.5
Lumbar Fz load (lbf) (compression)	1500	299	206	265
Seat pan resultant force (lbf)	Not required	1466	1366	1474
Left lap belt load (lbf) (tension)	Not required	1718	1713	1727
Right lap belt load (lbf) (tension)	Not required	2324	2420	2471
Left strap load (lbf) (tension)	1750[1]/2000[2]	1712	1586	1637
Right strap load (lbf) (tension)	1750[1]/2000[2]	N/A	N/A	N/A

N/A = not applicable

*Unlimited HIC is calculated according to the evaluation period (180 ms) for this test configuration.

[1]Individual shoulder strap

[2]Dual shoulder strap



(a)

(b)

Figure 112. Front (a) and Side (b) Views of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

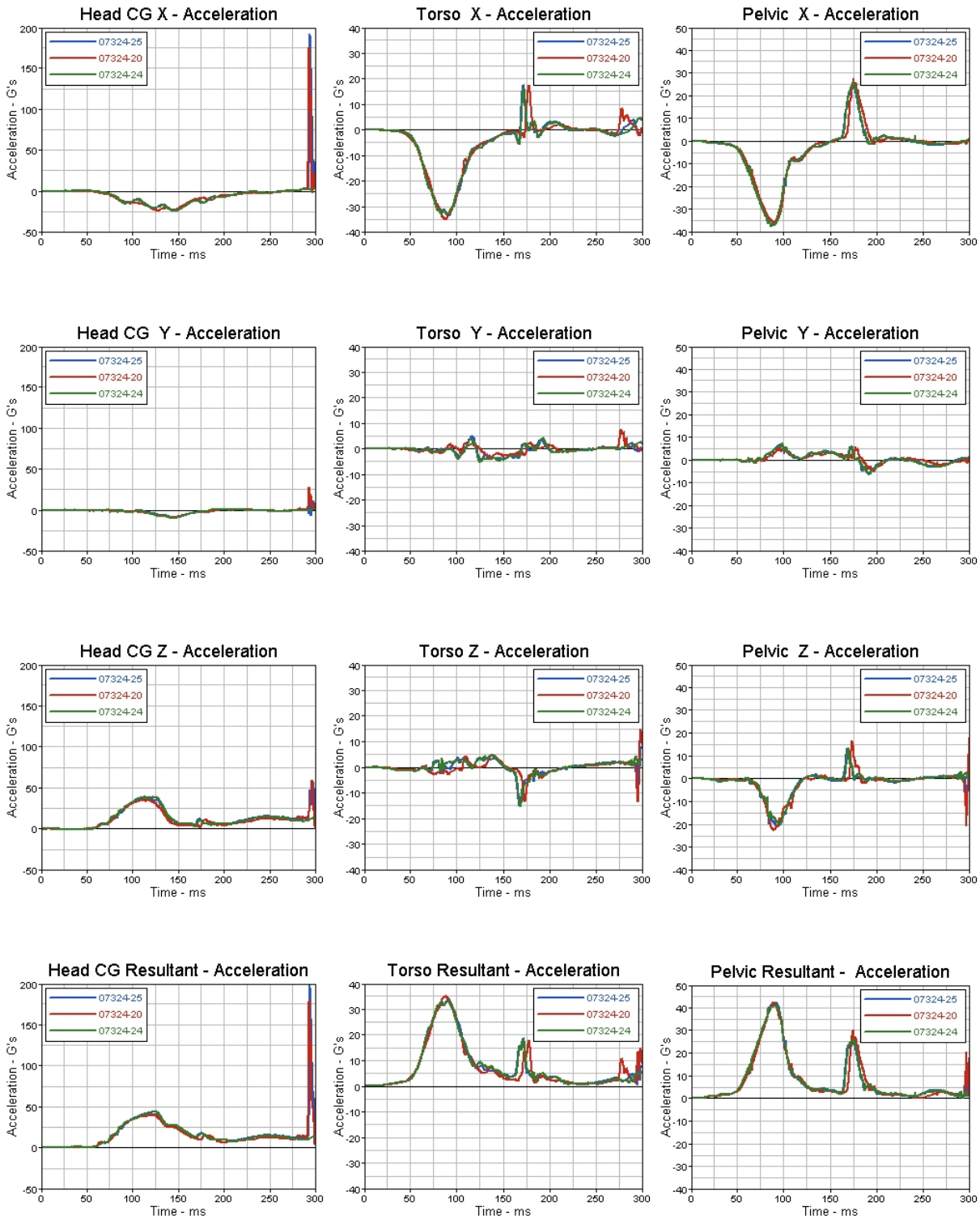


Figure 113. Head, Torso, and Pelvis Accelerations of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

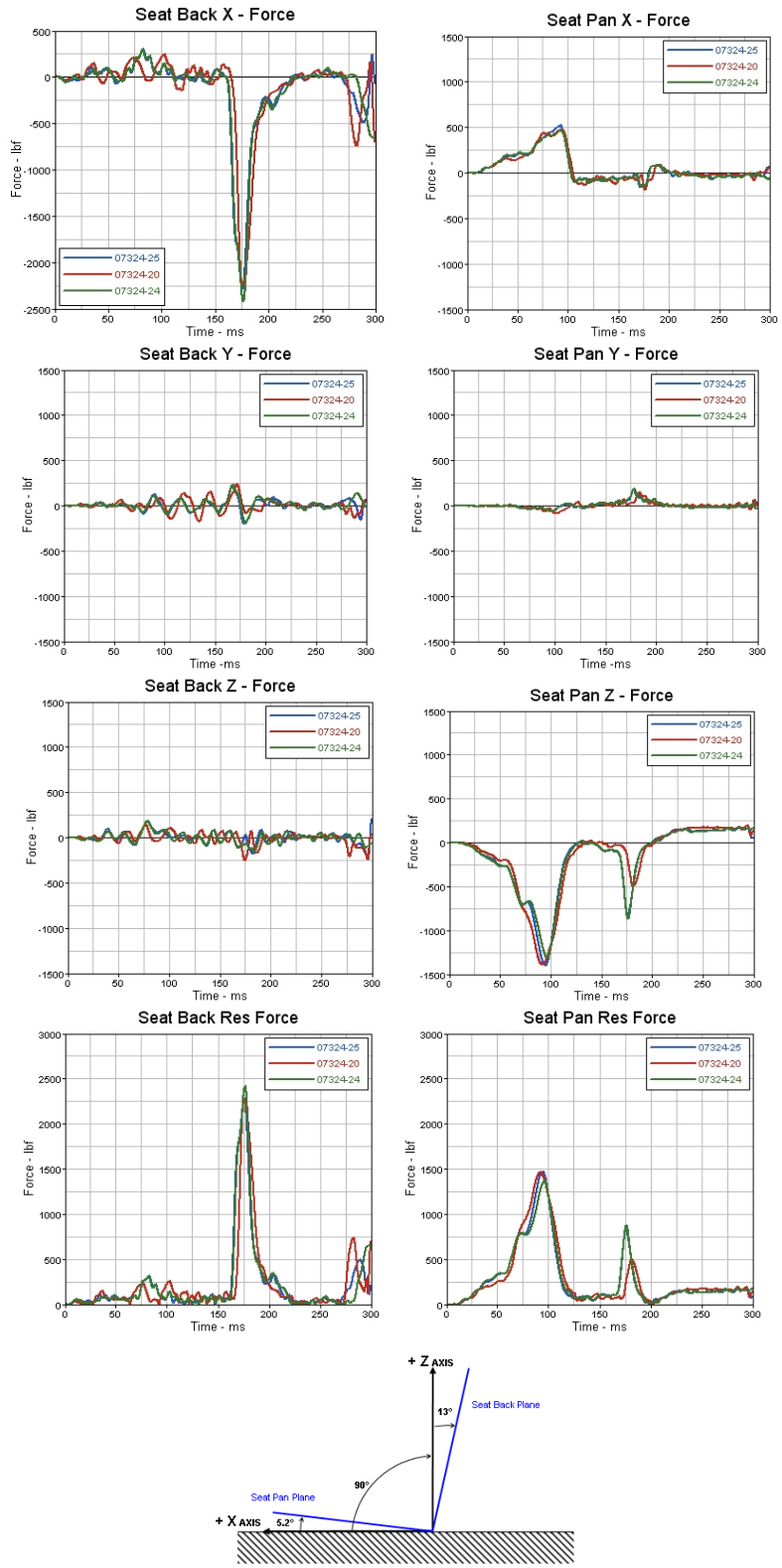


Figure 114. Seat Pan and Back Loads (Tare Compensation and Global Coordinates) of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

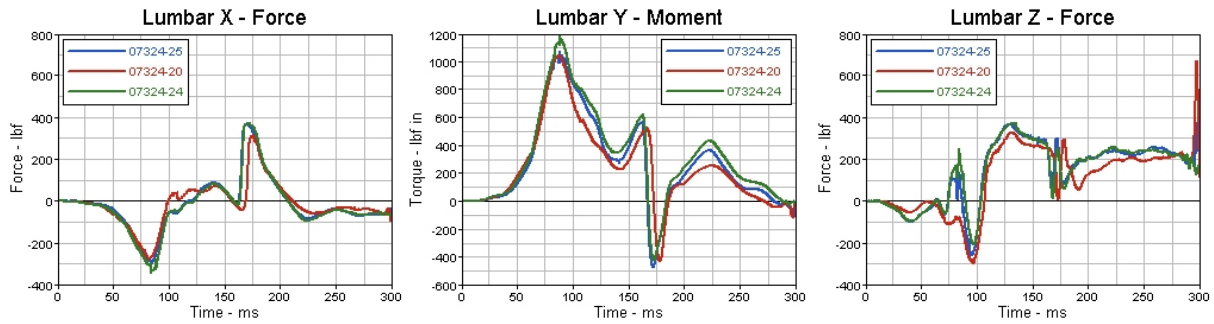


Figure 115. Lumbar Loads and Moments of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

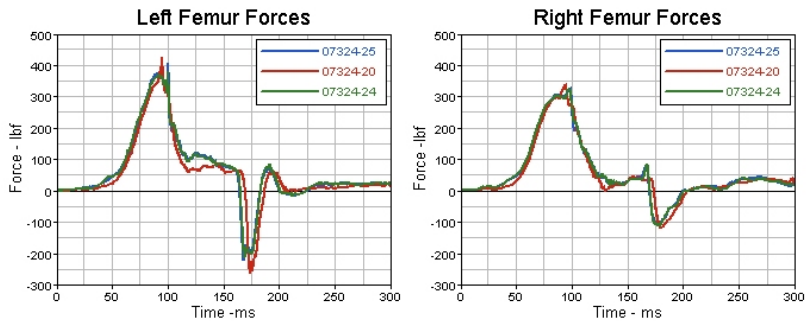


Figure 116. Femur Forces of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

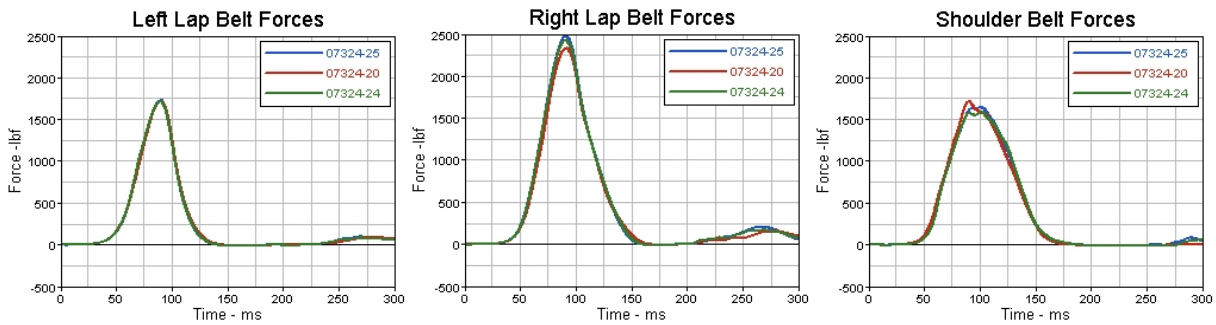


Figure 117. Lap Belt Forces of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

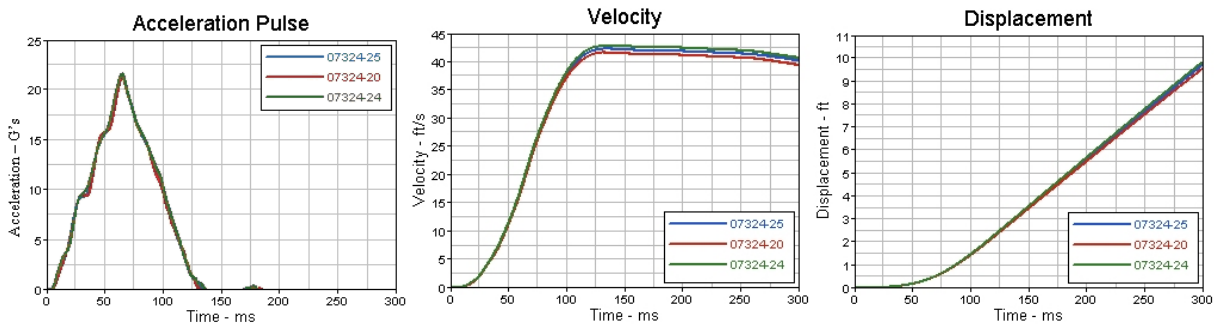


Figure 118. Acceleration Pulses of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

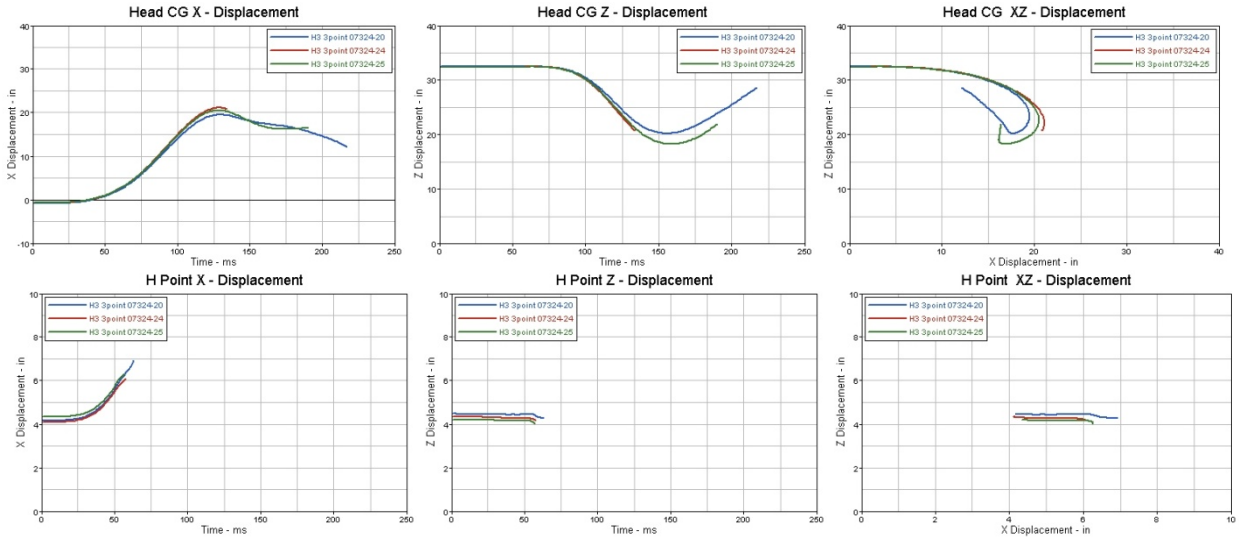


Figure 119. Head and H-Point Displacements of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

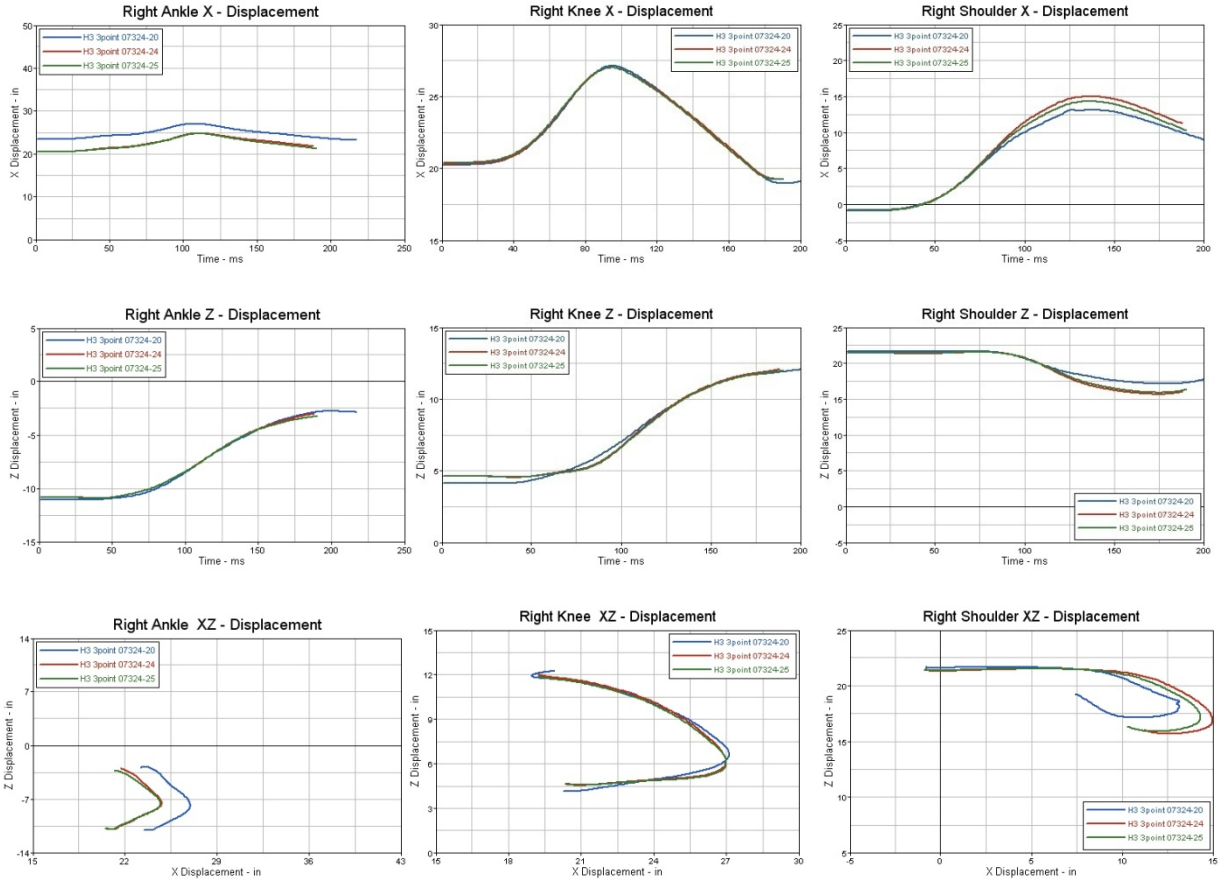


Figure 120. Right Ankle, Right Knee, and Right Shoulder Displacements of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

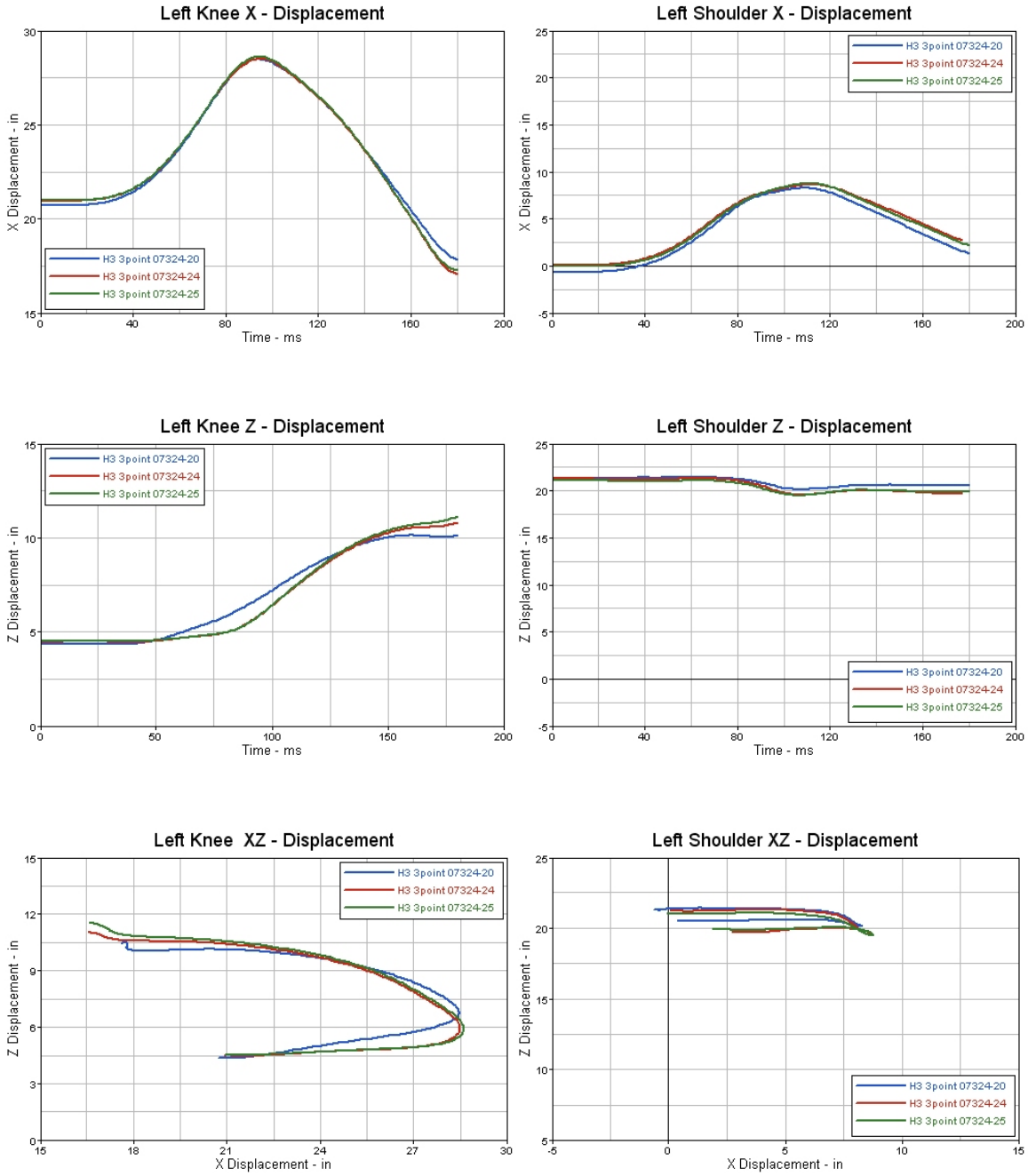


Figure 121. Left Knee and Left Shoulder Displacements of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

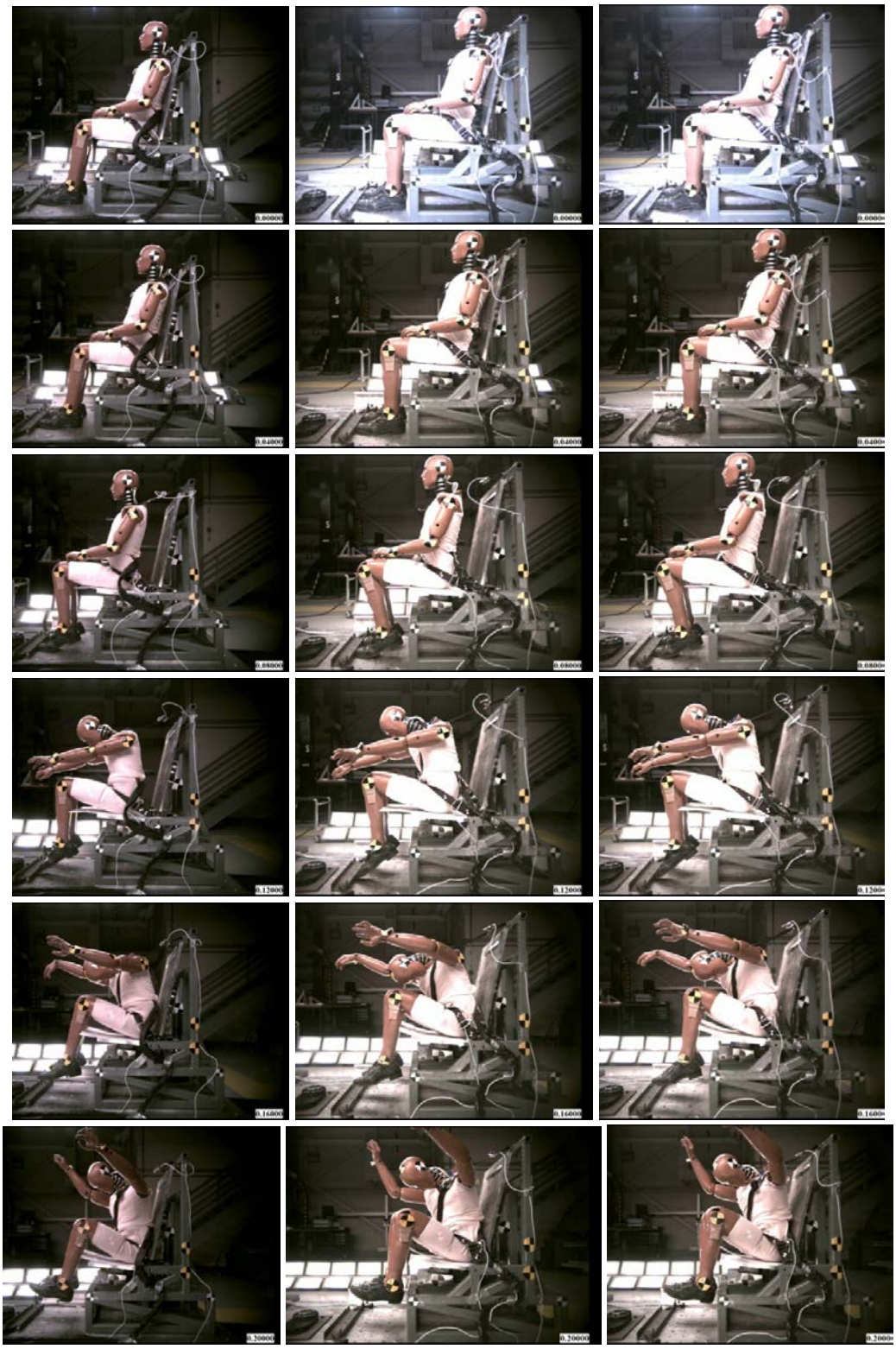


Figure 122. Test Kinematics 07324-20 (left), 07324-24 (middle), and 07324-25 (right) of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

3.7.2.4 The FAA Hybrid III ATD Four-Point Belt at 0° Pitch.

A series of tests of the FAA Hybrid III ATD with four-point belt at 0° pitch included test numbers 07324-21, 07324-22, and 07324-23. The dynamic test setup for these tests is summarized in table 32, and the significant peak values for reference are shown in table 33. The configuration consisted of a rigid seat, a four-point belt restraint, and 0° pitch (figure 123). The tests were performed using the 14 CFR 23.562 21-g acceleration pulse. For the calibration report and test data, please refer to appendices A and B, respectively. The channel data, derived data (from video), calculated data (from channel data), and images showing the ATD kinematics are shown in figures 124 to 134.

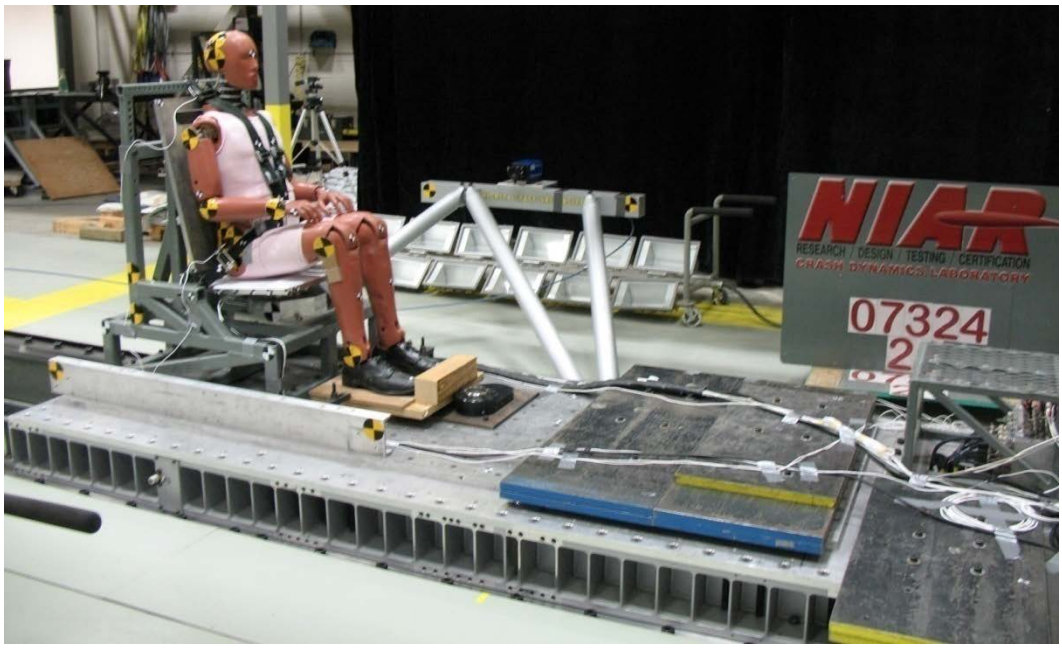
Table 32. Dynamic Test Configuration

Test Number	ATD Serial Number	Belt Point Type	Pitch Angle (degrees)	Load (g)	Seat Type	Belt Material	Acceleration Pulse	Test Data (page)
07324-21	FAA Hybrid III 289	4	0	21	Rigid	100% Nylon	23.562	B-31
07324-22	FAA Hybrid III 289	4	0	21	Rigid	100% Nylon	23.562	B-33
07324-23	FAA Hybrid III 289	4	0	21	Rigid	100% Nylon	23.562	B-35

Table 33. Significant Peak Values for Reference

Channel Description	Injury Criteria	FAA Hybrid III Test 07324-21	FAA Hybrid III Test 07324-22	FAA Hybrid III Test 07324-23
HIC (unlimited)*	1000	239	295	326
T1-ms	-	109	109	108
T2-ms	-	145	145	144
Head velocity (ft/s)	Not required	24.8	26.7	25.1
Head excursion (in.)	Not required	16.0	16.9	16.0
Lumbar Fz load (lbf) (compression)	1500	398	385	385
Seat pan resultant force (lbf)	Not required	1960	2154	2118
Left lap belt load (lbf) (tension)	Not required	1865	1961	1988
Right lap belt load (lbf) (tension)	Not required	1870	1913	1900
Left strap load (lbf) (tension)	1750[1]/2000[2]	854	828	840
Right strap load (lbf) (tension)	1750[1]/2000[2]	790	881	885

*Unlimited HIC is calculated according to the evaluation period (150 ms) for this test configuration.
[1]Individual shoulder strap
[2]Dual shoulder strap



(a)

(b)

Figure 123. Front (a) and Side (b) Views of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

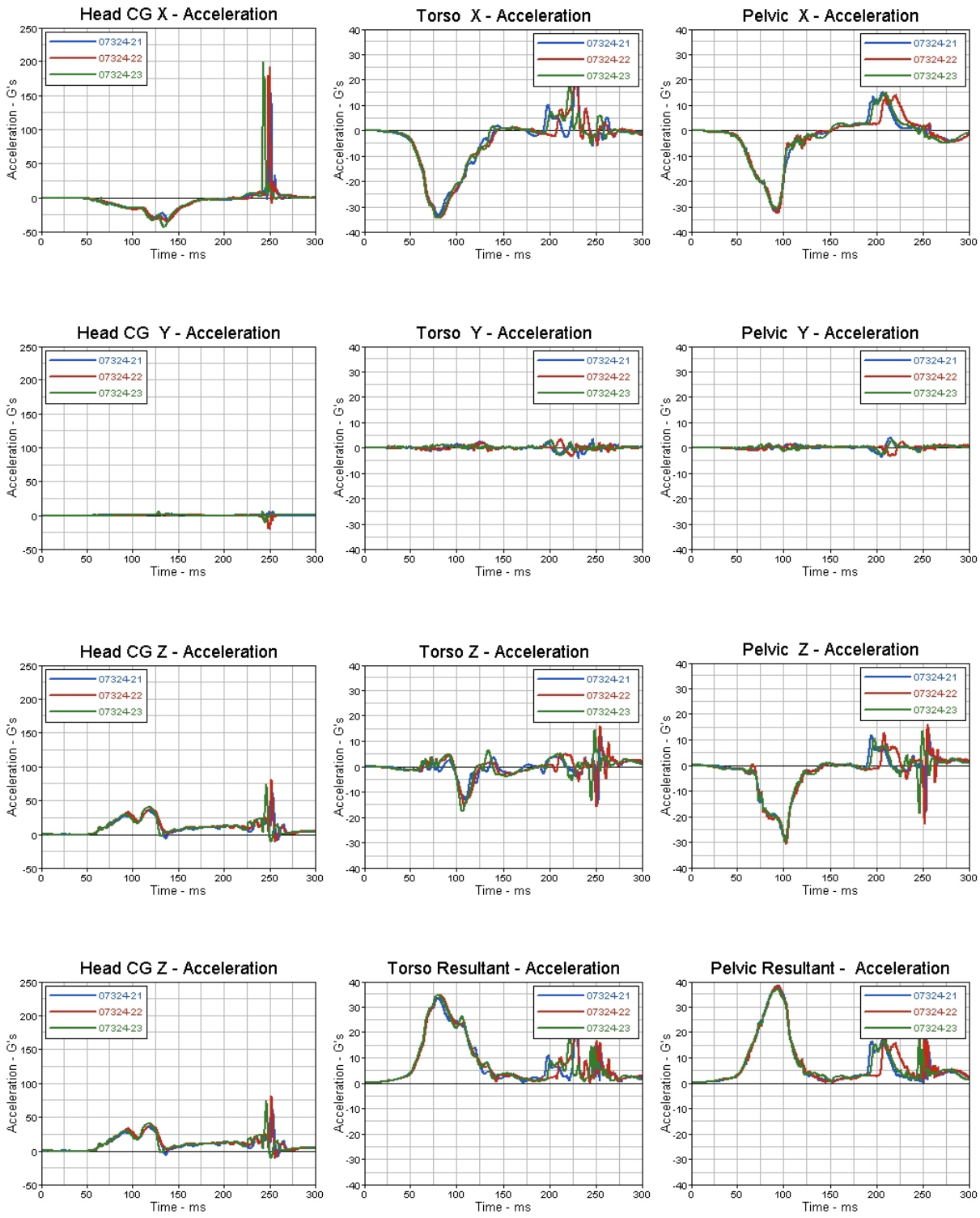


Figure 124. Head, Torso, and Pelvis Accelerations of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

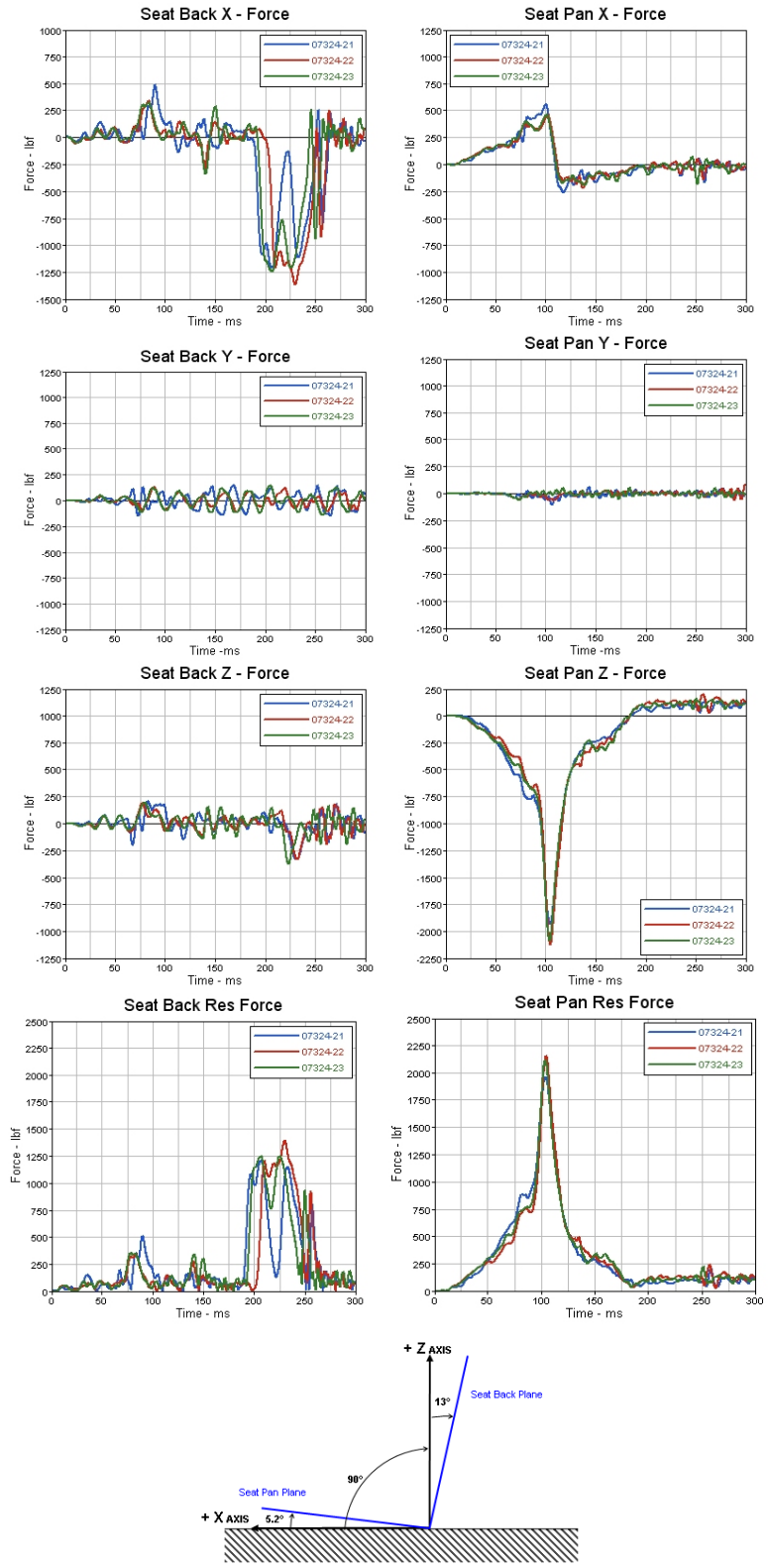


Figure 125. Seat Pan and Back Loads (Tare Compensation and Global Coordinates) of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

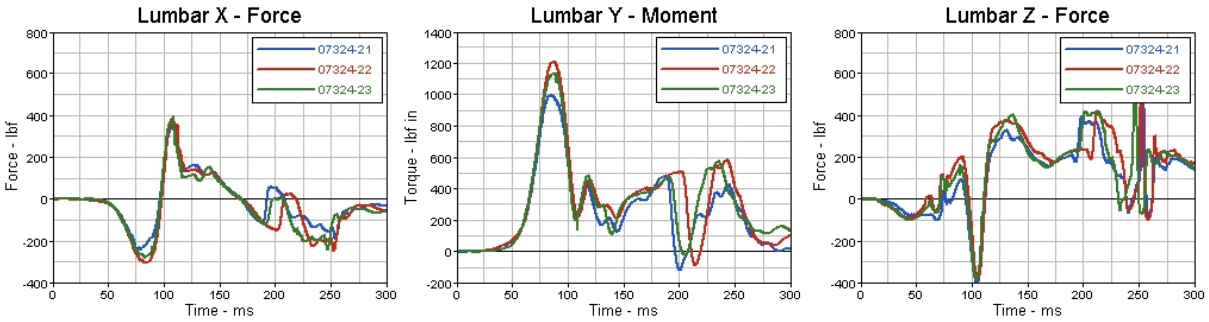


Figure 126. Lumbar Loads and Moments of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

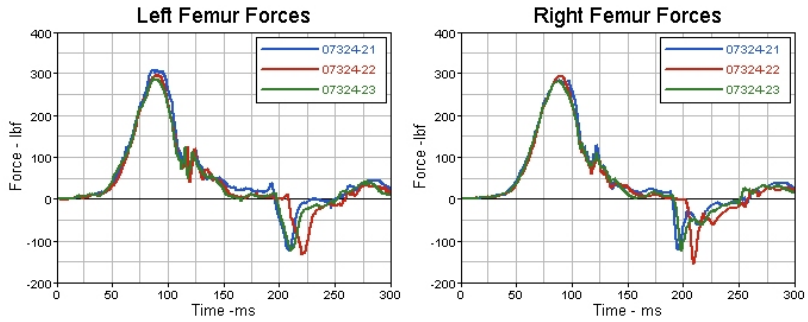


Figure 127. Femur Forces of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

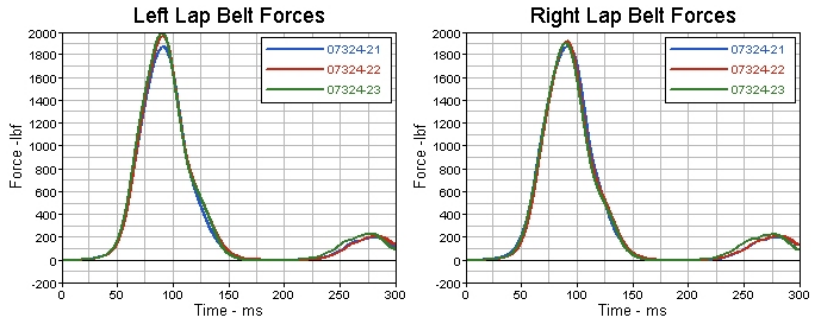


Figure 128. Lap Belt Forces of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

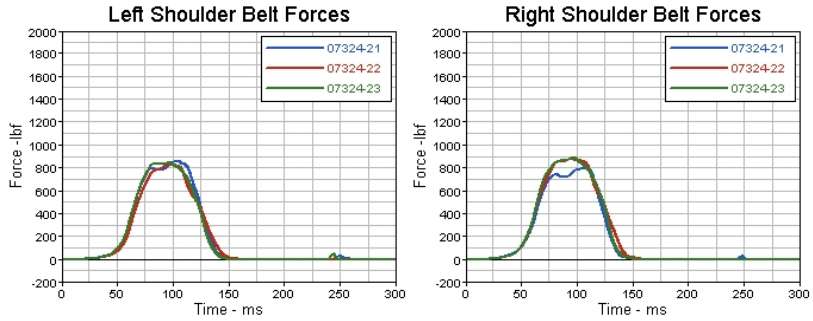


Figure 129. Shoulder Belt Forces of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

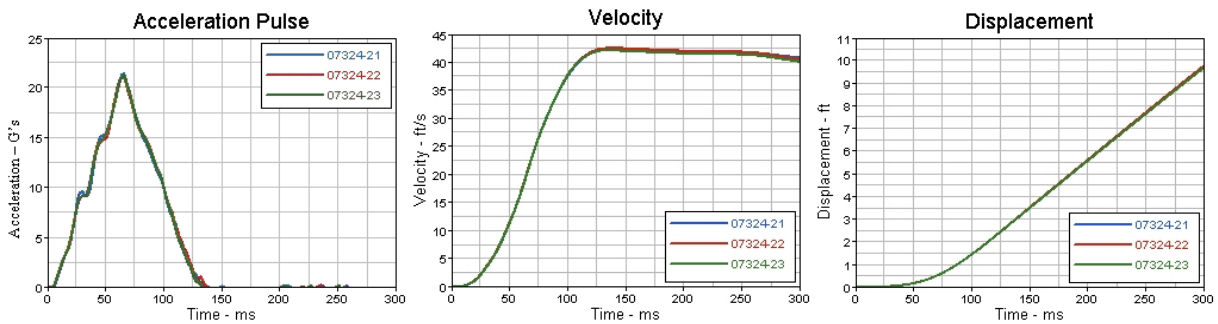


Figure 130. Acceleration Pulses of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

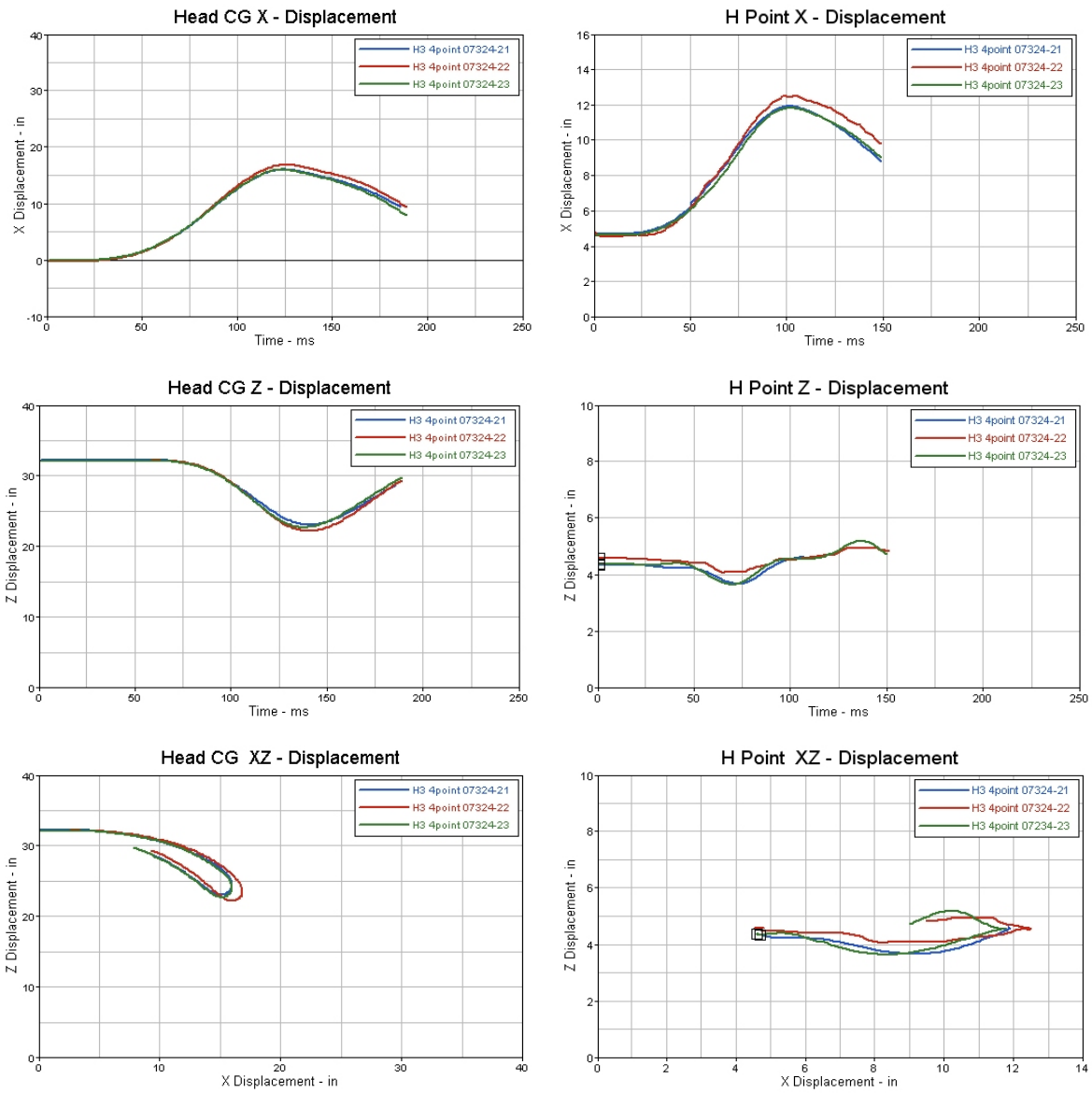


Figure 131. Head and H-Point Displacements of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

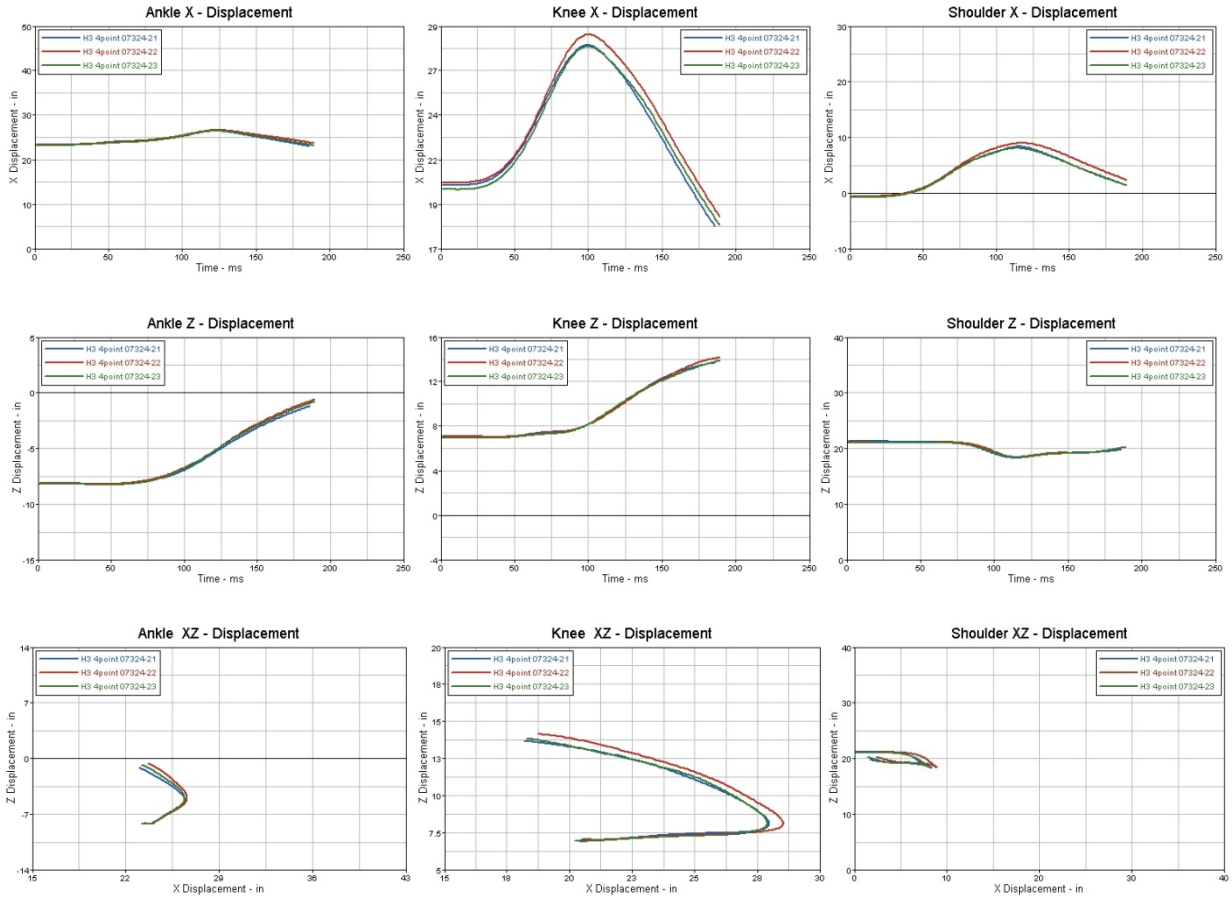


Figure 132. Ankle, Knee, and Shoulder Displacements of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

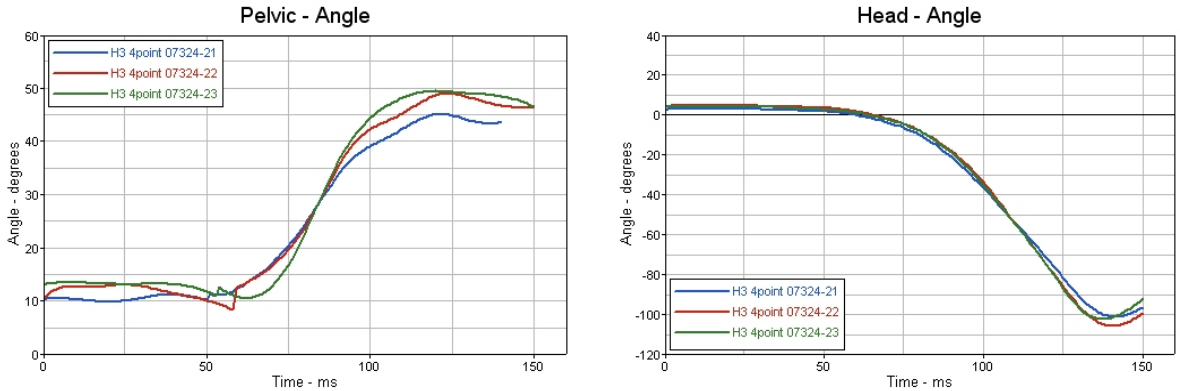


Figure 133. Pelvis and Head Angles of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

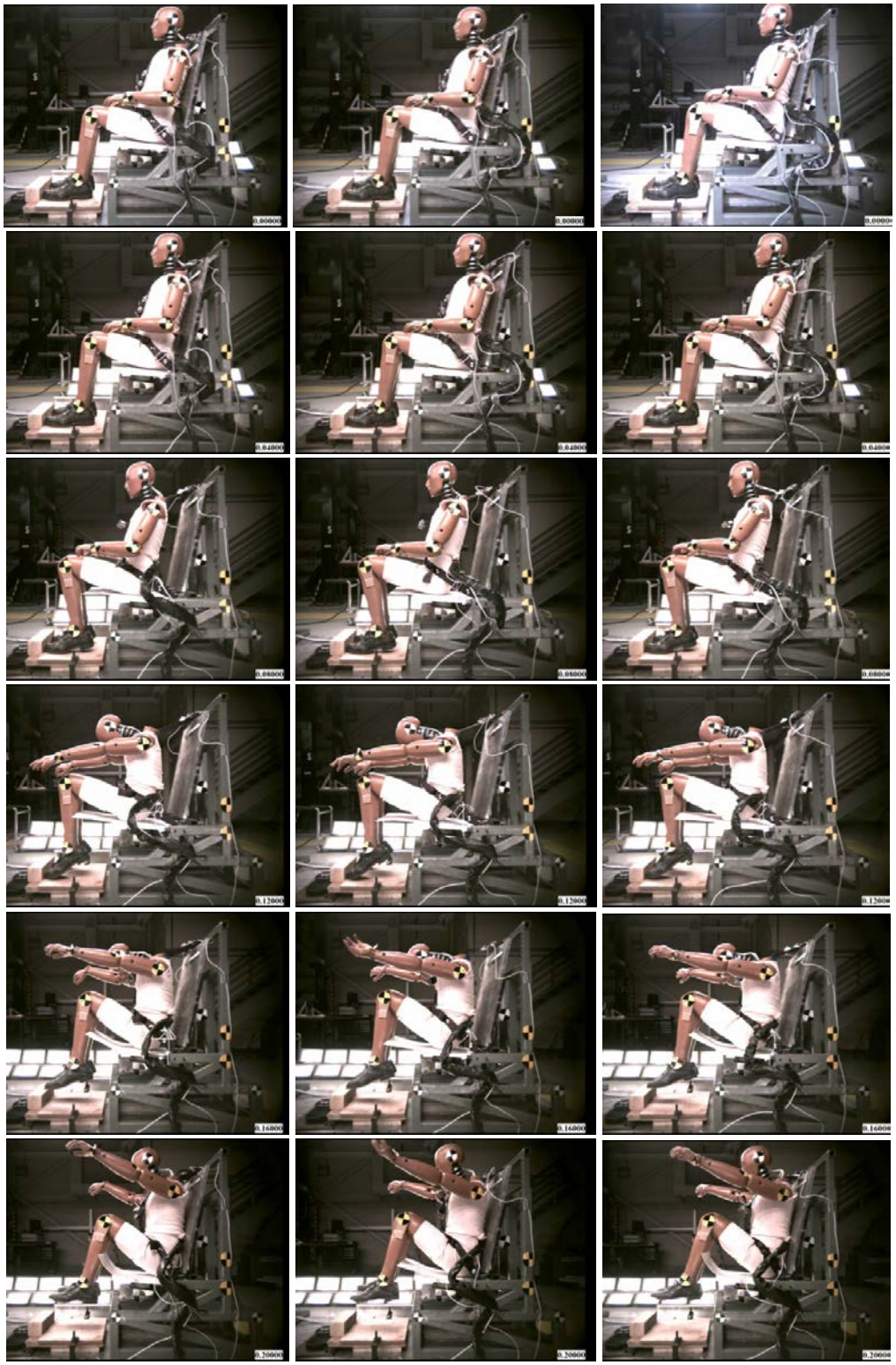


Figure 134. Test Kinematics 07324-21 (left), 07324-22 (middle), and 07324-23 (right) of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

4. VALIDATION METRICS AND CRITERIA.

This section describes the procedure for determining the test-to-test variability.

4.1 VALIDATION AND ERROR METRICS.

To quantitatively measure uncertainty in the experimental data, a number of validation or error metric methods were considered. These methods consist of computable measures that can quantitatively compare experimental results over a series of parameters (figure 135) to objectively assess experimental uncertainty over the traditional qualitative graphical comparison.

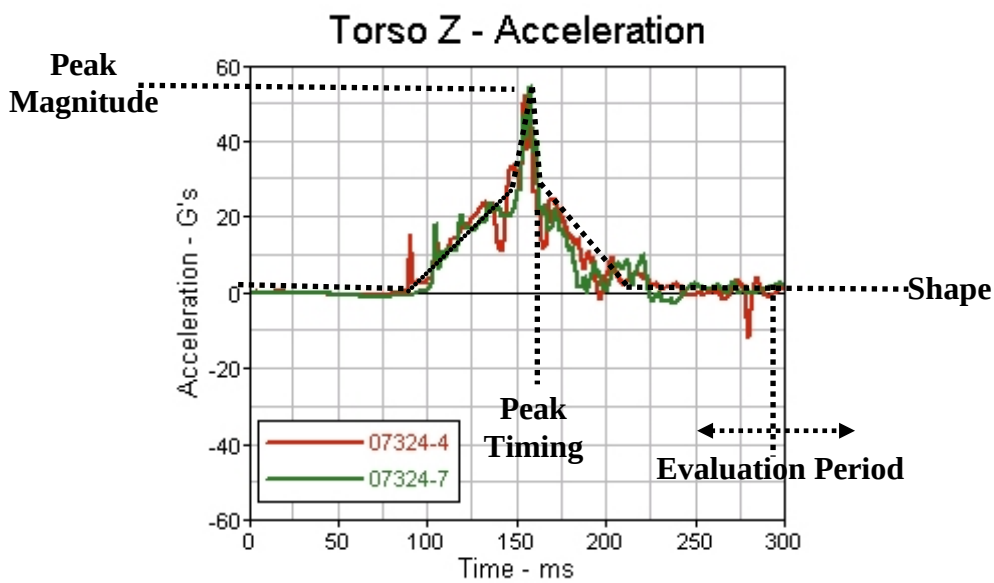


Figure 135. Validation Metric Measured Parameters

4.1.1 The Sprague and Geers Method.

The Sprague and Geers (S&G) method [12] considers a magnitude error factor that is insensitive to phase discrepancies and a phase error factor that is insensitive to magnitude discrepancies (figure 136). The total error factor or score is given by the following expressions.

$$Score = \sqrt{M^2 + P^2} \tag{9}$$

where

M = magnitude error factor
P = phase error factor

$$M = \sqrt{\frac{I_{gg}}{I_{ff}}} - 1 \tag{10}$$

$$P = \frac{1}{\pi} * ar\cos\left(\frac{I_{fg}}{\sqrt{I_{ff} * I_{gg}}}\right) \tag{11}$$

where

$$I_{ff} = \frac{1}{t_2 - t_1} * \int_{t_1}^{t_2} f^2(t)dt \tag{12}$$

$$I_{gg} = \frac{1}{t_2 - t_1} * \int_{t_1}^{t_2} g^2(t)dt \tag{13}$$

$$I_{fg} = \frac{1}{t_2 - t_1} * \int_{t_1}^{t_2} f(t) * g(t)dt \tag{14}$$

where

$t_1 < t < t_2$ = time span or evaluation period
f(t) = benchmark history or reference data
g(t) = candidate solution or data to compare

Note that this method is biased towards the *f*(*t*) data set.

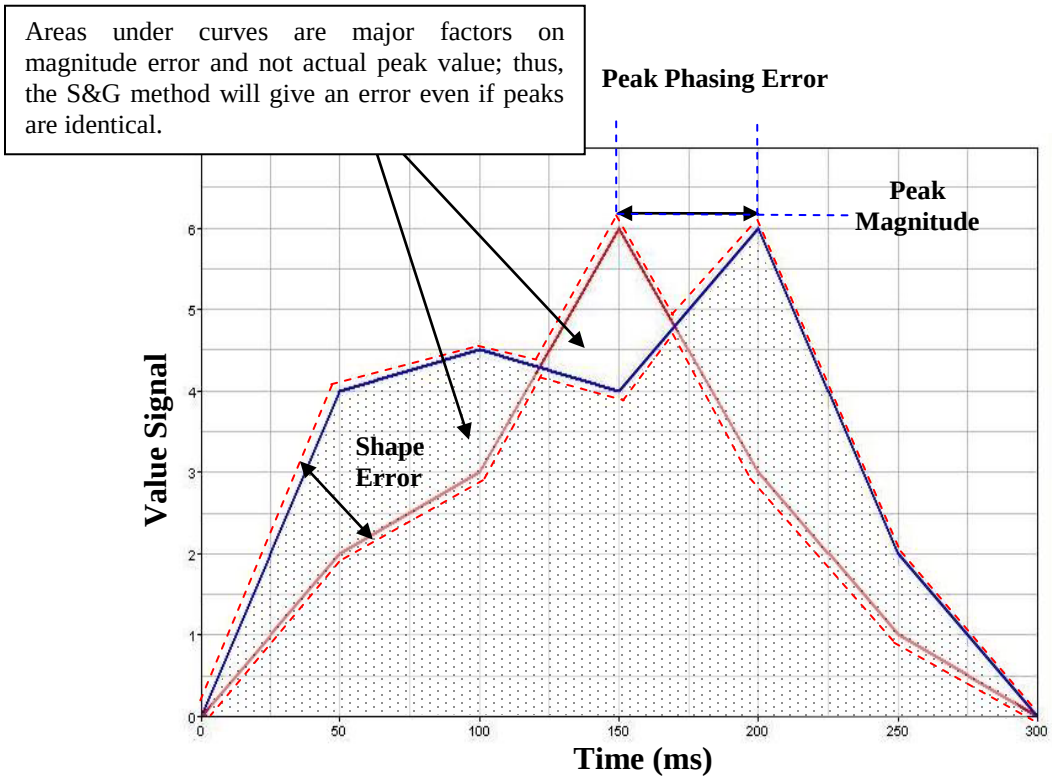


Figure 136. The S&G Metric Measured Parameters

4.1.2 Relative Error Method.

The relative error method is a very common metric used to compare two values quantitatively in the form of a percentage difference. This method does not consider time variations or phasing, so it is only useful to compare the maximum magnitude of a response (figure 137). The relative error is derived as follows:

$$Delta\ Error = Maxg(t) - Maxf(t) \tag{15}$$

$$Relative\ Error = Magnitude\ Error = \frac{Maxg(t) - Maxf(t)}{Maxf(t)} \tag{16}$$

where

Maxf(t) = Peak or maximum magnitude value (positive or negative) in reference data

Maxg(t) = Peak or maximum magnitude value (positive or negative) in candidate solution or data to compare

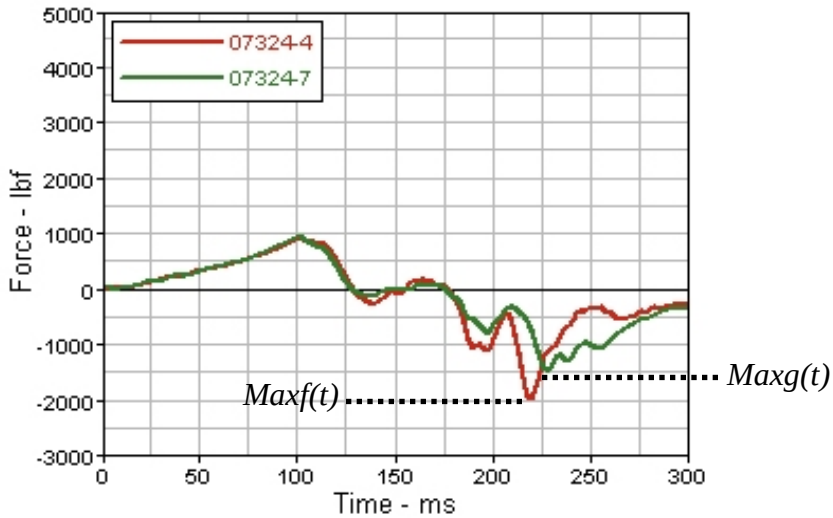


Figure 137. Relative Error Measured Parameters

Note that this method is biased towards the *f(t)* data set.

4.2 TEST SERIES II VARIABILITY.

The following sections present a summary of the test-to-test variability for the 07324 test series. All test variability data are located in appendix E.

4.2.1 Hybrid II ATD Test Variability.

This section presents the test data variability of the Hybrid II ATD for every test configuration. The variability is measured as an error between the ATD responses during two tests with identical configurations. Since there were three identical tests to compare and error metrics compare only two conditions at a time, all tests were compared among themselves, i.e., test 1 verus 2, test 1 versus 3, and test 2 versus 3. The largest error between these comparisons was used. It should be noted that changing the order of the comparison (1 versus 2 or 2 versus 1) did not give a significant difference in error values when the signals were similar to begin with; it was only a factor when differences were large. The error, or variability, between the two tests was divided into three types: delta, magnitude, and shape. This methodology was selected in cooperation with the SAE aircraft seat committee ARP 5765 working group. The magnitude error is the relative error (in percent), as explained in section 4.1.2; the delta error is the difference between the largest signal peaks of the two tests in question, also explained in section 4.1.2. The shape error is also known as the total error associated with the S&G technique, and is explained in section 4.1.1. The delta error is only used for expressing the error in ATD target trajectories, i.e., head excursions, knee and shoulder displacements, etc. The figures in this section show these errors in the form of bar charts, where the bar's height corresponds to the average error value obtained from the tests compared. The brackets shown on each bar extend from the minimum to the maximum error value for that signal. The data evaluation periods are listed in table 34.

Table 34. Evaluation Periods for Hybrid II ATD

Configuration	Accelerometer Signals (ms)	Load Cell Signals (ms)	Position (ms)
Hybrid II ATD with two-point restraint at 0° pitch	175	200	175
Hybrid II ATD with three-point restraint at 0° pitch	180	180	180
Hybrid II ATD with four-point restraint at 0° pitch	150	150	150
Hybrid II ATD with two-point restraint at 60° pitch	125	125	125

4.2.1.1 Test-to-Test Variability for Hybrid II ATD.

The test-to-test variability (error) for each channel of the Hybrid II ATD are shown in figures 138 through 149. Because of the variability in the data below, a special study of the Hybrid II ATD with two-point belt at 60° pitch comparing only tests 07324-11 and -12 was also completed, and the results are shown in appendix G.

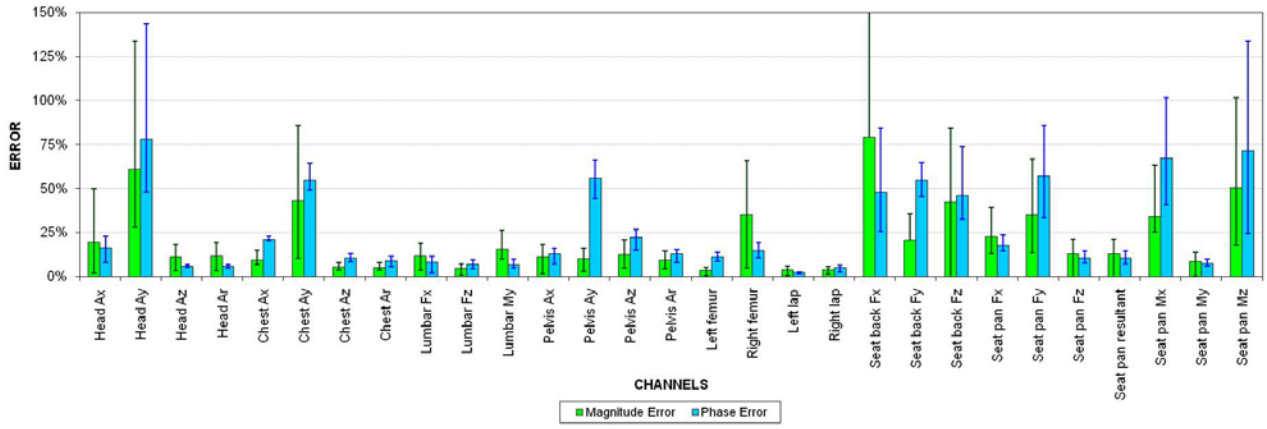


Figure 138. Averaged Responses of Hybrid II ATD With Two-Point Belt at 0° Pitch

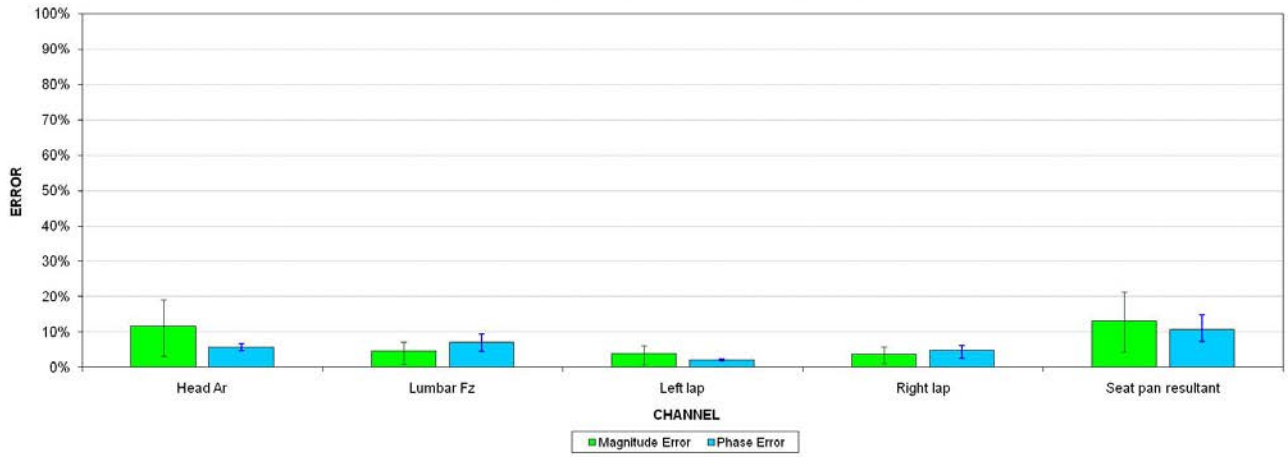


Figure 139. Averaged Compliance Responses of Hybrid II ATD With Two-Point Belt at 0° Pitch

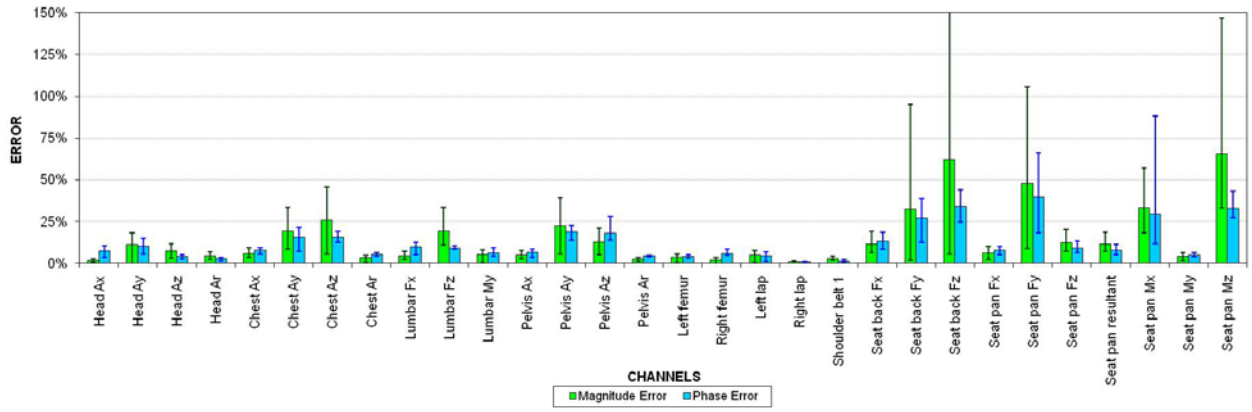


Figure 140. Averaged Responses of Hybrid II ATD With Three-Point Belt at 0° Pitch

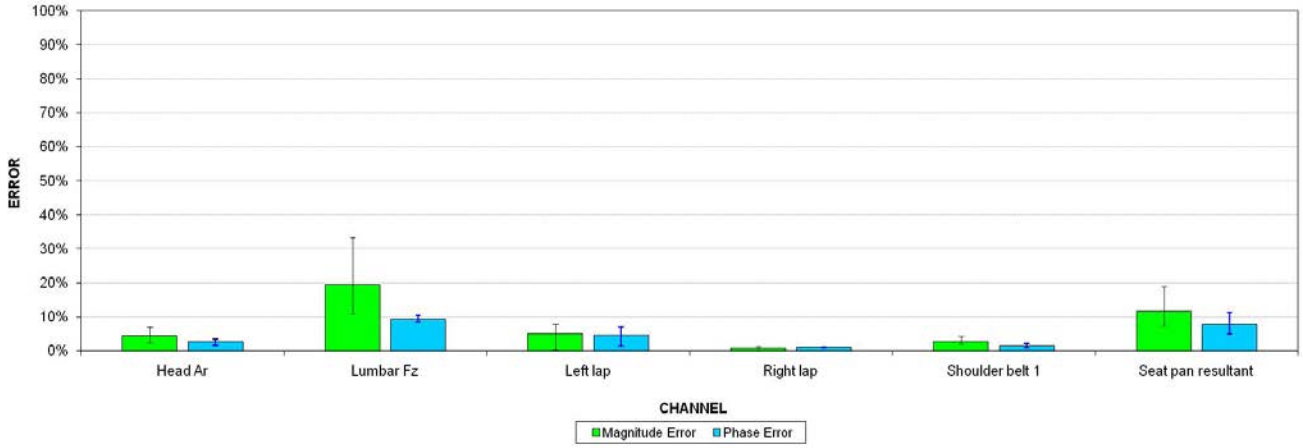


Figure 141. Averaged Compliance Responses of Hybrid II ATD With Three-Point Belt at 0° Pitch

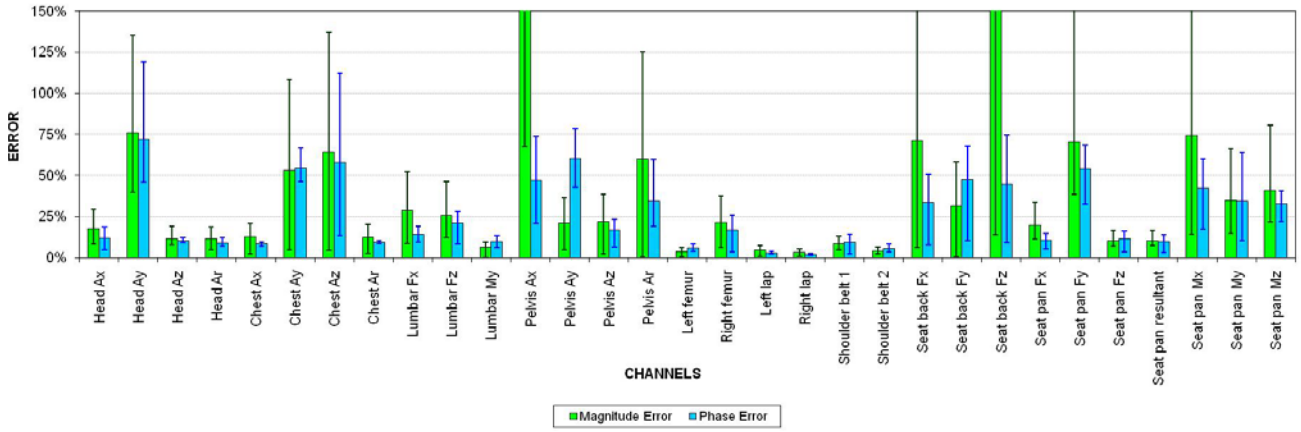


Figure 142. Averaged Responses of Hybrid II ATD With Four-Point Belt at 0° Pitch

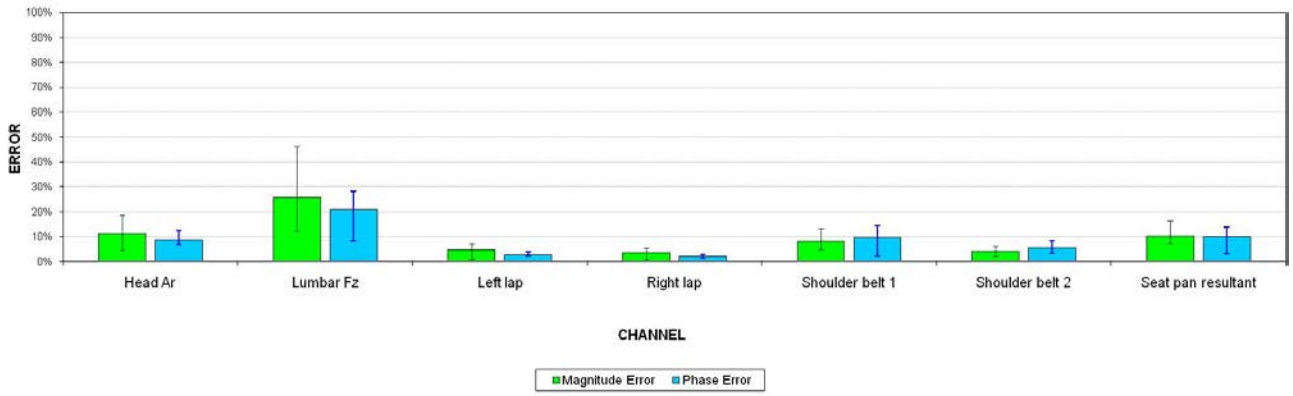


Figure 143. Averaged Compliance Responses of Hybrid II ATD With Four-Point Belt at 0° Pitch

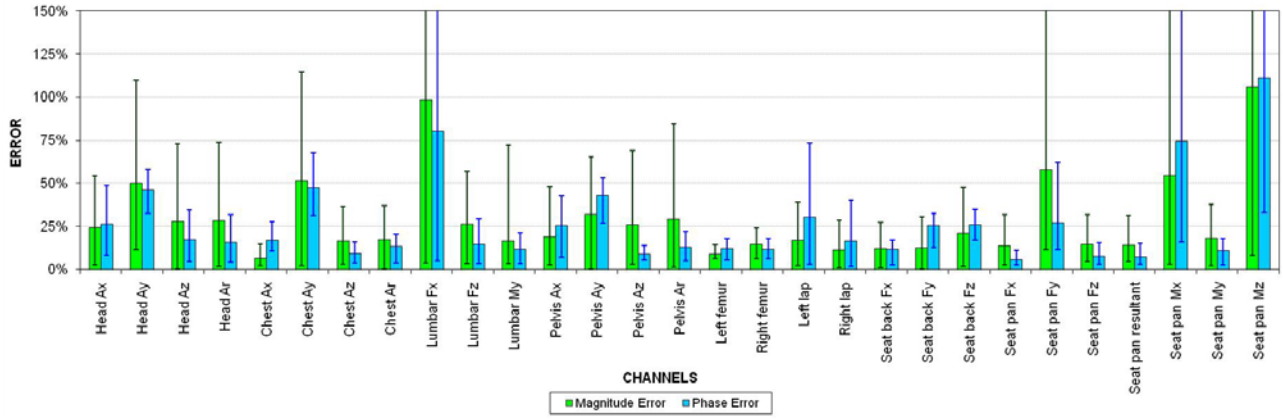


Figure 144. Averaged Responses of Hybrid II ATD With Two-Point Belt at 60° Pitch

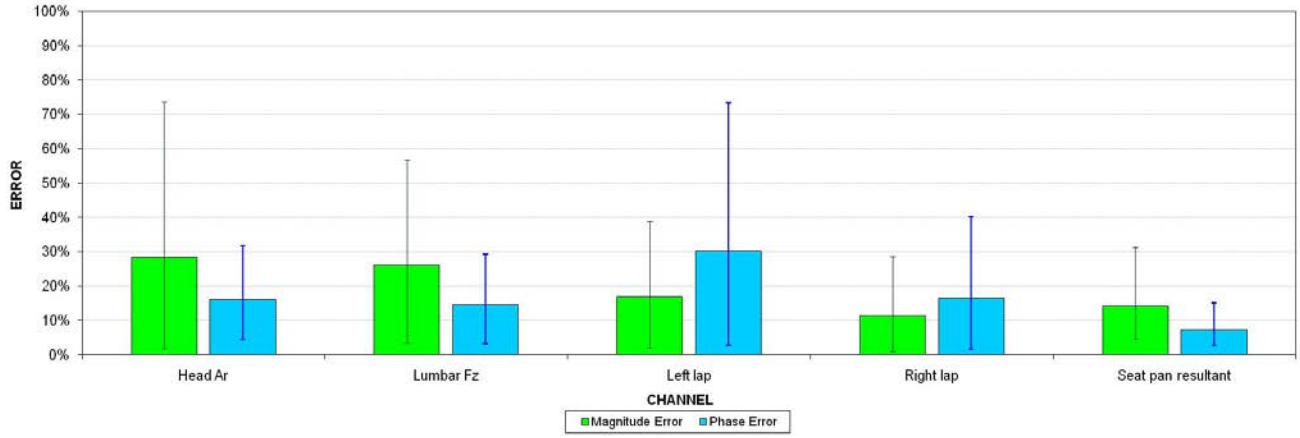


Figure 145. Averaged Compliance Responses of Hybrid II ATD With Two-Point Belt at 60° Pitch

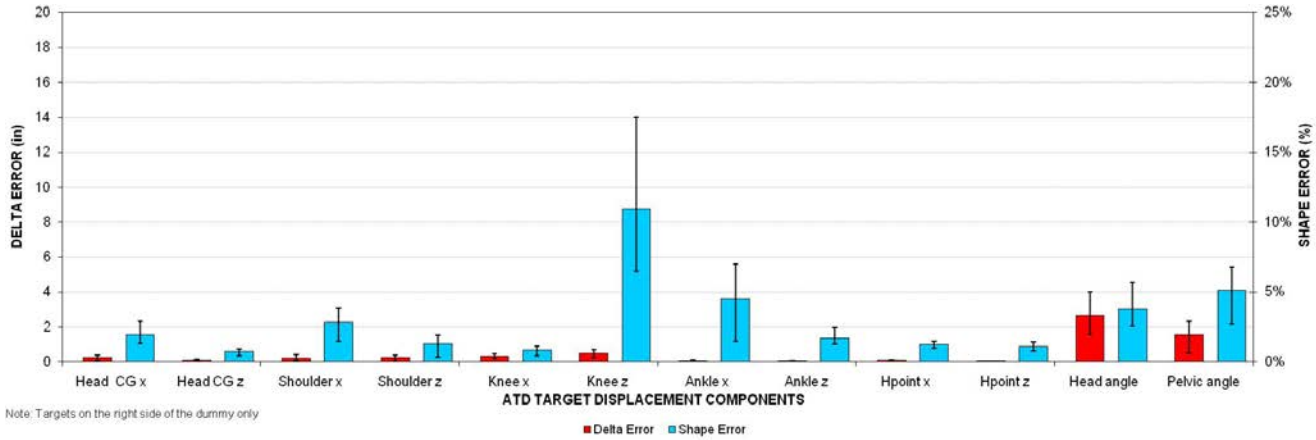


Figure 146. Averaged Displacement Responses of Hybrid II ATD With Two-Point Belt at 0° Pitch

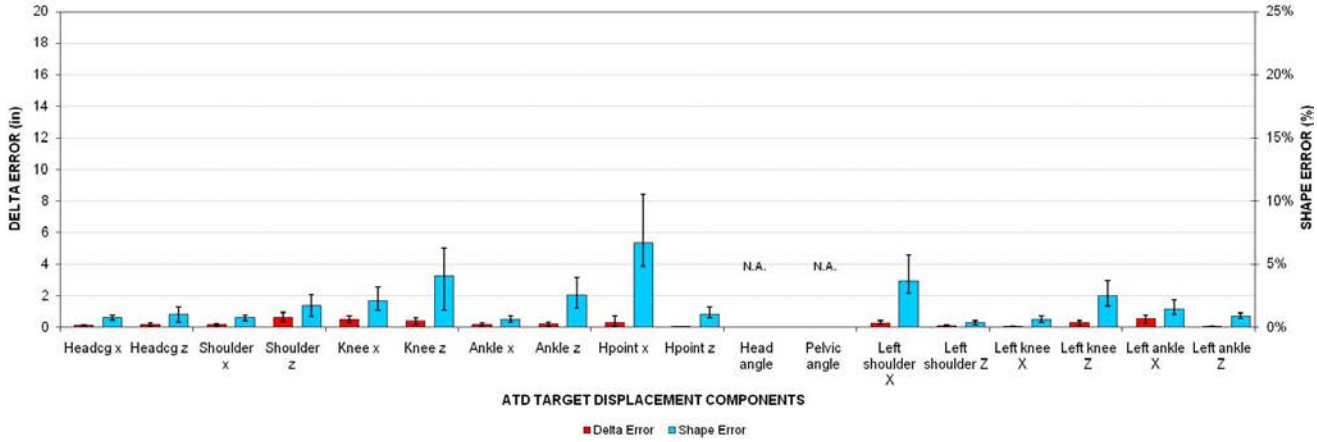


Figure 147. Averaged Displacement Responses of Hybrid II ATD With Three-Point Belt at 0° Pitch

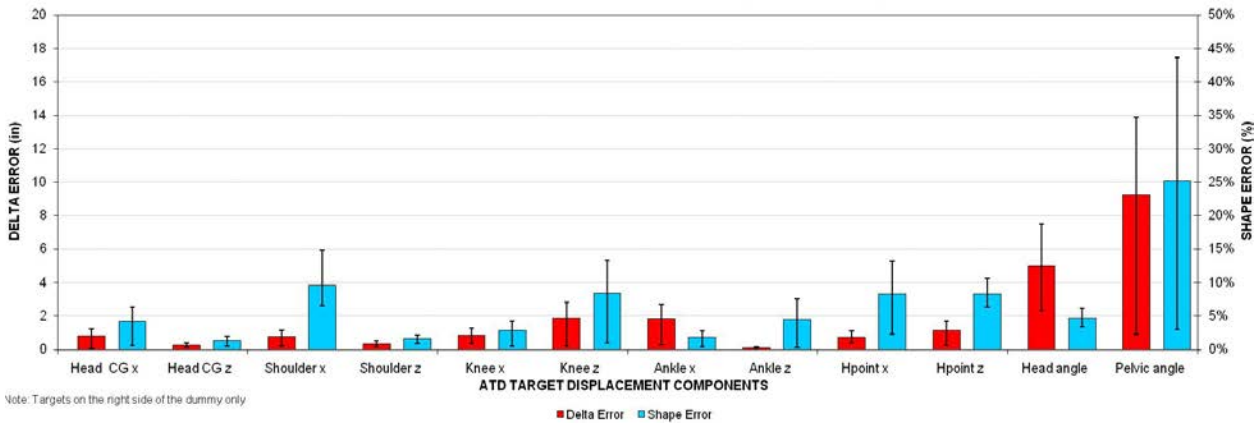


Figure 148. Averaged Displacement Responses of Hybrid II ATD With Four-Point Belt at 0° Pitch

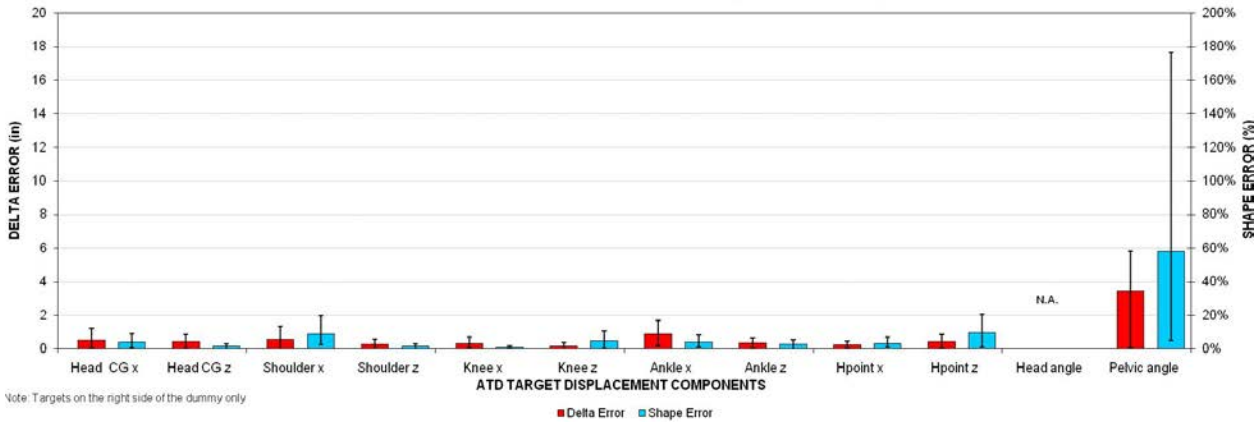


Figure 149. Averaged Displacement Responses of Hybrid II ATD With Two-Point Belt at 60° Pitch

4.2.1.2 Hybrid II Variability per Channel and Configuration.

The figures in this section show, in greater detail, the ATD responses and kinematic variability for each individual channel. The errors are presented in figures 150 to 166.

