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Comparison of Dynamic Responses of 50th percentile Hybrid II and FAA Hybrid III Anthropometric Test Devices (ATD) during Aircraft Seat Tests

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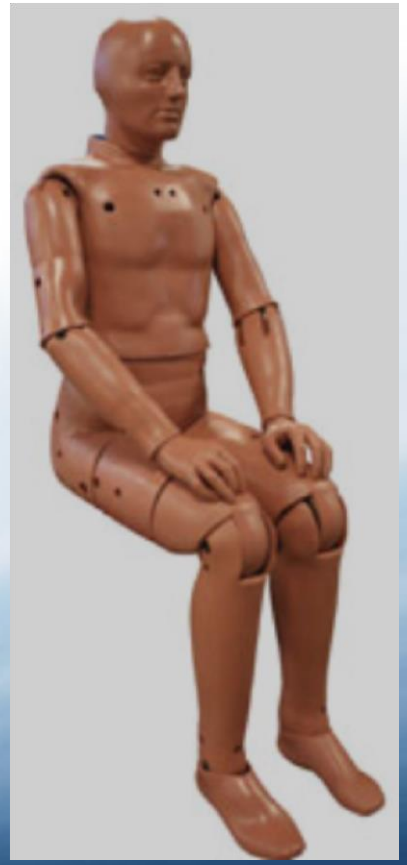


Hybrid II

FAA Hybrid III

Background

History:

- Aircraft seat dynamic qualification tests require use of a Hybrid II ATD or equivalent.
- Auto crash tests now use the Hybrid III ATD, which is a more advanced and biofidelic test dummy.
- A version of the Hybrid III was developed that has been approved by the FAA as equivalent to the Hybrid II [Ref 1].
- Although this ATD (called the FAA Hybrid III) has been available since 2000 it has not been widely used by the aviation industry.
- This lack of acceptance may be due to Industry's concerns that the ATD could interact with the seat/surroundings differently than with the Hybrid II and produce significantly different results.

Purpose:

- The purpose of this project was to review available FAA and Industry data to evaluate the actual differences between Hybrid II and FAA Hybrid III ATD response during dynamic seat tests.

Agenda

ATD Comparison

- Geometry
- Weight

ATD Dynamic Performance

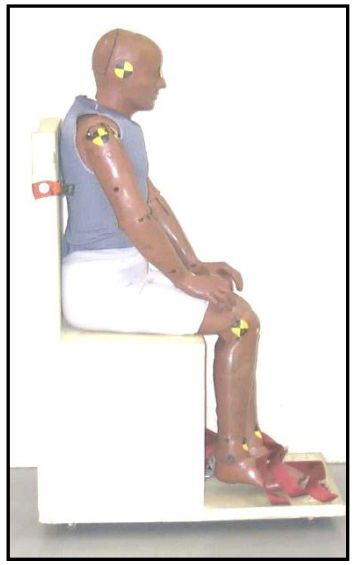
- Repeatability
  - Rigid Seat Vertical Test
  - Rigid Seat Horizontal Test
  - Real Seat Vertical Test
  - Real Seat Horizontal Test
- Test results comparison
  - Rigid Seat Vertical Test
  - Rigid Seat Horizontal Test
  - Real Seat Vertical Test
  - Real Seat Horizontal Test

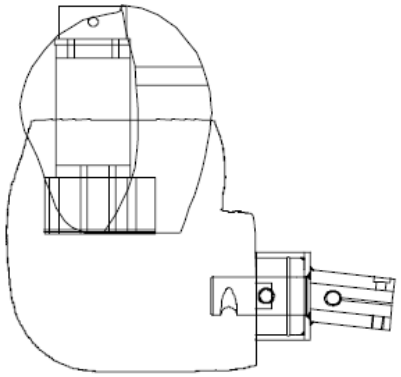
Findings

Conclusions

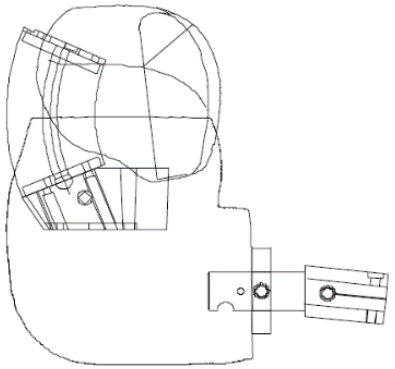
Comparison of Standard 50th Percentile ATDs

Hybrid II (1972)

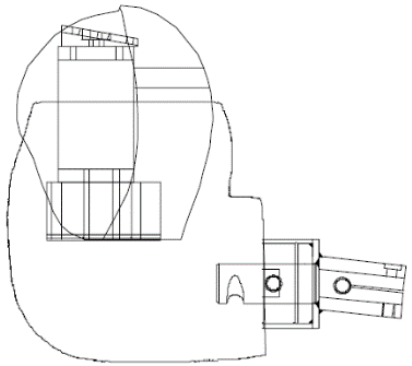




Hybrid III (1986)



FAA Hybrid III (2000)



FAA Hybrid III ATD is predominantly made up of Hybrid III ATD parts except:

- Hybrid II lumbar spine
- Hybrid II abdominal insert
- Hybrid II chest jacket
- Hybrid II upper leg bone
- Hybrid II lumbar load cell and pelvic adaptor block
- Custom thorax/lumbar adaptor

Reference: [1]

ATD Mass and Dimension Comparison

BODY COMPONENT/ SEGMENT	HYBRID II	FAA HYBRID III
HEAD	11.2	10
UPPER TORSO (INCLUDING LUMBAR SPINE)	41.5	41.3
LOWER TORSO (INCLUDING VISCERAL SAC AND UPPER THIGHS)	37.5	37.9
UPPER ARM (BOTH)	9.6	8.8
LOWER ARM (BOTH)	6.8	7.5
HAND (BOTH)	2.8	2.5
UPPER LEG (BOTH)	35.2	34
LOWER LEG AND FOOT (BOTH)	19.4	24
TOTAL (INCLUDING INSTRUMENTATION IN HEAD, CHEST, AND FEMURS)	164 (lb)	166 (lb)
SPECIFIED WEIGHT	**164 ±3 (lb)**	**164 ±3 (LB)**
SPECIFIED SITTING HEIGHT	**35.7 ±0.1 (in)**	**35.7 ±0.1 (in)**
HIP POINT HEIGHT TOLERANCE	**0.4 (in)**	**0.14 (in)**

- Specified total weight and sitting height are identical
- Segment weights are similar
- The pelvis manufacturing tolerances that control the thickness of rubber/foam on the bottom of the pelvis are different

Reference: [1, 4, 5]

ATD Dynamic Performance

ATD Repeatability

- Rigid Seat Vertical Test
- Rigid Seat Horizontal Test
- Real Seat Vertical Test
- Real Seat Horizontal Test

ATD-to-ATD Comparison

- Rigid Seat Vertical Test
- Rigid Seat Horizontal Test
- Real Seat Vertical Test
- Real Seat Horizontal Test

Vertical Test – Rigid Seat, Thin Cushion – Hybrid II

Test repeatability: Lumbar load

ATD	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Test Repeatability
Hybrid II	A12013	9	9.9	635	580	**4.7%**
Hybrid II	A12031	9	10.2	630	553	
Hybrid II	A12011	14	14.5	940	909	**12.6%**
Hybrid II	A12032	14	15.5	1148	1040	
Hybrid II	A12012	19	20.0	1954	1860	**8%**
Hybrid II	A12014	19	19.4	1866	1827	
Hybrid II	A12033*	19	18.4	1919	1986	
*Pulse Failed						

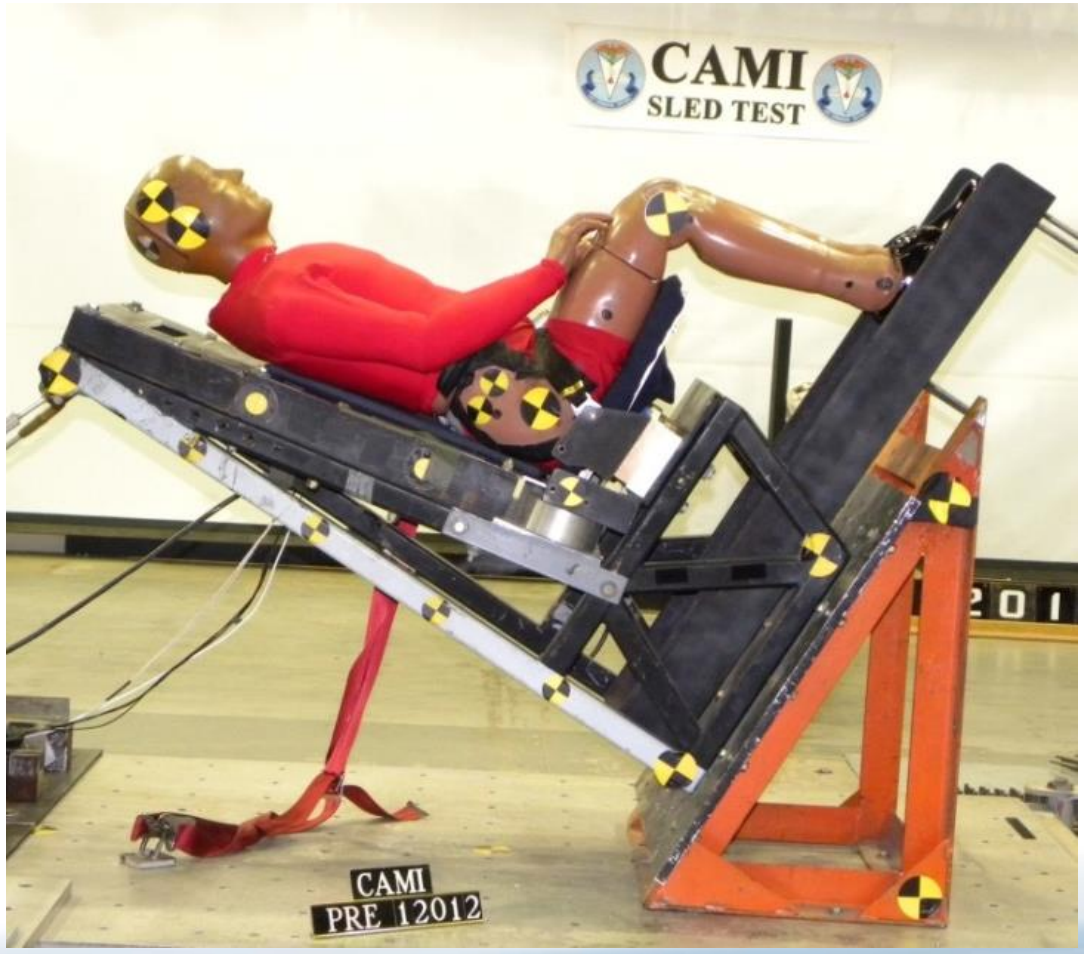
Reference: [2]

ATD	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (14G) (lb)	Test Repeatability
Hybrid II	96041	14	16.0	1362	1195	**3.3%**
Hybrid II	96042	14	16.0	1355	1186	
Hybrid II	96043	14	15.6	1288	1155	

Reference: [3]

$$\text{Test Repeatability} = \frac{\text{Maximum Load} - \text{Minimum Load}}{\text{Maximum Load}} * 100\%$$

Test Repeatability: 3.3% – 12.6%

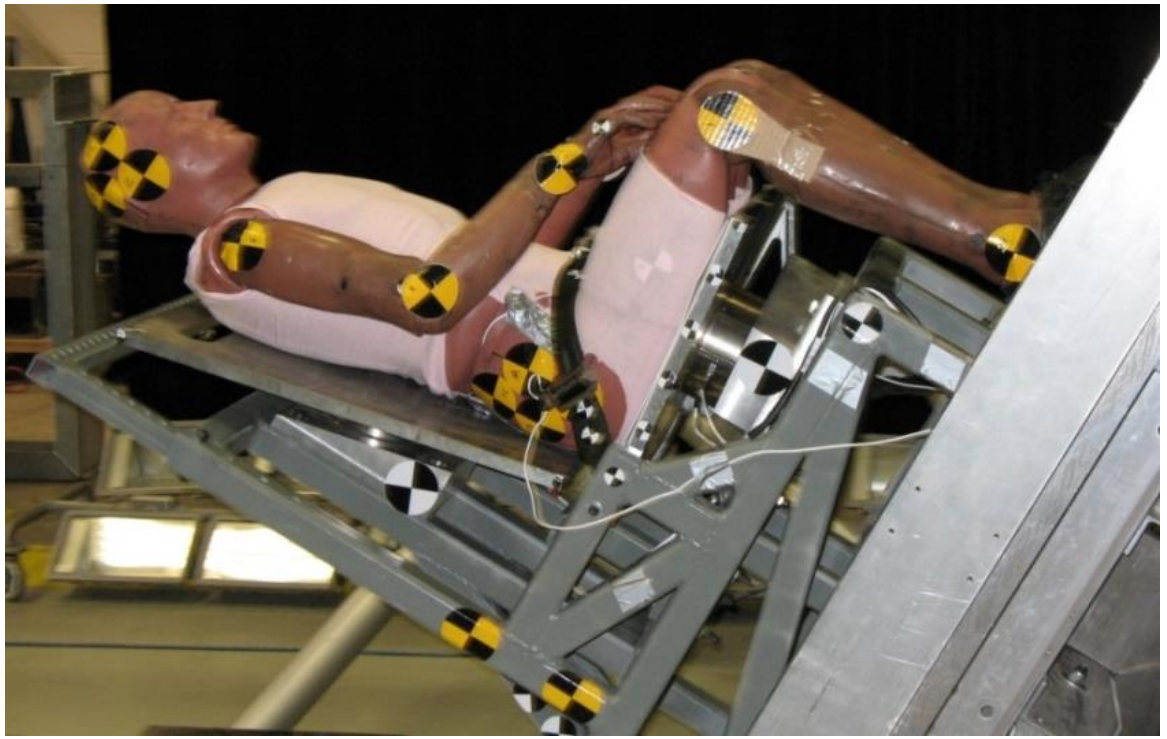


Vertical Test – Rigid Seat, No Cushion – Hybrid II

Test repeatability: Lumbar load

ATD	Teflon (# of sheets)	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Test Repeatability
Hybrid II	0	06165-5	14	14.7	858	817	**13.0%**
Hybrid II	0	06165-6	14	14.6	960	921	
Hybrid II	0	06165-25	14	14.65	837	800	
Hybrid II	0	06165-26	14	14.35	935	912	
Hybrid II	2	07324-11	19	19.66	1757	1698	**2.5%**
Hybrid II	2	07324-12	19	19.43	1693	1655	