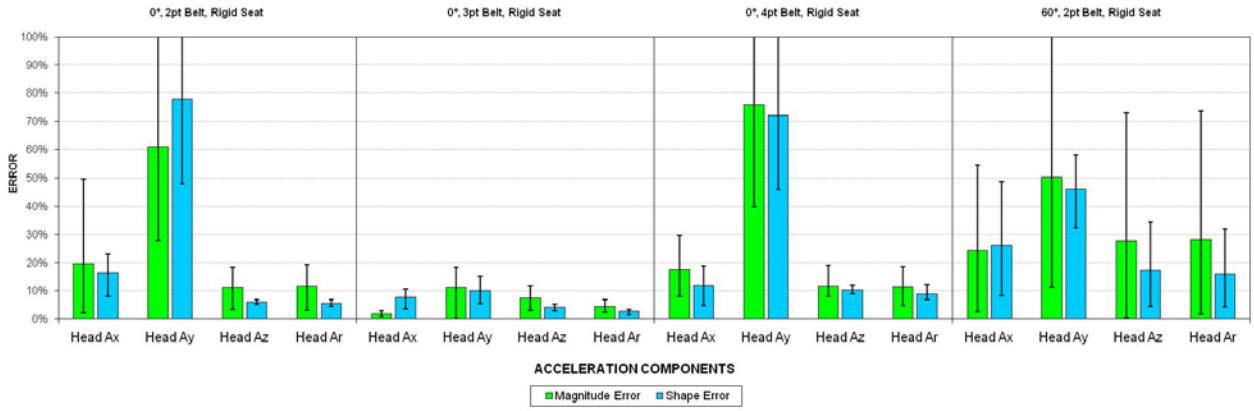


Figure 150. Averaged Head Accelerations of Hybrid II ATD for Each Configuration

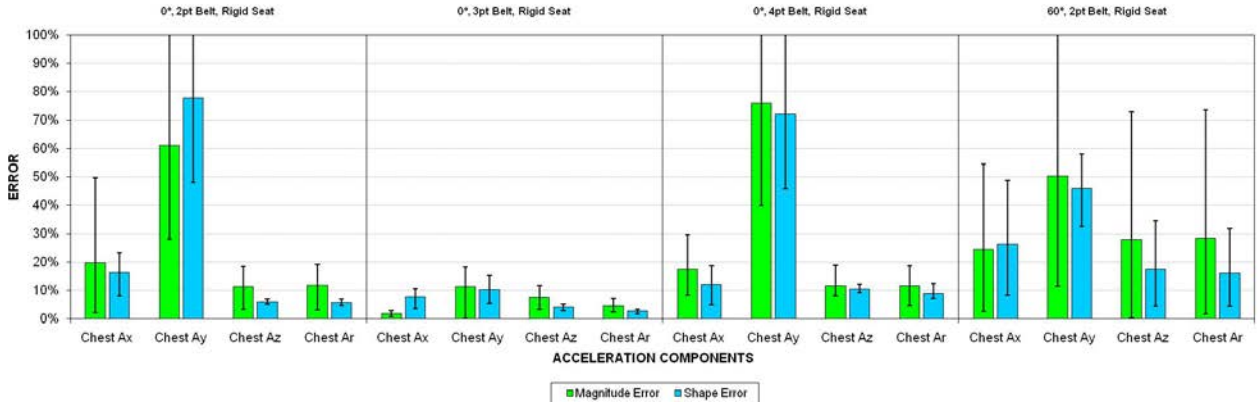


Figure 151. Averaged Torso Accelerations of Hybrid II ATD for Each Configuration

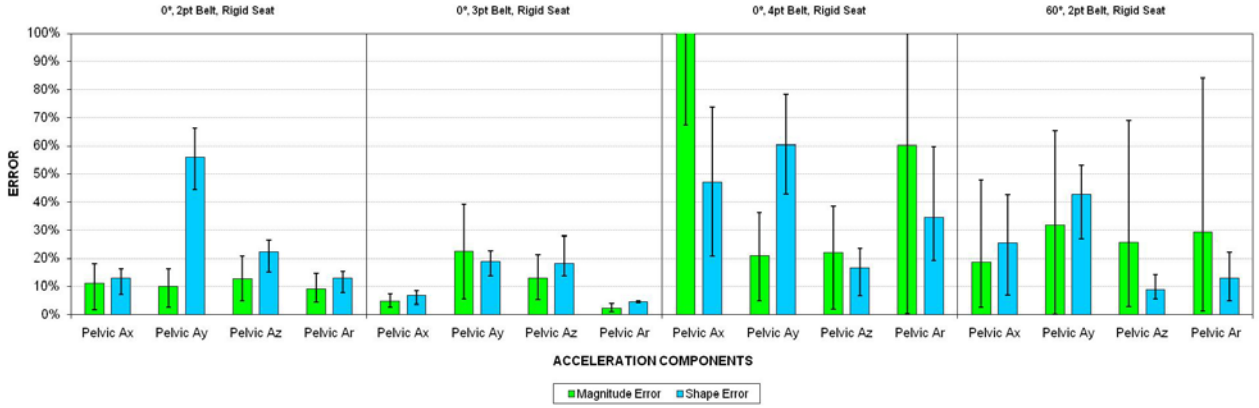


Figure 152. Averaged Pelvis Accelerations of Hybrid II ATD for Each Configuration

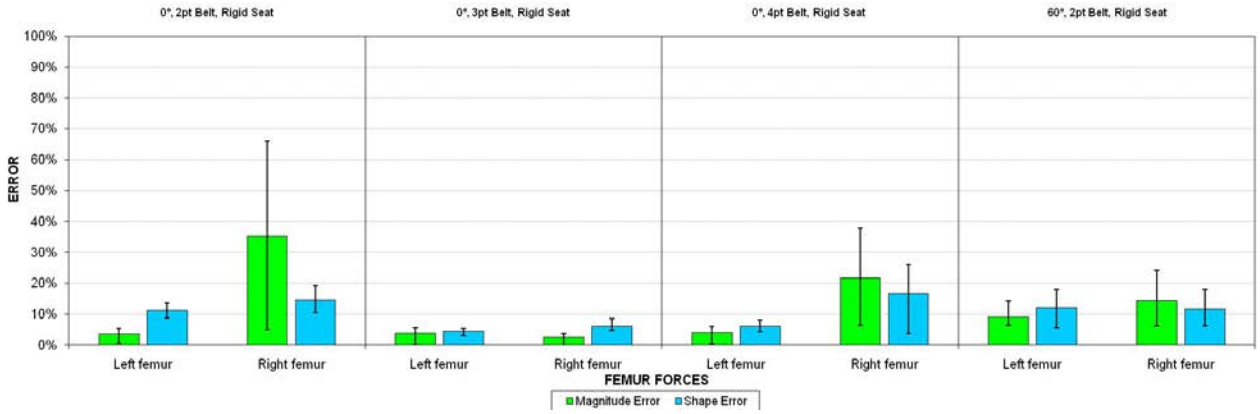


Figure 153. Averaged Femur Forces of Hybrid II ATD for Each Configuration

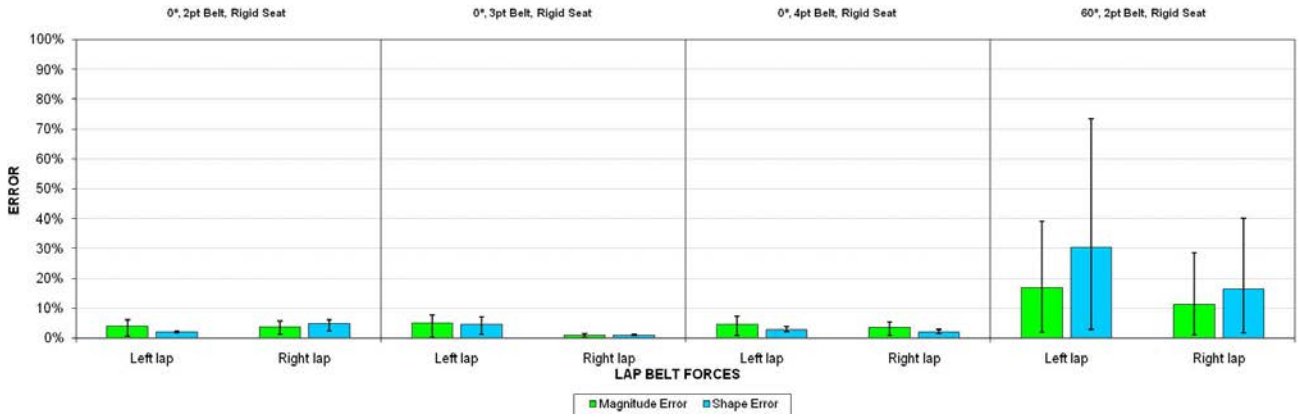


Figure 154. Averaged Lap Belt Forces of Hybrid II ATD for Each Configuration

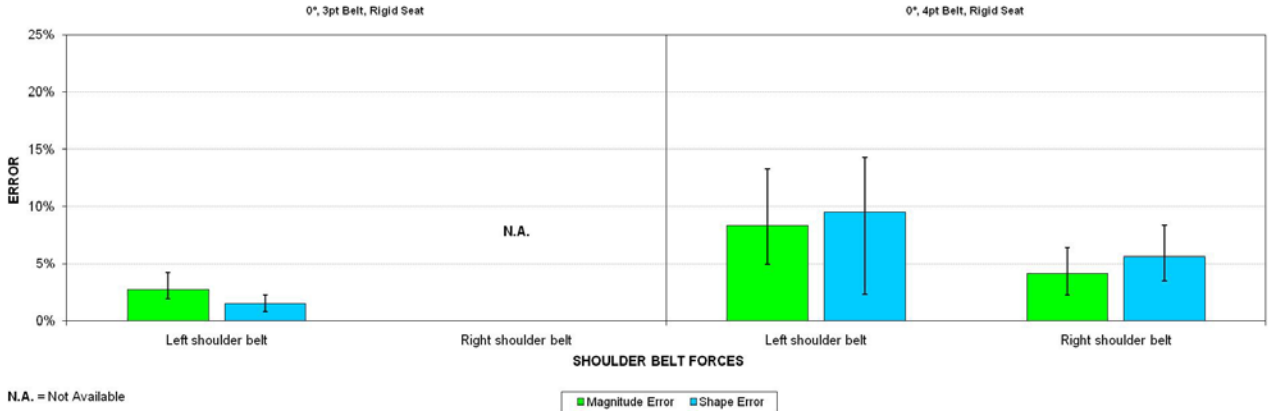


Figure 155. Averaged Shoulder Belt Forces of Hybrid II ATD for Each Configuration

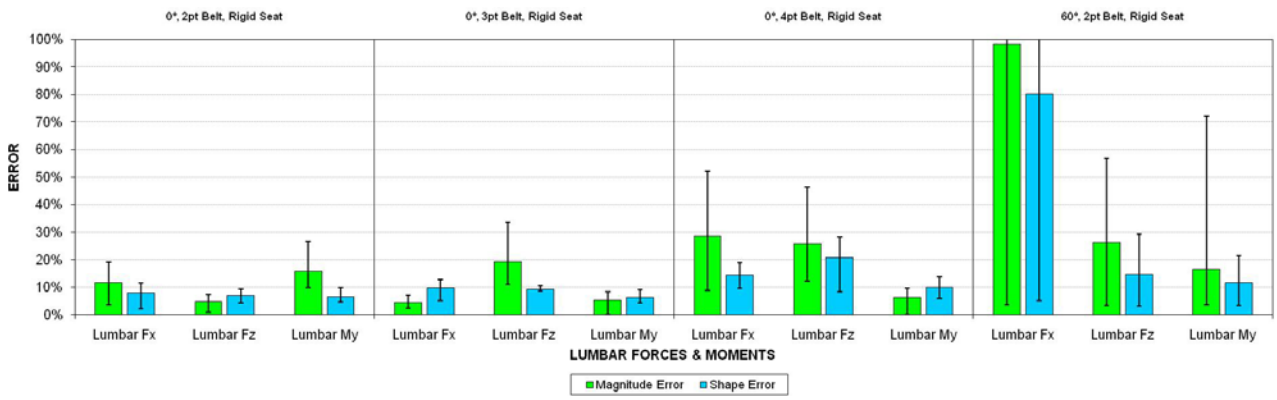


Figure 156. Averaged Lumbar Forces of Hybrid II ATD for Each Configuration

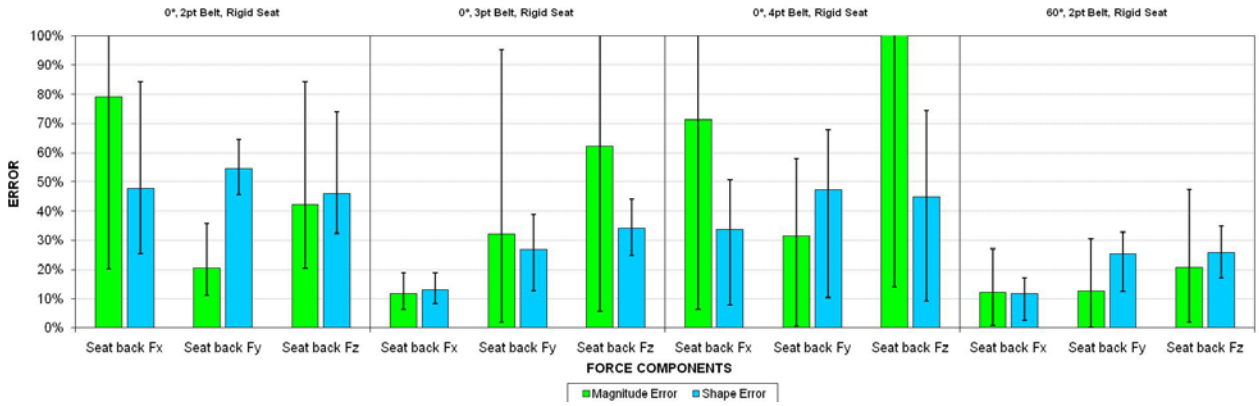


Figure 157. Averaged Seat Back Forces of Hybrid II ATD for Each Configuration

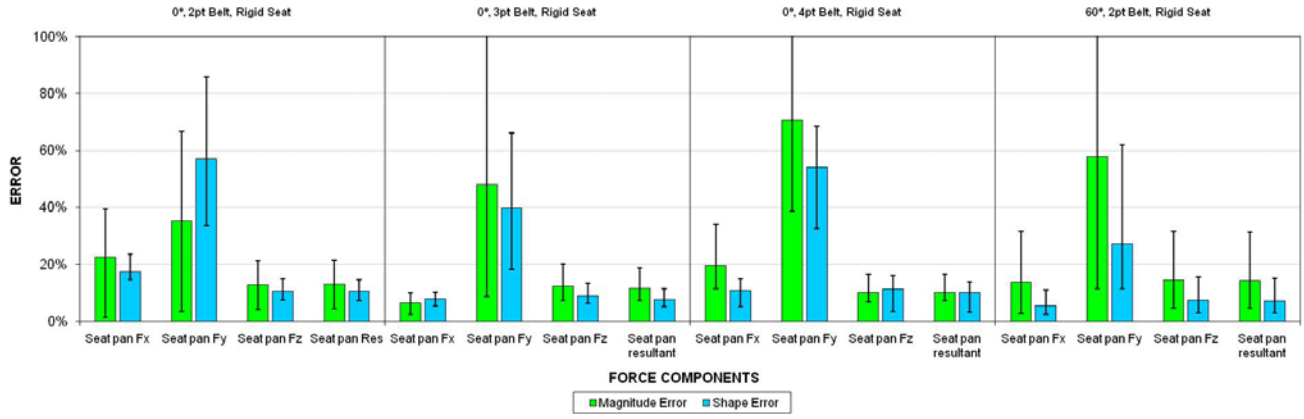


Figure 158. Averaged Seat Pan Forces of Hybrid II ATD for Each Configuration

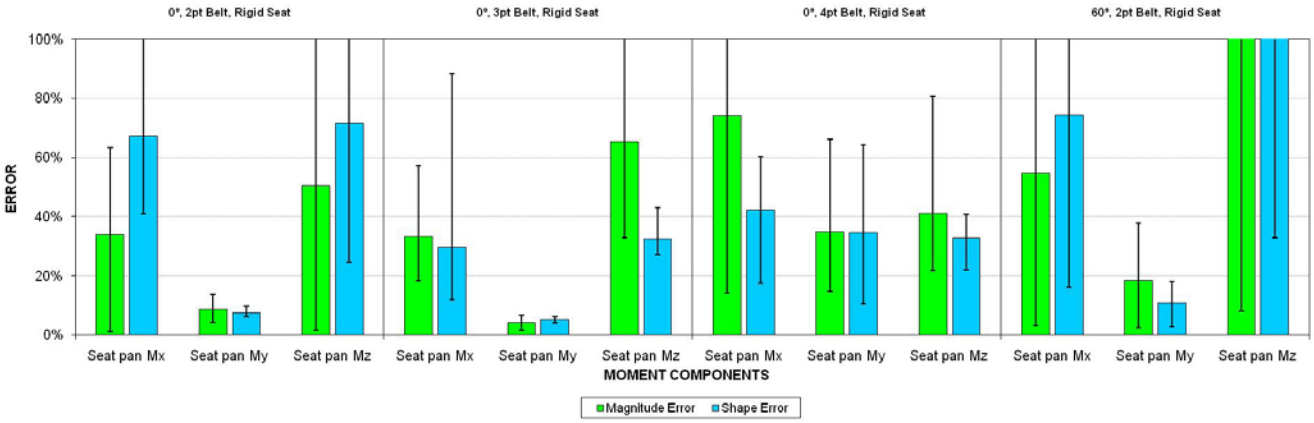


Figure 159. Averaged Seat Pan Moments of Hybrid II ATD for Each Configuration

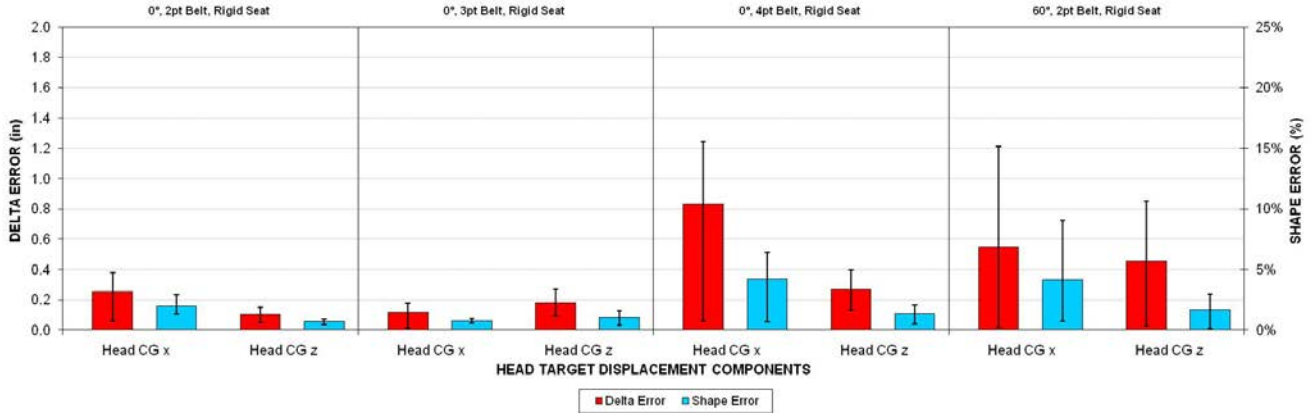


Figure 160. Averaged Head Excursions of Hybrid II ATD for Each Configuration

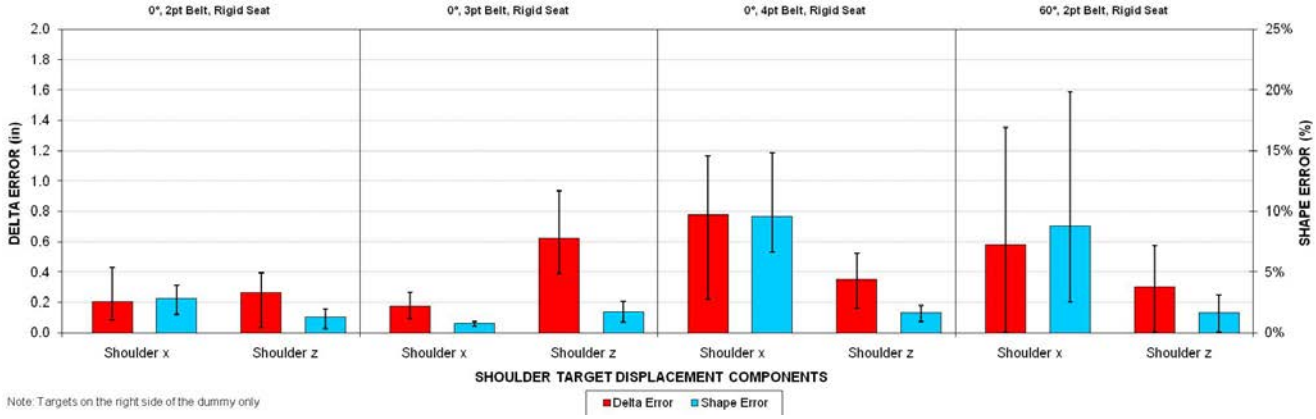


Figure 161. Averaged Shoulder Excursions of Hybrid II ATD for Each Configuration

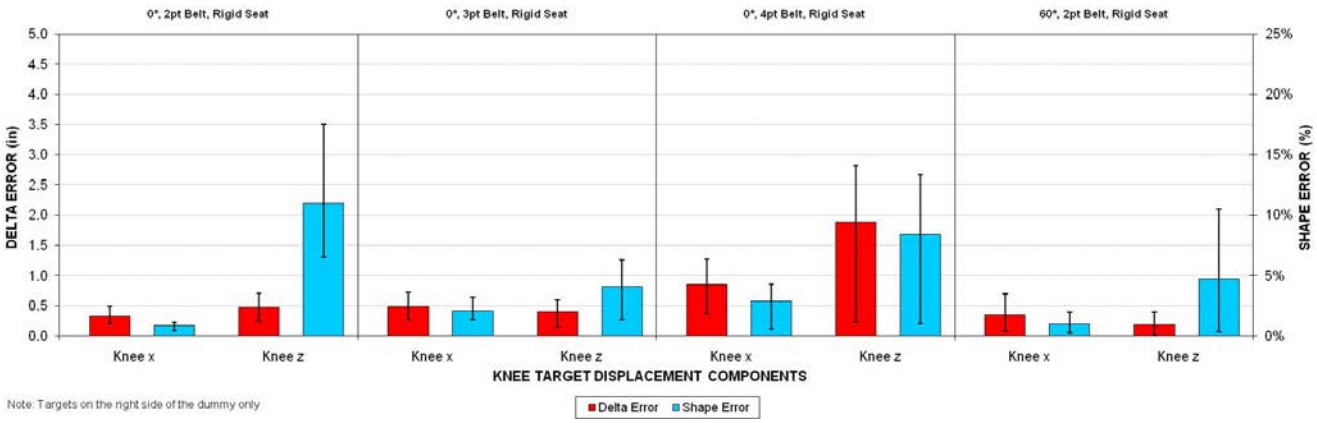


Figure 162. Averaged Knee Excursions of Hybrid II ATD for Each Configuration

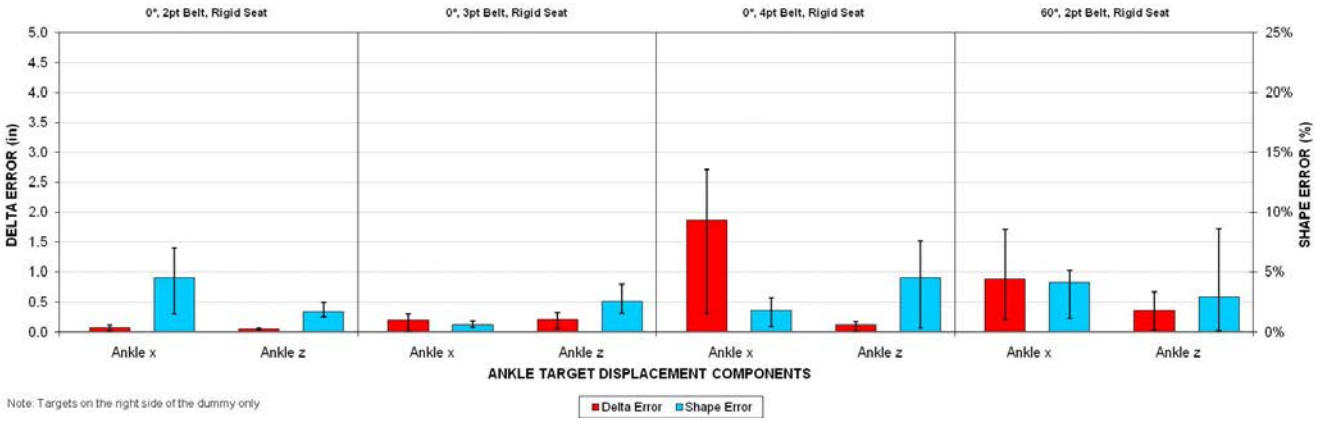


Figure 163. Averaged Ankle Excursions of Hybrid II ATD for Each Configuration

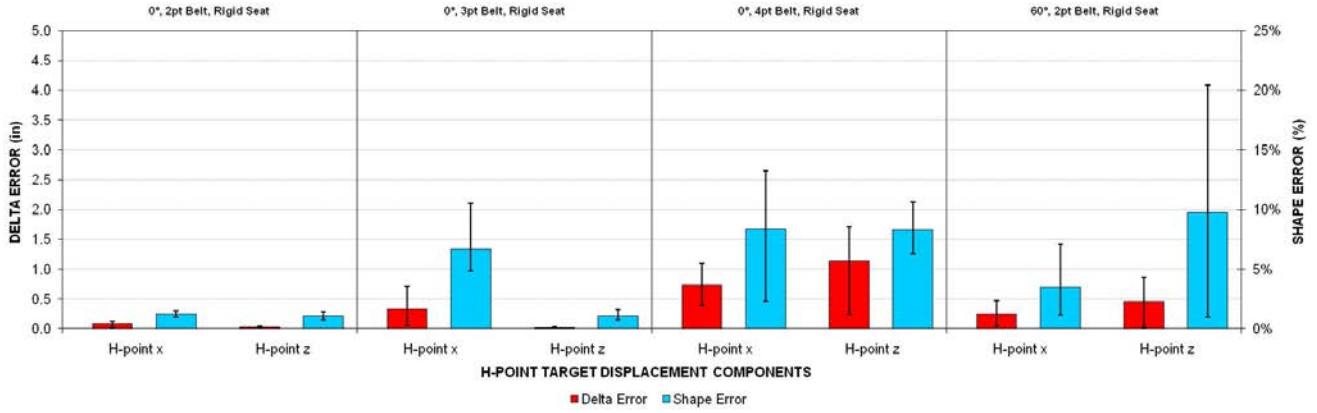


Figure 164. Averaged H-Point Excursions of Hybrid II ATD for Each Configuration

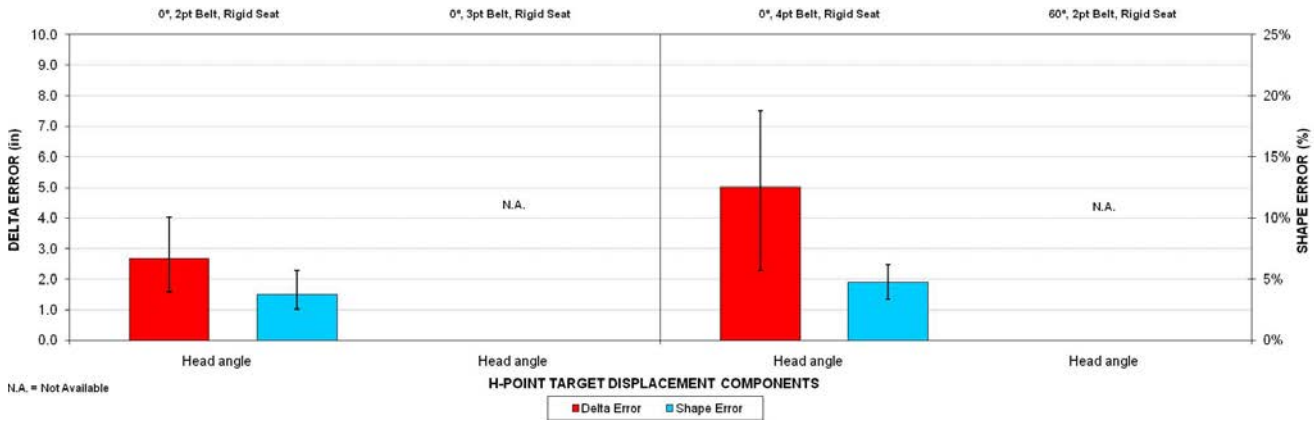


Figure 165. Averaged Head Angles of Hybrid II ATD for Each Configuration

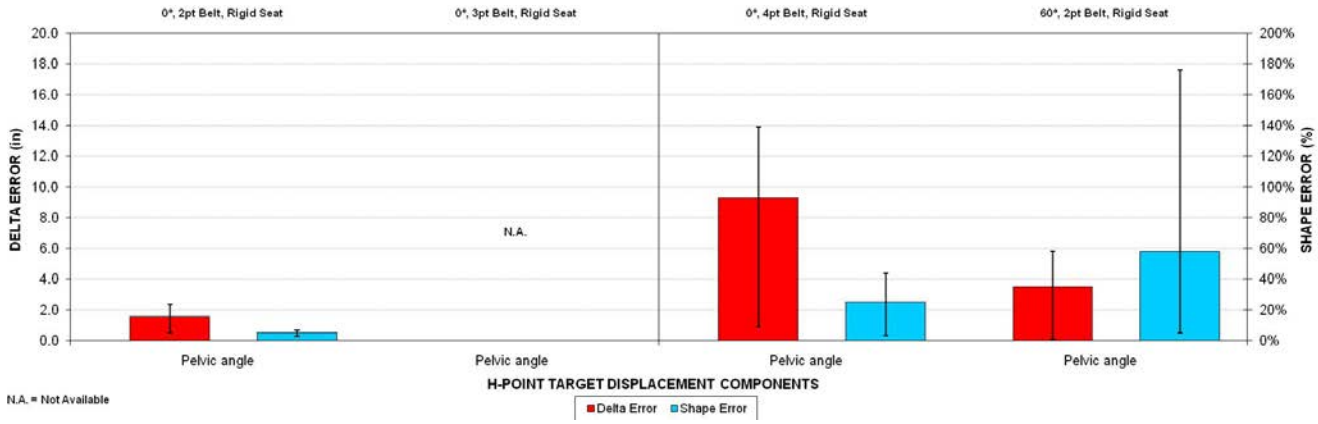


Figure 166. Averaged Pelvis Angles of Hybrid II ATD for Each Configuration

4.2.1.3 Hybrid II ATD—Upper End Limits Test Variability of Selected Channels.

This section contains the following information:

- Summary and relevant responses of the Hybrid II ATD maximum variability, which is calculated by using the maximum variability per channel among two-, three-, and four-point belts at 0° test configurations and the two-point belt at 60° test configuration. Therefore, what is shown is the worst variability recorded by Hybrid II ATD output channels for Test Series 07324. The maximum errors are presented in figures 167 to 190 in the form of bar charts, where the bar's height corresponds to the largest average error value obtained among all configurations per channel. The brackets shown on each bar extend from the minimum to the maximum error value among all configurations per channel.

- Relevant maximum variability responses for horizontal and horizontal-vertical configurations.

- Hybrid II ATD kinematics maximum variability using the aforementioned criteria.

- Maximum variability recorded per channel, responses, and kinematics for each configuration, which is also shown in the bar charts and summary tables.

- Maximum force, acceleration, and displacement errors are listed for all configurations in summary tables 35 to 42.

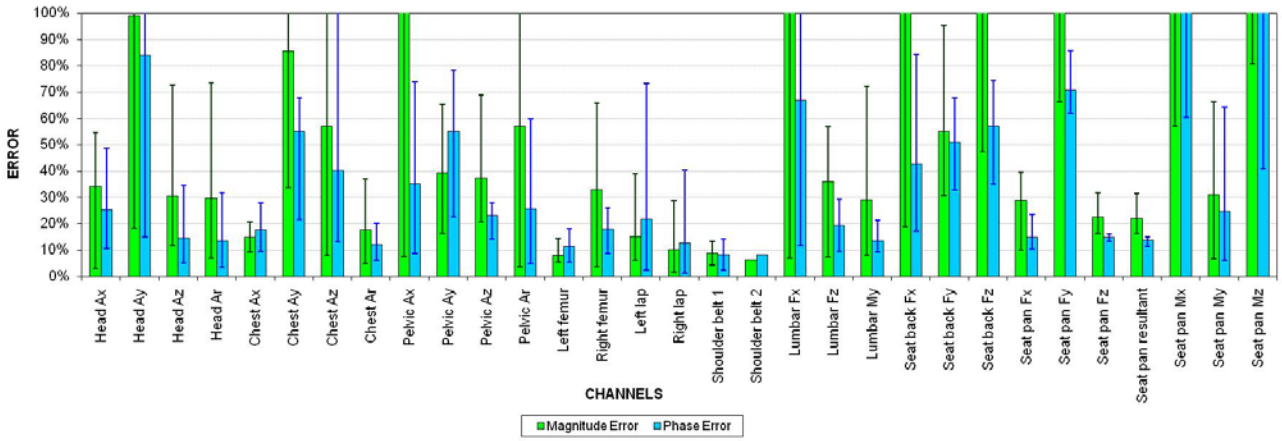


Figure 167. Averaged Responses of Hybrid II ATD From All Test Conditions (Worst Scenario)

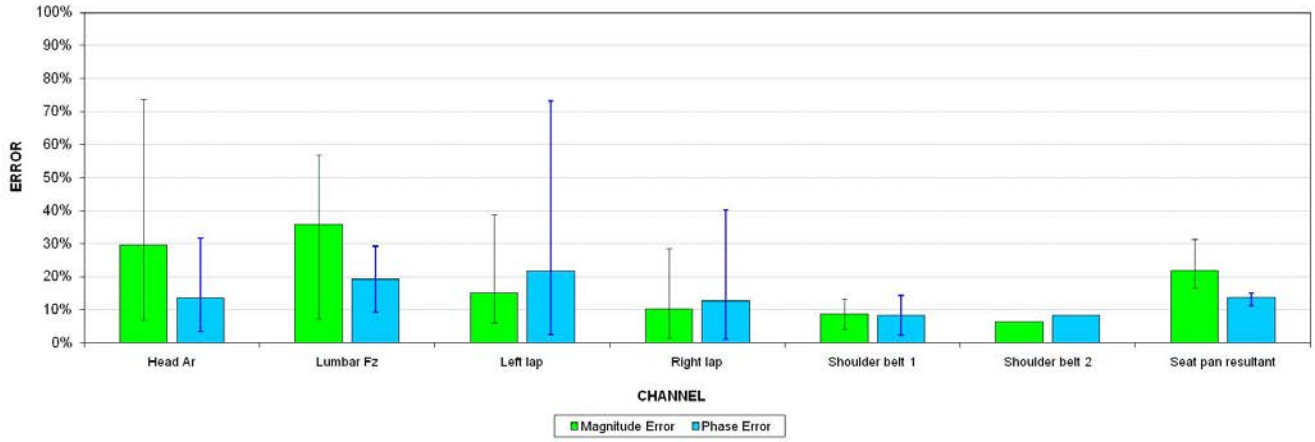


Figure 168. Compliance Response Variation of Hybrid II ATD on All Tests (Worst Scenario)

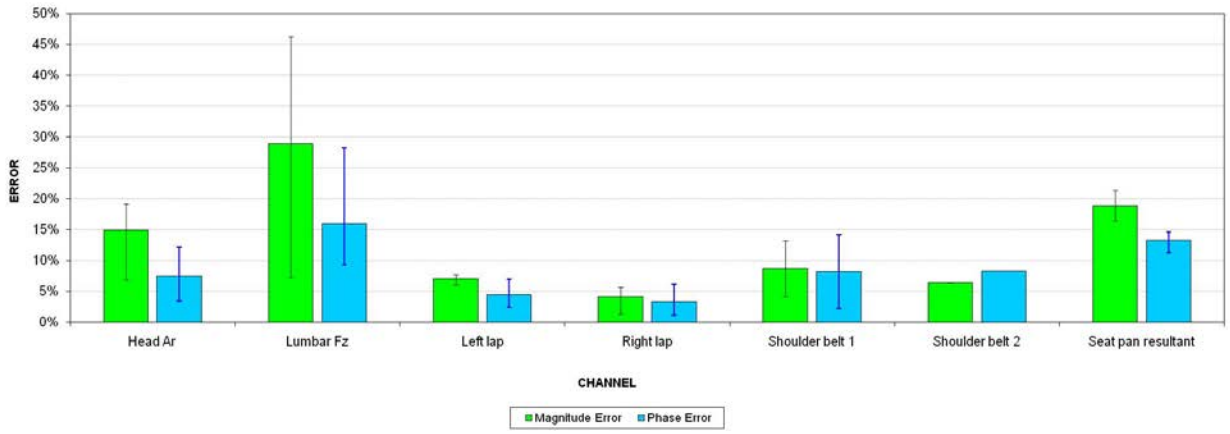


Figure 169. Compliance Response Variation of Hybrid II ATD on All 0° Pitch Tests (Worst Scenario)

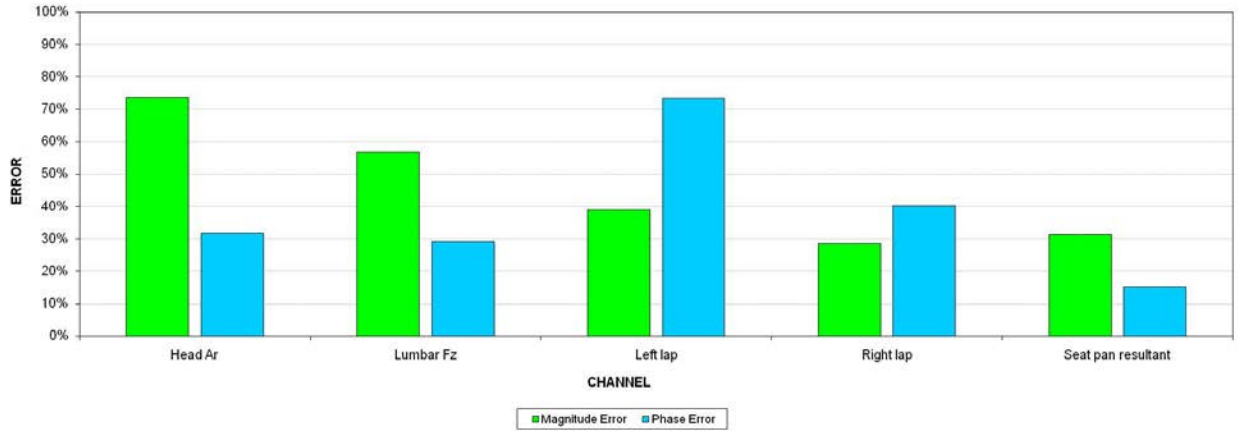


Figure 170. Compliance Response Variation of Hybrid II ATD on All 60° Pitch Tests (Worst Scenario)

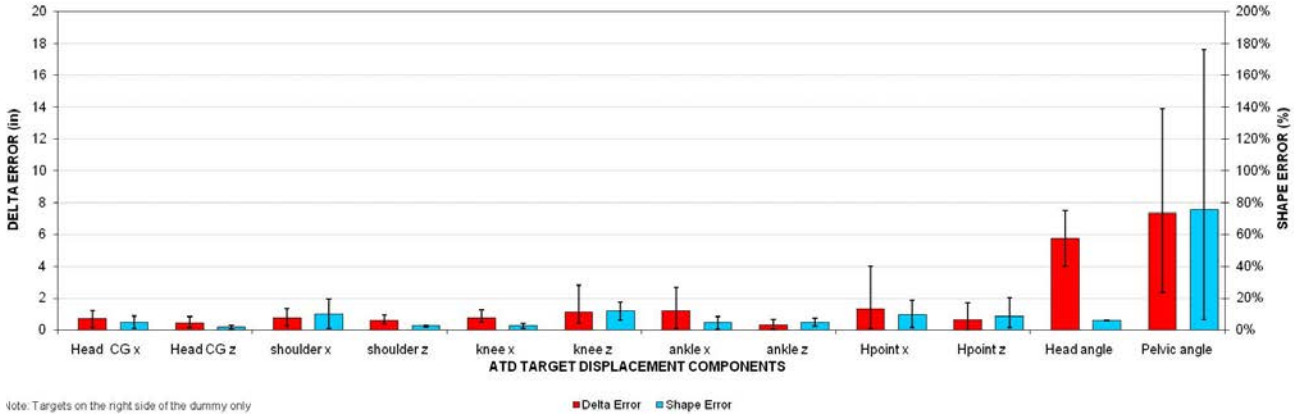


Figure 171. Displacement Response Variation of Hybrid II ATD on All Tests (Worst Scenario)

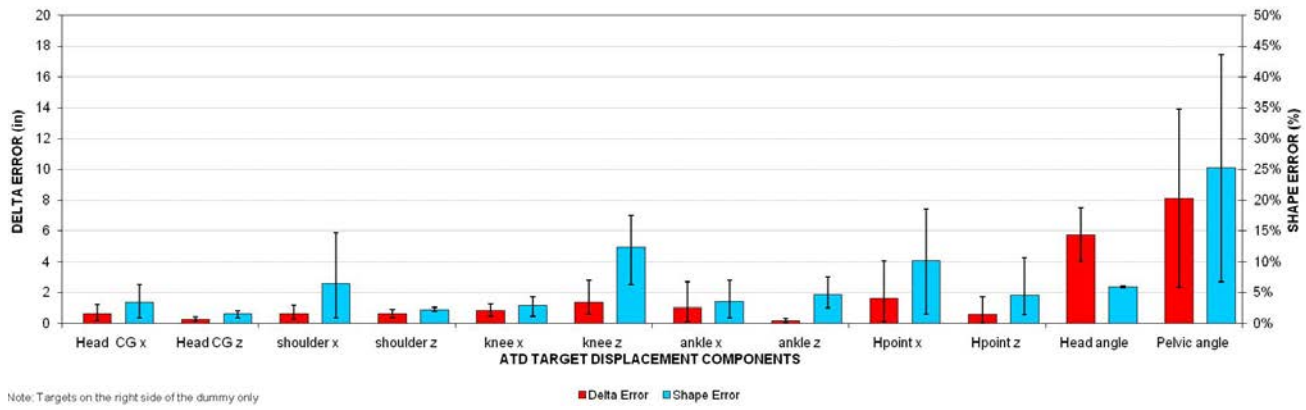


Figure 172. Displacement Response Variation of Hybrid II ATD on All 0° Pitch Tests (Worst Scenario)

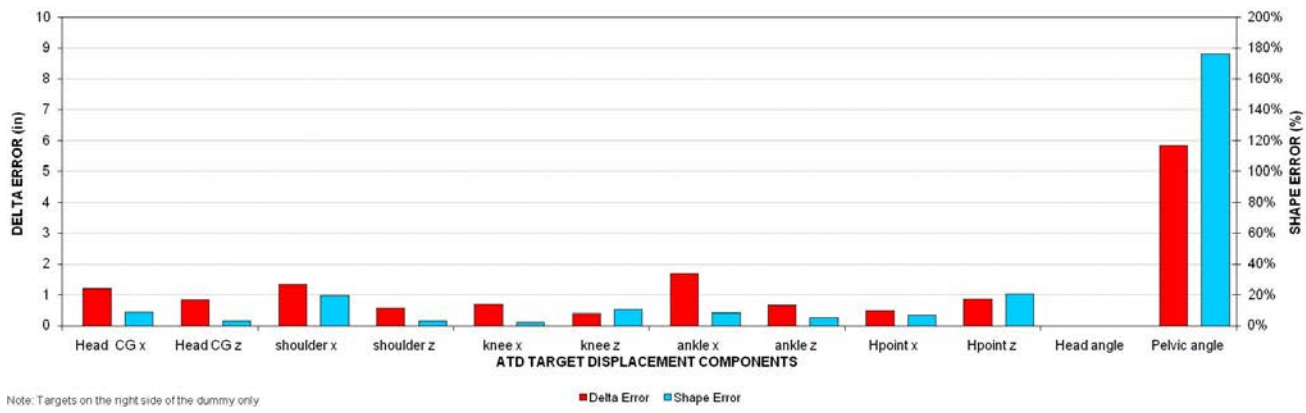


Figure 173. Displacement Response Variation of Hybrid II ATD on All 60° Pitch Tests (Worst Scenario)

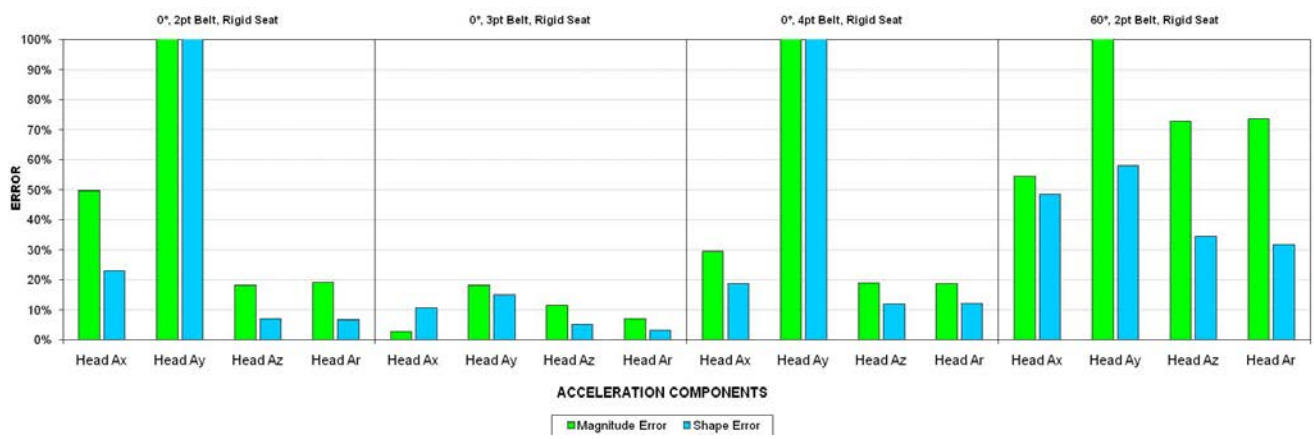


Figure 174. Head Acceleration Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

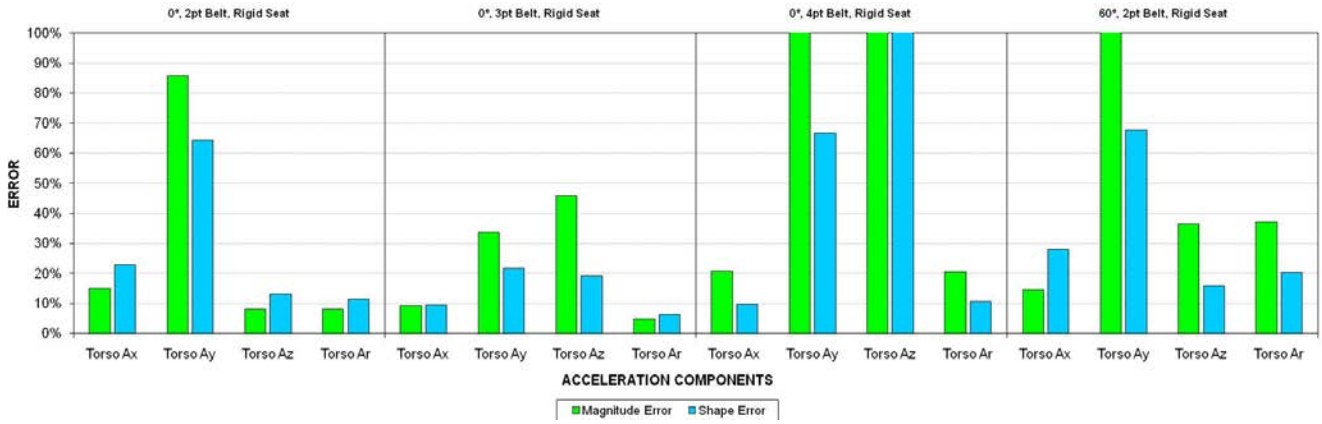


Figure 175. Torso Acceleration Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

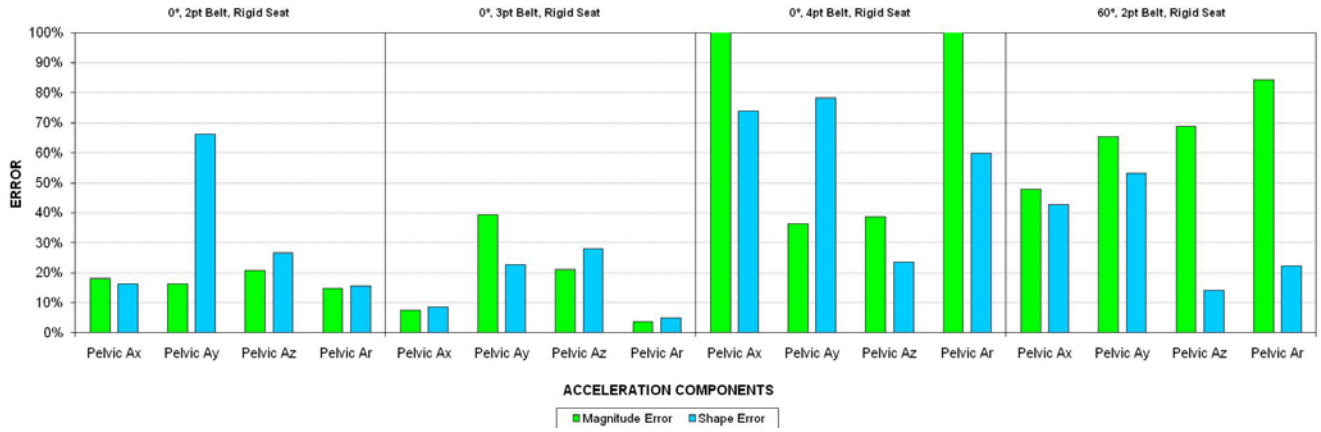


Figure 176. Pelvis Acceleration Response Variations of Hybrid II ATD at 0°and 60° Pitch for All Restraint Configurations (Worst Scenario)

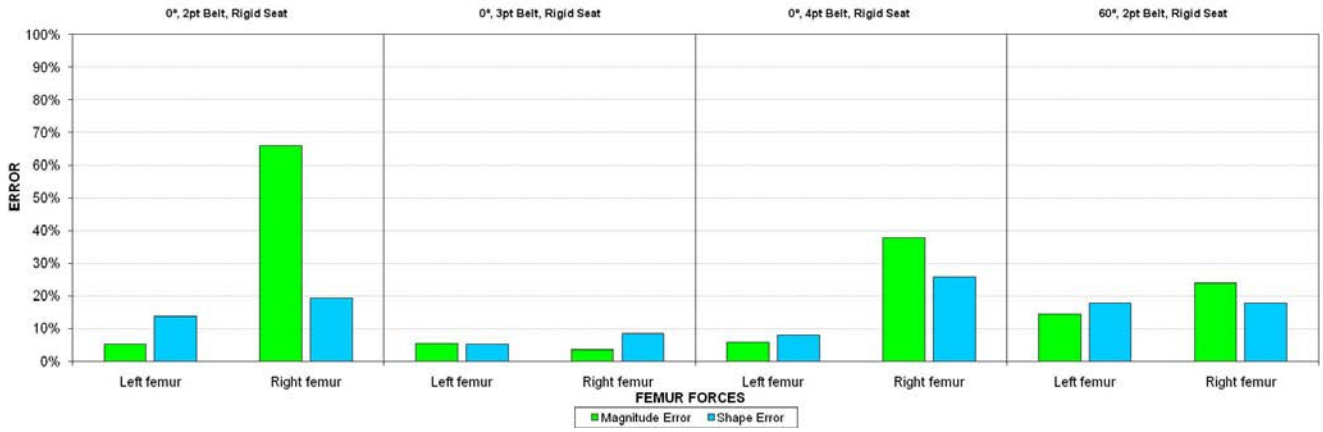


Figure 177. Femur Force Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

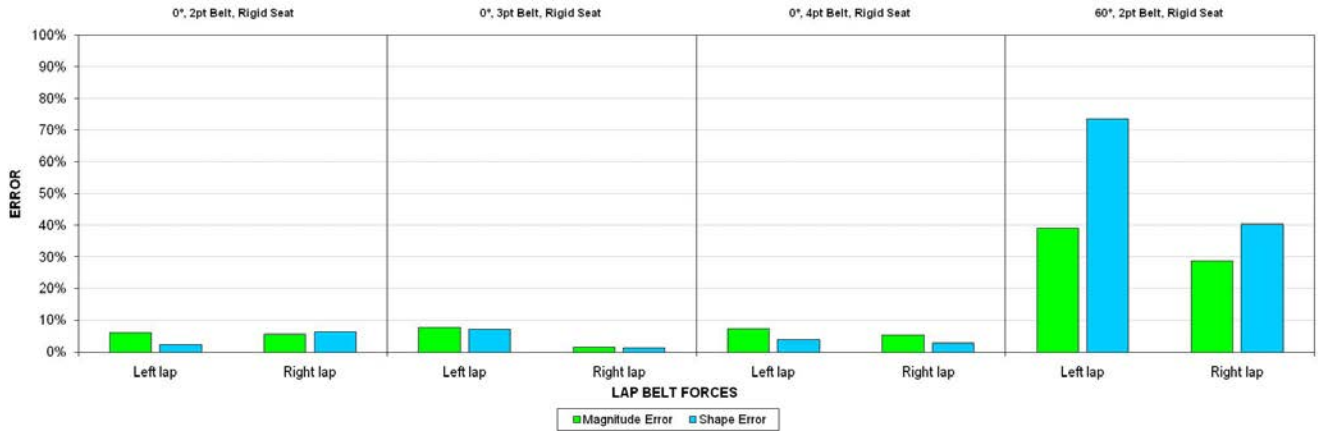


Figure 178. Lap Belt Force Response Variations of Hybrid II at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

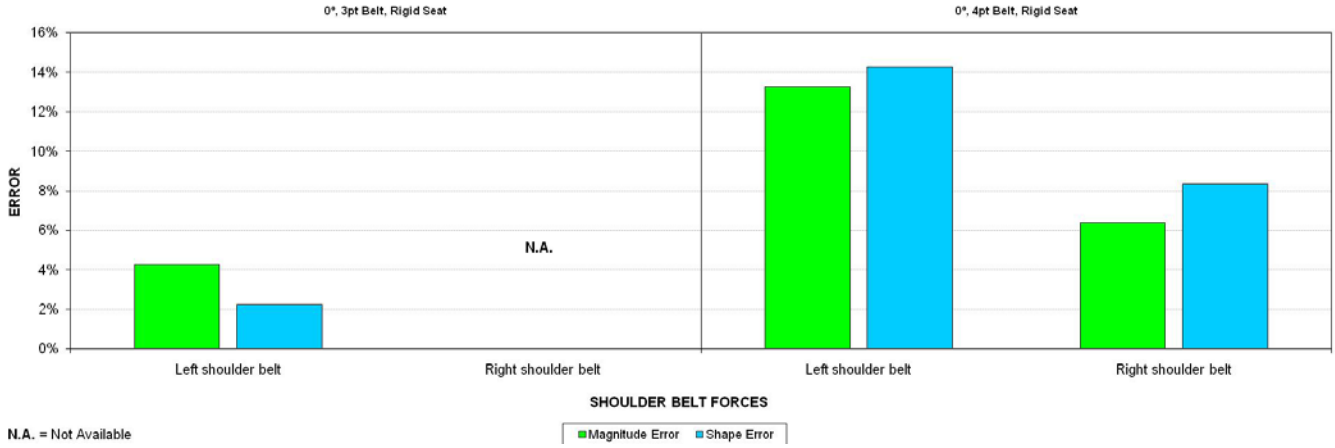


Figure 179. Shoulder Belt Force Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

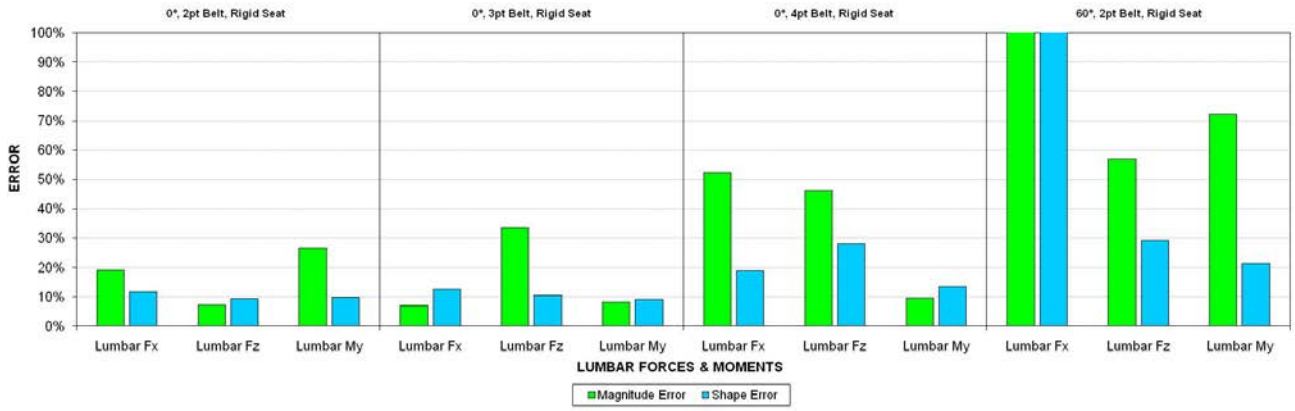


Figure 180. Lumbar Force Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

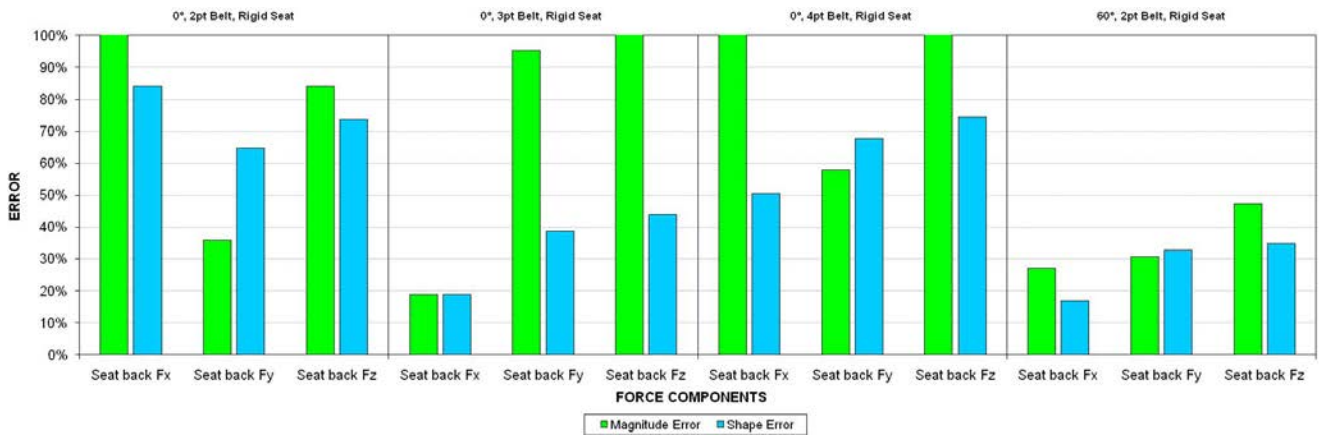


Figure 181. Seat Back Force Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

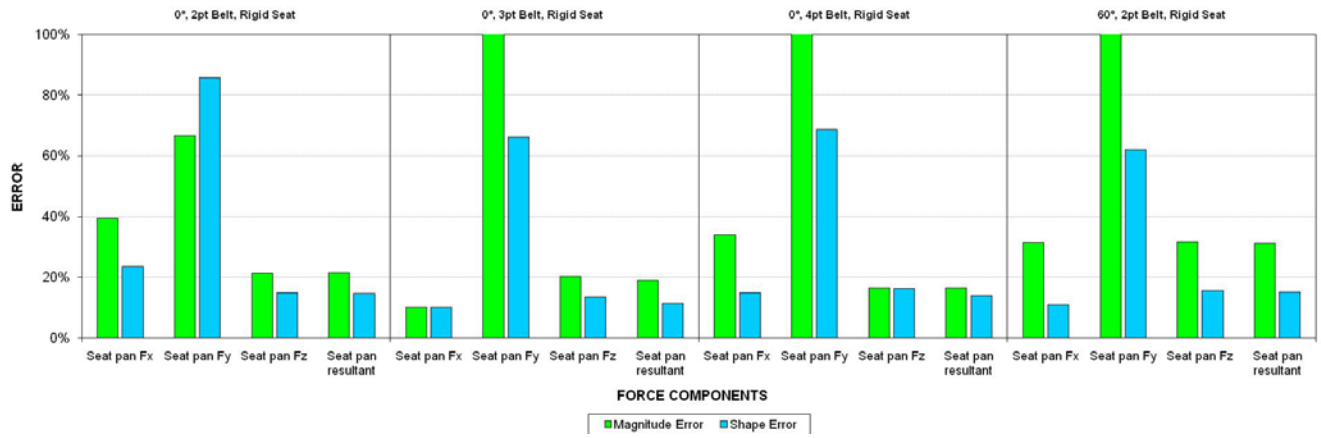


Figure 182. Seat Pan Force Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

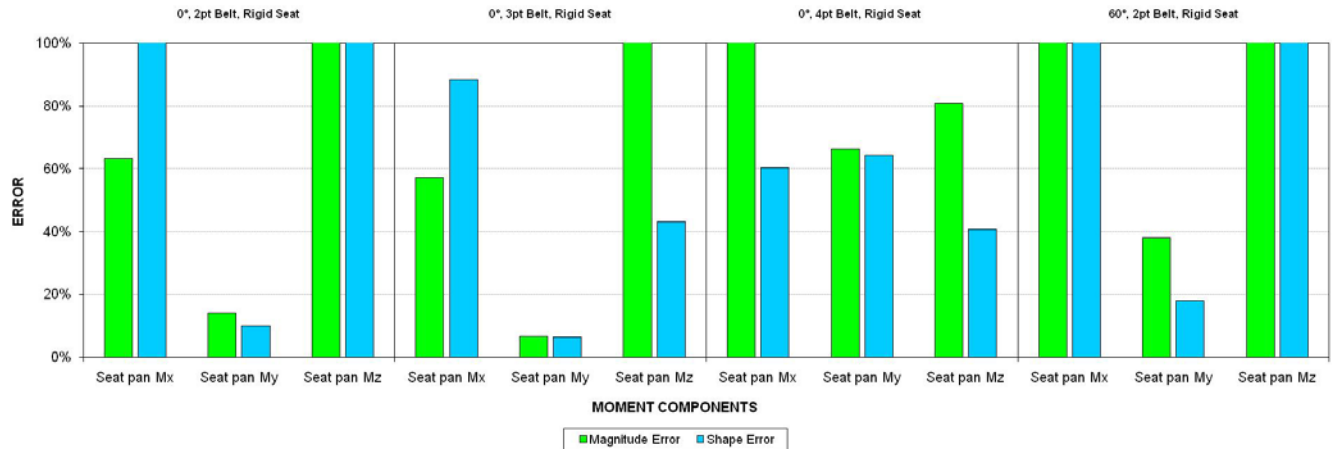


Figure 183. Seat Pan Moment Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

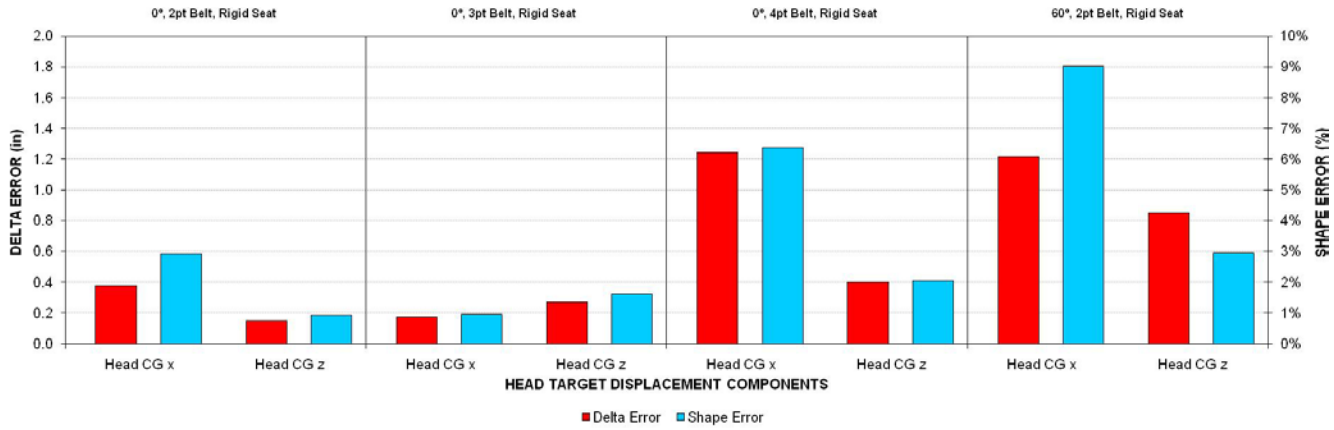


Figure 184. Head Excursion Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

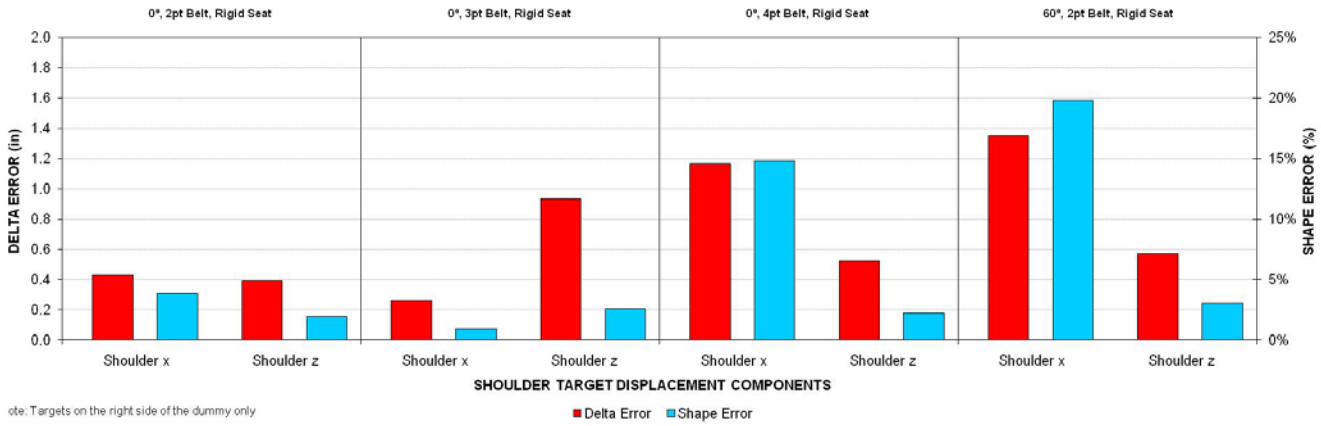


Figure 185. Shoulder Excursion Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

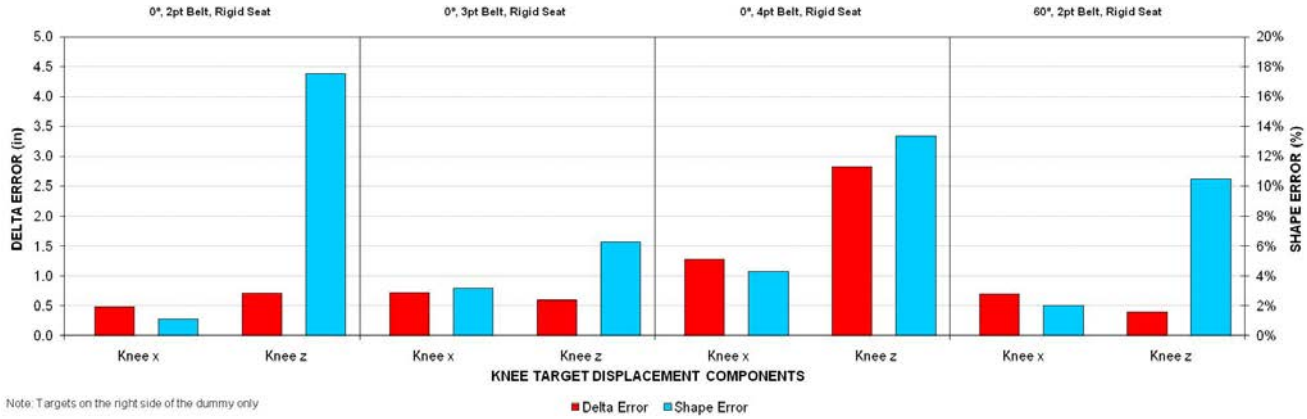


Figure 186. Knee Excursion Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

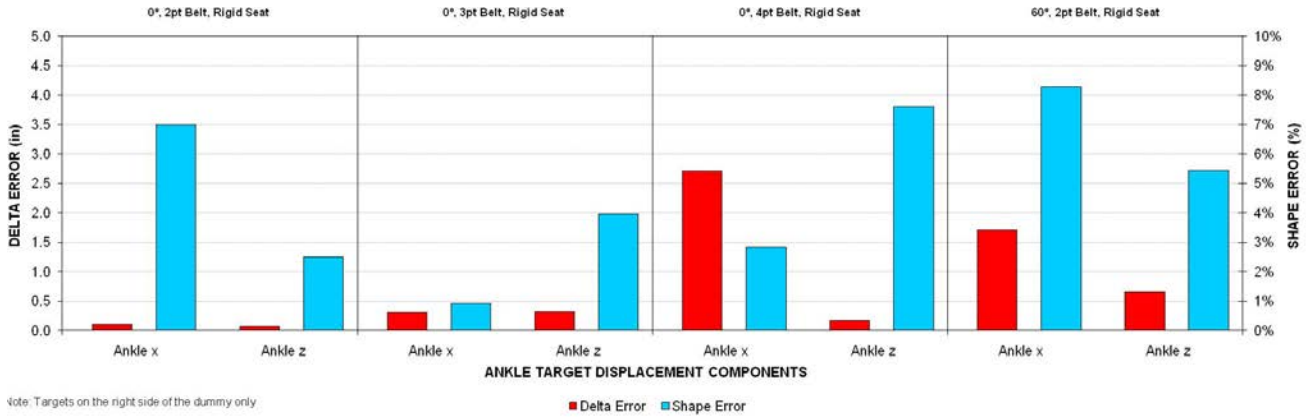


Figure 187. Ankle Excursion Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

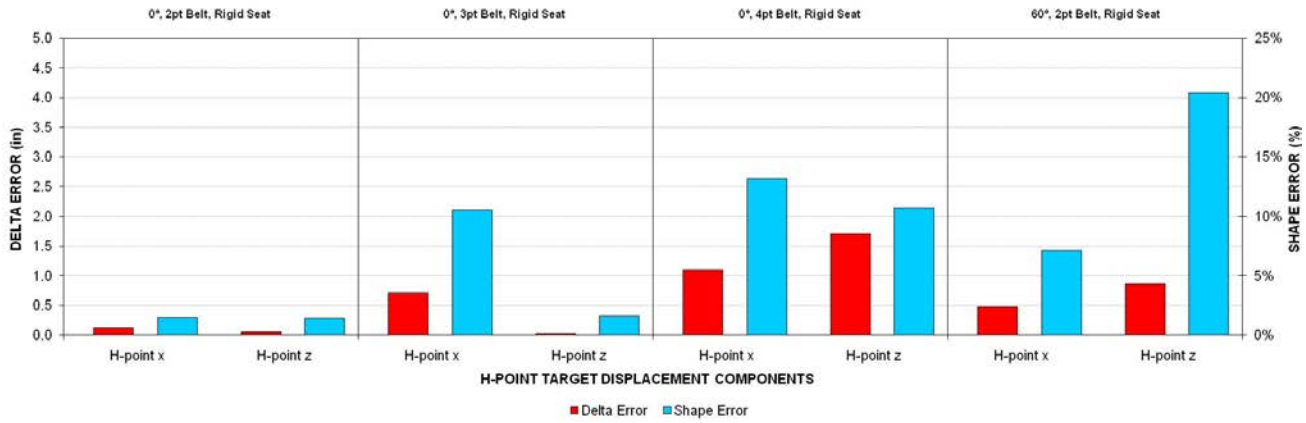


Figure 188. H-Point Excursion Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

Figure 189. Head Angle Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

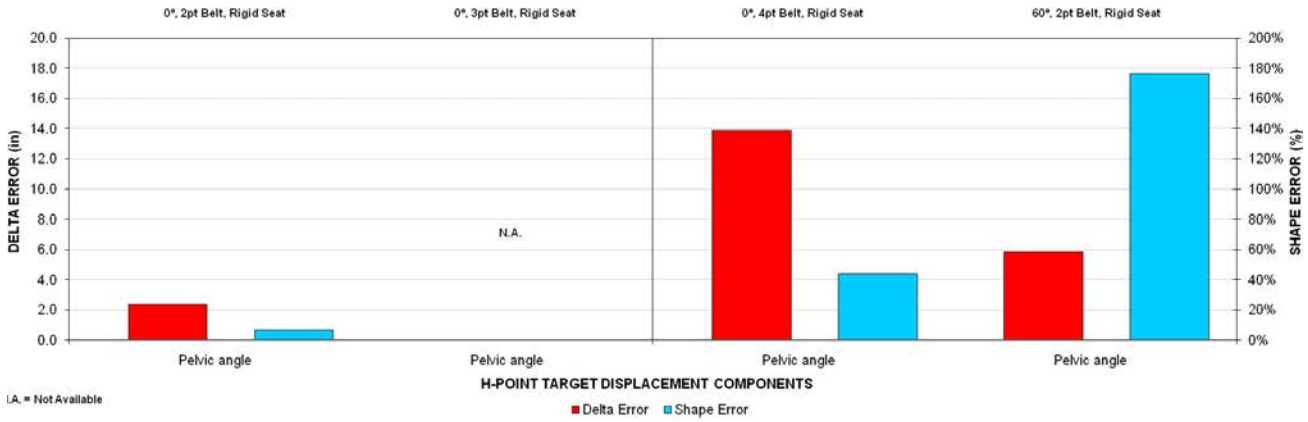


Figure 190. Pelvis Angle Response Variations of Hybrid II ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

Table 35. Hybrid II ATD With Two-Point Belt at 0° Pitch—Force, Moment, and Acceleration Data Channels Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error
Sled Ax	3	2	0.5 g	Left lap	6	2	115.0 lbf
Head Ax	50	23	5.9 g	Right lap	6	6	106.5 lbf
Head Ay	133	144	5.5 g	Lumbar Fx	19	12	299.4 lbf
Head Az	18	7	12.2 g	Lumbar Fz	7	9	220.8 lbf
Head Ar	19	7	12.8 g	Lumbar My	27	10	762.9 in-lb
Chest Ax	15	23	3.8 g	Seat back Fx	236	84	291.8 lbf
Chest Ay	86	64	4.6 g	Seat back Fy	36	65	32.6 lbf
Chest Az	8	13	4.1 g	Seat back Fz	84	74	220.8 lbf
Chest Ar	8	11	4.1 g	Seat pan Fx	39	24	254.0 lbf
Pelvis Ax	18	16	7.9 g	Seat pan Fy	67	86	82.0 lbf
Pelvis Ay	16	66	3.6 g	Seat pan Fz	21	15	747.4 lbf
Pelvis Az	21	27	10.9 g	Seat pan resultant	21	15	754.2 lbf
Pelvis Ar	15	15	9.9 g	Seat pan Mx	63	101	1204.8 in-lb
Left femur	5	14	25.6 lbf	Seat pan My	14	10	3449.4 in-lb
Right femur	66	19	320.0 lbf	Seat pan Mz	101	133	1924.8 in-lb

Table 36. Hybrid II ATD With Two-Point Belt at 0° Pitch—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	3	0.4	Right ankle x	7	0.1
Head path z direction	1	0.2	Right ankle z	2	0.1
Right shoulder x	4	0.4	H-point x	1	0.1
Right shoulder z	2	0.4	H-point z	1	0.1
Right knee x	1	0.5	Head angle	6	4.0
Right knee z	18	0.7	Pelvis angle	7	2.3

Table 37. Hybrid II ATD With Three-Point Belt at 0° Pitch—Force, Moment, and Acceleration Data Channels Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error
Sled Ax	2	2	0.4 g	Left lap	8	7	125.0 lbf
Head Ax	3	11	0.5 g	Right lap	1	1	34.5 lbf
Head Ay	18	15	3.0 g	Shoulder belt	4	2	66.8 lbf
Head Az	12	5	3.5 g	Lumbar Fx	7	13	22.6 lbf
Head Ar	7	3	2.3 g	Lumbar Fz	33	10	94.7 lbf
Chest Ax	9	9	2.5 g	Lumbar My	8	9	95.6 in-lb
Chest Ay	34	22	3.2 g	Seat back Fx	19	19	250.8 lbf
Chest Az	46	19	3.8 g	Seat back Fy	95	39	96.7 lbf
Chest Ar	5	6	1.4 g	Seat back Fz	193	44	113.8 lbf
Pelvis Ax	7	9	3.0 g	Seat pan Fx	10	10	50.0 lbf
Pelvis Ay	39	23	3.4 g	Seat pan Fy	106	66	63.2 lbf
Pelvis Az	21	28	4.7 g	Seat pan Fz	20	13	258.4 lbf
Pelvis Ar	4	5	1.8 g	Seat pan resultant	19	11	257.1 lbf
Left femur	6	5	22.7 lbf	Seat pan Mx	57	88	693.8 in-lb
Right femur	4	9	14.4 lbf	Seat pan My	7	6	363.6 in-lb
				Seat pan Mz	146	43	243.9 in-lb

Table 38. Hybrid II ATD With Three-Point Belt at 0° Pitch—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	1	0.2	H-point x	11	0.7
Head path z direction	2	0.3	H-point z	2	0.0
Right shoulder x	1	0.3	Left shoulder x	6	0.4
Right shoulder z	3	0.9	Left shoulder z	1	0.2
Right knee x	3	0.7	Left knee x	1	0.1
Right knee z	6	0.6	Left knee z	4	0.4
Right ankle x	1	0.3	Head angle	N/A	N/A
Right ankle z	4	0.3	Pelvis angle	N/A	N/A

N/A = Not applicable

Table 39. Hybrid II ATD With Four-Point Belt at 0° Pitch—Force, Moment, and Acceleration Data Channels Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error
Sled Ax	1	1	0.3 g	Right lap	5	3	100.0 lbf
Head Ax	30	19	6.3 g	Left shoulder	13	14	115.9 lbf
Head Ay	135	119	4.4 g	Right shoulder	6	8	59.9 lbf
Head Az	19	12	6.6 g	Lumbar Fx	52	19	133.8 lbf
Head Ar	19	12	6.7 g	Lumbar Fz	46	28	136.8 lbf
Chest Ax	21	10	6.7 g	Lumbar My	10	14	107.4 in-lb
Chest Ay	108	67	6.0 g	Seat back Fx	309	51	320.3 lbf
Chest Az	137	112	11.0 g	Seat back Fy	58	68	69.8 lbf
Chest Ar	21	11	6.7 g	Seat back Fz	396	75	388.2 lbf
Pelvis Ax	885	74	71.3 g	Seat pan Fx	34	15	144.1 lbf
Pelvis Ay	36	78	1.1 g	Seat pan Fy	157	69	44.6 lbf
Pelvis Az	39	24	11.8 g	Seat pan Fz	16	16	241.8 lbf
Pelvis Ar	125	60	46.5 g	Seat pan resultant	16	14	246.4 lbf
Left femur	6	8	21.5 lbf	Seat pan Mx	167	60	382.1 in-lb
Right femur	38	26	133.4 lbf	Seat pan My	66	64	3682.7 in-lb
Left lap	7	4	138.0 lbf	Seat pan Mz	81	41	170.1 in-lb

Table 40. Hybrid II ATD With Four-Point Belt at 0° Pitch—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	6	1.2	Right ankle x	3	2.7
Head path z direction	2	0.4	Right ankle z	8	0.2
Right shoulder x	15	1.2	H-point x	13	1.1
Right shoulder z	2	0.5	H-point z	11	1.7
Right knee x	4	1.3	Head angle	6	7.5
Right knee z	13	2.8	Pelvis angle	44	13.9

Table 41. Hybrid II ATD With Two-Point Belt at 60° Pitch—Force, Moment, and Acceleration Data Channels Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error
Sled Ax	3	1	0.6 g	Left lap	39	73	52.4 lbf
Head Ax	54	49	2.3 g	Right lap	29	40	34.3 lbf
Head Ay	110	58	1.3 g	Lumbar Fx	328	224	300.5 lbf
Head Az	73	35	13.6 g	Lumbar Fz	57	29	636.8 lbf
Head Ar	74	32	13.9 g	Lumbar My	72	21	223.9 in-lb
Chest Ax	15	28	0.6 g	Seat back Fx	27	17	65.4 lbf
Chest Ay	115	68	1.1 g	Seat back Fy	31	33	25.0 lbf
Chest Az	36	16	7.0 g	Seat back Fz	47	35	46.2 lbf
Chest Ar	37	20	7.8 g	Seat pan Fx	32	11	213.6 lbf
Pelvis Ax	48	43	3.0 g	Seat pan Fy	211	62	85.0 lbf
Pelvis Ay	65	53	1.3 g	Seat pan Fz	32	16	708.3 lbf
Pelvis Az	69	14	14.5 g	Seat pan resultant	31	15	732.3 lbf
Pelvis Ar	84	22	16.4 g	Seat pan Mx	196	262	1216.0 in-lb
Left femur	14	18	12.1 lbf	Seat pan My	38	18	1553.2 in-lb
Right femur	24	18	20.4 lbf	Seat pan Mz	535	520	509.7 in-lb

Table 42. Hybrid II ATD With Two-Point Belt at 60° Pitch—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	9	1.2	Right ankle x	8	1.7
Head path z direction	3	0.9	Right ankle z	5	0.7
Right shoulder x	20	1.4	H-point x	7	0.5
Right shoulder z	3	0.6	H-point z	20	0.9
Right knee x	2	0.7	Head angle	N/A	N/A
Right knee z	10	0.4	Pelvis angle	176	5.8

N/A = not applicable

4.2.2 The FAA Hybrid III ATD Test Variability.

This section presents the test data variability of the FAA Hybrid III ATD for every test configuration. The data evaluation periods are listed in table 43.

Table 43. Evaluation Periods for FAA Hybrid III ATD

Configuration	Accelerometer Signals (ms)	Load Cell Signals (ms)	Position (ms)
FAA Hybrid III ATD with two-point restraint at 0° pitch	175	200	175
FAA Hybrid III ATD with three-point restraint at 0° pitch	180	180	180
FAA Hybrid III ATD with four-point restraint at 0° pitch	150	150	150
FAA Hybrid III ATD with two-point restraint at 60° pitch	125	125	125

4.2.2.1 Test-to-Test Variability FAA Hybrid III.

The test-to-test variability (error) for each channel of the FAA Hybrid III ATD is presented in figures 191 to 202 in the form of bar charts, where the bar's height corresponds to the average error value obtained from the tests compared. The brackets shown on each bar extend from the minimum to the maximum error value among tests for each configuration.

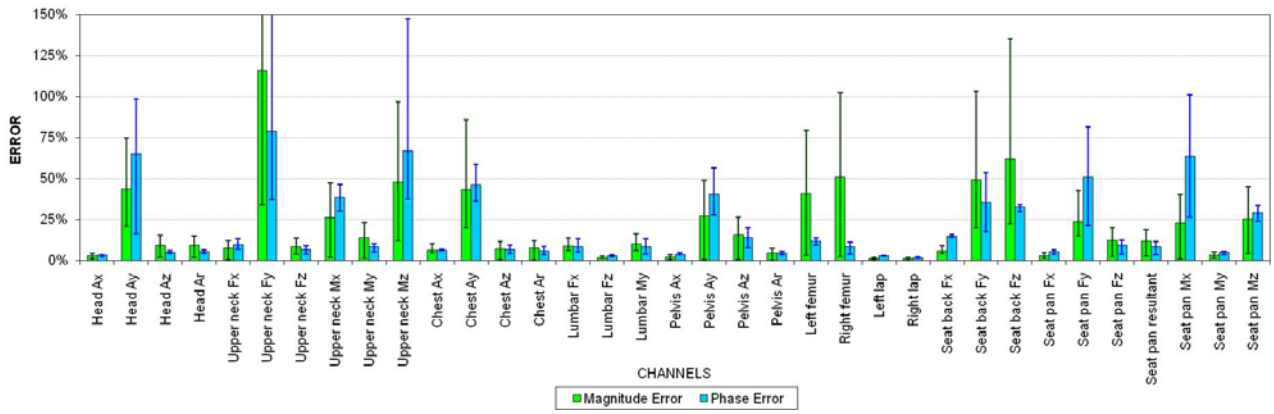


Figure 191. Averaged Responses of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

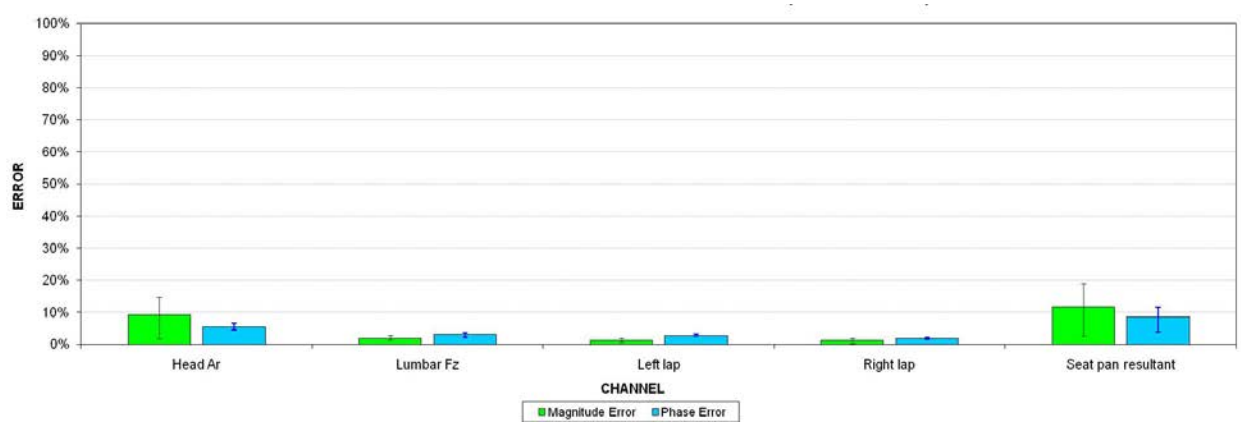


Figure 192. Averaged Compliance Responses of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

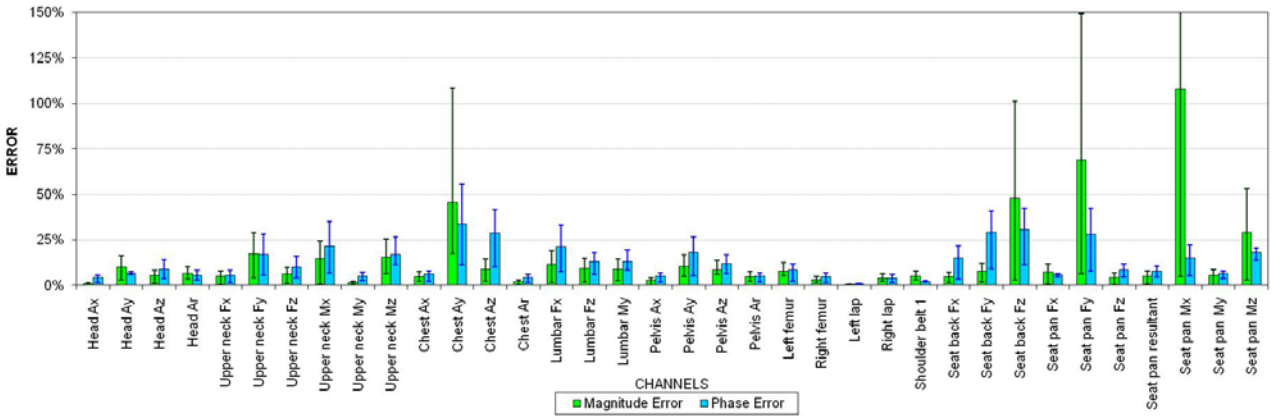


Figure 193. Averaged Responses of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

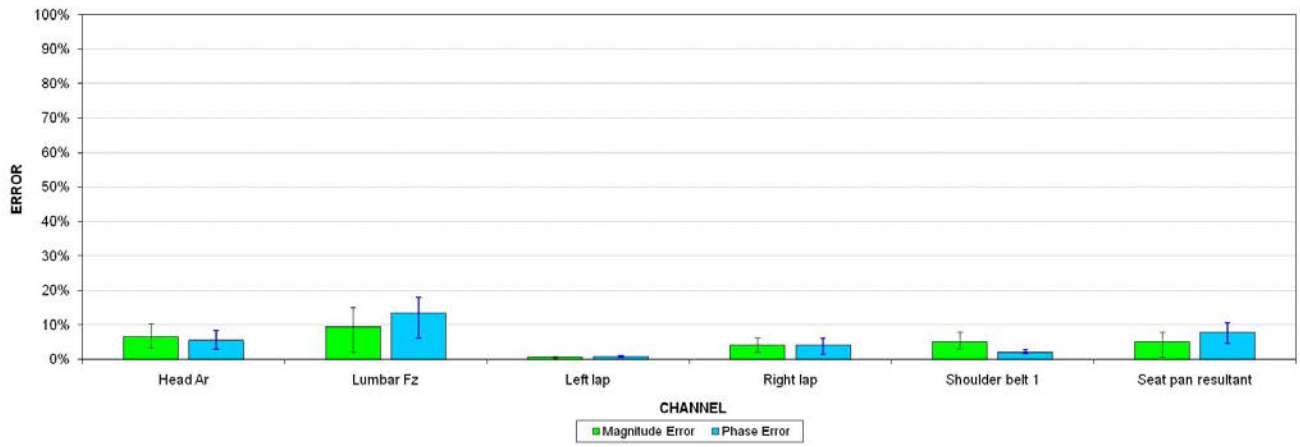


Figure 194. Averaged Compliance Responses of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

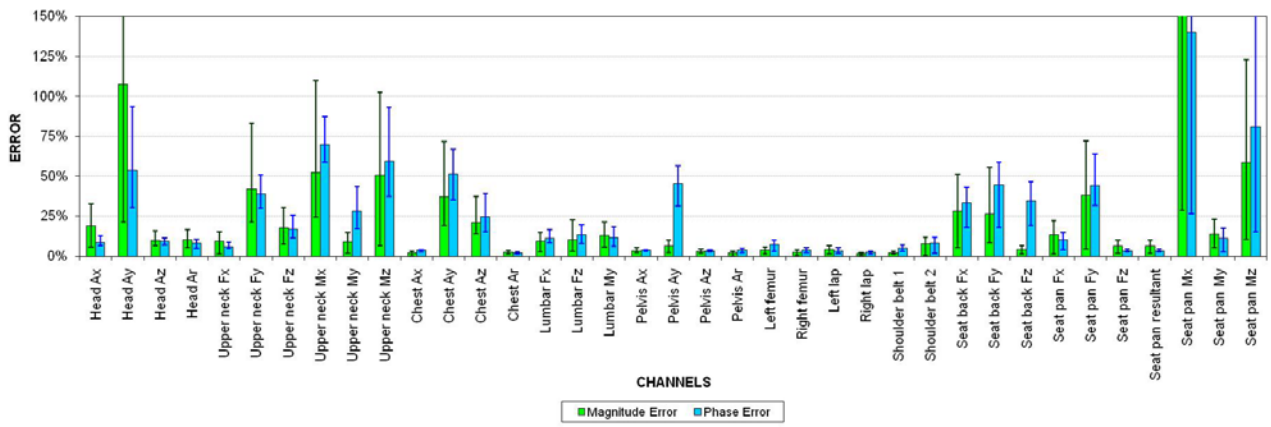


Figure 195. Averaged Responses of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

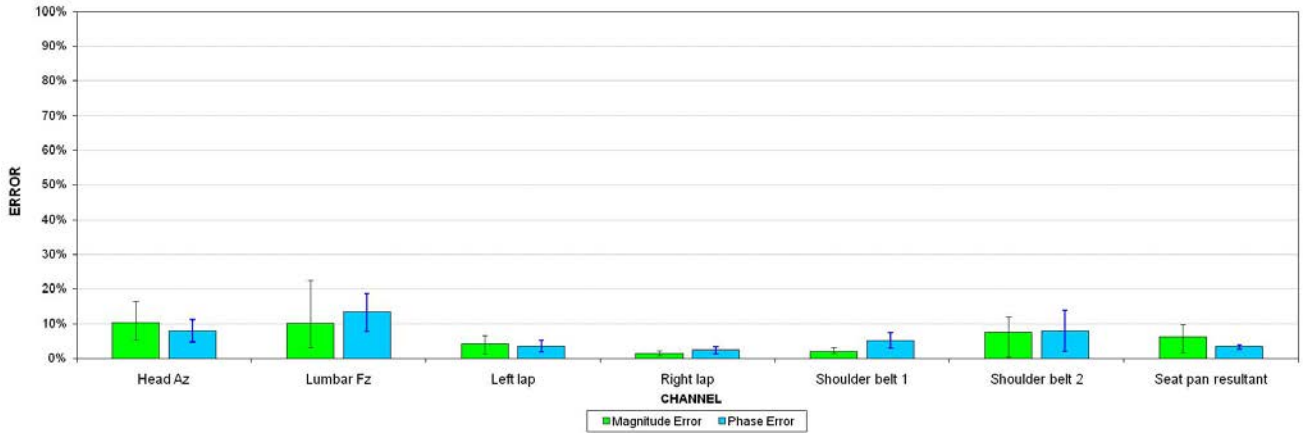


Figure 196. Averaged Compliance Responses of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

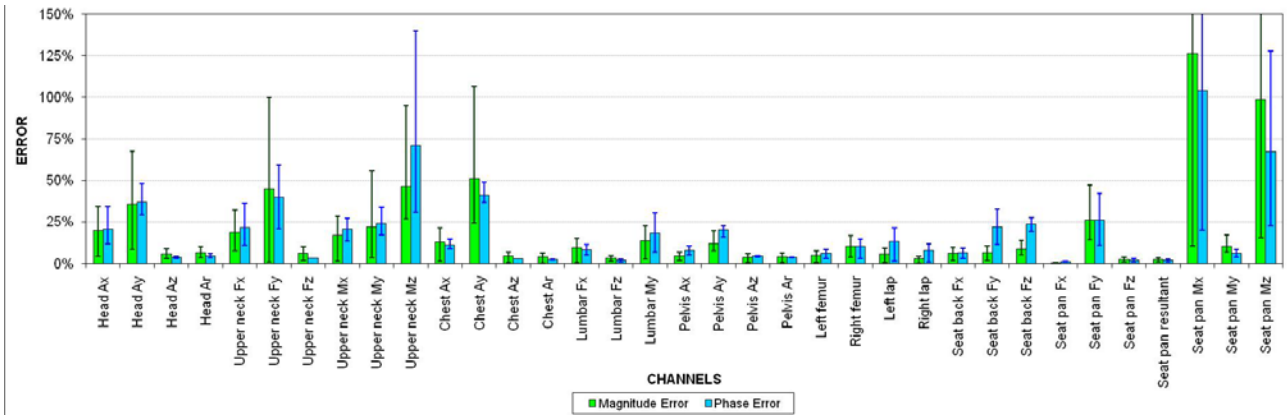


Figure 197. Averaged Responses of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

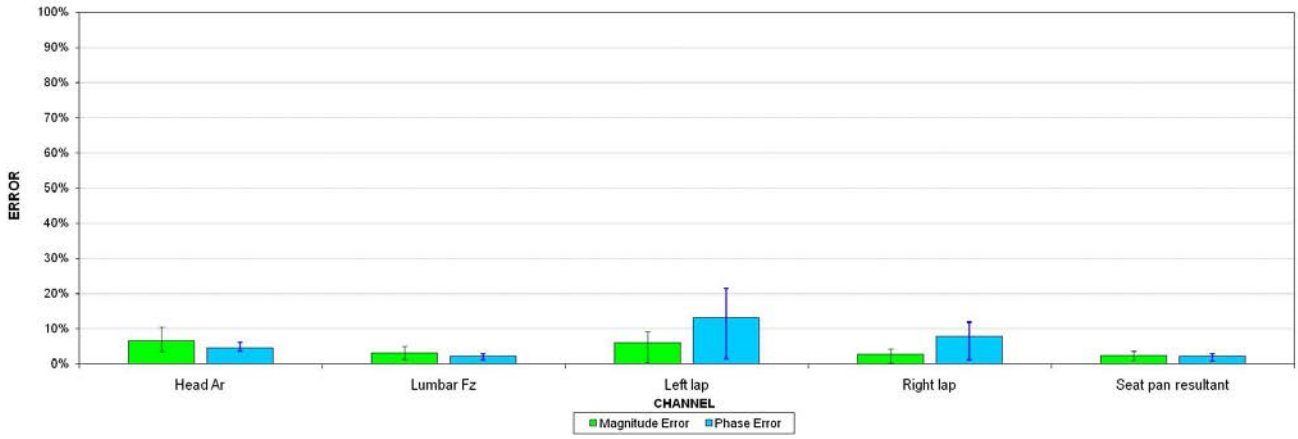


Figure 198. Averaged Compliance Responses of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

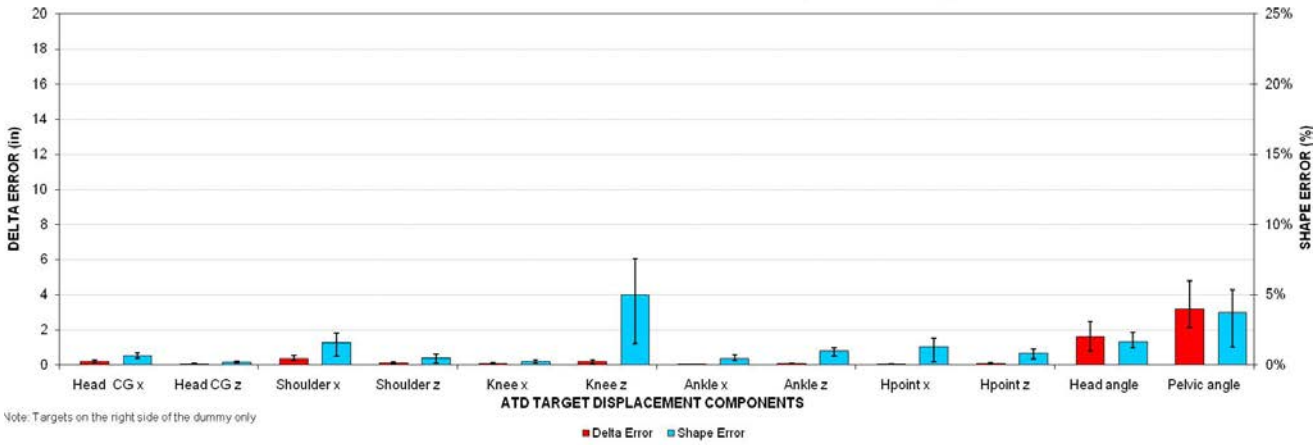


Figure 199. Averaged Displacement Responses of FAA Hybrid III ATD With Two-Point Belt at 0° Pitch

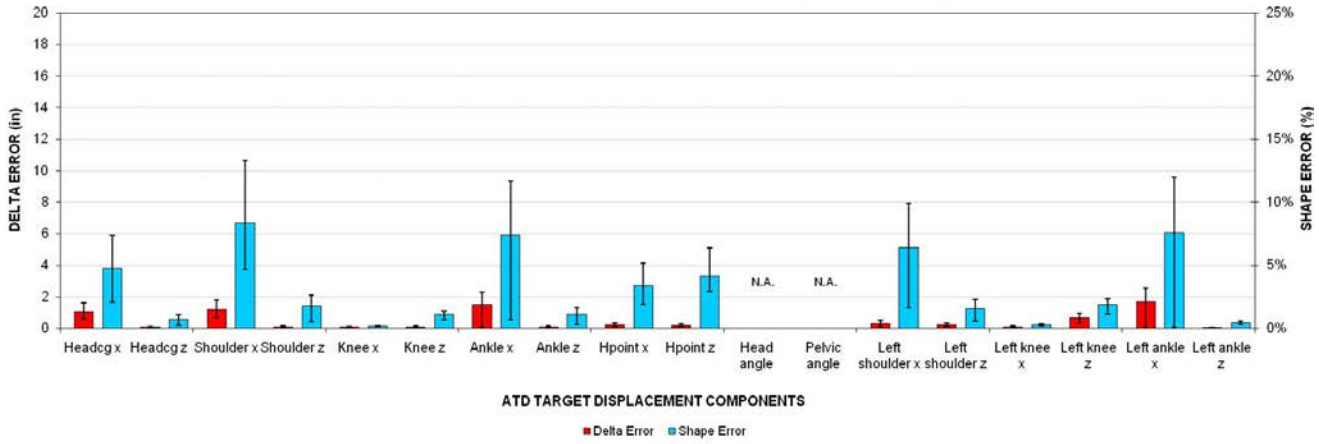


Figure 200. Averaged Displacement Responses of FAA Hybrid III ATD With Three-Point Belt at 0° Pitch

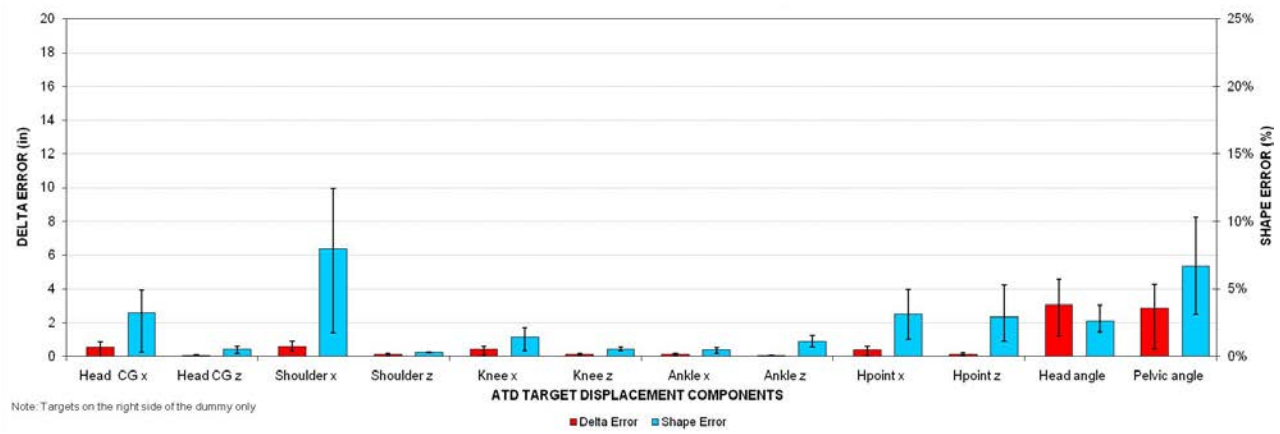


Figure 201. Averaged Displacement Responses of FAA Hybrid III ATD With Four-Point Belt at 0° Pitch

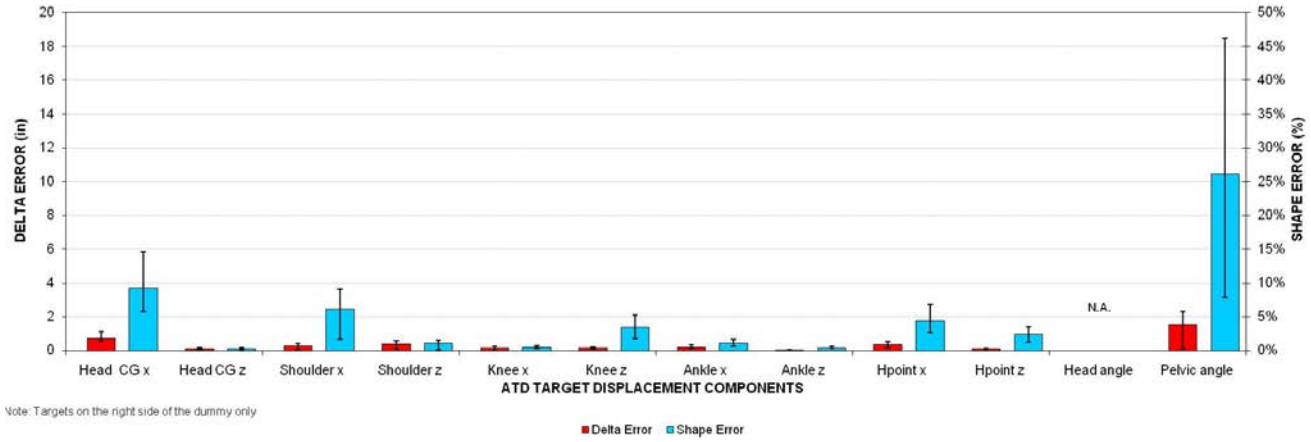


Figure 202. Averaged Displacement Responses of FAA Hybrid III ATD With Two-Point Belt at 60° Pitch

4.2.2.2 The FAA Hybrid III ATD Variability per Channel and Configuration.

Figures 203 to 221 show, in greater detail, all ATD responses and kinematic variability for each FAA Hybrid III ATD configuration. The errors are presented in the form of bar charts, where the bar's height corresponds to the average error value obtained from the tests compared. The brackets shown on each bar extend from the minimum to the maximum error value among tests for each configuration.