Test Repeatability: 2.5% – 13.0%



$$\text{Test Repeatability} = \frac{\text{Maximum Load} - \text{Minimum Load}}{\text{Maximum Load}} * 100\%$$

Reference: [3,4,5]

Vertical Test – Rigid Seat, w & w/o Cushion – FAA Hybrid III

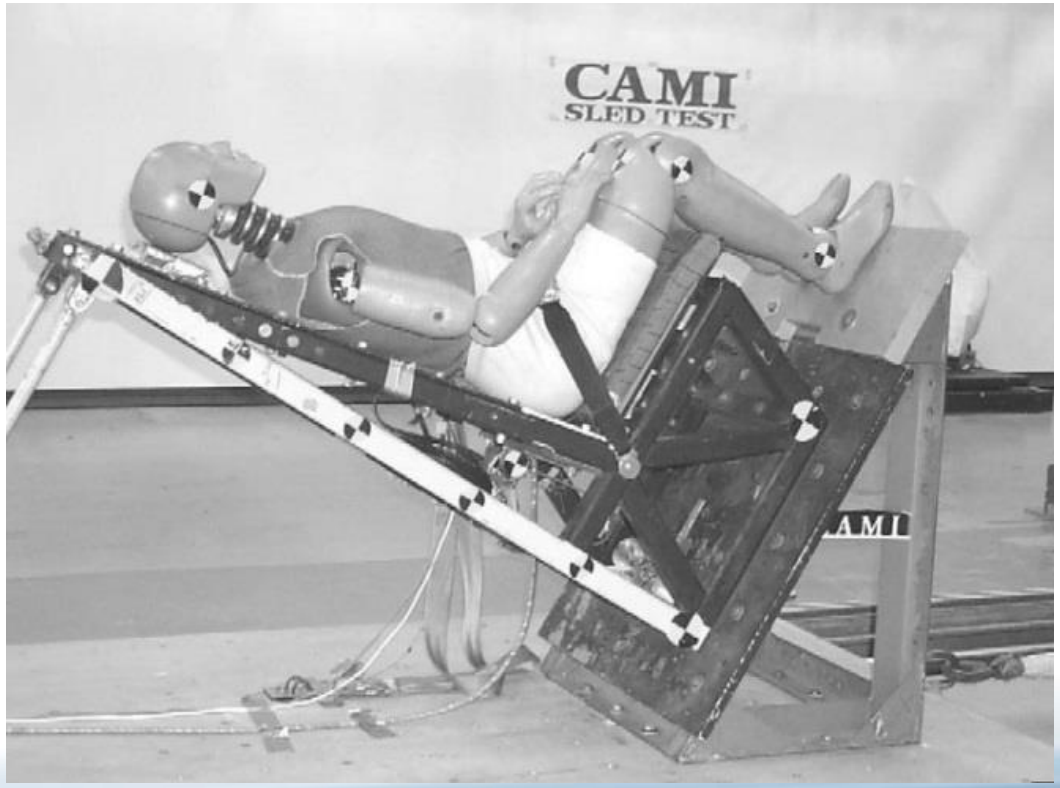
Test repeatability: Lumbar load

Test Repeatability: 4.3% – 6.7%

ATD	Teflon (# of sheets)	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Test Repeatability
FAA Hybrid III	2	07324-13	19	19.08	1713	1705	**4.3**
FAA Hybrid III	2	07324-14	19	19.14	1736	1723	
FAA Hybrid III	2	07324-15	19	19.18	1798	1781	
FAA Hybrid III	NA	06165-7	14	14.6	1013	971	**6.7**
FAA Hybrid III	NA	06165-8	14	14.8	1028	972	
FAA Hybrid III	NA	06165-28	14	14.28	924	906	

ATD	Teflon (# of sheets)	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Test Repeatability
FAA Hybrid III	NA	98032	14	15.0	1236	1154	**4.3**
FAA Hybrid III	NA	98033	14	15.2	1275	1174	
FAA Hybrid III	NA	99010	14	14.8	1275	1206	

$$\text{Test Repeatability} = \frac{\text{Maximum Load} - \text{Minimum Load}}{\text{Maximum Load}} * 100\%$$



Reference: [3,4,5]

Lumbar Load Comparison - Rigid Seat, Thin Cushion

Hybrid II vs FAA Hybrid III

ATD	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Average	Relative Error
Hybrid II	A12013	9	9.9	635	580	567	-8.3%
Hybrid II	A12031	9	10.2	630	553		
FAA Hybrid III	A12028	9	9.9	573	520	520	
Hybrid II	A12011	14	14.5	940	909	975	-10.4%
Hybrid II	A12032	14	15.5	1148	1040		
FAA Hybrid III	A12029	14	15.0	939	874	874	
Hybrid II	A12012	19	20.0	1954	1860	1891	-4.5%
Hybrid II	A12014	19	19.4	1866	1827		
Hybrid II	A12033*	19	18.4	1919	1986		
FAA Hybrid III	A12030*	19	18.7	1774	1806	1806	
*Pulse Failed							

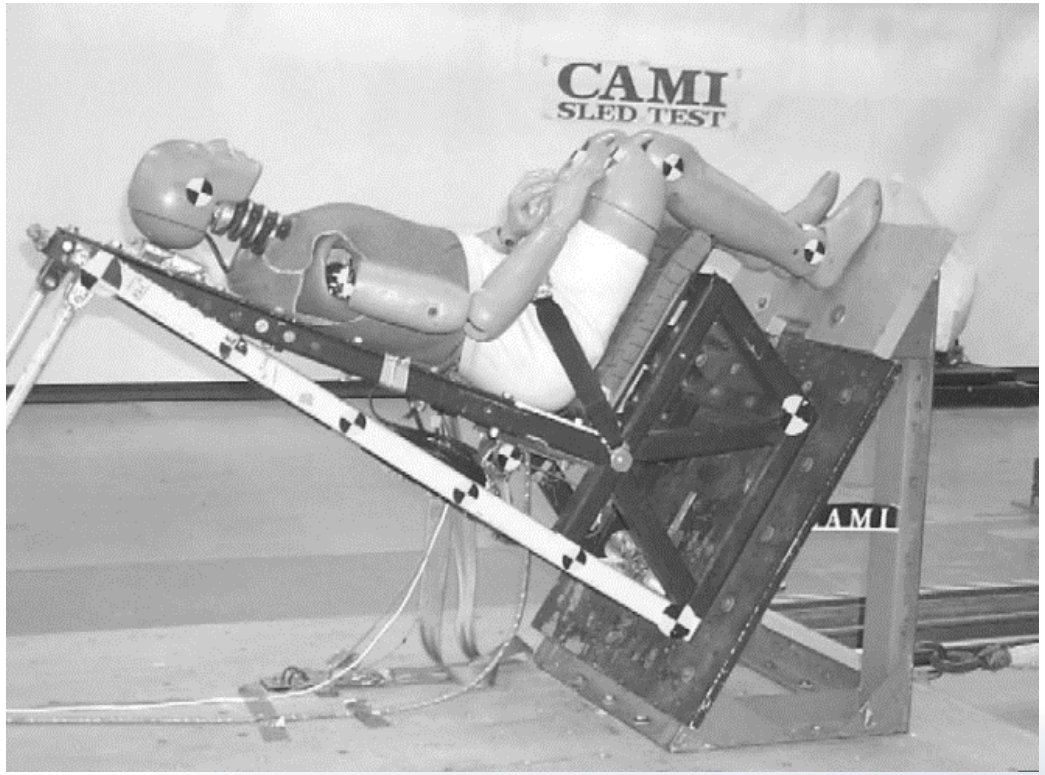
Reference: [2]