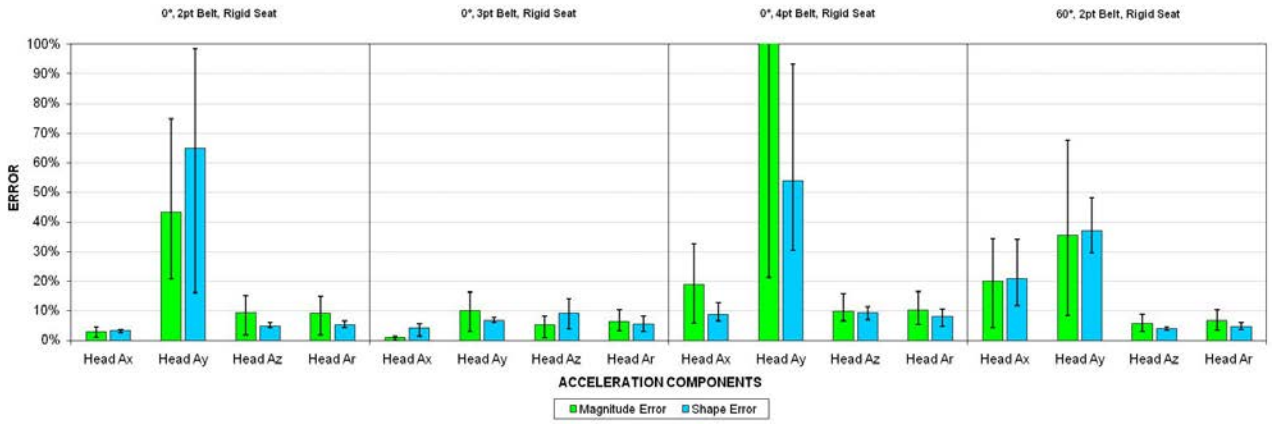


Figure 203. Averaged Head Accelerations of FAA Hybrid III ATD for Each Configuration

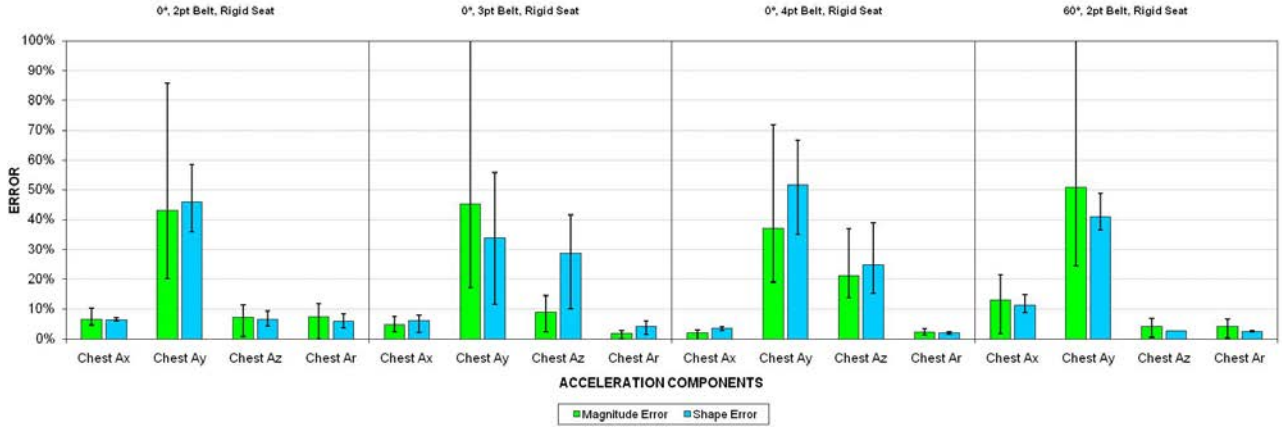


Figure 204. Averaged Torso Accelerations of FAA Hybrid III ATD for Each Configuration

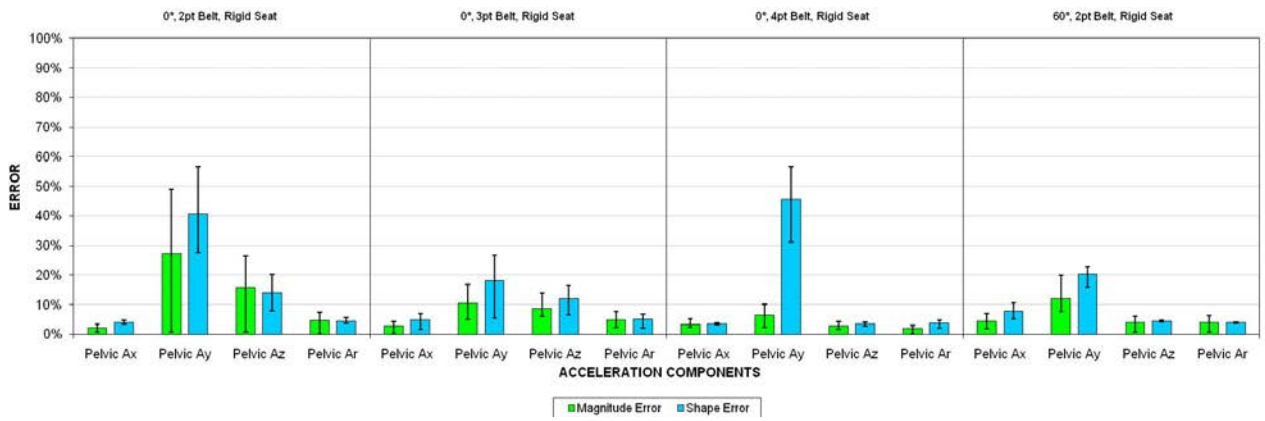


Figure 205. Averaged Pelvis Accelerations of FAA Hybrid III ATD for Each Configuration

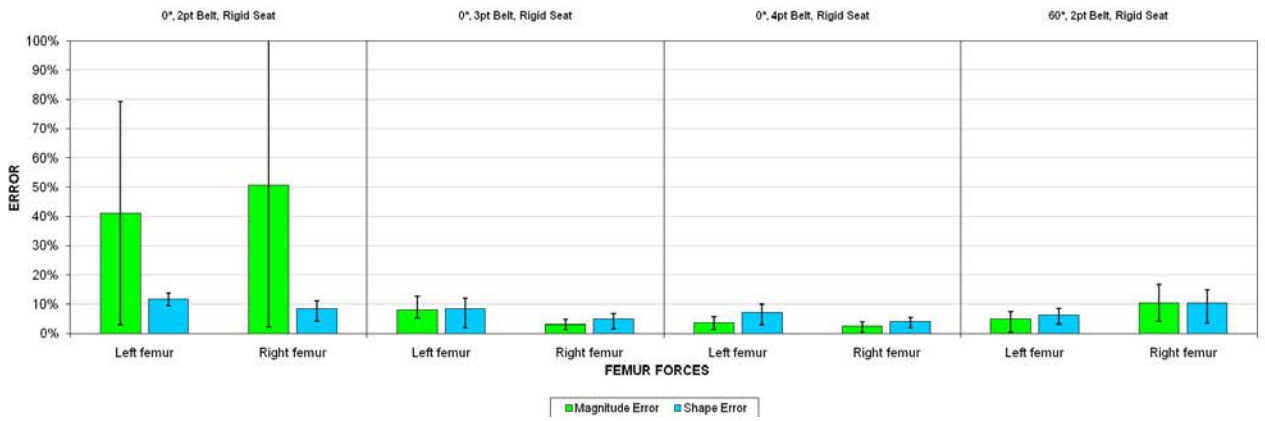


Figure 206. Averaged Femur Forces of FAA Hybrid III ATD for Each Configuration

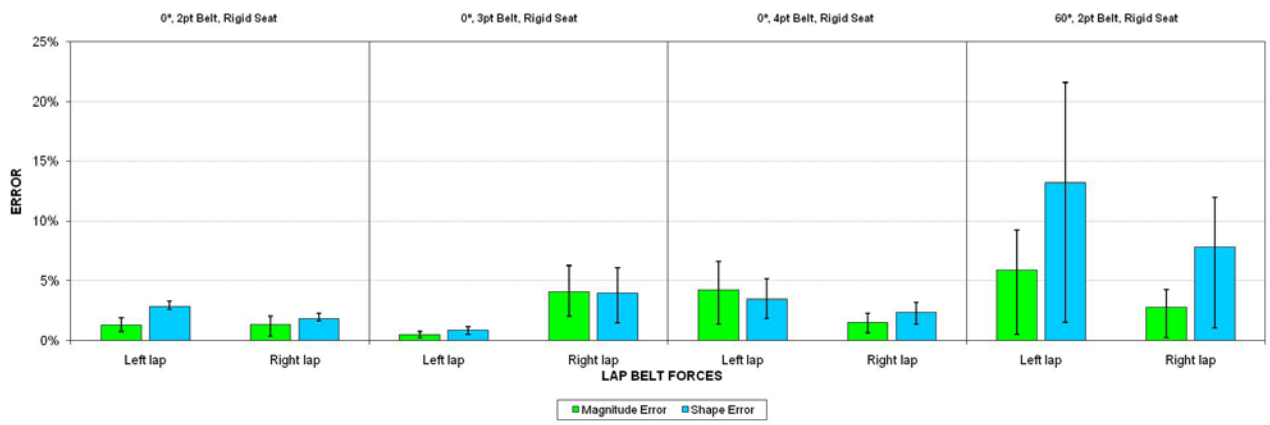


Figure 207. Averaged Lap Belt Forces of FAA Hybrid III ATD for Each Configuration

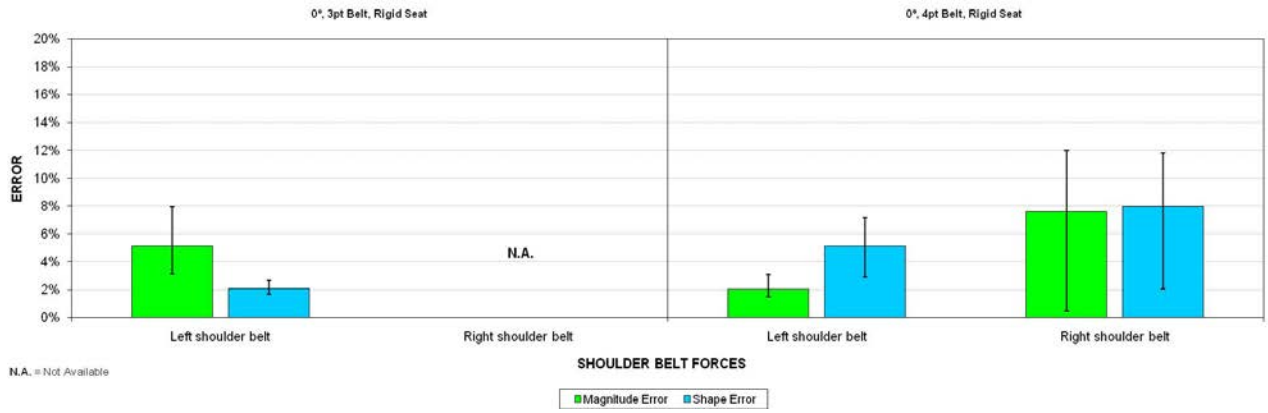


Figure 208. Averaged Shoulder Belt Forces of FAA Hybrid III ATD for Each Configuration

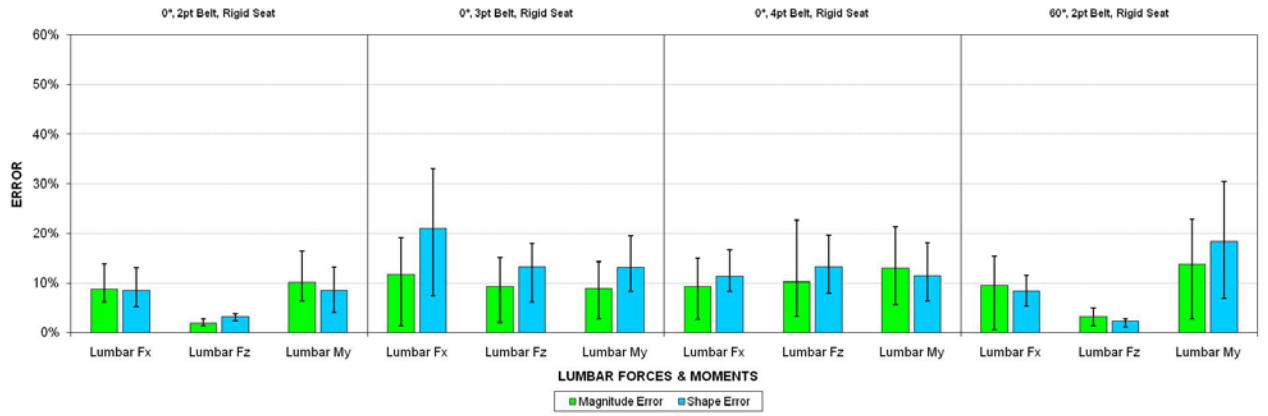


Figure 209. Averaged Lumbar Forces of FAA Hybrid III ATD for Each Configuration

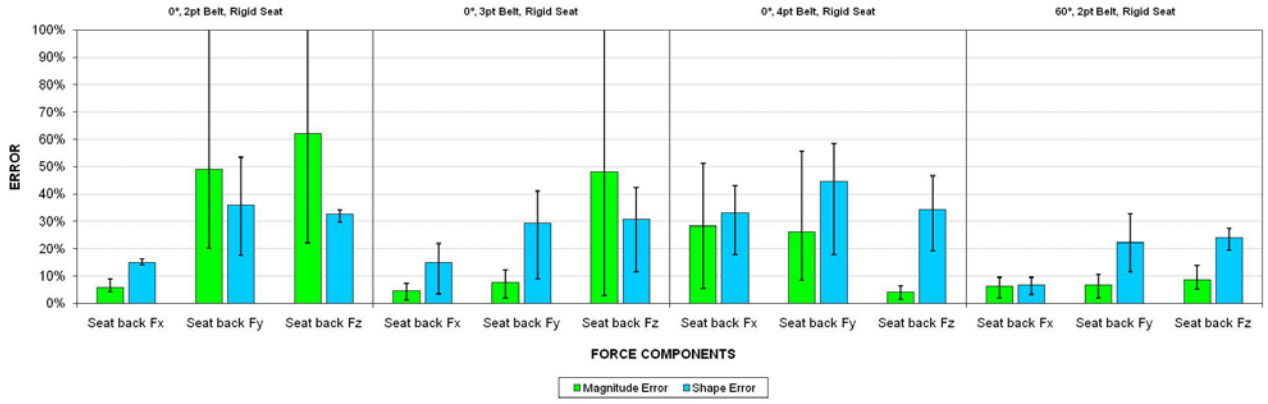


Figure 210. Averaged Seat Back Forces of FAA Hybrid III ATD for Each Configuration

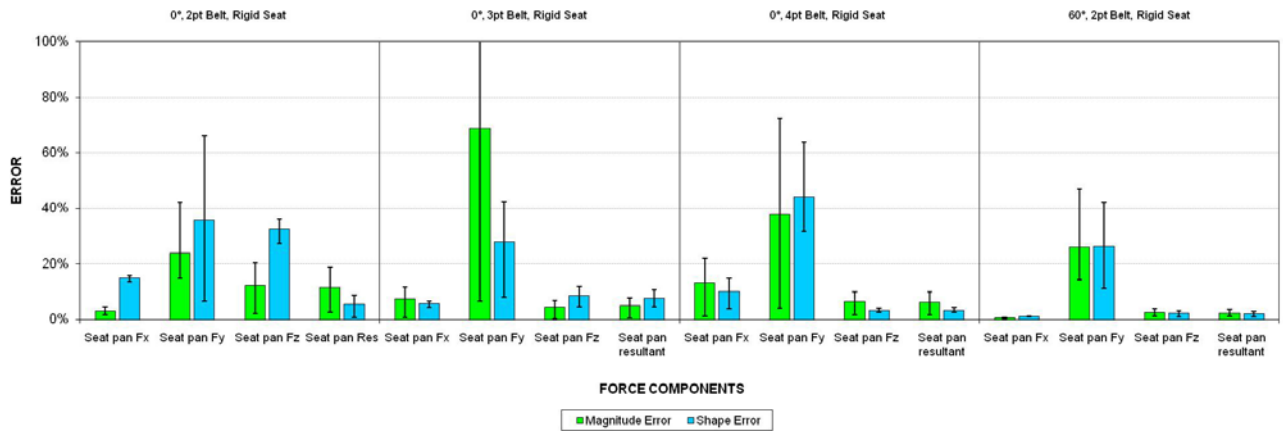


Figure 211. Averaged Seat Pan Forces of FAA Hybrid III ATD for Each Configuration

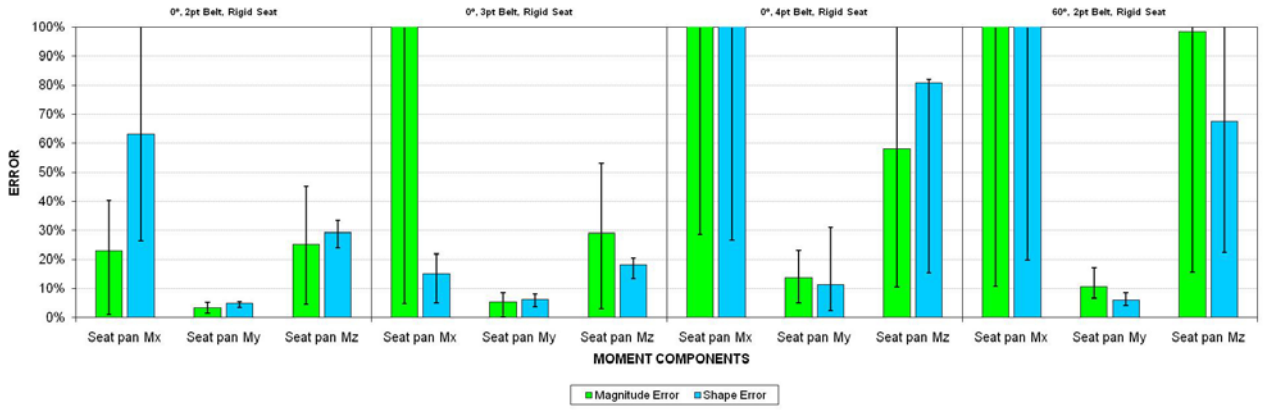


Figure 212. Averaged Seat Pan Moments of FAA Hybrid III ATD for Each Configuration

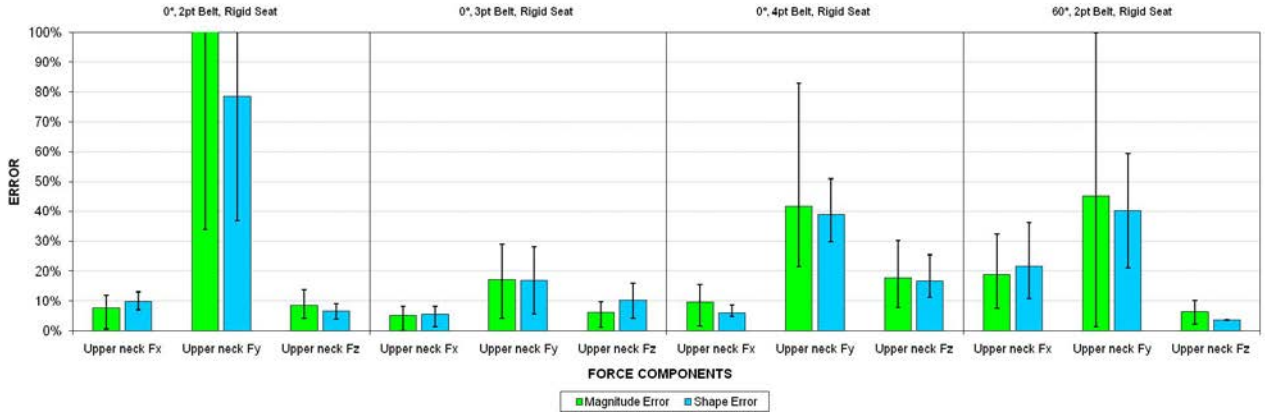


Figure 213. Averaged Upper Neck Forces of FAA Hybrid III ATD for Each Configuration

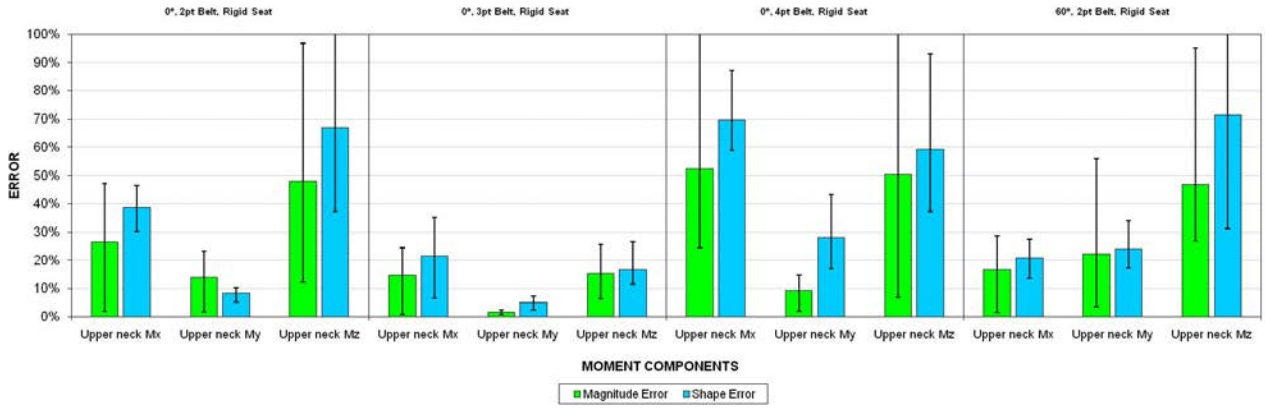


Figure 214. Averaged Upper Neck Moments of FAA Hybrid III ATD for Each Configuration

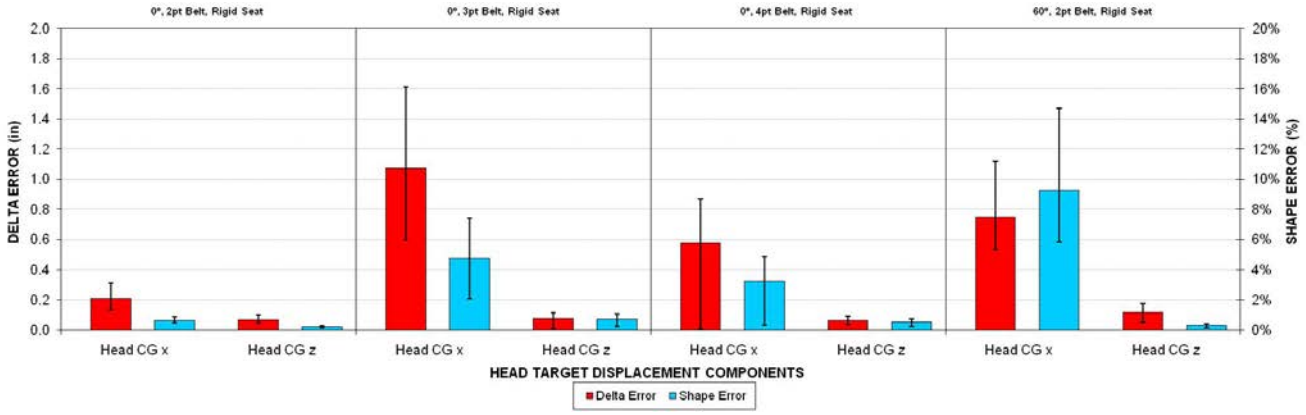


Figure 215. Averaged Head Excursions of FAA Hybrid III ATD for Each Configuration

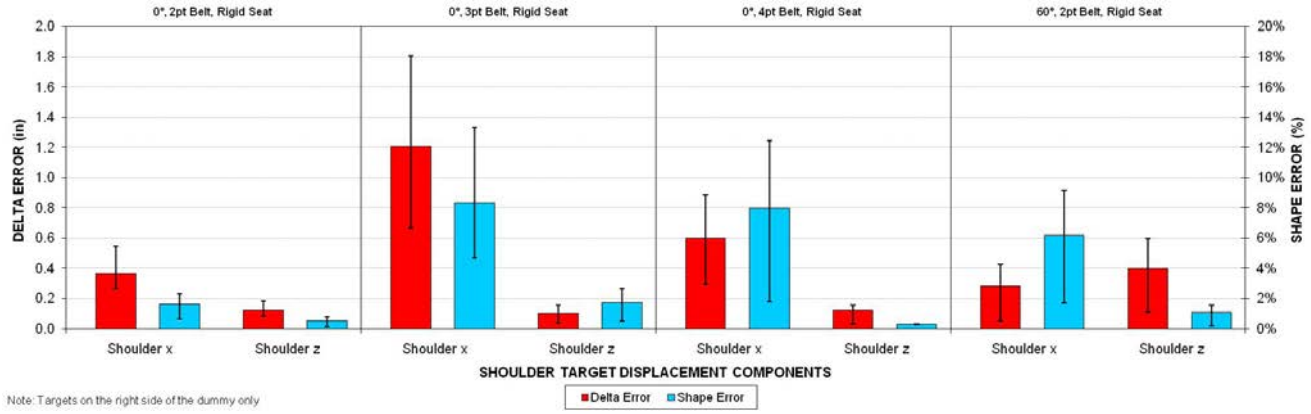


Figure 216. Averaged Shoulder Excursions of FAA Hybrid III ATD for Each Configuration

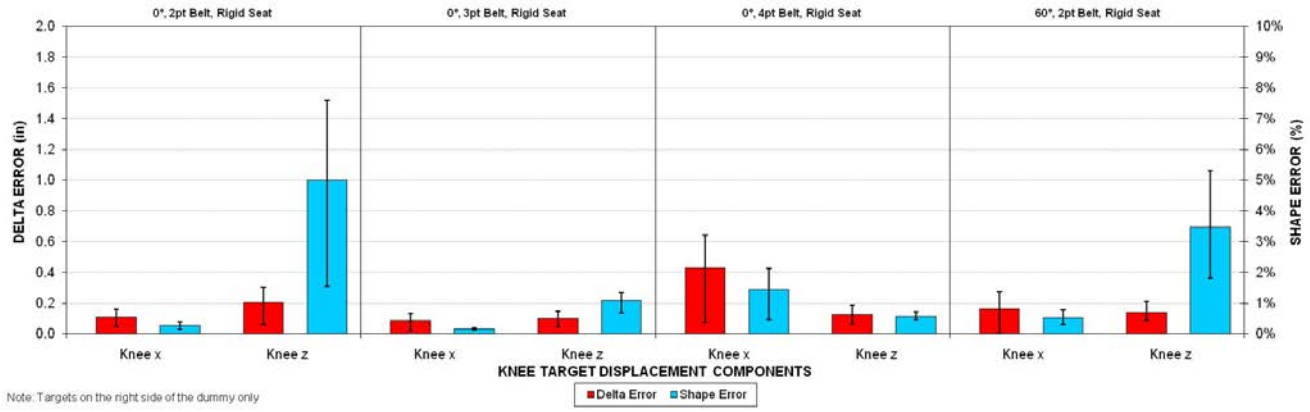


Figure 217. Averaged Knee Excursions of FAA Hybrid III ATD for Each Configuration

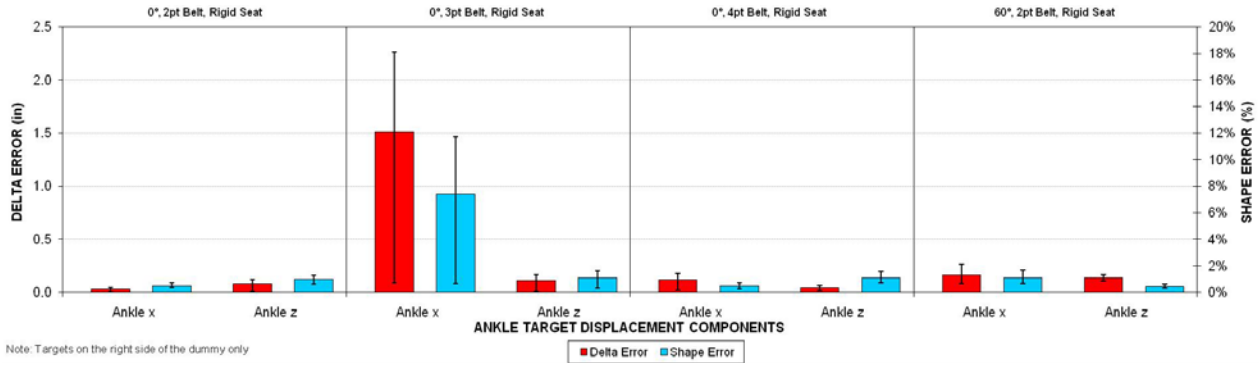


Figure 218. Averaged Ankle Excursions of FAA Hybrid III ATD for Each Configuration

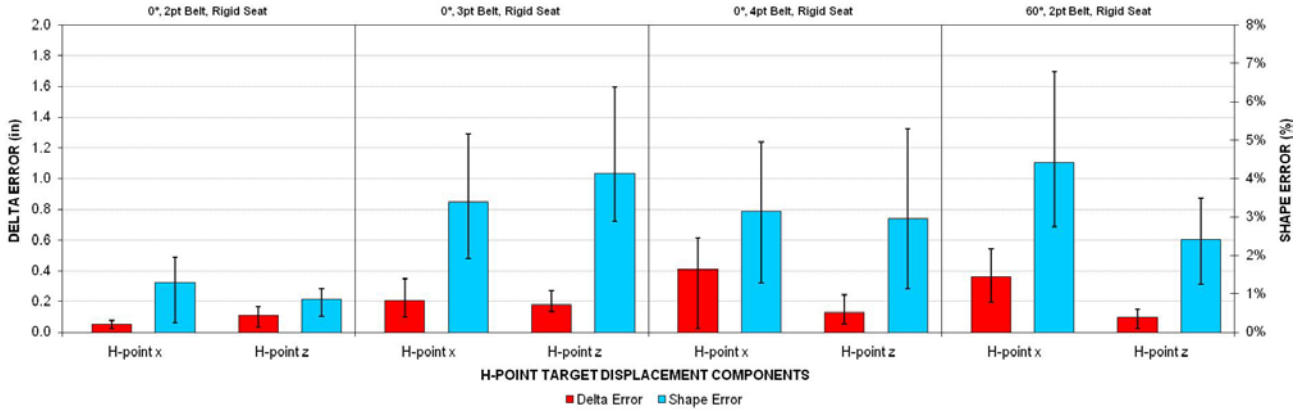


Figure 219. Averaged H-Point Excursions of FAA Hybrid III ATD for Each Configuration

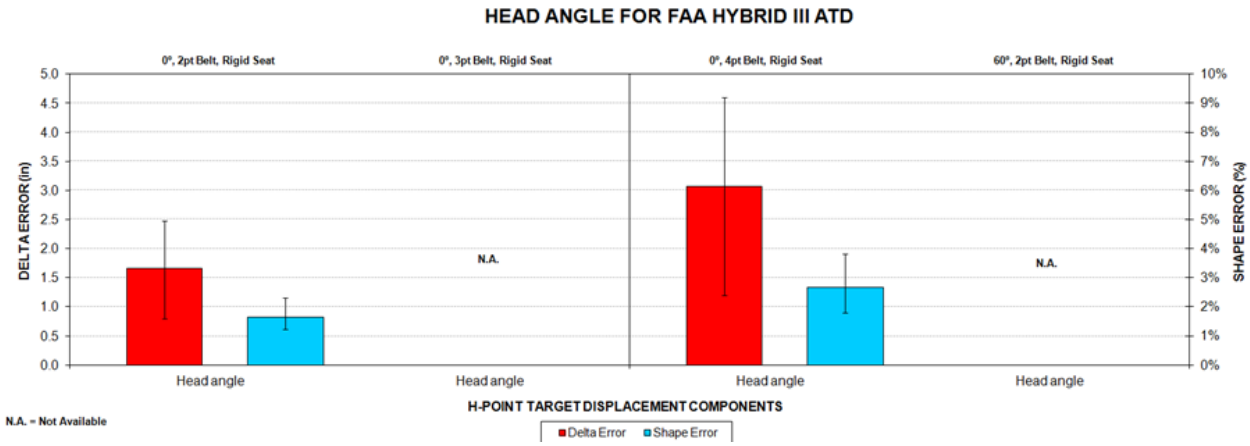


Figure 220. Averaged Head Angles of FAA Hybrid III ATD for Each Configuration

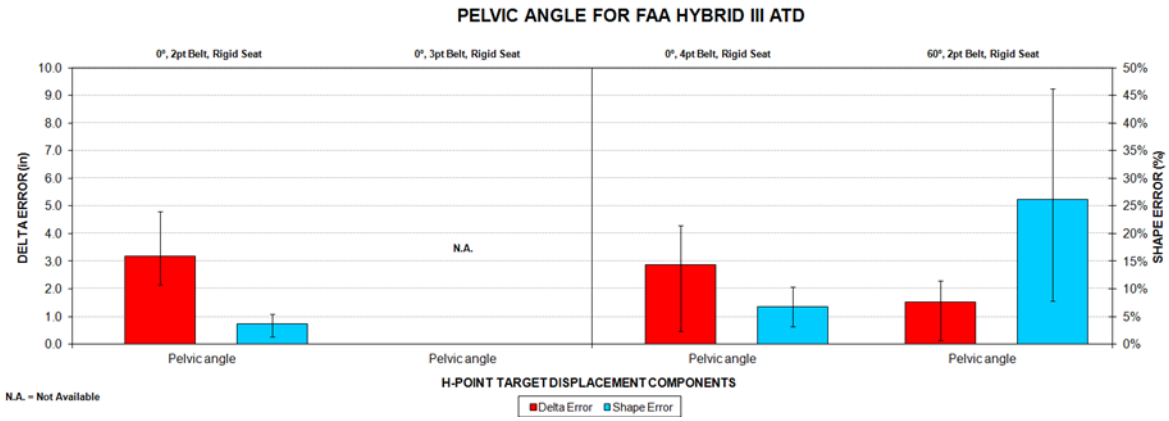


Figure 221. Averaged Pelvis Angles of FAA Hybrid III ATD for Each Configuration

4.2.2.3 The FAA Hybrid III ATD Upper End Limits Test Variability.

This section contains the following information:

- Summary and relevant responses of the ATD larger variability, which is calculated by using the maximum variability per channel among two-, three-, and four-point belts at 0° test configurations, and the two-point belt at 60° test configuration. Therefore, what is shown is the worst variability recorded by the FAA Hybrid III ATD output channels for Test Series 07324. The maximum errors are presented in figures 222 to 247 in the form of bar charts, where the bar's height corresponds to the largest average error value obtained among all configurations per channel. The brackets shown on each bar extend from the minimum to the maximum error value among all configurations per channel.

- The relevant maximum variability responses for horizontal and horizontal-vertical configurations.

- ATD kinematics maximum variability using the aforementioned criteria.

- Maximum variability recorded per channel, responses and kinematics for each configuration, which is also shown in the bar charts and summary tables. When referring to the bar charts, the error's height corresponds to the largest error value obtained from the compared test conditions.

- Maximum force, acceleration, and displacement errors are listed for all configurations in summary tables 44 to 51.

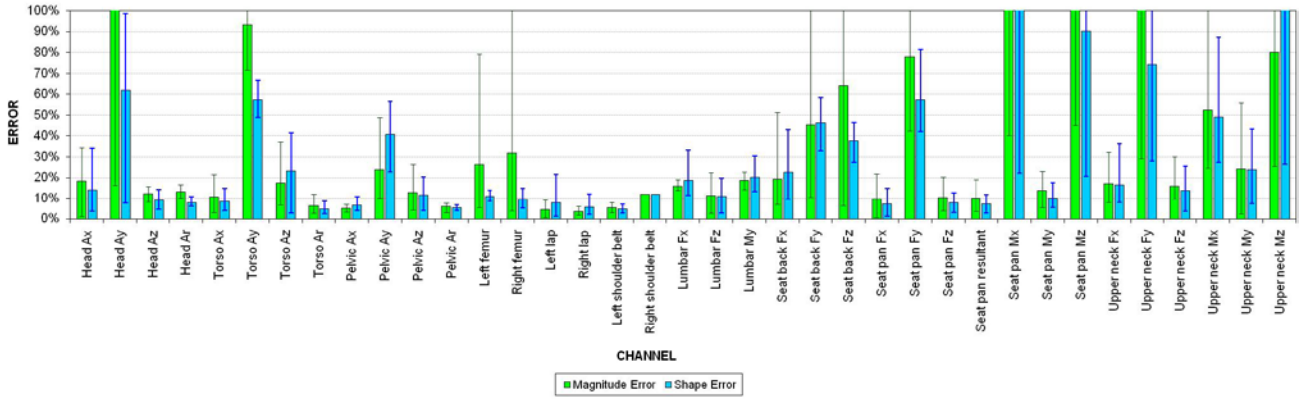


Figure 222. Averaged Responses of FAA Hybrid III ATD From All Test Conditions (Worst Scenario)

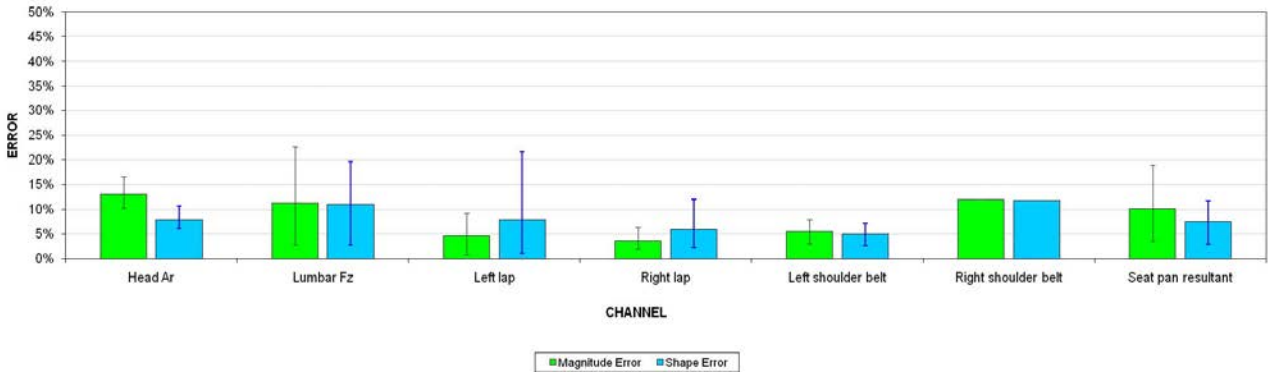


Figure 223. Compliance Response Variations of FAA Hybrid III ATD on All Tests (Worst Scenario)

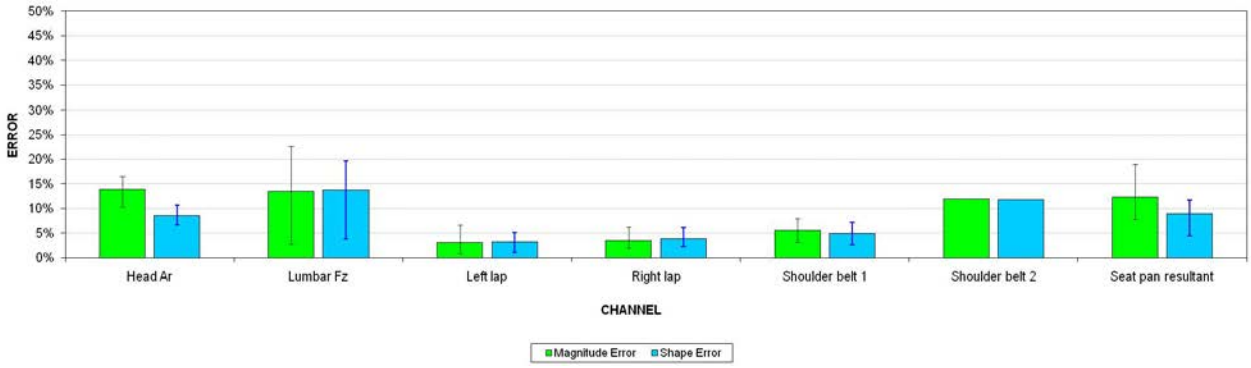


Figure 224. Compliance Response Variations of FAA Hybrid III ATD on All 0° Pitch Tests (Worst Scenario)

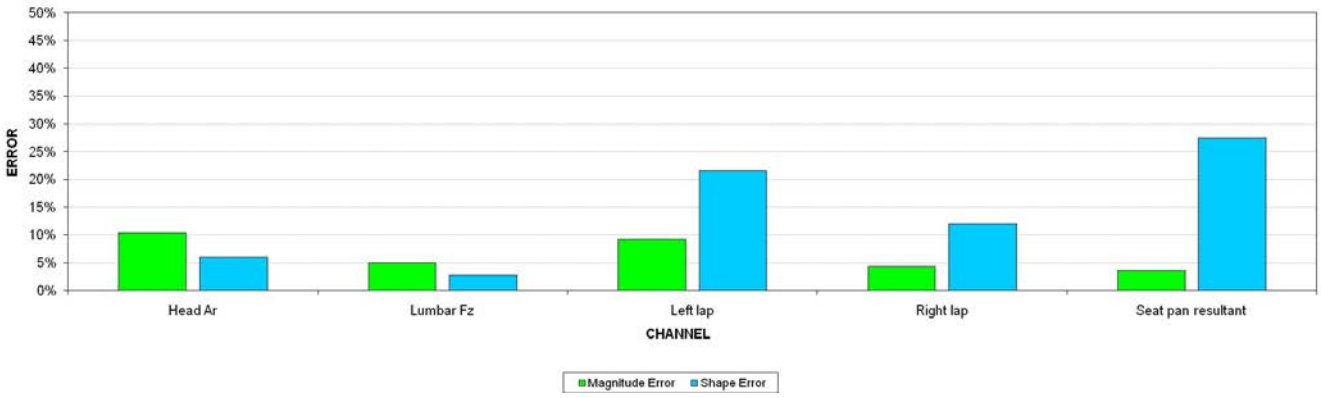


Figure 225. Compliance Response Variations of FAA Hybrid III ATD on All 60° Pitch Tests (Worst Scenario)

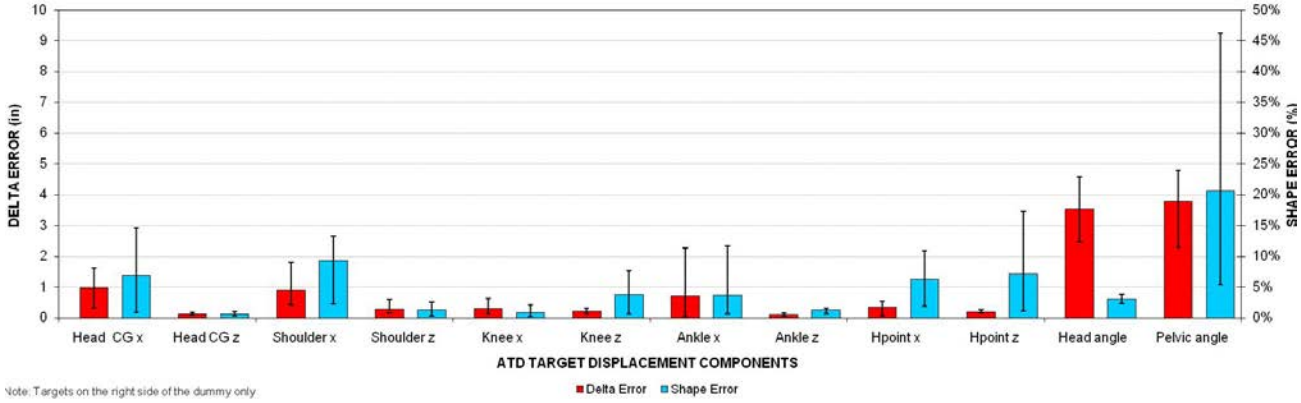


Figure 226. Displacement Response Variations of FAA Hybrid III ATD on All Tests (Worst Scenario)

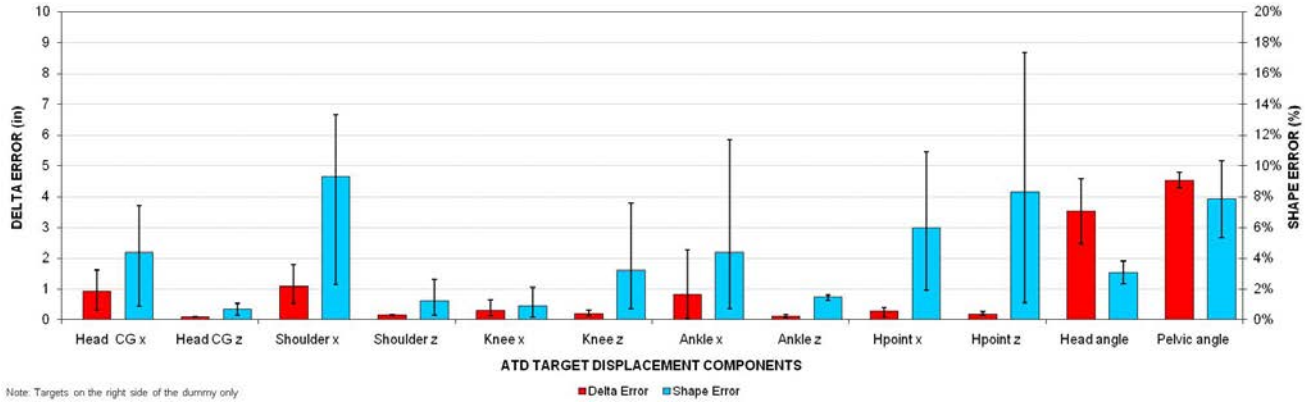


Figure 227. Displacement Response Variations of FAA Hybrid III ATD on All 0° Pitch Tests (Worst Scenario)

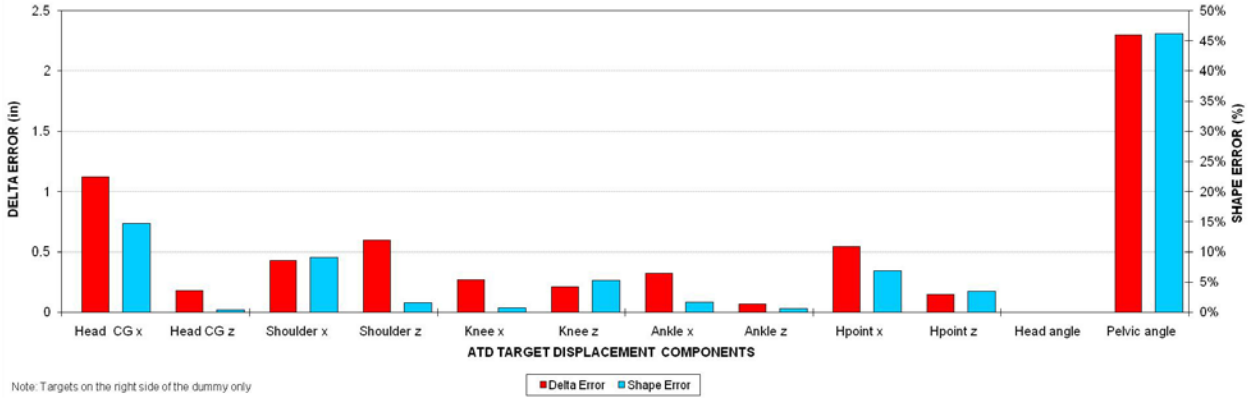


Figure 228. Displacement Response Variations of FAA Hybrid III ATD on All 60° Pitch Tests (Worst Scenario)

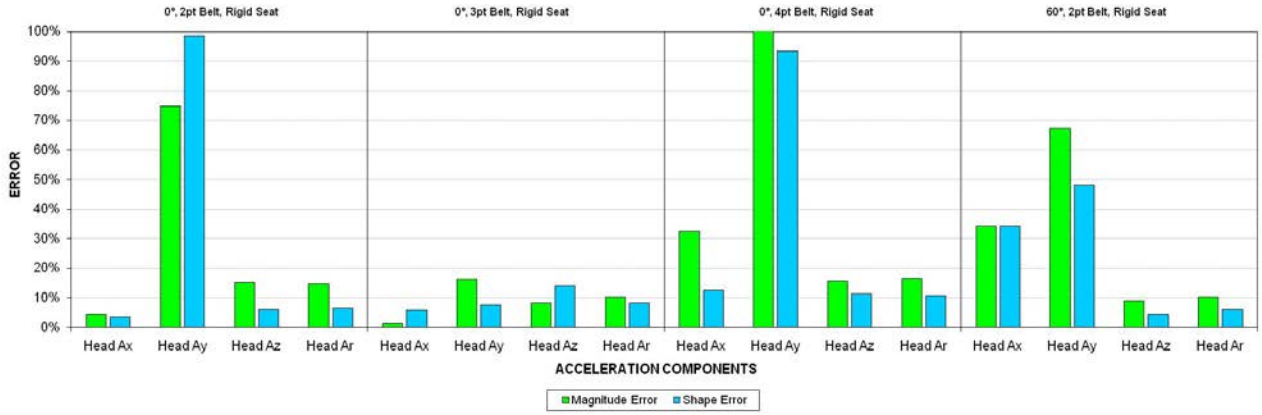


Figure 229. Head Acceleration Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

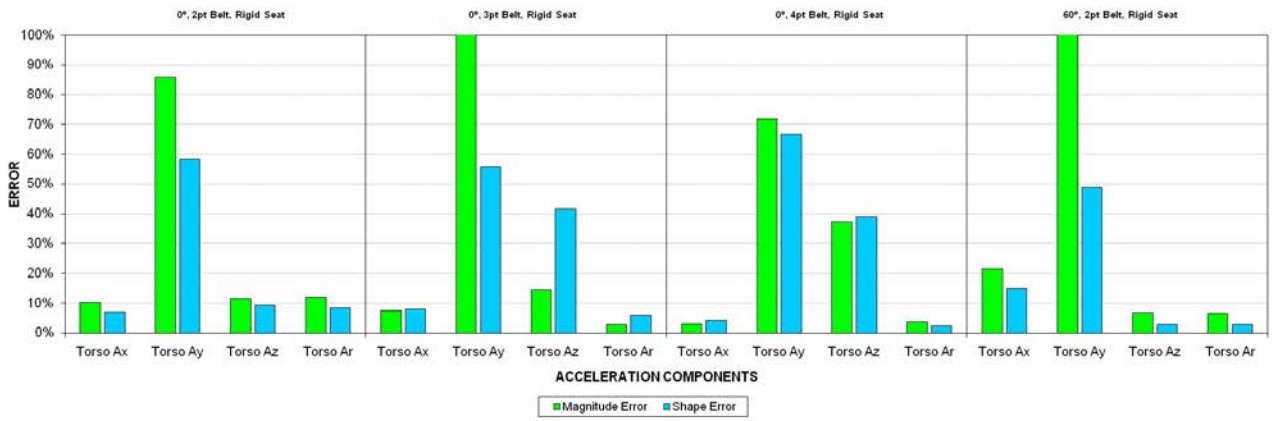


Figure 230. Torso Acceleration Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

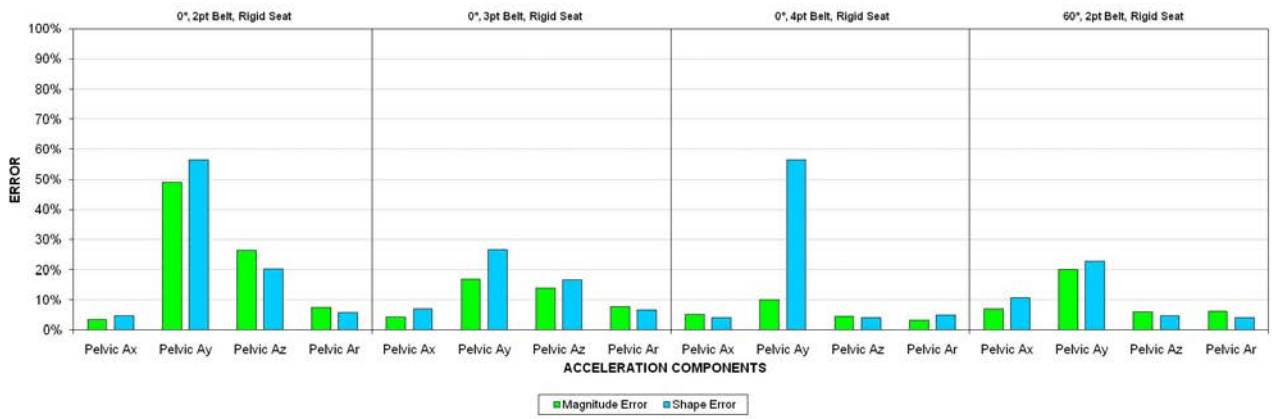


Figure 231. Pelvis Acceleration Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

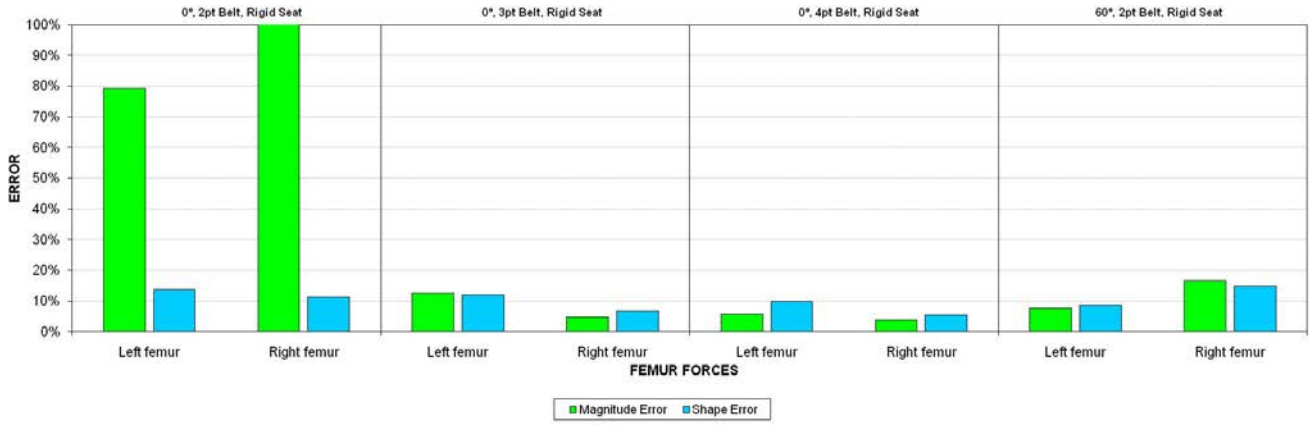


Figure 232. Femur Force Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

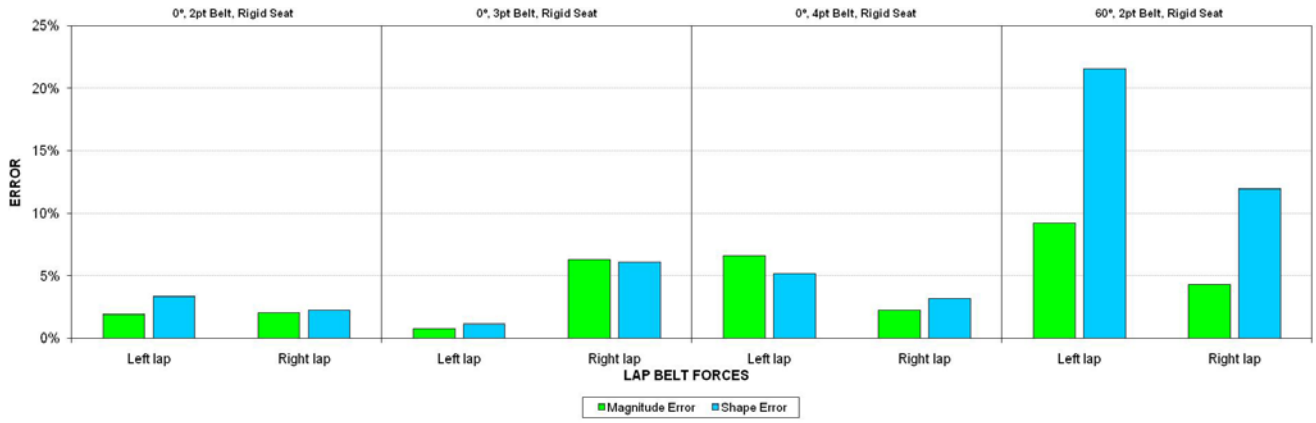


Figure 233. Lap Belt Force Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

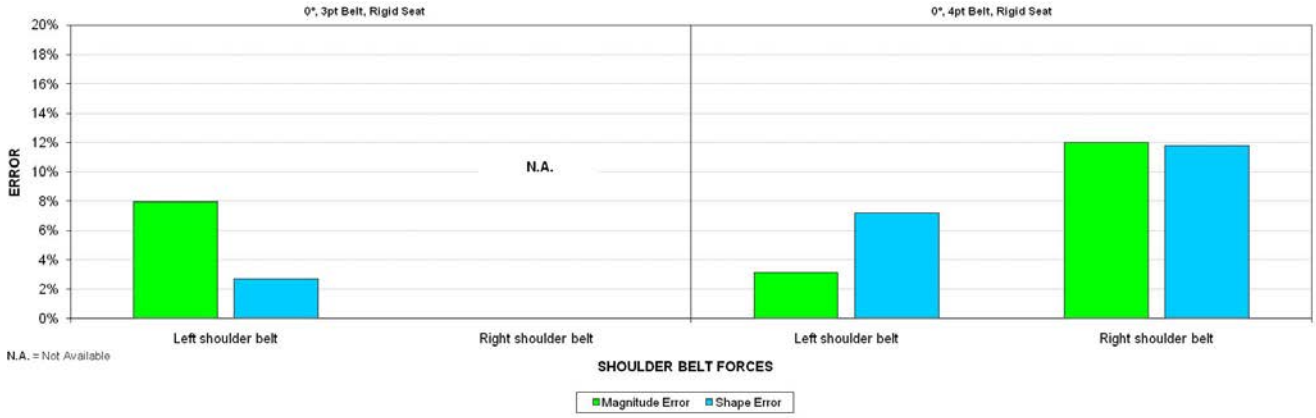


Figure 234. Shoulder Belt Force Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

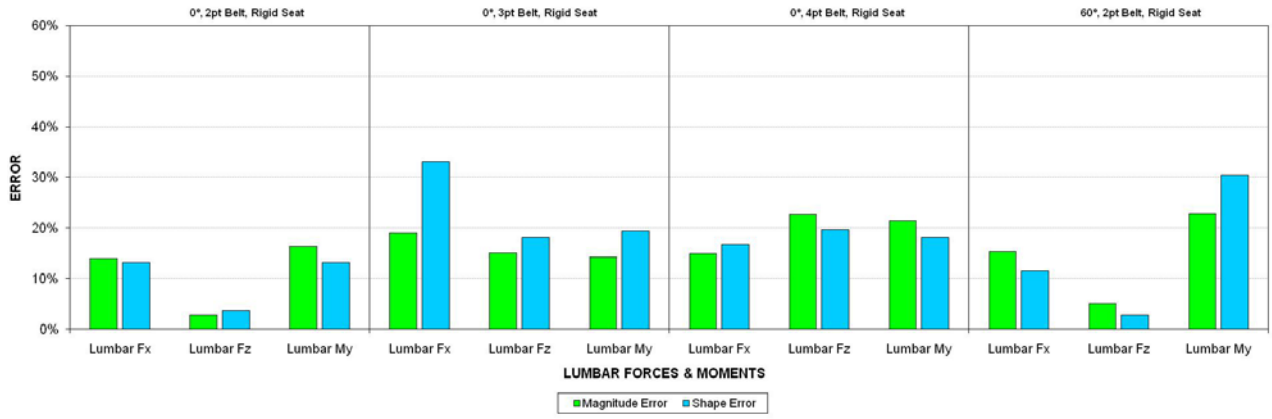


Figure 235. Lumbar Force Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

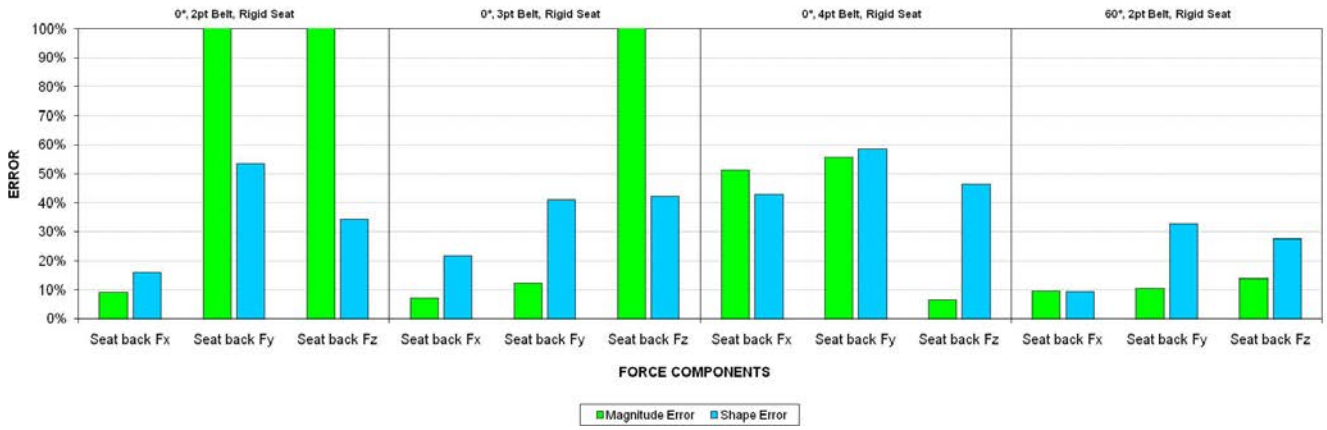


Figure 236. Seat Back Force Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

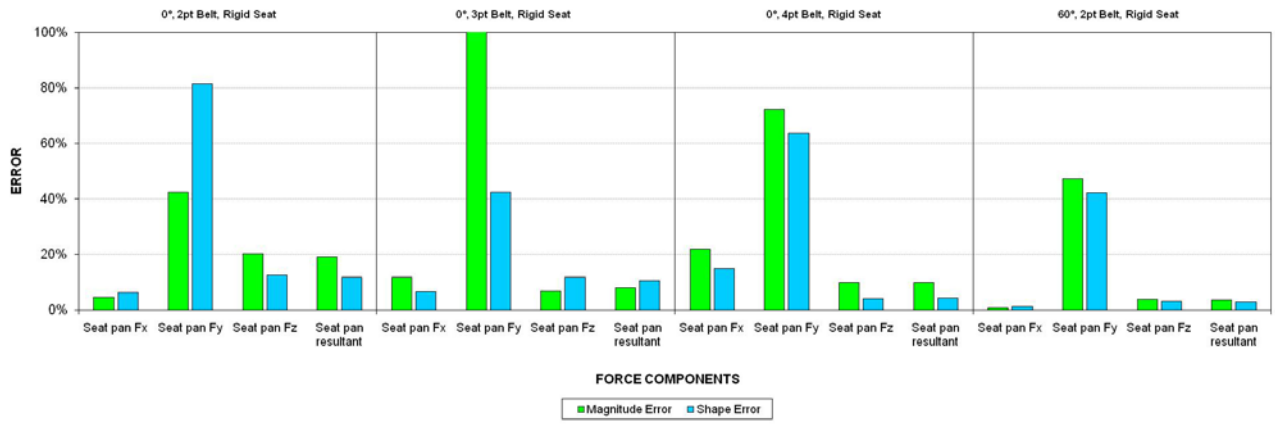


Figure 237. Seat Pan Force Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

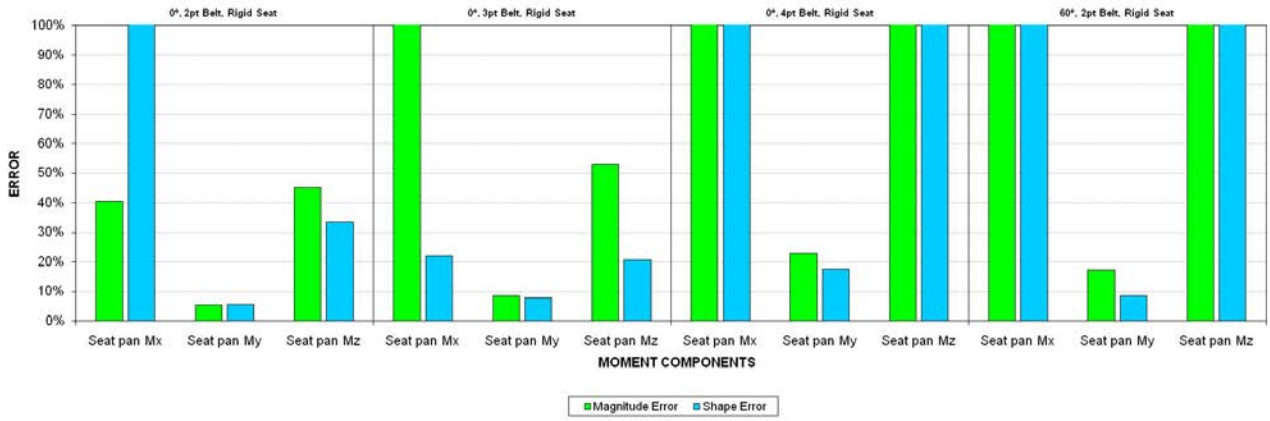


Figure 238. Seat Pan Moments Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

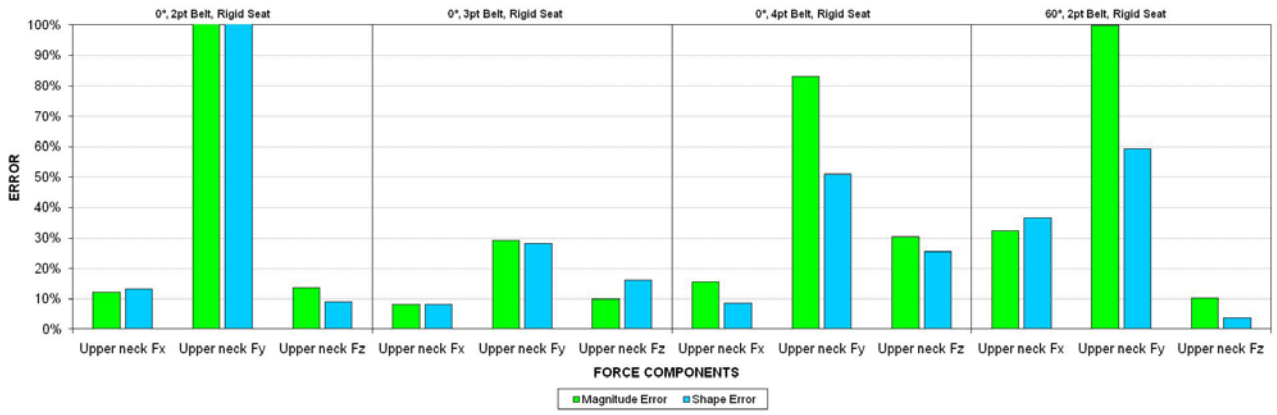


Figure 239. Neck Forces Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

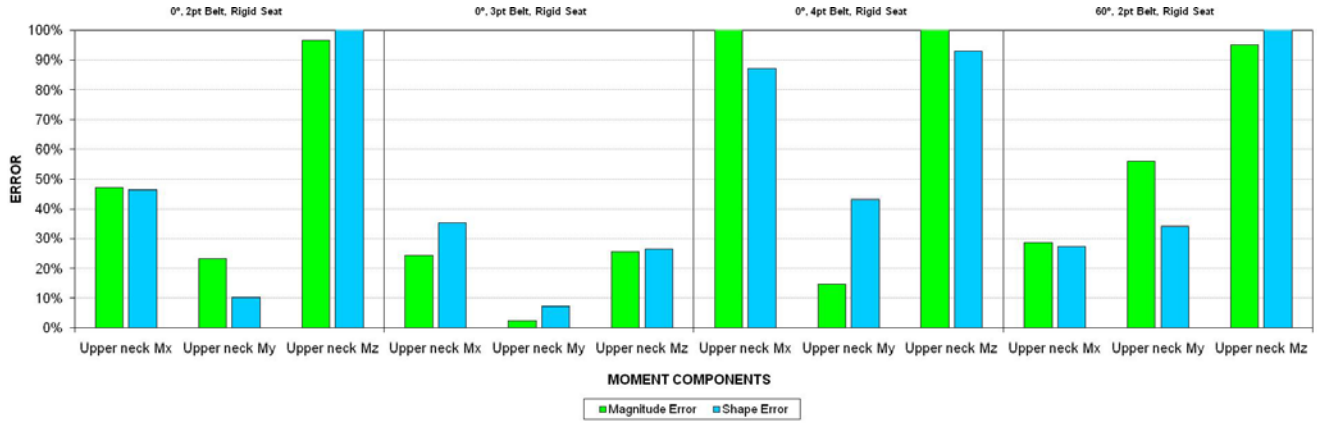


Figure 240. Neck Moments Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

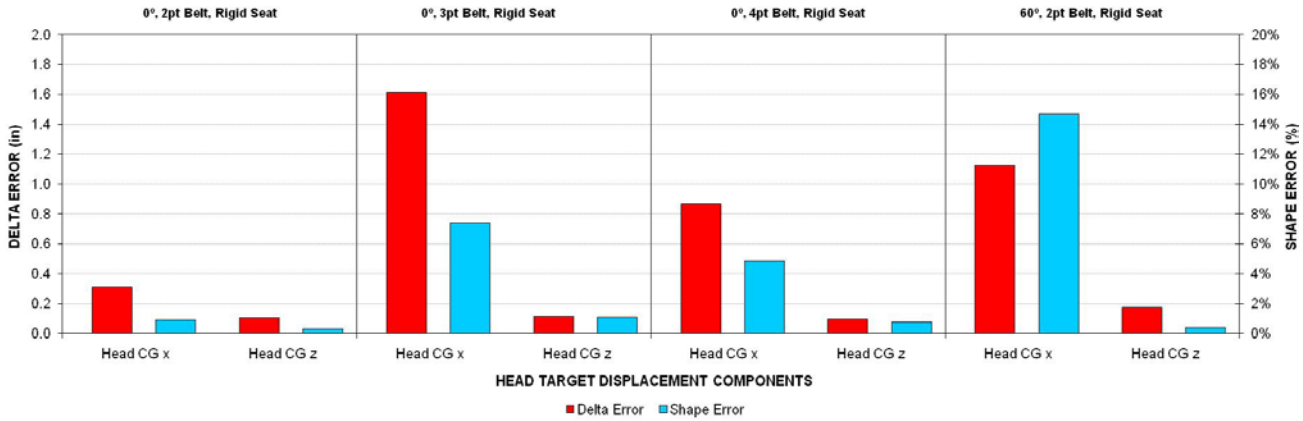


Figure 241. Head Excursion Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

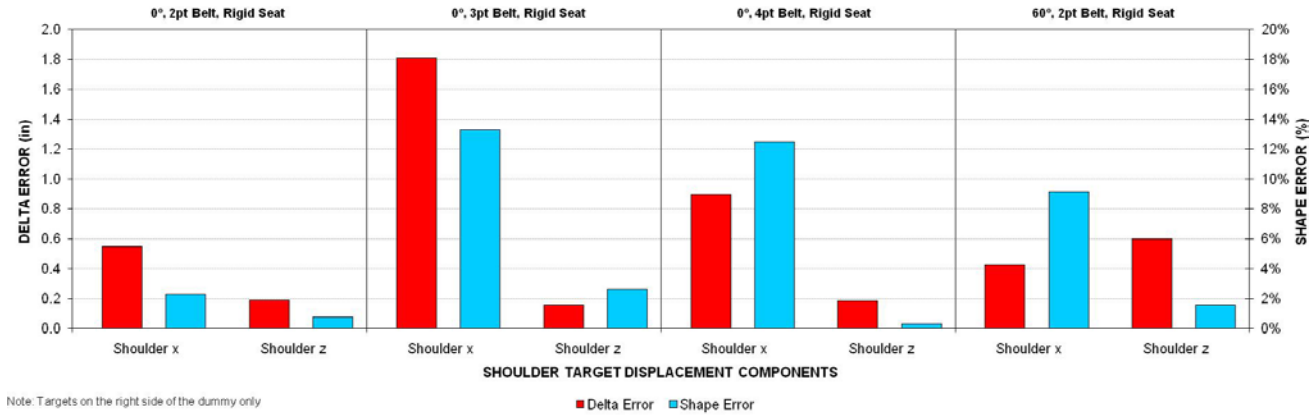


Figure 242. Shoulder Excursion Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

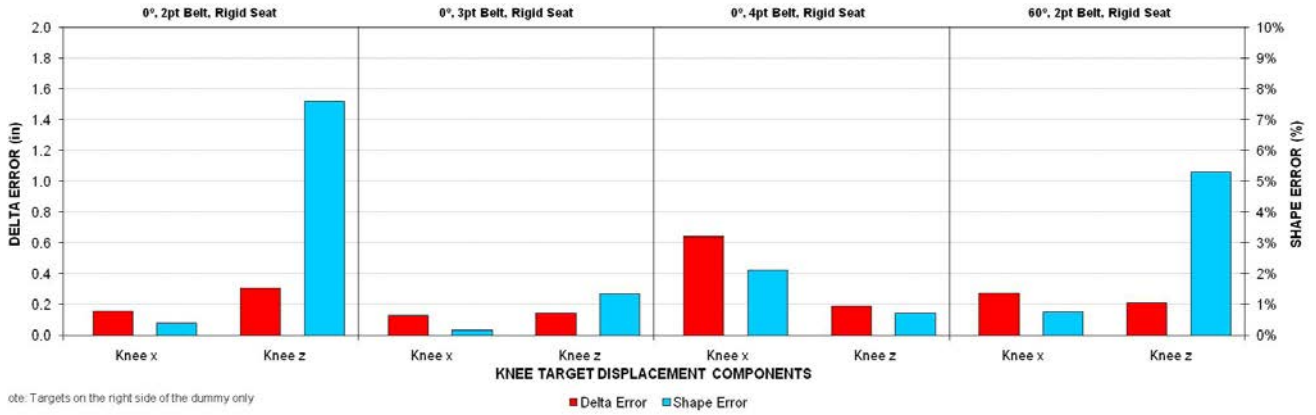


Figure 243. Knee Excursion Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

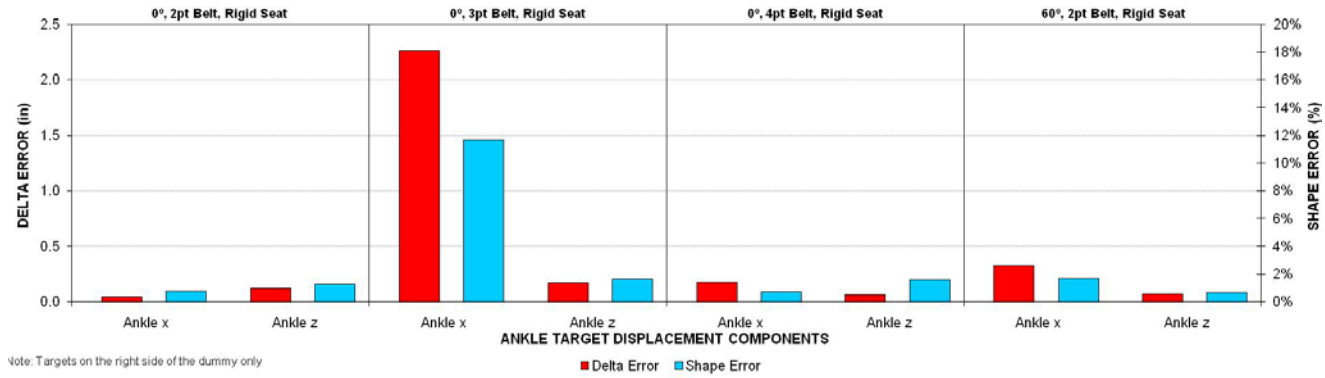


Figure 244. Ankle Excursion Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

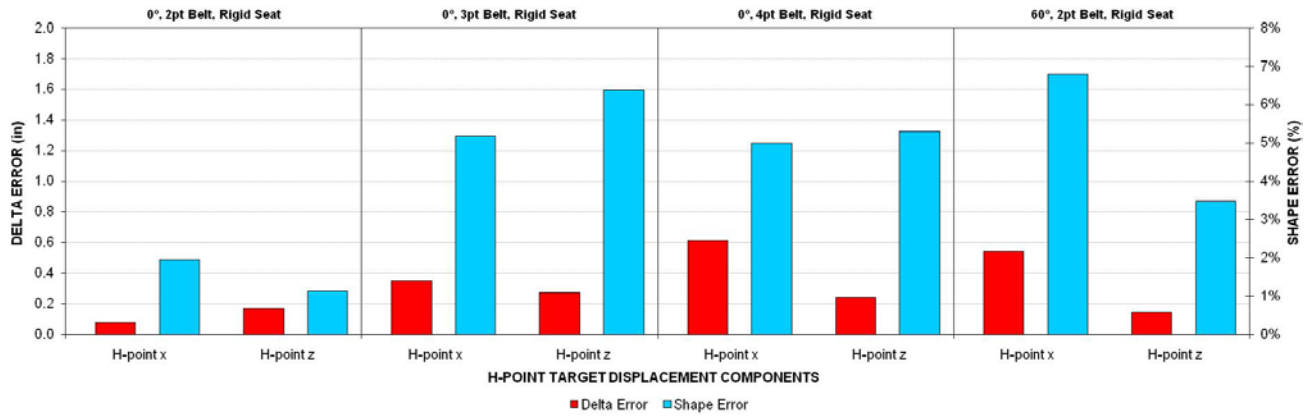


Figure 245. H-Point Excursion Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

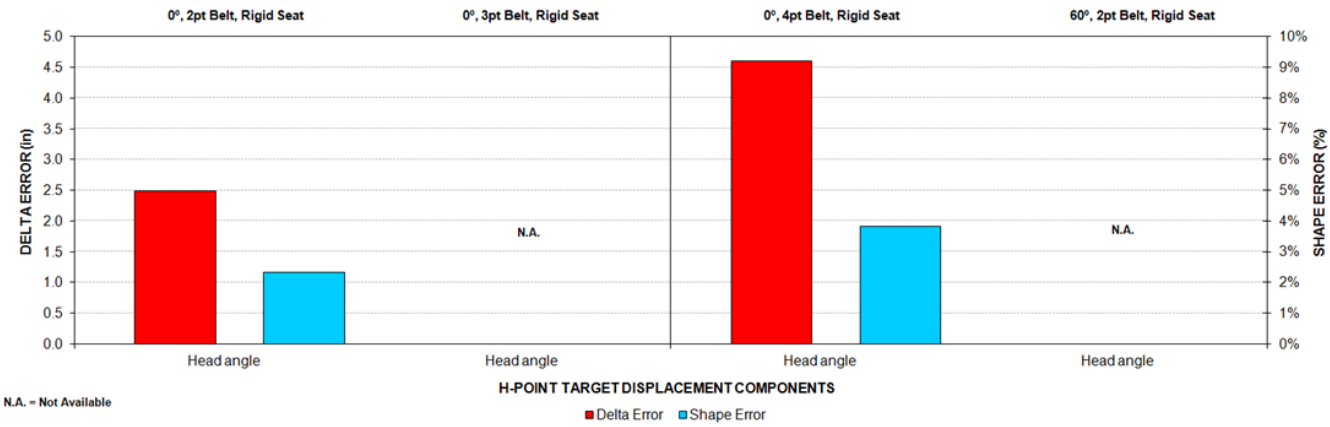


Figure 246. Head Angle Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

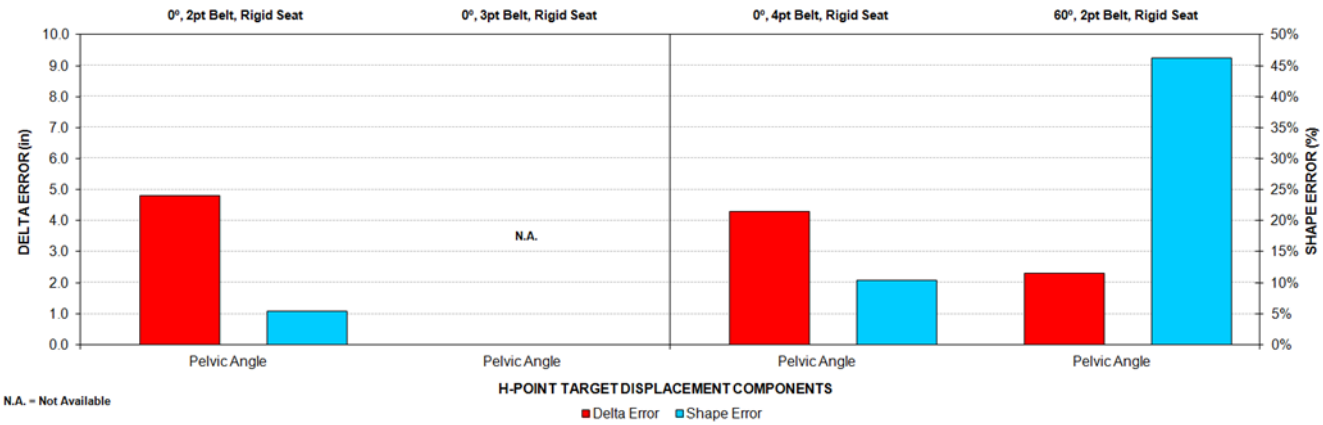


Figure 247. Pelvis Angle Response Variations of FAA Hybrid III ATD at 0° and 60° Pitch for All Restraint Configurations (Worst Scenario)

Table 44. The FAA Hybrid III ATD With Two-Point Belt at 0° Pitch—Force, Moment, and Acceleration Data Channels Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error
Sled Ax	0	2	0.1 g	Lumbar Fz	3	4	75.8 lbf
Head Ax	4	4	1.0 g	Lumbar My	16	13	373.6 in-lb
Head Ay	75	99	4.8 g	Seat back Fx	9	16	15.4 lbf
Head Az	15	6	9.8 g	Seat back Fy	103	53	54.9 lbf
Head Ar	15	7	10.1 g	Seat back Fz	135	34	65.3 lbf
Chest Ax	10	7	1.1 g	Seat pan Fx	5	6	62.3 lbf
Chest Ay	86	58	2.0 g	Seat pan Fy	42	81	43.4 lbf
Chest Az	12	9	3.7 g	Seat pan Fz	20	13	923.1 lbf
Chest Ar	12	9	3.8 g	Seat pan resultant	19	12	893.6 lbf
Pelvis Ax	3	5	1.0 g	Seat pan Mx	40	101	1209.5 in-lb
Pelvis Ay	49	57	2.3 g	Seat pan My	5	6	1503.8 in-lb
Pelvis Az	26	20	4.9 g	Seat pan Mz	45	34	775.4 in-lb
Pelvis Ar	7	6	2.2 g	Upper neck Fx	12	13	38.0 lbf
Left femur	79	14	400.0 lbf	Upper neck Fy	305	159	107.9 lbf
Right femur	102	11	554.8 lbf	Upper neck Fz	14	9	97.8 lbf
Left lap	2	3	34.8 lbf	Upper neck Mx	47	46	39.8 in-lb
Right lap	2	2	35.8 lbf	Upper neck My	23	10	125.2 in-lb
Lumbar Fx	14	13	170.2 lbf	Upper neck Mz	97	147	56.3 in-lb

Table 45. The FAA Hybrid III ATD With Two-Point Belt at 0° Pitch—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	1	0.3	Right ankle x	1	0.0
Head path z direction	0.3	0.1	Right ankle z	1	0.1
Right shoulder x	2	0.5	H-point x	2	0.1
Right shoulder z	1	0.2	H-point z	1	0.2
Right knee x	0.6	0.2	Head angle	2	2.5
Right knee z	8	0.3	Pelvis angle	5	4.8

Table 46. The FAA Hybrid III ATD With Three-Point Belt at 0° Pitch—Force, Moment, and Acceleration Data Channels Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error
Sled Ax	2	3	0.4 g	Lumbar Fx	19	33	59.4 lbf
Head Ax	1	6	0.3 g	Lumbar Fz	15	18	49.2 lbf
Head Ay	16	8	1.4 g	Lumbar My	14	19	148.9 in-lb
Head Az	8	14	3.0 g	Seat back Fx	7	22	163.3 lbf
Head Ar	10	8	4.1 g	Seat back Fy	12	41	26.1 lbf
Chest Ax	8	8	2.5 g	Seat back Fz	101	42	127.5 lbf
Chest Ay	109	56	2.6 g	Seat pan Fx	12	7	54.6 lbf
Chest Az	15	42	1.9 g	Seat pan Fy	150	43	111.3 lbf
Chest Ar	3	6	1.2 g	Seat pan Fz	7	12	88.8 lbf
Pelvis Ax	4	7	1.5 g	Seat pan resultant	8	11	107.6 lbf
Pelvis Ay	17	27	1.1 g	Seat pan Mx	257	22	1546.1 in-lb
Pelvis Az	14	17	2.7 g	Seat pan My	9	8	399.6 in-lb
Pelvis Ar	8	7	2.5 g	Seat pan Mz	53	21	149.6 in-lb
Left femur	13	12	47.9 lbf	Upper neck Fx	8	8	15.0 lbf
Right femur	5	7	15.7 lbf	Upper neck Fy	29	28	24.8 lbf
Left lap	1	1	13.4 lbf	Upper neck Fz	10	16	32.2 lbf
Right lap	6	6	146.2 lbf	Upper neck Mx	24	35	51.7 in-lb
Left shoulder belt	8	3	126.1 lbf	Upper neck My	2	7	14.4in-lb
				Upper neck Mz	26	27	9.2 in-lb

Table 47. The FAA Hybrid III ATD With Three-Point Belt at 0° Pitch—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	7	1.6	H-point x	5	0.4
Head path z direction	1	0.1	H-point z	6	0.3
Right shoulder x	13	1.8	Left shoulder x	10	0.5
Right shoulder z	3	0.2	Left shoulder z	2	0.4
Right knee x	0	0.1	Left knee x	1	0.1
Right knee z	7	1.6	Left knee z	12	2.3
Right ankle x	12	2.3	Head angle	N/A	N/A
Right ankle z	2	0.2	Pelvis angle	N/A	N/A

N/A = not applicable

Table 48. The FAA Hybrid III ATD With Four-Point Belt at 0° Pitch—Force, Moment, and Acceleration Data Channels Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error (in.)	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error (in.)
Sled Ax	1	1	0.3 g	Lumbar Fx	15	17	51.5 lbf
Head Ax	33	13	10.5 g	Lumbar Fz	23	20	74.5 lbf
Head Ay	268	93	4.4 g	Lumbar My	21	18	212.8 in-lb
Head Az	16	11	5.5 g	Seat back Fx	51	43	164.6 lbf
Head Ar	17	11	7.2 g	Seat back Fy	56	59	52.2 lbf
Chest Ax	3	4	1.0 g	Seat back Fz	6	47	12.4 lbf
Chest Ay	72	67	1.1 g	Seat pan Fx	22	15	100.9 lbf
Chest Az	37	39	4.8 g	Seat pan Fy	72	64	42.6 lbf
Chest Ar	4	2	1.4 g	Seat pan Fz	10	4	191.9 lbf
Pelvis Ax	5	4	1.6 g	Seat pan resultant	10	4	194.0 lbf
Pelvis Ay	10	57	0.2 g	Seat pan Mx	479	361	699.0 in-lb
Pelvis Az	4	4	1.3 g	Seat pan My	23	18	2110.0 in-lb
Pelvis Ar	3	5	1.0 g	Seat pan Mz	123	179	194.4 in-lb
Left femur	6	10	16.5 lbf	Upper neck Fx	15	9	43.0 in-lb
Right femur	4	5	11.1 lbf	Upper neck Fy	83	51	10.4 lbf
Left lap	7	5	123.2 lbf	Upper neck Fz	30	25	88.6 lbf
Right lap	2	3	42.4 lbf	Upper neck Mx	110	87	26.4 in-lb
Left shoulder belt	3	7	25.8 lbf	Upper neck My	15	43	127.8 in-lb
Right shoulder belt	12	12	94.8 lbf	Upper neck Mz	103	93	10.7 in-lb

Table 49. The FAA Hybrid III ATD With Four-Point Belt at 0° Pitch—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	5	0.9	Right ankle x	1	0.2
Head path z direction	1	0.1	Right ankle z	2	0.1
Right shoulder x	12	0.9	H-point x	5	0.6
Right shoulder z	0.8	0.2	H-point z	5	0.2
Right knee x	2	0.6	Head angle	4	4.6
Right knee z	1	0.2	Pelvis angle	10	4.3

Table 50. FAA Hybrid III ATD With Two-Point Belt at 60° Pitch—Force, Moment, and Acceleration Data Channels Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error
Sled Ax	0	1	0.1 g	Lumbar Fz	5	3	85.2 lbf
Head Ax	34	34	1.9 g	Lumbar My	23	30	72.8 in-lb
Head Ay	68	48	0.8 g	Seat back Fx	10	9	27.5 lbf
Head Az	9	5	2.2 g	Seat back Fy	11	33	9.4 lbf
Head Ar	10	6	2.7 g	Seat back Fz	14	27	18.4 lbf
Chest Ax	22	15	0.6 g	Seat pan Fx	1	1	7.9 lbf
Chest Ay	107	49	0.9 g	Seat pan Fy	47	42	22.9 lbf
Chest Az	7	3	1.8 g	Seat pan Fz	4	3	121.7 lbf
Chest Ar	7	3	1.7 g	Seat pan resultant	4	3	116.1 lbf
Pelvis Ax	7	11	0.4 g	Seat pan Mx	316	236	960.2 in-lb
Pelvis Ay	20	23	0.4 g	Seat pan My	17	9	499.3 in-lb
Pelvis Az	6	5	1.5 g	Seat pan Mz	237	128	231.6 in-lb
Pelvis Ar	6	4	1.5 g	Upper neck Fx	32	36	15.2 lbf
Left femur	8	9	5.2 g	Upper neck Fy	100	59	5.1 lbf
Right femur	17	15	12.5 g	Upper neck Fz	10	4	24.1 lbf
Left lap	9	22	16.2 lbf	Upper neck Mx	29	27	4.8 in-lb
Right lap	4	12	7.2 lbf	Upper neck My	56	34	28.8 in-lb
Lumbar Fx	15	12	22.4 lbf	Upper neck Mz	95	140	4.8 in-lb

Table 51. FAA Hybrid III ATD With Two-Point Belt at 60° Pitch—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	15	1.1	Right ankle x	2	0.3
Head path z direction	0.5	0.2	Right ankle z	1	0.1
Right shoulder x	9	0.4	H-point x	7	0.5
Right shoulder z	2	0.6	H-point z	3	0.1
Right knee x	1	0.3	Head Angle	N/A	N/A
Right knee z	5	0.2	Pelvis Angle	46	2.3

N/A = not applicable

5. SUMMARY.

The results showed that under the 14 CFR 23.562 horizontal test condition, the use of a four-point restraint belt resulted in reduced values of Head Injury Criteria (HIC (unlimited)) compared to the three-point restraint belt for both the Hybrid II and the FAA Hybrid III ATD.

The results also show that, in general, less variability was observed in the FAA Hybrid III ATDs when compared to the Hyrbid II ATDs. Tables 52 and 53 summarize the test-to-test variability for the channels defined necessary by the SAE ARP 5765 Working Group. Table 54 summarizes the channel evaluation period for the tests conducted. These values will be used by the SAE ARP 5765 Working Group to help define the allowable errors when validating numerical models of the Hybrid II and FAA Hybrid III anthropomorphic test dummies. Table 55 summarizes the maximum allowable peak error for forward-facing ATDs.

Table 52. Maximum Test Peak Error for Forward-Facing Hybrid II and FAA Hybrid III ATDs

Channel Description	Forward-Facing Two-Point Hybrid II/FAA Hybrid III ATD	60° Two-Point* Hybrid II/FAA Hybrid III ATD	Forward-Facing Three-Point Hybrid II/FAA Hybrid III ATD	Forward-Facing Four-Point Hybrid II/FAA Hybrid III ATD
Upper neck Fx*			NA/8%	NA/15%
Upper neck Fy*			NA/29%	
Upper neck Fz*			NA/10%	NA/30%
Upper neck Mx*			NA/24%	
Upper neck My*			NA/2%	NA/15%
Chest Ax (CFC 180)			9%/8%	21%/3%
Lumbar Fz		4%/5%		
Right lap belt load	6%/2%		1%/6%	5%/2%
Left lap belt load	6%/2%		8%/1%	7%/7%
Right shoulder belt load				6%/12%
Left shoulder belt load			4%/8%	13%/3%
Seat pan Fx	39%/5%	2.66%/1%	10%/12%	34%/22%
Seat pan Fz	21%/20%	5%/4%	20%/7%	16%/10%
Seat pan My	14%/5%	3%/17%	7%/9%	66%/23%
Head c.g. x position	0.4 in./0.3 in.		0.2 in./1.6 in.	1.2 in./0.9 in.
Head c.g. z position				0.4 in./0.1 in.
H-point x position	0.1 in./0.1 in.		0.7 in./0.4 in.	1.1 in./0.4 in.
H-point z position	0.1 in./0.2 in.	0.02/0.1 in.		
Right knee x position	0.5 in./0.2 in.			1.3 in./0.6 in.
Right shoulder x position			0.4 in./0.5 in.	1.2 in./0.9 in.
Right shoulder z position				0.5 in./0.2 in.
Left shoulder x position			0.3 in./1.8 in.	
Head angle				7.5°/4.6°
Pelvis angle	2.3°/4.8°	0.4°/2.3°		13.9°/4.3°

*Only two tests (07324-11 and 07324-12) used for the Hybrid II ATD with two-point belt at 60° configuration. See appendix G.

Table 53. Maximum Test Curve Shape Error for Forward-Facing Hybrid II and FAA Hybrid III ATDs

Channel Description	Forward-Facing Two-Point Hybrid II/FAA Hybrid III ATD (%)	60° Two-Point* Hybrid II/FAA Hybrid III ATD (%)	Forward-Facing Three-Point Hybrid II/ FAA Hybrid III ATD (%)	Forward-Facing Four-Point Hybrid II/FAA Hybrid III ATD (%)
Upper neck Fx			NA/8	NA/9
Upper neck Fy			NA/28	
Upper neck Fz			NA/16	NA/25
Upper neck Mx			35/40	
Upper neck My			7/10	NA/43
Chest Ax (CFC 180)			9/8/10	10/4
Lumbar Fz		3/3		
Lumbar My		3/30		
Right lap belt load	6/2		1/6	3/3
Left lap belt load	2/3		7/1	4/5
Right shoulder belt load				8/12
Left shoulder belt load			2/3	14/7
Seat pan Fx	24/6	2.5/1	10/7	15/15
Seat pan Fz	15/13	3/3	13/12	16/4
Seat pan My	10/6/	3/9	6/8	64/18
Head c.g. x position	3/1	1/15	1/7	6/5
Head c.g. z position	1/0.3	0.1/0.5	2/1	2/1
H-point x position	1/2		11/5	13/11
H-point z position	1/1	1/3		
Right knee x position	1/0.6			4/2/
Right knee z position	18/8			13/1
Right ankle x position	7/1			
Right ankle z position	2/1			
Right shoulder x position			6/10	15/12
Right shoulder z position			1/2	2/0.8
Left shoulder x position			1/13	
Left shoulder z position			3/3	
Head angle	6/2			6/4
Pelvis angle	7/5	7/46		44/10

*Only two tests (07324-11 and 07324-12) used for the Hybrid II ATD with two-point belt at 60° configuration. See appendix G.

Table 54. Evaluation Period for Forward-Facing Hybrid II and FAA Hybrid III ATDs

Channel Description	Forward-Facing Two-Point Hybrid II and FAA Hybrid III ATD (ms)	60° Two-Point* Hybrid II and FAA Hybrid III ATD (ms)	Forward-Facing Three-Point Hybrid II and FAA Hybrid III ATD (ms)	Forward-Facing Four-Point Hybrid II and FAA Hybrid III ATD (ms)
Upper neck Fx			180	150
Upper neck Fy			180	
Upper neck Fz			180	150
Upper neck Mx			180	
Upper neck My			180	150
Upper neck Mz			180	
Chest Ax (CFC 180)			100	150
Lumbar Fz		125		
Lumbar My		125		
Right lap belt load	200		180	150
Left lap belt load	200		180	150
Right shoulder belt load				150
Left shoulder belt load			180	150
Seat pan Fx	200	125	180	150
Seat pan Fz	200	125	180	150
Seat pan My	200	125	180	150
Head c.g. x position	175	125	180	150
Head c.g. z position	175	125	180	150
H-point x position	175		180	150
H-point z position	175	125		
Right knee x position	175			150
Right knee z position	175			150
Right ankle x position	175			
Right ankle z position	175			
Right shoulder x position			180	150
Right shoulder z position			180	150
Left shoulder x position			180	
Left shoulder z position			180	
Head angle	175			150
Pelvis angle	175	125		150

Table 55. Maximum Allowable Peak Error for Forward-Facing ATDs

Channel Description	Forward-Facing Two-Point Belt		Forward-Facing 60° Two-Point Belt		Forward-Facing Three-Point Belt		Forward-Facing Four-Point Belt	
Upper neck Fx *					10%	–	20%	–
Upper neck Fy *					30%	–		
Upper neck Fz *					15%	+	30%	+
Upper neck Mx *					25%	–		
Upper neck My *					10%	+	20%	+
Chest Ax (CFC 180)					10%	–	10%	–
Lumbar Fz			10%	–				
Right lap belt load	10%	+			10%	+	10%	+
Left lap belt load	10%	+			10%	+	10%	+
Right shoulder belt load							10%	+
Left shoulder belt load					10%	+	10%	+
Seat pan Fz	25%	–	10%	–	25%	–	10%	–
Seat pan My	20%	–	10%	–	10%	–	20%	–
Head c.g. x position	12.7 mm (0.5 in.)	+			44.45 mm (1.75 in.)	+	6.35 mm (0.25 in.)	+
Head c.g. z position							7.62 mm (0.3 in.)	–
H-point x position	6.35 mm (0.25 in.)	+			31.75 mm (1.25 in.)	+	12.7 mm (0.5 in.)	+
H-point z position	5.08 mm (0.2 in.)	+	2.54 mm (0.1 in.)	–				
Right knee x position	6.35 mm (0.25 in.)	+					12.7 mm (0.5 in.)	+
Right shoulder x position					50.8 mm (2.0 in.)	+	7.62 mm (0.3 in.)	+
Right shoulder z position							10.16 mm (0.4 in.)	–
Left shoulder x position					12.7 mm (0.5 in.)	+		
Head angle							8°	–
Pelvis angle	7°	–	3°	+			5°	+

6. CONCLUSIONS AND RECOMMENDATIONS.

The research presented in this document was conducted to provide the baseline test data required to define specifications for numerical occupant models of the Hybrid II and Federal Aviation Administration (FAA) Hybrid III anthropomorphic test dummies (ATD) suitable for aviation impact test simulations. The research also provides procedures for validation of both multibody

and finite element ATD models, and to convey modeling design guidelines to assist modelers in developing efficient and accurate models.

Prior to the completion of this work, existing anthropomorphic test dummy (ATD) specifications and calibration tests did not directly evaluate an ATD's response to all loading conditions that can occur during the dynamic testing of aircraft seats. To ensure that numerical ATDs adequately emulate physical ATDs when subjected to these unique loading conditions, comparisons with the results of representative full-scale sled tests were performed. The test parameters specified herein were defined to produce the range of ATD articulation, force application points, and force magnitudes that are typical of those observed during the tests of actual aircraft seats.

To minimize as many variables as possible, a rigid seat and restraint system with fixed anchorages were used. A series of 31 sled tests was conducted in the Crash Dynamics Laboratory of the National Institute for Aviation Research. Test data can be viewed at ftp://ftp.tc.faa.gov/actlibrary. A minimum of three repetitions for the following forward-facing configurations were evaluated for the Hybrid II and FAA Hybrid III ATDs:

- Forward-facing test with two-point belt, no toe stop, and acceleration pulse of 16 g's, Δv 44 ft/sec, Title 14 Code of Federal Regulations (CFR) 25.562 horizontal test condition

- Forward-facing 60° pitch test with two-point belt, and acceleration pulse of 19 g's, Δv 42 ft/sec, 14 CFR 23.562 vertical test condition

- Forward-facing test with three-point belt, adjustable shoulder belt to produce 1 inch of initial slack, and acceleration pulse of 21 g's, Δv 42 ft/sec, 14 CFR 23.562 horizontal test condition

- Forward-facing test with four-point belt, adjustable pre-tension of shoulder belts per SAE AS 8049 (about 5 lbf), and acceleration pulse of 21 g's, Δv 42 ft/sec, 14 CFR 23.562 horizontal test condition

For both the Hyrbid II and the FAA Hybrid III series of tests, the use of a four-point restraint belt resulted in reduced values of HIC (unlimited) compared to the two-point restraint belt.

In general, less variability was observed in the FAA Hybrid III ATDs when compared to the Hybrid II ATDs. Based on the data from this series and the previous results from the NIAR 06165 series tests, a report will be published highlighting the differences between the Hybrid II and the FAA Hybrid III ATDs, paying special attention to the Title 14 Code of Federal Regulations Part 23.562 vertical test condition for the lumbar load.

The data presented in this report provides data to support Aerospace Recommended Practice (ARP) 5765. ARP 5765 will provide the specifications and performance criteria for aviation-specific numerical ATD occupant models. It will define the minimum set of test parameters and data needed to evaluate the degree of correlation between the model and the physical test, and provide procedures for quantitative comparison of test and modeling results.

7. REFERENCES.

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10. AC 2 x.562-1A, 19 Jan 96, "Guidance for Demonstrating Compliance With Seat Dynamic Testing Deceleration Pulse Shapes," FAA memorandum, 1997.

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12. Sprague, M.A. and Geers, T.L., "A Spectral-Element Method for Modeling Cavitation in Transient Fluid-Structure Interaction," *International Journal for Numerical Methods in Engineering*, Vol. 60, No. 15, 2004, pp. 2467-2499.

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Calibration and Quality Systems Lab

NATIONAL INSTITUTE FOR AVIATION RESEARCH
Wichita State University

Hybrid II 50th Percentile Male

HII-50M (Model SA-150-M002)

SERIAL NUMBER: 698

CERTIFICATION DUE DATE: 12 April 2008
Supervisor: Joseph Mitchell
Technician: Andy Mackey

National Institute for Aviation Research, a KTEC Center of Excellence
Wichita State University • 1845 N. Fairmount • Wichita, KS 67260-0093
p: 316.978.6427 • f: 316.978.3175
www.niar.wichita.edu

Figure A-1. The 2007 Hybrid II 50th Percentile Male, Serial Number 698 Certification

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Wichita, KS 67260

Cert ID:	
Test ID:	1299
Test Date:	04/12/2007
Test Time:	02:50 PM

Test: Hybrid II 50th, Thorax, High Speed

Customer:	NIAR		
Serial Number:	698	**Corridor Type:**	NHTSA
Part Condition:	Used	**Work Instruction:**	119 inches

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		6.64	6.68	6.78	m/sec	Pass
Max Resistive Force	0.00		-10.01	-9.33	.00	kN	Pass
Peak Chest Deflection	0.00		-43.00	-31.58	.00	mm	Pass
Hysteresis	0.00		50.00	69.56	70.00	%	Pass
Temperature	0.00		18.90	22.30	25.60	degC	Pass
Humidity	0.00		10.00	37	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	09/26/07	1.00187	3000	None
2	Probe Accel	C19814	0	09/19/07	198.391	3000	180
3	Chest Pot	0022	0	12/14/07	0.99782	3000	180
	Probe	291-H3 50 TH	0	09/21/07	0	0	

Comments:

Technician: **Test Supervisor:**

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Figure A-2. The 2007 Hybrid II 50th Percentile Male, High Speed, Thorax, Serial Number 698 Certification

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Wichita, KS 67260

Cert ID:
Test ID: 1301
Test Date: 04/12/2007
Test Time: 03:51 PM

Test: Hybrid II 50th, Thorax, Low Speed

Customer: NIAR
Serial Number: 698
Part Condition: Used
Corridor Type: NHTSA
Work Instruction: 68.4 in

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		4.23	4.26	4.31	m/sec	Pass
Max Resistive Force	0.00		-6.45	-5.81	.00	kN	Pass
Peak Chest Deflection	0.00		-28.00	-20.23	.00	mm	Pass
Hysteresis	0.00		50.00	65.99	70.00	%	Pass
Temperature	0.00		18.90	22.30	25.60	degC	Pass
Humidity	0.00		10.00	38	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	09/26/07	1.00199	3000	None
2	Probe Accel	C19814	0	09/19/07	198.383	3000	180
3	Chest Pot	0022	0	12/14/07	0.99782	3000	180
	Probe	291-H3 50 Th	0	09/21/07	0	0	

Comments:

Technician: **Test Supervisor:**

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Figure A-3. The 2007 Hybrid II 50th Percentile Male, Low Speed, Serial Number 698 Certification

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Cert ID:	0
Test ID:	1294.01
Test Date:	04/10/2007
Test Time:	04:01 PM

Test: Hybrid II 50th, Knee, Knee Impact - Right Side

Customer:	NIAR			
Serial Number:	3043	**Corridor Type:**	NHTSA	
Part Condition:	Used	**Work Instruction:**	TLWI-2500	40.75in. probe height

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		2.08	2.09	2.12	m/sec	Pass
Max Knee Impact Force	0.00		8.23	9.64	11.12	kN	Pass
Impact Duration Above	4.45	kN	1.70	1.90	.00	mSec	Pass
Temperature	0.00		18.90	22.20	25.60	degC	Pass
Humidity	0.00		10.00	35	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	09/26/07	1.00193	3000	None
3	Femur Force	551	0	09/07/07	199.354	3000	600

Comments: _____

Technician: _____ **Test Supervisor:** _____

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Figure A-4. The 2007 Hybrid II 50th Percentile Right Side, Knee Impact, Serial Number 698 Certification

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Wichita, KS 67260

Cert ID:	0
Test ID:	1290.01
Test Date:	04/10/2007
Test Time:	03:14 PM

Test: Hybrid II 50th, Knee, Knee Impact - Left Side

Customer: NIAR
Serial Number: 1392
Part Condition: Used

Corridor Type: NHTSA
Work Instruction: TLWI-2500 40.75in. probe height

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		2.08	2.11	2.12	m/sec	Pass
Max Knee Impact Force	0.00		8.23	9.65	11.12	kN	Pass
Impact Duration Above	4.45	kN	1.70	1.90	.00	mSec	Pass
Temperature	0.00		18.90	22.20	25.60	degC	Pass
Humidity	0.00		10.00	35	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	09/26/07	1.00187	3000	None
3	Femur Force	551	0	09/07/07	199.371	3000	600

Comments: _____

Technician: _____ **Test Supervisor:** _____

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Figure A-5. The 2007 Hybrid II 50th Percentile Male, Left Side, Knee Impact, Serial Number 698 Certification

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Cert ID:	0
Test ID:	1250.01
Test Date:	04/02/2007
Test Time:	02:13 PM

Test: Hybrid II 50th, Head, Front

Customer: Inventory
Serial Number: X00028
Part Condition: Used
Corridor Type: NHTSA
Work Instruction: TLWI-2100

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Resultant Acceleration	0.00		210.00	247.99	260.00	g	Pass
Lateral Acceleration	0.00		-10.00	-3.34	10.00	g	Pass
Unimodal Oscillation	0.00		.00	.20	10.00	%	Pass
Temperature	0.00		18.90	24.60	25.60	degC	Pass
Humidity	0.00		10.00	45	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Trigger	100000	0	03/29/07	1.00193	3000	None
2	X-Axis	P52162	0	07/19/07	50.2083	3000	1000
3	Y-Axis	P52163	0	07/19/07	199.354	3000	1000
4	Z-Axis	P52164	0	07/19/07	50.6095	3000	1000

Comments: _____

Technician: _____ **Test Supervisor:** _____

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Figure A-6. The 2007 Hybrid II 50th Percentile Male, Head Front, Serial Number 698 Certification

Appendix:

Hybrid II Lumbar Flexion Test Data Sheet

Date: Mar 21, 2007		Time: 1:28 pm		Test I.D. No:		Operator 1: Andy Mackey	
Temp. °F: 79.3		R.H. % 50.8				Operator 2: Kelvin Hutchins	
Dummy No. 239		Pelvis No.		Lumbar Spine No:		Chest Flesh No:	
Force @ 20°, lbs. **Spec: 22/34**	Time t_{20} @20°, sec	Force @ 30°, lbs. **Spec: 34/46**	Time t_{30} @ 30°,Sec	Force @ 40° held 10 sec, lbs. **Spec: 46/58**	[2]First Time t_{40}, @ 40° sec	[3]Average angular rate R deg/sec **Spec. .5/1.5**	Return angle after 3 minutes **Spec: within 12 °**
25	18	34	29	46	45	1.07	13

Notes 1: Measure time from start of forward push using stopwatch or clock sweep second hand.
2: First Time @ 40°. Record time as 40° is reached at start of 10 second hold period.
3: Average angular rate R= $(t_{20}/20+t_{30}/30+t_{40}/40)/3$

Figure A-7. The 2007 Hybrid II 50th Percentile Lumbar Flexion, Serial Number 698 Certification

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Cert ID:	0
Test ID:	1146.02
Test Date:	03/16/2007
Test Time:	02:00 PM

Test: Hybrid II 50th, Abdomen, Compression

Customer: NIAR
Serial Number: 698
Part Condition: Used
Corridor Type: NHTSA

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		6.35	8.63	8.89	mm/se	Pass
Ab force-deflection @	25.40	mm	222.41	274.58	280.23	N	Pass
Ab force-deflection @	33.02	mm	324.72	381.96	391.44	N	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	34	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
9	velocity	TestVelABCC	0	10/09/07	0.993336	20	60
10	Force	181420	0	08/16/07	199.31	20	60
11	Deflect	0692	0	12/07/07	1.00168	20	60

Comments:

Technician: **Test Supervisor:**

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Figure A-8. The 2007 Hybrid II 50th Percentile Abdomen Compression, Serial Number 698 Certification

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Calibration and Quality Systems Lab

Hybrid II 50th Percentile Male

HII-50M (Model SA-150-M002)

SERIAL NUMBER: 698

Certification Due: 29 August 2009

National Institute for Aviation Research, a KTEC Center of Excellence
Wichita State University • 1845 N. Fairmount • Wichita, KS 67260-0093
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Figure A-9. The 2008 Hybrid II 50th Percentile Male, Serial Number 698 Certification

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1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	2018
Test Date:	08/25/2008
Test Time:	11:10 AM

Test: Hybrid II 50th, Head, Front

Customer: niar
Serial Number: 698
Part Condition: Used
Corridor Type: NHTSA
Work Instruction: TLWI-2100

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Resultant Acceleration	0.00		210.00	225.86	260.00	g	Pass
Lateral Acceleration	0.00		-10.00	6.42	10.00	g	Pass
Unimodal Oscillation	0.00		.00	.20	10.00	%	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	53	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Trigger	100000	0	03/29/20	1.00156	3000	None
2	X-Axis	P52162	0	08/18/09	50.1842	3000	1000
3	Y-Axis	P52163	0	08/18/09	199.31	3000	1000
4	Z-Axis	p48249	0	08/18/09	50.5853	3000	1000

Comments: _____

Technician: _____ **Test Supervisor:** _____

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Figure A-10. The 2008 Hybrid II 50th Percentile Male, Head Front, Serial Number 698 Certification

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1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	2047
Test Date:	08/27/2008
Test Time:	06:14 PM

Test: Hybrid II 50th, Neck, Pendulum

Serial Number: 698
Part Condition: Used
Corridor Type: NHTSA
Work Instruction: TLWI-2200

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		6.55	7.00	7.77	m/sec	Pass
Pendulum Time 5g-20g	5.00	g	.00	2.70	3.00	mSec	Pass
Pendulum Time Over	20.00	g	25.00	28.00	30.00	mSec	Pass
Pendulum Time 20g-5g	5.00	g	.00	4.90	10.00	mSec	Pass
Pendulum Average over 20g	0.00		20.00	23.27	24.00	g	Pass
Resultant Accel	0.00		.00	25.61	26.00	g	Pass
Time at Rotation	0.00	degre	-2.00	-.40	2.00	mSec	Pass
Time at Rotation	30.00	degre	25.60	27.40	34.40	mSec	Pass
Time at Rotation	60.00	degre	40.30	42.50	51.70	mSec	Pass
Time at Max Rotation	0.00		53.20	62.90	66.80	mSec	Pass
Time at Max Rotation	60.00	degre	67.00	70.70	83.00	mSec	Pass
Time at Max Rotation	30.00	degre	85.40	90.30	104.60	mSec	Pass
Time at Max Rotation	0.00	degre	101.00	104.60	123.00	mSec	Pass
Maximum Rotation	0.00		63.00	67.15	73.00	degree	Pass
Chordal at Rotation	0.00	degre	-13.00	.05	13.00	mm	Pass
Chordal at Rotation	30.00	degre	53.00	54.26	79.00	mm	Pass
Chordal at Rotation	60.00	degre	109.00	129.31	135.00	mm	Pass
Chordal at Max Rotation	0.00		127.00	146.80	152.00	mm	Pass
Chordal at Rotation	60.00	degre	109.00	129.22	135.00	mm	Pass
Chordal at Rotation	30.00	degre	53.00	55.79	76.00	mm	Pass
Chordal at Rotation	0.00	degre	-13.00	-5.09	13.00	mm	Pass
Temperature	0.00		18.90	21.00	25.60	degC	Pass
Humidity	0.00		10.00	52	70.00	%	Pass

Comments: 55445

Technician: _____ **Test Supervisor:** _____

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Figure A-11. The 2008 Hybrid II 50th Percentile Male, Neck Pendulum, Serial Number 698 Certification

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NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	2047
Test Date:	08/27/2008
Test Time:	06:14 PM

Test: Hybrid II 50th, Neck, Pendulum

Serial Number: 698
Part Condition: Used
Corridor Type: NHTSA
Work Instruction: TLWI-2200

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	NeckVel2	0	12/11/08	1	3000	None
2	X - Accel	P52162	0	08/18/09	500	3000	None
3	Y- Accel	P52163	0	08/18/09	500	3000	None
4	Z- Accel	p48249	0	08/18/09	500	3000	None
5	Pendulum Accel	C19817	0	10/02/08	100	3000	60
6	Pendulum Rotation	2712	0	04/04/09	2	3000	60
7	Head Rotation	2705	0	04/04/09	2	3000	60
8	Elongation Pot	0749	0	04/04/09	1	3000	60

Comments: 55445

Technician: _____ **Test Supervisor:** _____

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ID:

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Figure A-11. The 2008 Hybrid II 50th Percentile Male, Neck Pendulum, Serial Number 698 Certification (Continued)

Appendix:

Hybrid II Lumbar Flexion Test Data Sheet

Date: 8-28-08		Time: 10:35		Test I.D. No: —		Operator 1: Andy Mackey	
Temp. °F: 70.3		R.H. % 43°				Operator 2: Russell Baldridge	
Dummy No. 698		Pelvis No. —		Lumbar Spine No: —		Chest Flesh No: —	
Force @ 20°, lbs. **Spec: 22/34**	Time t_{20} @20°, sec	Force @ 30°, lbs. **Spec: 34/46**	Time t_{30} @ 30°,Sec	Force @ 40° held 10 sec, lbs. **Spec: 46/58**	[2]First Time t_{40}, @ 40° sec	[3]Average angular rate R deg/sec **Spec. .5/1.5**	Return angle after 3 minutes **Spec: within 12°**
23	22	35	29	47	45	.76°/sec	6°

Notes 1: Measure time from start of forward push using stopwatch or clock sweep second hand.
2: First Time @ 40°. Record time as 40° is reached at start of 10 second hold period.
3: Average angular rate R= $(t_{20}/20+t_{30}/30+t_{40}/40)/3$

Figure A-13. The 2008 Hybrid II 50th Percentile Male, Lumbar Flexion, Serial Number 698 Certification

Product Validation Report

NIAR
RESEARCH / DESIGN / TESTING / CERTIFICATION
CRASH DYNAMICS LABORATORY

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:
Test ID: 2049
Test Date: 08/28/2008
Test Time: 11:57 AM

Test: Hybrid II 50th, Abdomen, Compression

Serial Number: 698
Part Condition: Used
Corridor Type: NHTSA

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		6.35	7.93	8.89	mm/se	Pass
Ab force-deflection @	25.40	mm	222.41	244.07	280.23	N	Pass
Ab force-deflection @	33.02	mm	324.72	355.08	391.44	N	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	54	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
9	velocity	TestVelABCC	0	10/17/08	0.993149	20	60
10	Force	181420	0	11/20/08	199.284	20	60
11	Deflect	0692	0	04/28/09	1.00162	20	60

Comments:

Technician: **Test Supervisor:**

ACCREDITED
ID:

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Figure A-14. The 2008 Hybrid II 50th Percentile Male, Abdomen Compression, Serial Number 698 Certification

Product Validation Report

NIAR
RESEARCH / DESIGN / TESTING / CERTIFICATION
CRASH DYNAMICS LABORATORY

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:
Test ID: 2054
Test Date: 08/29/2008
Test Time: 12:26 PM

Test: Hybrid II 50th, Knee, Knee Impact - Right Side

Serial Number: 698
Part Condition: Used

Corridor Type: NHTSA
Work Instruction: TLWI-2500 40.75in. probe height

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		2.08	2.09	2.12	m/sec	Pass
Max Knee Impact Force	0.00		8.23	9.32	11.12	kN	Pass
Impact Duration Above	4.45	kN	1.70	2.00	.00	mSec	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	52	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	11/06/08	1.00156	3000	None
3	Femur Force	551	0	09/24/08	199.31	3000	600

Comments:

Technician: **Test Supervisor:**

ACCREDITED
ID:

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Figure A-15. The 2008 Hybrid II 50th Percentile Male, Right Side, Knee Impact, Serial Number 698 Certification

Product Validation Report

NIAR
RESEARCH / DESIGN / TESTING / CERTIFICATION
CRASH DYNAMICS LABORATORY

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	2057.01
Test Date:	08/29/2008
Test Time:	12:44 PM

Test: Hybrid II 50th, Knee, Knee Impact - Left Side

Serial Number: 698
Part Condition: Used

Corridor Type: NHTSA
Work Instruction: TLWI-2500 40.75in. probe height

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		2.08	2.10	2.12	m/sec	Pass
Max Knee Impact Force	0.00		8.23	11.10	11.12	kN	Pass
Impact Duration Above	4.45	kN	1.70	1.80	.00	mSec	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	52	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	11/06/08	1.00156	3000	None
3	Femur Force	551	0	09/24/08	199.301	3000	600

Comments:

Technician: **Test Supervisor:**

ACCREDITED
ID:

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Figure A-16. The 2008 Hybrid II 50th Percentile Male, Left Side, Knee Impact, Serial Number 698 Certification

Product Validation Report

NIAR
RESEARCH / DESIGN / TESTING / CERTIFICATION
CRASH DYNAMICS LABORATORY

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:
Test ID: 2058
Test Date: 08/29/2008
Test Time: 02:24 PM

Test: Hybrid II 50th, Thorax, High Speed

Serial Number: 698

Corridor Type: NHTSA
Work Instruction: 119 inches

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		6.64	6.74	6.78	m/sec	Pass
Max Resistive Force	0.00		-10.01	-9.45	.00	kN	Pass
Peak Chest Deflection	0.00		-43.00	-30.41	.00	mm	Pass
Hysteresis	0.00		50.00	63.59	70.00	%	Pass
Temperature	0.00		18.90	21.40	25.60	degC	Pass
Humidity	0.00		10.00	52	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	11/06/08	1.00143	3000	None
2	Probe Accel	C19633	0	10/16/08	198.339	3000	180
3	Chest Pot	0022	0	01/02/09	0.997446	3000	180
	Probe	291-H3 50 Th	0	11/06/08	0	0	

Comments:

Technician: **Test Supervisor:**

ACCREDITED
ID:

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Figure A-17. The 2008 Hybrid II 50th Percentile Male, High Speed, Thorax, Serial Number 698 Certification

Product Validation Report

NIAR
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CRASH DYNAMICS LABORATORY

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:
Test ID: 2062
Test Date: 08/29/2008
Test Time: 02:55 PM

Test: Hybrid II 50th, Thorax, Low Speed

Serial Number: 698
Part Condition: Used
Corridor Type: NHTSA
Work Instruction: 68.4 in

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		4.23	4.26	4.31	m/sec	Pass
Max Resistive Force	0.00		-6.45	-6.27	.00	kN	Pass
Peak Chest Deflection	0.00		-28.00	-18.71	.00	mm	Pass
Hysteresis	0.00		50.00	69.58	70.00	%	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	54	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	11/06/08	1.00162	3000	None
2	Probe Accel	C19633	0	10/16/08	198.33	3000	180
3	Chest Pot	0022	0	01/02/09	0.997509	3000	180
	Probe	291-H3 50 TH	0	11/06/08	0	0	

Comments:

Technician: **Test Supervisor:**

ID:

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Figure A-18. The 2008 Hybrid II 50th Percentile Male, Low Speed, Thorax, Serial Number 698 Certification

NATIONAL INSTITUTE FOR AVIATION RESEARCH
Wichita State University

RESEARCH / DESIGN / TESTING / CERTIFICATION
Calibration and Quality Systems Lab

Hybrid II 50th Percentile Male

HII-50M (Model SA-150-M002)

SERIAL NUMBER: 655

CERTIFICATION DUE DATE: 8 March 2008
Supervisor: Joseph Mitchell
Technician: Andy Mackey

National Institute for Aviation Research, a KTEC Center of Excellence
Wichita State University • 1845 N. Fairmount • Wichita, KS 67260-0093
p: 316.978.6427 • f: 316.978.3175
www.niar.wichita.edu

Figure A-19. The 2007 Hybrid II 50th Percentile Male, Serial Number 655 Certification

Product Validation Report

First Technology
Innovative Solutions

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	1037.01
Test Date:	01/26/2007
Test Time:	01:23 PM

Test: Hybrid II 50th, Head, Front

Customer: NIAR
Serial Number: 655
Part Condition: Used
Corridor Type: NHTSA
Work Instruction: TLWI-2100

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Resultant Acceleration	0.00		210.00	218.51	260.00	g	Pass
Lateral Acceleration	0.00		-10.00	4.98	10.00	g	Pass
Unimodal Oscillation	0.00		.00	.20	10.00	%	Pass
Temperature	0.00		18.90	21.90	25.60	degC	Pass
Humidity	0.00		10.00	37	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Trigger	100000	0	03/29/07	1.00199	3000	None
2	X-Axis	P52162	0	07/19/07	50.2039	3000	1000
3	Y-Axis	P52163	0	07/19/07	199.336	3000	1000
4	Z-Axis	P52164	0	07/19/07	50.6073	3000	1000

Comments:

Technician: **Test Supervisor:**

ACCREDITED
ID:

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Figure A-20. The 2007 Hybrid II 50th Percentile Male, Head Front, Serial Number 655 Certification

Product Validation Report

First Technology
Innovative Solutions

FTSS - Plymouth
ATD Certification Lab
47460 Galleon Drive
Plymouth, MI 48170

Cert ID:	0
Test ID:	138933
Test Date:	02/12/2007
Test Time:	05:36 AM

Test: Hybrid II 50th, Neck, Pendulum

Customer: Witchita State
Serial Number: 2441-3
Part Condition: Used
Corridor Type: NHTSA
Work Instruction: TLWI-2200

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		6.55	6.67	7.77	m/sec	Pass
Pendulum Time 5g-20g	5.00	g	.00	2.40	3.00	mSec	Pass
Pendulum Time Over	20.00	g	25.00	27.10	30.00	mSec	Pass
Pendulum Time 20g-5g	5.00	g	.00	7.30	10.00	mSec	Pass
Pendulum Average over 20g	0.00		20.00	21.46	24.00	g	Pass
Resultant Accel	0.00		.00	26.00	26.00	g	Pass
Time at Rotation	0.00	degre	-2.00	.00	2.00	mSec	Pass
Time at Rotation	30.00	degre	25.60	28.10	34.40	mSec	Pass
Time at Rotation	60.00	degre	40.30	46.20	51.70	mSec	Pass
Time at Max Rotation	0.00		53.20	60.20	66.80	mSec	Pass
Time at Max Rotation	60.00	degre	67.00	71.10	83.00	mSec	Pass
Time at Max Rotation	30.00	degre	85.40	94.10	104.60	mSec	Pass
Time at Max Rotation	0.00	degre	101.00	109.20	123.00	mSec	Pass
Maximum Rotation	0.00		63.00	65.56	73.00	degree	Pass
Chordal at Rotation	0.00	degre	-13.00	.22	13.00	mm	Pass
Chordal at Rotation	30.00	degre	53.00	57.88	79.00	mm	Pass
Chordal at Rotation	60.00	degre	109.00	129.59	135.00	mm	Pass
Chordal at Max Rotation	0.00		127.00	139.94	152.00	mm	Pass
Chordal at Rotation	60.00	degre	109.00	131.37	135.00	mm	Pass
Chordal at Rotation	30.00	degre	53.00	58.46	76.00	mm	Pass
Chordal at Rotation	0.00	degre	-13.00	3.26	13.00	mm	Pass
Temperature	0.00		18.90	21.30	25.60	degC	Pass
Humidity	0.00		10.00	14	70.00	%	Pass

Test Uncertainty Ratio (TUR) is greater than 4:1 with a 95% confidence level.

Comments: Witchita State Pendulum Bracket Modified

Technician: _____ **Test Supervisor:** John Rojanek

ACCREDITED
ID: 1850.02

First Technology Safety Systems 47460 Galleon Dr. Plymouth, MI 48170 Phone: +1 734-451-7878 Fax: +1 734-451-9549

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Figure A-21. The 2007 Hybrid II 50th Percentile Male, Neck Pendulum, Serial Number 655 Certification

Product Validation Report

First Technology
Innovative Solutions

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	1032.01
Test Date:	01/25/2007
Test Time:	05:01 PM

Test: Hybrid II 50th, Abdomen, Compression

Customer: NIAR
Serial Number: 655
Part Condition: Used
Corridor Type: NHTSA

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		6.35	8.75	8.89	mm/se	Pass
Ab force-deflection @	25.40	mm	222.41	271.06	280.23	N	Pass
Ab force-deflection @	33.02	mm	324.72	376.91	391.44	N	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	35	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
4	velocity	estVelABC(	0	10/09/07	1.00255	20	60
3	Force	181420	0	08/16/07	199.301	20	60
2	Deflect	0692	0	12/07/07	).99607(	20	60

Comments:

Technician: **Test Supervisor:**

ACCREDITED
ID:

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Page 1 of 1 Printed on 1/26/2007

Figure A-22. The 2007 Hybrid II 50th Percentile Male, Abdomen Compression, Serial Number 655 Certification

Appendix:

Hybrid II Lumbar Flexion Test Data Sheet

Date: 1-29-07		Time:		Test I.D. No:		Operator 1: Andy Mackey	
Temp. °F: 71.2		R.H. % 34				Operator 2: Brett Hart	
Dummy No. 655		Pelvis No.		Lumbar Spine No:		Chest Flesh No:	
Force @ 20°, lbs. **Spec: 22/34**	Time t_{20} @20°, sec	Force @ 30°, lbs. **Spec: 34/46**	Time t_{30} @ 30°,Sec	Force @ 40° held 10 sec, lbs. **Spec: 46/58**	[2]First Time t_{40}, @ 40° sec	[3]Average angular rate R deg/sec **Spec. .5/1.5**	Return angle after 3 minutes **Spec: within 12 °**
30	15	41	35	50	42	.98	14°

Notes 1: Measure time from start of forward push using stopwatch or clock sweep second hand.
2: First Time @ 40°. Record time as 40° is reached at start of 10 second hold period.
3: Average angular rate R= $(t_{20}/20+t_{30}/30+t_{40}/40)/3$

Figure A-23. The 2007 Hybrid II 50th Percentile Male, Lumbar Flexion, Serial Number 655 Certification

Product Validation Report

First Technology
Innovative Solutions

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	1073.01
Test Date:	03/08/2007
Test Time:	02:02 PM

Test: Hybrid II 50th, Knee, Knee Impact - Left Side

Serial Number: 655-6
Part Condition: Used

Corridor Type: NHTSA
Work Instruction: TLWI-2500

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		2.08	2.11	2.12	m/sec	Pass
Max Knee Impact Force	0.00		8.23	8.55	11.12	kN	Pass
Impact Duration Above	4.45	kN	1.70	2.20	.00	mSec	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	35	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	09/26/07	1.00206	3000	None
3	Femur Force	551	0	09/07/07	199.336	3000	600

Comments:

Technician: **Test Supervisor:**

ACCREDITED
ID:

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Figure A-24. The 2007 Hybrid II 50th Percentile Male, Left Side, Knee Impact, Serial Number 655 Certification

Product Validation Report

First Technology
Innovative Solutions

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	1067
Test Date:	03/08/2007
Test Time:	11:11 AM

Test: Hybrid II 50th, Knee, Knee Impact - Right Side

Serial Number:	655-3	**Corridor Type:**	NHTSA
Part Condition:	Used	**Work Instruction:**	TLWI-2500

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		2.08	2.11	2.12	m/sec	Pass
Max Knee Impact Force	0.00		8.23	10.97	11.12	kN	Pass
Impact Duration Above	4.45	kN	1.70	1.90	.00	mSec	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	34	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	09/26/07	1.00206	3000	None
3	Femur Force	551	0	09/07/07	199.362	3000	600

Comments:

Technician: **Test Supervisor:**

ACCREDITED
ID:

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Figure A-25. The 2007 Hybrid II 50th Percentile Male, Right Side, Knee Impact, Serial Number 655 Certification

Product Validation Report

First Technology
Innovative Solutions

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:	0
Test ID:	1074.03
Test Date:	03/08/2007
Test Time:	03:32 PM

Test: Hybrid II 50th, Thorax, High Speed

Customer: NIAR
Serial Number: 655-1
Part Condition: Used
Corridor Type: NHTSA

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		6.64	6.68	6.78	m/sec	Pass
Max Resistive Force	0.00		-10.01	-9.17	.00	kN	Pass
Peak Chest Deflection	0.00		-43.00	-31.85	.00	mm	Pass
Hysteresis	0.00		50.00	61.31	70.00	%	Pass
Temperature	0.00		18.90	21.60	25.60	degC	Pass
Humidity	0.00		10.00	32	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	09/26/07	1.00193	3000	None
2	Probe Accel	C19814	0	09/19/07	198.383	3000	180
3	Chest Pot	0022	0	12/14/07	).99775(	3000	180
	Probe	H3 50 THO	0	09/21/07	0	0	

Comments:

Technician: **Test Supervisor:**

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ID:

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Figure A-26. The 2007 Hybrid II 50th Percentile Male, High Speed, Thorax, Serial Number 655 Certification

Product Validation Report

First Technology
Innovative Solutions

NIAR
ATD Certification Lab
1845 Fairmount
Wichita, KS 67260

Cert ID:
Test ID: 1076
Test Date: 03/08/2007
Test Time: 04:19 PM

Test: Hybrid II 50th, Thorax, Low Speed

Customer: NIAR
Serial Number: 655-1
Part Condition: Used

Corridor Type: NHTSA

Test Result Details

Parameter Description	Test Point	Unit	Low	Result	High	Unit	Result
Velocity	0.00		4.23	4.28	4.31	m/sec	Pass
Max Resistive Force	0.00		-6.45	-5.96	.00	kN	Pass
Peak Chest Deflection	0.00		-28.00	-20.69	.00	mm	Pass
Hysteresis	0.00		50.00	59.87	70.00	%	Pass
Temperature	0.00		18.90	21.70	25.60	degC	Pass
Humidity	0.00		10.00	33	70.00	%	Pass

Test Setup Details

Channel	Channel Name	Sensor SN	Axis	Cal Due Date	Gain	Filter	Class
1	Velocity	TestVel1	0	09/26/07	1.00193	3000	None
2	Probe Accel	C19814	0	09/19/07	198.4	3000	180
3	Chest Pot	0022	0	12/14/07	).997758	3000	180
	Probe	H3 50 THO	0	09/21/07	0	0	

Comments:

Technician: Test Supervisor:

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ID:

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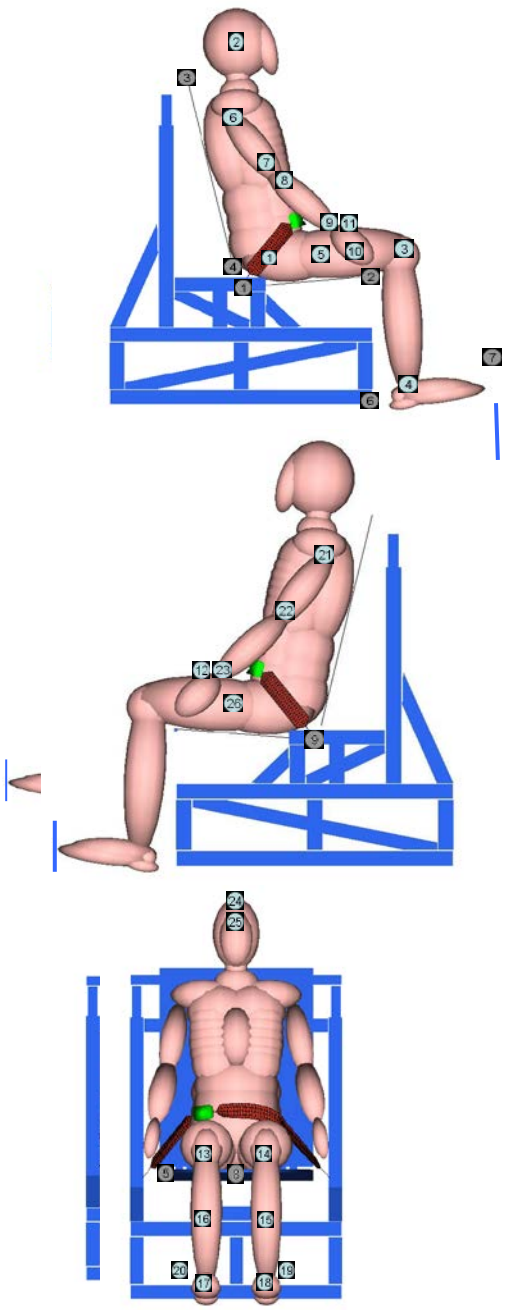
Figure A-27. The 2007 Hybrid II 50th Percentile Male, Low Speed, Thorax, Serial Number 655 Certification

APPENDIX B—PRETEST DATA SHEETS

Test Number	07324-4	Date	12/12/2007
ATD/ Serial Number	HYB II 698	Test Condition	0deg/16g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%



ATD Targets

ID	Name	X	Y	Z
1	H Point	3.3	6.9	-3.9
1a	H Point Vertical Auxiliary	3.2	6.2	-6.8
1b	H Point Horizontal Auxiliary	0.8	6.0	-5.1
1c	H Point Auxiliary	0.8	5.1	-8.1
2	Head CG	1.2	3.0	-31.1
2a	Head CG Vertical Auxiliary	1.4	2.8	-34.1
2b	Head CG Horizontal Auxiliary	-1.2	2.5	-32.8
3	Knee R	19.8	5.9	-4.3
4	Ankle R	23.9	5.9	11.5
5	Femur R	11.7	7.4	-4.1
6	Shoulder R	1.5	8.6	-22.4
7	Elbow1R	4.7	10.7	-13.6
8	Elbow2 R	5.3	10.3	-12.5
9	Wrist R	12.7	6.6	-7.5
10	Hand R	15.7	6.4	-8.1
11	Top hand wrist	13.3	5.5	-8.9
12	Top Hand Wrist	13.1	-6.5	-8.8
13	Knee R	22.4	4.0	-4.8
14	Knee L	22.4	-4.2	-4.5
15	Tibia L	24.3	-4.2	3.7
16	Tibia R	23.8	4.3	3.1
17	Shoe tip top R	32.6	4.5	13.9
18	Shoe tip top L	33.5	-3.9	14.2
19	Shoe back L	22.1	-3.1	13.5
20	Shoe back R	21.1	4.2	13.2
21	Shoulder L	1.7	-9.2	-23.3
22	Elbow L	4.6	-10.5	-13.3
23	Wrist L	12.3	-7.4	-7.6
24	Top Head	1.6	0.0	-35.8
25	Forehead	5.2	-0.1	-32.3
26	Femur L	11.8	-7.6	-3.7
27	Kee L	20.0	-6.1	-3.9
28	Ankle L	24.9	-4.8	11.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.2	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.2	13.9	16.1
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.3	-14.2	0.1
10	Plane of scale targets left side	-14.6	-14.1	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	84
Plane of scale targets right side	85

Distce from onbd lens to Seat	59.9
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	86
second point on rigid seat (R)	87
first point on rigid seat (L)	88
second point on rigid seat (L)	89

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	77.6	16
Femur Angle	3.4	1.7
Tibia Angle	80.2	71.4

Unit System

English
in, lbf, s, lb

Figure B-1. Test 07324-4 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

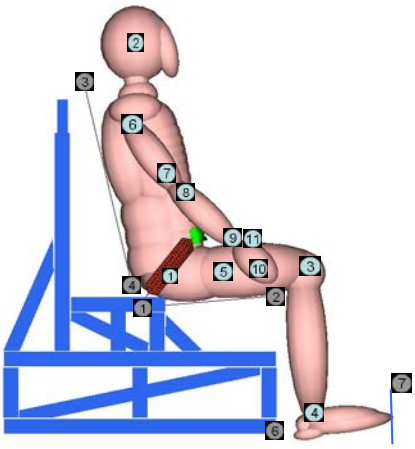
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.5	9.0	-2.2	90
SB2	Lap belt	3.4	8.3	-3.1	91
SB3	Lap belt	8.2	3.0	-7.3	92
SB4	Lap belt	9.2	0.7	-7.4	93
SB5	Lap belt	9.9	-1.8	-7.4	94
SB6	Lap belt	8.0	-3.2	-6.9	95
SB7	Lap belt	3.2	-8.5	-3.2	96
SB8	Lap belt	2.5	-9.1	-2.4	97
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

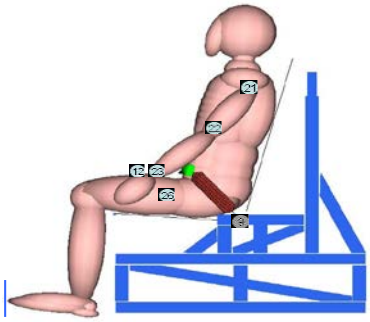
Webbing Length Measurements

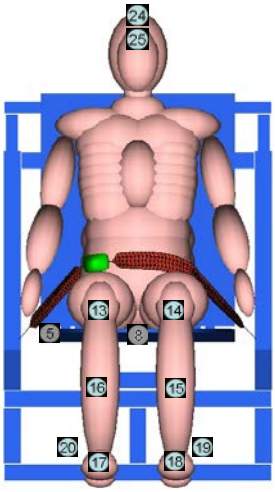
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	14.25"
Lap Strap LH	14.75"
Center Strap	NA

Figure B-2. Test 07324-4 Belt Pretest Data Sheet

Test Number	07324-5	Date	12/12/2007
ATD/ Serial Number	HYB II 698	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	4 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.6	7.2	-3.6
1a	H Point Vertical Auxiliary	3.4	6.6	-6.5
1b	H Point Horizontal Auxiliary	1.0	6.3	-4.8
1c	H Point Auxiliary	1.0	5.6	-7.8
2	Head CG	0.5	3.5	-31.0
2a	Head CG Vertical Auxiliary	0.6	3.3	-34.0
2b	Head CG Horizontal Auxiliary	-1.9	3.1	-32.6
3	Knee R	19.6	5.9	-7.2
4	Ankle R	23.4	5.4	8.6
5	Femur R	11.8	7.4	-5.1
6	Shoulder R	1.3	9.0	-22.4
7	Elbow1R	4.7	11.5	-13.6
8	Elbow2 R	5.2	11.2	-12.6
9	Wrist R	13.3	6.5	-10.0
10	Hand R	16.2	5.5	-10.6
11	Top hand wrist	13.3	5.2	-10.9
12	Top Hand Wrist	14.6	-6.9	-10.9
13	Knee R	21.9	3.9	-8.3
14	Knee L	21.8	-5.0	-8.1
15	Tibia L	23.5	-5.1	0.7
16	Tibia R	23.5	4.0	0.2
17	Shoe tip top R	32.1	4.3	10.9
18	Shoe tip top L	32.3	-4.5	11.5
19	Shoe back L	20.9	-4.4	10.4
20	Shoe back R	20.7	3.7	10.3
21	Shoulder L	0.9	-8.7	-23.2
22	Elbow L	5.4	-10.6	-13.9
23	Wrist L	13.8	-7.7	-9.6
24	Top Head	0.6	0.4	-35.7
25	Forehead	4.3	0.2	-32.3
26	Femur L	11.4	-7.8	-5.1
27	Kee L	19.4	-6.8	-7.0
28	Ankle L	23.9	-5.9	8.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.2	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.2	13.9	16.1
7	Centre front plate	33.2	-0.5	10.0
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.6	-14.1	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	89
Plane of scale targets right side	90

Distce from onbd lens to Seat	59.875
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	91
second point on rigid seat (R)	92
first point on rigid seat (L)	93
second point on rigid seat (L)	94

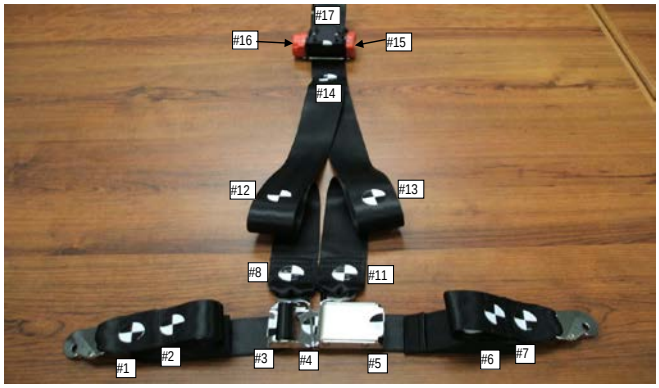
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	72.7	76.5
Femur Angle	13.7	15.5
Tibia Angle	81.6	87.5

Unit System

English
in, lbf, s, lb

Figure B-3. Test 07324-5 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

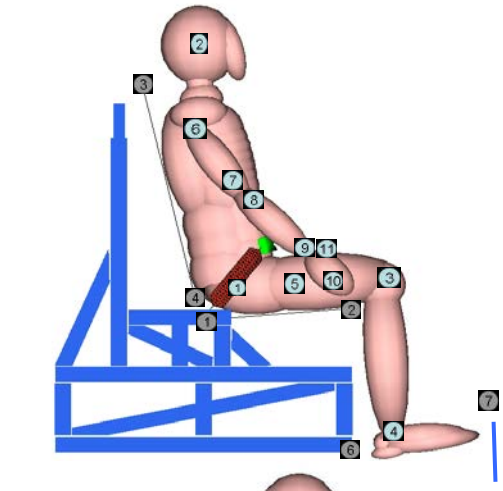
ID	Name	X	Y	Z
SB1	Lap belt	2.4	9.3	-2.0
SB2	Lap belt	3.3	8.6	-2.9
SB3	Lap belt	8.8	1.6	-8.2
SB4	Lap belt	8.9	-0.1	-8.3
SB5	Lap belt	9.1	-2.9	-8.4
SB6	Lap belt	3.1	-8.6	-3.0
SB7	Lap belt	2.4	-9.3	-2.0
SB8	Shoulder belt	8.4	0.7	-11.8
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.1	-0.8	-12.0
SB12	Shoulder belt	5.9	2.8	-21.1
SB13	Shoulder belt	5.9	-2.5	-20.8
SB14	Shoulder belt	-8.4	0.0	-29.4

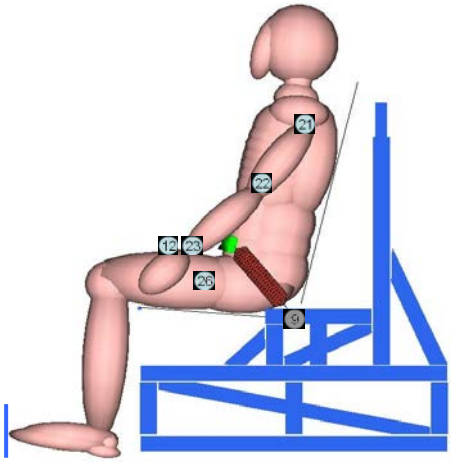
Webbing Length Measurements

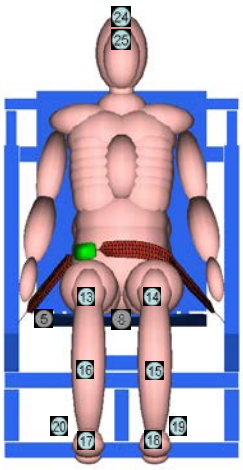
Shoulder Strap RH	28.5"
Shoulder Strap LH	28.0"
Lap Strap RH	15.75"
Lap Strap LH	14.0"

Figure B-4. Test 07324-5 Belt Pretest Data Sheet

Test Number	07324-7	Date	12/14/2007
ATD/ Serial Number	HII 698	Test Condition	0deg/16g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.5	7.1	-3.9
1a	H Point Vertical Auxiliary	3.2	6.3	-6.9
1b	H Point Horizontal Auxiliary	0.9	6.1	-5.0
1c	H Point Auxiliary	0.6	5.3	-7.9
2	Head CG	0.8	2.8	-31.0
2a	Head CG Vertical Auxiliary	1.1	2.5	-34.0
2b	Head CG Horizontal Auxiliary	-1.5	2.3	-32.7
3	Knee R	19.9	6.3	-4.5
4	Ankle R	23.0	6.3	11.6
5	Femur R	11.8	7.6	-4.1
6	Shoulder R	1.7	8.6	-23.1
7	Elbow1R	4.4	10.1	-14.0
8	Elbow2 R	4.5	9.8	-12.8
9	Wrist R	13.3	6.8	-10.3
10	Hand R	16.3	6.4	-9.8
11	Top hand wrist	13.9	5.3	-11.0
12	Top Hand Wrist	15.2	-5.2	-10.3
13	Knee R	22.5	4.5	-5.0
14	Knee L	22.5	-4.2	-5.0
15	Tibia L	23.3	-4.2	3.6
16	Tibia R	23.4	4.9	3.2
17	Shoe tip top R	31.8	4.5	13.8
18	Shoe tip top L	31.5	-4.0	14.4
19	Shoe back L	20.1	-3.5	13.3
20	Shoe back R	20.3	4.8	13.2
21	Shoulder L	2.4	-9.1	-23.0
22	Elbow L	5.5	-9.5	-12.7
23	Wrist L	14.2	-6.5	-9.3
24	Top Head	1.4	-0.2	-35.6
25	Forehead	4.9	-0.3	-32.0
26	Femur L	11.9	-7.4	-3.7
27	Kee L	20.0	-6.1	-4.4
28	Ankle L	23.0	-5.0	11.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0	14	0
2	Seatbottom	16	10	-1
3	Seatback	-6	10	-27
4	Seat back lower	0	10	-2
5	Seatbottom from front view	16	9	-1
6	Seat frame ground	16	14	16
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16	0	-1
9	SB L	0	-14	0
10	Plane of scale targets left side	-15	-14	7

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	77
Plane of scale targets right side	78

Distce from onbd lens to Seat	58
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	79
second point on rigid seat (R)	80
first point on rigid seat (L)	81
second point on rigid seat (L)	82

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	75.5	81.6
Femur Angle	3.1	10.1
Tibia Angle	88.2	82

Unit System

English
in, lbf, s, lb

Figure B-5. Test 07324-7 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

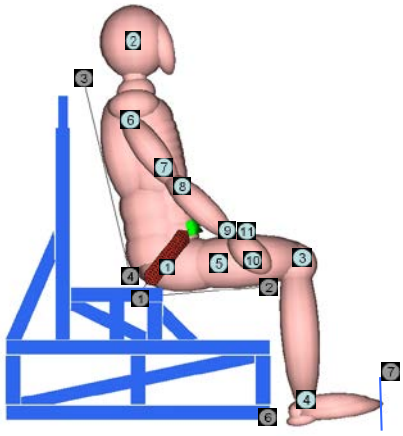
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.6	9.1	-2.3	83
SB2	Lap belt	3.3	8.3	-3.3	84
SB3	Lap belt	8.4	2.6	-7.5	85
SB4	Lap belt	9.0	0.7	-7.8	86
SB5	Lap belt	9.7	-1.8	-7.9	87
SB6	Lap belt	7.7	-3.4	-7.2	88
SB7	Lap belt	3.4	-8.3	-3.3	89
SB8	Lap belt	2.6	-9.1	-2.4	90
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

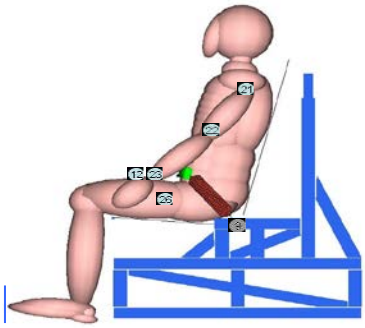
Webbing Length Measurements

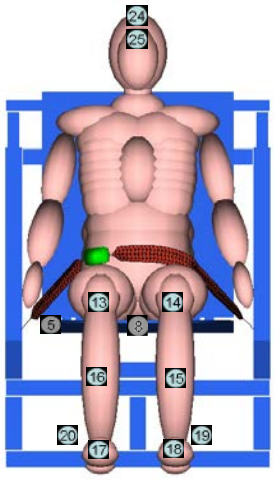
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	14.25
Lap Strap LH	13.5
Center Strap	NA

Figure B-6. Test 07324-7 Belt Pretest Data Sheet

Test Number	07324-8	Date	12/18/2007
ATD/ Serial Number	HYB II 698	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	3 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.4	7.0	-4.0
1a	H Point Vertical Auxiliary	3.3	6.4	-6.8
1b	H Point Horizontal Auxiliary	0.9	6.1	-5.0
1c	H Point Auxiliary	0.7	5.3	-7.9
2	Head CG	0.8	2.8	-31.2
2a	Head CG Vertical Auxiliary	1.0	2.5	-34.1
2b	Head CG Horizontal Auxiliary	-1.5	2.4	-32.8
3	Knee R	19.8	6.1	-4.5
4	Ankle R	23.4	6.1	11.4
5	Femur R	11.8	7.6	-4.1
6	Shoulder R	1.8	8.7	-23.3
7	Elbow1R	4.1	10.4	-14.2
8	Elbow2 R	4.3	10.0	-13.0
9	Wrist R	12.6	6.3	-9.3
10	Hand R	15.6	5.6	-9.4
11	Top hand wrist	13.2	4.6	-10.2
12	Top Hand Wrist	13.3	-5.9	-9.8
13	Knee R	22.4	4.2	-5.2
14	Knee L	22.4	-5.0	-4.8
15	Tibia L	23.6	-5.2	3.7
16	Tibia R	23.6	4.5	3.0
17	Shoe tip top R	32.2	4.7	13.7
18	Shoe tip top L	32.3	-4.4	14.4
19	Shoe back L	20.8	-4.9	13.4
20	Shoe back R	20.7	4.4	13.2
21	Shoulder L	2.0	-9.1	-23.0
22	Elbow L	3.6	-9.9	-12.5
23	Wrist L	12.4	-7.2	-8.8
24	Top Head	1.0	-0.3	-35.7
25	Forehead	4.7	-0.5	-32.3
26	Femur L	11.6	-7.8	-3.8
27	Kee L	19.8	-6.7	-4.2
28	Ankle L	23.9	-6.1	11.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.2	0.1
2	Seatbottom	16.1	10.0	-1.0
3	Seatback	-6.1	10.0	-26.7
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.3	13.8	16.1
7	Centre front plate	33.3	-0.8	14.4
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.4	-14.2	0.0
10	Plane of scale targets left side	-14.6	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	79
Plane of scale targets right side	80

Distce from onbd lens to Seat	63
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	81
second point on rigid seat (R)	82
first point on rigid seat (L)	83
second point on rigid seat (L)	84

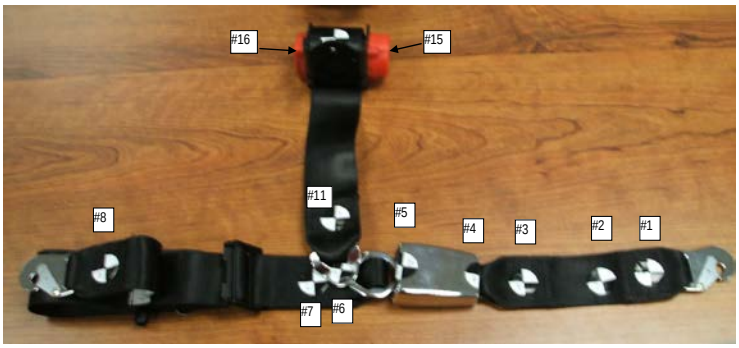
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	77.3	60.5
Femur Angle	3.2	4.3
Tibia Angle	81.5	86.1

Unit System

English
in, lbf, s, lb

Figure B-7. Test 07324-8 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

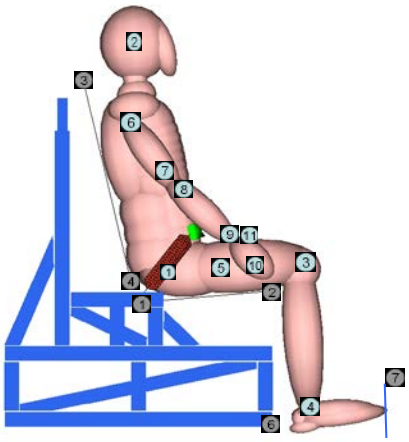
ID	Name	X	Y	Z
SB1	Lap belt	2.3	9.3	-2.0
SB2	Lap belt	3.2	8.6	-2.8
SB3	Lap belt	5.7	6.9	-5.7
SB4	Lap belt	6.4	7.4	-6.9
SB5	Lap belt	7.6	5.4	-7.7
SB6	Lap belt	8.6	3.7	-8.3
SB7	Lap belt	8.4	1.8	-7.4
SB8	Lap belt	2.2	-9.4	-2.0
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.2	2.6	-10.6
SB12	Shoulder belt	5.1	-2.1	-23.3
SB13	Shoulder belt	-5.8	-5.9	-28.2
SB14	Shoulder belt Anchor to seat	-8.4	-6.9	-29.4

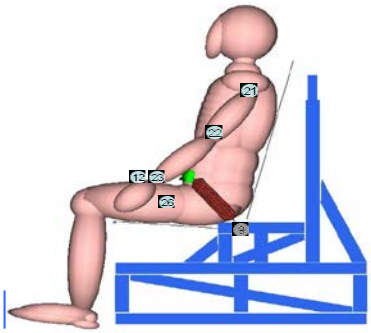
Webbing Length Measurements

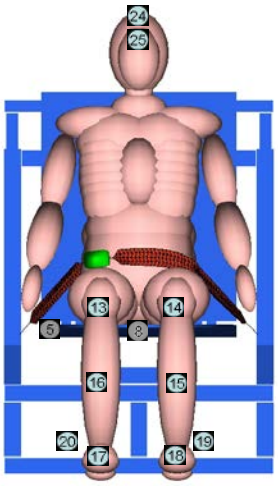
Shoulder Strap RH	NA
Shoulder Strap LH	31"
Lap Strap RH	8"
Lap Strap LH	20"
Center Strap	NA

Figure B-8. Test 07324-8 Belt Pretest Data Sheet

Test Number	07324-9	Date	12/18/2007
ATD/ Serial Number	HYB II 698	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	3 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.2	7.1	-3.9
1a	H Point Vertical Auxiliary	3.2	6.5	-6.7
1b	H Point Horizontal Auxiliary	0.7	6.2	-5.0
1c	H Point Auxiliary	0.6	5.4	-7.8
2	Head CG	0.9	3.1	-31.0
2a	Head CG Vertical Auxiliary	1.2	2.8	-34.0
2b	Head CG Horizontal Auxiliary	-1.4	2.7	-32.7
3	Knee R	19.7	6.5	-4.5
4	Ankle R	23.5	6.2	11.4
5	Femur R	11.7	7.7	-3.9
6	Shoulder R	1.7	9.0	-23.1
7	Elbow1R	4.3	10.3	-14.0
8	Elbow2 R	4.5	10.0	-12.9
9	Wrist R	13.3	6.2	-10.3
10	Hand R	16.1	5.8	-10.0
11	Top hand wrist	14.0	4.6	-11.1
12	Top Hand Wrist	14.1	-5.0	-10.7
13	Knee R	22.3	4.7	-5.2
14	Knee L	22.5	-4.6	-4.8
15	Tibia L	23.6	-4.7	3.7
16	Tibia R	23.6	4.9	3.0
17	Shoe tip top R	32.1	4.9	14.1
18	Shoe tip top L	32.0	-5.1	14.5
19	Shoe back L	20.6	-3.7	13.4
20	Shoe back R	20.7	4.5	13.2
21	Shoulder L	2.2	-8.8	-23.0
22	Elbow L	4.3	-10.0	-12.6
23	Wrist L	13.1	-6.6	-9.9
24	Top Head	1.3	0.0	-35.6
25	Forehead	4.9	-0.1	-32.2
26	Femur L	11.8	-7.6	-3.9
27	Kee L	19.9	-6.4	-4.2
28	Ankle L	23.4	-5.5	11.7

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.2	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.4	14.1	16.1
7	Centre front plate	33.4	-0.2	14.4
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.3	-14.2	0.1
10	Plane of scale targets left side	-3.3095	-14.0422	3.1559

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	83
Plane of scale targets right side	84

Distce from onbd lens to Seat	63
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	85
second point on rigid seat (R)	86
first point on rigid seat (L)	87
second point on rigid seat (L)	88

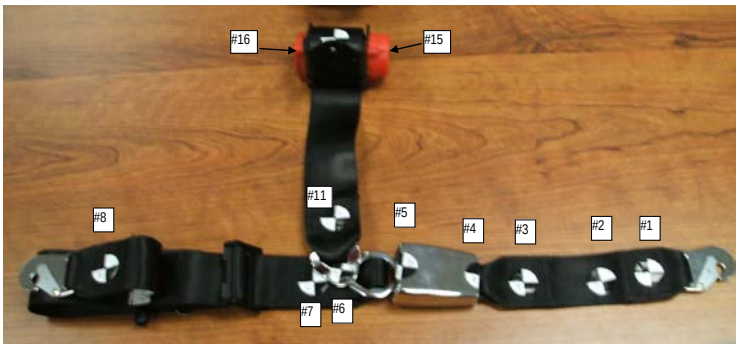
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	76.5	64
Femur Angle	4.3	5
Tibia Angle	81.8	86.8

Unit System

English
in, lbf, s, lb

Figure B-9. Test 07324-9 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

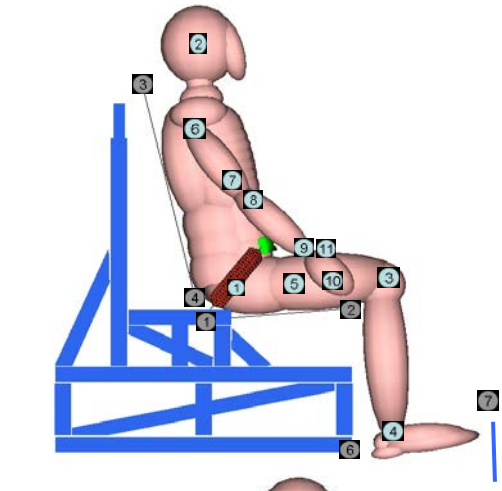
ID	Name	X	Y	Z
SB1	Lap belt	2.3	9.4	-1.9
SB2	Lap belt	3.2	8.7	-2.9
SB3	Lap belt	5.4	7.2	-5.4
SB4	Lap belt	5.9	7.7	-6.7
SB5	Lap belt	7.2	5.7	-7.4
SB6	Lap belt	8.2	4.1	-8.0
SB7	Lap belt	7.9	2.9	-7.0
SB8	Lap belt	2.1	-9.4	-1.8
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.0	3.0	-10.0
SB12	Shoulder belt	5.1	-2.0	-23.1
SB13	Shoulder belt	-5.9	-5.9	-28.1
SB14	Shoulder belt Anchor to seat	-8.4	-6.8	-29.3

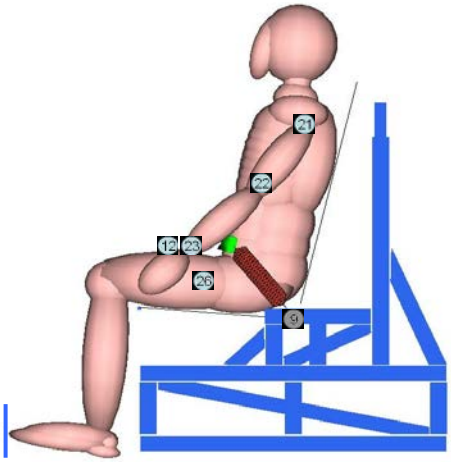
Webbing Length Measurements

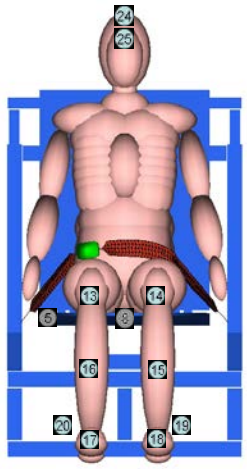
Shoulder Strap RH	NA
Shoulder Strap LH	30.75
Lap Strap RH	8
Lap Strap LH	20.75
Center Strap	NA

Figure B-10. Test 07324-9 Belt Pretest Data Sheet

Test Number	07324-10	Date	12/19/2007
ATD/ Serial Number	HYB II 698	Test Condition	60deg/19g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.2	7.0	-4.1
1a	H Point Vertical Auxiliary	2.9	6.2	-7.0
1b	H Point Horizontal Auxiliary	0.6	6.0	-5.0
1c	H Point Auxiliary	0.4	5.2	-7.9
2	Head CG	0.4	3.0	-31.1
2a	Head CG Vertical Auxiliary	0.6	2.8	-34.2
2b	Head CG Horizontal Auxiliary	-2.0	2.6	-32.8
3	Knee R	19.6	6.7	-4.6
4	Ankle R	21.3	6.5	11.6
5	Femur R	11.4	7.7	-3.8
6	Shoulder R	1.4	8.8	-23.3
7	Elbow1R	4.3	10.1	-14.2
8	Elbow2 R	4.4	9.7	-13.1
9	Wrist R	13.1	6.5	-10.6
10	Hand R	16.1	6.2	-9.9
11	Top hand wrist	14.3	5.0	-11.3
12	Top Hand Wrist	14.0	-6.1	-11.1
13	Knee R	22.2	5.2	-5.2
14	Knee L	22.3	-4.9	-5.2
15	Tibia L	22.3	-5.0	3.8
16	Tibia R	22.4	5.1	3.4
17	Shoe tip top R	30.0	5.4	14.0
18	Shoe tip top L	29.8	-5.0	14.5
19	Shoe back L	18.3	-4.3	13.7
20	Shoe back R	18.5	4.7	13.4
21	Shoulder L	1.8	-9.0	-23.3
22	Elbow L	3.7	-9.8	-12.8
23	Wrist L	12.8	-7.3	-10.2
24	Top Head	0.6	-0.1	-35.8
25	Forehead	4.4	-0.2	-32.5
26	Femur L	11.5	-7.8	-4.3
27	Kee L	19.7	-6.7	-4.6
28	Ankle L	21.3	-5.9	11.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.3	14.2	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	9.9	-26.6
4	Seat back lower	-0.5	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.3	14.0	16.1
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.4	-14.3	0.1
10	Plane of scale targets left side	-3.2	-14.1	3.2

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	91
Plane of scale targets right side	92

Distce from onbd lens to Seat	63
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	93
second point on rigid seat (R)	NA
first point on rigid seat (L)	94
second point on rigid seat (L)	95

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	78.9	70.6
Femur Angle	4.1	4.5
Tibia Angle	89.5	88

Unit System

English
in, lbf, s, lb

Figure B-11. Test 07324-10 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

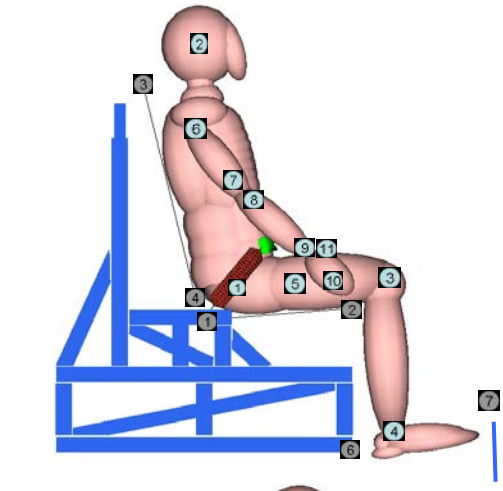
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.3	9.0	-2.2	96
SB2	Lap belt	3.1	8.1	-3.1	97
SB3	Lap belt	8.0	3.0	-7.5	98
SB4	Lap belt	9.1	0.6	-7.7	99
SB5	Lap belt	9.5	-1.8	-7.7	100
SB6	Lap belt	8.0	-2.6	-7.4	101
SB7	Lap belt	3.2	-8.3	-3.3	102
SB8	Lap belt	2.4	-9.1	-2.3	103
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

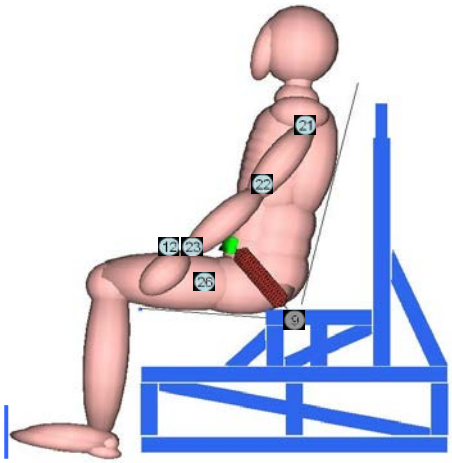
Webbing Length Measurements

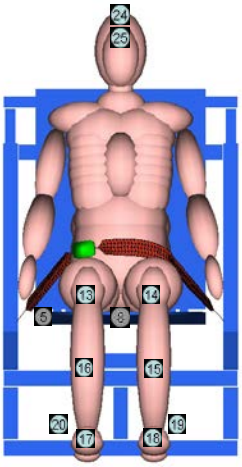
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	14
Lap Strap LH	15.75
Center Strap	NA

Figure B-12. Test 07324-10 Belt Pretest Data Sheet

Test Number	07324-11	Date	12/19/2007
ATD/ Serial Number	HYB II 698	Test Condition	60deg/19g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.2	7.1	-4.2
1a	H Point Vertical Auxiliary	3.1	6.4	-7.1
1b	H Point Horizontal Auxiliary	0.6	6.2	-5.4
1c	H Point Auxiliary	0.6	5.4	-8.4
2	Head CG	0.1	3.0	-31.5
2a	Head CG Vertical Auxiliary	0.2	2.7	-34.5
2b	Head CG Horizontal Auxiliary	-2.4	2.6	-33.0
3	Knee R	19.6	6.2	-4.5
4	Ankle R	22.0	6.5	11.6
5	Femur R	11.4	7.5	-3.9
6	Shoulder R	0.9	8.9	-23.6
7	Elbow1R	3.2	10.4	-14.3
8	Elbow2 R	3.4	9.9	-13.3
9	Wrist R	12.0	6.6	-9.9
10	Hand R	14.9	6.2	-9.7
11	Top hand wrist	12.7	5.0	-10.7
12	Top Hand Wrist	12.7	-6.3	-11.1
13	Knee R	22.2	4.6	-5.1
14	Knee L	22.0	-5.2	-5.1
15	Tibia L	22.6	-5.0	3.7
16	Tibia R	22.8	4.9	3.3
17	Shoe tip top R	30.9	5.2	13.8
18	Shoe tip top L	30.6	-4.6	14.2
19	Shoe back L	19.2	-3.9	13.5
20	Shoe back R	19.4	4.7	13.4
21	Shoulder L	1.1	-9.1	-23.5
22	Elbow L	2.5	-10.2	-13.0
23	Wrist L	11.9	-7.5	-10.2
24	Top Head	0.2	-0.1	-36.1
25	Forehead	4.0	-0.3	-32.9
26	Femur L	11.2	-7.8	-4.1
27	Kee L	19.4	-6.9	-4.4
28	Ankle L	22.0	-5.6	11.7

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.3	14.2	0.1
2	Seatbottom	16.0	10.0	-1.0
3	Seatback	-6.1	9.8	-26.6
4	Seat back lower	-0.5	9.9	-2.2
5	Seatbottom from front view	16.0	8.8	-1.4
6	Seat frame ground	16.2	13.9	16.0
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.4	-14.3	0.0
10	Plane of scale targets left side	-3.1	-14.1	0.2

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	98
Plane of scale targets right side	99

Distce from onbd lens to Seat	63
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	100
second point on rigid seat (R)	NA
first point on rigid seat (L)	101
second point on rigid seat (L)	102

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	71.2	70.6
Femur Angle	4.5	6.5
Tibia Angle	86.9	89.3

Unit System

English
in, lbf, s, lb

Figure B-13. Test 07324-11 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

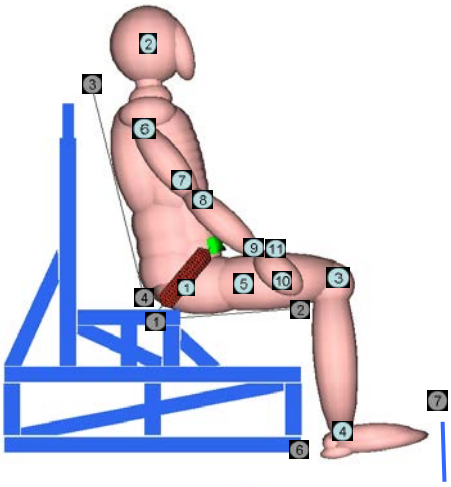
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.3	9.0	-2.2	103
SB2	Lap belt	3.2	8.3	-3.3	104
SB3	Lap belt	7.9	3.3	-7.6	105
SB4	Lap belt	9.2	0.8	-8.1	106
SB5	Lap belt	9.7	-1.4	-8.1	107
SB6	Lap belt	9.2	-1.5	-8.8	108
SB7	Lap belt	3.1	-8.3	-3.3	109
SB8	Lap belt	2.4	-9.1	-2.5	110
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

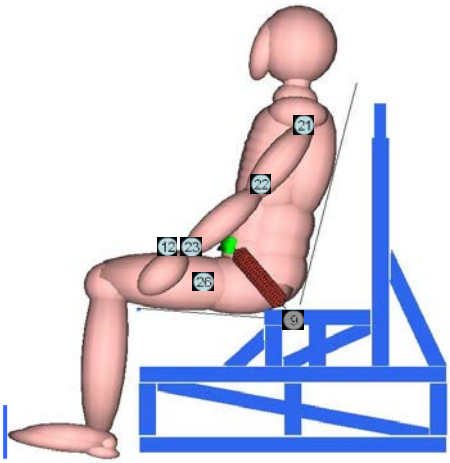
Webbing Length Measurements

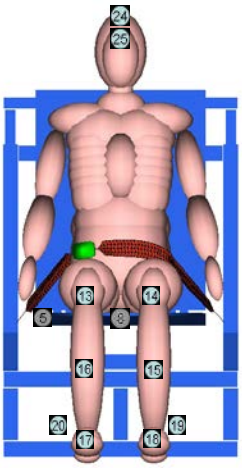
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	14
Lap Strap LH	15.25
Center Strap	NA

Figure B-14. Test 07324-11 Belt Pretest Data Sheet

Test Number	07324-12	Date	12/20/2007
ATD/ Serial Number	HYB II 698	Test Condition	60deg/19g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.2	7.5	-4.1
1a	H Point Vertical Auxiliary	3.1	6.8	-7.0
1b	H Point Horizontal Auxiliary	0.7	6.6	-5.2
1c	H Point Auxiliary	0.5	5.8	-8.2
2	Head CG	0.1	3.3	-31.4
2a	Head CG Vertical Auxiliary	0.2	3.0	-34.4
2b	Head CG Horizontal Auxiliary	-2.3	2.9	-33.0
3	Knee R	19.7	6.0	-4.6
4	Ankle R	21.5	6.1	11.5
5	Femur R	11.6	7.7	-4.0
6	Shoulder R	0.6	9.3	-23.5
7	Elbow1R	3.8	10.9	-14.6
8	Elbow2 R	4.1	10.5	-13.5
9	Wrist R	12.7	6.7	-10.6
10	Hand R	15.5	6.2	-10.2
11	Top hand wrist	13.4	5.0	-11.3
12	Top Hand Wrist	13.4	-5.6	-11.5
13	Knee R	22.2	4.3	-5.2
14	Knee L	22.0	-4.8	-5.1
15	Tibia L	22.6	-4.7	3.7
16	Tibia R	22.6	4.5	3.3
17	Shoe tip top R	30.3	4.6	13.9
18	Shoe tip top L	30.7	-3.7	14.2
19	Shoe back L	19.1	-4.0	13.5
20	Shoe back R	18.7	4.8	13.3
21	Shoulder L	0.9	-8.7	-23.5
22	Elbow L	3.2	-9.7	-13.0
23	Wrist L	12.6	-7.0	-10.7
24	Top Head	0.2	0.2	-36.0
25	Forehead	4.0	0.1	-32.8
26	Femur L	11.2	-7.5	-4.1
27	Kee L	19.4	-6.5	-4.4
28	Ankle L	22.2	-5.6	11.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.3	14.2	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.3	14.0	16.0
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.3	-14.2	0.1
10	Plane of scale targets left side	-12.3489	-14.0063	6.6618

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	85
Plane of scale targets right side	86

Distce from onbd lens to Seat	63
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	87
second point on rigid seat (R)	NA
first point on rigid seat (L)	88
second point on rigid seat (L)	89

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	74.6	69.8
Femur Angle	4.4	5.5
Tibia Angle	88.1	88.1

Unit System

English
in, lbf, s, lb

Figure B-15. Test 07324-12 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

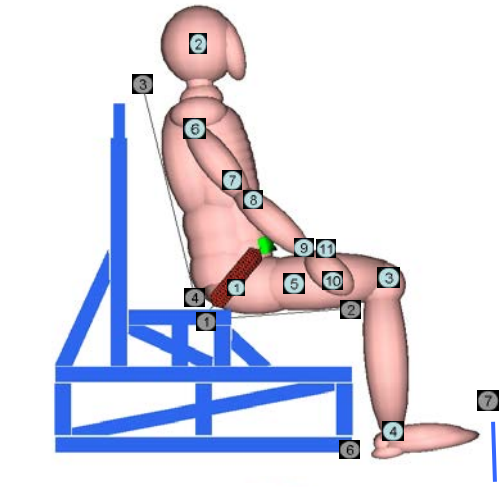
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.4	9.1	-2.4	90
SB2	Lap belt	3.3	8.4	-3.5	91
SB3	Lap belt	7.9	3.5	-7.7	92
SB4	Lap belt	9.0	1.2	-8.0	93
SB5	Lap belt	9.6	-1.2	-7.9	94
SB6	Lap belt	8.0	-2.2	-7.5	95
SB7	Lap belt	3.1	-8.1	-3.5	96
SB8	Lap belt	2.4	-8.9	-2.5	97
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

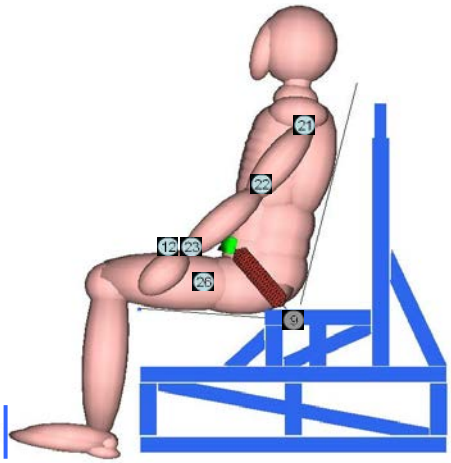
Webbing Length Measurements

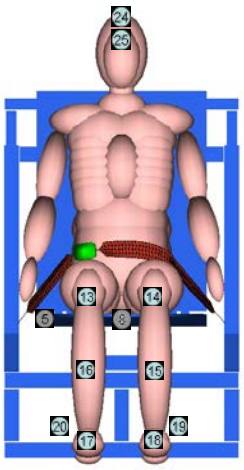
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	14
Lap Strap LH	14.75
Center Strap	NA