ATD	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Average	Relative Error
Hybrid II	96041	14	16.0	1362	1195	1179	0.0%
Hybrid II	96042	14	16.0	1355	1186		
Hybrid II	96043	14	15.6	1288	1155		
FAA Hybrid III	98032	14	15.0	1236	1154	1178	
FAA Hybrid III	98033	14	15.2	1275	1174		
FAA Hybrid III	99010	14	14.8	1275	1206		

Reference: [3]

$$\text{Relative Error} = \frac{\text{Avg(FAA Hybrid III Lumbar Load)} - \text{Avg(Hybrid II Lumbar Load)}}{\text{Avg(Hybrid II Lumbar Load)}}$$

Relative Error: 0.0% – -10.4%



Lumbar Load Comparison - Rigid Seat, No Cushion

Hybrid II vs FAA Hybrid III

Relative Error: 3.6% – 10.2%

ATD	Teflon (# of sheets)	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Average	Relative Error
Hybrid II	2	07324-11	19	19.66	1757	1698	1677	3.6%
Hybrid II	2	07324-12	19	19.43	1693	1655		
FAA Hybrid III	2	07324-13	19	19.08	1713	1705	1737	
FAA Hybrid III	2	07324-14	19	19.14	1736	1723		
FAA Hybrid III	2	07324-15	19	19.18	1798	1781		
Hybrid II	0	06165-5	14	14.7	858	817	862	10.2%
Hybrid II	0	06165-6	14	14.6	960	921		
Hybrid II	0	06165-25	14	14.65	837	800		
Hybrid II	0	06165-26	14	14.35	935	912		
FAA Hybrid III	0	06165-7	14	14.6	1013	971	950	
FAA Hybrid III	0	06165-8	14	14.8	1028	972		
FAA Hybrid III	0	06165-28	14	14.28	924	906		

$$\text{Relative Error} = \frac{\text{Avg(FAA Hybrid III Lumbar Load)} - \text{Avg(Hybrid II Lumbar Load)}}{\text{Avg(Hybrid II Lumbar Load)}}$$

Reference: [3, 4]

Lumbar Load Repeatability - Real Seat

Hybrid II vs FAA Hybrid III

Test Repeatability: 2.0% – 7.1%

ATD	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Test Repeatability
Hybrid II	A99017	14	14.2		1617	**7.1%**
Hybrid II	A99018	14	14.4		1503	
FAA Hybrid III	A99014	14	13.6		1590	**2.0%**
FAA Hybrid III	A99015	14	14.2		1622	

$$\text{Test Repeatability} = \frac{\text{Maximum Load} - \text{Minimum Load}}{\text{Maximum Load}} * 100\%$$

Reference: [9]

Lumbar Load Comparison - Real Seat

Hybrid II vs FAA Hybrid III

ATD	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Average	Relative Error
Hybrid II	A99017	14	14.2		1617	1560	3.0%
Hybrid II	A99018	14	14.4		1503		
FAA Hybrid III	A99014	14	13.6		1590	1606	
FAA Hybrid III	A99015	14	14.2		1622		

Reference: [9]

ATD	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Average	Relative Error
Hybrid II		14			1406	1406	2.2%
FAA Hybrid III		14			1437	1437	

Reference: [8]

$$\text{Relative Error} = \frac{\text{Avg(FAA Hybrid III Lumbar Load)} - \text{Avg(Hybrid II Lumbar Load)}}{\text{Avg(Hybrid II Lumbar Load)}}$$

Relative Error: 2.2% – 3.0%

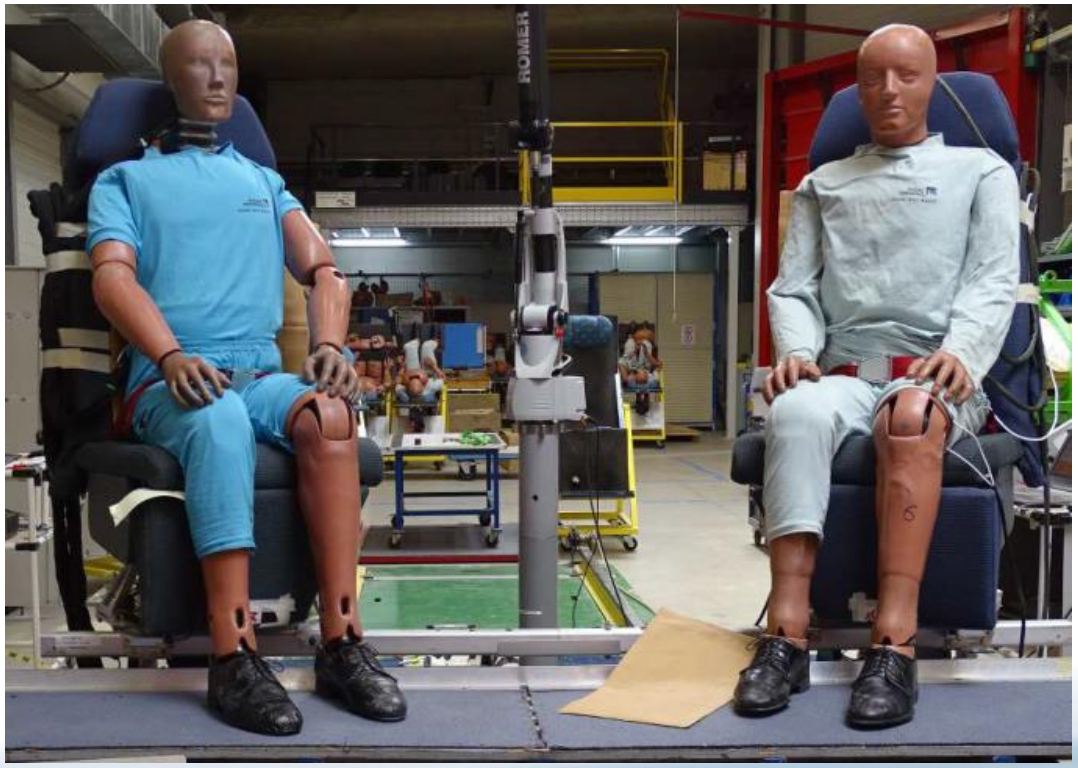
Lumbar Load Comparison - Oblique Bus. Class

Hybrid II vs FAA Hybrid III

Relative Error: 31.4%

ATD	Test Number	Goal G	Peak G	Peak Lumbar (lb)	Normalized Lumbar (lb)	Average	Relative Error
Hybrid II		14			1202	1209.5	31.4%
Hybrid II		14			1217		
FAA Hybrid III		14			1551	1589.5	
FAA Hybrid III		14			1628		

$$\text{Relative Error} = \frac{\text{Avg(FAA Hybrid III Lumbar Load)} - \text{Avg(Hybrid II Lumbar Load)}}{\text{Avg(Hybrid II Lumbar Load)}}$$



Reference: [8]

Findings: Lumbar Load

Rigid Seat

Test Repeatability:
Hybrid II = 3% to 13%
FAA Hybrid III = 4% to 7%

ATD Comparison Relative Error:
1996 Test Series: 0%
2006 Test Series: +4% to +10%
2012 Test Series: -4% to -10%