Figure B-16. Test 07324-12 Belt Pretest Data Sheet

Test Number	07324-13	Date	12/20/2007
ATD/ Serial Number	FAA HYB III 289	Test Condition	60deg/19g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.3	7.2	-4.5
1a	H Point Vertical Auxiliary	4.0	6.5	-7.3
1b	H Point Horizontal Auxiliary	1.6	6.6	-5.6
1c	H Point Auxiliary	1.4	6.0	-8.5
2	Head CG	-1.8	3.0	-32.4
2a	Head CG Vertical Auxiliary	-2.6	2.5	-35.2
2b	Head CG Horizontal Auxiliary	-4.6	2.3	-33.1
3	Knee R	20.1	6.7	-4.1
4	Ankle R	21.1	6.2	11.4
5	Femur R	11.9	7.7	-4.8
6	Shoulder R	-1.0	9.1	-21.8
7	Elbow1R	1.4	10.3	-14.3
8	Elbow2 R	3.2	10.6	-12.5
9	Wrist R	12.2	7.1	-10.2
10	Hand R	14.9	6.7	-9.7
11	Top hand wrist	13.0	5.5	-11.2
12	Top Hand Wrist	12.6	-6.3	-10.8
13	Knee R	22.8	4.7	-4.8
14	Knee L	22.7	-4.5	-4.4
15	Tibia L	22.8	-5.0	3.0
16	Tibia R	22.9	4.7	3.2
17	Shoe tip top R	29.6	4.7	13.8
18	Shoe tip top L	29.6	-4.7	14.0
19	Shoe back L	18.3	-4.7	13.5
20	Shoe back R	18.6	4.4	13.6
21	Shoulder L	-0.7	-9.1	-21.8
22	Elbow L	3.0	-10.4	-12.1
23	Wrist L	11.8	-7.4	-9.8
24	Top Head	-2.8	0.0	-36.3
25	Forehead	2.2	0.1	-34.1
26	Femur L	11.8	-7.6	-4.3
27	Kee L	20.1	-6.6	-4.0
28	Ankle L	21.5	-6.3	11.2

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.2	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.1	-2.2
5	Seatbottom from front view	16.1	9.0	-1.4
6	Seat frame ground	16.2	14.1	16.1
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-0.5	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	95
Plane of scale targets right side	96

Distce from onbd lens to Seat	63"
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	97
second point on rigid seat (R)	NA
first point on rigid seat (L)	98
second point on rigid seat (L)	99

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	71.1	68
Femur Angle	3.4	3.7
Tibia Angle	87.2	83.4

Unit System

English
in, lbf, s, lb

Figure B-17. Test 07324-13 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

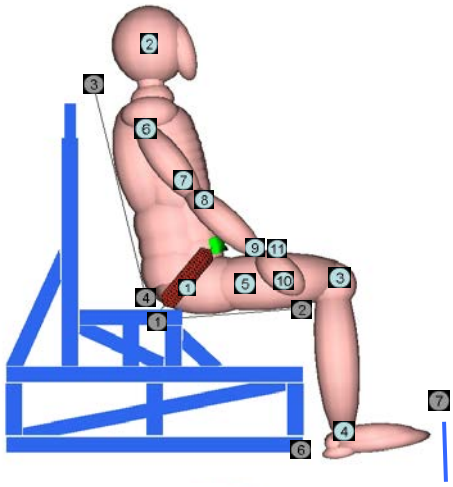
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.4	9.2	-2.1	100
SB2	Lap belt	3.3	8.5	-3.1	101
SB3	Lap belt	8.1	3.8	-7.7	102
SB4	Lap belt	9.3	1.4	-7.8	103
SB5	Lap belt	9.8	-1.0	-7.9	104
SB6	Lap belt	8.4	-1.8	-7.7	105
SB7	Lap belt	3.1	-8.1	-3.1	106
SB8	Lap belt	2.3	-9.0	-2.2	107
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

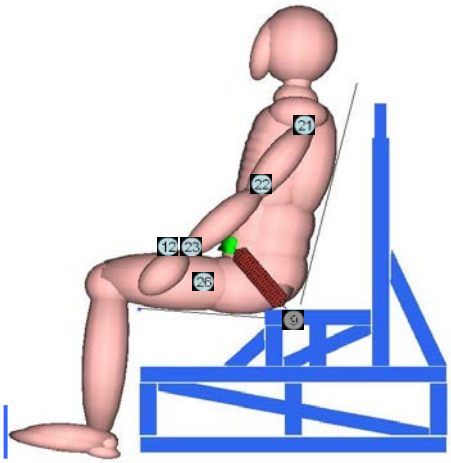
Webbing Length Measurements

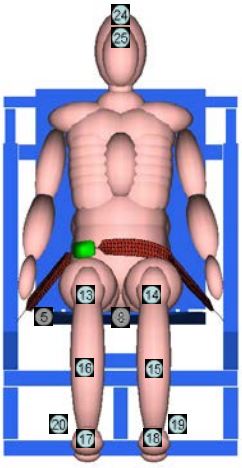
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	13.75
Lap Strap LH	15.5
Center Strap	NA

Figure B-18. Test 07324-13 Belt Pretest Data Sheet

Test Number	07324-14	Date	12/21/2007
ATD/ Serial Number	FAA HYB III 289	Test Condition	60deg/19g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.1	6.9	-4.5
1a	H Point Vertical Auxiliary	3.9	6.2	-7.4
1b	H Point Horizontal Auxiliary	1.5	6.3	-5.7
1c	H Point Auxiliary	1.3	5.6	-8.6
2	Head CG	-2.0	3.4	-32.4
2a	Head CG Vertical Auxiliary	-3.0	2.9	-35.1
2b	Head CG Horizontal Auxiliary	-4.8	2.8	-33.0
3	Knee R	19.9	5.2	-4.6
4	Ankle R	NA	NA	NA
5	Femur R	11.8	7.2	-4.9
6	Shoulder R	-0.9	9.1	-21.7
7	Elbow1R	1.3	10.1	-14.1
8	Elbow2 R	3.1	10.3	-12.3
9	Wrist R	12.0	6.7	-9.7
10	Hand R	14.7	6.2	-9.5
11	Top hand wrist	12.5	5.0	-10.6
12	Top Hand Wrist	12.9	-6.2	-11.2
13	Knee R	22.6	3.9	-4.8
14	Knee L	22.6	-4.5	-4.4
15	Tibia L	22.7	-5.0	3.0
16	Tibia R	22.7	4.2	3.2
17	Shoe tip top R	29.3	4.4	13.9
18	Shoe tip top L	29.4	-5.1	14.0
19	Shoe back L	18.2	-4.5	13.5
20	Shoe back R	18.3	4.4	13.5
21	Shoulder L	-1.1	-9.1	-22.1
22	Elbow L	3.6	-10.7	-12.9
23	Wrist L	12.1	-7.4	-10.3
24	Top Head	-3.4	0.5	-36.3
25	Forehead	1.7	0.3	-34.3
26	Femur L	11.8	-7.8	-4.4
27	Kee L	20.0	-6.6	-4.5
28	Ankle L	21.4	-6.4	11.2

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.3	14.3	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.5	10.1	-2.2
5	Seatbottom from front view	16.0	9.0	-1.4
6	Seat frame ground	16.3	14.0	16.1
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.3	-14.2	0.1
10	Plane of scale targets left side	-12.1	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	84
Plane of scale targets right side	85

Distce from onbd lens to Seat	63"
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	86
second point on rigid seat (R)	NA
first point on rigid seat (L)	87
second point on rigid seat (L)	88

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	70.8	68.6
Femur Angle	4.3	1.6
Tibia Angle	87.5	82.4

Unit System

English
in, lbf, s, lb

Figure B-19. Test 07324-14 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

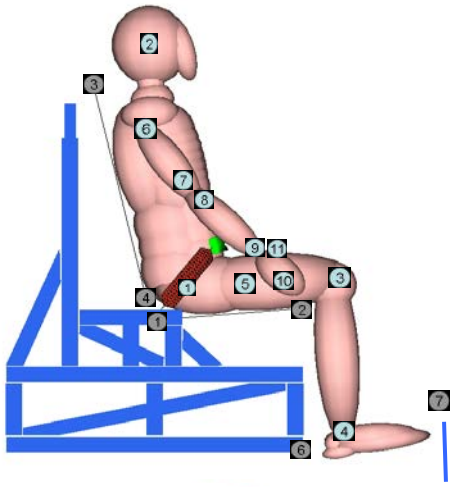
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.4	9.0	-2.5	89
SB2	Lap belt	3.3	8.3	-3.5	90
SB3	Lap belt	8.0	3.1	-7.6	91
SB4	Lap belt	9.1	0.7	-7.6	92
SB5	Lap belt	9.6	-1.6	-7.6	93
SB6	Lap belt	8.1	-2.4	-7.4	94
SB7	Lap belt	3.4	-8.3	-3.5	95
SB8	Lap belt	2.5	-9.1	-2.5	96
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

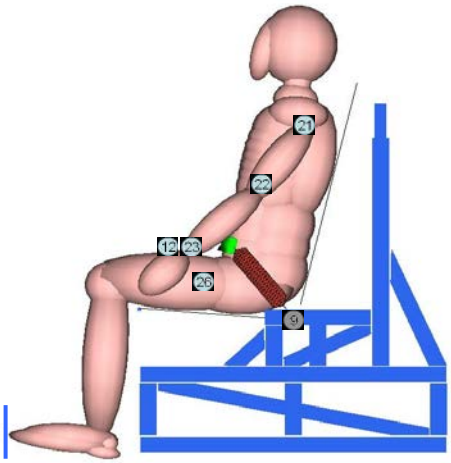
Webbing Length Measurements

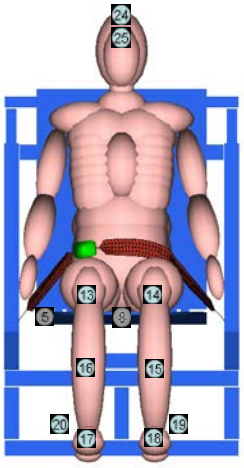
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	14
Lap Strap LH	15.25
Center Strap	NA

Figure B-20. Test 07324-14 Belt Pretest Data Sheet

Test Number	07324-15	Date	12/21/2007
ATD/ Serial Number	FAA HYB III 289	Test Condition	60deg/19g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.1	7.0	-4.6
1a	H Point Vertical Auxiliary	4.0	6.1	-7.5
1b	H Point Horizontal Auxiliary	1.5	6.3	-5.8
1c	H Point Auxiliary	1.4	5.6	-8.8
2	Head CG	-2.3	2.8	-32.5
2a	Head CG Vertical Auxiliary	-3.3	2.3	-35.2
2b	Head CG Horizontal Auxiliary	-5.1	2.2	-33.0
3	Knee R	19.8	5.8	-4.6
4	Ankle R	21.3	5.9	11.3
5	Femur R	11.7	7.5	-4.8
6	Shoulder R	-1.0	8.8	-22.0
7	Elbow1R	1.4	10.2	-14.5
8	Elbow2 R	3.2	10.5	-12.8
9	Wrist R	12.4	7.4	-10.6
10	Hand R	14.9	6.9	-9.7
11	Top hand wrist	13.4	5.9	-11.7
12	Top Hand Wrist	12.3	-6.7	-11.2
13	Knee R	22.6	4.6	-4.9
14	Knee L	22.5	-4.7	-4.5
15	Tibia L	22.9	-5.2	2.9
16	Tibia R	22.8	4.6	3.1
17	Shoe tip top R	29.8	4.5	13.8
18	Shoe tip top L	30.0	-4.9	13.8
19	Shoe back L	18.7	-5.0	13.5
20	Shoe back R	18.7	4.1	13.5
21	Shoulder L	-1.1	-9.4	-22.0
22	Elbow L	2.9	-11.1	-12.5
23	Wrist L	11.6	-7.8	-10.0
24	Top Head	-3.7	-0.2	-36.3
25	Forehead	1.4	-0.2	-34.5
26	Femur L	11.7	-7.9	-4.4
27	Kee L	19.9	-6.0	-4.6
28	Ankle L	21.8	-6.7	11.1

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.3	14.3	0.0
2	Seatbottom	16.0	10.2	-1.0
3	Seatback	-6.2	10.0	-26.7
4	Seat back lower	-0.4	10.1	-2.3
5	Seatbottom from front view	16.0	9.0	-1.5
6	Seat frame ground	16.3	14.0	16.0
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.3	-14.2	0.0
10	Plane of scale targets left side	-12.2	-14.0	6.7

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	79
Plane of scale targets right side	80

Distce from onbd lens to Seat	63"
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	81
second point on rigid seat (R)	NA
first point on rigid seat (L)	82
second point on rigid seat (L)	83

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	70.1	67.7
Femur Angle	3.3	4.5
Tibia Angle	88.5	83.5

Unit System

English
in, lbf, s, lb

Figure B-21. Test 07324-15 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

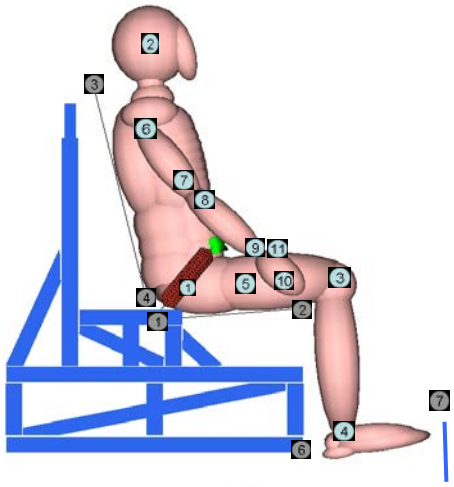
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.3	9.1	-2.5	84
SB2	Lap belt	3.1	8.3	-3.4	85
SB3	Lap belt	8.0	3.5	-7.6	86
SB4	Lap belt	9.1	1.2	-7.5	87
SB5	Lap belt	9.7	-1.2	-7.7	88
SB6	Lap belt	8.2	-2.1	-7.5	89
SB7	Lap belt	3.1	-8.3	-3.5	90
SB8	Lap belt	2.3	-9.1	-2.4	91
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

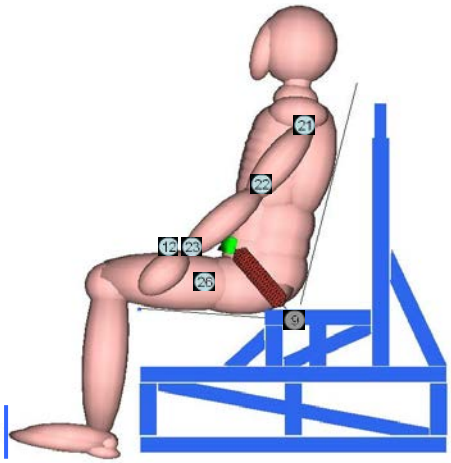
Webbing Length Measurements

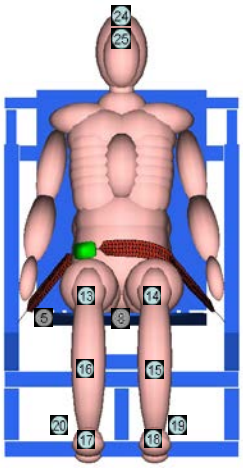
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	13.25
Lap Strap LH	15.5
Center Strap	NA

Figure B-22. Test 07324-15 Belt Pretest Data Sheet

Test Number	07324-16	Date	1/9/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/16g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.5	7.2	-4.3
1a	H Point Vertical Auxiliary	4.2	6.4	-7.2
1b	H Point Horizontal Auxiliary	1.8	6.5	-5.4
1c	H Point Auxiliary	1.6	5.9	-8.4
2	Head CG	-0.3	3.3	-32.4
2a	Head CG Vertical Auxiliary	-0.6	2.8	-35.3
2b	Head CG Horizontal Auxiliary	-2.9	2.7	-33.6
3	Knee R	20.3	5.7	-4.4
4	Ankle R	23.3	6.3	11.2
5	Femur R	12.2	7.6	-4.7
6	Shoulder R	-0.6	9.1	-21.6
7	Elbow1R	1.9	10.3	-14.0
8	Elbow2 R	3.5	10.6	-12.2
9	Wrist R	12.8	7.6	-10.8
10	Hand R	15.4	7.4	-9.9
11	Top hand wrist	13.7	6.0	-11.5
12	Top Hand Wrist	13.3	-6.1	-10.7
13	Knee R	23.0	4.5	-4.7
14	Knee L	22.8	-4.0	-4.2
15	Tibia L	24.1	-4.5	2.7
16	Tibia R	24.0	4.7	2.9
17	Shoe tip top R	31.7	4.6	13.8
18	Shoe tip top L	32.0	-4.1	14.1
19	Shoe back L	20.8	-4.2	13.3
20	Shoe back R	20.7	4.5	13.5
21	Shoulder L	-0.4	-9.0	-21.7
22	Elbow L	3.9	-10.5	-12.3
23	Wrist L	12.5	-7.2	-9.8
24	Top Head	-0.7	0.3	-36.4
25	Forehead	3.8	0.2	-33.3
26	Femur L	12.2	-7.5	-4.2
27	Kee L	20.2	-5.4	-4.3
28	Ankle L	24.1	-5.9	11.0

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.2	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.3	13.8	16.1
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.6	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	81
Plane of scale targets right side	82

Distce from onbd lens to Seat	NA
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	83
second point on rigid seat (R)	84
first point on rigid seat (L)	85
second point on rigid seat (L)	86

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	NA	
Femur Angle	NA	
Tibia Angle	NA	

Unit System

English
in, lbf, s, lb

Figure B-23. Test 07324-16 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

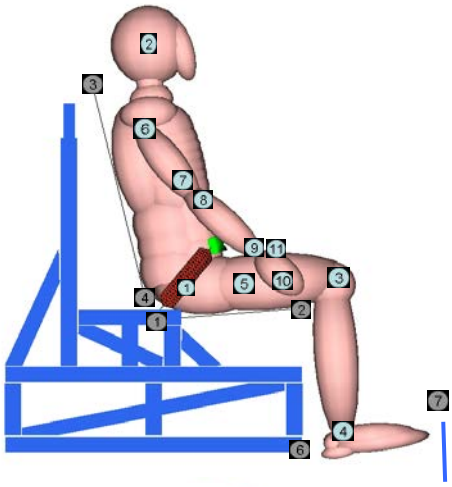
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.6	9.1	-2.2	87
SB2	Lap belt	3.6	8.4	-3.2	88
SB3	Lap belt	8.4	3.4	-7.4	89
SB4	Lap belt	9.4	1.1	-7.5	90
SB5	Lap belt	10.0	-1.3	-7.6	91
SB6	Lap belt	7.9	-2.9	-7.0	92
SB7	Lap belt	7.0	-4.7	-6.9	93
SB8	Lap belt	2.6	-9.0	-2.3	94
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

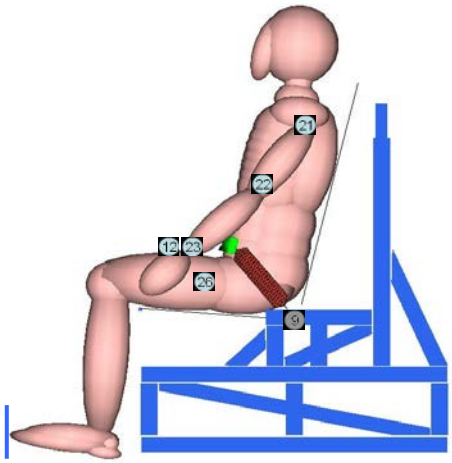
Webbing Length Measurements

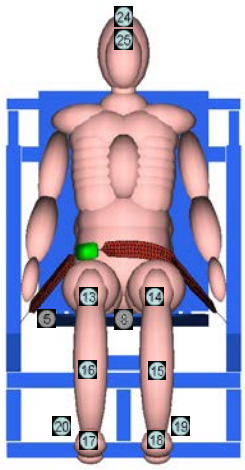
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	NA
Lap Strap LH	NA
Center Strap	NA

Figuer B-24. Test 07324-16 Belt Pretest Data Sheet

Test Number	07324-17	Date	1/10/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/16g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.3	7.1	-4.3
1a	H Point Vertical Auxiliary	4.2	6.3	-7.1
1b	H Point Horizontal Auxiliary	1.7	6.3	-5.4
1c	H Point Auxiliary	1.6	5.7	-8.3
2	Head CG	-0.8	2.9	-32.4
2a	Head CG Vertical Auxiliary	-1.1	2.3	-35.2
2b	Head CG Horizontal Auxiliary	-3.4	2.2	-33.5
3	Knee R	20.2	5.4	-4.5
4	Ankle R	23.1	5.2	11.1
5	Femur R	12.2	7.4	-4.5
6	Shoulder R	-0.7	8.7	-21.6
7	Elbow1R	2.2	10.0	-14.1
8	Elbow2 R	4.1	10.2	-12.5
9	Wrist R	13.1	6.7	-10.4
10	Hand R	15.8	6.4	-9.9
11	Top hand wrist	13.8	4.9	-11.0
12	Top Hand Wrist	13.3	-6.1	-10.8
13	Knee R	22.9	4.2	-5.0
14	Knee L	23.1	-4.4	-4.6
15	Tibia L	23.8	-4.3	2.8
16	Tibia R	23.9	4.1	2.8
17	Shoe tip top R	31.6	3.1	13.9
18	Shoe tip top L	31.2	-2.9	14.0
19	Shoe back L	20.0	-3.6	13.4
20	Shoe back R	20.6	3.7	13.2
21	Shoulder L	-0.4	-9.3	-21.6
22	Elbow L	4.0	-10.8	-12.2
23	Wrist L	12.5	-7.2	-9.9
24	Top Head	-1.2	-0.2	-36.3
25	Forehead	3.4	-0.1	-33.4
26	Femur L	12.3	-7.7	-3.9
27	Kee L	20.3	-5.8	-4.3
28	Ankle L	23.2	-5.0	11.1

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.2	13.9	16.1
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.6	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	80
Plane of scale targets right side	81

Distce from onbd lens to Seat	NA
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	82
second point on rigid seat (R)	83
first point on rigid seat (L)	84
second point on rigid seat (L)	85

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	NA	
Femur Angle	NA	
Tibia Angle	NA	

Unit System

English
in, lbf, s, lb

Figure B-25. Test 07324-17 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

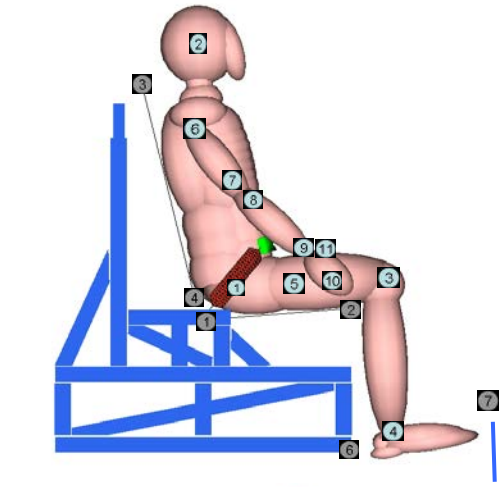
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.7	9.2	-2.1	86
SB2	Lap belt	3.5	8.5	-2.9	87
SB3	Lap belt	8.3	3.5	-7.3	88
SB4	Lap belt	9.4	1.1	-7.4	89
SB5	Lap belt	10.0	-1.4	-7.5	90
SB6	Lap belt	8.5	-2.1	-7.1	91
SB7	Lap belt	7.0	-5.6	-6.6	92
SB8	Lap belt	2.8	-9.0	-2.3	93
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

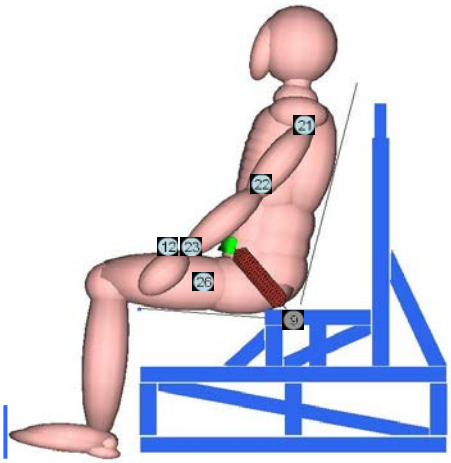
Webbing Length Measurements

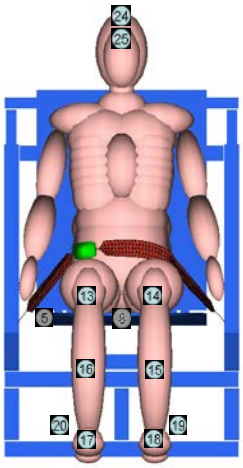
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	NA
Lap Strap LH	NA
Center Strap	NA

Figure B-26. Test 07324-17 Belt Pretest Data Sheet

Test Number	07324-18	Date	1/10/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/16g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.5	7.5	-4.4
1a	H Point Vertical Auxiliary	4.3	6.7	-7.3
1b	H Point Horizontal Auxiliary	1.9	6.9	-5.5
1c	H Point Auxiliary	1.7	6.2	-8.5
2	Head CG	-0.6	3.1	-32.4
2a	Head CG Vertical Auxiliary	-1.0	2.5	-35.3
2b	Head CG Horizontal Auxiliary	-3.3	2.5	-33.5
3	Knee R	20.3	5.8	-4.5
4	Ankle R	22.9	5.4	11.2
5	Femur R	12.3	7.8	-4.5
6	Shoulder R	-0.3	9.1	-21.7
7	Elbow1R	2.1	10.6	-14.2
8	Elbow2 R	3.7	10.9	-12.4
9	Wrist R	12.8	7.4	-10.8
10	Hand R	15.5	7.2	-10.0
11	Top hand wrist	13.7	5.8	-11.5
12	Top Hand Wrist	13.1	-4.8	-11.3
13	Knee R	23.0	4.3	-4.9
14	Knee L	22.9	-3.7	-4.5
15	Tibia L	23.9	-4.2	2.6
16	Tibia R	23.8	4.3	2.9
17	Shoe tip top R	31.5	3.5	13.8
18	Shoe tip top L	31.6	-3.7	14.1
19	Shoe back L	20.4	-4.0	13.3
20	Shoe back R	20.4	3.6	13.5
21	Shoulder L	-0.7	-9.0	-21.5
22	Elbow L	4.2	-10.4	-12.4
23	Wrist L	12.5	-6.1	-10.7
24	Top Head	-1.1	0.0	-36.4
25	Forehead	3.4	-0.1	-33.4
26	Femur L	12.3	-7.1	-4.6
27	Kee L	20.2	-5.2	-4.5
28	Ankle L	23.5	-5.6	10.9

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.3	13.9	16.1
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.3	-14.2	0.1
10	Plane of scale targets left side	-14.6	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	82
Plane of scale targets right side	83

Distce from onbd lens to Seat	
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	84
second point on rigid seat (R)	85
first point on rigid seat (L)	86
second point on rigid seat (L)	87

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle		
Femur Angle		
Tibia Angle		

Unit System

English
in, lbf, s, lb

Figure B-27. Test 07324-18 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

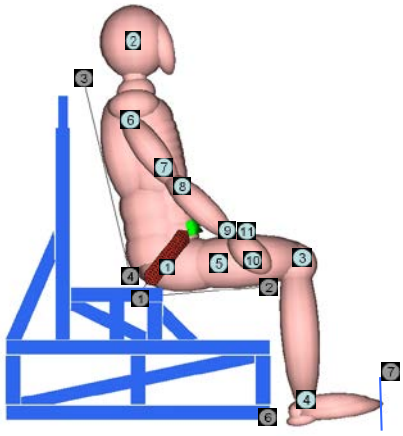
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.7	9.2	-2.2	88
SB2	Lap belt	3.8	8.6	-3.2	89
SB3	Lap belt	8.4	3.8	-7.4	90
SB4	Lap belt	9.5	1.4	-7.3	91
SB5	Lap belt	10.0	-1.1	-7.5	92
SB6	Lap belt	8.3	-2.1	-7.2	93
SB7	Lap belt	6.5	-5.4	-6.4	94
SB8	Lap belt	2.6	-9.0	-2.1	95
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

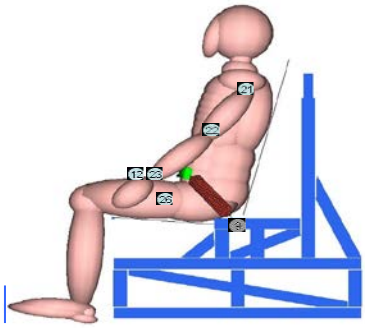
Webbing Length Measurements

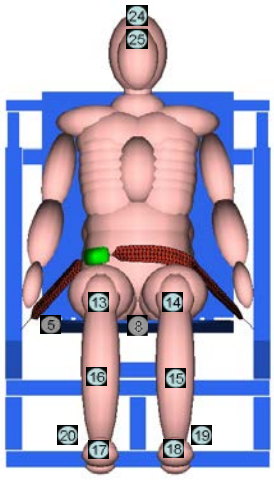
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	
Lap Strap LH	
Center Strap	NA

Figure B-28. Test 07324-18 Belt Pretest Data Sheet

Test Number	07324-20	Date	1/11/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	3 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.2	7.0	-4.4
1a	H Point Vertical Auxiliary	4.1	6.3	-7.3
1b	H Point Horizontal Auxiliary	1.6	6.3	-5.6
1c	H Point Auxiliary	1.4	5.7	-8.5
2	Head CG	-0.7	2.8	-32.4
2a	Head CG Vertical Auxiliary	-0.9	2.2	-35.3
2b	Head CG Horizontal Auxiliary	-3.3	2.2	-33.6
3	Knee R	20.1	5.4	-4.3
4	Ankle R	23.5	6.3	11.2
5	Femur R	12.1	7.4	-4.8
6	Shoulder R	-0.7	8.8	-21.6
7	Elbow1R	1.8	10.0	-14.2
8	Elbow2 R	3.7	10.2	-12.4
9	Wrist R	12.5	6.1	-10.6
10	Hand R	15.1	5.7	-10.0
11	Top hand wrist	13.0	4.3	-10.9
12	Top Hand Wrist	12.8	-5.4	-10.7
13	Knee R	22.8	4.2	-4.5
14	Knee L	22.9	-3.9	-4.4
15	Tibia L	24.1	-4.4	2.7
16	Tibia R	24.1	4.6	2.9
17	Shoe tip top R	32.0	4.0	13.9
18	Shoe tip top L	31.9	-4.4	14.3
19	Shoe back L	20.7	-4.2	13.3
20	Shoe back R	20.9	4.6	13.5
21	Shoulder L	-0.5	-9.3	-21.5
22	Elbow L	3.9	-10.7	-12.2
23	Wrist L	12.2	-6.6	-9.8
24	Top Head	-1.0	-0.2	-36.4
25	Forehead	3.5	-0.2	-33.3
26	Femur L	12.4	-7.4	-4.5
27	Kee L	20.3	-5.4	-4.4
28	Ankle L	24.1	-5.8	10.9

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.3	13.8	16.1
7	Centre front plate	33.3	-0.1	14.4
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.3	-14.2	0.1
10	Plane of scale targets left side	-14.6	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	87
Plane of scale targets right side	88

Distce from onbd lens to Seat	NA
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	89
second point on rigid seat (R)	90
first point on rigid seat (L)	91
second point on rigid seat (L)	92

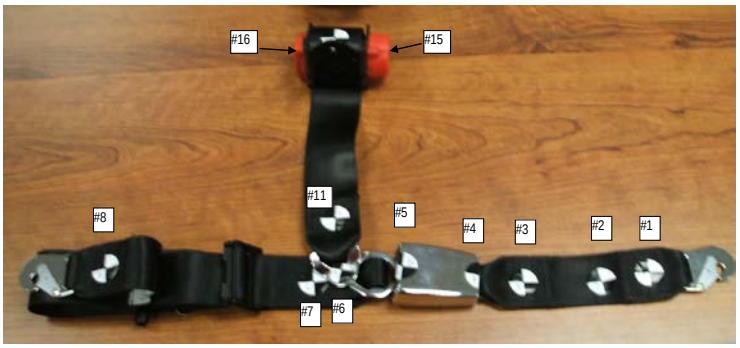
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	NA	
Femur Angle	NA	
Tibia Angle	NA	

Unit System

English
in, lbf, s, lb

Figure B-29. Test 07324-20 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

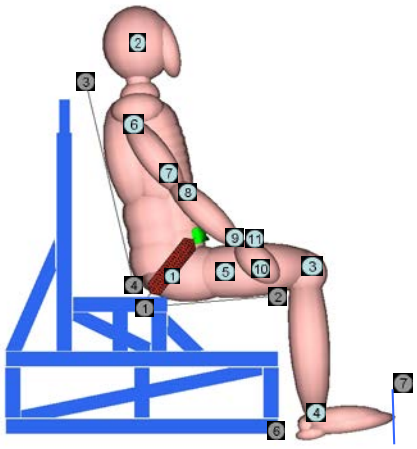
ID	Name	X	Y	Z
SB1	Lap belt	2.2	-9.2	-2.1
SB2	Lap belt	3.1	-8.5	-3.0
SB3	Lap belt	7.5	-4.0	-6.8
SB4	Lap belt	8.3	4.1	-8.4
SB5	Lap belt	7.3	5.7	-7.7
SB6	Lap belt	6.0	7.7	-6.9
SB7	Lap belt	3.2	8.6	-2.8
SB8	Lap belt	2.4	9.3	-2.0
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.3	3.3	-10.6
SB12	Shoulder belt	4.6	-0.9	-23.0
SB13	Shoulder belt	-0.8	-3.3	-25.6
SB14	Shoulder belt Anchor to seat	-8.4	-6.8	-29.3

Webbing Length Measurements

Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	NA
Lap Strap LH	NA
Center Strap	NA

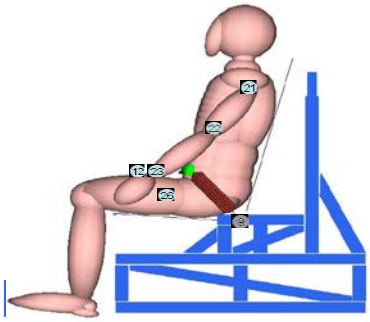
Figure B-30. Test 07324-20 Belt Pretest Data Sheet

Test Number	07324-21	Date	1/29/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	4 pt belt	Ambient Humidity	20-30%



ATD Targets

ID	Name	X	Y	Z
1	H Point	4.8	7.2	-4.3
1a	H Point Vertical Auxiliary	4.3	6.5	-7.1
1b	H Point Horizontal Auxiliary	2.1	6.7	-5.1
1c	H Point Auxiliary	1.6	6.1	-8.0
2	Head CG	-0.1	3.4	-32.1
2a	Head CG Vertical Auxiliary	-0.2	2.9	-35.0
2b	Head CG Horizontal Auxiliary	-2.6	2.8	-33.4
3	Knee R	20.3	5.5	-7.2
4	Ankle R	23.3	5.9	8.4
5	Femur R	12.4	7.4	-6.1
6	Shoulder R	-0.5	9.3	-21.2
7	Elbow1R	1.6	10.4	-13.6
8	Elbow2 R	3.2	10.7	-11.7
9	Wrist R	11.9	5.3	-11.9
10	Hand R	15.2	6.9	-11.4
11	Top hand wrist	13.1	5.6	-12.7
12	Top Hand Wrist	12.2	-5.2	-12.8
13	Knee R	22.9	4.2	-8.0
14	Knee L	22.7	-3.8	-7.9
15	Tibia L	24.0	-4.1	-0.1
16	Tibia R	24.0	4.4	0.1
17	Shoe tip top R	31.8	4.0	10.8
18	Shoe tip top L	31.8	-3.5	11.1
19	Shoe back L	20.6	-3.7	10.4
20	Shoe back R	20.8	4.2	10.5
21	Shoulder L	-0.4	-8.6	-21.3
22	Elbow L	3.1	-10.5	-11.8
23	Wrist L	11.2	-4.7	-12.2
24	Top Head	-0.2	0.4	-36.2
25	Forehead	4.1	0.4	-32.9
26	Femur L	12.3	-7.2	-5.8
27	Kee L	20.0	-5.2	-7.1
28	Ankle L	24.1	-5.4	8.1



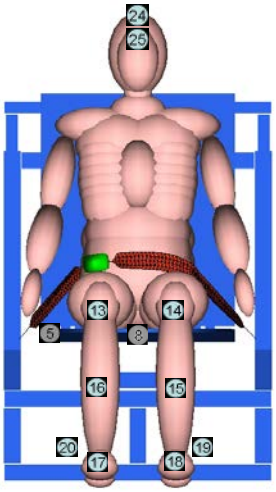
Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.2	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.1	9.0	-1.4
6	Seat frame ground	16.3	13.8	16.1
7	Centre front plate	33.2	0.3	9.9
8	Seat bottom center from front	16.2	0.1	-1.0
9	SB L	0.5	-14.2	0.1
10	Plane of scale targets left side	11.7	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	48
Plane of scale targets right side	49

Distce from onbd lens to Seat	56.5
Distce from outbd lens to Sled	248.5



Points to measure photometric error

	POINT #
first point on rigid seat (R)	50
second point on rigid seat (R)	51
first point on rigid seat (L)	52
second point on rigid seat (L)	53

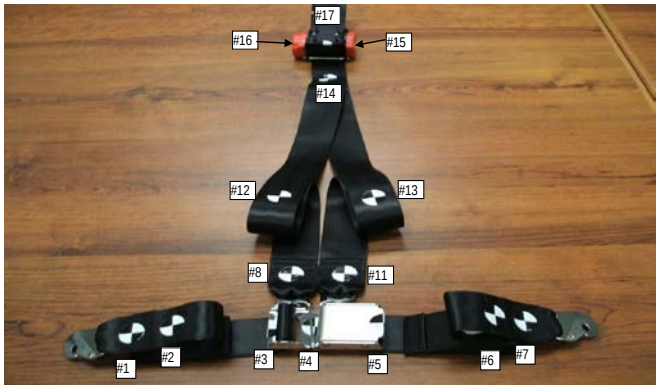
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	63.7	
Femur Angle	18.8	
Tibia Angle	85.7	

Unit System

English
in, lbf, s, lb

Figure B-31. Test 07324-21 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

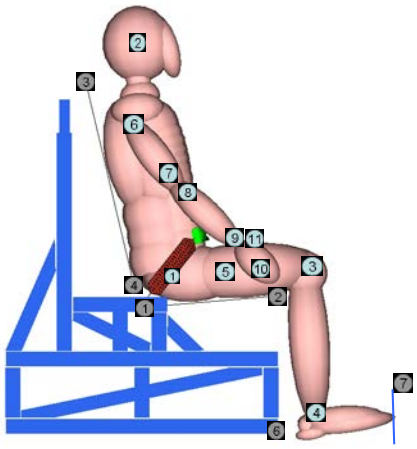
ID	Name	X	Y	Z
SB1	Lap belt	3.2	8.7	-2.9
SB2	Lap belt	6.0	6.6	-6.4
SB3	Lap belt	9.0	2.3	-8.6
SB4	Lap belt	8.9	0.7	-8.6
SB5	Lap belt	8.8	-2.1	-8.5
SB6	Lap belt	5.7	-6.5	-6.1
SB7	Lap belt	3.4	-8.3	-3.0
SB8	Shoulder belt	8.9	1.4	-12.2
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.8	0.0	-12.4
SB12	Shoulder belt	6.0	2.3	-20.1
SB13	Shoulder belt	6.0	-1.3	-20.2
SB14	Shoulder belt	-8.3	0.0	-29.3
SB15	Retractor			
SB16	Retractor			
SB17	Retractor			
SB18	Top slider bar contact			
SB19	Top slider bar contact			

Webbing Length Measurements

Shoulder Strap RH	27.75
Shoulder Strap LH	27.75
Lap Strap RH	15.25
Lap Strap LH	14.25
Center Strap	NA

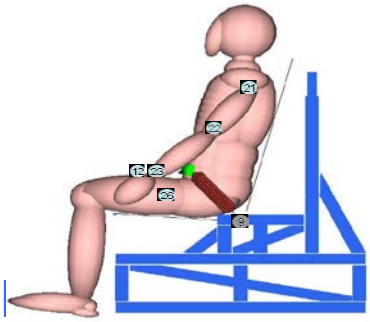
Figure B-32. Test 07324-21 Belt Pretest Data Sheet

Test Number	07324-22	Date	1/29/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	4 pt belt	Ambient Humidity	20-30%



ATD Targets

ID	Name	X	Y	Z
1	H Point	4.9	7.2	-4.3
1a	H Point Vertical Auxiliary	4.3	6.5	-7.1
1b	H Point Horizontal Auxiliary	2.1	6.6	-5.1
1c	H Point Auxiliary	1.6	6.0	-8.0
2	Head CG	-0.1	3.4	-32.0
2a	Head CG Vertical Auxiliary	-0.3	2.9	-34.9
2b	Head CG Horizontal Auxiliary	-2.7	2.8	-33.2
3	Knee R	20.4	5.3	-7.2
4	Ankle R	23.4	5.9	8.2
5	Femur R	12.5	7.4	-6.1
6	Shoulder R	-0.5	9.3	-21.1
7	Elbow1R	1.9	10.4	-13.5
8	Elbow2 R	3.6	10.6	-11.7
9	Wrist R	12.1	4.9	-11.6
10	Hand R	15.5	6.3	-11.8
11	Top hand wrist	13.2	5.0	-12.6
12	Top Hand Wrist	12.6	-5.4	-12.5
13	Knee R	22.9	4.0	-8.0
14	Knee L	22.8	-3.9	-8.1
15	Tibia L	24.2	-4.5	-0.1
16	Tibia R	24.1	4.3	0.0
17	Shoe tip top R	31.8	4.4	10.8
18	Shoe tip top L	31.8	-3.9	11.1
19	Shoe back L	20.6	-4.3	10.4
20	Shoe back R	20.9	3.8	10.5
21	Shoulder L	-0.4	-8.7	-21.2
22	Elbow L	3.4	-10.5	-11.7
23	Wrist L	11.7	-4.9	-11.8
24	Top Head	-0.4	0.4	-36.0
25	Forehead	4.0	0.3	-32.9
26	Femur L	12.5	-7.3	-5.9
27	Kee L	20.2	-5.3	-7.1
28	Ankle L	24.2	-6.0	8.0



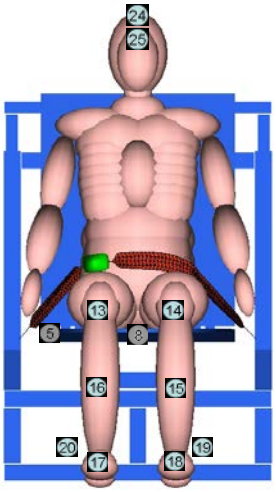
Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.2	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.1	8.9	-1.4
6	Seat frame ground	16.3	14.0	16.1
7	Centre front plate	33.1	0.4	10.0
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.5	-14.2	0.1
10	Plane of scale targets left side	-14.5	-14.1	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	80
Plane of scale targets right side	81

Distce from onbd lens to Seat	56.5
Distce from outbd lens to Sled	248.5



Points to measure photometric error

	POINT #
first point on rigid seat (R)	82
second point on rigid seat (R)	83
first point on rigid seat (L)	84
second point on rigid seat (L)	85

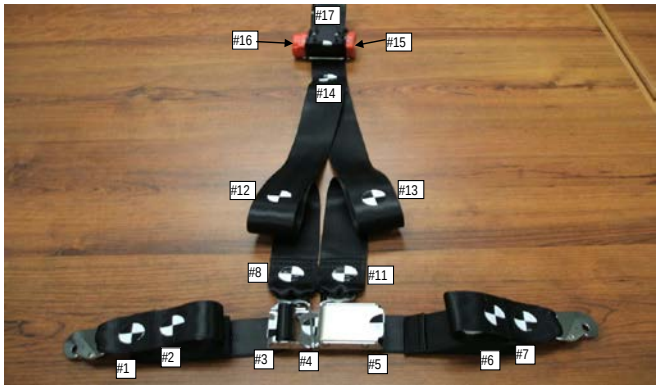
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	69.5	
Femur Angle	12.4	
Tibia Angle	85.3	

Unit System

English
in, lbf, s, lb

Figure B-33. Test 07324-22 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

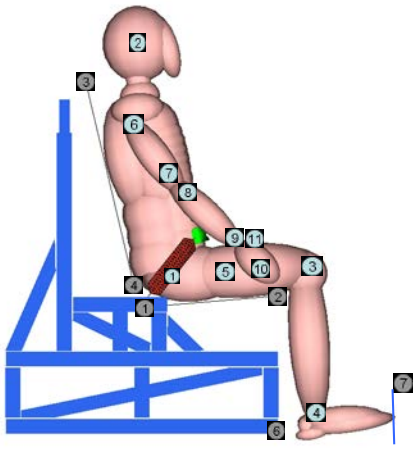
ID	Name	X	Y	Z
SB1	Lap belt	2.4	9.4	-1.9
SB2	Lap belt	5.3	7.2	-5.6
SB3	Lap belt	9.0	1.7	-8.8
SB4	Lap belt	8.9	0.1	-8.9
SB5	Lap belt	8.6	-2.6	-8.6
SB6	Lap belt	6.8	-5.5	-7.3
SB7	Lap belt	2.5	-9.1	-2.3
SB8	Shoulder belt	8.7	0.9	-12.4
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.5	-0.5	-12.6
SB12	Shoulder belt	6.0	2.0	-20.3
SB13	Shoulder belt	6.0	-1.8	-20.3
SB14	Shoulder belt	-8.3	0.0	-29.5
SB15	Retractor			
SB16	Retractor			
SB17	Retractor			
SB18	Top slider bar contact			
SB19	Top slider bar contact			

Webbing Length Measurements

Shoulder Strap RH	27.5
Shoulder Strap LH	27.2
Lap Strap RH	15.75
Lap Strap LH	13.6
Center Strap	

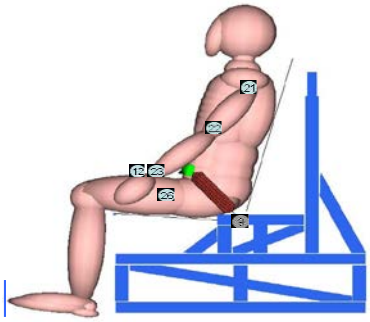
Figure B-34. Test 07324-22 Belt Pretest Data Sheet

Test Number	07324-23	Date	1/29/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	4 pt belt	Ambient Humidity	20-30%



ATD Targets

ID	Name	X	Y	Z
1	H Point	4.6	7.0	-4.2
1a	H Point Vertical Auxiliary	4.0	6.2	-7.1
1b	H Point Horizontal Auxiliary	1.8	6.3	-5.1
1c	H Point Auxiliary	1.3	5.6	-8.0
2	Head CG	0.1	3.1	-31.9
2a	Head CG Vertical Auxiliary	-0.1	2.6	-34.9
2b	Head CG Horizontal Auxiliary	-2.5	2.5	-33.3
3	Knee R	20.0	5.8	-7.1
4	Ankle R	23.3	5.3	8.3
5	Femur R	12.1	7.4	-5.8
6	Shoulder R	-0.7	9.0	-21.0
7	Elbow1R	2.3	10.1	-13.8
8	Elbow2 R	4.2	10.5	-12.1
9	Wrist R	12.7	4.9	-12.1
10	Hand R	16.1	6.3	-11.7
11	Top hand wrist	14.0	5.1	-12.9
12	Top Hand Wrist	13.9	-5.3	-13.4
13	Knee R	22.7	4.6	-7.9
14	Knee L	22.7	-3.7	-8.2
15	Tibia L	23.9	-4.2	-0.2
16	Tibia R	23.9	4.3	-0.1
17	Shoe tip top R	31.8	3.6	10.8
18	Shoe tip top L	31.7	-4.1	11.0
19	Shoe back L	20.6	-3.2	10.4
20	Shoe back R	20.8	3.3	10.5
21	Shoulder L	-0.3	-9.0	-21.2
22	Elbow L	4.6	-10.6	-12.3
23	Wrist L	12.7	-4.9	-12.8
24	Top Head	-0.1	0.1	-36.0
25	Forehead	4.2	0.2	-32.7
26	Femur L	12.3	-7.4	-5.9
27	Kee L	20.1	-5.2	-7.2
28	Ankle L	23.8	-5.6	8.0



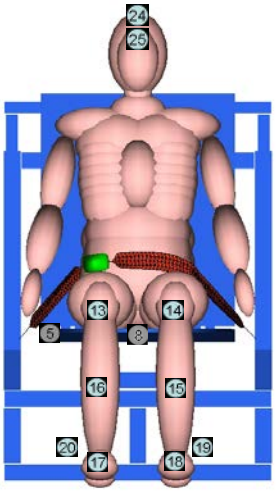
Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.2	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	9.0	-1.3
6	Seat frame ground	16.1	14.0	16.1
7	Centre front plate	33.1	0.2	9.9
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.6	-14.1	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	83
Plane of scale targets right side	84

Distce from onbd lens to Seat	56.5
Distce from outbd lens to Sled	248.5



Points to measure photometric error

	POINT #
first point on rigid seat (R)	85
second point on rigid seat (R)	86
first point on rigid seat (L)	87
second point on rigid seat (L)	88

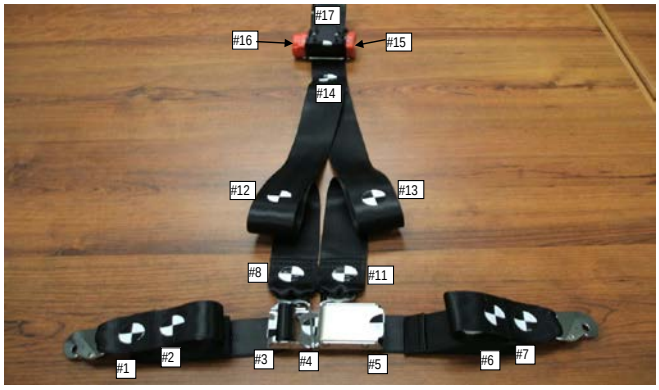
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	69.6	
Femur Angle	10.9	
Tibia Angle	84.9	

Unit System

English
in, lbf, s, lb

Figure B-35. Test 07324-23 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

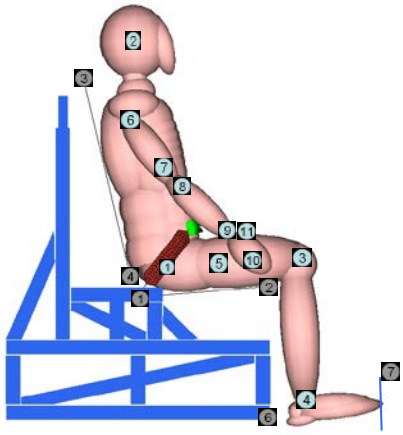
ID	Name	X	Y	Z
SB1	Lap belt	2.3	9.0	-2.2
SB2	Lap belt	5.0	7.0	-5.4
SB3	Lap belt	8.7	1.6	-8.6
SB4	Lap belt	8.7	-0.1	-8.9
SB5	Lap belt	8.3	-2.9	-8.5
SB6	Lap belt	5.1	-7.1	-5.3
SB7	Lap belt	2.4	-9.2	-2.2
SB8	Shoulder belt	8.4	0.6	-12.3
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.2	-0.7	-12.5
SB12	Shoulder belt	6.0	1.9	-19.9
SB13	Shoulder belt	6.0	-1.6	-20.0
SB14	Shoulder belt	-8.3	0.0	-29.5
SB15	Retractor			
SB16	Retractor			
SB17	Retractor			
SB18	Top slider bar contact			
SB19	Top slider bar contact			

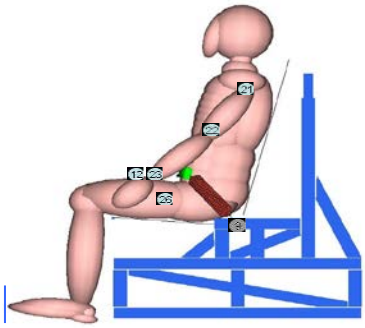
Webbing Length Measurements

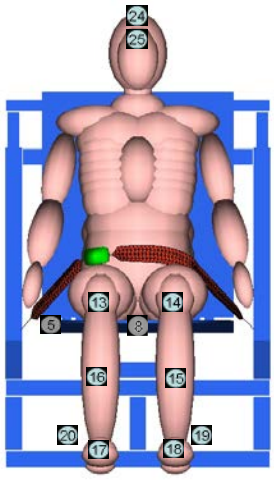
Shoulder Strap RH	27.25
Shoulder Strap LH	27.25
Lap Strap RH	16.25
Lap Strap LH	13.25
Center Strap	

Figure B-36. Test 07324-23 Belt Pretest Data Sheet

Test Number	07324-24	Date	1/30/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	3 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.2	7.2	-4.3
1a	H Point Vertical Auxiliary	4.0	6.4	-7.1
1b	H Point Horizontal Auxiliary	1.6	6.4	-5.4
1c	H Point Auxiliary	1.4	5.8	-8.3
2	Head CG	-0.6	3.0	-32.2
2a	Head CG Vertical Auxiliary	-0.9	2.5	-35.1
2b	Head CG Horizontal Auxiliary	-3.3	2.3	-33.3
3	Knee R	20.1	5.5	-4.6
4	Ankle R	20.5	5.9	10.9
5	Femur R	12.1	7.5	-4.8
6	Shoulder R	-0.8	9.0	-21.4
7	Elbow1R	2.2	10.3	-14.1
8	Elbow2 R	4.0	10.6	-12.5
9	Wrist R	12.7	5.7	-10.2
10	Hand R	15.9	7.5	-9.7
11	Top hand wrist	14.0	6.0	-11.0
12	Top Hand Wrist	12.5	-5.8	-10.4
13	Knee R	22.8	4.3	-5.1
14	Knee L	23.1	-4.2	-5.1
15	Tibia L	22.8	-4.5	3.0
16	Tibia R	22.6	4.4	2.9
17	Shoe tip top R	28.9	4.1	14.1
18	Shoe tip top L	28.9	-3.9	14.2
19	Shoe back L	17.7	-3.8	13.4
20	Shoe back R	17.9	4.4	13.4
21	Shoulder L	-0.1	-9.0	-21.4
22	Elbow L	3.4	-10.6	-11.8
23	Wrist L	11.6	-5.3	-9.7
24	Top Head	-0.9	0.0	-36.3
25	Forehead	3.6	0.2	-33.3
26	Femur L	12.4	-7.6	-4.5
27	Kee L	20.3	-5.6	-4.5
28	Ankle L	21.2	-5.7	11.0

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.2	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.1	-2.3
5	Seatbottom from front view	16.0	9.0	-1.4
6	Seat frame ground	16.2	14.0	16.1
7	Centre front plate	30.3	0.0	14.4
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.5	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	79
Plane of scale targets right side	80

Distce from onbd lens to Seat	NA
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	81
second point on rigid seat (R)	82
first point on rigid seat (L)	83
second point on rigid seat (L)	84

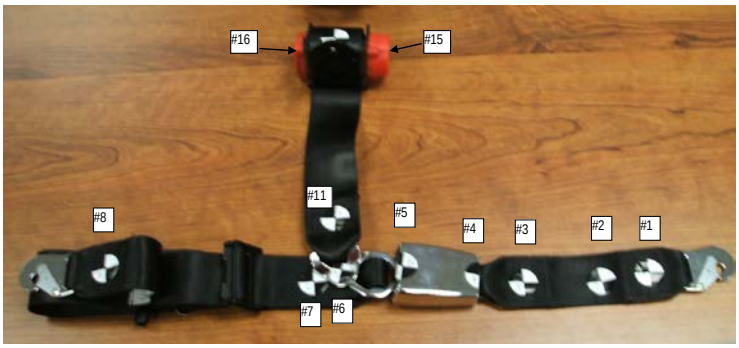
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	70.2	
Femur Angle	3.9	
Tibia Angle	85	

Unit System

English
in, lbf, s, lb

Figure B-37. Test 07324-24 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

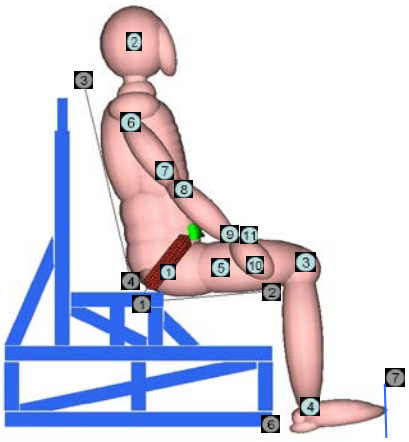
ID	Name	X	Y	Z
SB1	Lap belt	2.4	9.4	-2.0
SB2	Lap belt	5.1	7.3	-5.1
SB3	Lap belt	5.8	7.3	-6.3
SB4	Lap belt	7.5	5.6	-7.6
SB5	Lap belt	8.4	4.0	-8.3
SB6	Lap belt	8.5	-1.7	-7.2
SB7	Lap belt	5.8	-6.6	-5.7
SB8	Lap belt	2.4	-9.3	-1.8
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.4	3.1	-10.4
SB12	Shoulder belt	4.7	-2.0	-22.9
SB13	Shoulder belt	-1.1	-4.1	-25.3
SB14	Shoulder belt Anchor to seat	-8.4	-6.9	-29.5

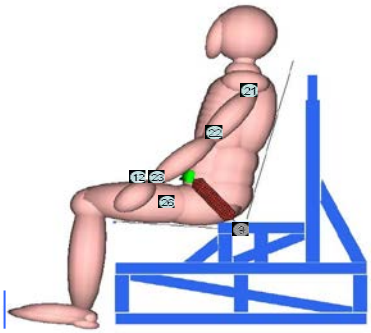
Webbing Length Measurements

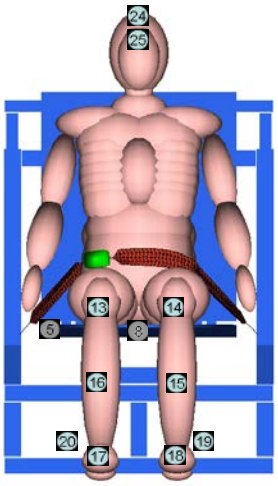
Shoulder Strap RH	NA
Shoulder Strap LH	31
Lap Strap RH	8.2
Lap Strap LH	21.75
Center Strap	NA

Figure B-38. Test 07324-24 Belt Pretest Data Sheet

Test Number	07324-25	Date	1/30/2008
ATD/ Serial Number	FAA HYB III 289	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	3 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.4	7.0	-4.2
1a	H Point Vertical Auxiliary	4.1	6.3	-7.1
1b	H Point Horizontal Auxiliary	1.8	6.4	-5.3
1c	H Point Auxiliary	1.5	5.8	-8.3
2	Head CG	-0.5	2.8	-32.2
2a	Head CG Vertical Auxiliary	-0.7	2.2	-35.1
2b	Head CG Horizontal Auxiliary	-3.1	2.1	-33.4
3	Knee R	20.3	5.6	-4.7
4	Ankle R	20.6	6.1	11.0
5	Femur R	12.2	7.4	-4.8
6	Shoulder R	-0.8	8.8	-21.4
7	Elbow1R	2.0	10.3	-14.1
8	Elbow2 R	4.0	10.6	-12.5
9	Wrist R	12.1	5.1	-9.7
10	Hand R	15.6	6.5	-9.7
11	Top hand wrist	13.4	5.2	-10.7
12	Top Hand Wrist	13.6	-5.8	-11.0
13	Knee R	22.9	4.3	-5.1
14	Knee L	23.1	-3.8	-5.1
15	Tibia L	22.8	-4.3	3.0
16	Tibia R	22.7	4.5	3.0
17	Shoe tip top R	28.9	4.3	13.9
18	Shoe tip top L	28.8	-3.7	14.2
19	Shoe back L	17.6	-3.8	13.5
20	Shoe back R	17.9	4.2	13.4
21	Shoulder L	-0.2	-9.1	-21.2
22	Elbow L	4.3	-10.7	-12.0
23	Wrist L	12.6	-5.2	-10.4
24	Top Head	-0.8	-0.3	-36.3
25	Forehead	3.8	-0.1	-33.2
26	Femur L	12.5	-7.4	-4.7
27	Kee L	20.3	-5.2	-4.5
28	Ankle L	21.2	-5.7	11.1

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.2	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.1	9.0	-1.4
6	Seat frame ground	16.3	14.0	16.1
7	Centre front plate	30.3	0.1	14.4
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.5	-14.1	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	86
Plane of scale targets right side	87

Distce from onbd lens to Seat	56.5
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	88
second point on rigid seat (R)	89
first point on rigid seat (L)	90
second point on rigid seat (L)	91

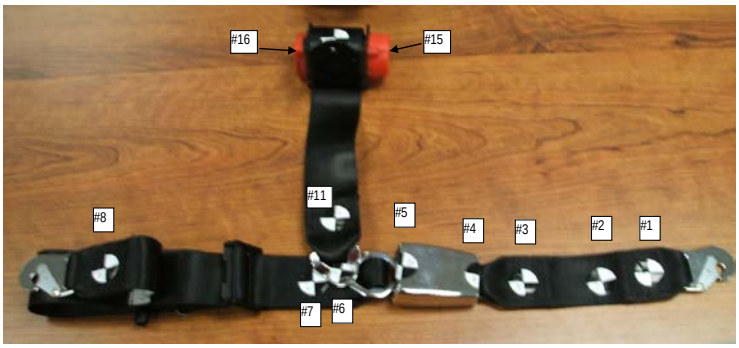
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	70.8	
Femur Angle	3.1	
Tibia Angle	84.5	

Unit System

English
in, lbf, s, lb

Figure B-39. Test 07324-25 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

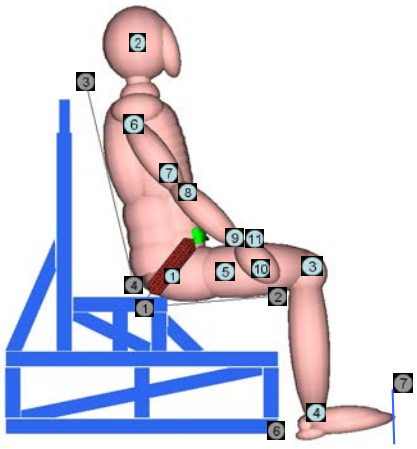
ID	Name	X	Y	Z
SB1	Lap belt	2.6	9.2	-2.1
SB2	Lap belt	5.0	7.4	-4.9
SB3	Lap belt	5.6	7.3	-6.1
SB4	Lap belt	7.3	5.7	-7.5
SB5	Lap belt	8.7	0.8	-7.4
SB6	Lap belt	7.1	-4.7	-6.7
SB7	Lap belt	5.3	-7.0	-5.0
SB8	Lap belt	2.4	-9.2	-2.0
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	8.3	3.0	-10.4
SB12	Shoulder belt	4.8	-2.1	-22.7
SB13	Shoulder belt	0.6	-3.7	-24.6
SB14	Shoulder belt Anchor to seat	-8.4	-6.9	-29.4

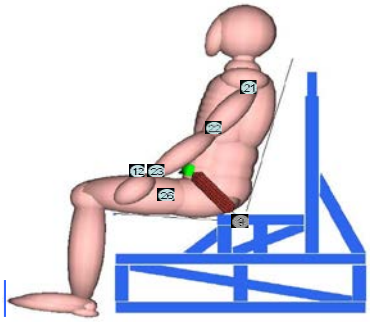
Webbing Length Measurements

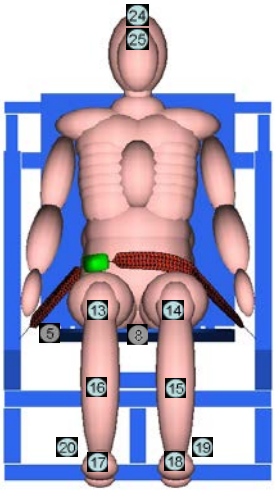
Shoulder Strap RH	NA
Shoulder Strap LH	30.5
Lap Strap RH	7.75
Lap Strap LH	21.5
Center Strap	NA

Figure B-40. Test 07324-25 Belt Pretest Data Sheet

Test Number	07324-26	Date	1/31/2008
ATD/ Serial Number	HYB II 698	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	4 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.9	7.2	-3.7
1a	H Point Vertical Auxiliary	3.3	6.6	-6.5
1b	H Point Horizontal Auxiliary	1.2	6.4	-4.4
1c	H Point Auxiliary	0.6	5.6	-7.2
2	Head CG	1.1	3.3	-30.6
2a	Head CG Vertical Auxiliary	1.5	3.1	-33.6
2b	Head CG Horizontal Auxiliary	-1.2	2.9	-32.4
3	Knee R	19.8	6.3	-7.3
4	Ankle R	23.2	5.9	8.7
5	Femur R	12.0	7.5	-5.3
6	Shoulder R	1.9	9.1	-22.9
7	Elbow1R	3.6	10.6	-14.6
8	Elbow2 R	4.0	10.7	-12.5
9	Wrist R	12.5	5.3	-12.3
10	Hand R	16.1	6.7	-11.6
11	Top hand wrist	14.1	5.5	-13.1
12	Top Hand Wrist	14.0	-5.5	-12.9
13	Knee R	22.4	4.4	-7.8
14	Knee L	22.2	-4.4	-8.0
15	Tibia L	23.6	-4.5	0.6
16	Tibia R	23.5	4.5	0.4
17	Shoe tip top R	31.9	4.7	10.8
18	Shoe tip top L	32.0	-4.1	11.5
19	Shoe back L	20.8	-3.8	10.4
20	Shoe back R	20.7	4.0	10.3
21	Shoulder L	1.8	-8.7	-22.7
22	Elbow L	3.6	-10.0	-12.3
23	Wrist L	12.4	-5.0	-12.2
24	Top Head	1.6	0.2	-35.3
25	Forehead	5.2	0.2	-31.7
26	Femur L	11.8	-7.4	-5.2
27	Kee L	19.7	-6.2	-7.2
28	Ankle L	23.9	-5.2	8.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.2	0.1
2	Seatbottom	16.0	10.1	-0.9
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.1	9.0	-1.4
6	Seat frame ground	16.3	13.9	16.1
7	Centre front plate	33.2	-0.2	10.0
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.5	-14.1	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	79
Plane of scale targets right side	80

Distce from onbd lens to Seat	56.5
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	81
second point on rigid seat (R)	82
first point on rigid seat (L)	83
second point on rigid seat (L)	84

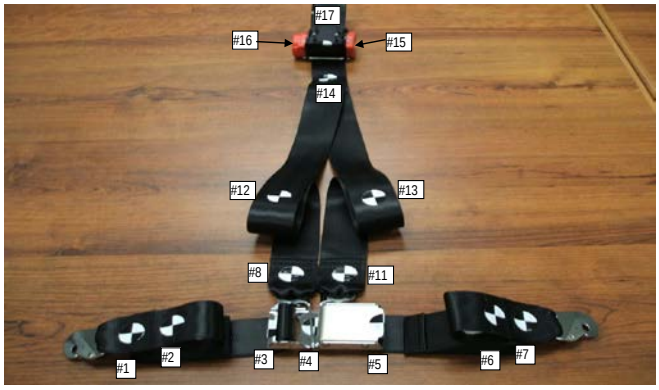
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	75	
Femur Angle	13.6	
Tibia Angle	83.9	

Unit System

English
in, lbf, s, lb

Figure B-41. Test 07324-26 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

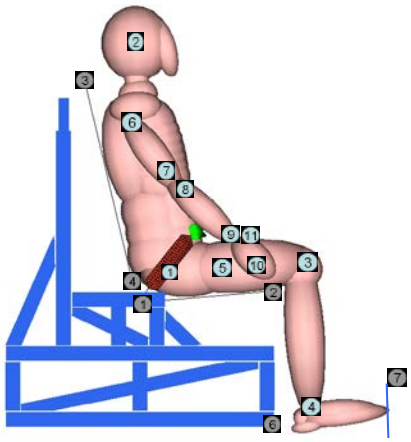
ID	Name	X	Y	Z
SB1	Lap belt	2.3	9.4	-1.9
SB2	Lap belt	4.9	7.1	-5.3
SB3	Lap belt	8.4	1.9	-9.0
SB4	Lap belt	8.4	0.3	-9.1
SB5	Lap belt	8.2	-2.6	-8.8
SB6	Lap belt	6.2	-5.6	-7.2
SB7	Lap belt	2.3	-9.2	-2.2
SB8	Shoulder belt	7.6	0.9	-12.9
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	7.4	-0.5	-12.8
SB12	Shoulder belt	5.8	2.2	-20.8
SB13	Shoulder belt	5.9	-1.9	-20.4
SB14	Shoulder belt	-8.3	0.0	-29.5
SB15	Retractor			
SB16	Retractor			
SB17	Retractor			
SB18	Top slider bar contact			
SB19	Top slider bar contact			

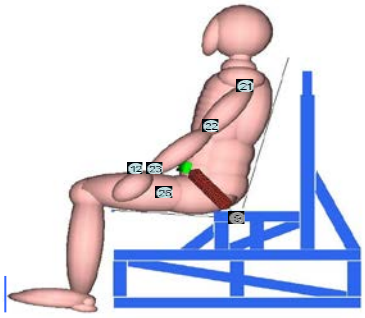
Webbing Length Measurements

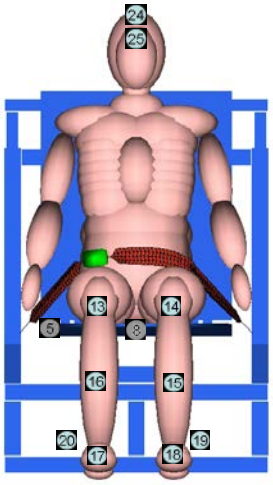
Shoulder Strap RH	28
Shoulder Strap LH	27.7
Lap Strap RH	15.75
Lap Strap LH	13.5
Center Strap	

Figure B-42. Test 07324-26 Belt Pretest Data Sheet

Test Number	07324-27	Date	1/31/2008
ATD/ Serial Number	HYB II 698	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	4 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	4.0	7.4	-3.7
1a	H Point Vertical Auxiliary	3.2	6.7	-6.5
1b	H Point Horizontal Auxiliary	1.2	6.5	-4.3
1c	H Point Auxiliary	0.5	5.7	-7.0
2	Head CG	1.2	3.1	-30.5
2a	Head CG Vertical Auxiliary	1.6	2.8	-33.5
2b	Head CG Horizontal Auxiliary	-1.1	2.6	-32.3
3	Knee R	20.0	6.2	-7.2
4	Ankle R	23.4	5.7	8.7
5	Femur R	12.2	7.6	-5.0
6	Shoulder R	0.9	9.1	-22.5
7	Elbow1R	2.9	10.5	-14.3
8	Elbow2 R	3.7	10.5	-12.2
9	Wrist R	12.2	5.4	-11.8
10	Hand R	15.8	6.8	-11.4
11	Top hand wrist	13.7	5.6	-12.6
12	Top Hand Wrist	13.6	-5.5	-12.1
13	Knee R	22.5	4.2	-7.8
14	Knee L	22.3	-4.4	-8.0
15	Tibia L	23.6	-4.5	0.6
16	Tibia R	23.6	4.3	0.4
17	Shoe tip top R	31.9	4.8	10.9
18	Shoe tip top L	32.0	-4.2	11.5
19	Shoe back L	20.8	-3.6	10.4
20	Shoe back R	20.7	3.6	10.2
21	Shoulder L	1.3	-8.8	-22.3
22	Elbow L	3.3	-10.0	-11.9
23	Wrist L	12.1	-5.1	-11.3
24	Top Head	1.8	0.0	-35.1
25	Forehead	5.4	0.1	-31.5
26	Femur L	11.9	-7.4	-5.2
27	Kee L	19.8	-6.4	-7.1
28	Ankle L	23.8	-5.2	8.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.2	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	9.0	-1.4
6	Seat frame ground	16.2	14.0	16.1
7	Centre front plate	33.2	-0.3	10.0
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.5	-14.2	0.1
10	Plane of scale targets left side	-14.5	-14.1	6.5

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	79
Plane of scale targets right side	80

Distce from onbd lens to Seat	56.5
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	81
second point on rigid seat (R)	82
first point on rigid seat (L)	83
second point on rigid seat (L)	84

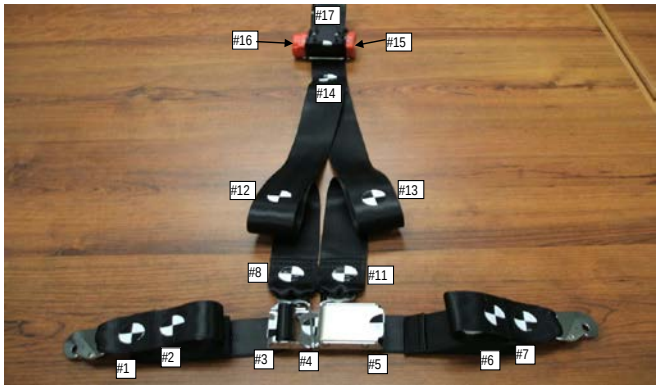
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	77	
Femur Angle	13.6	
Tibia Angle	83.7	

Unit System

English
in, lbf, s, lb

Figure B-43. Test 07324-27 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

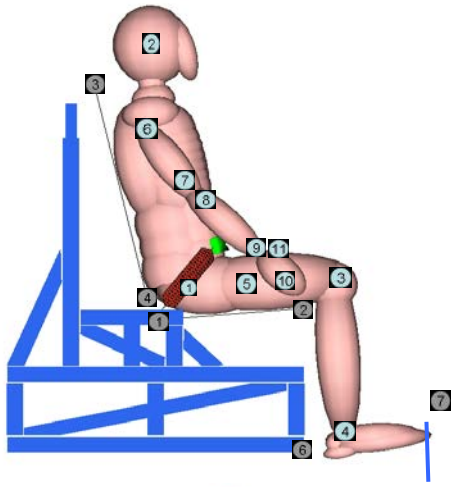
ID	Name	X	Y	Z
SB1	Lap belt	2.4	9.3	-2.1
SB2	Lap belt	5.1	7.0	-5.8
SB3	Lap belt	8.5	1.8	-8.8
SB4	Lap belt	8.6	0.2	-8.9
SB5	Lap belt	7.9	-2.7	-8.7
SB6	Lap belt	5.3	-6.3	-6.2
SB7	Lap belt	2.3	-9.2	-2.2
SB8	Shoulder belt	7.6	0.9	-12.6
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt	7.3	-0.6	-12.3
SB12	Shoulder belt	5.6	2.8	-20.3
SB13	Shoulder belt	5.8	-2.4	-20.2
SB14	Shoulder belt	-8.3	0.0	-29.5
SB15	Retractor			
SB16	Retractor			
SB17	Retractor			
SB18	Top slider bar contact			
SB19	Top slider bar contact			

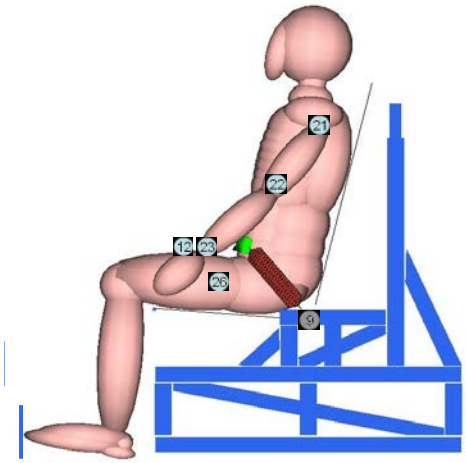
Webbing Length Measurements

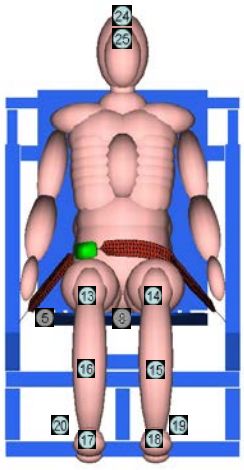
Shoulder Strap RH	27.5
Shoulder Strap LH	27.25
Lap Strap RH	15.75
Lap Strap LH	13.25
Center Strap	

Figure B-44. Test 07324-27 Belt Pretest Data Sheet

Test Number	07324-28	Date	2/1/2008
ATD/ Serial Number	HYB II 698	Test Condition	0deg/16g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.6	7.3	-4.0
1a	H Point Vertical Auxiliary	3.2	6.6	-6.8
1b	H Point Horizontal Auxiliary	1.0	6.5	-4.9
1c	H Point Auxiliary	0.6	5.6	-7.6
2	Head CG	1.4	2.8	-30.8
2a	Head CG Vertical Auxiliary	1.7	2.4	-33.8
2b	Head CG Horizontal Auxiliary	-0.9	2.2	-32.6
3	Knee R	20.0	6.3	-4.7
4	Ankle R	21.0	5.7	11.5
5	Femur R	12.0	7.8	-4.0
6	Shoulder R	0.9	8.8	-22.8
7	Elbow1R	3.5	10.2	-14.6
8	Elbow2 R	4.5	10.1	-12.8
9	Wrist R	12.5	4.7	-10.4
10	Hand R	16.2	6.1	-10.1
11	Top hand wrist	14.2	4.6	-11.2
12	Top Hand Wrist	14.2	-5.3	-10.8
13	Knee R	22.6	4.3	-4.8
14	Knee L	22.6	-3.9	-5.1
15	Tibia L	22.3	-4.1	3.7
16	Tibia R	22.5	4.3	3.3
17	Shoe tip top R	29.5	3.8	13.9
18	Shoe tip top L	29.3	-3.6	14.5
19	Shoe back L	18.1	-3.6	13.4
20	Shoe back R	18.2	4.2	13.2
21	Shoulder L	1.6	-9.2	-22.6
22	Elbow L	4.3	-10.4	-12.4
23	Wrist L	12.5	-5.0	-10.3
24	Top Head	2.0	-0.4	-35.4
25	Forehead	5.5	-0.3	-31.9
26	Femur L	11.9	-7.2	-3.9
27	Kee L	20.0	-5.9	-4.7
28	Ankle L	21.1	-5.0	11.6

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.1	10.1	-1.0
3	Seatback	-6.1	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.2	14.0	16.1
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.5	-14.1	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	81
Plane of scale targets right side	82

Distce from onbd lens to Seat	56.5
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	83
second point on rigid seat (R)	84
first point on rigid seat (L)	85
second point on rigid seat (L)	86

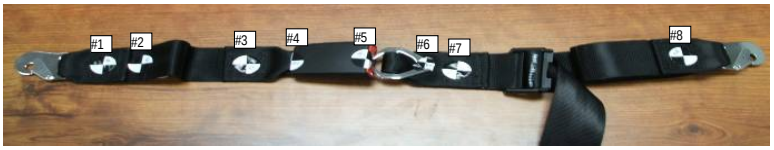
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	77.2	
Femur Angle	4.9	
Tibia Angle	87.5	

Unit System

English
in, lbf, s, lb

Figure B-45. Test 07324-28 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

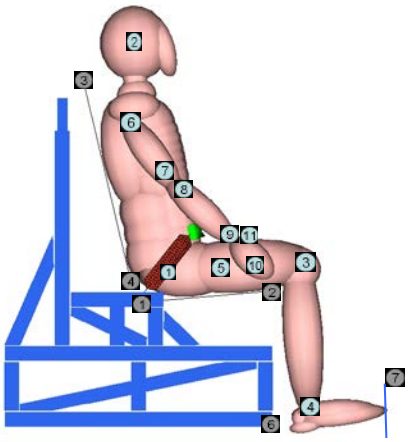
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.6	9.1	-2.4	87
SB2	Lap belt	5.7	6.6	-6.1	88
SB3	Lap belt	8.0	3.1	-7.5	89
SB4	Lap belt	9.2	0.9	-7.6	90
SB5	Lap belt	9.6	-1.5	-7.8	91
SB6	Lap belt	7.7	-3.0	-7.0	92
SB7	Lap belt	6.1	-5.6	-6.2	93
SB8	Lap belt	2.5	-9.0	-2.2	94
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

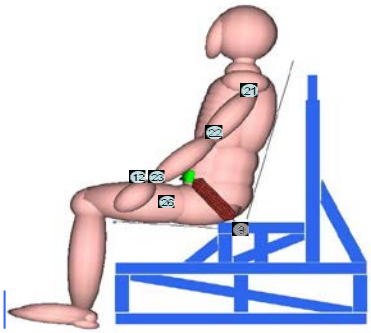
Webbing Length Measurements

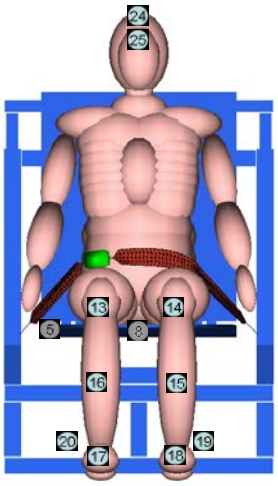
Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	14.5
Lap Strap LH	13.75
Center Strap	NA

Figure B-46. Test 07324-28 Belt Pretest Data Sheet

Test Number	07324-29	Date	2/22/2008
ATD/ Serial Number	HYB II 698	Test Condition	0deg/21g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	3 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.6	7.2	-3.9
1a	H Point Vertical Auxiliary	3.2	6.5	-6.8
1b	H Point Horizontal Auxiliary	1.0	6.3	-4.8
1c	H Point Auxiliary	0.5	5.5	-7.6
2	Head CG	1.3	2.9	-30.9
2a	Head CG Vertical Auxiliary	1.6	2.6	-33.9
2b	Head CG Horizontal Auxiliary	-1.1	2.4	-32.7
3	Knee R	20.1	6.0	-4.3
4	Ankle R	23.5	5.5	11.6
5	Femur R	12.1	7.6	-3.8
6	Shoulder R	1.3	8.9	-23.1
7	Elbow1R	3.3	10.5	-14.1
8	Elbow2 R	3.8	10.2	-12.7
9	Wrist R	11.7	4.5	-10.4
10	Hand R	15.5	5.9	-9.5
11	Top hand wrist	13.2	4.7	-11.1
12	Top Hand Wrist	12.2	-6.1	-10.5
13	Knee R	22.7	4.1	-4.5
14	Knee L	22.3	-4.9	-4.8
15	Tibia L	23.7	-4.9	3.6
16	Tibia R	23.8	4.0	3.3
17	Shoe tip top R	31.9	4.1	13.9
18	Shoe tip top L	32.0	-4.2	14.6
19	Shoe back L	20.8	-4.6	13.3
20	Shoe back R	20.6	3.7	13.3
21	Shoulder L	1.7	-9.0	-22.8
22	Elbow L	2.5	-10.6	-12.2
23	Wrist L	10.7	-5.2	-9.8
24	Top Head	1.9	-0.2	-35.5
25	Forehead	5.4	-0.2	-32.2
26	Femur L	11.6	-7.8	-3.7
27	Kee L	19.7	-6.7	-4.1
28	Ankle L	24.0	-5.7	11.5

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.4	14.3	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.1	10.0	-26.5
4	Seat back lower	-0.4	10.1	-2.2
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.3	13.9	16.1
7	Centre front plate	33.3	0.2	14.4
8	Seat bottom center from front	16.1	0.1	-1.0
9	SB L	0.4	-14.2	0.1
10	Plane of scale targets left side	-14.6	-14.0	6.6

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	86
Plane of scale targets right side	87

Distce from onbd lens to Seat	61
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	88
second point on rigid seat (R)	89
first point on rigid seat (L)	90
second point on rigid seat (L)	91

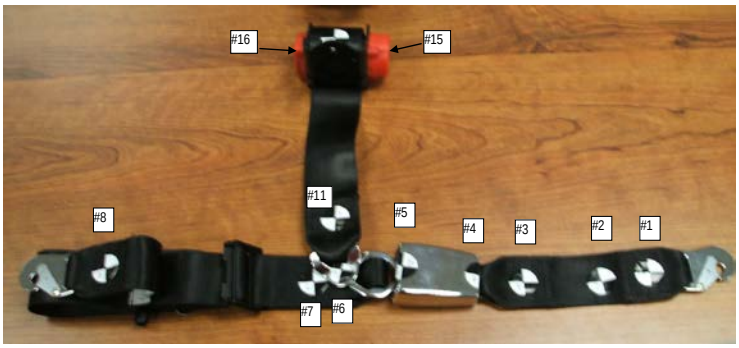
ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness	NA	
Toroso Angle	74.5	
Femur Angle	3.1	
Tibia Angle	83.2	

Unit System

English
in, lbf, s, lb

Figure B-47. Test 07324-29 Anthropomorphic Test Dummy Pretest Data Sheet



Belt Targets

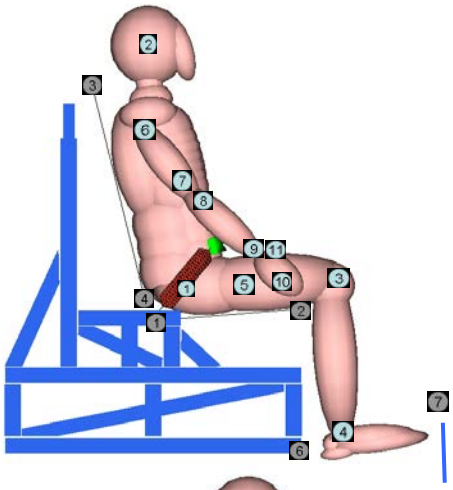
ID	Name	X	Y	Z
SB1	Lap belt	2.4	9.4	-2.0
SB2	Lap belt	5.8	7.3	-6.1
SB3	Lap belt	7.3	5.5	-7.6
SB4	Lap belt	8.2	3.8	-8.3
SB5	Lap belt	8.4	-1.4	-7.4
SB6	Lap belt	5.3	-6.6	-6.0
SB7	Lap belt	2.3	-9.4	-2.1
SB8	Lap belt	5.4	-2.6	-21.7
SB9	Anchor pt L	NA	NA	NA
SB10	Anchor pt R	NA	NA	NA
SB11	Shoulder belt			
SB12	Shoulder belt			
SB13	Shoulder belt			
SB14	Shoulder belt Anchor to seat	-8.5	-6.9	-29.5

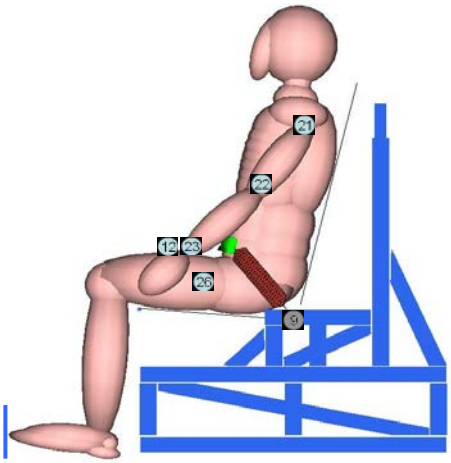
Webbing Length Measurements

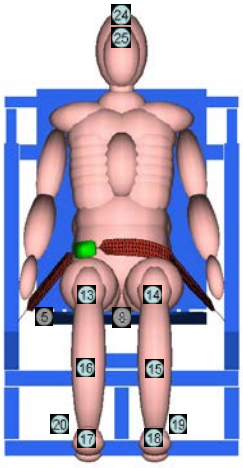
Shoulder Strap RH	NA
Shoulder Strap LH	31
Lap Strap RH	8
Lap Strap LH	22
Center Strap	NA

Figure B-48. Test 07324-29 Belt Pretest Data Sheet

Test Number	07324-30	Date	9/4/2008
ATD/ Serial Number	HYB II 698	Test Condition	60deg/19g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%







ATD Targets

ID	Name	X	Y	Z
1	H Point	3.5	7.1	-3.5
1a	H Point Vertical Auxiliary	3.1	6.5	-6.4
1b	H Point Horizontal Auxiliary	0.9	6.3	-4.5
1c	H Point Auxiliary	NA	NA	NA
2	Head CG	0.9	3.6	-30.4
2a	Head CG Vertical Auxiliary	1.2	3.4	-33.4
2b	Head CG Horizontal Auxiliary	-1.4	3.0	-32.2
3	Knee R	20.0	6.4	-4.9
4	Ankle R	21.0	5.4	11.3
5	Femur R	11.8	7.6	-3.8
6	Shoulder R	1.8	9.1	-22.8
7	Elbow1R	3.9	10.4	-15.2
8	Elbow2 R	5.1	10.3	-12.6
9	Wrist R	13.5	4.8	-11.4
10	Hand R	16.6	6.6	-10.8
11	Top hand wrist	15.0	4.8	-12.0
12	Top Hand Wrist	14.8	-4.8	-11.7
13	Knee R	22.6	4.3	-5.6
14	Knee L	22.6	-4.0	-5.7
15	Tibia L	22.6	-4.6	3.2
16	Tibia R	22.5	4.2	3.1
17	Shoe tip top R	29.6	3.8	13.3
18	Shoe tip top L	29.7	-4.8	13.9
19	Shoe back L	18.6	-4.7	14.0
20	Shoe back R	18.2	3.6	13.2
21	Shoulder L	2.3	-8.7	-22.8
22	Elbow L	4.8	-9.8	-12.6
23	Wrist L	13.2	-4.3	-11.2
24	Top Head	1.4	0.6	-35.1
25	Forehead	5.1	0.5	-32.6
26	Femur L	11.9	-7.3	-4.5
27	Kee L	20.0	-6.0	-5.2
28	Ankle L	21.4	-6.2	11.1

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.3	14.3	0.1
2	Seatbottom	16.0	10.1	-1.0
3	Seatback	-6.2	10.0	-26.6
4	Seat back lower	-0.4	10.0	-2.1
5	Seatbottom from front view	16.0	8.9	-1.4
6	Seat frame ground	16.4	14.0	15.5
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1	0.0	-1.0
9	SB L	0.3	-14.3	0.1
10	Plane of scale targets left side	0.7	-14.1	6.7

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	84
Plane of scale targets right side	85

Distce from onbd lens to ORIGIN	86
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	87
second point on rigid seat (R)	88
first point on rigid seat (L)	89
second point on rigid seat (L)	90

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle	15	13.9
Femur Angle	66.1	62.2
Tibia Angle	27.8	38

Unit System

English
in, lbf, s, lb

Figure B-49. Test 07324-30 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

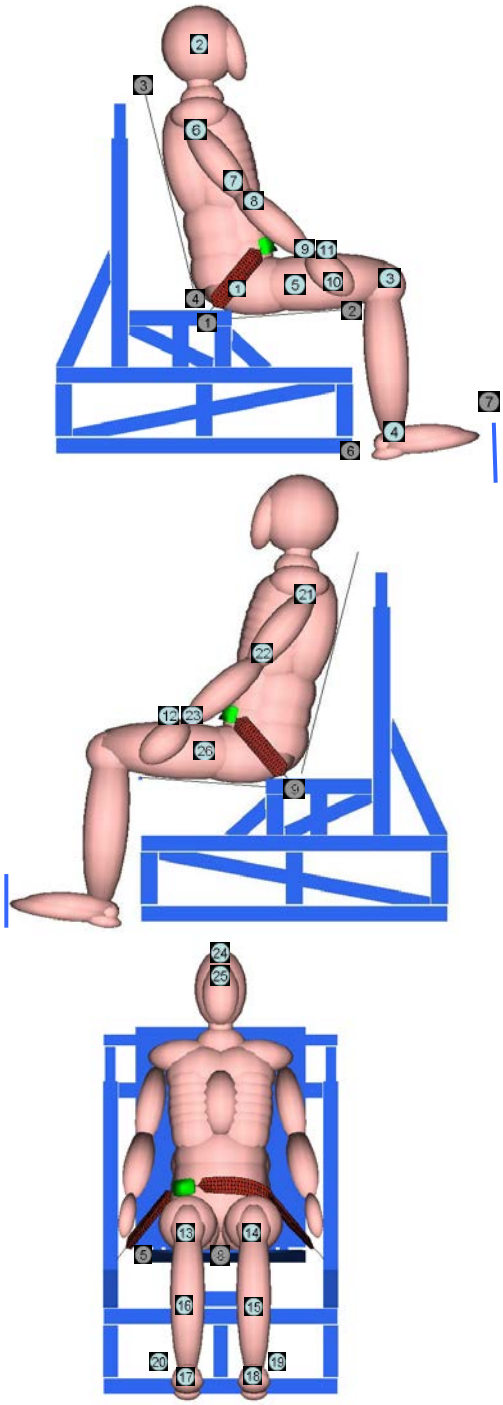
ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.5	9.2	-2.1	91
SB2	Lap belt	3.4	8.4	-3.1	92
SB3	Lap belt	6.7	4.7	-6.7	93
SB4	Lap belt	9.2	0.5	-7.4	94
SB5	Lap belt	9.6	-1.9	-7.5	95
SB6	Lap belt	7.2	-3.7	-6.8	96
SB7	Lap belt	3.3	-8.3	-3.2	97
SB8	Lap belt	2.4	-9.1	-2.3	98
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

Webbing Length Measurements

Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	14.25"
Lap Strap LH	13.25"
Center Strap	NA

Figure B-50. Test 07324-30 Belt Pretest Data Sheet

Test Number	07324-31	Date	9/5/2008
ATD/ Serial Number	HYB II 698	Test Condition	60deg/19g loading
Seat Part number	Not Applicable	Ambient Temperature	70 deg F
Restraint System	2 pt belt	Ambient Humidity	20-30%



ATD Targets

ID	Name	X	Y	Z
1	H Point	3.4005	7.3142	-3.9109
1a	H Point Vertical Auxiliary	2.9287	6.6099	-6.7396
1b	H Point Horizontal Auxiliary	0.7489	6.4556	-4.7553
1c	H Point Auxiliary	NA	NA	NA
2	Head CG	0.5942	2.9895	-30.8313
2a	Head CG Vertical Auxiliary	0.8664	2.6779	-33.8423
2b	Head CG Horizontal Auxiliary	-1.7472	2.4636	-32.5803
3	Knee R	19.8332	6.3709	-4.9751
4	Ankle R	18.9629	5.4667	11.2335
5	Femur R	11.7167	7.7182	-4.1002
6	Shoulder R	0.9373	8.9272	-23.1945
7	Elbow1R	2.2002	10.5171	-15.4852
8	Elbow2 R	3.2433	10.5602	-12.7705
9	Wrist R	11.6601	5.3296	-11.0313
10	Hand R	14.7952	7.1168	-10.5532
11	Top hand wrist	13.097	5.3995	-11.7638
12	Top Hand Wrist	13.4116	-5.739	-11.5806
13	Knee R	22.4343	4.2645	-5.609
14	Knee L	22.3298	-4.6333	-5.7179
15	Tibia L	21.939	-4.8828	3.3245
16	Tibia R	22.2212	4.1429	3.1134
17	Shoe tip top R	29.3052	3.6869	13.2394
18	Shoe tip top L	28.8783	-4.6931	13.7046
19	Shoe back L	17.702	-4.133	12.409
20	Shoe back R	18.0547	3.1712	12.5242
21	Shoulder L	1.2952	-9.1305	-22.8213
22	Elbow L	3.2472	-10.3118	-12.4752
23	Wrist L	11.7958	-5.115	-11.163
24	Top Head	0.92	-0.1787	-35.4637
25	Forehead	4.6951	-0.2106	-33.0705
26	Femur L	11.5201	-7.4368	-4.8023
27	Kee L	19.6803	-6.6101	-5.1387
28	Ankle L	20.3943	-6.0634	11.1136

Seat Targets

ID	Name	X	Y	Z
1	SB R	0.37	14.2875	0.1058
2	Seatbottom	15.9683	10.1152	-0.9795
3	Seatback	-6.1806	10.0016	-26.5753
4	Seat back lower	-0.5259	10.0262	-2.0586
5	Seatbottom from front view	16.077	8.8761	-1.3816
6	Seat frame ground	16.3522	13.9557	15.4866
7	Centre front plate	NA	NA	NA
8	Seat bottom center from front	16.1102	-0.0236	-0.9954
9	SB L	0.2945	-14.2529	0.1471
10	Plane of scale targets left side	1.9872	-14.1181	6.7425

Points to measure distance to lens

	POINT #
Edge of Sled facing outbd lens	
Plane of scale targets right side	

Distce from onbd lens to ORIGIN	85
Distce from outbd lens to Sled	248.5

Points to measure photometric error

	POINT #
first point on rigid seat (R)	86
second point on rigid seat (R)	87
first point on rigid seat (L)	88
second point on rigid seat (L)	89

ATD Measurements

	PRETEST	POSTTEST
Distance Between Kness		
Toroso Angle		
Femur Angle		
Tibia Angle		

Unit System

English
in, lbf, s, lb

Figure B-51. Test 07324-31 Anthropomorphic Test Dummy Pretest Data Sheet

Belt Targets

ID	Name	X	Y	Z	POINT #
SB1	Lap belt	2.4	9.2	-2.3	90
SB2	Lap belt	3.2	8.4	-3.4	91
SB3	Lap belt	6.5	4.8	-7.0	92
SB4	Lap belt	9.1	0.6	-7.7	93
SB5	Lap belt	9.4	-1.8	-7.7	94
SB6	Lap belt	6.7	-4.0	-6.9	95
SB7	Lap belt	3.1	-8.2	-3.4	96
SB8	Lap belt	2.3	-9.0	-2.4	97
SB9	Anchor pt L	NA	NA	NA	NA
SB 10	Anchor pt R	NA	NA	NA	NA

Webbing Length Measurements

Shoulder Strap RH	NA
Shoulder Strap LH	NA
Lap Strap RH	
Lap Strap LH	
Center Strap	NA

Figure B-52. Test 07324-31 Belt Pretest Data Sheet

APPENDIX C—TEST SERIES II SEAT AND ANTHROPOMORPHIC TEST DUMMY TARGETS

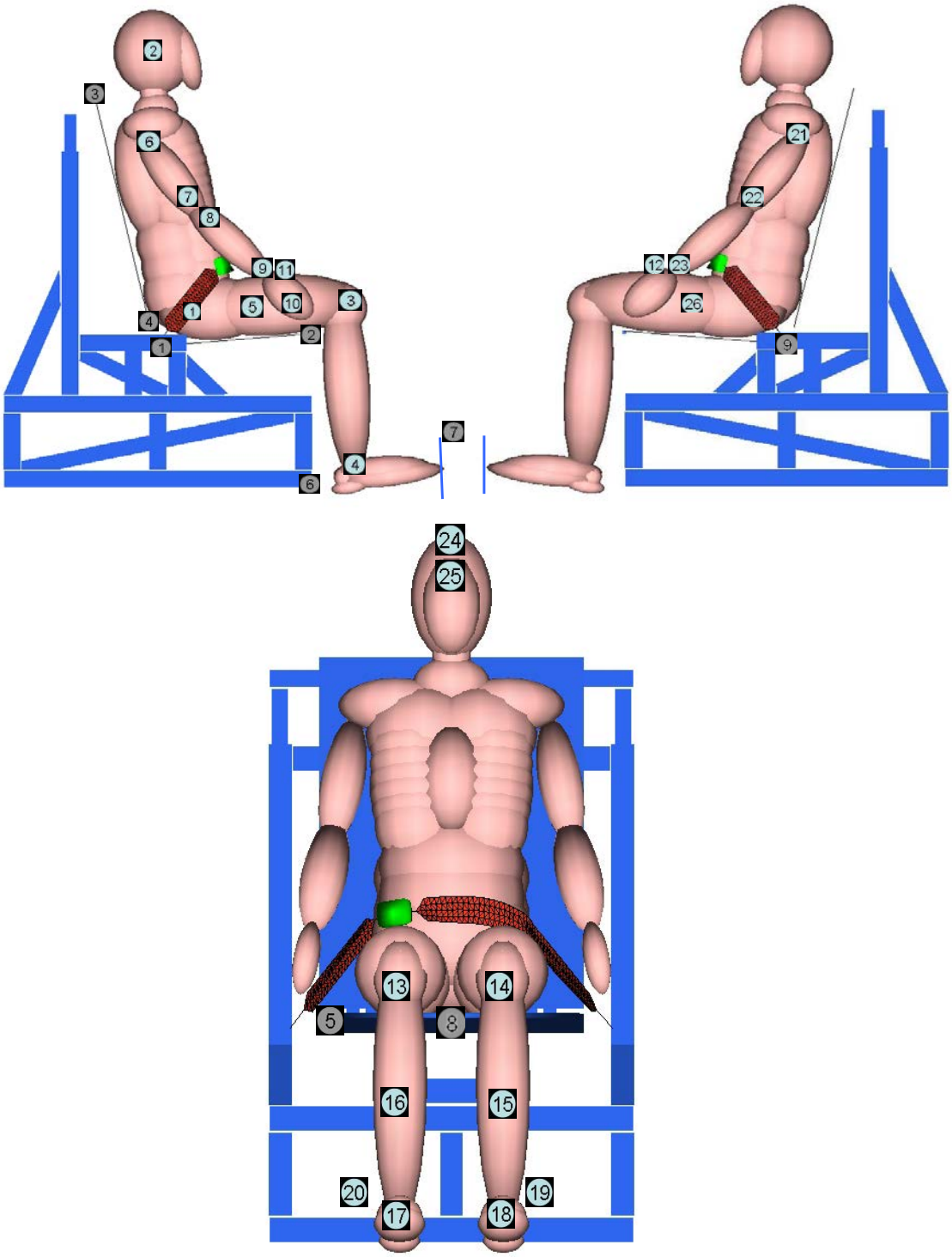


Figure C-1. Test Series II Seat and Anthropomorphic Test Dummy Targets

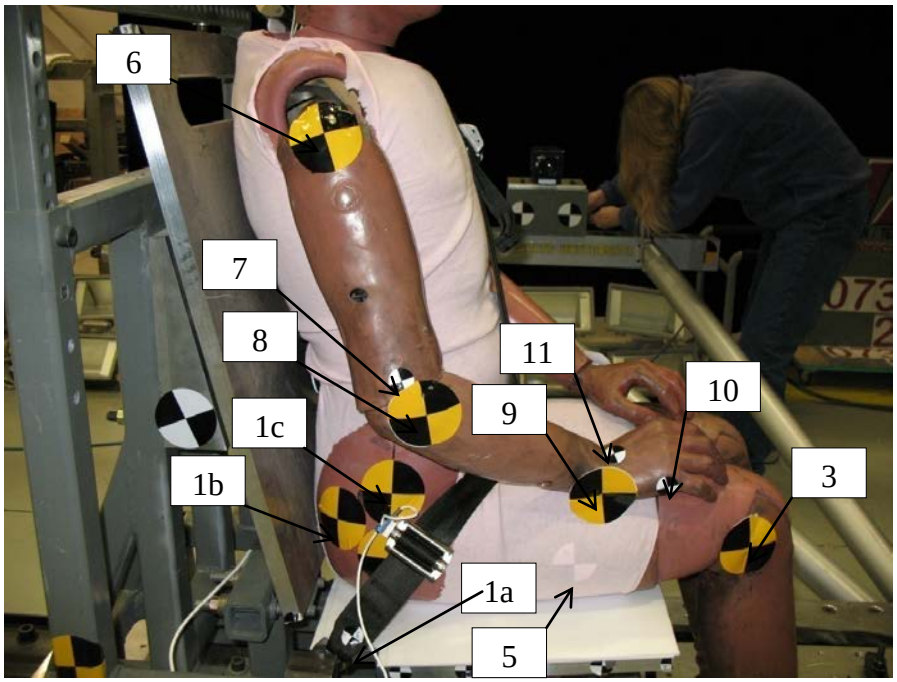


Figure C-2. Hybrid II Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch Targets (Right Side)

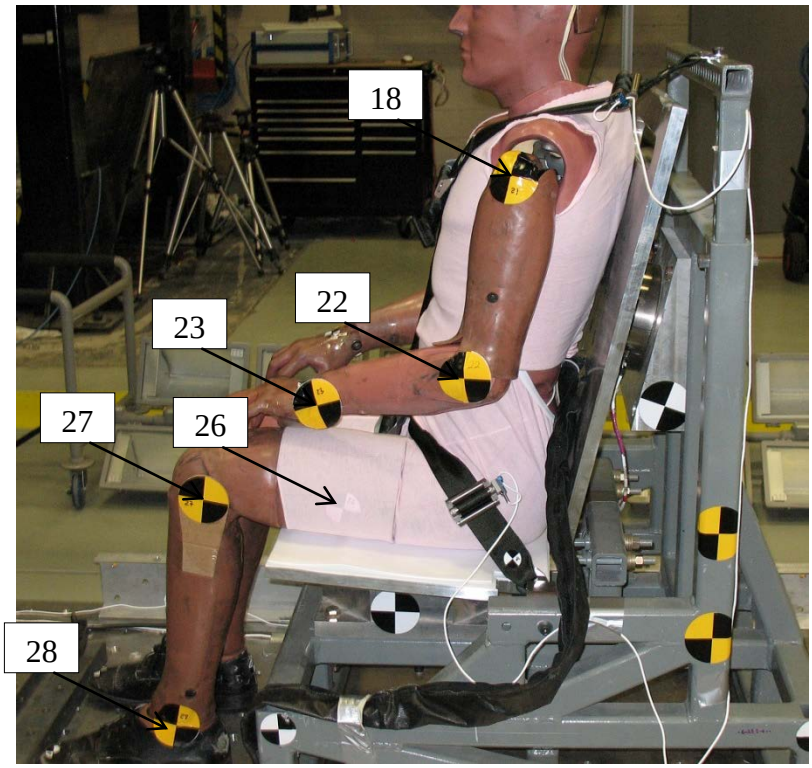


Figure C-3. Hybrid II Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch Targets (Left Side)

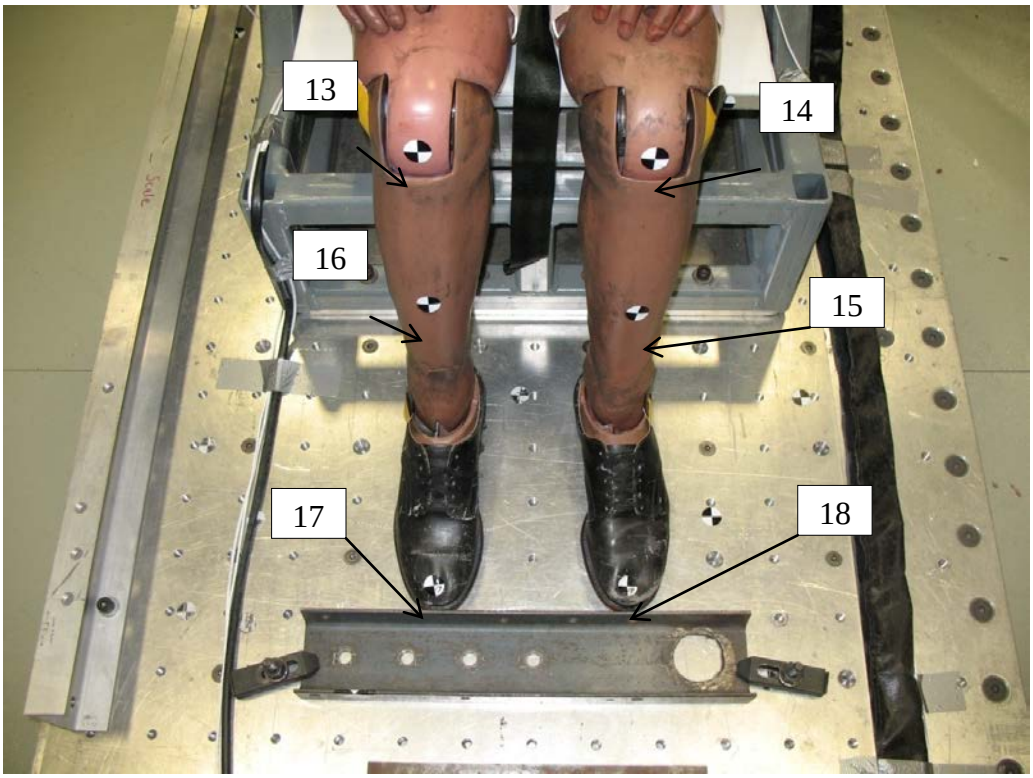


Figure C-4. Hybrid II Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch Targets (Top View)

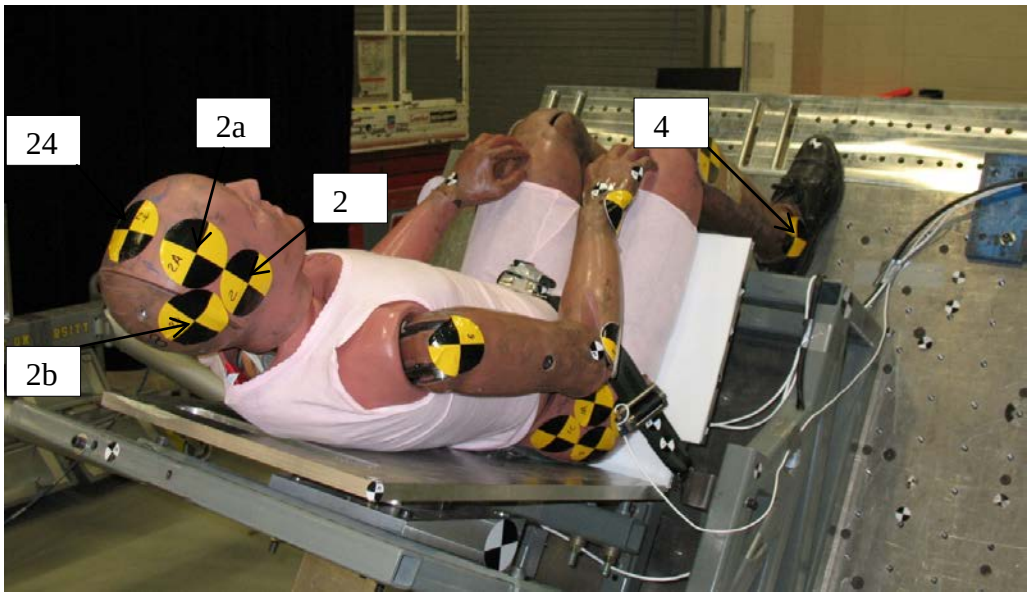


Figure C-5. Hybrid II Anthropomorphic Test Dummy With Three-Point Belts at 0° Pitch Targets (Oblique Angle)

APPENDIX D—ANTHROPOMORPHIC TEST DUMMY INITIAL POSITION DATA

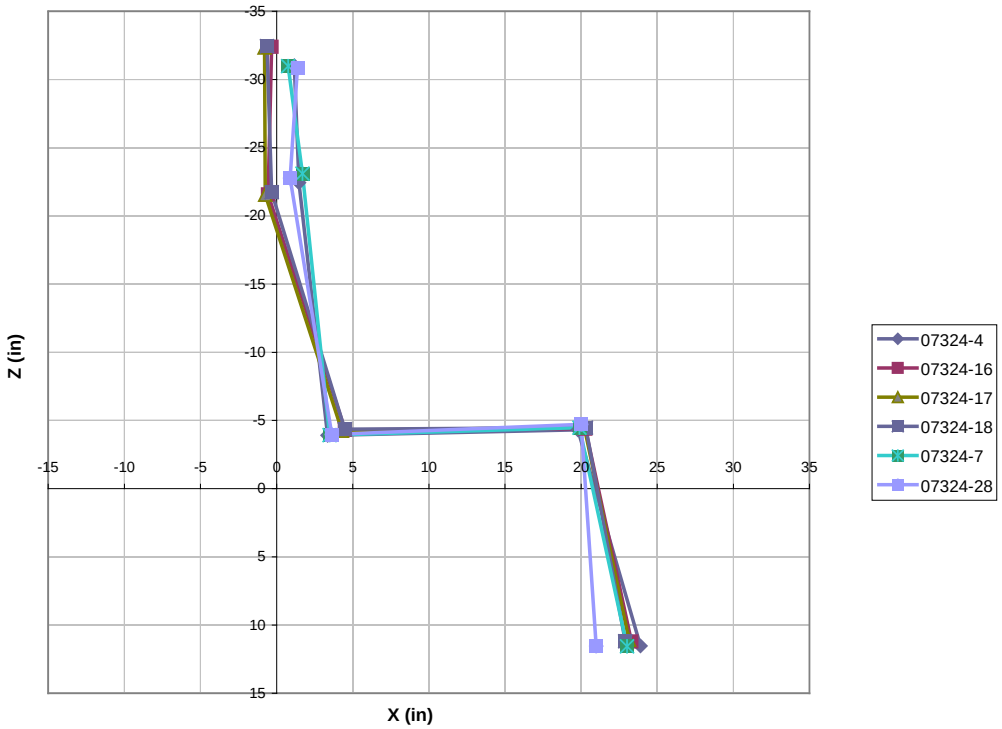


Figure D-1. Profile of Two-Point Belt at 0° Pitch Pretest Positioning

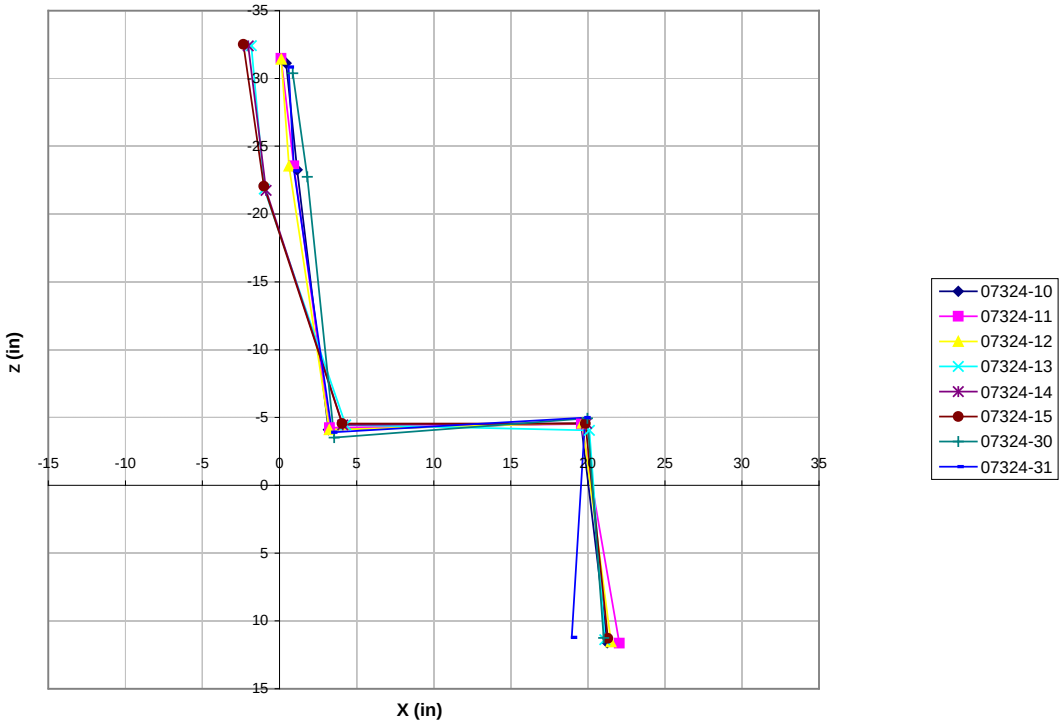


Figure D-2. Profile of Two-Point Belt at 60° Pitch Pretest Positioning

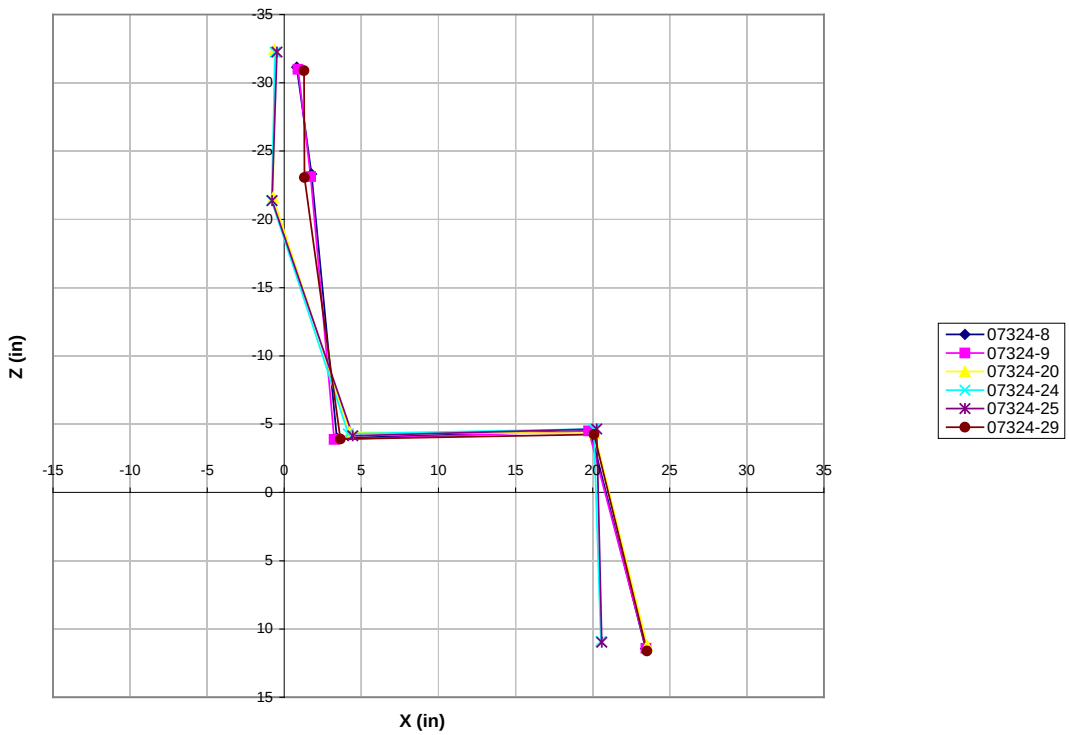


Figure D-3. Profile of Three-Point Belt at 0° Pitch Pretest Positioning

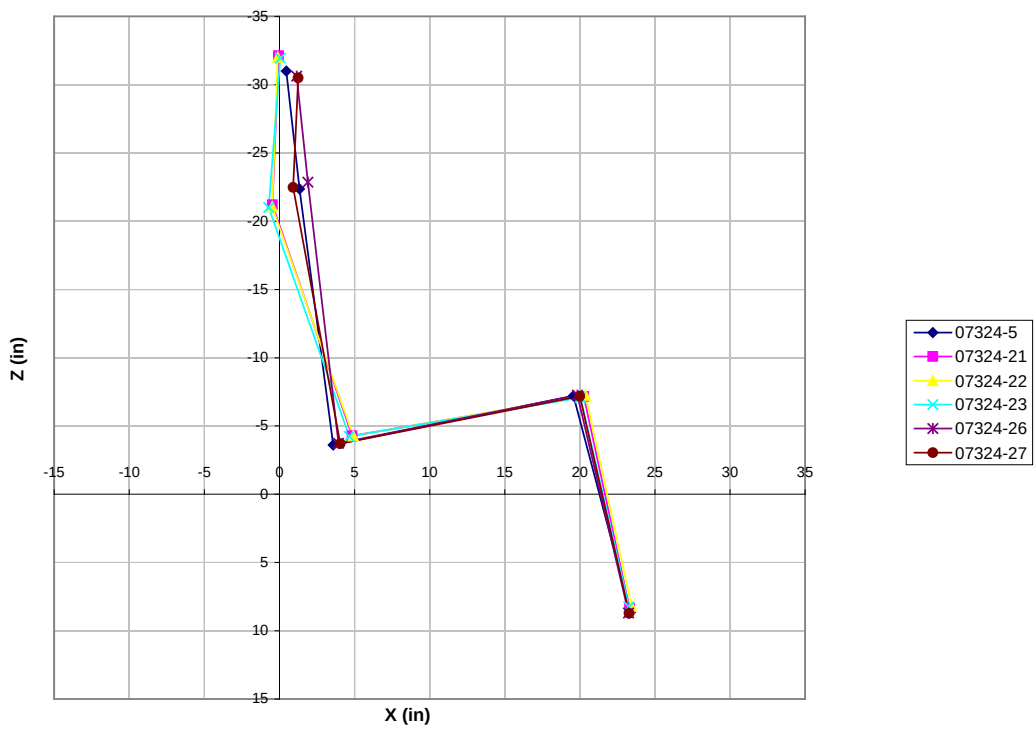


Figure D-4. Profile of Four-Point Belt at 0° Pitch Pretest Positioning

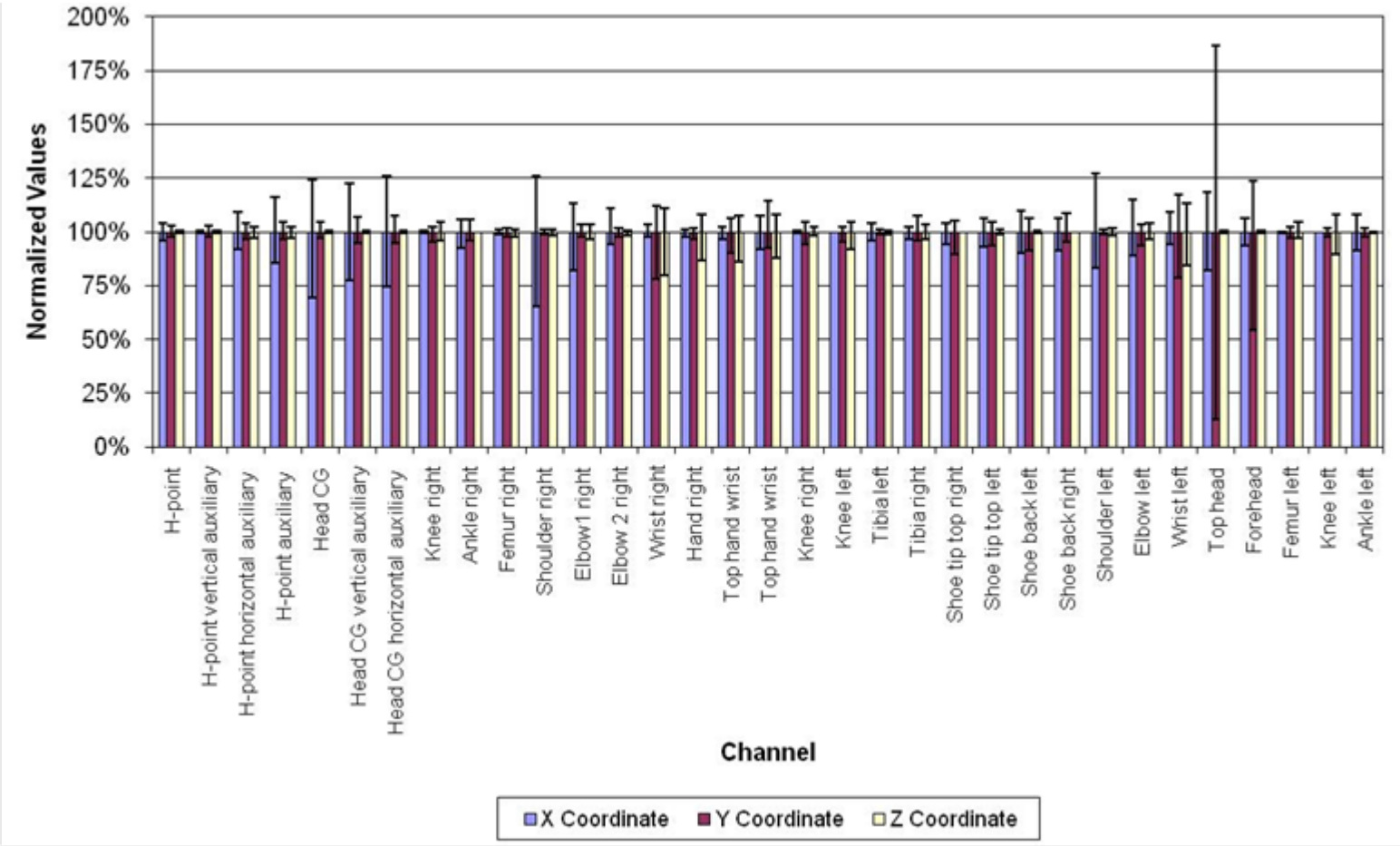


Figure D-5. Normalized Initial Position Data for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch

Table D-1. Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch—Initial Position Data of x Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	3.630	3.345	3.487	0.143	0.143
H-point vertical auxiliary	3.231	3.201	3.212	0.019	0.011
H-point horizontal auxiliary	0.968	0.815	0.886	0.081	0.071
H-point auxiliary	0.760	0.557	0.653	0.107	0.096
Head c.g.	1.370	0.763	1.100	0.270	0.337
Head c.g. vertical auxiliary	1.747	1.105	1.426	0.321	0.321
Head c.g. horizontal auxiliary	-0.893	-1.503	-1.193	0.300	0.311
Knee R	20.012	19.788	19.898	0.114	0.111
Ankle R	23.900	20.988	22.636	1.264	1.648
Femur R	11.976	11.715	11.839	0.137	0.125
Shoulder R	1.704	0.886	1.354	0.350	0.468
Elbow 1 R	4.745	3.456	4.195	0.550	0.740
Elbow 2 R	5.283	4.487	4.761	0.521	0.274
Wrist R	13.311	12.536	12.842	0.469	0.306
Hand R	16.333	15.740	16.107	0.226	0.367
Top hand wrist R	14.168	13.301	13.804	0.365	0.503
Top hand wrist L	15.248	13.053	14.178	1.070	1.125
Knee R	22.629	22.358	22.497	0.133	0.139
Knee L	22.569	22.447	22.494	0.075	0.048
Tibia L	24.272	22.320	23.309	0.963	0.989
Tibia R	23.810	22.507	23.248	0.562	0.741
Shoe tip top R	32.571	29.497	31.274	1.297	1.777
Shoe tip top L	33.533	29.314	31.458	2.075	2.144
Shoe back L	22.077	18.105	20.079	1.998	1.974
Shoe back R	21.143	18.182	19.867	1.276	1.685
Shoulder L	2.371	1.556	1.865	0.506	0.309
Elbow L	5.519	4.260	4.795	0.725	0.534
Wrist L	14.240	12.274	12.996	1.244	0.722
Top head	1.960	1.354	1.649	0.310	0.295
Forehead	5.547	4.895	5.219	0.328	0.324
Femur L	11.900	11.828	11.867	0.032	0.039
Knee L	20.034	19.951	19.983	0.051	0.031
Ankle L	24.901	21.059	22.981	1.920	1.923

c.g. = Center of gravity L = Left R = Right

Table D-2. Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch—Initial Position Data of y Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	7.343	6.948	7.114	0.229	0.166
H-point vertical auxiliary	6.574	6.225	6.368	0.206	0.143
H-point horizontal auxiliary	6.451	5.964	6.179	0.272	0.215
H-point auxiliary	5.555	5.128	5.318	0.237	0.190
Head c.g.	3.009	2.788	2.867	0.142	0.079
Head c.g. vertical auxiliary	2.765	2.439	2.579	0.186	0.139
Head c.g. horizontal auxiliary	2.525	2.230	2.349	0.176	0.119
Knee R	6.287	5.864	6.144	0.143	0.280
Ankle R	6.341	5.742	5.986	0.355	0.244
Femur R	7.754	7.433	7.607	0.148	0.173
Shoulder R	8.769	8.579	8.660	0.109	0.081
Elbow 1 R	10.687	10.128	10.350	0.337	0.222
Elbow 2 R	10.293	9.836	10.084	0.209	0.248
Wrist R	6.786	4.712	6.044	0.742	1.332
Hand R	6.425	6.110	6.309	0.116	0.199
Top hand wrist R	5.463	4.626	5.141	0.322	0.516
Top hand wrist L	-5.224	-6.456	-5.647	0.423	0.808
Knee R	4.472	4.035	4.271	0.202	0.236
Knee L	-3.920	-4.218	-4.112	0.193	0.106
Tibia L	-4.127	-4.204	-4.161	0.035	0.043
Tibia R	4.855	4.348	4.517	0.338	0.169
Shoe tip top R	4.509	3.824	4.278	0.231	0.454
Shoe tip top L	-3.624	-4.030	-3.857	0.233	0.173
Shoe back L	-3.083	-3.590	-3.381	0.298	0.209
Shoe back R	4.754	4.178	4.374	0.380	0.196
Shoulder L	-9.064	-9.246	-9.159	0.095	0.087
Elbow L	-9.508	-10.462	-10.121	0.614	0.341
Wrist L	-4.984	-7.411	-6.312	1.328	1.100
Top head	-0.030	-0.429	-0.230	0.201	0.199
Forehead	-0.116	-0.263	-0.212	0.096	0.051
Femur L	-7.224	-7.615	-7.428	0.205	0.186
Knee L	-5.902	-6.136	-6.029	0.128	0.106
Ankle L	-4.847	-5.032	-4.954	0.107	0.078

c.g. = Center of gravity L = Left R = Right

Table D-3. Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch—Initial Position Data of z Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	-3.910	-3.971	-3.936	0.026	0.035
H-point vertical auxiliary	-6.802	-6.878	-6.832	0.031	0.046
H-point horizontal auxiliary	-4.859	-5.117	-4.993	0.134	0.123
H-point auxiliary	-7.636	-8.057	-7.867	0.230	0.191
Head c.g.	-30.819	-31.117	-30.970	0.151	0.147
Head c.g. vertical auxiliary	-33.801	-34.108	-33.956	0.154	0.152
Head c.g. horizontal auxiliary	-32.556	-32.818	-32.699	0.144	0.119
Knee R	-4.316	-4.718	-4.505	0.189	0.213
Ankle R	11.563	11.530	11.544	0.019	0.015
Femur R	-3.953	-4.093	-4.040	0.087	0.053
Shoulder R	-22.446	-23.101	-22.770	0.324	0.331
Elbow 1 R	-13.627	-14.605	-14.090	0.462	0.515
Elbow 2 R	-12.495	-12.800	-12.686	0.191	0.114
Wrist R	-7.521	-10.435	-9.407	1.886	1.027
Hand R	-8.104	-10.081	-9.336	1.231	0.746
Top hand wrist R	-8.938	-11.170	-10.379	1.442	0.791
Top hand wrist L	-8.778	-10.800	-9.972	1.195	0.828
Knee R	-4.809	-4.994	-4.882	0.074	0.112
Knee L	-4.489	-5.103	-4.867	0.378	0.236
Tibia L	3.687	3.619	3.653	0.034	0.035
Tibia R	3.311	3.088	3.203	0.108	0.115
Shoe tip top R	13.881	13.842	13.863	0.018	0.021
Shoe tip top L	14.520	14.176	14.371	0.149	0.195
Shoe back L	13.477	13.333	13.397	0.079	0.064
Shoe back R	13.244	13.197	13.217	0.027	0.020
Shoulder L	-22.627	-23.334	-22.980	0.354	0.354
Elbow L	-12.410	-13.344	-12.826	0.416	0.519
Wrist L	-7.648	-10.278	-9.073	1.425	1.205
Top head	-35.378	-35.802	-35.600	0.222	0.202
Forehead	-31.863	-32.288	-32.057	0.195	0.230
Femur L	-3.675	-3.943	-3.774	0.099	0.169
Knee L	-3.874	-4.676	-4.323	0.449	0.353
Ankle L	11.633	11.562	11.592	0.041	0.030

c.g. = Center of gravity L = Left R = Right

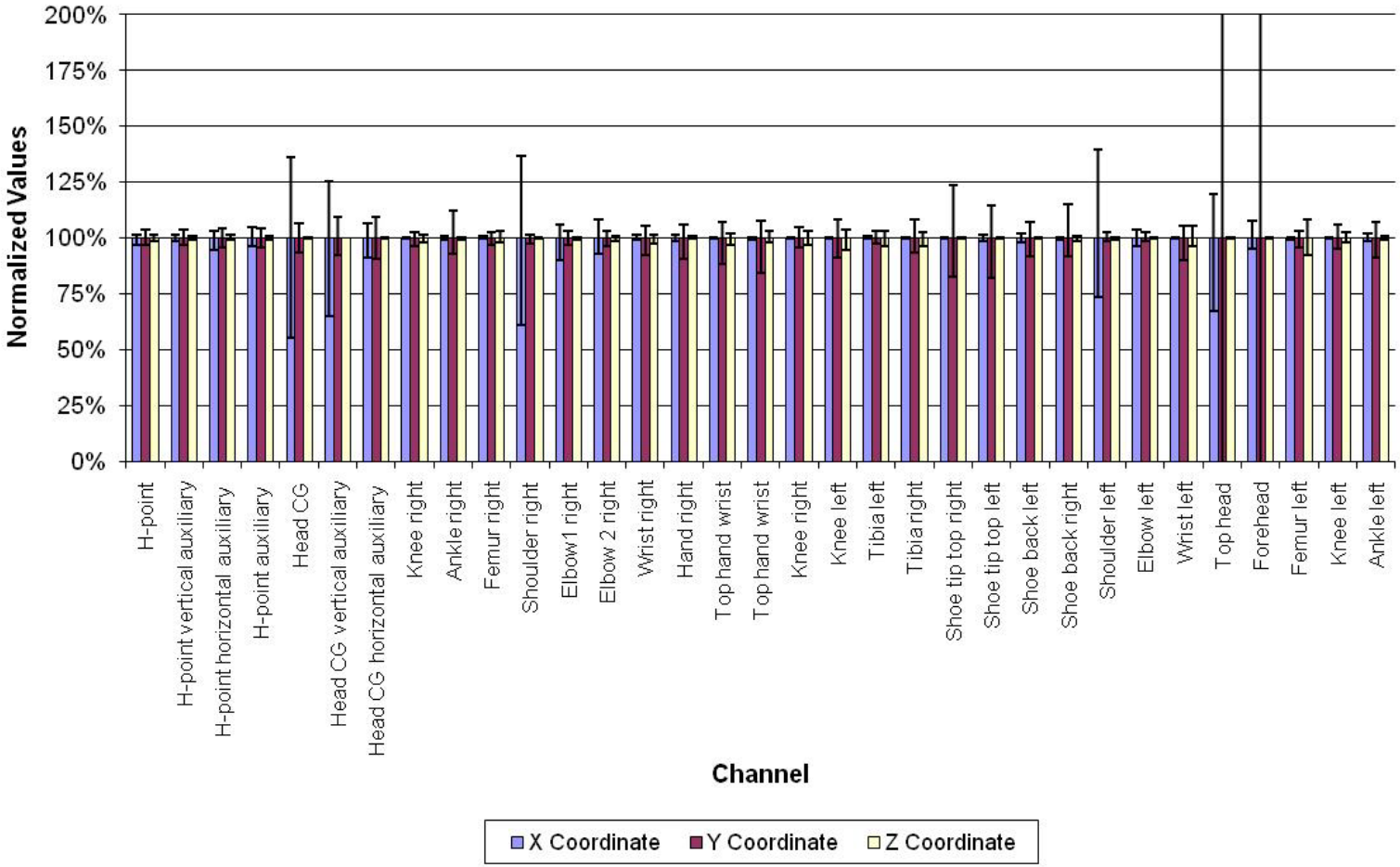


Figure D-6. Normalized Initial Position Data for Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch

Table D-4. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch——Initial Position Data at x Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	4.490	4.285	4.419	0.071	0.135
H-point vertical auxiliary	4.291	4.167	4.231	0.060	0.064
H-point horizontal auxiliary	1.853	1.697	1.797	0.056	0.099
H-point auxiliary	1.694	1.558	1.613	0.081	0.055
Head c.g.	-0.324	-0.792	-0.582	0.259	0.210
Head c.g. vertical auxiliary	-0.579	-1.123	-0.894	0.315	0.230
Head c.g. horizontal auxiliary	-2.939	-3.428	-3.221	0.282	0.207
Knee R	20.306	20.210	20.264	0.042	0.054
Ankle R	23.309	22.908	23.121	0.188	0.213
Femur R	12.320	12.175	12.226	0.094	0.050
Shoulder R	-0.333	-0.748	-0.547	0.214	0.202
Elbow 1 R	2.196	1.864	2.068	0.127	0.204
Elbow 2 R	4.098	3.513	3.781	0.317	0.268
Wrist R	13.119	12.808	12.919	0.200	0.111
Hand R	15.830	15.390	15.576	0.253	0.187
Top hand wrist R	13.780	13.708	13.743	0.038	0.034
Top hand wrist L	13.313	13.145	13.242	0.071	0.097
Knee R	22.982	22.900	22.945	0.038	0.044
Knee L	23.063	22.840	22.940	0.123	0.100
Tibia L	24.068	23.793	23.911	0.157	0.117
Tibia R	23.989	23.844	23.921	0.067	0.078
Shoe tip top R	31.719	31.492	31.603	0.116	0.111
Shoe tip top L	32.023	31.242	31.625	0.398	0.382
Shoe back L	20.788	20.016	20.389	0.399	0.373
Shoe back R	20.660	20.404	20.548	0.112	0.145
Shoulder L	-0.364	-0.690	-0.495	0.131	0.195
Elbow L	4.185	3.891	4.026	0.159	0.135
Wrist L	12.541	12.462	12.493	0.047	0.031
Top head	-0.681	-1.217	-1.015	0.334	0.202
Forehead	3.793	3.369	3.527	0.265	0.158
Femur L	12.332	12.158	12.254	0.078	0.096
Knee L	20.272	20.172	20.208	0.064	0.036
Ankle L	24.061	23.232	23.606	0.455	0.374

c.g. = Center of gravity L = Left R = Right

Table D-5. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch——Initial Position Data at y Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	7.538	7.060	7.275	0.263	0.215
H-point vertical auxiliary	6.729	6.269	6.474	0.255	0.205
H-point horizontal auxiliary	6.852	6.295	6.562	0.290	0.267
H-point auxiliary	6.213	5.701	5.953	0.260	0.252
Head c.g.	3.300	2.898	3.095	0.205	0.198
Head c.g. vertical auxiliary	2.779	2.347	2.539	0.240	0.193
Head c.g. horizontal auxiliary	2.708	2.245	2.471	0.237	0.226
Knee R	5.782	5.432	5.648	0.134	0.216
Ankle R	6.315	5.225	5.632	0.682	0.408
Femur R	7.774	7.376	7.593	0.180	0.218
Shoulder R	9.074	8.742	8.963	0.111	0.221
Elbow 1 R	10.608	9.961	10.302	0.306	0.341
Elbow 2 R	10.931	10.196	10.585	0.346	0.389
Wrist R	7.640	6.701	7.259	0.380	0.558
Hand R	7.408	6.355	7.001	0.407	0.647
Top hand wrist R	5.995	4.933	5.589	0.406	0.656
Top hand wrist L	-4.807	-6.113	-5.676	0.869	0.437
Knee R	4.541	4.151	4.336	0.204	0.185
Knee L	-3.674	-4.357	-4.017	0.343	0.341
Tibia L	-4.218	-4.461	-4.328	0.110	0.133
Tibia R	4.710	4.065	4.350	0.360	0.285
Shoe tip top R	4.641	3.105	3.746	0.895	0.641
Shoe tip top L	-2.931	-4.090	-3.563	0.632	0.527
Shoe back L	-3.622	-4.236	-3.950	0.328	0.286
Shoe back R	4.500	3.593	3.917	0.583	0.324
Shoulder L	-8.964	-9.318	-9.096	0.132	0.222
Elbow L	-10.383	-10.808	-10.550	0.167	0.258
Wrist L	-6.148	-7.203	-6.836	0.688	0.367
Top head	0.291	-0.152	0.032	0.259	0.185
Forehead	0.237	-0.080	0.035	0.202	0.115
Femur L	-7.090	-7.663	-7.409	0.319	0.254
Knee L	-5.182	-5.783	-5.448	0.266	0.335
Ankle L	-5.004	-5.879	-5.494	0.490	0.385

c.g. = Center of gravity L = Left R = Right

Table D-6. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch—Initial Position Data at z Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	-4.258	-4.368	-4.313	0.055	0.055
H-point vertical auxiliary	-7.120	-7.257	-7.194	0.074	0.063
H-point horizontal auxiliary	-5.427	-5.550	-5.470	0.043	0.080
H-point auxiliary	-8.344	-8.477	-8.401	0.057	0.076
Head c.g.	-32.351	-32.439	-32.397	0.046	0.042
Head c.g. vertical auxiliary	-35.207	-35.257	-35.240	0.033	0.018
Head c.g. horizontal auxiliary	-33.463	-33.581	-33.523	0.060	0.058
Knee R	-4.391	-4.529	-4.466	0.075	0.063
Ankle R	11.206	11.081	11.157	0.050	0.075
Femur R	-4.500	-4.736	-4.583	0.083	0.153
Shoulder R	-21.561	-21.732	-21.622	0.061	0.110
Elbow 1 R	-13.985	-14.190	-14.107	0.122	0.083
Elbow 2 R	-12.159	-12.486	-12.337	0.179	0.149
Wrist R	-10.397	-10.830	-10.677	0.280	0.152
Hand R	-9.880	-9.985	-9.917	0.037	0.068
Top hand wrist R	-10.979	-11.540	-11.326	0.346	0.214
Top hand wrist L	-10.749	-11.328	-10.956	0.208	0.371
Knee R	-4.715	-5.018	-4.861	0.147	0.156
Knee L	-4.226	-4.614	-4.457	0.231	0.157
Tibia L	2.812	2.636	2.729	0.083	0.094
Tibia R	2.927	2.751	2.846	0.080	0.096
Shoe tip top R	13.939	13.819	13.867	0.072	0.048
Shoe tip top L	14.119	14.036	14.080	0.038	0.045
Shoe back L	13.393	13.284	13.334	0.059	0.050
Shoe back R	13.473	13.160	13.363	0.111	0.202
Shoulder L	-21.495	-21.724	-21.607	0.112	0.117
Elbow L	-12.240	-12.377	-12.299	0.059	0.078
Wrist L	-9.765	-10.661	-10.104	0.338	0.557
Top head	-36.342	-36.407	-36.369	0.026	0.038
Forehead	-33.303	-33.392	-33.360	0.056	0.032
Femur L	-3.870	-4.558	-4.197	0.327	0.361
Knee L	-4.251	-4.454	-4.331	0.080	0.123
Ankle L	11.117	10.899	11.015	0.102	0.116

c.g. = Center of gravity L = Left R = Right

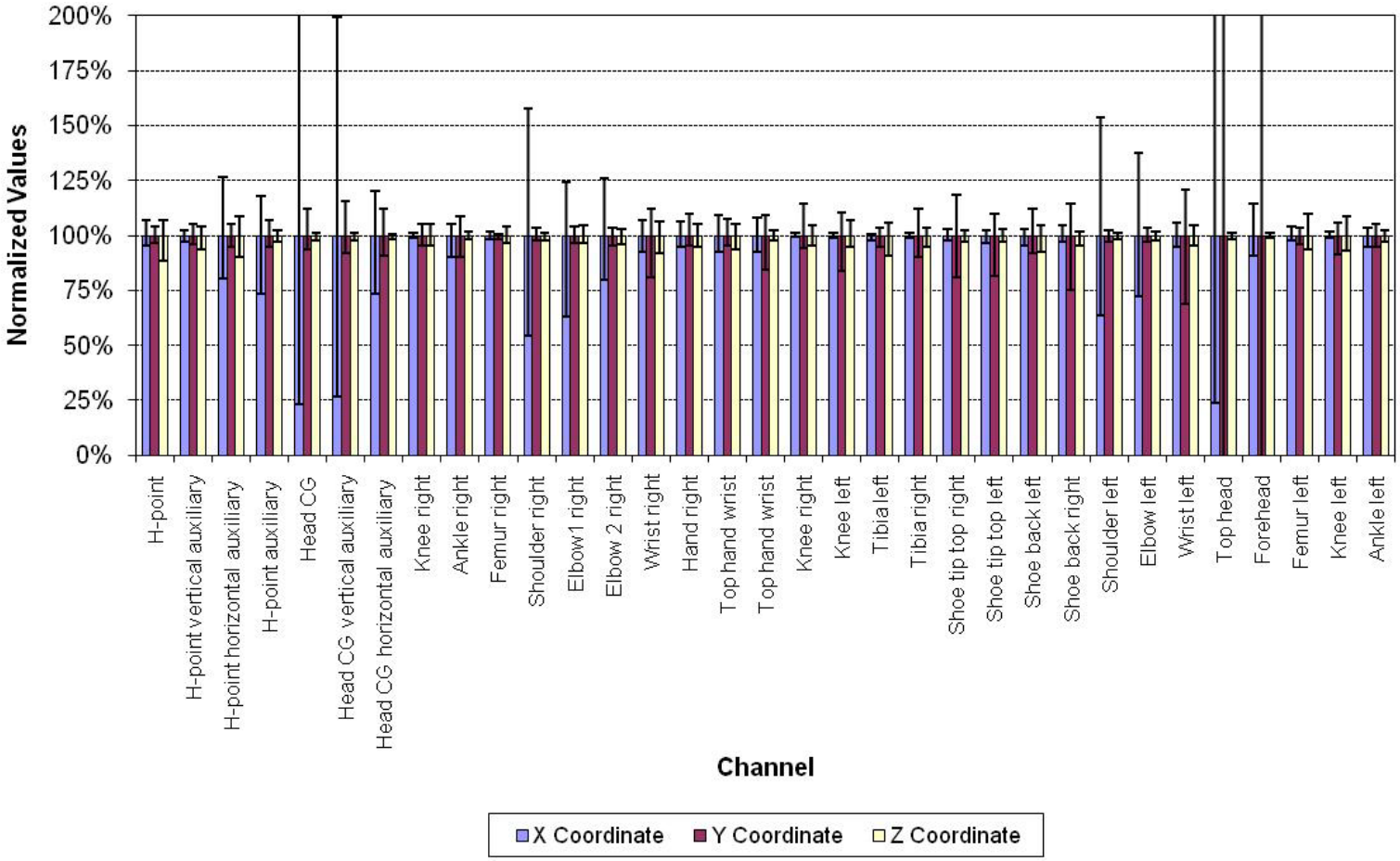


Figure D-7. Normalized Initial Position Data for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch

Table D-7. Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Initial Position Data at x Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	3.548	3.176	3.320	0.228	0.144
H-point vertical auxiliary	3.087	2.923	3.015	0.071	0.092
H-point horizontal auxiliary	0.898	0.570	0.710	0.189	0.140
H-point Auxiliary	0.584	0.365	0.496	0.088	0.130
Head c.g.	0.862	0.097	0.420	0.442	0.323
Head c.g. vertical auxiliary	1.216	0.163	0.610	0.606	0.447
Head c.g. horizontal auxiliary	-1.445	-2.357	-1.964	0.519	0.393
Knee R	19.974	19.555	19.720	0.255	0.164
Ankle R	22.045	18.963	20.959	1.085	1.996
Femur R	11.812	11.397	11.596	0.215	0.200
Shoulder R	1.795	0.617	1.138	0.658	0.521
Elbow 1 R	4.326	2.200	3.484	0.842	1.284
Elbow 2 R	5.110	3.243	4.059	1.051	0.816
Wrist R	13.454	11.660	12.598	0.856	0.938
Hand R	16.563	14.795	15.564	0.999	0.769
Top hand wrist R	15.015	12.711	13.704	1.311	0.992
Top hand wrist L	14.792	12.674	13.667	1.125	0.993
Knee R	22.564	22.151	22.293	0.271	0.143
Knee L	22.555	22.013	22.247	0.308	0.234
Tibia L	22.610	21.939	22.408	0.202	0.469
Tibia R	22.792	22.221	22.515	0.277	0.294
Shoe tip top R	30.868	29.305	30.011	0.857	0.706
Shoe tip top L	30.656	28.878	29.928	0.728	1.050
Shoe back L	19.186	17.702	18.592	0.594	0.890
Shoe back R	19.404	18.055	18.580	0.824	0.525
Shoulder L	2.290	0.947	1.490	0.800	0.543
Elbow L	4.805	2.528	3.491	1.314	0.963
Wrist L	13.187	11.796	12.456	0.731	0.660
Top head	1.410	0.160	0.671	0.739	0.511
Forehead	5.104	4.037	4.448	0.656	0.411
Femur L	11.927	11.192	11.475	0.451	0.283
Knee L	20.024	19.397	19.649	0.374	0.253
Ankle L	22.169	20.394	21.457	0.712	1.063

c.g. = Center of gravity L = Left R = Right

Table D-8. Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Initial Position Data at y Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	7.480	6.953	7.191	0.289	0.238
H-point vertical auxiliary	6.825	6.231	6.500	0.326	0.269
H-point horizontal auxiliary	6.646	5.997	6.311	0.335	0.314
H-point auxiliary	5.835	5.169	5.452	0.383	0.282
Head c.g.	3.557	2.959	3.165	0.392	0.206
Head c.g. vertical auxiliary	3.356	2.678	2.907	0.449	0.229
Head c.g. horizontal auxiliary	3.033	2.464	2.709	0.323	0.246
Knee R	6.675	6.048	6.339	0.336	0.291
Ankle R	6.503	5.381	5.974	0.529	0.593
Femur R	7.722	7.522	7.656	0.066	0.134
Shoulder R	9.314	8.844	9.021	0.293	0.178
Elbow 1 R	10.907	10.090	10.457	0.450	0.367
Elbow 2 R	10.560	9.733	10.218	0.342	0.485
Wrist R	6.714	4.843	5.984	0.730	1.141
Hand R	7.117	6.154	6.462	0.655	0.308
Top hand wrist R	5.400	4.797	5.021	0.378	0.224
Top hand wrist L	-4.825	-6.252	-5.709	0.884	0.543
Knee R	5.168	4.265	4.514	0.655	0.249
Knee L	-3.952	-5.184	-4.695	0.743	0.489
Tibia L	-4.604	-5.012	-4.840	0.237	0.172
Tibia R	5.139	4.143	4.579	0.560	0.436
Shoe tip top R	5.390	3.687	4.551	0.839	0.864
Shoe tip top L	-3.733	-5.019	-4.568	0.835	0.450
Shoe back L	-3.863	-4.718	-4.198	0.336	0.520
Shoe back R	4.810	3.171	4.209	0.601	1.038
Shoulder L	-8.676	-9.131	-8.917	0.241	0.214
Elbow L	-9.711	-10.312	-9.966	0.255	0.346
Wrist L	-4.278	-7.541	-6.236	1.958	1.305
Top head	0.601	-0.179	0.075	0.526	0.253
Forehead	0.461	-0.269	-0.037	0.499	0.232
Femur L	-7.266	-7.804	-7.548	0.282	0.256
Knee L	-5.984	-6.901	-6.535	0.551	0.367
Ankle L	-5.587	-6.197	-5.873	0.286	0.323

c.g. = Center of gravity L = Left R = Right

Table D-9. Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Initial Position Data at z Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	-3.519	-4.245	-3.972	0.453	0.273
H-point vertical auxiliary	-6.443	-7.132	-6.855	0.412	0.277
H-point horizontal auxiliary	-4.483	-5.404	-4.960	0.476	0.444
H-point auxiliary	-7.930	-8.360	-8.148	0.218	0.212
Head c.g.	-30.388	-31.480	-31.048	0.660	0.432
Head c.g. vertical auxiliary	-33.392	-34.491	-34.063	0.672	0.428
Head c.g. horizontal auxiliary	-32.183	-32.995	-32.698	0.516	0.297
Knee R	-4.517	-4.975	-4.723	0.206	0.252
Ankle R	11.638	11.234	11.456	0.182	0.223
Femur R	-3.824	-4.100	-3.947	0.123	0.153
Shoulder R	-22.750	-23.555	-23.259	0.509	0.296
Elbow 1 R	-14.225	-15.485	-14.764	0.538	0.721
Elbow 2 R	-12.563	-13.476	-13.055	0.492	0.421
Wrist R	-9.862	-11.383	-10.704	0.842	0.679
Hand R	-9.705	-10.778	-10.222	0.517	0.556
Top hand wrist R	-10.690	-12.005	-11.402	0.712	0.603
Top hand wrist L	-11.121	-11.654	-11.396	0.275	0.259
Knee R	-5.095	-5.619	-5.353	0.259	0.265
Knee L	-5.061	-5.718	-5.348	0.288	0.370
Tibia L	3.779	3.245	3.563	0.216	0.317
Tibia R	3.358	3.074	3.235	0.123	0.161
Shoe tip top R	13.966	13.239	13.637	0.328	0.398
Shoe tip top L	14.507	13.705	14.118	0.388	0.414
Shoe back L	14.013	12.409	13.412	0.601	1.003
Shoe back R	13.373	12.524	13.158	0.215	0.633
Shoulder L	-22.776	-23.518	-23.175	0.400	0.343
Elbow L	-12.475	-12.981	-12.751	0.276	0.230
Wrist L	-10.232	-11.223	-10.716	0.484	0.507
Top head	-35.100	-36.121	-35.708	0.608	0.414
Forehead	-32.473	-33.071	-32.756	0.283	0.314
Femur L	-4.089	-4.802	-4.365	0.276	0.437
Knee L	-4.420	-5.170	-4.747	0.327	0.423
Ankle L	11.673	11.073	11.412	0.261	0.339

c.g. = Center of gravity L = Left R = Right

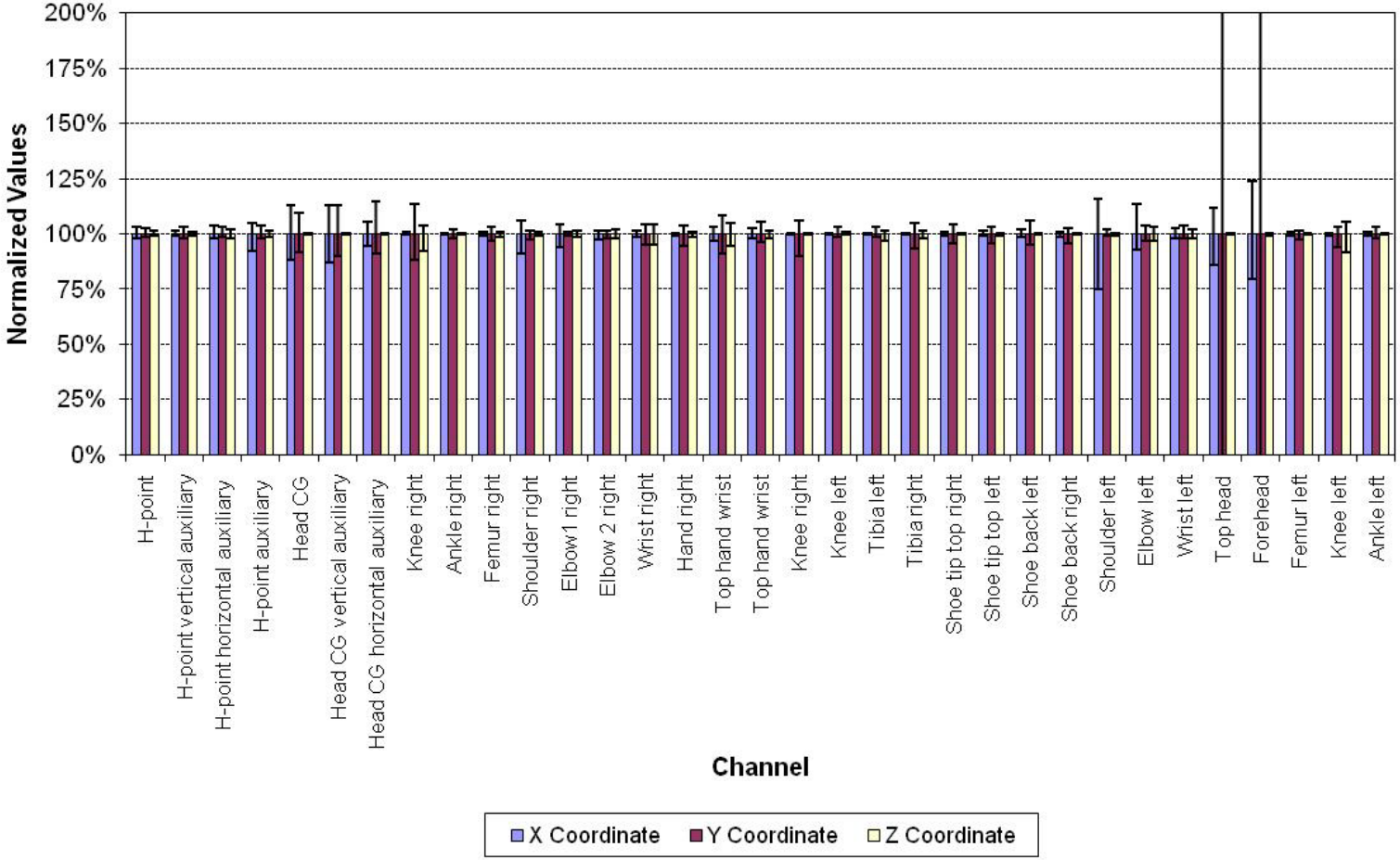


Figure D-8. Normalized Initial Position Data for Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch

Table D-10. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Initial Position Data at x Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	4.282	4.062	4.147	0.136	0.085
H-point vertical auxiliary	4.028	3.931	3.972	0.056	0.042
H-point horizontal auxiliary	1.587	1.499	1.529	0.058	0.030
H-point auxiliary	1.428	1.257	1.359	0.069	0.102
Head c.g.	-1.832	-2.342	-2.071	0.239	0.272
Head c.g. vertical auxiliary	-2.583	-3.339	-2.964	0.381	0.376
Head c.g. horizontal auxiliary	-4.569	-5.116	-4.840	0.271	0.276
Knee R	20.104	19.844	19.952	0.152	0.108
Ankle R	21.298	21.109	21.204	0.094	0.094
Femur R	11.912	11.712	11.821	0.090	0.109
Shoulder R	-0.867	-1.010	-0.955	0.087	0.055
Elbow 1 R	1.449	1.299	1.385	0.064	0.086
Elbow 2 R	3.224	3.093	3.176	0.048	0.083
Wrist R	12.393	12.004	12.211	0.182	0.207
Hand R	14.900	14.683	14.819	0.081	0.136
Top hand wrist R	13.364	12.526	12.954	0.410	0.428
Top hand wrist L	12.944	12.334	12.612	0.332	0.278
Knee R	22.760	22.556	22.640	0.121	0.084
Knee L	22.682	22.531	22.599	0.082	0.068
Tibia L	22.871	22.665	22.768	0.103	0.103
Tibia R	22.861	22.687	22.794	0.067	0.106
Shoe tip top R	29.792	29.341	29.576	0.216	0.235
Shoe tip top L	30.004	29.385	29.648	0.356	0.263
Shoe back L	18.701	18.161	18.373	0.328	0.212
Shoe back R	18.724	18.308	18.534	0.190	0.226
Shoulder L	-0.744	-1.148	-0.993	0.249	0.155
Elbow L	3.580	2.926	3.158	0.422	0.232
Wrist L	12.123	11.595	11.835	0.288	0.240
Top head	-2.838	-3.690	-3.303	0.466	0.386
Forehead	2.159	1.387	1.745	0.414	0.357
Femur L	11.826	11.656	11.747	0.079	0.091
Knee L	20.117	19.869	20.005	0.111	0.136
Ankle L	21.805	21.401	21.564	0.242	0.162

c.g. = Center of gravity L = Left R = Right

Table D-11. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 60 Pitch—Initial Position Data at y Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	7.232	6.946	7.044	0.188	0.098
H-point vertical auxiliary	6.464	6.143	6.255	0.209	0.113
H-point horizontal auxiliary	6.568	6.255	6.360	0.208	0.105
H-point auxiliary	5.954	5.629	5.743	0.211	0.114
Head c.g.	3.379	2.827	3.082	0.297	0.255
Head c.g. vertical auxiliary	2.913	2.311	2.578	0.335	0.267
Head c.g. horizontal auxiliary	2.841	2.250	2.472	0.369	0.222
Knee R	6.720	5.233	5.916	0.804	0.684
Ankle R	6.158	5.927	6.042	0.116	0.116
Femur R	7.706	7.230	7.472	0.234	0.243
Shoulder R	9.138	8.817	9.026	0.112	0.208
Elbow 1 R	10.305	10.091	10.196	0.109	0.106
Elbow 2 R	10.579	10.260	10.457	0.122	0.197
Wrist R	7.352	6.695	7.055	0.298	0.360
Hand R	6.880	6.243	6.624	0.256	0.380
Top hand wrist R	5.921	4.976	5.459	0.462	0.483
Top hand wrist L	-6.153	-6.713	-6.377	0.224	0.336
Knee R	4.657	3.940	4.390	0.267	0.450
Knee L	-4.488	-4.710	-4.565	0.076	0.145
Tibia L	-4.952	-5.185	-5.031	0.080	0.154
Tibia R	4.728	4.196	4.501	0.226	0.305
Shoe tip top R	4.749	4.359	4.545	0.204	0.186
Shoe tip top L	-4.686	-5.053	-4.891	0.206	0.162
Shoe back L	-4.495	-5.025	-4.735	0.240	0.289
Shoe back R	4.411	4.109	4.293	0.118	0.183
Shoulder L	-9.132	-9.431	-9.236	0.104	0.196
Elbow L	-10.376	-11.146	-10.733	0.357	0.413
Wrist L	-7.379	-7.826	-7.549	0.170	0.277
Top head	0.454	-0.220	0.083	0.371	0.304
Forehead	0.319	-0.224	0.078	0.241	0.302
Femur L	-7.591	-7.902	-7.772	0.181	0.130
Knee L	-6.006	-6.622	-6.406	0.400	0.216
Ankle L	-6.336	-6.662	-6.454	0.118	0.208

c.g. = Center of gravity L = Left R = Right

Table D-12. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Initial Position Data at z Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	-4.456	-4.557	-4.490	0.035	0.067
H-point vertical auxiliary	-7.340	-7.480	-7.402	0.062	0.078
H-point horizontal auxiliary	-5.566	-5.806	-5.682	0.116	0.124
H-point auxiliary	-8.526	-8.751	-8.635	0.109	0.116
Head c.g.	-32.393	-32.515	-32.439	0.046	0.076
Head c.g. vertical auxiliary	-35.105	-35.171	-35.149	0.044	0.022
Head c.g. horizontal auxiliary	-32.965	-33.121	-33.019	0.054	0.102
Knee R	-4.057	-4.569	-4.394	0.337	0.175
Ankle R	11.382	11.281	11.331	0.050	0.050
Femur R	-4.759	-4.879	-4.826	0.066	0.053
Shoulder R	-21.741	-22.048	-21.878	0.137	0.170
Elbow 1 R	-14.103	-14.550	-14.316	0.214	0.233
Elbow 2 R	-12.301	-12.805	-12.545	0.244	0.260
Wrist R	-9.684	-10.618	-10.173	0.489	0.445
Hand R	-9.487	-9.689	-9.621	0.134	0.068
Top hand wrist R	-10.595	-11.727	-11.175	0.580	0.552
Top hand wrist L	-10.807	-11.213	-11.057	0.250	0.156
Knee R	-4.816	-4.850	-4.829	0.013	0.021
Knee L	-4.428	-4.472	-4.446	0.018	0.026
Tibia L	3.032	2.897	2.983	0.049	0.086
Tibia R	3.191	3.091	3.153	0.038	0.062
Shoe tip top R	13.908	13.765	13.840	0.067	0.075
Shoe tip top L	14.032	13.840	13.966	0.066	0.126
Shoe back L	13.533	13.508	13.521	0.012	0.013
Shoe back R	13.569	13.525	13.544	0.024	0.019
Shoulder L	-21.805	-22.059	-21.959	0.155	0.099
Elbow L	-12.116	-12.894	-12.514	0.398	0.380
Wrist L	-9.849	-10.269	-10.055	0.207	0.214
Top head	-36.261	-36.297	-36.284	0.024	0.013
Forehead	-34.124	-34.523	-34.329	0.205	0.194
Femur L	-4.343	-4.377	-4.365	0.022	0.012
Knee L	-4.002	-4.593	-4.366	0.363	0.227
Ankle L	11.177	11.113	11.152	0.026	0.039

c.g. = Center of gravity L = Left R = Right

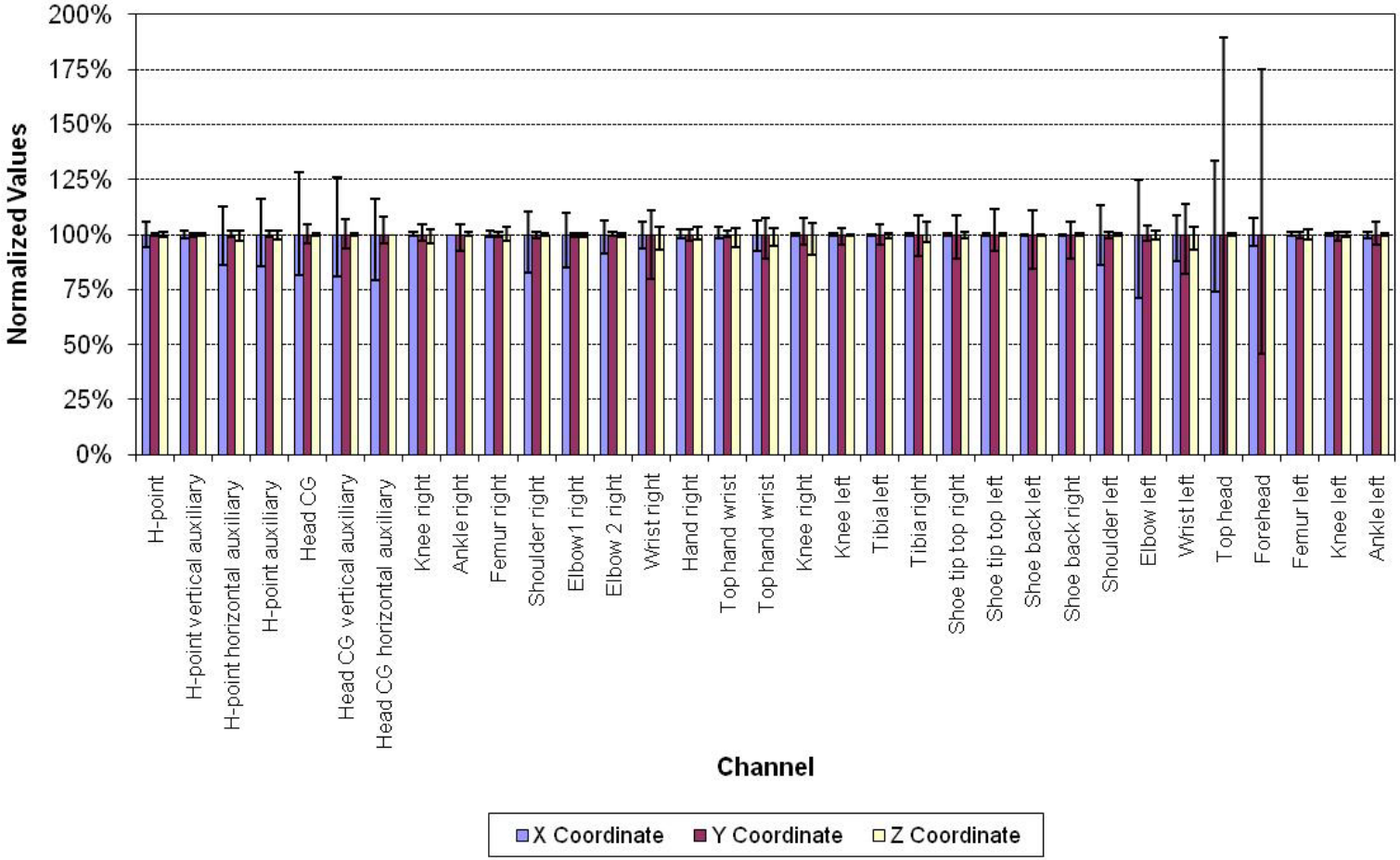


Figure D-9. Normalized Initial Position Data for Hybrid II Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch

Table D-13. Hybrid II Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch—Initial Position Data at x Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	3.633	3.237	3.428	0.205	0.191
H-point vertical auxiliary	3.256	3.154	3.200	0.056	0.046
H-point horizontal auxiliary	0.955	0.728	0.846	0.109	0.118
H-point auxiliary	0.743	0.547	0.640	0.103	0.093
Head c.g.	1.279	0.811	0.996	0.283	0.185
Head c.g. vertical auxiliary	1.612	1.032	1.277	0.335	0.245
Head c.g. horizontal auxiliary	-1.056	-1.544	-1.329	0.273	0.214
Knee R	20.086	19.747	19.894	0.192	0.146
Ankle R	23.520	23.432	23.470	0.050	0.038
Femur R	12.056	11.700	11.846	0.210	0.147
Shoulder R	1.765	1.315	1.594	0.171	0.279
Elbow 1 R	4.317	3.344	3.923	0.394	0.579
Elbow 2 R	4.462	3.828	4.194	0.268	0.367
Wrist R	13.278	11.729	12.539	0.738	0.810
Hand R	16.134	15.472	15.719	0.415	0.247
Top hand wrist R	13.963	13.211	13.463	0.501	0.252
Top hand wrist L	14.056	12.232	13.209	0.847	0.978
Knee R	22.683	22.334	22.473	0.210	0.139
Knee L	22.480	22.309	22.380	0.100	0.071
Tibia L	23.724	23.586	23.651	0.073	0.065
Tibia R	23.805	23.608	23.683	0.122	0.074
Shoe tip top R	32.181	31.916	32.063	0.118	0.147
Shoe tip top L	32.304	31.957	32.078	0.226	0.121
Shoe back L	20.832	20.646	20.760	0.072	0.115
Shoe back R	20.734	20.646	20.699	0.035	0.052
Shoulder L	2.225	1.691	1.967	0.258	0.277
Elbow L	4.317	2.463	3.453	0.864	0.991
Wrist L	13.134	10.652	12.074	1.060	1.421
Top head	1.877	1.043	1.403	0.474	0.360
Forehead	5.361	4.725	4.988	0.373	0.264
Femur L	11.802	11.598	11.673	0.129	0.074
Knee L	19.913	19.728	19.810	0.103	0.082
Ankle L	24.029	23.408	23.771	0.258	0.363

c.g. = Center of gravity L = Left R = Right

Table D-14. Hybrid II Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch—Initial Position Data at y Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	7.151	7.043	7.097	0.054	0.054
H-point vertical auxiliary	6.481	6.381	6.438	0.043	0.058
H-point horizontal auxiliary	6.346	6.142	6.218	0.128	0.076
H-point auxiliary	5.497	5.349	5.401	0.096	0.052
Head c.g.	3.071	2.811	2.934	0.137	0.123
Head c.g. Vertical Auxiliary	2.841	2.493	2.654	0.188	0.161
Head c.g. horizontal auxiliary	2.709	2.408	2.510	0.198	0.103
Knee R	6.464	5.986	6.171	0.293	0.185
Ankle R	6.224	5.479	5.932	0.292	0.453
Femur R	7.725	7.554	7.616	0.109	0.062
Shoulder R	8.981	8.720	8.856	0.124	0.136
Elbow 1 R	10.467	10.290	10.377	0.090	0.087
Elbow 2 R	10.158	9.991	10.058	0.101	0.066
Wrist R	6.328	4.541	5.706	0.622	1.166
Hand R	5.939	5.621	5.789	0.150	0.168
Top hand wrist R	4.737	4.591	4.647	0.090	0.056
Top hand wrist L	-5.032	-6.079	-5.659	0.627	0.420
Knee R	4.655	4.125	4.331	0.324	0.206
Knee L	-4.650	-5.006	-4.861	0.211	0.145
Tibia L	-4.727	-5.180	-4.941	0.213	0.240
Tibia R	4.858	4.046	4.479	0.379	0.433
Shoe tip top R	4.949	4.062	4.563	0.387	0.501
Shoe tip top L	-4.207	-5.087	-4.549	0.342	0.538
Shoe back L	-3.723	-4.900	-4.418	0.696	0.482
Shoe back R	4.454	3.741	4.203	0.251	0.462
Shoulder L	-8.821	-9.073	-8.977	0.155	0.096
Elbow L	-9.903	-10.592	-10.162	0.259	0.431
Wrist L	-5.192	-7.192	-6.325	1.134	0.866
Top head	0.022	-0.312	-0.165	0.186	0.147
Forehead	-0.142	-0.541	-0.309	0.168	0.232
Femur L	-7.571	-7.784	-7.704	0.133	0.080
Knee L	-6.438	-6.695	-6.605	0.167	0.090
Ankle L	-5.521	-6.108	-5.785	0.264	0.323

c.g. = Center of gravity L = Left R = Right

Table D-15. Hybrid II Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch—Initial Position Data at Z-Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	-3.884	-3.972	-3.922	0.038	0.050
H-point vertical auxiliary	-6.711	-6.798	-6.755	0.045	0.043
H-point horizontal auxiliary	-4.797	-5.020	-4.924	0.127	0.097
H-point auxiliary	-7.631	-7.941	-7.806	0.175	0.135
Head c.g.	-30.884	-31.152	-31.006	0.122	0.146
Head c.g. vertical auxiliary	-33.892	-34.132	-33.996	0.105	0.136
Head c.g. horizontal auxiliary	-32.654	-32.798	-32.713	0.060	0.085
Knee R	-4.256	-4.525	-4.428	0.172	0.096
Ankle R	11.615	11.416	11.490	0.125	0.074
Femur R	-3.842	-4.106	-3.965	0.123	0.142
Shoulder R	-23.064	-23.317	-23.168	0.104	0.149
Elbow 1 R	-13.973	-14.159	-14.090	0.117	0.069
Elbow 2 R	-12.701	-12.970	-12.868	0.166	0.103
Wrist R	-9.340	-10.411	-10.028	0.688	0.383
Hand R	-9.442	-10.030	-9.668	0.226	0.362
Top hand wrist R	-10.160	-11.089	-10.777	0.617	0.312
Top hand wrist L	-9.849	-10.677	-10.355	0.505	0.322
Knee R	-4.532	-5.239	-4.980	0.449	0.258
Knee L	-4.797	-4.827	-4.813	0.016	0.014
Tibia L	3.721	3.634	3.691	0.031	0.056
Tibia R	3.296	3.014	3.115	0.182	0.101
Shoe tip top R	14.076	13.653	13.884	0.192	0.230
Shoe tip top L	14.555	14.406	14.491	0.064	0.084
Shoe back L	13.449	13.313	13.403	0.045	0.090
Shoe back R	13.333	13.156	13.239	0.094	0.083
Shoulder L	-22.754	-23.015	-22.911	0.157	0.104
Elbow L	-12.171	-12.622	-12.429	0.258	0.193
Wrist L	-8.832	-9.867	-9.505	0.673	0.362
Top head	-35.488	-35.750	-35.621	0.132	0.129
Forehead	-32.157	-32.303	-32.211	0.054	0.092
Femur L	-3.684	-3.867	-3.775	0.091	0.092
Knee L	-4.125	-4.220	-4.176	0.051	0.044
Ankle L	11.723	11.541	11.632	0.091	0.091

c.g. = Center of gravity L = Left R = Right

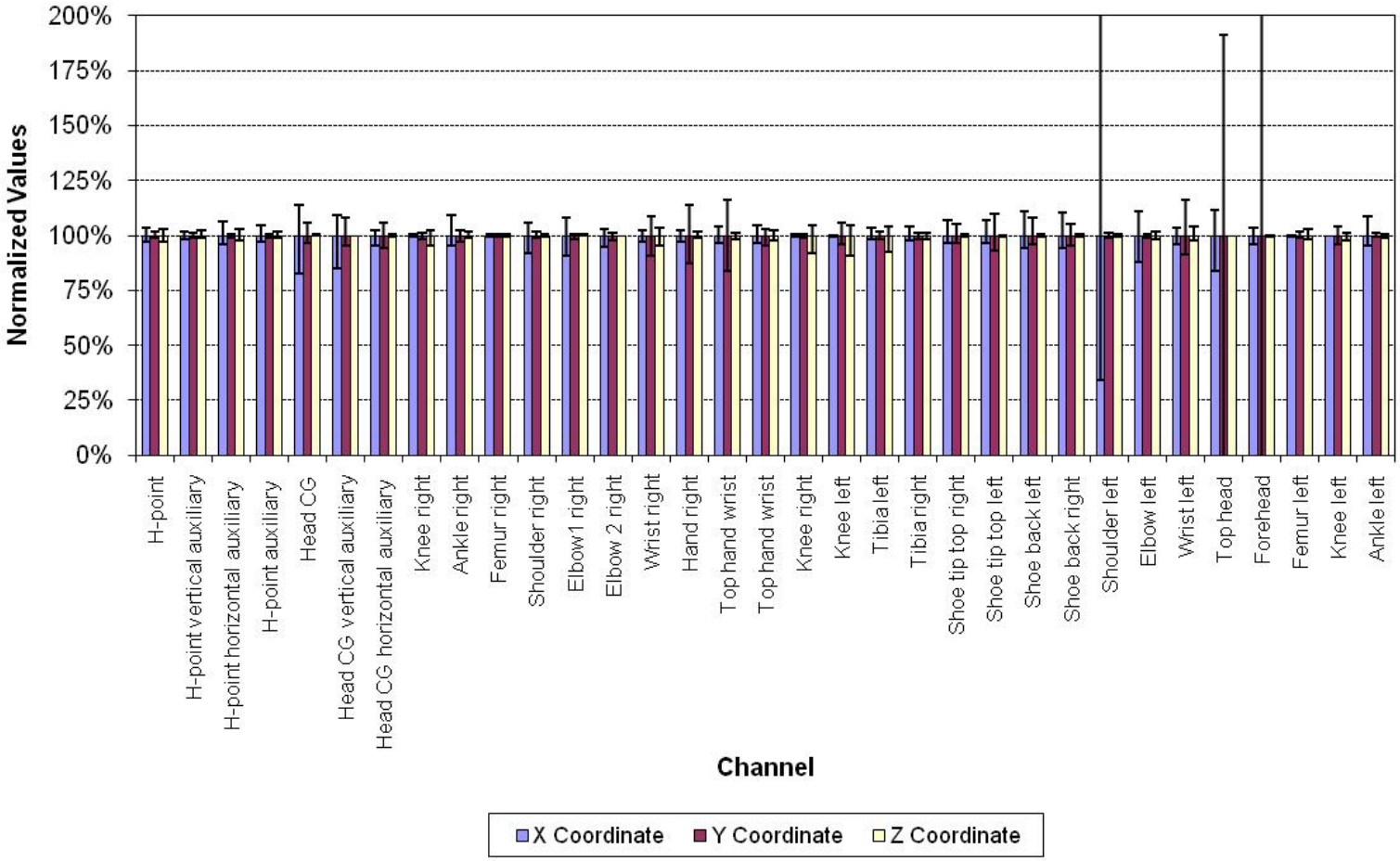


Figure D-10. Normalized Initial Position Data for Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch

Table D-16. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch—Initial Position Data at x Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	4.434	4.160	4.276	0.158	0.116
H-point vertical auxiliary	4.145	4.011	4.070	0.075	0.059
H-point horizontal auxiliary	1.764	1.585	1.654	0.110	0.069
H-point auxiliary	1.517	1.408	1.450	0.067	0.043
Head c.g.	-0.475	-0.653	-0.572	0.098	0.080
Head c.g. vertical auxiliary	-0.721	-0.927	-0.847	0.126	0.080
Head c.g. horizontal auxiliary	-3.067	-3.279	-3.208	0.141	0.071
Knee R	20.257	20.078	20.151	0.106	0.074
Ankle R	23.537	20.538	21.558	1.979	1.020
Femur R	12.207	12.080	12.133	0.074	0.053
Shoulder R	-0.715	-0.825	-0.777	0.062	0.048
Elbow 1 R	2.158	1.811	1.993	0.165	0.182
Elbow 2 R	3.992	3.675	3.882	0.110	0.207
Wrist R	12.712	12.133	12.450	0.263	0.317
Hand R	15.912	15.147	15.547	0.364	0.401
Top hand wrist R	13.985	12.997	13.447	0.538	0.449
Top hand wrist L	13.616	12.543	12.995	0.622	0.451
Knee R	22.929	22.777	22.844	0.085	0.066
Knee L	23.061	22.944	23.021	0.040	0.076
Tibia L	24.118	22.797	23.242	0.876	0.445
Tibia R	24.059	22.599	23.120	0.939	0.521
Shoe tip top R	31.988	28.865	29.915	2.073	1.050
Shoe tip top L	31.934	28.847	29.890	2.044	1.043
Shoe back L	20.692	17.644	18.665	2.027	1.021
Shoe back R	20.923	17.859	18.898	2.026	1.039
Shoulder L	-0.091	-0.540	-0.266	0.174	0.274
Elbow L	4.338	3.433	3.902	0.436	0.469
Wrist L	12.564	11.607	12.117	0.447	0.510
Top head	-0.759	-1.009	-0.903	0.144	0.106
Forehead	3.766	3.500	3.634	0.132	0.134
Femur L	12.452	12.379	12.421	0.032	0.041
Knee L	20.312	20.262	20.289	0.023	0.027
Ankle L	24.116	21.176	22.165	1.951	0.989

c.g. = Center of gravity L = Left R = Right

Table D-17. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch—Initial Position Data at y Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	7.218	7.026	7.093	0.125	0.067
H-point vertical auxiliary	6.419	6.262	6.334	0.085	0.072
H-point horizontal auxiliary	6.414	6.316	6.370	0.044	0.053
H-point auxiliary	5.800	5.677	5.756	0.044	0.079
Head c.g.	3.029	2.768	2.859	0.170	0.091
Head c.g. vertical auxiliary	2.510	2.219	2.325	0.185	0.106
Head c.g. horizontal auxiliary	2.306	2.055	2.173	0.133	0.118
Knee R	5.589	5.441	5.521	0.069	0.079
Ankle R	6.260	5.941	6.110	0.151	0.168
Femur R	7.486	7.391	7.427	0.059	0.037
Shoulder R	9.019	8.794	8.872	0.147	0.078
Elbow 1 R	10.267	10.004	10.176	0.091	0.172
Elbow 2 R	10.599	10.235	10.471	0.127	0.237
Wrist R	6.074	5.072	5.599	0.475	0.527
Hand R	7.479	5.743	6.558	0.921	0.816
Top hand wrist R	5.990	4.323	5.159	0.831	0.836
Top hand wrist L	-5.395	-5.825	-5.665	0.270	0.160
Knee R	4.259	4.176	4.231	0.028	0.055
Knee L	-3.841	-4.243	-4.000	0.159	0.243
Tibia L	-4.325	-4.480	-4.389	0.064	0.091
Tibia R	4.564	4.430	4.500	0.064	0.070
Shoe tip top R	4.349	4.000	4.138	0.211	0.138
Shoe tip top L	-3.744	-4.429	-4.021	0.277	0.408
Shoe back L	-3.774	-4.248	-3.934	0.160	0.314
Shoe back R	4.627	4.203	4.395	0.231	0.192
Shoulder L	-9.026	-9.265	-9.139	0.114	0.126
Elbow L	-10.595	-10.743	-10.680	0.086	0.063
Wrist L	-5.177	-6.600	-5.676	0.499	0.924
Top head	0.036	-0.326	-0.170	0.207	0.155
Forehead	0.199	-0.232	-0.051	0.249	0.181
Femur L	-7.370	-7.579	-7.463	0.094	0.115
Knee L	-5.190	-5.645	-5.410	0.220	0.235
Ankle L	-5.678	-5.772	-5.716	0.038	0.057

c.g. = Center of gravity L = Left R = Right

Table D-18. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch—Initial Position Data at z Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	-4.155	-4.416	-4.288	0.133	0.128
H-point vertical auxiliary	-7.054	-7.300	-7.136	0.082	0.164
H-point horizontal auxiliary	-5.314	-5.575	-5.421	0.107	0.154
H-point auxiliary	-8.250	-8.515	-8.361	0.111	0.154
Head c.g.	-32.244	-32.422	-32.304	0.060	0.118
Head c.g. vertical auxiliary	-35.095	-35.293	-35.171	0.076	0.123
Head c.g. horizontal auxiliary	-33.337	-33.560	-33.426	0.090	0.134
Knee R	-4.326	-4.656	-4.543	0.217	0.113
Ankle R	11.212	10.897	11.028	0.185	0.131
Femur R	-4.792	-4.836	-4.818	0.025	0.018
Shoulder R	-21.364	-21.612	-21.451	0.088	0.161
Elbow 1 R	-14.086	-14.170	-14.116	0.030	0.054
Elbow 2 R	-12.440	-12.477	-12.459	0.019	0.018
Wrist R	-9.729	-10.560	-10.176	0.448	0.384
Hand R	-9.725	-9.969	-9.810	0.085	0.159
Top hand wrist R	-10.681	-11.029	-10.876	0.195	0.154
Top hand wrist L	-10.444	-10.962	-10.694	0.250	0.268
Knee R	-4.511	-5.113	-4.892	0.381	0.221
Knee L	-4.437	-5.132	-4.897	0.460	0.235
Tibia L	3.007	2.670	2.892	0.115	0.223
Tibia R	2.990	2.903	2.946	0.043	0.043
Shoe tip top R	14.122	13.938	14.003	0.119	0.066
Shoe tip top L	14.254	14.178	14.211	0.043	0.033
Shoe back L	13.491	13.302	13.402	0.089	0.100
Shoe back R	13.531	13.378	13.431	0.100	0.053
Shoulder L	-21.204	-21.500	-21.364	0.160	0.135
Elbow L	-11.763	-12.214	-11.984	0.221	0.231
Wrist L	-9.721	-10.361	-9.954	0.233	0.407
Top head	-36.257	-36.444	-36.327	0.070	0.117
Forehead	-33.159	-33.350	-33.254	0.096	0.095
Femur L	-4.468	-4.675	-4.546	0.078	0.130
Knee L	-4.377	-4.521	-4.469	0.092	0.052
Ankle L	11.105	10.895	11.009	0.095	0.114

c.g. = Center of gravity L = Left R = Right

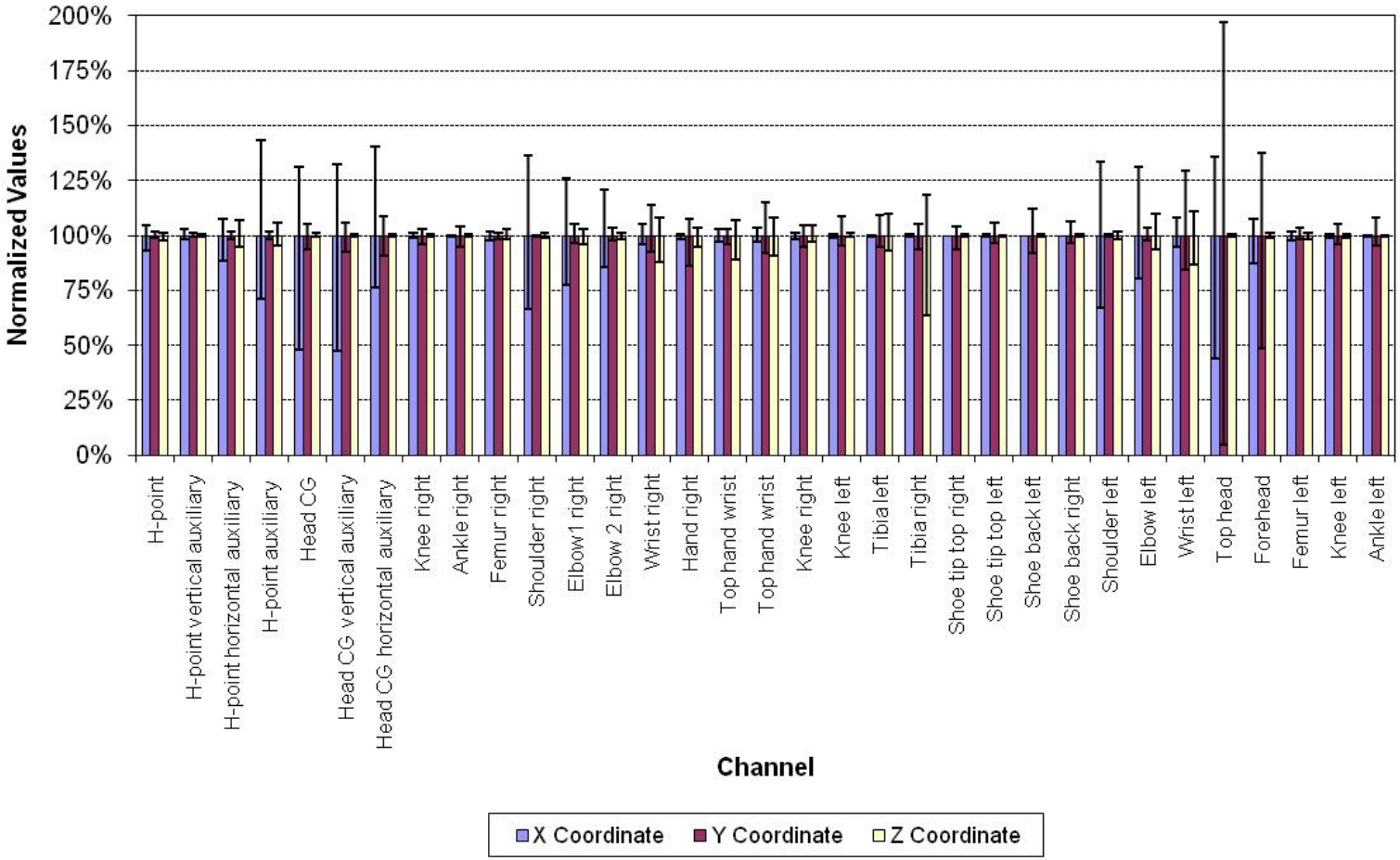


Figure D-11. Normalized Initial Position Data for Hybrid II Anthropomorphic Test Dummy With Four-Point Belt at 0° Pitch