Overall Repeatability is 13%

Overall Error is ± 10%

Real seats*

Test Repeatability:
Hybrid II = 7%
FAA Hybrid III = 2%

Comparison Relative Error:
1999 Test Series: +3%
2019 Test Series: +2%
2019 Oblique Test Series: +31%

** based on data from a very limited number of tests*

Horizontal Test – Rigid Seat, Thin Cushion – Hybrid II

Hybrid II repeatability: Head path/ Belt load

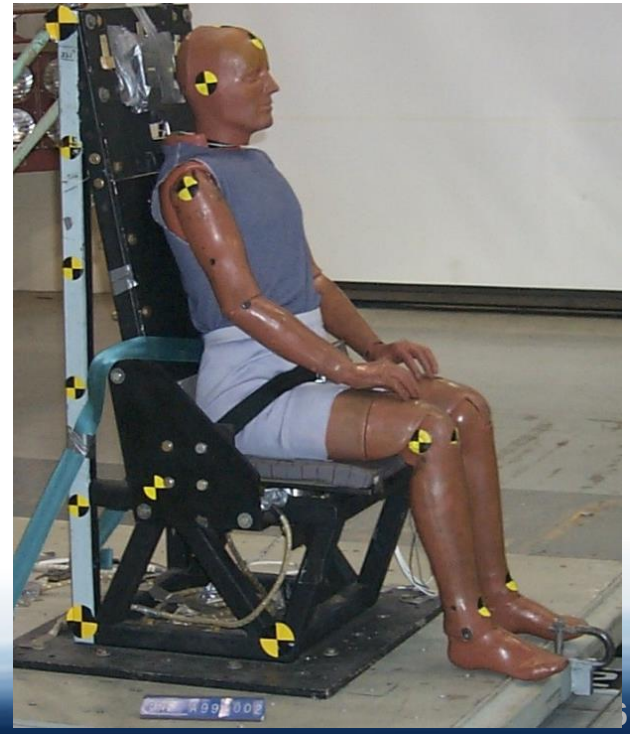
Test Repeatability:

Head path: 0 – 0.4 inch

Lap belt: 0.5% – 3.0%

Torso strap load: 4.8%

Test Config.	ATD	Test Number	Goal G	Peak G	Head Excursion (in)	Test repeatability (in)	Lap Belt Load (lb)	Test repeatability	Torso Strap Load (lb)	Test repeatability
Lap Belt Horizontal	Hybrid II	A99001	18	18.1	39.9	**0.4**	2100	**3.0%**	N/A	N/A
		A99002	18	17.9	40.3		2164		N/A	
4- Point Restraint Horizontal	Hybrid II	A99003	16	16.3	19.5	**0.0**	1839	**0.5%**	1050	**4.8%**
		A99004	16	16.1	19.5		1830		1000	



Comment: Although the sled peak acceleration varied somewhat between the tests, the data was not normalized.

$$\text{Test Repeatability} = \frac{\text{Maximum Load} - \text{Minimum Load}}{\text{Maximum Load}} * 100\%$$

Reference: [1]

Horizontal Test – Rigid Seat, No Cushion – Hybrid II

Hybrid II repeatability: Head path/ Belt load

ATD	Test Number	Belt Type	Goal G	Head Excursion (in)	Left Lap Belt Force (lb)	Right Lap Belt Force (lb)	Shoulder Belt Force - Left (lb)	Shoulder Belt Force - Right (lb)
Hybrid II	07324-4	2	16	35.2	1887.0	1870.0		
Hybrid II	07324-7	2	16	35.7	2002.0	1952.0		
Hybrid II	07324-28	2	16	36.2	1989.0	1976.0		
Hybrid II	07324-8	3	21	18.9	1724.0	2475.0	1606.0	
Hybrid II	07324-9	3	21	18.9	1720.0	2509.0	1641.0	
Hybrid II	07324-29	3	21	19.1	1599.0	2474.0	1574.0	
Hybrid II	07324-5	4	21	14.7	1904.0	1858.0	990.0	935.0
Hybrid II	07324-26	4	21	13.4	2024.0	1958.0	920.0	995.0
Hybrid II	07324-27	4	21	13.5	2042.0	1941.0	874.0	973.0

ATD	Belt Type	Goal G	Head Excursion (in)	Left Lap Belt Force	Right Lap Belt Force	Shoulder Belt Force – Left	Shoulder Belt Force - Right
Hybrid II	2	16	**1.0**	**5.7%**	**5.4%**	N/A	N/A
Hybrid II	3	21	**0.2**	**7.3%**	**1.4%**	**4.1%**	N/A
Hybrid II	4	21	**1.3**	**6.7%**	**5.1%**	**11.7%**	**6.0%**

Comment: Although the sled peak acceleration varied somewhat between the tests, the data was not normalized.

Reference: [4]

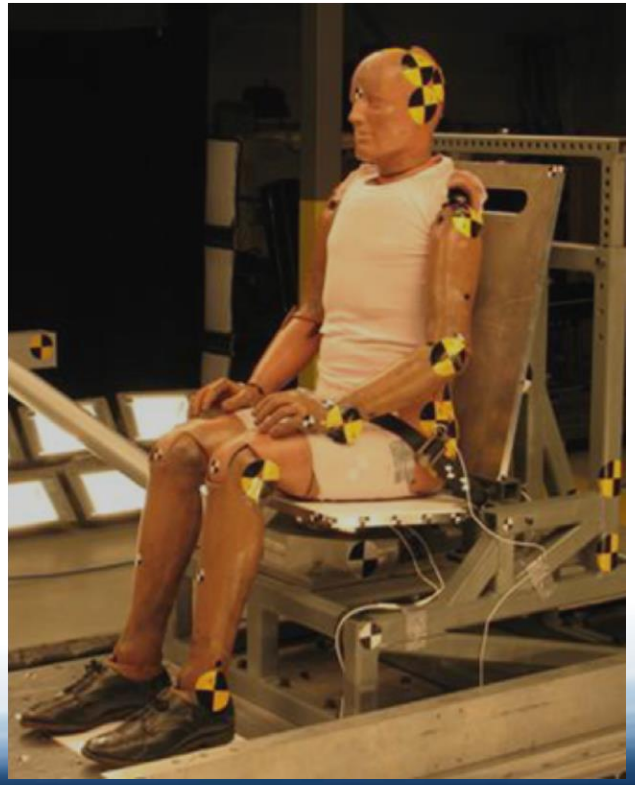
$$\text{Test Repeatability} = \frac{\text{Maximum Load} - \text{Minimum Load}}{\text{Maximum Load}} * 100\%$$

Test Repeatability:

Head path: 0.2 – 1.3 inch

Lap belt: 1.4% – 7.3%

Torso strap load: 4.1% – 11.7%



Horizontal Test – Rigid Seat, Thin Cushion – FAA Hybrid III

FAA Hybrid III repeatability: Head path/ Belt load

Test Config.	ATD	Test Number	Goal G	Peak G	Head Excursion (in)	Lap Belt Load (lb)	Torso Strap Load (lb)
Lap Belt Horizontal	FAA Hybrid III	A98045	18	18.1	40.6	2174	NA
		A98046	18	17.9	40.6	2208	NA
4- Point Restraint Horizontal	FAA Hybrid III	A99005	16	16.3	19.2	1984	900
		A99006	16	15.9	19.5	2068	950