Table D-19. Hybrid II Anthropomorphic Test Dummy With Four-Point Belt at 0° Pitch—Initial Position Data at x Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	4.046	3.583	3.855	0.191	0.271
H-point vertical auxiliary	3.377	3.228	3.288	0.089	0.060
H-point horizontal auxiliary	1.212	0.999	1.126	0.085	0.128
H-point auxiliary	0.972	0.483	0.677	0.296	0.194
Head c.g.	1.241	0.456	0.947	0.294	0.491
Head c.g. vertical auxiliary	1.638	0.588	1.238	0.400	0.650
Head c.g. horizontal auxiliary	-1.058	-1.943	-1.384	0.326	0.559
Knee R	19.994	19.573	19.803	0.191	0.231
Ankle R	23.391	23.248	23.339	0.051	0.092
Femur R	12.176	11.755	11.991	0.185	0.235
Shoulder R	1.888	0.916	1.382	0.506	0.465
Elbow 1 R	4.744	2.933	3.771	0.973	0.838
Elbow 2 R	5.198	3.689	4.305	0.893	0.616
Wrist R	13.302	12.162	12.667	0.635	0.506
Hand R	16.154	15.770	16.014	0.139	0.244
Top hand wrist R	14.102	13.349	13.704	0.398	0.356
Top hand wrist L	14.562	13.633	14.058	0.504	0.425
Knee R	22.525	21.919	22.289	0.236	0.370
Knee L	22.275	21.830	22.101	0.173	0.271
Tibia L	23.611	23.472	23.554	0.057	0.082
Tibia R	23.633	23.476	23.543	0.091	0.066
Shoe tip top R	32.096	31.928	31.985	0.111	0.057
Shoe tip top L	32.319	31.962	32.094	0.225	0.132
Shoe back L	20.864	20.808	20.835	0.029	0.027
Shoe back R	20.742	20.670	20.698	0.044	0.028
Shoulder L	1.784	0.896	1.338	0.446	0.442
Elbow L	5.359	3.278	4.083	1.276	0.805
Wrist L	13.808	12.072	12.758	1.050	0.686
Top head	1.818	0.590	1.340	0.478	0.750
Forehead	5.356	4.344	4.980	0.376	0.636
Femur L	11.890	11.437	11.707	0.183	0.270
Knee L	19.783	19.380	19.628	0.155	0.248
Ankle L	23.882	23.771	23.837	0.045	0.067

c.g. = Center of gravity L = Left R = Right

Table D-20. Hybrid II Anthropomorphic Test Dummy With Four-Point Belt at 0° Pitch—Initial Position Data at y Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	7.387	7.183	7.263	0.124	0.080
H-point vertical auxiliary	6.688	6.559	6.608	0.080	0.049
H-point horizontal auxiliary	6.531	6.310	6.426	0.106	0.116
H-point auxiliary	5.740	5.558	5.642	0.098	0.084
Head c.g.	3.497	3.112	3.317	0.180	0.206
Head c.g. vertical auxiliary	3.259	2.845	3.078	0.181	0.234
Head c.g. horizontal auxiliary	3.146	2.632	2.899	0.247	0.266
Knee R	6.300	5.866	6.123	0.177	0.257
Ankle R	5.934	5.387	5.686	0.248	0.299
Femur R	7.592	7.376	7.504	0.088	0.128
Shoulder R	9.091	9.013	9.065	0.026	0.052
Elbow 1 R	11.467	10.529	10.871	0.595	0.342
Elbow 2 R	11.170	10.538	10.791	0.379	0.253
Wrist R	6.474	5.261	5.695	0.779	0.434
Hand R	6.809	5.473	6.332	0.477	0.858
Top hand wrist R	5.586	5.197	5.421	0.165	0.224
Top hand wrist L	-5.513	-6.875	-5.978	0.465	0.897
Knee R	4.362	3.942	4.168	0.194	0.226
Knee L	-4.401	-5.036	-4.622	0.222	0.414
Tibia L	-4.458	-5.116	-4.688	0.229	0.428
Tibia R	4.538	4.048	4.307	0.231	0.259
Shoe tip top R	4.782	4.290	4.589	0.193	0.299
Shoe tip top L	-4.120	-4.533	-4.277	0.157	0.256
Shoe back L	-3.614	-4.405	-3.928	0.314	0.477
Shoe back R	4.013	3.635	3.773	0.240	0.138
Shoulder L	-8.663	-8.781	-8.725	0.062	0.056
Elbow L	-9.979	-10.563	-10.180	0.201	0.383
Wrist L	-5.034	-7.715	-5.960	0.926	1.755
Top head	0.447	0.011	0.227	0.220	0.216
Forehead	0.209	0.074	0.152	0.057	0.078
Femur L	-7.405	-7.833	-7.549	0.144	0.284
Knee L	-6.239	-6.823	-6.479	0.240	0.344
Ankle L	-5.169	-5.875	-5.425	0.256	0.449

c.g. = Center of gravity L = Left R = Right

Table D-21. Hybrid II Anthropomorphic Test Dummy With Four-Point Belt at 0°Pitch—Initial Position Data at z Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	-3.605	-3.730	-3.678	0.073	0.052
H-point vertical auxiliary	-6.457	-6.545	-6.503	0.046	0.043
H-point horizontal auxiliary	-4.285	-4.815	-4.506	0.221	0.309
H-point auxiliary	-7.026	-7.773	-7.345	0.319	0.428
Head c.g.	-30.496	-30.998	-30.707	0.211	0.291
Head c.g. vertical auxiliary	-33.530	-33.987	-33.711	0.181	0.276
Head c.g. horizontal auxiliary	-32.314	-32.589	-32.437	0.122	0.152
Knee R	-7.179	-7.259	-7.217	0.038	0.042
Ankle R	8.723	8.635	8.684	0.039	0.050
Femur R	-5.046	-5.270	-5.131	0.085	0.139
Shoulder R	-22.365	-22.859	-22.568	0.203	0.292
Elbow 1 R	-13.607	-14.595	-14.156	0.548	0.440
Elbow 2 R	-12.227	-12.596	-12.444	0.217	0.152
Wrist R	-9.961	-12.272	-11.342	1.381	0.930
Hand R	-10.621	-11.618	-11.216	0.595	0.402
Top hand wrist R	-10.889	-13.064	-12.194	1.305	0.870
Top hand wrist L	-10.881	-12.937	-11.983	1.102	0.954
Knee R	-7.762	-8.344	-7.976	0.214	0.368
Knee L	-7.960	-8.101	-8.011	0.051	0.091
Tibia L	0.704	0.595	0.639	0.065	0.044
Tibia R	0.353	0.191	0.298	0.055	0.108
Shoe tip top R	10.894	10.791	10.850	0.044	0.059
Shoe tip top L	11.514	11.454	11.481	0.033	0.027
Shoe back L	10.437	10.352	10.399	0.038	0.047
Shoe back R	10.338	10.226	10.275	0.062	0.049
Shoulder L	-22.321	-23.177	-22.744	0.423	0.433
Elbow L	-11.908	-13.949	-12.723	0.815	1.226
Wrist L	-9.564	-12.208	-11.012	1.448	1.196
Top head	-35.090	-35.658	-35.338	0.249	0.319
Forehead	-31.521	-32.320	-31.862	0.341	0.458
Femur L	-5.076	-5.231	-5.165	0.089	0.066
Knee L	-7.042	-7.173	-7.119	0.077	0.054
Ankle L	8.645	8.593	8.619	0.026	0.026

c.g. = Center of gravity L = Left R = Right

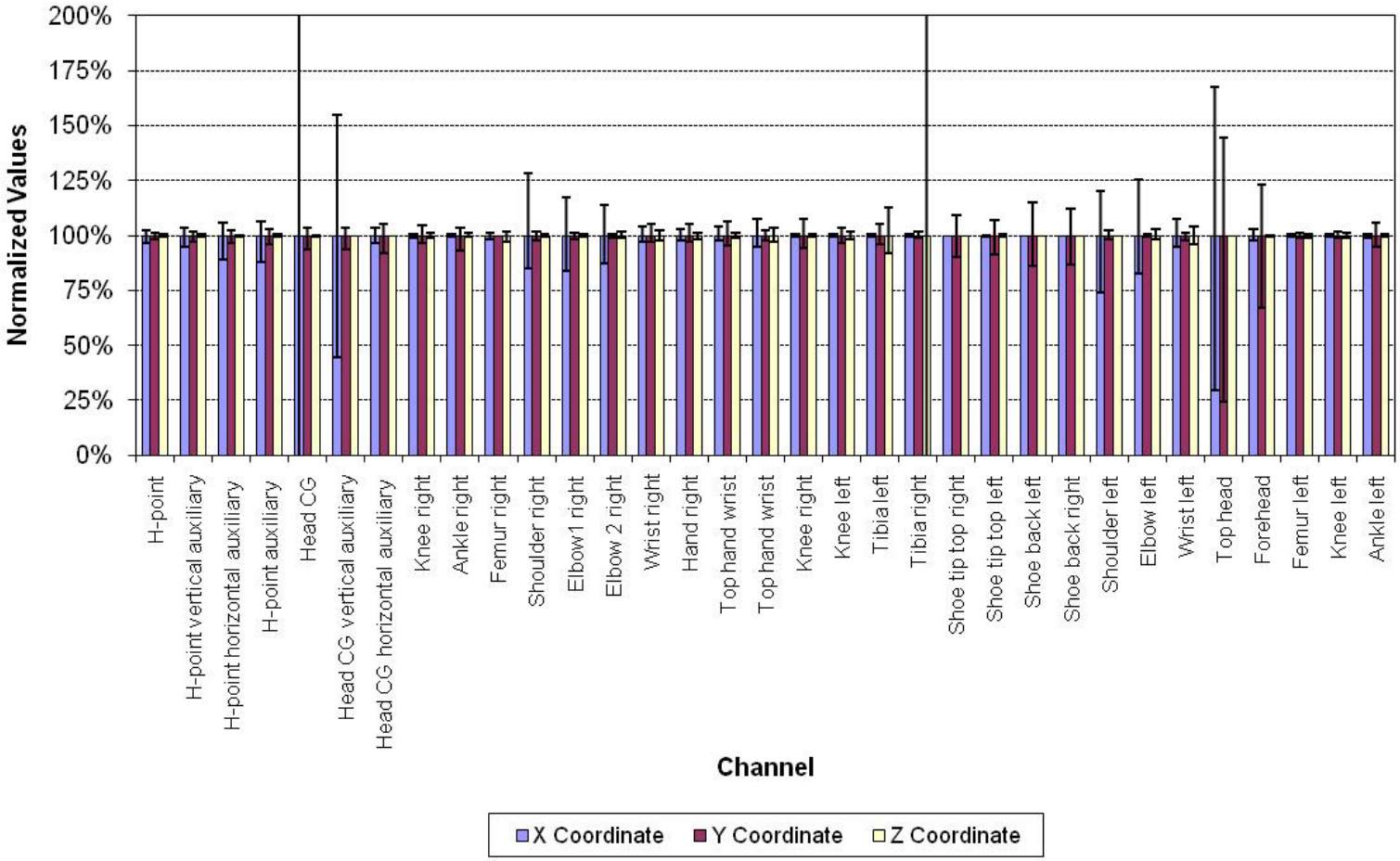


Table D-12. Normalized Initial Position Data for Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Four-Point Belt at 0° Pitch

Table D-22. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Four-Point Belt at 0° Pitch—Initial Position Data at x Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	4.909	4.646	4.797	0.112	0.151
H-point vertical auxiliary	4.345	3.982	4.208	0.137	0.226
H-point horizontal auxiliary	2.091	1.764	1.974	0.117	0.210
H-point auxiliary	1.589	1.320	1.496	0.093	0.176
Head c.g.	0.057	-0.119	-0.040	0.097	0.079
Head c.g. vertical auxiliary	-0.093	-0.322	-0.208	0.114	0.115
Head c.g. horizontal auxiliary	-2.534	-2.718	-2.624	0.089	0.094
Knee R	20.378	20.041	20.228	0.151	0.187
Ankle R	23.440	23.270	23.341	0.099	0.072
Femur R	12.460	12.087	12.305	0.154	0.219
Shoulder R	-0.474	-0.713	-0.556	0.082	0.157
Elbow 1 R	2.301	1.645	1.960	0.341	0.315
Elbow 2 R	4.208	3.221	3.684	0.524	0.463
Wrist R	12.709	11.863	12.214	0.495	0.350
Hand R	16.079	15.203	15.578	0.501	0.375
Top hand wrist R	13.979	13.149	13.447	0.532	0.298
Top hand wrist L	13.851	12.249	12.898	0.953	0.649
Knee R	22.940	22.658	22.828	0.111	0.171
Knee L	22.836	22.651	22.714	0.122	0.063
Tibia L	24.195	23.893	24.033	0.162	0.139
Tibia R	24.120	23.920	24.018	0.102	0.098
Shoe tip top R	31.813	31.779	31.793	0.020	0.014
Shoe tip top L	31.840	31.686	31.779	0.061	0.093
Shoe back L	20.615	20.564	20.589	0.026	0.024
Shoe back R	20.850	20.780	20.812	0.039	0.032
Shoulder L	-0.269	-0.437	-0.363	0.094	0.074
Elbow L	4.632	3.059	3.686	0.946	0.627
Wrist L	12.750	11.236	11.880	0.870	0.643
Top head	-0.072	-0.403	-0.241	0.169	0.163
Forehead	4.233	4.014	4.111	0.121	0.097
Femur L	12.466	12.279	12.350	0.116	0.071
Knee L	20.222	20.033	20.129	0.093	0.096
Ankle L	24.229	23.775	24.020	0.210	0.244

c.g. = Center of gravity L = Left R = Right

Table D-23. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Four-Point Belt at 0° Pitch—Initial Position Data at y Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	7.245	7.026	7.155	0.090	0.129
H-point vertical auxiliary	6.491	6.193	6.381	0.110	0.188
H-point horizontal auxiliary	6.658	6.266	6.502	0.156	0.236
H-point auxiliary	6.075	5.644	5.892	0.183	0.249
Head c.g.	3.380	3.061	3.273	0.107	0.212
Head c.g. vertical auxiliary	2.886	2.611	2.790	0.095	0.179
Head c.g. horizontal auxiliary	2.819	2.463	2.685	0.134	0.222
Knee R	5.801	5.347	5.545	0.256	0.198
Ankle R	5.909	5.332	5.713	0.196	0.380
Femur R	7.433	7.408	7.422	0.011	0.014
Shoulder R	9.329	8.961	9.186	0.142	0.226
Elbow 1 R	10.406	10.148	10.308	0.097	0.161
Elbow 2 R	10.665	10.470	10.593	0.072	0.123
Wrist R	5.314	4.903	5.051	0.263	0.148
Hand R	6.858	6.334	6.511	0.346	0.177
Top hand wrist R	5.565	4.985	5.221	0.344	0.236
Top hand wrist L	-5.178	-5.415	-5.297	0.118	0.118
Knee R	4.609	4.050	4.284	0.325	0.234
Knee L	-3.672	-3.918	-3.792	0.120	0.126
Tibia L	-4.083	-4.485	-4.249	0.166	0.236
Tibia R	4.448	4.313	4.361	0.087	0.048
Shoe tip top R	4.378	3.625	4.007	0.371	0.382
Shoe tip top L	-3.502	-4.091	-3.824	0.322	0.267
Shoe back L	-3.230	-4.298	-3.735	0.505	0.563
Shoe back R	4.236	3.289	3.778	0.458	0.489
Shoulder L	-8.631	-8.960	-8.765	0.134	0.194
Elbow L	-10.470	-10.588	-10.531	0.061	0.057
Wrist L	-4.711	-4.889	-4.822	0.111	0.066
Top head	0.410	0.070	0.284	0.126	0.214
Forehead	0.380	0.207	0.309	0.071	0.102
Femur L	-7.242	-7.416	-7.336	0.093	0.081
Knee L	-5.174	-5.316	-5.230	0.056	0.086
Ankle L	-5.358	-5.973	-5.643	0.285	0.329

c.g. = Center of gravity L = Left R = Right

Table D-24. Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Four-Point Belt at 0° Pitch—Initial Position Data at z Coordinate

Channel Description	Maximum (in.)	Minimum (in.)	Average (in.)	Delta Maximum (in.)	Delta Minimum (in.)
H-point	-4.229	-4.289	-4.263	0.033	0.027
H-point vertical auxiliary	-7.068	-7.118	-7.085	0.017	0.033
H-point horizontal auxiliary	-5.111	-5.145	-5.130	0.019	0.015
H-point auxiliary	-7.977	-8.035	-8.003	0.026	0.032
Head c.g.	-31.946	-32.124	-32.027	0.081	0.097
Head c.g. vertical auxiliary	-34.853	-34.985	-34.904	0.051	0.081
Head c.g. horizontal auxiliary	-33.241	-33.378	-33.296	0.055	0.082
Knee R	-7.082	-7.250	-7.163	0.081	0.086
Ankle R	8.367	8.218	8.279	0.088	0.061
Femur R	-5.801	-6.077	-5.978	0.177	0.099
Shoulder R	-21.008	-21.204	-21.089	0.081	0.115
Elbow 1 R	-13.545	-13.767	-13.646	0.101	0.121
Elbow 2 R	-11.706	-12.072	-11.835	0.129	0.237
Wrist R	-11.598	-12.127	-11.867	0.269	0.260
Hand R	-11.424	-11.790	-11.626	0.203	0.164
Top hand wrist R	-12.569	-12.882	-12.707	0.137	0.175
Top hand wrist L	-12.538	-13.381	-12.913	0.374	0.468
Knee R	-7.912	-8.012	-7.969	0.056	0.044
Knee L	-7.949	-8.229	-8.086	0.136	0.144
Tibia L	-0.140	-0.171	-0.152	0.012	0.019
Tibia R	0.063	-0.131	-0.034	0.097	0.097
Shoe tip top R	10.841	10.803	10.817	0.024	0.014
Shoe tip top L	11.094	10.955	11.035	0.058	0.081
Shoe back L	10.405	10.352	10.370	0.035	0.019
Shoe back R	10.523	10.493	10.505	0.018	0.012
Shoulder L	-21.151	-21.269	-21.194	0.043	0.075
Elbow L	-11.697	-12.255	-11.903	0.206	0.352
Wrist L	-11.798	-12.787	-12.263	0.466	0.523
Top head	-36.028	-36.162	-36.077	0.048	0.086
Forehead	-32.748	-32.868	-32.824	0.076	0.045
Femur L	-5.804	-5.928	-5.878	0.073	0.050
Knee L	-7.066	-7.238	-7.145	0.080	0.092
Ankle L	8.107	8.011	8.054	0.052	0.044

c.g. = Center of gravity L = Left R = Right

APPENDIX E—ERROR METRIC RESULTS

Table E-1. Error Metric Results for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch

07324-4vs7vs28	Maximum			Minimum			Average			Upper Limit			Lower Limit		
2pt 0deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	49.7	23.0	5.9 G	2.2	8.0	0.4 G	19.6	16.3	2.9 G	30.0	6.7	3.0 G	17.4	8.4	2.6 G
Head Ay	133.5	143.5	5.5 G	27.9	48.0	1.6 G	61.0	78.0	3.7 G	72.4	65.6	1.8 G	33.2	30.0	2.1 G
Head Az	18.3	6.9	12.2 G	3.3	5.2	2.6 G	11.2	6.0	8.1 G	7.1	0.9	4.1 G	8.0	0.8	5.5 G
Head Ar	19.2	6.8	12.8 G	3.1	4.7	2.5 G	11.8	5.7	8.6 G	7.4	1.1	4.3 G	8.6	1.0	6.1 G
Chest Ax	15.1	22.9	3.8 G	6.8	20.3	1.8 G	9.4	21.1	2.5 G	5.7	1.9	1.3 G	2.6	0.8	0.7 G
Chest Ay	85.7	64.3	4.6 G	10.3	48.9	0.9 G	42.9	54.6	3.1 G	42.8	9.7	1.5 G	32.6	5.7	2.3 G
Chest Az	8.1	13.0	4.1 G	3.7	8.2	1.9 G	5.2	10.6	2.7 G	2.9	2.4	1.4 G	1.5	2.4	0.8 G
Chest Ar	8.1	11.3	4.1 G	3.7	5.8	2.0 G	5.2	9.0	2.7 G	2.9	2.3	1.4 G	1.5	3.3	0.7 G
Lumbar Fx	19.1	11.6	299.4 lbf	3.6	2.2	58.9 lbf	11.7	8.0	199. 6 lbf	7.4	3.6	99.8 lbf	8.1	5.8	140.6 lbf
Lumbar Fz	7.2	9.4	220.8 lbf	0.9	4.5	28.5 lbf	4.7	7.1	147.2 lbf	2.6	2.3	73.6 lbf	3.8	2.6	118.7 lbf
Lumbar My	26.5	9.8	762.9 in-lb	9.9	4.7	316.6 in-lb	15.8	6.6	508.6 in-lb	10.7	3.2	254.3 in-lb	5.9	1.9	192.0 in-lb
Pelvis Ax	18.1	16.2	7.9 G	1.8	7.2	0.8 G	11.1	13.0	5.3 G	7.0	3.2	2.6 G	9.3	5.8	4.4 G
Pelvis Ay	16.3	66.3	3.6 G	2.7	44.3	0.7 G	10.1	55.9	2.4 G	6.2	10.4	1.2 G	7.4	11.6	1.7 G
Pelvis Az	20.8	26.6	10.9 G	4.8	15.1	3.0 G	12.6	22.2	7.3 G	8.1	4.4	3.6 G	7.8	7.0	4.2 G
Pelvis Ar	14.7	15.5	9.9 G	4.4	7.8	3.4 G	9.2	12.8	6.6 G	5.6	2.6	3.3 G	4.8	5.0	3.2 G
Left femur	5.4	13.8	25.6 lbf	0.6	8.7	3.0 lbf	3.5	11.1	17.1 lbf	1.9	2.6	8.5 lbf	2.9	2.4	14.1 lbf
Right femur	66.0	19.3	320.0 lbf	4.8	10.5	39.0 lbf	35.1	14.7	213.3 lbf	30.9	4.6	106.7 lbf	30.2	4.2	174.3 lbf
Left lap	6.1	2.4	115.0 lbf	0.7	1.8	13.7 lbf	3.9	2.1	76.7 lbf	2.1	0.3	38.3 lbf	3.3	0.3	62.9 lbf
Right lap	5.7	6.2	106.5 lbf	1.2	2.5	23.9 lbf	3.7	4.8	71.0 lbf	2.0	1.4	35.5 lbf	2.5	2.4	47.0 lbf
Seat back Fx	236.4	84.3	291.8 lbf	20.1	25.4	62.9 lbf	79.2	47.7	179.3 lbf	157.2	36.6	112.5 lbf	59.1	22.3	116.4 lbf
Seat back Fy	35.9	64.7	32.6 lbf	11.0	45.6	11.2 lbf	20.6	54.6	21.7 lbf	15.2	10.1	10.9 lbf	9.7	9.0	10.5 lbf
Seat back Fz	84.2	73.9	220.8 lbf	20.4	32.4	98.6 lbf	42.4	46.0	147.2 lbf	41.8	28.0	73.6 lbf	22.0	13.6	48.6 lbf
Seat pan Fx	39.5	23.6	254.0 lbf	1.6	14.7	10.2 lbf	22.6	17.4	169.4 lbf	16.9	6.2	84.7 lbf	21.0	2.7	159.1 lbf
Seat pan Fy	66.5	85.8	82.0 lbf	3.4	33.6	4.4 lbf	35.3	57.0	54.7 lbf	31.2	28.8	27.3 lbf	31.9	23.4	50.3 lbf
Seat pan Fz	21.2	14.7	747.4 lbf	4.1	7.7	149.7 lbf	12.9	10.5	498.2 lbf	8.3	4.2	249.1 lbf	8.8	2.9	348.6 lbf
Seat pan resultant	21.4	14.7	754.2 lbf	4.3	7.3	159.9 lbf	13.0	10.7	502.8 lbf	8.4	4.0	251.4 lbf	8.6	3.4	342.9 lbf
Seat pan Mx	63.3	101.4	1204.8 in-lb	1.4	40.8	42.5 in-lb	34.0	67.3	803.2 in-lb	29.3	34.1	401.6 in-lb	32.6	26.5	760.8 in-lb
Seat pan My	13.9	9.8	3449.4 in-lb	4.3	6.1	1128.9 in-lb	8.7	7.5	2299.6 in-lb	5.2	2.3	1149.8 in-lb	4.3	1.4	1170.7 in-lb
Seat pan Mz	101.4	133.5	1924.8 in-lb	1.7	24.6	32.5 in-lb	50.4	71.6	1283.2 in-lb	50.9	61.9	641.6 in-lb	48.8	47.0	1250.7 in-lb
Sled acceleration	2.8	1.6	0.5 G	0.0	0.8	0.0 G	1.8	1.3	0.3 G	0.9	0.3	0.2 G	1.8	0.5	0.3 G
Head c.g. x	1.1	2.9	0.4 in	0.2	1.3	0.1 in	0.7	1.9	0.3 in	0.4	1.0	0.1 in	0.5	0.6	0.2 in
Head c.g. z	0.5	0.9	0.2 in	0.2	0.5	0.1 in	0.3	0.7	0.1 in	0.2	0.2	0.1 in	0.2	0.3	0.0 in
Shoulder x	1.4	3.9	0.4 in	0.3	1.5	0.1 in	0.7	2.9	0.2 in	0.7	1.0	0.2 in	0.4	1.4	0.1 in
Shoulder z	1.7	2.0	0.4 in	0.1	0.4	0.0 in	1.1	1.3	0.3 in	0.6	0.6	0.1 in	1.0	0.9	0.2 in
Knee x	1.8	1.1	0.5 in	0.8	0.5	0.2 in	1.2	0.9	0.3 in	0.6	0.3	0.2 in	0.5	0.4	0.1 in
Knee z	18.0	17.5	0.7 in	5.6	6.5	0.2 in	11.1	11.0	0.5 in	6.9	6.6	0.2 in	5.4	4.5	0.2 in
Ankle x	0.3	7.0	0.1 in	0.0	1.5	0.0 in	0.2	4.5	0.1 in	0.1	2.5	0.0 in	0.1	3.0	0.1 in
Ankle z	0.6	2.5	0.1 in	0.3	1.3	0.0 in	0.4	1.7	0.0 in	0.2	0.8	0.0 in	0.1	0.5	0.0 in
H-point x	1.5	1.5	0.1 in	0.3	1.0	0.0 in	1.0	1.2	0.1 in	0.5	0.3	0.0 in	0.7	0.3	0.1 in
H-point z	0.7	1.4	0.1 in	0.3	0.8	0.0 in	0.5	1.1	0.0 in	0.2	0.3	0.0 in	0.2	0.3	0.0 in
Head angle	4.0	5.7	4.0 deg	1.5	2.6	1.6 deg	2.6	3.8	2.7 deg	1.4	1.9	1.3 deg	1.1	1.2	1.1 deg
Pelvic angle	3.9	6.8	2.3 deg	0.8	2.7	0.5 deg	2.6	5.2	1.6 deg	1.3	1.6	0.8 deg	1.7	2.4	1.0 deg

Table E-2. Error Metric Results for Hybrid II Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch

07324-8vs9vs29	Maximum			Minimum			Average			Upper Limit			Lower Limit		
3pt 0deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	2.8	10.6	0.5 G	0.8	3.5	0.1 G	1.87	7.65	0.3 G	0.97	2.92	0.2 G	1.12	4.12	0.2 G
Head Ay	18.2	15.1	3.0 G	0.0	5.5	0.0 G	11.22	10.13	2.0 G	7.01	4.96	1.0 G	11.19	4.67	2.0 G
Head Az	11.7	5.2	3.5 G	3.2	2.9	1.1 G	7.39	4.20	2.3 G	4.31	1.00	1.2 G	4.16	1.33	1.2 G
Head Ar	7.0	3.4	2.3 G	2.4	1.6	0.9 G	4.50	2.77	1.5 G	2.48	0.64	0.8 G	2.07	1.20	0.7 G
Chest Ax	9.3	9.5	2.5 G	3.7	5.7	1.0 G	5.93	7.88	1.7 G	3.36	1.60	0.8 G	2.22	2.15	0.6 G
Chest Ay	33.6	21.6	3.2 G	8.5	7.3	0.9 G	19.49	15.57	2.1 G	14.10	6.07	1.1 G	10.99	8.27	1.2 G
Chest Az	45.9	19.2	3.8 G	5.8	12.6	0.5 G	25.66	15.53	2.5 G	20.23	3.69	1.3 G	19.87	2.95	2.0 G
Chest Ar	4.9	6.3	1.4 G	0.1	4.3	0.0 G	3.18	5.57	0.9 G	1.70	0.70	0.5 G	3.06	1.24	0.9 G
Lumbar Fx	7.1	12.7	22.6 lbf	2.5	5.2	8.2 lbf	4.56	9.75	15.1 lbf	2.51	2.93	7.5 lbf	2.07	4.55	6.9 lbf
Lumbar Fz	33.5	10.5	94.7 lbf	11.0	8.5	41.5 lbf	19.42	9.27	63.1 lbf	14.05	1.18	31.6 lbf	8.42	0.73	21.6 lbf
Lumbar My	8.2	9.1	95.6 in-lb	0.2	4.4	2.5 in-lb	5.27	6.16	63.7 in-lb	2.95	2.99	31.9 in-lb	5.07	1.78	61.2 in-lb
Pelvis Ax	7.5	8.6	3.0 G	2.7	3.6	1.1 G	4.81	6.79	2.0 G	2.67	1.80	1.0 G	2.09	3.15	0.9 G
Pelvis Ay	39.3	22.7	3.4 G	5.5	13.8	0.5 G	22.43	19.09	2.3 G	16.89	3.58	1.1 G	16.90	5.29	1.8 G
Pelvis Az	21.1	28.0	4.7 G	5.2	13.8	1.4 G	12.82	18.23	3.1 G	8.29	9.75	1.6 G	7.64	4.46	1.7 G
Pelvis Ar	3.8	4.9	1.8 G	1.0	4.1	0.5 G	2.47	4.52	1.2 G	1.31	0.35	0.6 G	1.43	0.37	0.7 G
Left femur	5.6	5.3	22.7 lbf	0.3	3.0	1.1 lbf	3.63	4.29	15.2 lbf	1.96	1.02	7.6 lbf	3.36	1.29	14.0 lbf
Right femur	3.6	8.6	14.4 lbf	0.1	4.7	0.3 lbf	2.34	6.00	9.6 lbf	1.23	2.60	4.8 lbf	2.25	1.30	9.3 lbf
Left lap	7.8	7.0	125.4 lbf	0.2	1.3	3.8 lbf	5.04	4.72	83.6 lbf	2.80	2.32	41.8 lbf	4.81	3.44	79.7 lbf
Right lap	1.4	1.2	34.5 lbf	0.0	0.9	0.9 lbf	0.92	1.02	23.0 lbf	0.47	0.16	11.5 lbf	0.89	0.11	22.1 lbf
Shoulder belt 1	4.2	2.2	66.8 lbf	2.0	0.9	31.7 lbf	2.77	1.53	44.5 lbf	1.47	0.69	22.3 lbf	0.80	0.67	12.9 lbf
Seat back Fx	18.9	18.8	250.8 lbf	6.3	8.4	88.7 lbf	11.59	12.99	167.2 lbf	7.33	5.85	83.6 lbf	5.31	4.57	78.4 lbf
Seat back Fy	95.2	38.7	96.7 lbf	1.9	12.8	3.2 lbf	32.33	27.01	46.9 lbf	62.88	11.69	49.8 lbf	30.48	14.24	43.6 lbf
Seat back Fz	193.4	44.0	113.8 lbf	5.7	24.7	7.2 lbf	62.11	34.08	62.6 lbf	131.26	9.88	51.2 lbf	56.46	9.35	55.4 lbf
Seat pan Fx	10.1	10.2	50.0 lbf	2.5	5.4	13.6 lbf	6.40	7.95	33.3 lbf	3.67	2.21	16.7 lbf	3.91	2.58	19.7 lbf
Seat pan Fy	105.8	66.1	63.2 lbf	8.7	18.3	7.7 lbf	48.07	39.74	40.7 lbf	57.72	26.41	22.5 lbf	39.37	21.40	33.0 lbf
Seat pan Fz	20.3	13.4	258.4 lbf	7.3	6.3	100.3 lbf	12.38	8.98	172.3 lbf	7.94	4.40	86.1 lbf	5.06	2.66	71.9 lbf
Seat pan resultant	18.9	11.3	257.1 lbf	7.3	5.0	107.3 lbf	11.55	7.77	171.4 lbf	7.30	3.58	85.7 lbf	4.26	2.73	64.2 lbf
Seat pan Mx	57.1	88.3	693.8 in-lb	18.2	11.8	246.0 in-lb	33.24	29.70	362.4 in-lb	23.89	58.65	331.4 in-lb	15.00	17.90	116.4 in-lb
Seat pan My	6.6	6.3	363.6 in-lb	1.7	4.0	98.8 in-lb	4.29	5.05	242.4 in-lb	2.35	1.24	121.2 in-lb	2.60	1.01	143.6 in-lb
Seat pan Mz	146.5	43.1	243.9 in-lb	33.0	27.3	82.1 in-lb	65.45	32.65	162.6 in-lb	81.01	10.43	81.3 in-lb	32.43	5.34	80.5 in-lb
Sled acceleration	1.8	2.2	0.4 G	0.4	0.9	0.1 G	1.16	1.61	0.2 G	0.59	0.57	0.1 G	0.75	0.68	0.2 G
Head cg x	0.9	1.0	0.2 in	0.1	0.6	0.0 in	0.62	0.75	0.1 in	0.31	0.22	0.1 in	0.55	0.15	0.1 in
Head cg z	0.9	1.6	0.3 in	0.3	0.4	0.1 in	0.58	1.08	0.2 in	0.29	0.54	0.1 in	0.29	0.66	0.1 in
Shoulder x	1.5	0.9	0.3 in	0.5	0.5	0.1 in	0.99	0.77	0.2 in	0.51	0.18	0.1 in	0.47	0.25	0.1 in
Shoulder z	4.0	2.6	0.9 in	1.7	0.8	0.4 in	2.65	1.72	0.6 in	1.40	0.88	0.3 in	0.98	0.88	0.2 in
Knee x	2.7	3.2	0.7 in	1.0	1.3	0.3 in	1.79	2.09	0.5 in	0.93	1.08	0.2 in	0.79	0.74	0.2 in
Knee z	5.2	6.3	0.6 in	1.2	1.3	0.2 in	3.39	4.10	0.4 in	1.83	2.19	0.2 in	2.14	2.76	0.2 in
Ankle x	1.1	0.9	0.3 in	0.0	0.4	0.0 in	0.70	0.62	0.2 in	0.36	0.31	0.1 in	0.68	0.21	0.2 in
Ankle z	2.8	4.0	0.3 in	0.5	1.5	0.1 in	1.82	2.57	0.2 in	0.95	1.39	0.1 in	1.34	1.03	0.2 in
H-point x	9.9	10.5	0.7 in	1.0	4.8	0.1 in	4.74	6.71	0.3 in	5.13	3.84	0.4 in	3.70	1.86	0.3 in
H-point z	0.8	1.6	0.0 in	0.1	0.8	0.0 in	0.56	1.06	0.0 in	0.29	0.57	0.0 in	0.48	0.28	0.0 in
Head angle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pelvic angle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Left shoulder x	5.3	5.7	0.4 in	2.5	2.7	0.2 in	3.43	3.67	0.3 in	1.85	2.04	0.1 in	0.90	1.01	0.1 in
Left shoulder z	0.7	0.5	0.2 in	0.2	0.2	0.0 in	0.50	0.37	0.1 in	0.25	0.17	0.1 in	0.28	0.17	0.1 in
Left knee x	0.3	0.9	0.1 in	0.1	0.4	0.0 in	0.17	0.64	0.0 in	0.09	0.30	0.0 in	0.09	0.24	0.0 in
Left knee z	4.6	3.7	0.4 in	1.2	1.7	0.1 in	3.28	2.49	0.3 in	1.36	1.17	0.1 in	2.04	0.79	0.2 in
Left ankle x	2.8	2.2	0.8 in	0.9	1.0	0.2 in	1.86	1.45	0.5 in	0.97	0.74	0.3 in	0.98	0.43	0.3 in
Left ankle z	0.6	1.1	0.1 in	0.2	0.7	0.0 in	0.42	0.87	0.0 in	0.21	0.27	0.0 in	0.17	0.16	0.0 in

Table E-3. Error Metric Results for Hybrid II Anthropomorphic Test Dummy With Four-Point Belt at 0° Pitch

07324-5vs26vs27	Maximum			Minimum			Average			Upper Limit			Lower Limit		
4pt 0deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	29.6	18.7	6.3 G	8.1	4.9	2.2 G	17.4	12.0	4.2 G	12.2	6.8	2.1 G	9.3	7.1	2.0 G
Head Ay	135.1	119.0	4.4 G	39.7	45.9	2.7 G	75.9	72.0	3.4 G	59.2	47.0	1.0 G	36.2	26.2	0.6 G
Head Az	19.0	12.1	6.6 G	8.0	9.0	3.3 G	11.6	10.3	4.4 G	7.4	1.8	2.2 G	3.6	1.3	1.1 G
Head Ar	18.7	12.3	6.7 G	4.7	7.0	2.0 G	11.5	8.8	4.5 G	7.2	3.5	2.2 G	6.7	1.8	2.5 G
Chest Ax	20.7	9.8	6.7 G	2.1	6.9	0.8 G	12.6	8.6	4.5 G	8.1	1.2	2.2 G	10.5	1.7	3.6 G
Chest Ay	108.3	66.6	6.0 G	4.7	46.6	0.3 G	53.0	54.4	4.0 G	55.3	12.2	2.0 G	48.3	7.8	3.7 G
Chest Az	137.1	112.2	11.0 G	4.4	13.4	0.8 G	64.4	57.8	7.3 G	72.7	54.4	3.7 G	60.0	44.4	6.5 G
Chest Ar	20.6	10.6	6.7 G	2.7	8.5	1.1 G	12.5	9.5	4.5 G	8.0	1.1	2.2 G	9.8	0.9	3.4 G
Lumbar Fx	52.3	18.9	133.8 lbf	8.8	9.6	34.3 lbf	28.7	14.3	89.2 lbf	23.6	4.6	44.6 lbf	19.9	4.7	54.9 lbf
Lumbar Fz	46.3	28.2	136.8 lbf	12.4	8.3	41.7 lbf	25.8	20.9	91.2 lbf	20.5	7.3	45.6 lbf	13.4	12.6	49.5 lbf
Lumbar My	9.6	13.6	107.4 in-lb	0.1	6.0	1.6 in-lb	6.1	9.8	71.6 in-lb	3.5	3.8	35.8 in-lb	6.0	3.9	70.0 in-lb
Pelvis Ax	885.3	73.8	71.3 G	67.6	20.8	16.8 G	256.5	47.0	47.5 G	628.7	26.8	23.8 G	188.9	26.2	30.7 G
Pelvis Ay	36.3	78.4	1.1 G	4.8	43.0	0.2 G	20.9	60.3	0.8 G	15.4	18.0	0.4 G	16.1	17.3	0.6 G
Pelvis Az	38.5	23.6	11.8 G	2.1	6.6	0.6 G	22.1	16.6	7.9 G	16.4	7.0	3.9 G	20.0	10.0	7.2 G
Pelvis Ar	125.1	59.8	46.5 G	0.4	19.3	0.1 G	60.2	34.6	31.0 G	64.9	25.2	15.5 G	59.8	15.3	30.9 G
Left femur	5.9	8.2	21.5 lbf	0.4	4.2	1.5 lbf	3.8	6.0	14.3 lbf	2.1	2.2	7.2 lbf	3.4	1.8	12.8 lbf
Right femur	37.8	26.0	133.4 lbf	6.3	3.5	23.8 lbf	21.6	16.5	89.0 lbf	16.1	9.5	44.5 lbf	15.3	13.0	65.2 lbf
Left lap	7.2	3.9	138.0 lbf	0.9	2.2	18.3 lbf	4.7	2.8	92.0 lbf	2.6	1.1	46.0 lbf	3.8	0.6	73.7 lbf
Right lap	5.4	2.8	100.0 lbf	0.8	1.4	16.4 lbf	3.5	2.1	66.7 lbf	1.9	0.7	33.3 lbf	2.7	0.7	50.3 lbf
Shoulder belt 1	13.3	14.2	115.9 lbf	4.9	2.3	45.5 lbf	8.3	9.5	77.3 lbf	4.9	4.7	38.6 lbf	3.4	7.2	31.8 lbf
Shoulder belt 2	6.4	8.3	59.9 lbf	2.2	3.5	22.3 lbf	4.1	5.6	39.9 lbf	2.3	2.7	20.0 lbf	1.9	2.2	17.6 lbf
Seat back Fx	309.1	50.7	320.3 lbf	6.3	7.8	27.0 lbf	71.3	33.6	135.6 lbf	237.8	17.1	184.7 lbf	65.0	25.8	108.6 lbf
Seat back Fy	57.9	67.8	69.8 lbf	0.6	10.3	1.0 lbf	31.6	47.3	46.7 lbf	26.3	20.5	23.1 lbf	31.0	37.0	45.7 lbf
Seat back Fz	395.8	74.5	388.2 lbf	14.0	9.4	35.2 lbf	156.7	44.8	267.7 lbf	239.0	29.8	120.5 lbf	142.7	35.4	232.5 lbf
Seat pan Fx	34.0	14.8	144.1 lbf	11.5	5.3	55.1 lbf	19.7	10.8	96.1 lbf	14.3	3.9	48.0 lbf	8.2	5.6	41.0 lbf
Seat pan Fy	157.0	68.7	44.6 lbf	38.8	32.6	37.8 lbf	70.5	54.1	40.1 lbf	86.5	14.6	4.5 lbf	31.8	21.4	2.4 lbf
Seat pan Fz	16.5	16.2	241.8 lbf	6.9	3.4	118.3 lbf	10.2	11.3	161.2 lbf	6.3	4.9	80.6 lbf	3.3	7.9	42.9 lbf
Seat pan resultant	16.5	13.9	246.4 lbf	7.2	3.2	120.5 lbf	10.2	10.0	164.3 lbf	6.3	3.9	82.1 lbf	3.0	6.8	43.8 lbf
Seat pan Mx	166.8	60.3	382.1 in-lb	14.3	17.6	87.4 in-lb	74.2	42.3	254.7 in-lb	92.6	18.0	127.4 in-lb	59.9	24.7	167.3 in-lb
Seat pan My	66.3	64.3	3682.7 in-lb	14.7	10.6	1355.5 in-lb	34.9	34.6	2455.2 in-lb	31.4	29.6	1227.6 in-lb	20.2	24.1	1099.6 in-lb
Seat pan Mz	80.8	40.8	170.1 in-lb	21.7	22.1	58.4 in-lb	41.0	32.7	113.4 in-lb	39.8	8.1	56.7 in-lb	19.2	10.6	55.0 in-lb
Sled acceleration	1.3	1.0	0.3 G	0.3	0.8	0.1 G	0.9	0.9	0.2 G	0.5	0.1	0.1 G	0.6	0.1	0.1 G
Head c.g. x	9.3	6.4	1.2 in	0.4	0.7	0.1 in	5.9	4.2	0.8 in	3.4	2.2	0.4 in	5.5	3.6	0.8 in
Head c.g. z	1.3	2.0	0.4 in	0.4	0.5	0.1 in	0.9	1.4	0.3 in	0.4	0.7	0.1 in	0.4	0.8	0.1 in
Shoulder x	13.0	14.8	1.2 in	2.4	6.6	0.2 in	8.2	9.6	0.8 in	4.8	5.2	0.4 in	5.8	3.0	0.6 in
Shoulder z	2.3	2.2	0.5 in	0.7	0.9	0.2 in	1.5	1.7	0.3 in	0.8	0.6	0.2 in	0.8	0.7	0.2 in
Knee x	4.7	4.3	1.3 in	1.3	0.5	0.4 in	3.1	2.9	0.9 in	1.6	1.5	0.4 in	1.8	2.3	0.5 in
Knee z	24.4	13.3	2.8 in	1.5	1.0	0.2 in	14.7	8.4	1.9 in	9.8	4.9	0.9 in	13.1	7.4	1.7 in
Ankle x	10.5	2.8	2.7 in	1.0	0.4	0.3 in	6.9	1.8	1.9 in	3.6	1.0	0.8 in	5.9	1.4	1.6 in
Ankle z	2.0	7.6	0.2 in	0.2	0.3	0.0 in	1.3	4.6	0.1 in	0.7	3.1	0.1 in	1.2	4.2	0.1 in
H-point x	10.2	13.2	1.1 in	3.3	2.3	0.4 in	6.5	8.4	0.7 in	3.7	4.9	0.4 in	3.2	6.0	0.3 in
H-point z	47.1	10.7	1.7 in	6.2	6.3	0.2 in	26.2	8.3	1.1 in	20.8	2.3	0.6 in	20.0	2.0	0.9 in
Head angle	9.7	6.2	7.5 deg	2.7	3.4	2.3 deg	6.2	4.7	5.0 deg	3.5	1.4	2.5 deg	3.5	1.3	2.7 deg
Pelvic angle	31.4	43.7	13.9 deg	1.6	3.0	0.9 deg	18.4	25.2	9.3 deg	13.0	18.4	4.6 deg	16.8	22.2	8.3 deg

Table E-4. Error Metric Results for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch

07324-10vs11vs12vs30vs31	Maximum			Minimum			Average			Upper Limit			Lower Limit		
2pt 60deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	54.5	48.7	2.3 G	2.6	8.3	0.2 G	24.3	26.1	1.3 G	30.2	22.5	1.0 G	21.7	17.9	1.1 G
Head Ay	109.8	58.0	1.3 G	11.4	32.4	0.2 G	50.1	45.9	0.8 G	59.7	12.1	0.5 G	38.7	13.5	0.6 G
Head Az	72.9	34.5	13.6 G	0.4	4.5	0.1 G	27.9	17.3	6.8 G	45.0	17.3	6.8 G	27.5	12.8	6.7 G
Head Ar	73.7	31.8	13.9 G	1.8	4.4	0.4 G	28.3	15.9	7.0 G	45.4	15.8	6.9 G	26.5	11.6	6.6 G
Chest Ax	14.5	27.9	0.6 G	2.1	10.6	0.1 G	6.6	16.8	0.3 G	8.0	11.0	0.3 G	4.4	6.3	0.2 G
Chest Ay	114.5	67.8	1.1 G	2.2	31.3	0.0 G	51.5	47.3	0.7 G	63.0	20.5	0.4 G	49.4	16.1	0.7 G
Chest Az	36.4	15.9	7.0 G	2.9	4.0	0.8 G	16.5	9.4	3.7 G	19.9	6.5	3.3 G	13.7	5.4	3.0 G
Chest Ar	37.1	20.2	7.8 G	0.1	3.8	0.0 G	17.3	13.2	4.2 G	19.8	7.0	3.6 G	17.2	9.5	4.2 G
Lumbar Fx	328.1	223.9	300.5 lbf	3.7	5.1	3.9 lbf	98.2	80.2	163.0 lbf	229.9	143.6	137.5 lbf	94.5	75.1	159.1 lbf
Lumbar Fz	56.8	29.3	636.8 lbf	3.5	3.2	40.4 lbf	26.1	14.7	361.1 lbf	30.8	14.6	275.7 lbf	22.6	11.5	320.7 lbf
Lumbar My	72.1	21.3	223.9 in-lb	3.6	3.3	19.5 in-lb	16.6	11.6	83.6 in-lb	55.5	9.7	140.3 in-lb	13.0	8.3	64.1 in-lb
Pelvis Ax	47.9	42.8	3.0 G	2.8	6.9	0.2 G	18.8	25.6	1.5 G	29.1	17.2	1.6 G	16.0	18.7	1.2 G
Pelvis Ay	65.4	53.1	1.3 G	0.1	27.0	0.0 G	31.8	42.8	1.3 G	33.6	10.3	0.0 G	31.7	15.8	1.3 G
Pelvis Az	68.9	14.1	14.5 G	3.1	5.4	0.9 G	25.8	9.0	6.9 G	43.1	5.1	7.6 G	22.8	3.6	6.0 G
Pelvis Ar	84.2	22.1	16.4 G	1.3	4.9	0.3 G	29.2	13.0	7.6 G	55.0	9.2	8.8 G	27.9	8.1	7.3 G
Left femur	14.4	17.9	12.1 lbf	6.3	5.5	0.0 lbf	9.0	12.0	2.4 lbf	5.4	5.9	9.7 lbf	2.6	6.5	2.4 lbf
Right femur	24.1	17.9	20.4 lbf	6.3	6.2	0.0 lbf	14.5	11.7	4.1 lbf	9.6	6.2	16.3 lbf	8.2	5.5	4.1 lbf
Left lap	39.0	73.4	52.4 lbf	2.0	2.8	2.8 lbf	16.8	30.2	26.2 lbf	22.2	43.2	26.3 lbf	14.8	27.4	23.4 lbf
Right lap	28.7	40.2	34.3 lbf	1.0	1.7	1.2 lbf	11.3	16.5	15.1 lbf	17.4	23.8	19.2 lbf	10.3	14.8	13.9 lbf
Seat back Fx	27.2	17.0	65.4 lbf	0.8	2.6	2.4 lbf	12.1	11.7	33.1 lbf	15.1	5.4	32.3 lbf	11.3	9.0	30.7 lbf
Seat back Fy	30.6	32.7	25.0 lbf	0.2	12.6	0.2 lbf	12.7	25.5	11.7 lbf	17.9	7.3	13.4 lbf	12.4	12.9	11.5 lbf
Seat back Fz	47.4	34.9	46.2 lbf	1.9	17.1	2.3 lbf	20.9	25.8	24.4 lbf	26.5	9.1	21.8 lbf	19.0	8.7	22.1 lbf
Seat pan Fx	31.6	11.0	213.6 lbf	2.6	2.4	23.0 lbf	13.7	5.6	107.0 lbf	17.8	5.4	106.6 lbf	11.1	3.2	84.0 lbf
Seat pan Fy	210.7	62.1	85.0 lbf	11.4	11.4	7.6 lbf	57.7	27.1	40.0 lbf	153.0	35.0	45.0 lbf	46.2	15.8	32.3 lbf
Seat pan Fz	31.7	15.5	708.3 lbf	4.8	2.9	134.9 lbf	14.5	7.5	370.0 lbf	17.2	8.0	338.3 lbf	9.7	4.6	235.1 lbf
Seat pan resultant	31.4	15.0	732.3 lbf	4.7	2.8	144.2 lbf	14.2	7.2	380.4 lbf	17.1	7.8	351.9 lbf	9.5	4.4	236.2 lbf
Seat pan Mx	195.9	261.5	1216.0 in-lb	3.2	16.1	22.5 in-lb	54.6	74.3	525.7 in-lb	141.3	187.2	690.3 in-lb	51.5	58.2	503.2 in-lb
Seat pan My	37.9	18.0	1553.2 in-lb	2.4	2.6	99.7 in-lb	18.4	10.8	876.6 in-lb	19.6	7.2	676.6 in-lb	16.0	8.2	776.9 in-lb
Seat pan Mz	535.3	519.8	509.7 in-lb	8.1	32.9	22.8 in-lb	106.2	111.2	225.4 in-lb	429.2	408.6	284.3 in-lb	98.0	78.3	202.6 in-lb
Sled acceleration	3.2	1.5	0.6 G	0.5	0.8	0.1 G	1.6	1.1	0.3 G	1.6	0.4	0.3 G	1.1	0.3	0.2 G
Head c.g. x	8.2	9.0	1.2 in	0.1	0.7	0.0 in	3.6	4.1	0.5 in	4.7	4.9	0.7 in	3.5	3.4	0.5 in
Head c.g. z	2.8	3.0	0.9 in	0.1	0.1	0.0 in	1.5	1.7	0.5 in	1.3	1.3	0.4 in	1.4	1.6	0.4 in
Shoulder x	13.4	19.8	1.4 in	0.0	2.5	0.0 in	5.4	8.8	0.6 in	8.0	11.0	0.8 in	5.3	6.2	0.6 in
Shoulder z	2.5	3.1	0.6 in	0.0	0.1	0.0 in	1.3	1.6	0.3 in	1.2	1.4	0.3 in	1.3	1.5	0.3 in
Knee x	3.2	2.0	0.7 in	0.4	0.3	0.1 in	1.6	1.0	0.4 in	1.6	1.0	0.3 in	1.2	0.7	0.3 in
Knee z	9.6	10.5	0.4 in	0.2	0.3	0.0 in	4.3	4.7	0.2 in	5.3	5.7	0.2 in	4.1	4.4	0.2 in
Ankle x	8.4	8.3	1.7 in	1.0	1.1	0.2 in	4.2	4.1	0.9 in	4.2	4.2	0.8 in	3.2	3.0	0.7 in
Ankle z	5.8	5.4	0.7 in	0.2	0.1	0.0 in	3.1	2.9	0.4 in	2.8	2.5	0.3 in	2.8	2.8	0.3 in
H-point x	10.0	7.1	0.5 in	1.0	1.2	0.0 in	4.9	3.5	0.2 in	5.1	3.6	0.2 in	4.0	2.3	0.2 in
H-point z	23.9	20.4	0.9 in	0.5	1.0	0.0 in	11.2	9.8	0.5 in	12.7	10.6	0.4 in	10.7	8.8	0.4 in
Head angle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pelvic angle	95.4	176.4	5.8 deg	0.5	5.1	0.1 deg	41.3	58.2	3.5 deg	54.1	118.2	2.3 deg	40.8	53.1	3.4 deg

Table E-5. Error Metric Results for Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 0° Pitch

07324-16vs17vs18	Maximum			Minimum			Average			Upper Limit			Lower Limit		
2pt 0deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	4.5	3.7	1.0 G	1.2	2.5	0.3 G	2.9	3.2	0.7 G	1.6	0.5	0.3 G	1.7	0.7	0.4 G
Head Ay	74.9	98.6	4.8 G	20.8	16.1	0.0 G	43.4	65.1	4.4 G	31.5	33.5	0.4 G	22.6	49.0	4.3 G
Head Az	15.3	6.0	9.8 G	1.8	4.3	1.4 G	9.5	4.9	6.5 G	5.8	1.1	3.3 G	7.7	0.6	5.2 G
Head Ar	14.9	6.6	10.1 G	1.8	4.4	1.4 G	9.3	5.4	6.8 G	5.6	1.2	3.4 G	7.4	1.0	5.3 G
Upper neck Fx	12.0	13.1	38.0 lbf	0.7	7.1	2.3 lbf	7.6	9.7	25.3 lbf	4.4	3.4	12.7 lbf	6.9	2.7	23.0 lbf
Upper neck Fy	304.8	158.6	107.9 lbf	33.9	37.0	48.6 lbf	115.9	78.6	71.9 lbf	188.9	80.0	36.0 lbf	82.0	41.6	23.3 lbf
Upper neck Fz	13.6	9.1	97.8 lbf	4.1	3.9	33.7 lbf	8.5	6.7	65.2 lbf	5.1	2.3	32.6 lbf	4.4	2.8	31.5 lbf
Upper neck Mx	47.0	46.4	39.8 in-lb	1.9	30.2	1.6 in-lb	26.3	38.7	26.5 in-lb	20.7	7.8	13.3 in-lb	24.4	8.4	24.9 in-lb
Upper neck My	23.2	10.3	125.2 in-lb	1.6	5.2	8.7 in-lb	14.0	8.5	83.5 in-lb	9.2	1.8	41.7 in-lb	12.4	3.3	74.8 in-lb
Upper neck Mz	96.7	146.9	56.3 in-lb	12.2	37.3	8.1 in-lb	47.8	66.8	37.5 in-lb	48.9	80.1	18.8 in-lb	35.6	29.5	29.5 in-lb
Chest Ax	10.3	7.1	1.1 G	4.7	6.0	0.5 G	6.5	6.4	0.7 G	3.8	0.7	0.4 G	1.8	0.4	0.2 G
Chest Ay	85.8	58.5	2.0 G	20.2	36.0	0.6 G	43.1	46.1	1.3 G	42.8	12.4	0.7 G	22.9	10.1	0.7 G
Chest Az	11.5	9.4	3.7 G	0.8	4.3	0.3 G	7.3	6.6	2.4 G	4.2	2.7	1.2 G	6.5	2.3	2.2 G
Chest Ar	11.9	8.5	3.8 G	0.1	3.8	0.0 G	7.5	6.0	2.6 G	4.4	2.5	1.3 G	7.4	2.2	2.5 G
Lumbar Fx	13.9	13.2	170.2 lbf	6.2	5.3	80.2 lbf	8.7	8.5	113.4 lbf	5.2	4.6	56.7 lbf	2.6	3.3	33.3 lbf
Lumbar Fz	2.8	3.8	75.8 lbf	1.3	2.3	36.5 lbf	1.8	3.2	50.5 lbf	1.0	0.6	25.3 lbf	0.5	0.9	14.0 lbf
Lumbar My	16.4	13.2	373.6 in-lb	6.3	4.0	168.2 in-lb	10.1	8.5	249.1 in-lb	6.2	4.7	124.5 in-lb	3.8	4.5	80.9 in-lb
Pelvis Ax	3.4	4.7	1.0 G	0.7	3.5	0.2 G	2.3	3.9	0.6 G	1.2	0.8	0.3 G	1.5	0.5	0.4 G
Pelvis Ay	49.0	56.6	2.3 G	0.8	27.6	0.1 G	27.3	40.7	1.5 G	21.7	16.0	0.8 G	26.5	13.1	1.5 G
Pelvis Az	26.4	20.3	4.9 G	0.8	8.0	0.2 G	15.8	14.0	3.3 G	10.7	6.3	1.6 G	14.9	6.0	3.1 G
Pelvis Ar	7.4	5.8	2.2 G	0.0	3.8	0.0 G	4.7	4.5	1.5 G	2.6	1.2	0.7 G	4.7	0.8	1.5 G
Left femur	79.4	13.8	400.0 lbf	3.0	9.5	15.7 lbf	41.0	11.7	266.7 lbf	38.3	2.1	133.3 lbf	38.0	2.2	251.0 lbf
Right femur	102.4	11.2	554.8 lbf	2.2	4.1	12.4 lbf	50.8	8.5	369.9 lbf	51.6	2.6	184.9 lbf	48.6	4.4	357.5 lbf
Left lap	1.9	3.3	34.8 lbf	0.7	2.6	13.7 lbf	1.3	2.8	23.2 lbf	0.7	0.5	11.6 lbf	0.5	0.3	9.5 lbf
Right lap	2.0	2.2	35.8 lbf	0.3	1.7	6.2 lbf	1.3	1.9	23.9 lbf	0.7	0.4	11.9 lbf	1.0	0.2	17.7 lbf
Seat back Fx	9.1	16.0	15.4 lbf	4.3	14.1	7.5 lbf	5.8	14.9	10.3 lbf	3.3	1.1	5.1 lbf	1.6	0.8	2.8 lbf
Seat back Fy	102.9	53.4	54.9 lbf	20.2	17.6	16.0 lbf	49.0	35.8	36.9 lbf	53.8	17.6	18.0 lbf	28.9	18.1	20.9 lbf
Seat back Fz	135.3	34.2	65.3 lbf	22.1	29.8	25.1 lbf	62.0	32.7	43.5 lbf	73.3	1.5	21.8 lbf	39.9	2.9	18.5 lbf
Seat pan Fx	4.7	6.4	62.3 lbf	1.7	4.2	23.6 lbf	3.1	5.5	41.5 lbf	1.6	0.9	20.8 lbf	1.4	1.4	17.9 lbf
Seat pan Fy	42.3	81.4	43.4 lbf	14.9	21.6	21.7 lbf	23.8	50.9	28.9 lbf	18.5	30.5	14.5 lbf	9.0	29.3	7.3 lbf
Seat pan Fz	20.3	12.7	923.1 lbf	2.3	4.0	123.0 lbf	12.4	9.3	615.4 lbf	7.9	3.4	307.7 lbf	10.1	5.3	492.4 lbf
Seat pan resultant	19.0	11.7	893.6 lbf	2.7	3.8	148.9 lbf	11.7	8.6	595.8 lbf	7.4	3.1	297.9 lbf	9.0	4.8	446.9 lbf
Seat pan Mx	40.4	100.9	1209.5 in-lb	1.0	26.6	43.7 in-lb	23.0	63.3	806.3 in-lb	17.4	37.5	403.2 in-lb	22.0	36.8	762.6 in-lb
Seat pan My	5.4	5.6	1503.8 in-lb	1.6	3.6	473.0 in-lb	3.5	4.9	1002.5 in-lb	1.9	0.7	501.3 in-lb	1.9	1.3	529.5 in-lb
Seat pan Mz	45.2	33.6	775.4 in-lb	4.6	24.1	115.6 in-lb	25.4	29.4	516.9 in-lb	19.9	4.2	258.5 in-lb	20.7	5.3	401.4 in-lb
Sled acceleration	0.4	1.7	0.1 G	0.1	0.8	0.0 G	0.3	1.3	0.0 G	0.1	0.4	0.0 G	0.2	0.5	0.0 G
Head c.g. x	0.8	0.9	0.3 in	0.4	0.5	0.1 in	0.6	0.6	0.2 in	0.3	0.3	0.1 in	0.2	0.2	0.1 in
Head c.g. z	0.3	0.3	0.1 in	0.1	0.1	0.0 in	0.2	0.2	0.1 in	0.1	0.1	0.0 in	0.1	0.1	0.0 in
Shoulder x	2.0	2.3	0.5 in	1.0	0.7	0.3 in	1.3	1.6	0.4 in	0.7	0.7	0.2 in	0.4	1.0	0.1 in
Shoulder z	0.8	0.8	0.2 in	0.4	0.1	0.1 in	0.6	0.5	0.1 in	0.3	0.2	0.1 in	0.2	0.4	0.0 in
Knee x	0.6	0.4	0.2 in	0.2	0.1	0.0 in	0.4	0.3	0.1 in	0.2	0.1	0.1 in	0.2	0.1	0.1 in
Knee z	7.0	7.6	0.3 in	1.4	1.6	0.1 in	4.5	5.0	0.2 in	2.5	2.6	0.1 in	3.1	3.5	0.1 in
Ankle x	0.1	0.7	0.0 in	0.0	0.4	0.0 in	0.1	0.5	0.0 in	0.0	0.2	0.0 in	0.1	0.1	0.0 in
Ankle z	1.1	1.3	0.1 in	0.1	0.6	0.0 in	0.7	1.0	0.1 in	0.4	0.2	0.0 in	0.6	0.4	0.1 in
H-point x	0.9	1.9	0.1 in	0.3	0.3	0.0 in	0.6	1.3	0.1 in	0.3	0.6	0.0 in	0.3	1.0	0.0 in
H-point z	2.5	1.1	0.2 in	0.5	0.4	0.0 in	1.6	0.9	0.1 in	0.9	0.3	0.1 in	1.2	0.4	0.1 in
Head angle	3.5	2.3	2.5 deg	1.1	1.2	0.8 deg	2.3	1.7	1.7 deg	1.2	0.7	0.8 deg	1.2	0.4	0.9 deg
Pelvic angle	7.6	5.4	4.8 deg	3.2	1.3	2.2 deg	4.9	3.7	3.2 deg	2.7	1.6	1.6 deg	1.7	2.5	1.0 deg

Table E-6. Error Metric Results for Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Three-Point Belt at 0° Pitch

07324-20vs24vs25	Maximum			Minimum			Average			Upper Limit			Lower Limit		
3pt 0deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	1.4	5.8	0.3 G	0.1	1.5	0.0 G	0.9	4.3	0.2 G	0.5	1.5	0.1 G	0.01	0.03	0.2 G
Head Ay	16.3	7.7	1.4 G	2.9	6.1	0.3 G	10.1	6.6	0.9 G	6.2	1.1	0.5 G	0.07	0.01	0.6 G
Head Az	8.3	14.0	3.0 G	0.9	3.9	0.4 G	5.3	9.1	2.0 G	3.0	5.0	1.0 G	0.04	0.05	1.6 G
Head Ar	10.3	8.3	4.1 G	3.3	3.0	1.5 G	6.6	5.5	2.8 G	3.8	2.7	1.4 G	0.03	0.03	1.3 G
Upper neck Fx	8.1	8.2	15.0 lbf	0.2	1.3	0.4 lbf	5.2	5.7	10.0 lbf	2.9	2.5	5.0 lbf	0.05	0.04	9.6 lbf
Upper neck Fy	29.1	28.1	24.8 lbf	4.2	5.8	4.6 lbf	17.2	17.0	16.5 lbf	11.9	11.1	8.3 lbf	0.13	0.11	11.9 lbf
Upper neck Fz	9.8	16.0	32.2 lbf	1.1	4.2	3.9 lbf	6.3	10.2	21.5 lbf	3.6	5.8	10.7 lbf	0.05	0.06	17.6 lbf
Upper neck Mx	24.5	35.2	51.7 in-lb	0.8	6.6	2.0 in-lb	14.7	21.6	34.5 in-lb	9.8	13.6	17.2 in-lb	0.14	0.15	32.4 in-lb
Upper neck My	2.4	7.4	14.4 in-lb	0.7	2.4	4.3 in-lb	1.6	5.2	9.6 in-lb	0.8	2.2	4.8 in-lb	0.01	0.03	5.3 in-lb
Upper neck Mz	25.7	26.6	9.2 in-lb	6.3	11.4	2.4 in-lb	15.3	16.8	6.1 in-lb	10.3	9.8	3.1 in-lb	0.09	0.05	3.7 in-lb
Chest Ax	7.6	8.0	2.5 G	2.4	2.3	0.8 G	4.9	6.1	1.7 G	2.7	2.0	0.8 G	0.02	0.04	0.9 G
Chest Ay	108.7	55.8	2.6 G	17.4	11.6	0.9 G	45.4	33.8	1.7 G	63.3	22.1	0.9 G	0.28	0.22	0.8 G
Chest Az	14.5	41.6	1.9 G	2.4	10.2	0.4 G	9.1	28.6	1.3 G	5.5	13.0	0.6 G	0.07	0.18	0.9 G
Chest Ar	2.9	6.0	1.2 G	0.3	1.4	0.1 G	1.9	4.3	0.8 G	1.0	1.7	0.4 G	0.02	0.03	0.7 G
Lumbar Fx	19.0	33.1	59.4 lbf	1.4	7.4	5.2 lbf	11.7	21.0	39.6 lbf	7.4	12.1	19.8 lbf	0.10	0.14	34.4 lbf
Lumbar Fz	15.0	18.0	49.2 lbf	2.0	6.1	7.6 lbf	9.4	13.3	32.8 lbf	5.7	4.7	16.4 lbf	0.07	0.07	25.2 lbf
Lumbar My	14.3	19.4	148.9 in-lb	2.8	8.3	29.8 in-lb	8.9	13.1	99.3 in-lb	5.4	6.3	49.6 in-lb	0.06	0.05	69.5 in-lb
Pelvis Ax	4.3	6.9	1.5 G	0.1	1.7	0.0 G	2.8	5.0	1.0 G	1.5	2.0	0.5 G	0.03	0.03	1.0 G
Pelvis Ay	16.8	26.8	1.1 G	5.0	5.5	0.3 G	10.4	18.1	0.7 G	6.4	8.7	0.4 G	0.05	0.13	0.4 G
Pelvis Az	13.9	16.7	2.7 G	6.1	6.6	1.3 G	8.7	12.2	1.8 G	5.2	4.6	0.9 G	0.03	0.06	0.5 G
Pelvis Ar	7.6	6.7	2.5 G	2.3	2.0	0.8 G	4.9	5.1	1.7 G	2.7	1.6	0.8 G	0.03	0.03	0.9 G
Left femur	12.7	12.0	47.9 lbf	5.2	2.1	22.1 lbf	8.0	8.4	32.0 lbf	4.7	3.6	16.0 lbf	0.03	0.06	9.9 lbf
Right femur	4.8	6.7	15.7 lbf	1.3	1.5	4.3 lbf	3.2	4.8	10.5 lbf	1.7	1.9	5.2 lbf	0.02	0.03	6.1 lbf
Left lap	0.8	1.1	13.4 lbf	0.2	0.5	4.0 lbf	0.5	0.9	8.9 lbf	0.3	0.3	4.5 lbf	0.00	0.00	4.9 lbf
Right lap	6.3	6.1	146.2 lbf	2.0	1.5	50.6 lbf	4.1	4.0	97.5 lbf	2.2	2.1	48.7 lbf	0.02	0.03	46.8 lbf
Shoulder belt 1	7.9	2.7	126.1 lbf	3.1	1.7	51.5 lbf	5.1	2.1	84.1 lbf	2.8	0.6	42.0 lbf	0.02	0.00	32.6 lbf
Seat back Fx	7.2	21.9	163.3 lbf	1.4	3.5	32.2 lbf	4.7	15.0	108.9 lbf	2.6	6.9	54.4 lbf	0.03	0.11	76.7 lbf
Seat back Fy	12.3	41.0	26.1 lbf	1.9	9.1	4.6 lbf	7.7	29.3	17.4 lbf	4.5	11.6	8.7 lbf	0.06	0.20	12.8 lbf
Seat back Fz	101.1	42.3	127.5 lbf	3.0	11.5	5.6 lbf	47.9	30.7	83.0 lbf	53.2	11.6	44.5 lbf	0.45	0.19	77.4 lbf
Seat pan Fx	11.8	6.6	54.6 lbf	0.7	4.5	3.5 lbf	7.4	5.8	36.4 lbf	4.3	0.8	18.2 lbf	0.07	0.01	32.9 lbf
Seat pan Fy	149.6	42.5	111.3 lbf	6.6	8.1	12.2 lbf	68.9	28.2	74.2 lbf	80.7	14.4	37.1 lbf	0.62	0.20	62.0 lbf
Seat pan Fz	6.8	11.9	88.8 lbf	0.2	4.6	2.8 lbf	4.4	8.6	59.2 lbf	2.4	3.3	29.6 lbf	0.04	0.04	56.4 lbf
Seat pan resultant	7.9	10.6	107.6 lbf	0.6	4.5	8.4 lbf	5.1	7.8	71.7 lbf	2.8	2.9	35.9 lbf	0.04	0.03	63.3 lbf
Seat pan Mx	256.8	22.1	1546.1 in-lb	4.9	5.2	105.7 in-lb	108.1	15.2	1030.7 in-lb	148.7	6.9	515.4 in-lb	1.03	0.10	925.0 in-lb
Seat pan My	8.6	8.0	399.6 in-lb	0.1	3.7	5.1 in-lb	5.5	6.5	266.4 in-lb	3.1	1.6	133.2 in-lb	0.05	0.03	261.3 in-lb
Seat pan Mz	53.1	20.7	149.6 in-lb	3.1	13.7	13.4 in-lb	29.2	18.2	99.7 in-lb	23.9	2.5	49.9 in-lb	0.26	0.05	86.3 in-lb
Sled acceleration	1.8	2.6	0.4 G	0.2	1.3	0.0 G	1.2	1.8	0.3 G	0.6	0.8	0.1 G	0.01	0.00	0.2 G
Head c.g. x	8.3	7.4	1.6 in	2.8	2.1	0.6 in	5.3	4.8	1.1 in	3.0	2.6	0.5 in	0.02	0.03	0.5 in
Head c.g. z	0.4	1.1	0.1 in	0.0	0.2	0.0 in	0.2	0.7	0.1 in	0.1	0.4	0.0 in	0.00	0.00	0.1 in
Shoulder x	13.7	13.3	1.8 in	4.5	4.7	0.7 in	8.6	8.3	1.2 in	5.1	5.0	0.6 in	0.04	0.04	0.5 in
Shoulder z	0.7	2.6	0.2 in	0.2	0.5	0.0 in	0.5	1.7	0.1 in	0.2	0.9	0.1 in	0.00	0.01	0.1 in
Knee x	0.5	0.2	0.1 in	0.1	0.1	0.0 in	0.3	0.2	0.1 in	0.2	0.0	0.0 in	0.00	0.00	0.1 in
Knee z	1.2	1.3	0.1 in	0.4	0.7	0.0 in	0.8	1.1	0.1 in	0.4	0.3	0.0 in	0.00	0.00	0.0 in
Ankle x	9.2	11.7	2.3 in	0.4	0.7	0.1 in	5.9	7.4	1.5 in	3.3	4.3	0.8 in	0.05	0.07	1.4 in
Ankle z	1.6	1.6	0.2 in	0.1	0.3	0.0 in	1.0	1.1	0.1 in	0.5	0.5	0.1 in	0.01	0.01	0.1 in
H-point x	5.8	5.2	0.4 in	1.6	1.9	0.1 in	3.3	3.4	0.2 in	2.4	1.8	0.1 in	0.02	0.01	0.1 in
H-point z	6.5	6.4	0.3 in	3.0	2.9	0.1 in	4.2	4.1	0.2 in	2.3	2.2	0.1 in	0.01	0.01	0.0 in
Head angle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pelvic angle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Left shoulder x	6.0	9.9	0.5 in	1.4	1.6	0.1 in	3.86	6.43	0.3 in	2.1	3.5	0.2 in	0.02	0.05	0.2 in
Left shoulder z	1.6	2.3	0.3 in	0.5	0.6	0.1 in	1.08	1.53	0.2 in	0.6	0.7	0.1 in	0.01	0.01	0.1 in
Left knee x	0.5	0.4	0.1 in	0.1	0.2	0.0 in	0.34	0.31	0.1 in	0.2	0.1	0.0 in	0.00	0.00	0.1 in
Left knee z	9.6	2.4	1.0 in	2.9	1.1	0.3 in	6.14	1.91	0.7 in	3.5	0.5	0.3 in	0.03	0.01	0.3 in
Left ankle x	10.2	12.0	2.5 in	0.2	0.1	0.1 in	6.50	7.59	1.7 in	3.7	4.4	0.8 in	0.06	0.08	1.6 in
Left ankle z	0.5	0.6	0.1 in	0.1	0.3	0.0 in	0.32	0.42	0.0 in	0.2	0.2	0.0 in	0.00	0.00	0.0 in

Table E-7. Error Metric Results for Federal Aviation Administration Hybrid III With Four-Point Belt at 0° Pitch

07324-21vs22vs23	Maximum			Minimum			Average			Upper Limit			Lower Limit		
4pt 0deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	32.5	12.7	10.5 G	5.8	6.6	2.0 G	19.0	8.7	7.0 G	13.6	4.0	3.5 G	13.2	2.1	5.0 G
Head Ay	267.6	93.4	4.4 G	21.2	30.5	0.4 G	107.3	53.9	2.9 G	160.3	39.6	1.5 G	86.1	23.4	2.5 G
Head Az	15.8	11.4	5.5 G	6.7	7.1	2.7 G	9.8	9.5	3.7 G	6.0	2.0	1.8 G	3.1	2.4	1.0 G
Head Ar	16.6	10.7	7.2 G	5.4	4.8	2.7 G	10.3	8.0	4.8 G	6.3	2.7	2.4 G	4.8	3.2	2.0 G
Upper neck Fx	15.5	8.7	43.0 lbf	1.5	4.8	4.3 lbf	9.6	6.1	28.6 lbf	5.9	2.5	14.3 lbf	8.1	1.3	24.4 lbf
Upper neck Fy	82.9	50.9	10.4 lbf	21.5	30.0	3.4 lbf	41.8	39.0	6.9 lbf	41.1	11.9	3.5 lbf	20.3	8.9	3.5 lbf
Upper neck Fz	30.3	25.5	88.6 lbf	7.6	11.4	29.1 lbf	17.8	16.6	59.0 lbf	12.5	8.9	29.5 lbf	10.1	5.3	29.9 lbf
Upper neck Mx	109.9	87.2	26.4 in-lb	24.5	58.8	7.8 in-lb	52.4	69.6	17.6 in-lb	57.4	17.6	8.8 in-lb	27.9	10.8	9.8 in-lb
Upper neck My	14.8	43.3	127.8 in-lb	1.8	17.2	16.3 in-lb	9.2	28.1	85.2 in-lb	5.6	15.2	42.6 in-lb	7.3	10.9	68.9 in-lb
Upper neck Mz	102.5	93.1	10.7 in-lb	6.8	37.3	1.4 in-lb	50.5	59.2	7.1 in-lb	52.0	33.9	3.6 in-lb	43.7	21.9	5.7 in-lb
Chest Ax	3.1	4.1	1.0 G	0.0	2.8	0.0 G	2.0	3.6	0.7 G	1.1	0.6	0.3 G	2.0	0.7	0.7 G
Chest Ay	71.8	66.8	1.1 G	19.2	35.1	0.5 G	37.2	51.6	0.7 G	34.6	15.2	0.4 G	18.0	16.4	0.2 G
Chest Az	37.2	39.0	4.8 G	13.9	15.2	2.3 G	21.3	24.8	3.2 G	15.9	14.2	1.6 G	7.4	9.6	0.9 G
Chest Ar	3.6	2.5	1.4 G	1.3	1.5	0.5 G	2.4	2.1	0.9 G	1.3	0.4	0.5 G	1.1	0.7	0.4 G
Lumbar Fx	14.9	16.7	51.5 lbf	2.6	8.3	10.4 lbf	9.3	11.2	34.4 lbf	5.6	5.5	17.2 lbf	6.7	2.9	23.9 lbf
Lumbar Fz	22.6	19.6	74.5 lbf	3.2	7.9	12.8 lbf	10.2	13.3	37.9 lbf	12.4	6.3	36.6 lbf	7.0	5.5	25.1 lbf
Lumbar My	21.4	18.1	212.8 lbf	5.7	6.4	69.0 lbf	13.0	11.4	141.9 lbf	8.4	6.7	70.9 lbf	7.3	5.0	72.9 lbf
Pelvis Ax	5.3	4.0	1.6 G	2.2	3.1	0.7 G	3.4	3.6	1.1 G	1.8	0.4	0.5 G	1.2	0.5	0.4 G
Pelvis Ay	10.1	56.6	0.2 G	2.4	31.2	0.0 G	6.4	45.5	0.1 G	3.7	11.1	0.1 G	4.1	14.4	0.1 G
Pelvis Az	4.5	4.1	1.3 G	1.7	2.7	0.5 G	2.9	3.5	0.9 G	1.5	0.6	0.4 G	1.2	0.8	0.4 G
Pelvis Ar	3.1	4.9	1.0 G	0.0	2.2	0.0 G	2.0	3.8	0.7 G	1.1	1.1	0.3 G	2.0	1.7	0.7 G
Left femur	5.6	10.0	16.5 lbf	1.3	3.0	4.0 lbf	3.6	7.1	11.0 lbf	2.0	2.9	5.5 lbf	2.3	4.1	7.0 lbf
Right femur	3.9	5.4	11.1 lbf	0.5	2.1	1.3 lbf	2.6	4.0	7.4 lbf	1.4	1.4	3.7 lbf	2.1	1.8	6.1 lbf
Left lap	6.6	5.2	123.2 lbf	1.4	1.9	27.7 lbf	4.3	3.5	82.2 lbf	2.3	1.7	41.1 lbf	2.9	1.6	54.4 lbf
Right lap	2.3	3.2	42.4 lbf	0.7	1.4	12.6 lbf	1.5	2.4	28.3 lbf	0.8	0.8	14.1 lbf	0.8	1.0	15.7 lbf
Shoulder belt 1	3.1	7.2	25.8 lbf	1.5	2.9	12.3 lbf	2.0	5.1	17.2 lbf	1.1	2.1	8.6 lbf	0.6	2.2	4.9 lbf
Shoulder belt 2	12.0	11.8	94.8 lbf	0.5	2.0	4.5 lbf	7.6	8.0	63.2 lbf	4.4	3.8	31.6 lbf	7.1	5.9	58.8 lbf
Seat back Fx	51.3	43.0	164.6 lbf	5.5	17.7	18.6 lbf	28.3	33.1	109.8 lbf	23.0	9.9	54.9 lbf	22.8	15.4	91.2 lbf
Seat back Fy	55.5	58.5	52.2 lbf	8.4	17.8	11.1 lbf	26.2	44.6	31.5 lbf	29.3	13.9	20.7 lbf	17.8	26.8	20.4 lbf
Seat back Fz	6.4	46.6	12.4 lbf	1.4	19.3	2.8 lbf	4.2	34.4	8.3 lbf	2.3	12.2	4.1 lbf	2.7	15.1	5.5 lbf
Seat pan Fx	22.0	14.9	100.9 lbf	1.3	4.0	6.0 lbf	13.3	10.2	67.2 lbf	8.7	4.7	33.6 lbf	12.0	6.2	61.2 lbf
Seat pan Fy	72.3	63.7	42.6 lbf	4.2	31.7	2.6 lbf	37.9	43.9	28.4 lbf	34.4	19.8	14.2 lbf	33.6	12.2	25.8 lbf
Seat pan Fz	10.0	4.2	191.9 lbf	1.6	2.7	34.3 lbf	6.3	3.3	127.9 lbf	3.6	0.9	64.0 lbf	4.7	0.6	93.7 lbf
Seat pan resultant	9.9	4.4	194.0 lbf	1.7	2.7	36.0 lbf	6.3	3.4	129.3 lbf	3.6	1.0	64.7 lbf	4.6	0.6	93.3 lbf
Seat pan Mx	478.9	361.3	699.0 in-lb	28.7	26.7	242.9 in-lb	169.8	140.0	466.0 in-lb	309.0	221.2	233.0 in-lb	141.1	113.3	223.1 in-lb
Seat pan My	23.0	17.7	2110.0 in-lb	5.2	2.5	502.8 in-lb	13.9	11.3	1406.6 in-lb	9.1	6.3	703.3 in-lb	8.7	8.8	903.8 in-lb
Seat pan Mz	123.1	179.5	194.4 in-lb	10.6	15.4	37.3 in-lb	58.3	81.0	129.6 in-lb	64.8	98.5	64.8 in-lb	47.7	65.6	92.3 in-lb
Sled acceleration	1.3	0.9	0.3 G	0.6	0.8	0.1 G	0.8	0.8	0.2 G	0.4	0.1	0.1 G	0.2	0.0	0.0 G
Head c.g. x	5.4	4.9	0.9 in	0.0	0.3	0.0 in	3.5	3.3	0.6 in	1.9	1.6	0.3 in	3.5	2.9	0.6 in
Head c.g. z	0.3	0.8	0.1 in	0.1	0.2	0.0 in	0.2	0.5	0.1 in	0.1	0.2	0.0 in	0.1	0.3	0.0 in
Shoulder x	11.1	12.5	0.9 in	3.5	1.8	0.3 in	7.1	7.9	0.6 in	4.1	4.5	0.3 in	3.6	6.2	0.3 in
Shoulder z	0.9	0.3	0.2 in	0.2	0.3	0.0 in	0.6	0.3	0.1 in	0.3	0.0	0.1 in	0.4	0.0	0.1 in
Knee x	2.3	2.1	0.6 in	0.3	0.5	0.1 in	1.5	1.4	0.4 in	0.8	0.7	0.2 in	1.3	1.0	0.4 in
Knee z	1.5	0.7	0.2 in	0.5	0.5	0.1 in	1.0	0.6	0.1 in	0.5	0.2	0.1 in	0.5	0.1	0.1 in
Ankle x	0.7	0.7	0.2 in	0.1	0.3	0.0 in	0.4	0.5	0.1 in	0.2	0.2	0.1 in	0.4	0.2	0.1 in
Ankle z	0.8	1.6	0.1 in	0.2	0.7	0.0 in	0.5	1.1	0.0 in	0.3	0.5	0.0 in	0.4	0.4	0.0 in
H-point x	5.2	4.9	0.6 in	0.2	1.3	0.0 in	3.4	3.2	0.4 in	1.8	1.8	0.2 in	3.2	1.9	0.4 in
H-point z	4.9	5.3	0.2 in	1.2	1.1	0.1 in	2.6	3.0	0.1 in	2.3	2.3	0.1 in	1.4	1.8	0.1 in
Head angle	4.5	3.8	4.6 deg	1.2	1.8	1.2 deg	3.0	2.7	3.1 deg	1.6	1.2	1.5 deg	1.8	0.9	1.9 deg
Pelvic angle	9.5	10.3	4.3 deg	1.0	3.1	0.5 deg	6.1	6.7	2.9 deg	3.4	3.6	1.4 deg	5.1	3.6	2.4 deg

Table E-8. Error Metric Results for Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch

07324-13vs14vs15	Maximum			Minimum			Average			Upper Limit			Lower Limit		
2pt 60deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	34.4	34.3	1.9 G	4.4	11.8	0.3 G	19.9	20.8	1.3 G	14.4	13.4	0.6 G	15.5	9.0	0.9 G
Head Ay	67.5	48.1	0.8 G	8.5	29.5	0.2 G	35.6	37.0	0.5 G	31.9	11.1	0.3 G	27.1	7.5	0.4 G
Head Az	8.9	4.6	2.2 G	3.0	3.3	0.8 G	5.7	3.9	1.5 G	3.2	0.7	0.7 G	2.7	0.6	0.7 G
Head Ar	10.4	6.1	2.7 G	3.5	3.7	1.0 G	6.6	4.7	1.8 G	3.8	1.4	0.9 G	3.1	1.0	0.8 G
Upper neck Fx	32.4	36.4	15.2 lbf	7.6	10.9	4.7 lbf	18.9	21.7	10.1 lbf	13.5	14.7	5.1 lbf	11.3	10.8	5.4 lbf
Upper neck Fy	99.9	59.3	5.1 lbf	1.2	21.0	0.1 lbf	45.1	40.1	3.2 lbf	54.8	19.2	1.9 lbf	43.9	19.2	3.1 lbf
Upper neck Fz	10.2	3.8	24.1 lbf	2.1	3.5	5.1 lbf	6.5	3.6	16.1 lbf	3.7	0.2	8.0 lbf	4.4	0.1	11.0 lbf
Upper neck Mx	28.5	27.4	4.8 in-lb	1.5	13.6	0.3 in-lb	16.9	20.7	3.2 in-lb	11.6	6.8	1.6 in-lb	15.4	7.1	2.9 in-lb
Upper neck My	55.9	34.1	28.8 in-lb	3.6	17.5	2.7 in-lb	22.2	24.0	14.7 in-lb	33.7	10.0	14.2 in-lb	18.6	6.6	12.0 in-lb
Upper neck Mz	95.2	140.0	4.8 in-lb	26.7	31.1	1.8 in-lb	46.7	71.2	3.2 in-lb	48.5	68.7	1.6 in-lb	20.1	40.1	1.4 in-lb
Chest Ax	21.6	14.8	0.6 G	1.7	8.9	0.1 G	13.1	11.3	0.4 G	8.5	3.5	0.2 G	11.4	2.5	0.3 G
Chest Ay	106.8	48.8	0.9 G	24.5	36.7	0.4 G	51.0	41.0	0.6 G	55.8	7.7	0.3 G	26.5	4.3	0.2 G
Chest Az	6.9	2.9	1.8 G	0.7	2.8	0.2 G	4.4	2.8	1.2 G	2.4	0.0	0.6 G	3.7	0.0	1.0 G
Chest Ar	6.6	2.8	1.7 G	0.5	2.3	0.1 G	4.3	2.6	1.1 G	2.3	0.2	0.6 G	3.8	0.3	1.0 G
Lumbar Fx	15.3	11.5	22.4 lbf	0.6	5.3	1.1 lbf	9.5	8.4	14.9 lbf	5.8	3.1	7.5 lbf	8.9	3.1	13.9 lbf
Lumbar Fz	5.0	2.8	85.2 lbf	1.4	1.1	23.5 lbf	3.2	2.2	56.8 lbf	1.7	0.6	28.4 lbf	1.9	1.1	33.3 lbf
Lumbar My	22.9	30.5	72.8 lbf	2.7	6.8	10.7 lbf	13.8	18.4	48.5 lbf	9.1	12.1	24.3 lbf	11.1	11.6	37.8 lbf
Pelvis Ax	7.1	10.7	0.4 G	1.9	5.2	0.1 G	4.6	7.9	0.3 G	2.5	2.8	0.1 G	2.7	2.7	0.2 G
Pelvis Ay	19.9	22.8	0.4 G	7.7	15.9	0.1 G	12.2	20.3	0.2 G	7.8	2.6	0.1 G	4.5	4.3	0.1 G
Pelvis Az	6.2	4.8	1.5 G	0.8	4.2	0.2 G	4.0	4.5	1.0 G	2.2	0.3	0.5 G	3.2	0.3	0.8 G
Pelvis Ar	6.4	4.1	1.5 G	0.9	3.6	0.2 G	4.1	3.9	1.0 G	2.2	0.2	0.5 G	3.3	0.3	0.8 G
Left femur	7.6	8.6	5.2 lbf	0.6	3.1	0.4 lbf	4.9	6.4	3.5 lbf	2.7	2.2	1.7 lbf	4.3	3.2	3.1 lbf
Right femur	16.7	14.9	12.5 lbf	4.1	3.3	3.6 lbf	10.3	10.4	8.3 lbf	6.4	4.5	4.2 lbf	6.2	7.0	4.8 lbf
Left lap	9.2	21.6	16.2 lbf	0.5	1.5	0.9 lbf	5.9	13.2	10.8 lbf	3.3	8.4	5.4 lbf	5.4	11.7	9.8 lbf
Right lap	4.3	12.0	7.2 lbf	0.3	1.0	0.4 lbf	2.8	7.8	4.8 lbf	1.5	4.2	2.4 lbf	2.5	6.7	4.3 lbf
Seat back Fx	9.7	9.4	27.5 lbf	2.1	3.3	6.0 lbf	6.2	6.8	18.3 lbf	3.5	2.6	9.2 lbf	4.1	3.5	12.3 lbf
Seat back Fy	10.5	32.9	9.4 lbf	2.0	11.5	1.9 lbf	6.7	22.2	6.2 lbf	3.8	10.6	3.1 lbf	4.6	10.7	4.4 lbf
Seat back Fz	13.9	27.5	18.4 lbf	5.2	19.5	7.2 lbf	8.7	23.9	12.3 lbf	5.2	3.6	6.1 lbf	3.5	4.4	5.0 lbf
Seat pan Fx	0.8	1.3	7.9 lbf	0.3	1.1	3.4 lbf	0.5	1.2	5.2 lbf	0.3	0.1	2.6 lbf	0.2	0.1	1.9 lbf
Seat pan Fy	47.2	42.1	22.9 lbf	14.4	11.1	10.3 lbf	26.2	26.3	15.3 lbf	21.0	15.8	7.6 lbf	11.7	15.2	4.9 lbf
Seat pan Fz	4.0	3.2	121.7 lbf	1.2	1.0	39.3 lbf	2.6	2.3	81.2 lbf	1.4	0.9	40.6 lbf	1.4	1.3	41.9 lbf
Seat pan resultant	3.6	2.9	116.1 lbf	1.1	1.0	37.9 lbf	2.4	2.1	77.4 lbf	1.3	0.8	38.7 lbf	1.2	1.1	39.5 lbf
Seat pan Mx	315.7	236.4	960.2 in-lb	10.8	20.0	136.6 in-lb	126.4	103.8	640.1 in-lb	189.3	132.6	320.1 in-lb	115.6	83.8	503.5 in-lb
Seat pan My	17.3	8.6	499.3 in-lb	6.8	4.2	212.0 in-lb	10.6	6.1	332.9 in-lb	6.6	2.4	166.4 in-lb	3.8	1.9	120.9 in-lb
Seat pan Mz	237.0	127.7	231.6 in-lb	15.7	22.5	51.6 in-lb	98.4	67.5	154.4 in-lb	138.6	60.2	77.2 in-lb	82.7	45.0	102.7 in-lb
Sled acceleration	0.5	1.2	0.1 G	0.2	0.9	0.0 G	0.3	1.0	0.1 G	0.2	0.1	0.0 G	0.1	0.2	0.0 G
Head c.g. x	12.4	14.7	1.1 in	5.6	5.8	0.5 in	7.8	9.3	0.7 in	4.6	5.4	0.4 in	2.2	3.4	0.2 in
Head c.g. z	0.5	0.4	0.2 in	0.2	0.1	0.1 in	0.4	0.3	0.1 in	0.2	0.1	0.1 in	0.2	0.2	0.1 in
Shoulder x	7.9	9.1	0.4 in	0.9	1.7	0.0 in	5.1	6.2	0.3 in	2.8	2.9	0.1 in	4.2	4.5	0.2 in
Shoulder z	2.9	1.6	0.6 in	0.5	0.2	0.1 in	1.9	1.1	0.4 in	1.0	0.5	0.2 in	1.4	0.9	0.3 in
Knee x	1.4	0.8	0.3 in	0.0	0.3	0.0 in	0.8	0.5	0.2 in	0.6	0.3	0.1 in	0.8	0.2	0.2 in
Knee z	5.8	5.3	0.2 in	2.4	1.8	0.1 in	3.8	3.5	0.1 in	2.0	1.8	0.1 in	1.4	1.7	0.1 in
Ankle x	1.6	1.7	0.3 in	0.7	0.7	0.1 in	1.1	1.1	0.2 in	0.6	0.6	0.1 in	0.4	0.4	0.1 in
Ankle z	0.6	0.6	0.1 in	0.1	0.3	0.0 in	0.4	0.4	0.0 in	0.2	0.2	0.0 in	0.3	0.1	0.0 in
H-point x	10.2	6.8	0.5 in	3.3	2.8	0.2 in	6.5	4.4	0.4 in	3.7	2.4	0.2 in	3.2	1.7	0.2 in
H-point z	3.4	3.5	0.1 in	0.5	1.3	0.0 in	2.3	2.4	0.1 in	1.2	1.1	0.0 in	1.8	1.2	0.1 in
Head angle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pelvic angle	26.7	46.2	2.3 deg	1.4	7.8	0.1 deg	15.9	26.1	1.5 deg	10.8	20.1	0.8 deg	14.5	18.3	1.4 deg