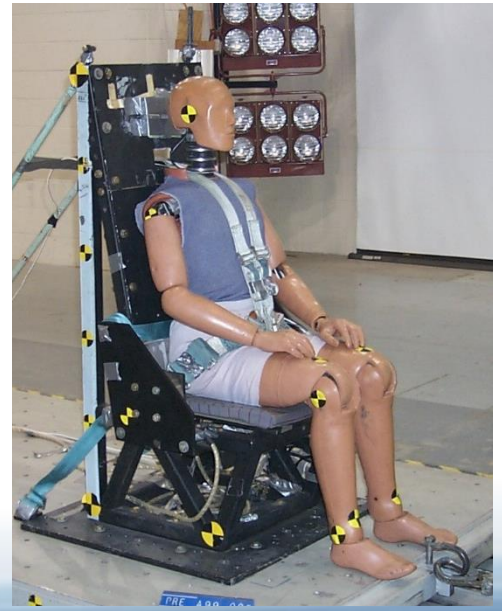
ATD	Belt Type	Goal G	Head Excursion (in)	Lap Belt Force	Shoulder Belt Force - Right
FAA Hybrid III	2	18	**0.0**	**1.5%**	N/A
FAA Hybrid III	4	16	**0.3**	**4.1%**	**5.3%**

Test Repeatability:

Head path: 0.0 – 0.3 inch

Lap belt: 1.5% – 4.1%

Torso strap load: 5.3%



Comment: Although the sled peak acceleration varied somewhat between the tests, the data was not normalized.

$$\text{Test Repeatability} = \frac{\text{Maximum Load} - \text{Minimum Load}}{\text{Maximum Load}} * 100\%$$

Reference: [1]

Horizontal Test – Rigid Seat, No Cushion – FAA Hybrid III

FAA Hybrid III repeatability: Head path/ Belt load

ATD	Test Number	Belt Type	Goal G	Head Excursion (in)	Left Lap Belt Force (lb)	Right Lap Belt Force (lb)	Shoulder Belt Force - Left (lb)	Shoulder Belt Force - Right (lb)
FAA Hybrid III	07324-16	2	16	36.9	1851.0	1776.0		
FAA Hybrid III	07324-17	2	16	37.1	1837.0	1812.0		
FAA Hybrid III	07324-18	2	16	37.4	1817.0	1783.0		
FAA Hybrid III	07324-20	3	21	19.5	1718.0	2324.0	1712.0	
FAA Hybrid III	07324-24	3	21	21.1	1713.0	2420.0	1586.0	
FAA Hybrid III	07324-25	3	21	20.5	1727.0	2471.0	1637.0	
FAA Hybrid III	07324-21	4	21	16.0	1865.0	1870.0	854.0	790.0
FAA Hybrid III	07324-22	4	21	16.9	1961.0	1913.0	828.0	881.0
FAA Hybrid III	07324-23	4	21	16.0	1988.0	1900.0	840.0	885.0

ATD	Belt Type	Goal G	Head Excursion (in)	Left Lap Belt Force	Right Lap Belt Force	Shoulder Belt Force – Left	Shoulder Belt Force - Right
FAA Hybrid III	2	16	**0.5**	**1.8%**	**1.2%**	N/A	N/A
FAA Hybrid III	3	21	**1.6**	**0.8%**	**5.9%**	**7.4%**	N/A
FAA Hybrid III	4	21	**0.9**	**6.2%**	**2.2%**	**3.0%**	**10.7%**

Comment: Although the sled peak acceleration varied somewhat between the tests, the data was not normalized.

$$\text{Test Repeatability} = \frac{\text{Maximum Load} - \text{Minimum Load}}{\text{Maximum Load}} * 100\%$$

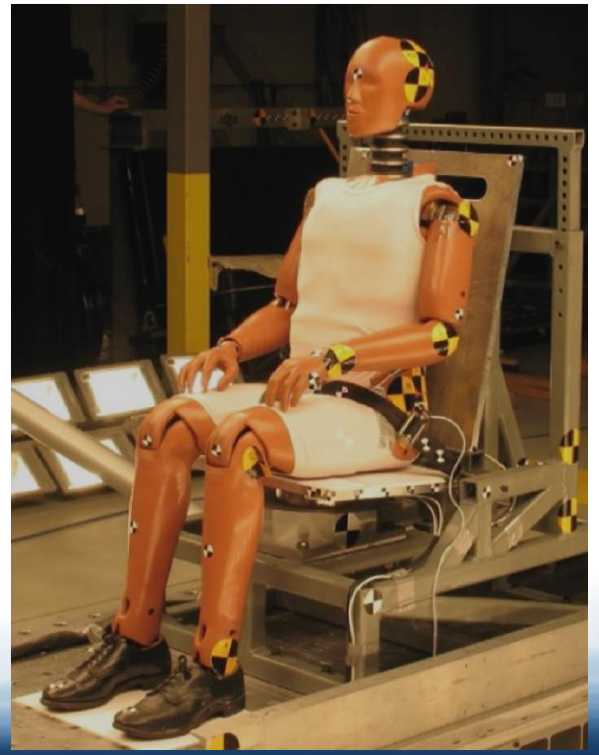
Reference: [4]

Test Repeatability:

Head path: 0.5 – 1.6 inch

Lap belt: 0.8% – 6.2%

Torso strap load: 3.0% – 10.7%



Head Path and Belt Load Comparison - Rigid Seat, Thin Cushion

Hybrid II vs FAA Hybrid III comparison: Head path/ Belt load

Test Config.	ATD	Test Number	Goal G	Peak G	Head Excursion (in)	Lap Belt Load (lb)	Torso Strap Load (lb)
Lap Belt Horizontal	Hybrid II	A99001	18	18.1	39.9	2100	NA
		A99002	18	17.9	40.3	2164	
	FAA Hybrid III	A98045	18	18.1	40.6	2174	
		A98046	18	17.9	40.6	2208	
4- Point Restraint Horizontal	Hybrid II	A99003	16	16.3	19.5	1839	1050
		A99004	16	16.1	19.5	1830	1000
	FAA Hybrid III	A99005	16	16.3	19.2	1984	900
		A99006	16	15.9	19.5	2068	950

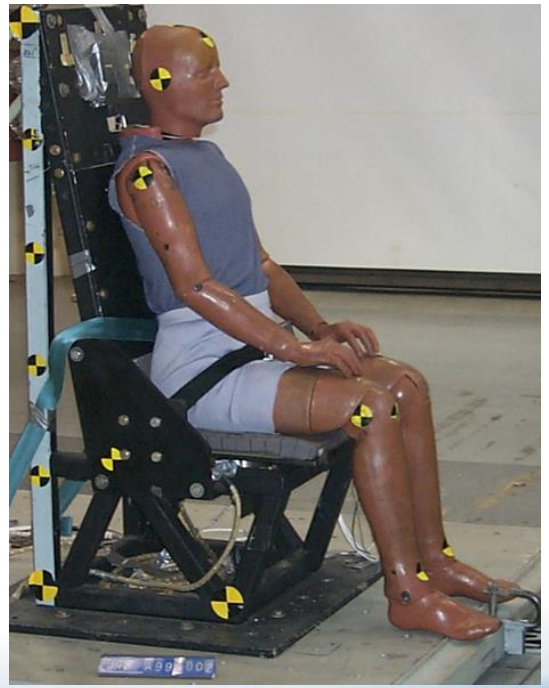
Belt Type	Goal G	Head Excursion (in)	Lap Belt Load	Torso Strap Load
2	18	**0.5**	**2.8%**	N/A
4	16	**-0.2**	**10.4%**	**-9.8%**

Relative Error:

Head path: -0.2 – 0.5 inch

Lap belt: 2.8% – 10.4%

Torso strap load: -9.8%



Comment: Although the sled peak acceleration varied somewhat between the tests, the data was not normalized.

$$\text{Relative Error} = \frac{\text{Avg(FAA Hybrid III Load)} - \text{Avg(Hybrid II Load)}}{\text{Avg (Hybrid II Load)}}$$

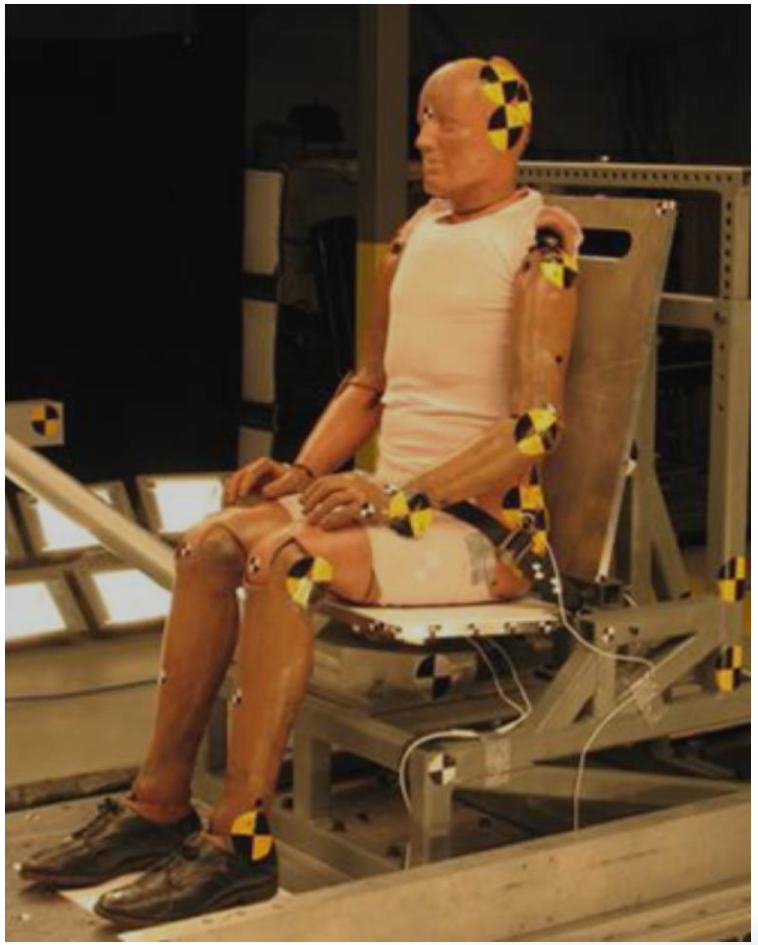
Reference: [1]

Head Path and Belt Load Comparison - Rigid Seat, No Cushion

Hybrid II Vs FAA Hybrid III Test comparison: Head path/ Belt load

Raw Data

ATD	Test Number	Belt Type	Goal G	Head Excursion (in)	Left Lap Belt Force (lb)	Right Lap Belt Force (lb)	Shoulder Belt Force - Left (lb)	Shoulder Belt Force - Right (lb)
Hybrid II	07324-4	2	16	35.2	1887.0	1870.0		
Hybrid II	07324-7	2	16	35.7	2002.0	1952.0		
Hybrid II	07324-28	2	16	36.2	1989.0	1976.0		
FAA Hybrid III	07324-16	2	16	36.9	1851.0	1776.0		
FAA Hybrid III	07324-17	2	16	37.1	1837.0	1812.0		
FAA Hybrid III	07324-18	2	16	37.4	1817.0	1783.0		
Hybrid II	07324-8	3	21	18.9	1724.0	2475.0	1606.0	
Hybrid II	07324-9	3	21	18.9	1720.0	2509.0	1641.0	
Hybrid II	07324-29	3	21	19.1	1599.0	2474.0	1574.0	
FAA Hybrid III	07324-20	3	21	19.5	1718.0	2324.0	1712.0	
FAA Hybrid III	07324-24	3	21	21.1	1713.0	2420.0	1586.0	
FAA Hybrid III	07324-25	3	21	20.5	1727.0	2471.0	1637.0	
Hybrid II	07324-5	4	21	14.7	1904.0	1858.0	990.0	935.0
Hybrid II	07324-26	4	21	13.4	2024.0	1958.0	920.0	995.0
Hybrid II	07324-27	4	21	13.5	2042.0	1941.0	874.0	973.0
FAA Hybrid III	07324-21	4	21	16.0	1865.0	1870.0	854.0	790.0
FAA Hybrid III	07324-22	4	21	16.9	1961.0	1913.0	828.0	881.0
FAA Hybrid III	07324-23	4	21	16.0	1988.0	1900.0	840.0	885.0



Reference: [4]

Head Path and Belt Load Comparison - Rigid Seat, No Cushion

Hybrid II Vs FAA Hybrid III Test comparison: Head path/ Belt load

Relative Error

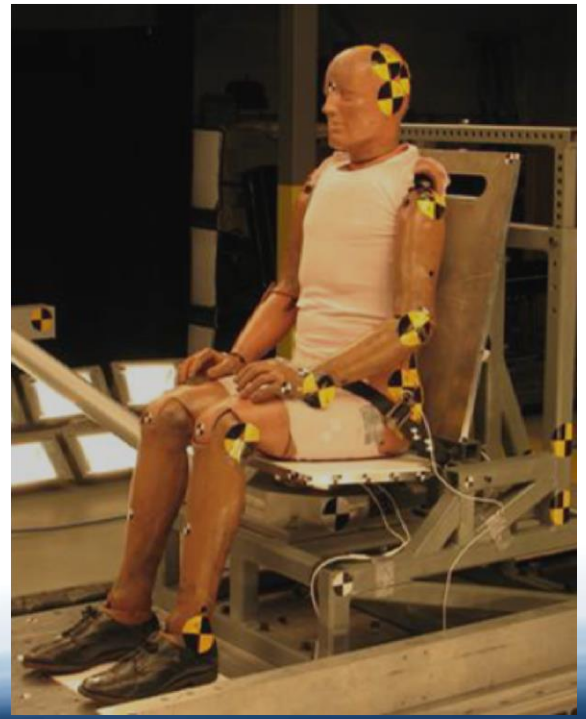
Belt Type	Goal G	Head Excursion (in)	Left Lap Belt Force	Right Lap Belt Force	Shoulder Belt Force – Left	Shoulder Belt Force - Right
2	16	**1.4**	**-6.3%**	**-7.3%**	N/A	N/A
3	21	**1.4**	**2.3%**	**-3.2%**	**2.4%**	N/A
4	21	**2.4**	**2.7%**	**1.3%**	**-9.4%**	**-12.0%**

Relative Error:

Head path: 1.4 – 2.4 inch

Lap belt: -7.3% – 2.7%

Torso strap load: -12.0 – 2.4%



$$\text{Relative Error} = \frac{\text{Avg(FAA Hybrid III Load)} - \text{Avg(Hybrid II Load)}}{\text{Avg (Hybrid II Load)}}$$