APPENDIX F—NYLON BELT WEBBING EXPERIMENTAL DATA

Table F-1. Test Number 2 Data Points

Loading Test Number 2 (0.25 in/min)		Unloading Test Number 2 (0.25 in/min)	
Elongation (%)	Load (lbf)	Elongation (%)	Load (lbf)
0.00	0	21.00	2600
0.60	100	21.00	2500
1.25	250	20.75	2250
2.75	500	20.50	2000
6.00	750	20.00	1750
8.50	1000	19.00	1500
10.75	1250	18.50	1250
12.75	1500	17.75	1000
14.75	1750	16.50	750
16.50	2000	15.00	500
18.50	2250	12.75	250
20.50	2500	11.00	100
21.00	2600	0.00	0

Table F-2. Test Number 3 Data Points

Loading Test Number 3 (6 in/min)		Unloading Test Number 3 (6 in/min)	
Elongation (%)	Load (lbf)	Elongation (%)	Load (lbf)
0.00	0	21.50	2525
0.75	100	21.00	2500
1.50	250	21.00	2250
2.50	500	20.75	2000
5.00	750	20.00	1750
8.00	1000	19.50	1500
10.50	1250	19.00	1250
12.50	1500	18.00	1000
14.50	1750	16.50	750
16.50	2000	15.00	500
18.50	2250	13.00	250
20.50	2500	10.75	100
21.50	2590	0.00	0

APPENDIX G—SPECIAL STUDY DATA FOR HYBRID II ANTHROPOMORPHIC TEST DUMMY WITH TWO-POINT BELT AT 60°—TWO TESTS ONLY (07324-11 VS 07324-12)

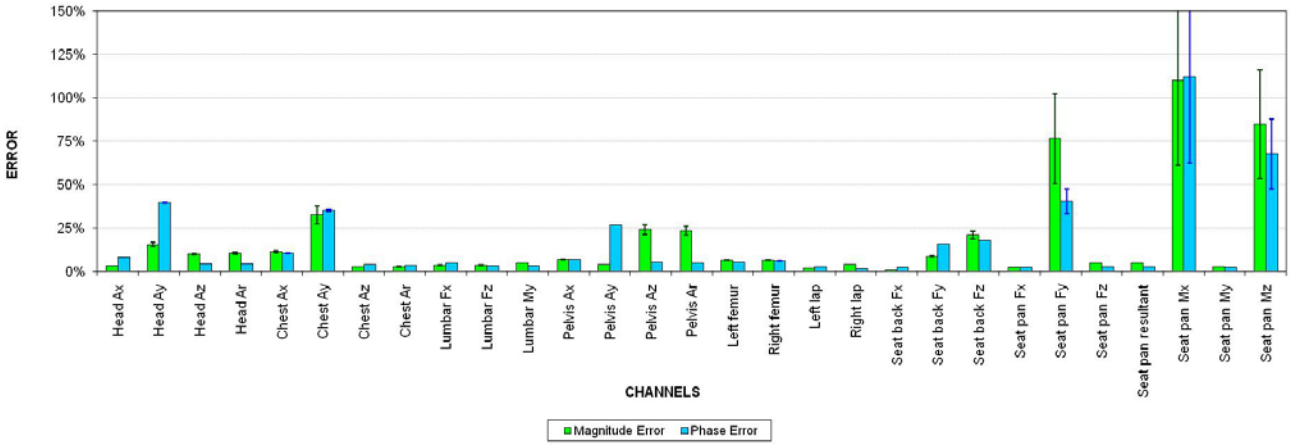


Figure G-1. Averaged Responses for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch

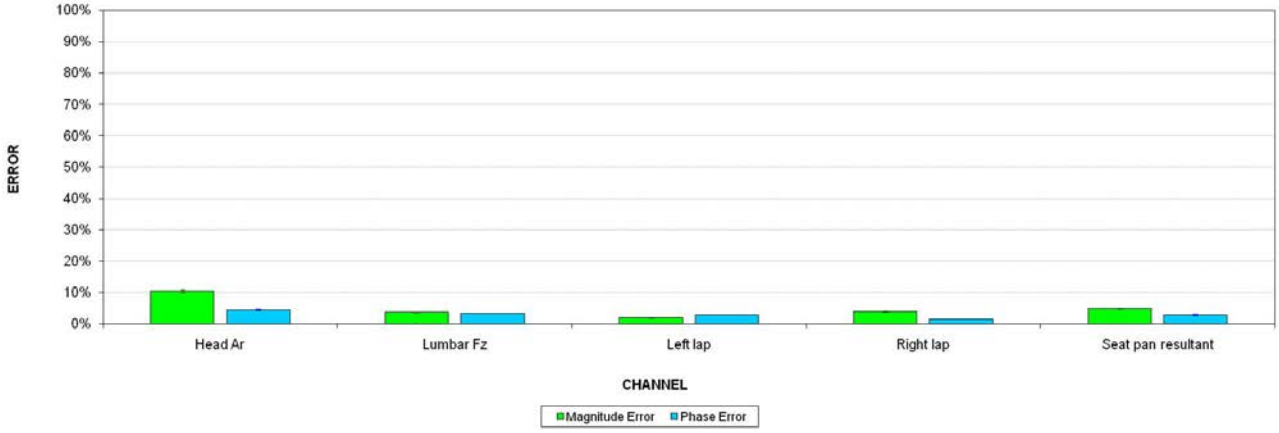


Figure G-2. Averaged Compliance Responses for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch

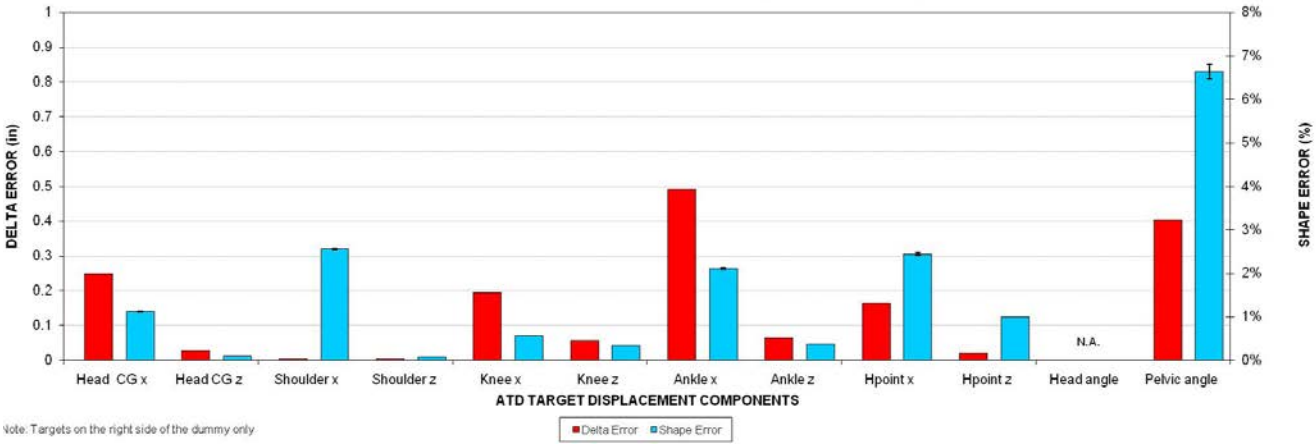


Figure G-3. Averaged Displacement Responses for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch

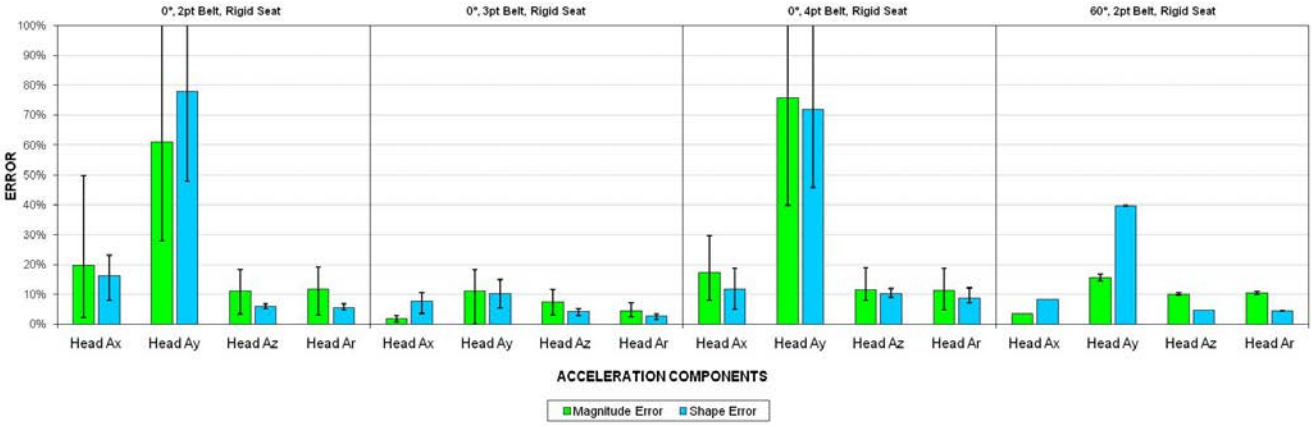


Figure G-4. Averaged Head Accelerations for Each Hybrid II Anthropomorphic Test Dummy Configuration

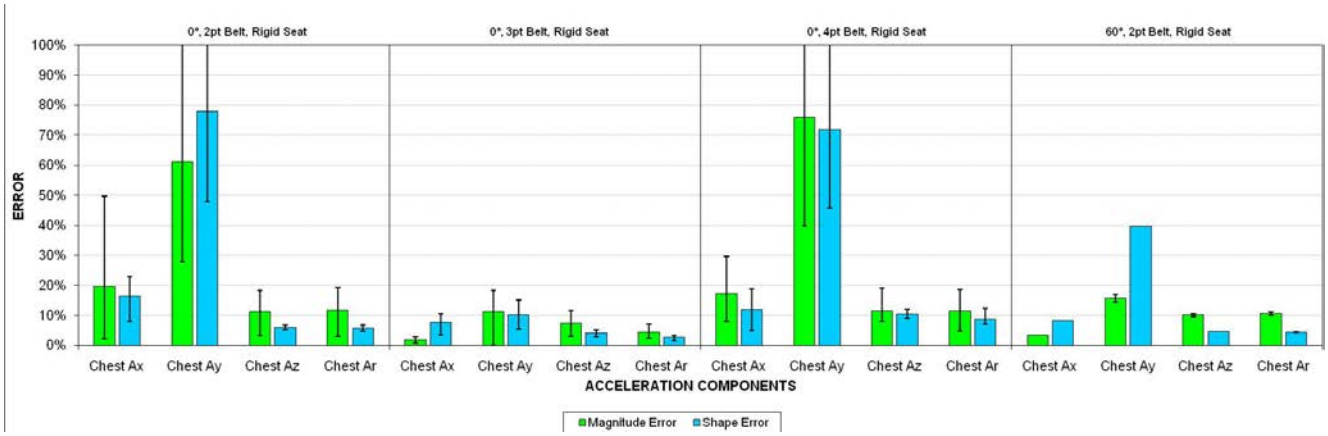


Figure G-5. Averaged Torso Accelerations for Each Hybrid II Anthropomorphic Test Dummy Configuration

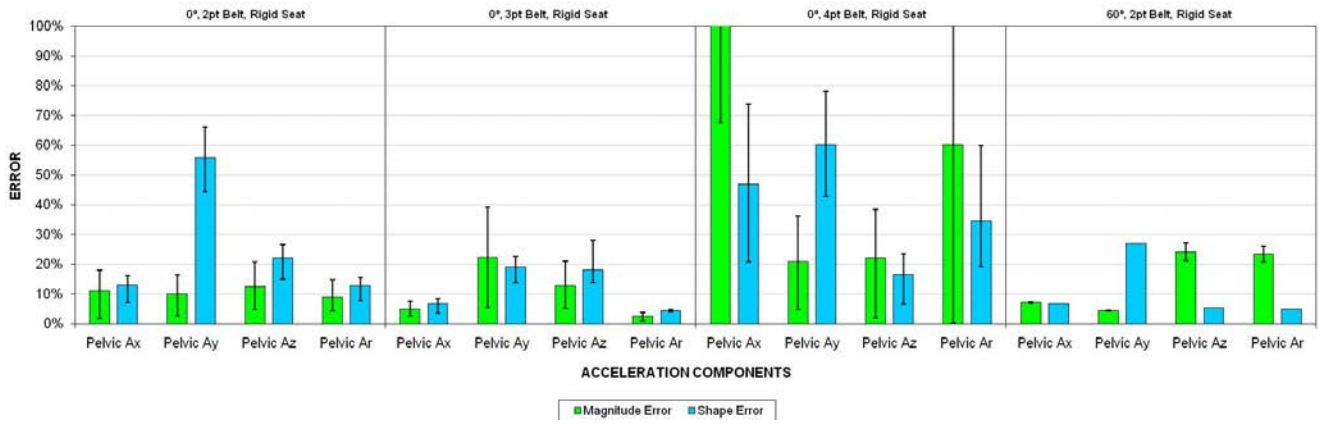


Figure G-6. Averaged Pelvis Accelerations for Each Hybrid II Anthropomorphic Test Dummy Configuration

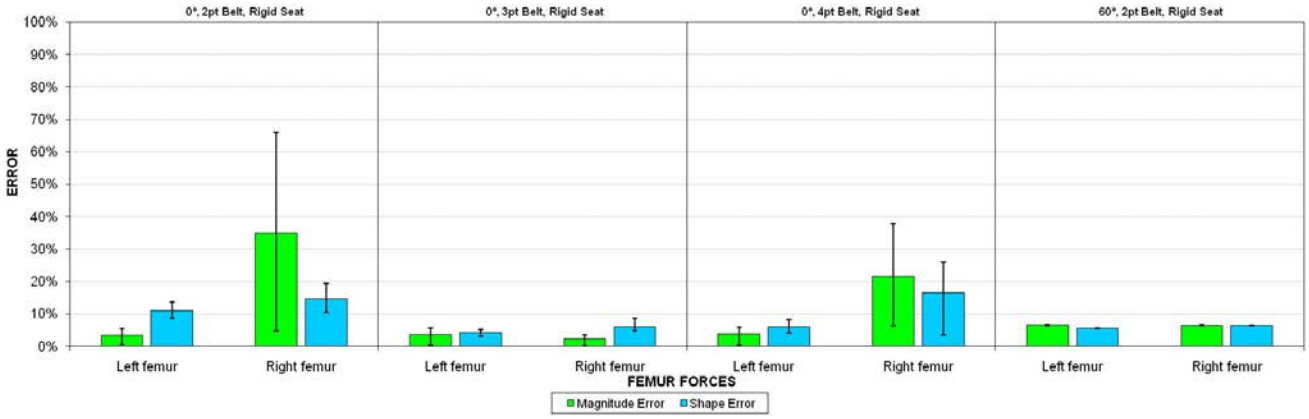


Figure G-7. Averaged Femur Forces for Each Hybrid II Anthropomorphic Test Dummy Configuration

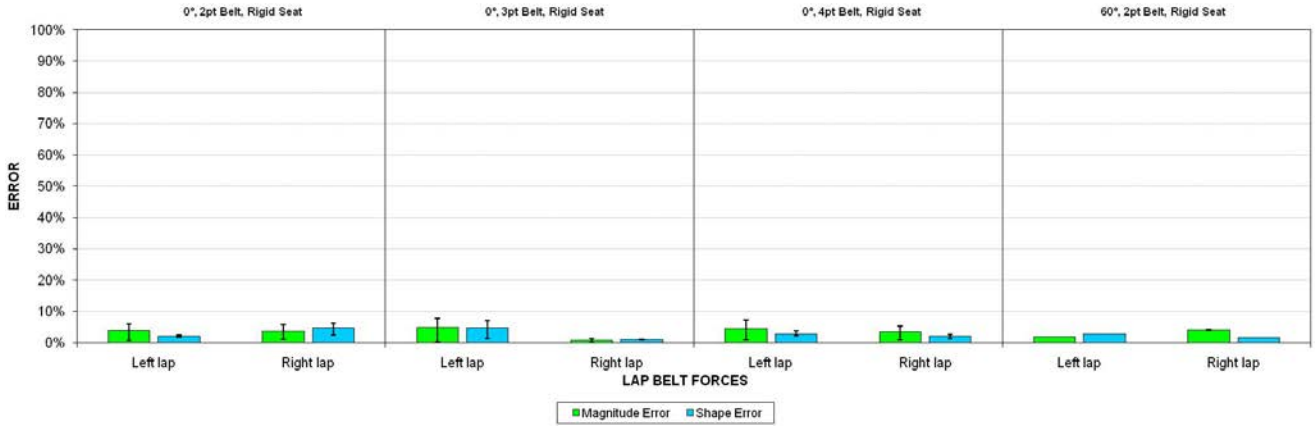


Figure G-8. Averaged Lap Belt Forces for Each Hybrid II Anthropomorphic Test Dummy Configuration

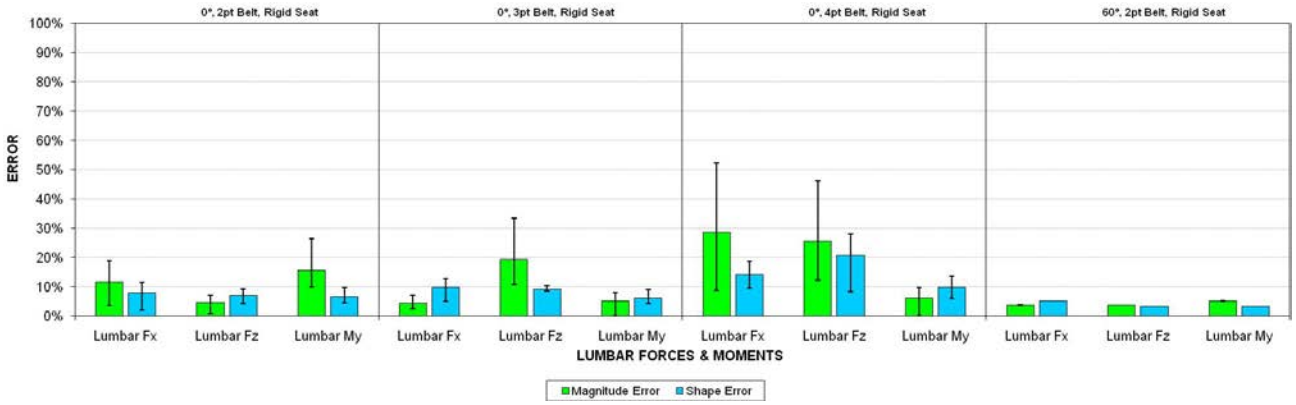


Figure G-9. Averaged Lumbar Forces for Each Hybrid II Anthropomorphic Test Dummy Configuration

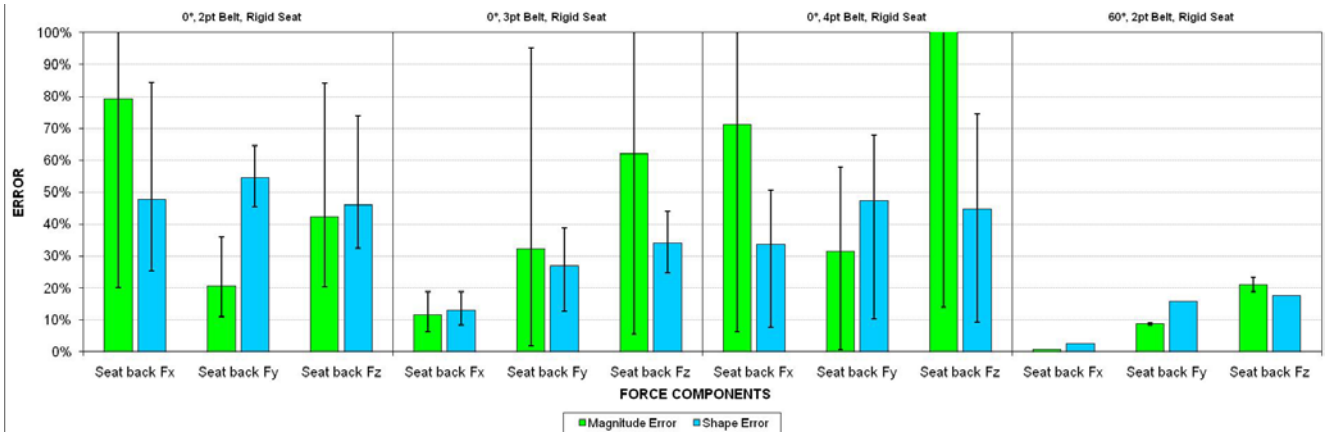


Figure G-10. Averaged Seat Back Forces for Each Hybrid II Anthropomorphic Test Dummy Configuration

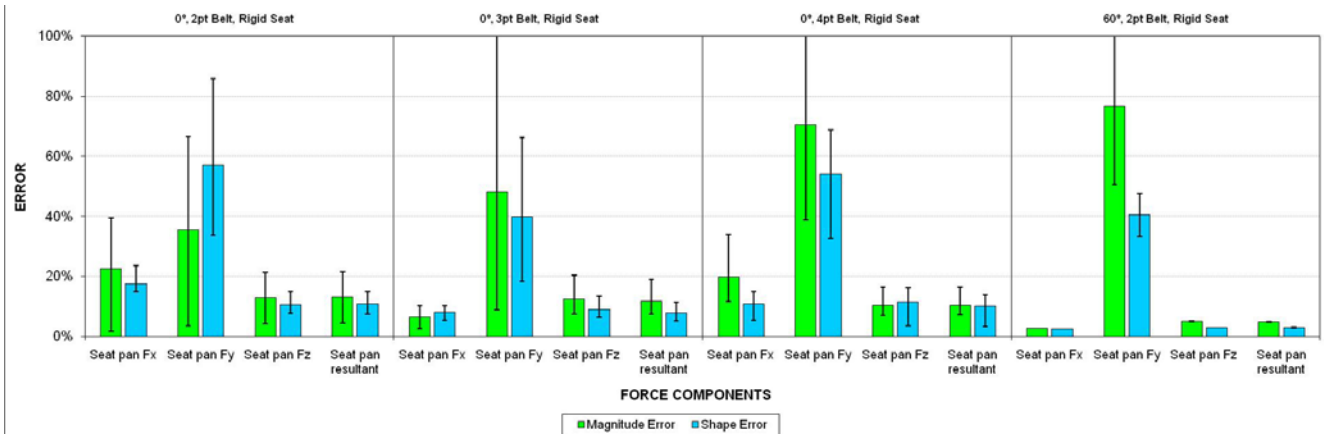


Figure G-11. Averaged Seat Pan Forces for Each Hybrid II Anthropomorphic Test Dummy Configuration

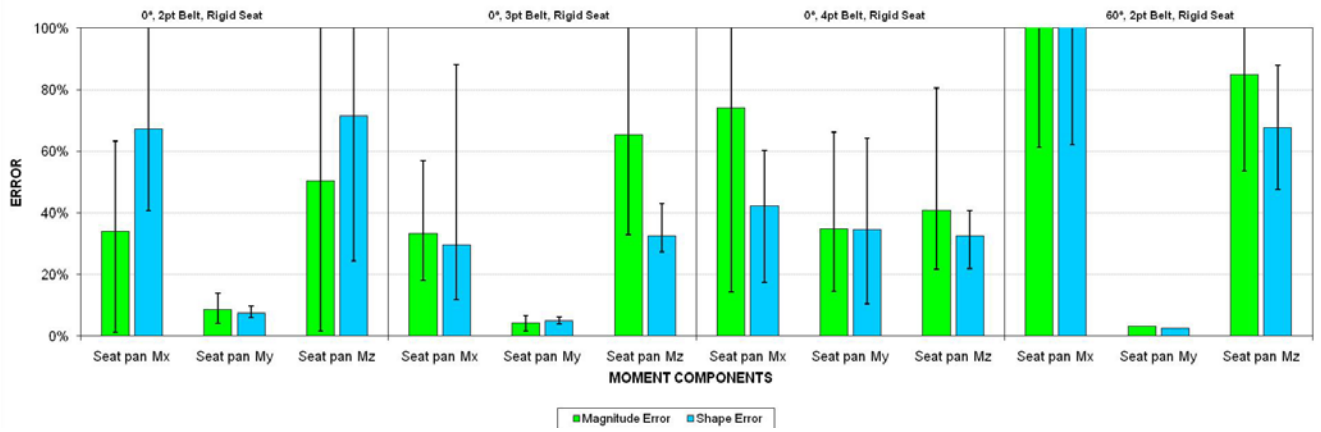


Figure G-12. Averaged Seat Pan Moments for Each Hybrid II Anthropomorphic Test Dummy Configuration

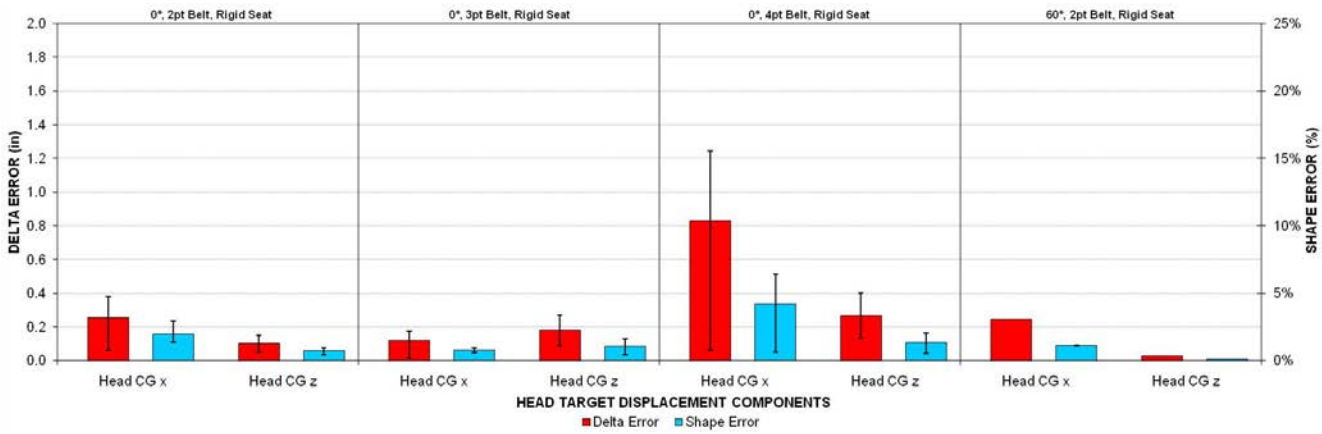


Figure G-13. Averaged Head Excursions for Each Hybrid II Anthropomorphic Test Dummy Configuration

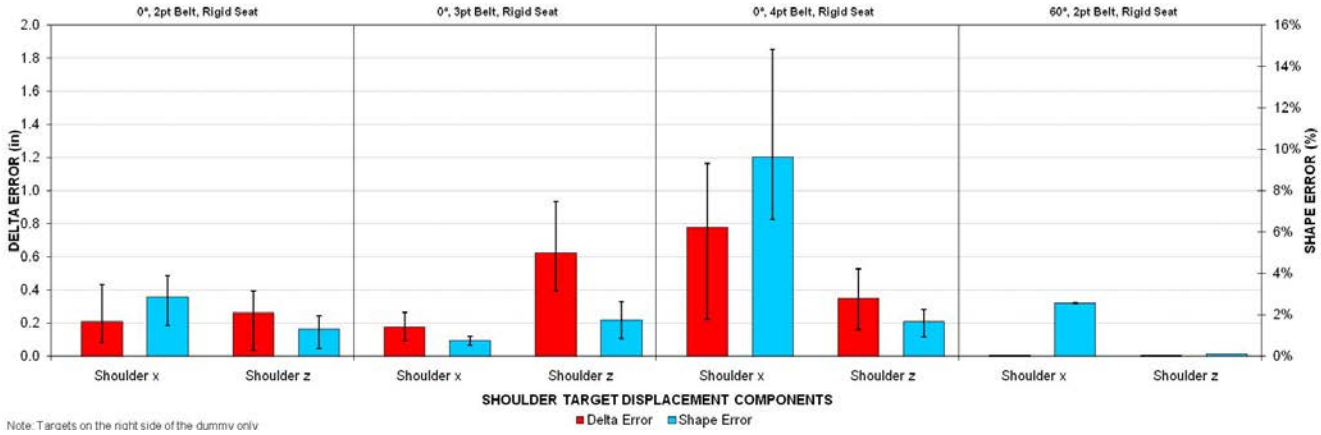


Figure G-14. Averaged Shoulder Excursions for Each Hybrid II Anthropomorphic Test Dummy Configuration

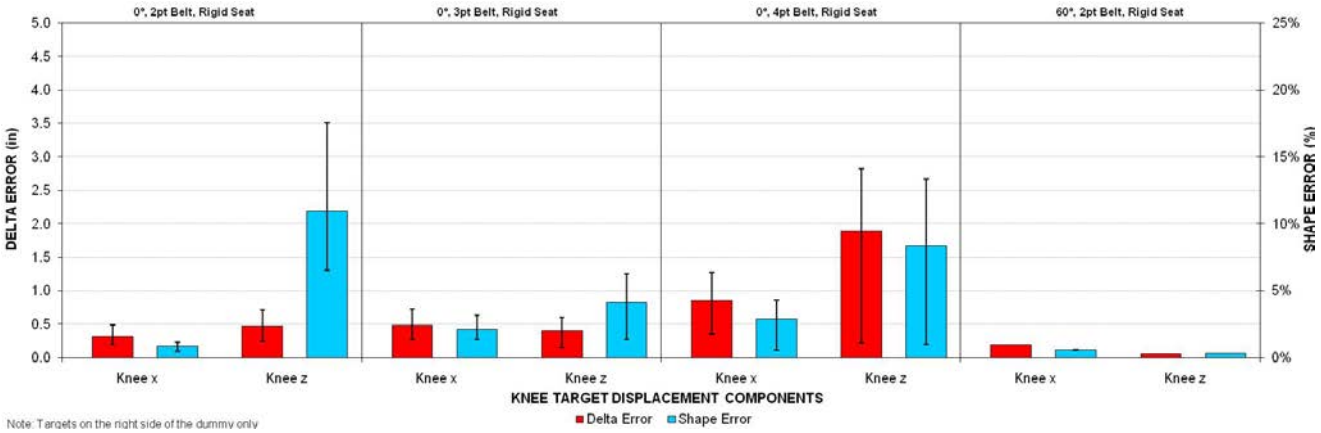


Figure G-15. Averaged Knee Excursions for Each Hybrid II Anthropomorphic Test Dummy Configuration

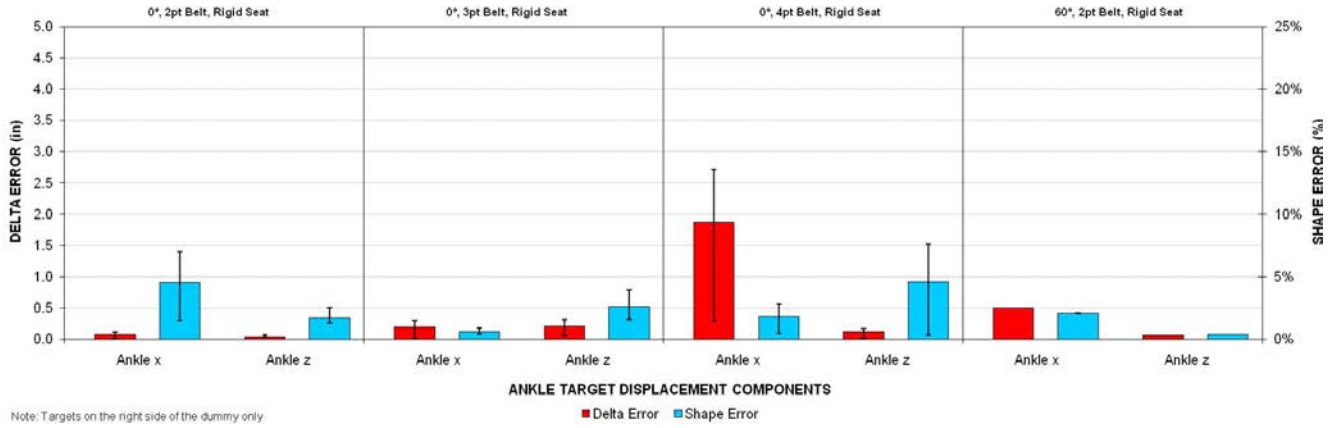


Figure G-16. Averaged Ankle Excursions for Each Hybrid II Anthropomorphic Test Dummy Configuration

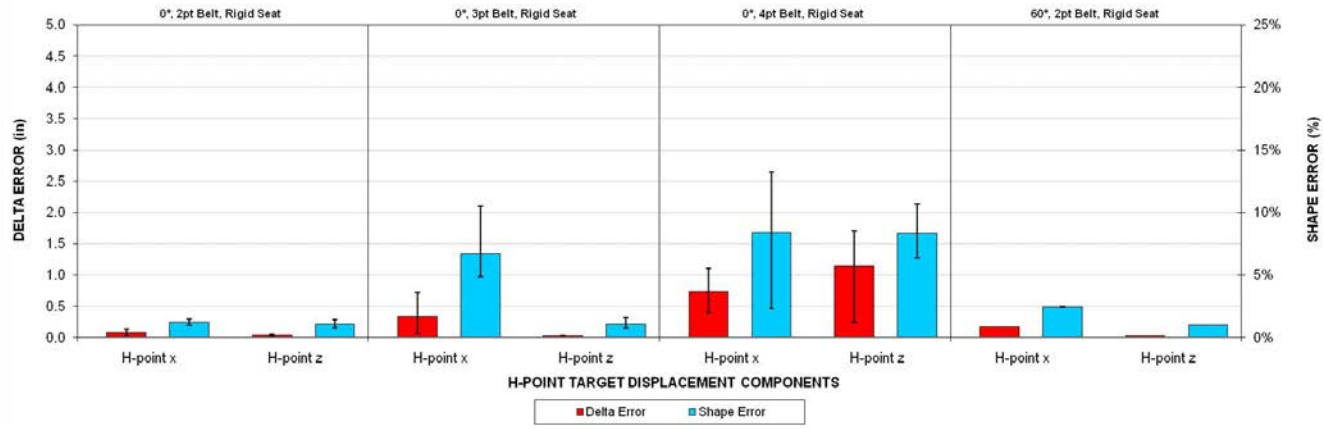


Figure G-17. Averaged H-Point Excursions for Each Hybrid II Anthropomorphic Test Dummy Configuration

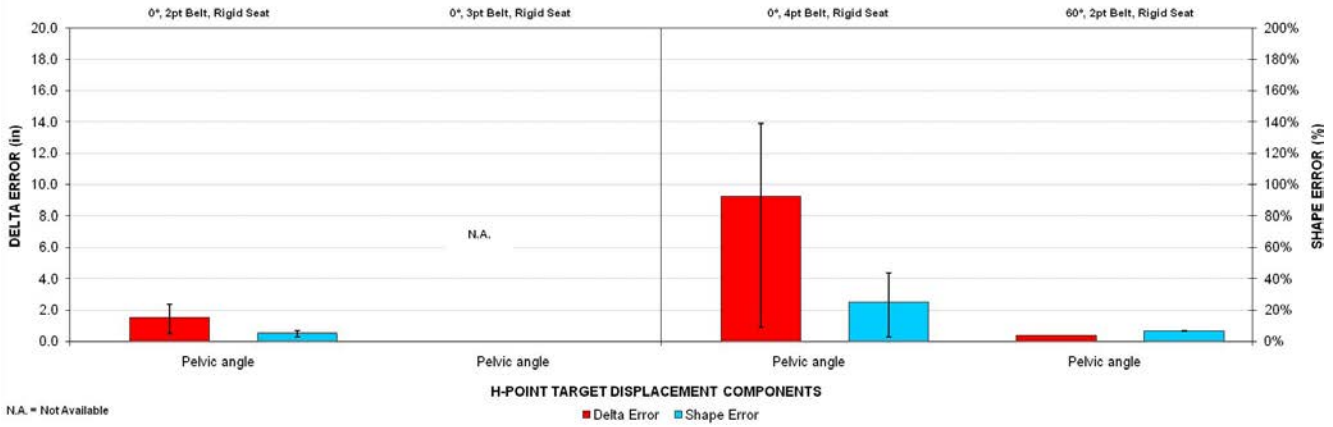


Figure G-18. Averaged Pelvis Angles for Each Hybrid II Anthropomorphic Test Dummy Configuration

Table G-1. Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Two Tests Only (07324-11 vs 07324-12)—Force and Acceleration Largest Variability

Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error	Channel Description	Magnitude Error (%)	Shape Error (%)	Delta Error
Sled Ax	1	1	0.2 g	Left lap	2	3	2.8 lbf
Head Ax	4	8	0.2 g	Right lap	4	2	4.9 lbf
Head Ay	17	40	0.2 g	Lumbar Fx	4	5	3.9 lbf
Head Az	11	5	3.1 g	Lumbar Fz	4	3	64.4 lbf
Head Ar	11	4	3.3 g	Lumbar My	5	3	28.5 in-lb
Chest Ax	12	11	0.5 g	Seat back Fx	1	3	2.4 lbf
Chest Ay	38	36	0.6 g	Seat back Fy	9	16	7.5 lbf
Chest Az	3	4	0.8 g	Seat back Fz	23	18	27.2 lbf
Chest Ar	3	4	0.8 g	Seat pan Fx	3	2	23.0 lbf
Pelvis Ax	7	7	0.6 g	Seat pan Fy	103	48	63.5 lbf
Pelvis Ay	4	27	0.1 g	Seat pan Fz	5	3	140.1 lbf
Pelvis Az	27	6	7.5 g	Seat pan resultant	5	3	144.2 lbf
Pelvis Ar	26	5	7.5 g	Seat pan Mx	159	162	1127.0 in-lb
Left femur	7	6	5.7 lbf	Seat pan My	3	3	176.7 in-lb
Right femur	7	6	5.6 lbf	Seat pan Mz	116	88	325.1 in-lb

Table G-2. Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Two Tests Only (07324-11 vs 07324-12)—Target Trajectory Largest Variability

Channel Description	Shape Error (%)	Delta Error (in.)	Channel Description	Shape Error (%)	Delta Error (in.)
Head path x direction	1	0.2	Ankle x	2	0.5
Head path z direction	0.1	0.03	Ankle z	0.4	0.1
Shoulder x	3	0.005	H-point x	2	0.2
Shoulder z	0.01	0.003	H-point z	1	0.02
Knee x	1	0.2	Head angle	N/A	N/A
Knee z	0.3	0.1	Pelvis angle	7	0.4

N/A = Not applicable

Table G-3. Error Metric Results for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Two Tests Only (07324-11 vs 07324-12)

07324-11vs12 only	Maximum			Minimum			Average			Upper Limit			Lower Limit		
2pt 60deg	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error	Magnitude Error (%)	Shape Error (%)	Delta Error
Head Ax	3.7	8.3	N/A	3.5	8.3	N/A	3.6	8.3	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Head Ay	16.8	39.7	N/A	14.4	39.7	N/A	15.6	39.7	N/A	1.2	0.0	N/A	1.2	0.0	N/A
Head Az	10.6	4.6	N/A	9.6	4.5	N/A	10.1	4.5	N/A	0.5	0.0	N/A	0.5	0.0	N/A
Head Ar	11.1	4.5	N/A	10.0	4.4	N/A	10.5	4.4	N/A	0.6	0.0	N/A	0.6	0.0	N/A
Chest Ax	12.1	10.9	N/A	10.8	10.6	N/A	11.5	10.8	N/A	0.7	0.2	N/A	0.7	0.2	N/A
Chest Ay	37.8	35.7	N/A	27.5	34.7	N/A	32.6	35.2	N/A	5.2	0.5	N/A	5.2	0.5	N/A
Chest Az	2.9	4.0	N/A	2.9	4.0	N/A	2.9	4.0	N/A	0.0	0.0	N/A	0.0	0.0	N/A
Chest Ar	3.1	3.8	N/A	3.0	3.8	N/A	3.0	3.8	N/A	0.0	0.0	N/A	0.0	0.0	N/A
Lumbar Fx	3.8	5.1	N/A	3.7	5.1	N/A	3.8	5.1	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Lumbar Fz	3.8	3.3	N/A	3.7	3.2	N/A	3.7	3.3	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Lumbar My	5.3	3.3	N/A	5.0	3.3	N/A	5.1	3.3	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Pelvis Ax	7.4	6.9	N/A	6.9	6.9	N/A	7.1	6.9	N/A	0.3	0.0	N/A	0.3	0.0	N/A
Pelvis Ay	4.5	27.0	N/A	4.3	27.0	N/A	4.4	27.0	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Pelvis Az	27.0	5.5	N/A	21.3	5.4	N/A	24.2	5.5	N/A	2.9	0.0	N/A	2.9	0.0	N/A
Pelvis Ar	26.3	4.9	N/A	20.8	4.9	N/A	23.5	4.9	N/A	2.7	0.0	N/A	2.7	0.0	N/A
Left femur	6.8	5.6	N/A	6.3	5.5	N/A	6.6	5.5	N/A	0.2	0.0	N/A	0.2	0.0	N/A
Right femur	6.7	6.4	N/A	6.3	6.2	N/A	6.5	6.3	N/A	0.2	0.1	N/A	0.2	0.1	N/A
Left lap	2.0	2.9	N/A	2.0	2.8	N/A	2.0	2.9	N/A	0.0	0.0	N/A	0.0	0.0	N/A
Right lap	4.1	1.7	N/A	4.0	1.7	N/A	4.1	1.7	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Seat back Fx	0.8	2.6	N/A	0.8	2.6	N/A	0.8	2.6	N/A	0.0	0.0	N/A	0.0	0.0	N/A
Seat back Fy	9.1	15.8	N/A	8.4	15.8	N/A	8.7	15.8	N/A	0.4	0.0	N/A	0.4	0.0	N/A
Seat back Fz	23.3	17.7	N/A	18.9	17.7	N/A	21.1	17.7	N/A	2.2	0.0	N/A	2.2	0.0	N/A
Seat pan Fx	2.7	2.5	N/A	2.6	2.4	N/A	2.6	2.5	N/A	0.0	0.0	N/A	0.0	0.0	N/A
Seat pan Fy	102.6	47.6	N/A	50.6	33.3	N/A	76.6	40.5	N/A	26.0	7.1	N/A	26.0	7.1	N/A
Seat pan Fz	5.0	3.0	N/A	4.8	2.9	N/A	4.9	2.9	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Seat pan resultant	4.9	2.9	N/A	4.7	2.8	N/A	4.8	2.9	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Seat pan Mx	158.8	162.2	N/A	61.4	62.3	N/A	110.1	112.3	N/A	48.7	50.0	N/A	48.7	50.0	N/A
Seat pan My	3.2	2.7	N/A	3.1	2.6	N/A	3.2	2.7	N/A	0.1	0.0	N/A	0.1	0.0	N/A
Seat pan Mz	116.2	88.0	N/A	53.7	47.5	N/A	85.0	67.8	N/A	31.2	20.3	N/A	31.2	20.3	N/A
Sled acceleration	1.2	1.1	N/A	1.2	1.1	N/A	1.2	1.1	N/A	0.0	0.0	N/A	0.0	0.0	N/A
Head c.g. x	1.7	1.1	0.2 in	1.7	1.1	0.2 in	1.7	1.1	0.2 in	0.0	0.0	N/A	0.0	0.0	N/A
Head c.g. z	0.1	0.1	0.0 in	0.1	0.1	0.0 in	0.1	0.1	0.0 in	0.0	0.0	N/A	0.0	0.0	N/A
Shoulder x	0.0	2.6	0.0 in	0.0	2.5	0.0 in	0.0	2.6	0.0 in	0.0	0.0	N/A	0.0	0.0	N/A
Shoulder z	0.0	0.1	0.0 in	0.0	0.1	0.0 in	0.0	0.1	0.0 in	0.0	0.0	N/A	0.0	0.0	N/A
Knee x	0.9	0.6	0.2 in	0.9	0.6	0.2 in	0.9	0.6	0.2 in	0.0	0.0	N/A	0.0	0.0	N/A
Knee z	1.3	0.3	0.1 in	1.3	0.3	0.1 in	1.3	0.3	0.1 in	0.0	0.0	N/A	0.0	0.0	N/A
Ankle x	2.3	2.1	0.5 in	2.2	2.1	0.5 in	2.3	2.1	0.5 in	0.0	0.0	N/A	0.0	0.0	N/A
Ankle z	0.5	0.4	0.1 in	0.5	0.4	0.1 in	0.5	0.4	0.1 in	0.0	0.0	N/A	0.0	0.0	N/A
H-point x	3.3	2.5	0.2 in	3.2	2.4	0.2 in	3.3	2.4	0.2 in	0.1	0.0	N/A	0.1	0.0	N/A
H-point z	0.5	1.0	0.0 in	0.5	1.0	0.0 in	0.5	1.0	0.0 in	0.0	0.0	N/A	0.0	0.0	N/A
Pelvic angle	6.4	6.8	0.4 deg	6.0	6.5	0.4 deg	6.2	6.6	0.4 deg	0.2	0.2	N/A	0.2	0.2	N/A

N/A = Not available
c.g. = Center of gravity

Table G-4. Maximum Allowable Peak Error-Two Tests Only for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch (07324-1 vs 07324-12)

Channel Description	Forward-Facing Two-Point Hybrid II/ Federal Aviation Administration Hybrid III Anthropomorphic Test Dummies	60° Two-Point* Hybrid II/ Federal Aviation Administration Hybrid III Anthropomorphic Test Dummies	Forward-Facing Three-Point Hybrid II/ Federal Aviation Administration Hybrid III Anthropomorphic Test Dummies	Forward-Facing Four Point Hybrid II/ Federal Aviation Administration Hybrid III Anthropomorphic Test Dummies
Upper neck Fx*			NA/8%	NA/15%
Upper neck Fy*			NA/29%	
Upper neck Fz*			NA/10%	NA/30%
Upper neck Mx*			NA/24%	
Upper neck My*			NA/2%	NA/15%
Chest Ax (CFC 180)			9%/8%	21%/3%
Lumbar Fz		4%/5%		
Right lap belt load	6%/2%		1%/6%	5%/2%
Left lap belt load	6%/2%		8%/1%	7%/7%
Right shoulder belt load				6%/12%
Left shoulder belt load			4%/8%	13%/3%
Seat pan Fx	39%/5%	2.66%/1%	10%/12%	34%/22%
Seat pan Fz	21%/20%	5%/4%	20%/7%	16%/10%
Seat pan My	14%/5%	3%/17/%	7%/9%	66%/23%
Head c.g. x position	0.4 in./0.3 in.		0.2 in./1.6 in.	1.2 in./0.9 in.
Head c.g. z position				0.4 in./0.1 in.
H-point x position	0.1 in./0.1 in.		0.7 in./0.4 in.	1.1 in./0.4 in.
H-point z position	0.1 in./0.2 in.	0.02 in./0.1 in		
Knee x position	0.5 in./0.2 in.			1.3 in./0.6 in.
Shoulder x position			0.4 in./0.5 in.	1.2 in./0.9 in.
Shoulder z position				0.5 in./0.2 in.
Opposite shoulder x position			0.3 in./1.8 in.	
Head angle				7.5°/4.6°
Pelvis angle	2.3°/4.8°	0.4°/2.3°		13.9°/4.3°

*Only two tests (07324-11 and 07324-12) used for Hybrid II Anthropomorphic Test Dummy with two-point belt at 60° configuration.
c.g. = Center of gravity
NA = Not applicable

Table G-5. Maximum Allowable Curve Shape Error for Hybrid II Anthropomorphic Test Dummy With Two-Point Belt at 60° Pitch—Two Tests Only (07324-11 vs 07324-12)

Channel Description	Forward-Facing Two-Point Hybrid II/ Federal Aviation Administration Hybrid III Anthropomorphic Test Dummies (%)	60° Two-Point* Hybrid II/ Federal Aviation Administration Hybrid III Anthropomorphic Test Dummies (%)	Forward-Facing Three-Point Hybrid II/ Federal Aviation Administration Hybrid III Anthropomorphic Test Dummies (%)	Forward-Facing Four Point Hybrid II/ Federal Aviation Administration Hybrid III Anthropomorphic Test Dummies (%)
Upper neck Fx			NA/8	NA/9
Upper neck Fy			NA/28	
Upper neck Fz			NA/16	NA/25
Upper neck Mx			35/40	
Upper neck My			7/10	NA/43
Chest Ax (CFC 180)			9/8	10/4
Lumbar Fz		3/3		
Lumbar My		3/30		
Right lap belt load	6/2		1/6	3/3
Left lap belt load	2/3		7/1	4/5
Right shoulder belt load				8/12
Left shoulder belt load			2/3	14/7
Seat pan Fx	24/6	2.5/1	10/7	15/15
Seat pan Fz	15/13	3/3	13/12	16/4
Seat pan My	10/6	3/9	6/8	64/18
Head c.g. x position	3/1	1/15	1/7	6/5
Head c.g. z position	1/0.3	0.1/0.5	2/1	2/1
H-point x position	1/2		11/5	13/11
H-point z position	1/1	1/3		
Knee x position	1/0.6			4/2
Knee z position	18/8			13/1
Ankle x position	7/1			
Ankle z position	2/1			
Shoulder x position			6/10	15/12
Shoulder z position			1/2	2/0.8
Opposite shoulder x position			1/13	
Opposite shoulder z position			3/3	
Head angle	6/2			6/4
Pelvis angle	7/5	7/46		44/10

*Only two tests (07324-11 and 07324-12) used for Hybrid II Anthropomorphic Test Dummy with two-point belt at 60° configuration.

CFC = Channel frequency class c.g. = Center of gravity NA = Not applicable

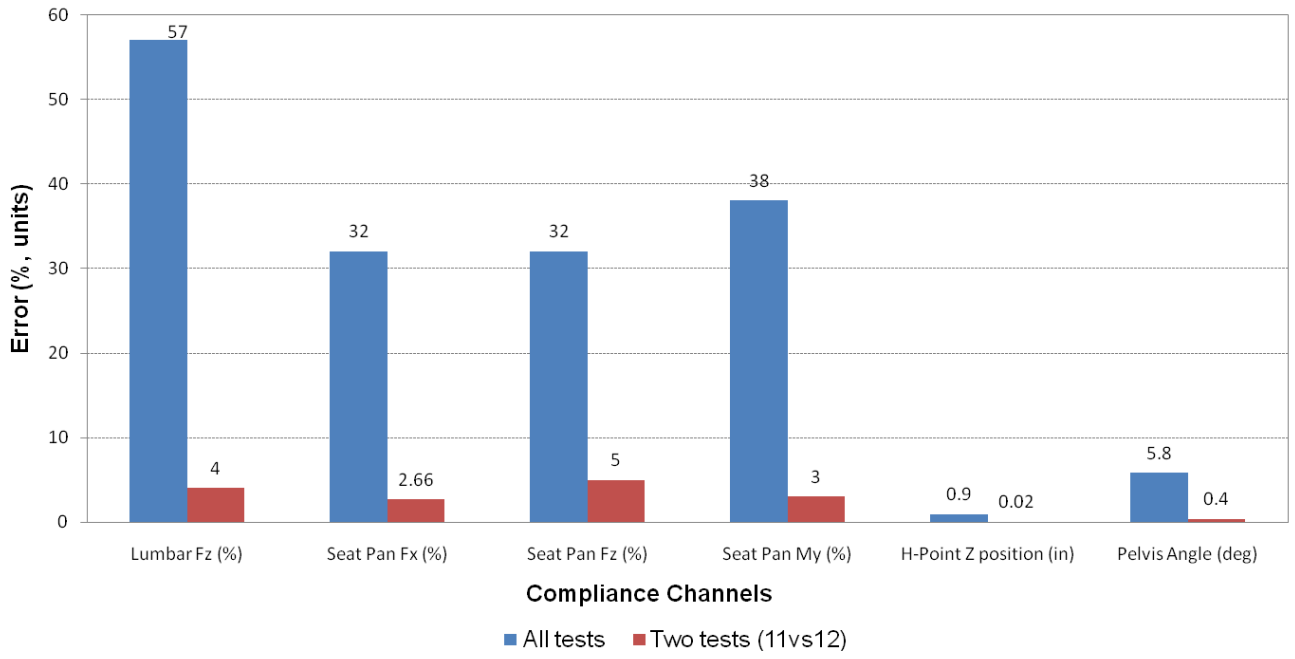


Figure G-19. Comparison ARP Values of Anthropomorphic Test Dummies With Two-Point Belt at 60° Pitch for All Tests vs Two Tests (07324-11 vs 07324-12) (Allowable Peak Error)

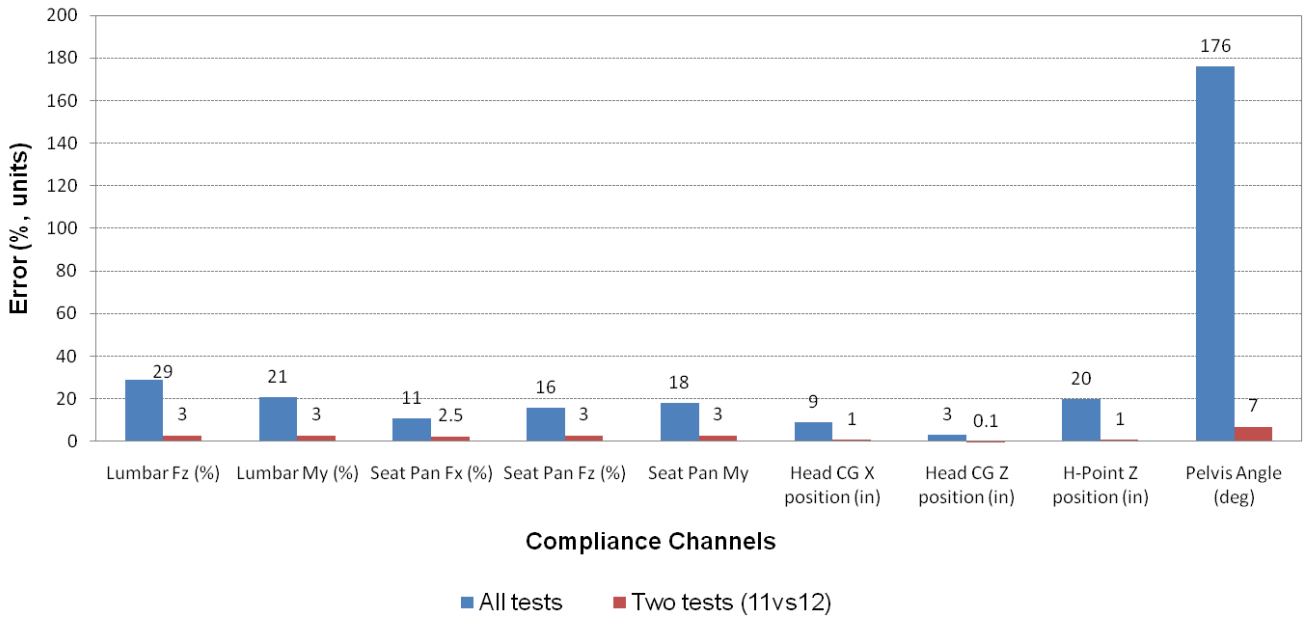


Figure G-20. Comparison ARP Values of Anthropomorphic Test Dummies With Two-Point Belt at 60° Pitch for All Tests vs Two Tests (07324-11 vs 07324-12) (Curve Shape Error)

APPENDIX H—SEAT PAN y MOMENTS CORRECTED FOR ALL CONFIGURATIONS

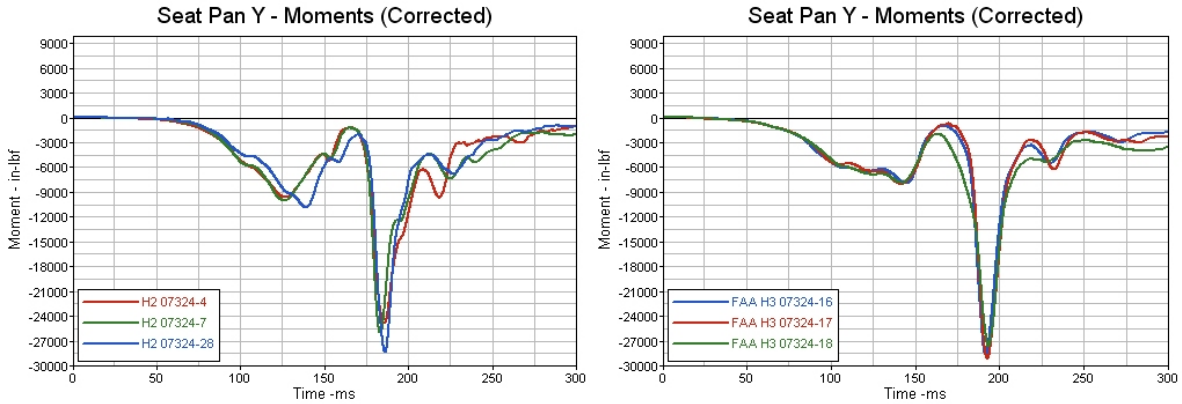


Figure H-1. Seat Pan y Moments Corrected for Hybrid II Anthropomorphic Test Dummy (Left) and Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy (Right) With Two-Point Belt at 0° Pitch

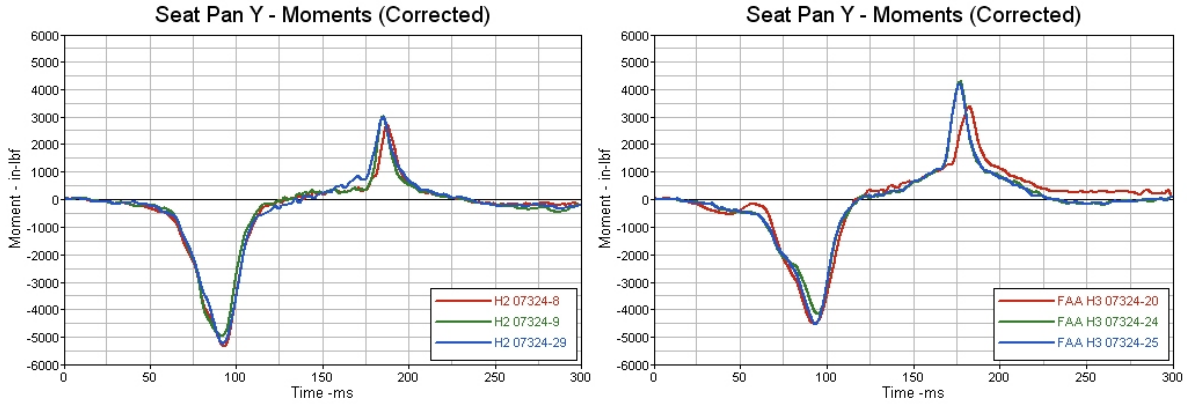


Figure H-2. Seat Pan y Moments Corrected for Hybrid II Anthropomorphic Test Dummy (Left) and Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy (Right) With Three-Point Belt at 0° Pitch

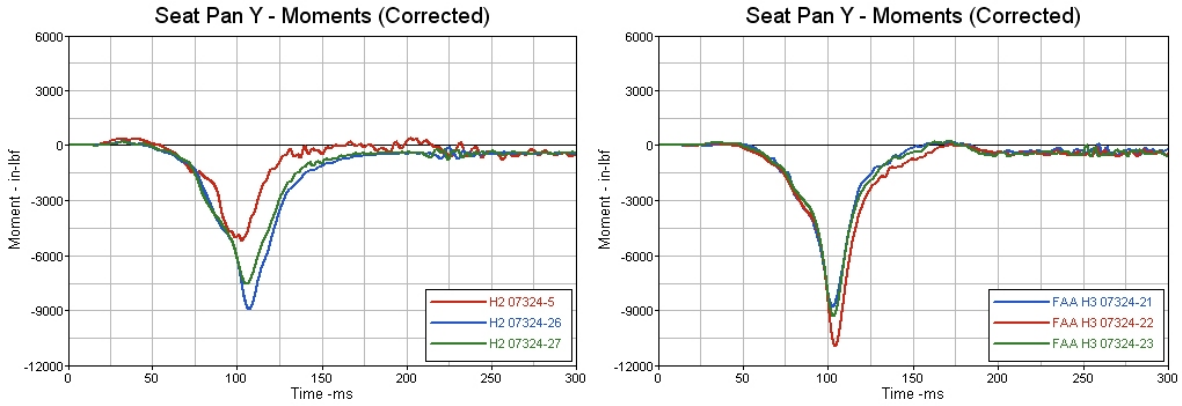


Figure H-3. Seat Pan y Moments Corrected for Hybrid II Anthropomorphic Test Dummy (Left) and Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy (Right) With Four-Point Belt at 0° Pitch

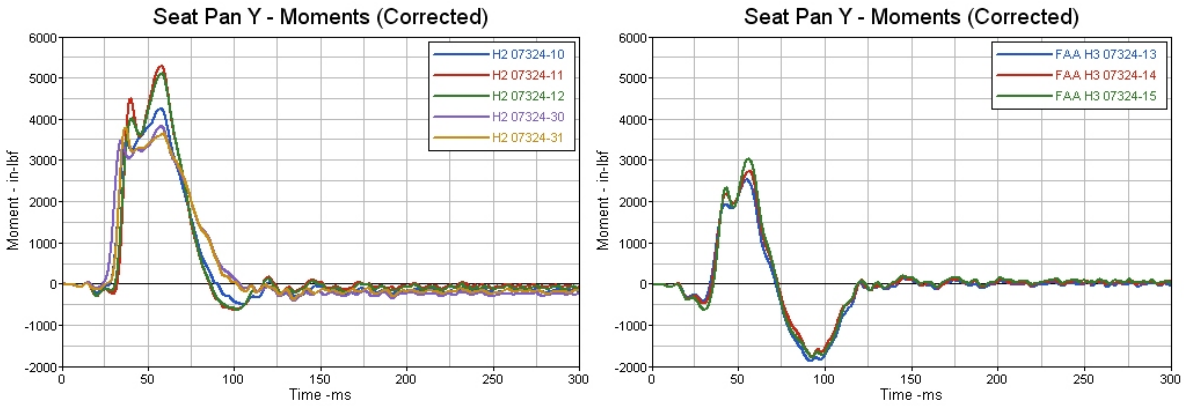


Figure H-4. Hybrid II Seat Pan y Moments Corrected for Hybrid II Anthropomorphic Test Dummy (Left) and Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy (Right) With Two-Point Belt at 60° Pitch

APPENDIX I—H-POINT INITIAL POSITION ANALYSIS

The current Hybrid II Anthropomorphic Test Dummy (ATD) does not come with a specific method to measure the H-Point location. Figure I-1 shows the Hybrid II pelvis drawings. As shown, the H-Point location is defined with respect to the rigid parts of the pelvis. Measurements to the outer surface are reference dimensions only.

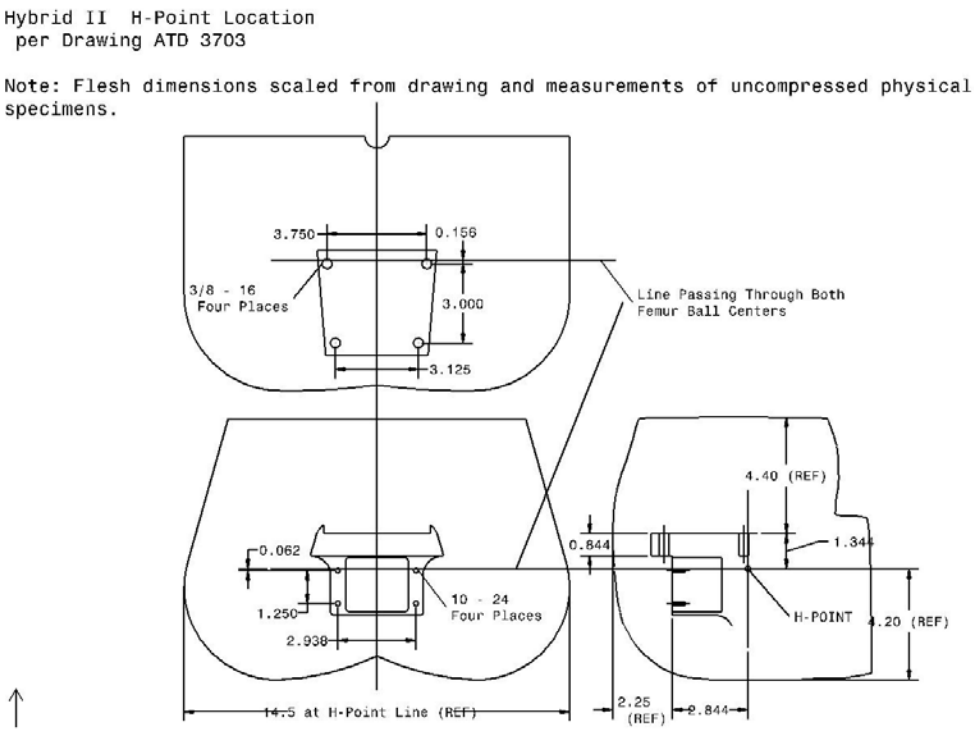


Figure I-1. Hybrid II ATD H-Point Location

Figure I-2 shows the pretest configuration for tests 07324-4, -7, and -28, respectively.

Figure I-2. Tests 07324-4 (left), 07324-7 (middle), and 07324-28 (right) Pretest Configurations Without Cushions

Table I-1 shows the location of important targets with respect to the seat reference point for tests 07324-4, -7, and -28, respectively. Table I-2 shows the maximum difference between ATD target locations. The maximum difference between H-point locations is 0.28 inch in the x direction and 0.06 inch in the z direction.

Table I-1. Tests 07324-4, 07324-7, and 07324-28 Pretest Measurements Without Cushion

	07324-4 Pretest			07324-7 Pretest			07324-28 Pretest		
	x (in.)	y (in.)	z (in.)	x (in.)	y (in.)	z (in.)	x (in.)	y (in.)	z (in.)
Head	1.17	3.01	31.1	0.76	2.8	31	1.37	2.78	30.8
Shoulder R	1.47	8.63	22.4	1.7	8.58	23.1	0.89	8.77	22.8
H-point R	3.35	6.95	3.91	3.49	7.05	3.93	3.63	7.34	3.97
Knee R	19.8	5.86	4.32	19.9	6.28	4.48	20	6.29	4.72
Ankle R	23.9	5.88	-11.5	23	6.34	-11.6	21	5.74	-11.5

R = Right

Table I-2. Maximum Difference Between ATD Targets With a Two-Point Belt at 0° Pitch Without Cushion Pretest Positions

Maximum Difference	x (in.)	y (in.)	z (in.)
Head	0.61	0.23	0.3
Shoulder R	0.81	0.19	0.7
H-point R	0.28	0.39	0.06
Knee R	0.2	0.43	0.4
Ankle R	2.9	0.6	0.1

R = Right

The ATD profiles for these tests are shown in figure I-3. The largest differences are seen in the lower and upper extremities.

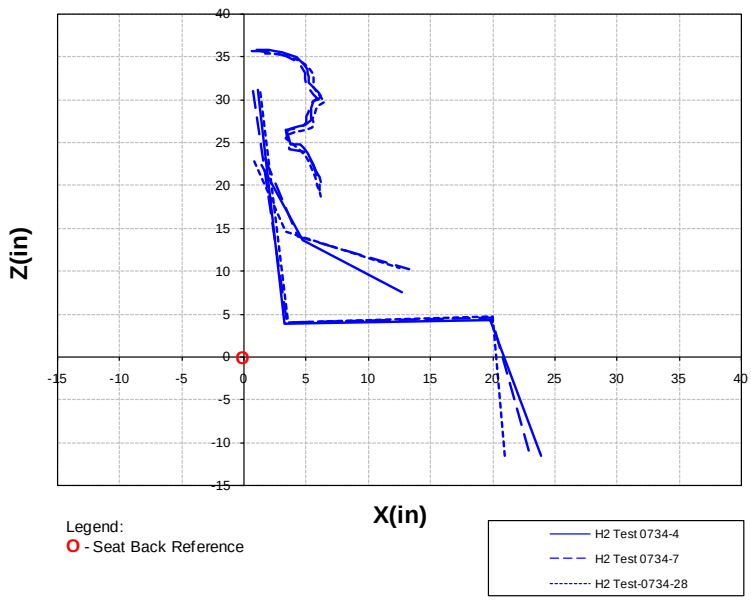


Figure I-3. Pretest Coordinate Comparison for Hybrid II ATDs With a Two-Point Belt at 0° Pitch Without Cushion With Respect to the Seat Reference Point

To better understand the H-point location variability, six new tests were performed using three different ATDs. Three of these tests were performed using a 4-inch-thick cushion on the seat pan.

Each ATD was placed on the rigid seat twice, once with and once without the cushion. In each case, target measurements were taken for head, shoulder, H-point, knee, and ankle. Figure I-4 shows the pelvis for each ATD used.

Figure I-4. HII 719 (left), HII 717 (middle), and HII 699 (right) ATD Pelvises

For these new tests, the test conditions used for tests 07324-4, -7, and -28 were replicated:

- Two sheets of Teflon were used for the seat pan
- One Teflon sheet was used for the floor
- Two-point belt restraint with the same location for the anchor points
- Rigid seat with a seat back angle of 13° and a seat pan angle of 5°
- Same origin for the measurements (center seat pan back edge)

Figure I-5 shows a front view of the initial position for the three ATDs, and figure I-6 shows a close-up of the pelvis position for each ATD.

Figure I-5. HII 719 (left), HII 717 (middle), and HII 699 (right) ATDs With Two-Point Belts at 0° Pitch Without Cushion Pretest Position

Figure I-6. HII 719 (left), HII 717 (middle), and HII 699 (right) ATDs With Two-Point Belts at 0° Pitch Without Cushion

Table I-3 shows the location of important targets with respect to the seat reference point for each ATD. Table I-4 shows the maximum difference between ATD target locations. The maximum difference between H-point locations for these new tests is 0.39 inch in the x direction and 0.45 inch in the z direction. The ATD profiles for these tests are shown in figure I-7.

Table I-3. HII 719, HII 717, and HII 699 ATDs With a Two-Point Belt at 0° Pitch Without Cushion Pretest Measurements

	HII 719 Pretest			HII 717 Pretest			HII 699 Pretest		
	x (in.)	y (in.)	z (in.)	x (in.)	y (in.)	z (in.)	x (in.)	y (in.)	z (in.)
Head	0.43	2.71	31	-0.12	3.20	31.1	1.08	2.21	31
Shoulder R	0.79	8.30	22.3	0.09	9.01	22.4	1.00	8.11	23.2
H-point R	4.14	7.22	4.06	4.41	7.35	4.28	4.53	6.64	3.83
Knee R	19.9	6.31	4.17	20.1	6.20	3.97	20.1	6.51	4.37
Ankle R	24	4.57	-11.5	25.1	4.67	-11.6	24.3	5.42	-11.4

R = Right

Table I-4. Maximum Difference Between ATD Targets With a Two-Point Belt at 0° Pitch Without Cushion Pretest Positions (HII 719, HII 717, and HII 699 ATDs)

Maximum Difference	x (in.)	y (in.)	z (in.)
Head	1.2	0.99	0.11
Shoulder R	0.91	0.9	0.92
H-point R	0.39	0.71	0.45
Knee R	0.23	1.06	0.4
Ankle R	1.09	0.84	0.20

R = Right

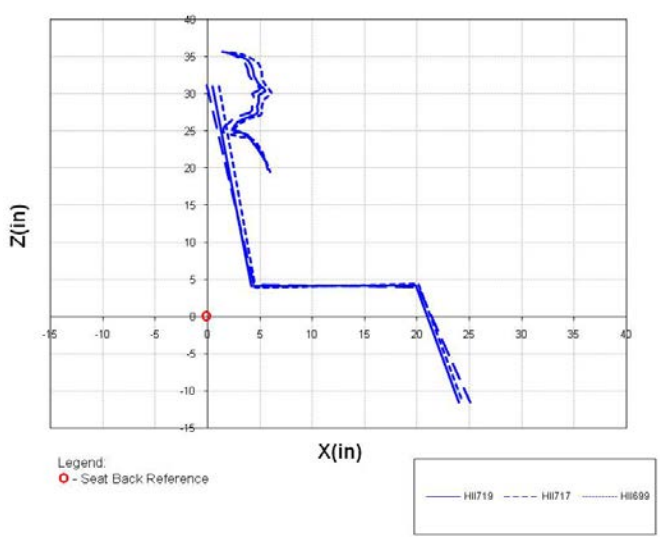


Figure I-7. Pretest Coordinate Comparison for HII 719, HII 717, and HII 699 ATDs With a Two-Point Belt at 0° Pitch Without Seat Cushion With Respect to the Seat Reference Point

Table I-5 shows a detailed comparison between the target locations for tests 07324-4, -7, and -28, respectively. This comparison reveals a small variability in the H-point location for those tests. It is important to notice that these three tests were done using the same ATD and, therefore, the same pelvis.

Table I-6 shows the detailed comparison between the target locations of the new tests using the HII 717, HII 719, and HII 699 ATDs. For these three ATDs, the variability of the H-point location is larger: 0.39 inch in the x direction and 0.45 inch in the z direction.

Thus, the variability of the first series of tests was too small to be used as a reference for further analysis. Figure I-8 shows the ATD profiles for all tests.

Table I-5. Tests 07324-4, 07324-7, and 07324-28 Detailed Target Location Comparisons

FAA Tests	Average x (in.)	Average z (in.)	Maximum x (in.)	Maximum z (in.)	Minimum x (in.)	Minimum z (in.)	Maximum Difference x (in.)	Maximum Difference z (in.)
Head	1.10	30.97	1.37	31.10	0.76	30.80	0.61	0.30
Shoulder R	1.35	22.77	1.70	23.10	0.89	22.40	0.81	0.70
H-point	3.49	3.94	3.63	3.97	3.35	3.91	0.28	0.06
Knee R	19.90	4.51	20.00	4.72	19.80	4.32	0.20	0.40
Ankle	22.63	-11.53	23.90	-11.50	21.00	-11.60	2.90	0.10

R = Right
FAA = Federal Aviation Administration

Table I-6. Test HII 717, HII 719, and HII 699 Detailed Target Location Comparisons

HII Position Tests	Average x (in.)	Average z (in.)	Maximum x (in.)	Maximum z (in.)	Minimum x (in.)	Minimum z (in.)	Maximum Difference x (in.)	Maximum Difference z (in.)
Head	0.46	31.02	1.08	31.06	-0.12	30.95	1.20	0.11
Shoulder R	0.63	22.63	1.00	23.21	0.09	22.29	0.91	0.92
H-point	4.36	4.06	4.53	4.28	4.14	3.83	0.39	0.45
Knee R	20.04	4.17	20.12	4.37	19.89	3.97	0.23	0.40
Ankle	24.44	-11.48	25.06	-11.35	23.96	-11.55	1.09	0.20

R = Right

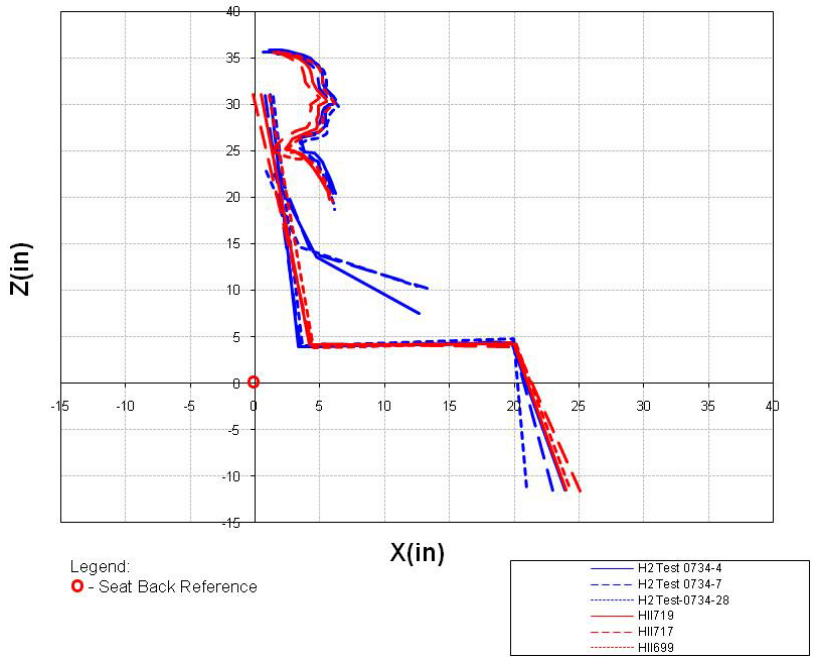


Figure I-8. Pretest Coordinate Comparison of Federal Aviation Administration Tests and HII Position Tests With a Two-Point Belt at 0° Pitch Without Cushion With Respect to the Seat Reference Point

Figure I-9 shows the area where the H-point location should be fitted during the positioning of the ATDs. This area was obtained by using the maximum difference in both x and z coordinates.

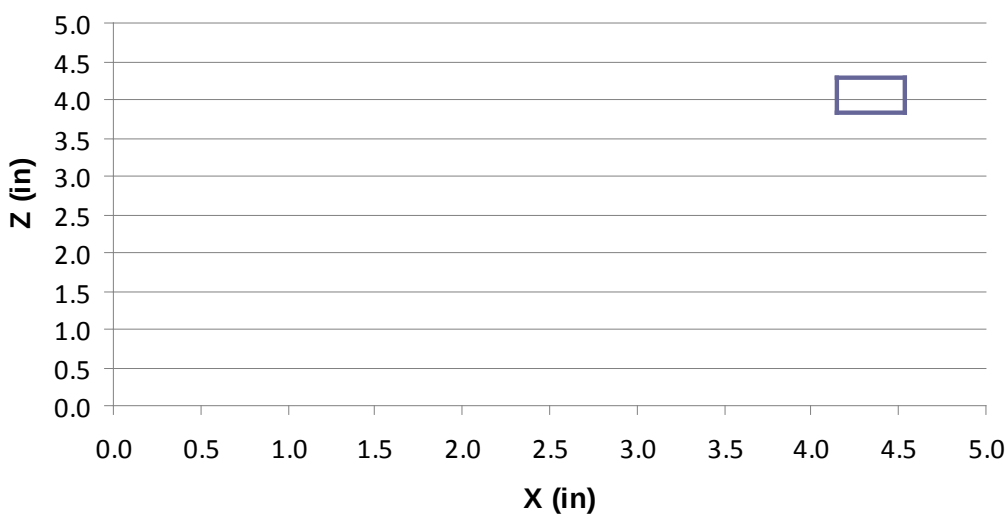


Figure I-9. H-Point Expected Location Region for the HII ATD Without Cushion With Respect to the Seat Reference Point

To more properly understand the variability of the H-point location, three more tests were performed. These three tests used a cushion instead of seating the ATD on top of a rigid surface. The same three HII ATDs were used (HII 717, HII 719, and HII 699).

The cushion used for these tests had a thickness of 4 inches. The material properties are defined by the following load versus deflection curves (figure I-10). The maximum displacement during the test was 3.6 inches (90% of thickness). The loading rate was set at 0.2 in/min.

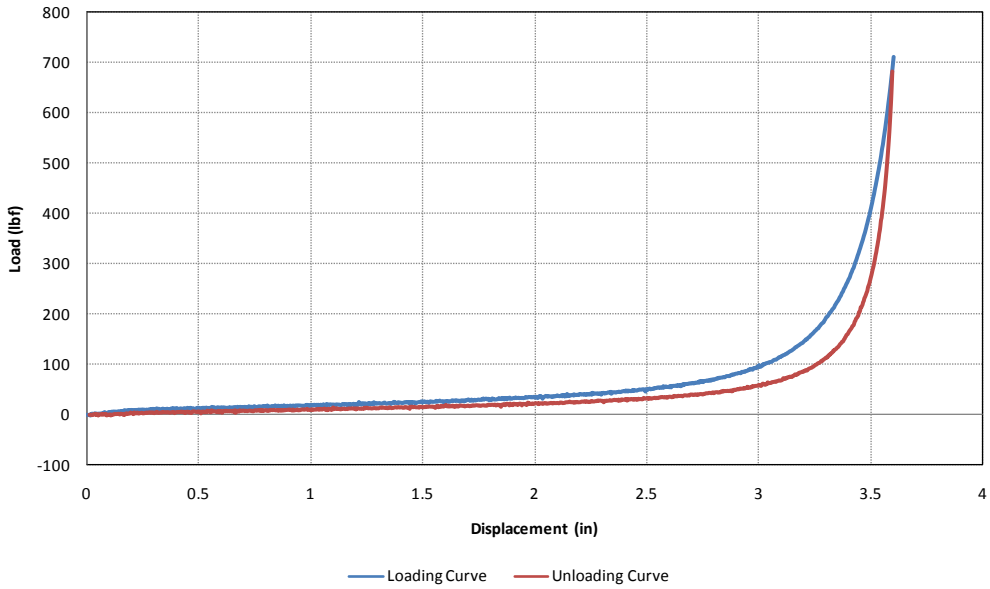


Figure I-10. Quasi-Static Cushion Properties (cushion thickness = 4 inches)

Figure I-11 shows a front view of the initial position for the three ATDs, and figure I-12 shows a close-up of the pelvis position for each ATD.

Figure I-11. The HII 719 (left), HII 717 (middle), and HII 699 (right) ATDs With a Two-Point Belt at 0° Pitch With a 4-Inch Cushion Pretest Position

Figure I-12. The HII 719 (left), HII 717 (middle), and HII 699 (right) ATDs With Two-Point Belt at 0° Pitch With a 4-Inch Cushion

Table I-7 shows the location for important targets with respect to the seat reference point for each ATD. Table I-8 shows the maximum difference between ATD target locations. The maximum difference between H-point locations for these three tests was 0.11 inch in the x direction and 0.56 inch in the z direction. The ATD profiles for these tests are shown in figure I-13.

Table I-7. The HII 719, HII 717, and HII 699 ATDs With a Two-Point Belt at 0° Pitch With a 4-Inch Cushion Pretest Position

	HII 719 Pretest Cushion			HII 717 Pretest Cushion			HII 699 Pretest Cushion		
	x (in.)	y (in.)	z (in.)	x (in.)	y (in.)	z (in.)	x (in.)	y (in.)	z (in.)
Head	-0.04	2.38	32.7	-0.15	1.53	32.6	0.64	1.98	32.7
Shoulder R	0.63	8.25	24.1	-0.21	7.57	24.1	0.62	7.81	24.8
H-point R	3.88	7.68	5.59	3.80	6.60	5.71	3.77	6.11	5.15
Knee R	19.5	6.81	4.78	19.6	5.45	4.40	19.4	6.37	4.41
Ankle R	22	5.33	-11.3	24.1	6.19	-11.2	24.4	6.11	-11.2

R = Right

Table I-8. Maximum Difference Between ATD Targets for a Two-Point Belt at 0° Pitch With a 4-Inch Cushion Pretest Positions (HII 719, HII 717, and HII 699 ATDs)

Maximum Difference	x (in.)	y (in.)	z (in.)
Head	0.79	1.72	0.17
Shoulder R	0.84	1.22	0.72
H-point R	0.11	1.57	0.56
Knee R	0.20	1.36	0.38
Ankle R	2.37	1.08	0.10

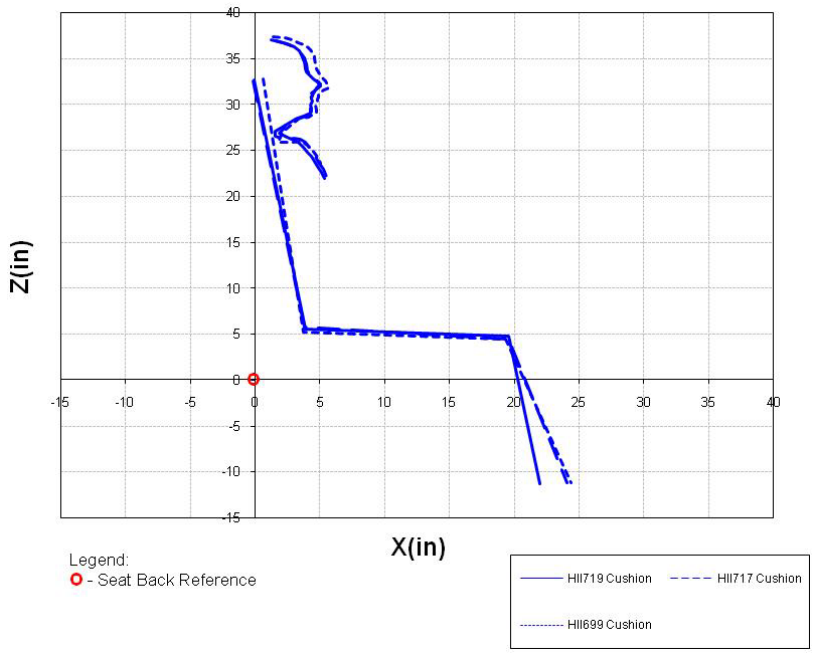


Figure I-13. Pretest Coordinate Comparison for HII 719, HII 717, and HII 699 ATDs With a Two-Point Belt at 0° Pitch With a 4-Inch Cushion With Respect to the Seat Reference Point

Table I-10 shows a detailed comparison between the target locations of the HII 717, HII 719, and HII 699 ATDs. For these three tests, the variability of the H-point location is larger than the previous tests in the z direction (0.56 inch), but smaller in the x direction (0.11 inch).

Figure I-14 shows the comparison between the target locations for both tests, with and without the seat cushion.

Table I-10. Test HII 717, HII 719, and HII 699 Detailed Target Location Comparison With Seat Cushion

HII Position Tests	Average x (in.)	Average z (in.)	Maximum x (in.)	Maximum z (in.)	Minimum x (in.)	Minimum z (in.)	Maximum Difference x (in.)	Maximum Difference z (in.)
Head	0.15	32.65	0.64	32.72	-0.15	32.55	0.79	0.17
Shoulder R	0.34	24.31	0.63	24.77	-0.21	24.05	0.84	0.72
H-point	3.82	5.48	3.88	5.71	3.77	5.15	0.11	0.56
Knee R	19.48	4.53	19.55	4.78	19.35	4.40	0.20	0.38
Ankle	23.47	-11.25	24.35	-11.21	21.98	-11.31	2.37	0.10

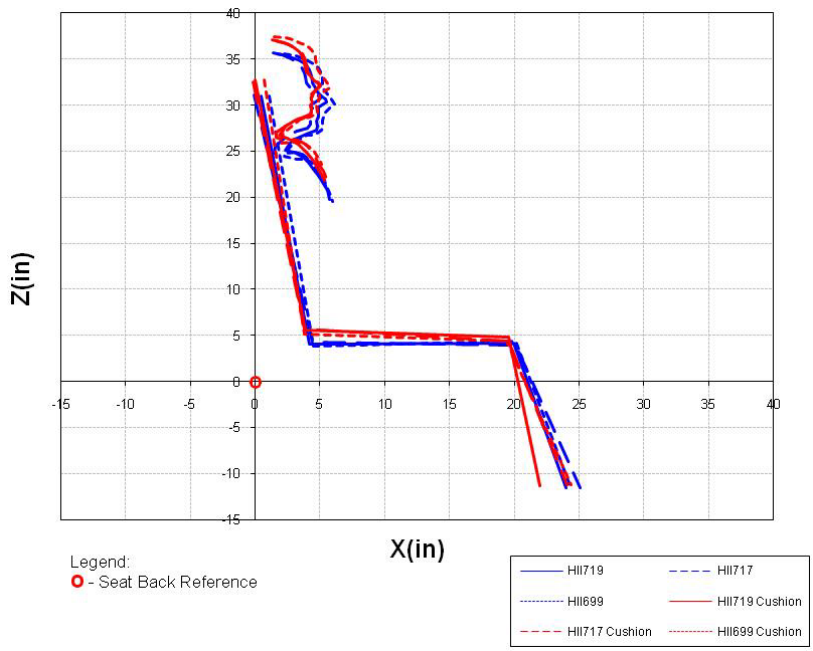


Figure I-14. Pretest Coordinate Comparison of HII Position Tests With and Without Cushion With Two-Point Belt at 0° Pitch With Respect to the Seat Reference Point

Figure I-15 shows the area where the H-point location should be fitted during the position of ATDs for tests with a seat cushion. This area was obtained by using the maximum difference in both x and z coordinates from table I-10.

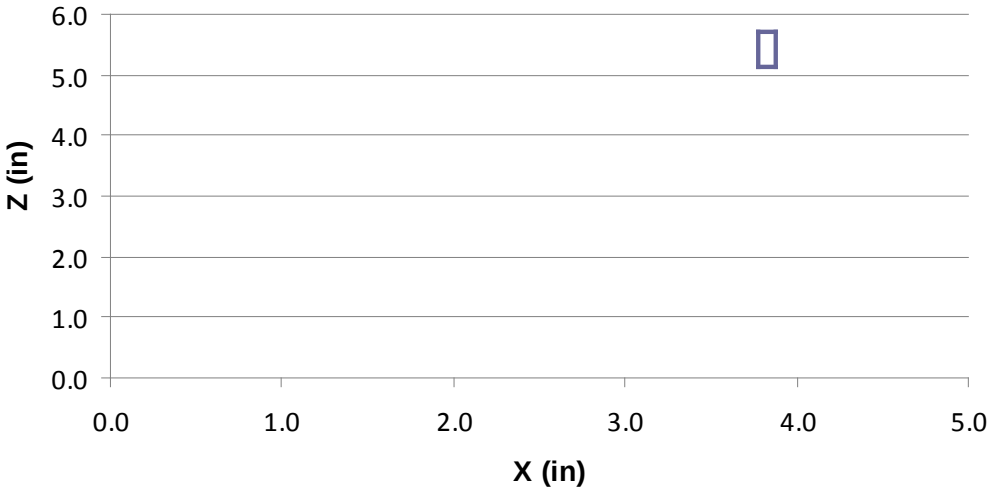


Figure I-15. H-Point Expected Location Region for the HII ATD With Cushion With Respect to the Seat Reference Point

APPENDIX J – SLED TEST REFERENCE DATA AND FOLDER STRUCTURE

The data used in this project is hosted by the FAA and can be accessed from the following website: ftp://ftp.tc.faa.gov/actlibrary

The data are organized as follows:

ROOT – FOLDER

- Test Number – Folder (e.g. 07324-1)
  - DATA – Folder
    - Test Report
    - Data File (.xls)
    - Text Files – Folder
      - Data Channel Data (.txt and .cvs)
  - PICTURES – Folder
    - PRE TEST – Folder
      - Pre-test pictures of the test setup
    - POST TEST – Folder
      - Post-test pictures of the test setup
  - SETUP DATA – Folder
    - Pre-test Data Sheet
    - Pre-test Coordinate Data (.csv and .igs)
    - Post-test Coordinate Data (.csv and .igs)
  - VIDEOS – Folder
    - Test Videos
- Error Metric Macro – Folder
  - Error Metric.xls
- Test Matrix.txt
- Test Matrix.xls
- Test Paper (.doc)

For more information about each test, refer to the test matrix in the folder described above or to table 7 in the main report.