Reference: [4]

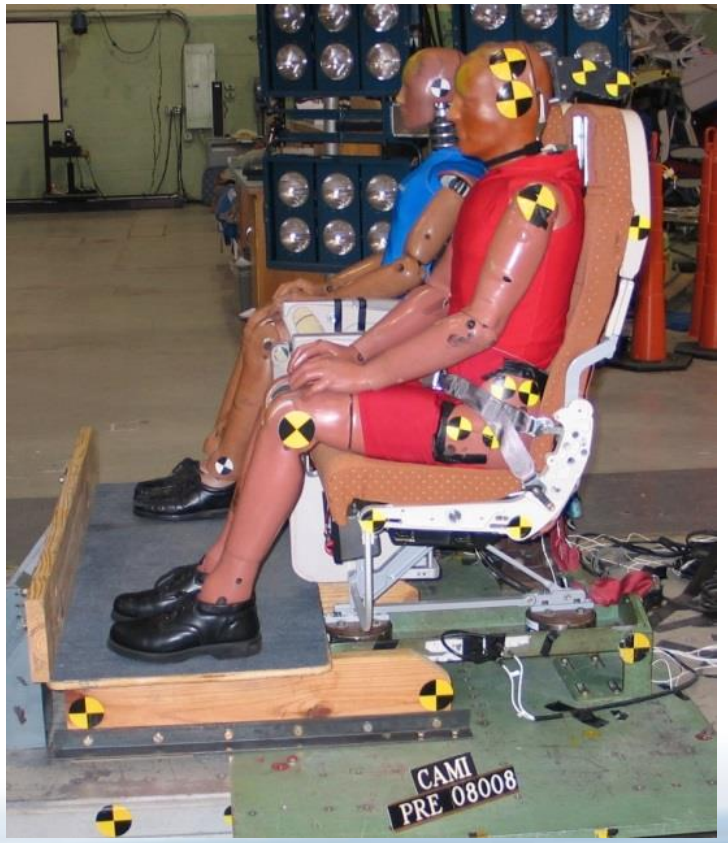
Horizontal Test – Real Seat – Hybrid II

Hybrid II repeatability: Head path/ Belt load

Test Repeatability: 0.3 inch

Y Belt and No Wall Configuration (Real Seat)

ATD	Test Number	Belt and Wall Config		Peak G	dV (ft/s)	X-Path peak (in)	X-Path difference (in)
Hybrid II	A08008	Y Belt	No	17.1	46.9	37.4	**0.3**
Hybrid II	A08009	Y Belt	No	17.7	47.0	37.7	



Comment: Although the sled peak acceleration varied somewhat between the tests, the total sled velocity change was essentially the same. Therefore the excursion data was not normalized.

Reference: [6,7]

Head Path Comparison - Real Seat

Hybrid II Vs FAA Hybrid III Test comparison: Head path/ Belt load

Y Belt and No Wall/ near wall Configuration (Real Seat)

ATD	Test Number	Belt and Wall Config		Peak G	dV (ft/s)	X-Path peak (in)	Relative Error (in)
Hybrid II	A09005	Nylon, Lap Belt	No	16.5	46.6	40.7	**0.6**
FAA Hybrid III	A09007	Nylon, Lap Belt	No	16.0	46.5	41.3	
Hybrid II	A09006	Poly, Lap Belt	No	15.8	46.3	40	**0.4**
FAA Hybrid III	A09008	Poly, Lap Belt	No	17.1	46.9	40.4	
Hybrid II	A09008	Y Belt	No	17.1	46.9	37.4	**0.45 (avg)**
Hybrid II	A09009	Y Belt	No	17.7	47.0	37.7	
FAA Hybrid III	A09009	Y Belt	No	17.7	47.0	38	
Hybrid II	A09011	Y Belt	Near Wall	16.2	44.5	35.9	**0.2**
FAA Hybrid III	A09011	Y Belt	Near Wall	16.2	44.5	35.7	

Relative Error: 0.2 – 0.6 inch

Reference: [6,7]

$$\text{Relative Error} = \frac{\text{FAA Hybrid III Load} - \text{Hybrid II Load}}{\text{Hybrid II Load}}$$

Findings: Head Path During Horizontal Tests - Rigid Seat

Test Repeatability:

Lap Belt:
Hybrid II = 1 inch
FAA Hybrid III = 0.5 inch

3-Point Belt:
Hybrid II = 0.2 inch
FAA Hybrid III = 1.6 inch

4-Point Belt:
Hybrid II = 1.3 inch
FAA Hybrid III = 0.9 inch

Comparison Relative Error:

Lap Belt:
1999 Series: +0.5 inch
2007 Series: +1.4 inch

3-Point Belt:
2007 Series: +1.4 inch

4-Point Belt:
1999 Series: -0.2 inch
2007 Series: +2.4 inch

Findings: Head Path During Horizontal Tests – Real Seat

Test Repeatability:

Lap Belt:
Hybrid II = 0.3 inch
Hybrid III = no data available

Comparison Relative Error:

Lap Belt:
Nylon Belt: +0.6 inch
Poly Belt: +0.4 inch
Y-belt: +0.5 inch
Y-belt near wall: -0.2 inch

Findings: Lap Belt Tension – Rigid Seat

Test Repeatability:

Lap Belt:
Hybrid II = 3.0 to 5.7%
FAA Hybrid III = 1.2 to 1.8%

3-Point Belt:
Hybrid II = 1.4 to 7.3%
FAA Hybrid III = 0.8 to 5.9%

4-Point Belt:
Hybrid II = 5.1 to 6.7%
FAA Hybrid III = 2.2 to 6.2%

Comparison Relative Error:

Lap Belt:
1999 Series: +2.8%
2007 Series: -6.3 to -7.3%

3-Point Belt:
2007 Series: -3.2 to +2.3%

4-Point Belt:
1999 Series: +10.4%
2007 Series: +1.3 to +2.7%

Findings: Shoulder Belt Tension – Rigid Seat

Test Repeatability:

3-Point Belt:
Hybrid II = 4.1%
FAA Hybrid III = 7.4%

4-Point Belt:
Hybrid II = 4.8 to 11.7%
FAA Hybrid III = 3.0 to 10.7%

Comparison Relative Error:

3-Point Belt:
2007 Series: +2.4%

4-Point Belt:
1999 Series: -9.8%
2007 Series: -9.4 to -12.0%

Conclusions

Forward-facing seats:

- ***Rigid seats:***
  - Overall, the FAA Hybrid III ATD showed better repeatability than Hybrid II for lumbar load, head path, and belt tension.
  - The relative error between the FAA Hybrid III and Hybrid II was generally within the repeatability range of the ATDs.
- ***Real seats:***
  - Real seat vertical test results showed better repeatability for both ATD's and better relative error than the rigid seat tests. This observation, however, is based on a very small number of real seat tests.

Obliquely-facing seats:

- Large lumbar load differences between the two ATDs were observed.
- Further investigation is needed to determine the source of this difference.

References

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4). Gerardo Olivares, “Hybrid II and Federal Aviation Administration Hybrid III Anthropomorphic Test Dummy Dynamic Evaluation Test Series”. DOT/FAA/AR-11/24, 2011.

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8). H2 and H3 FAA lumbar load response in 14G test, Safron Seats France, Unpublished Case Study, 2019.

9). Previously unpublished data from FAA Civil Aerospace Medical Institute follow-on tests related to project described in Ref 1.