NHTSA's Initial Evaluation of Child Side Impact Protection

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May 14, 2008

Outline

- Background
- Test Conditions
- Test Series
- Future Work

Children Involved in Side Impacts

- Children represent more than 50% of the rear seat occupants in motor vehicle crashes
  - Side impacts account for 27% of crashes involving 0-12 yr old occupants (NASS-CDS 1995, 1996, 1998-2004)
    - 42% involved 0-3 years old
    - 36% involved 4-8 year olds
    - 22% involved 9-12 year olds

Children Involved in Side Impacts

- Side impacts with $\Delta V \geq 30$ kph produced 104 injuries in 28 children ages 1-3 yrs. (unweighted due to paucity of data, NASS-CDS)
  - PDOF of side impact crashes is approx. 30° off lateral
  - Near-side and center occupants suffered more severe injuries (AIS2+) than far-side occupants
  - Direct contact with vehicle interior responsible for 45% (47) of injuries
    - Head - 57% of injuries
    - Torso - 21% of injuries
    - Neck, upper and lower extremities - 6%-9% of injuries

Children Involved in Side Impacts

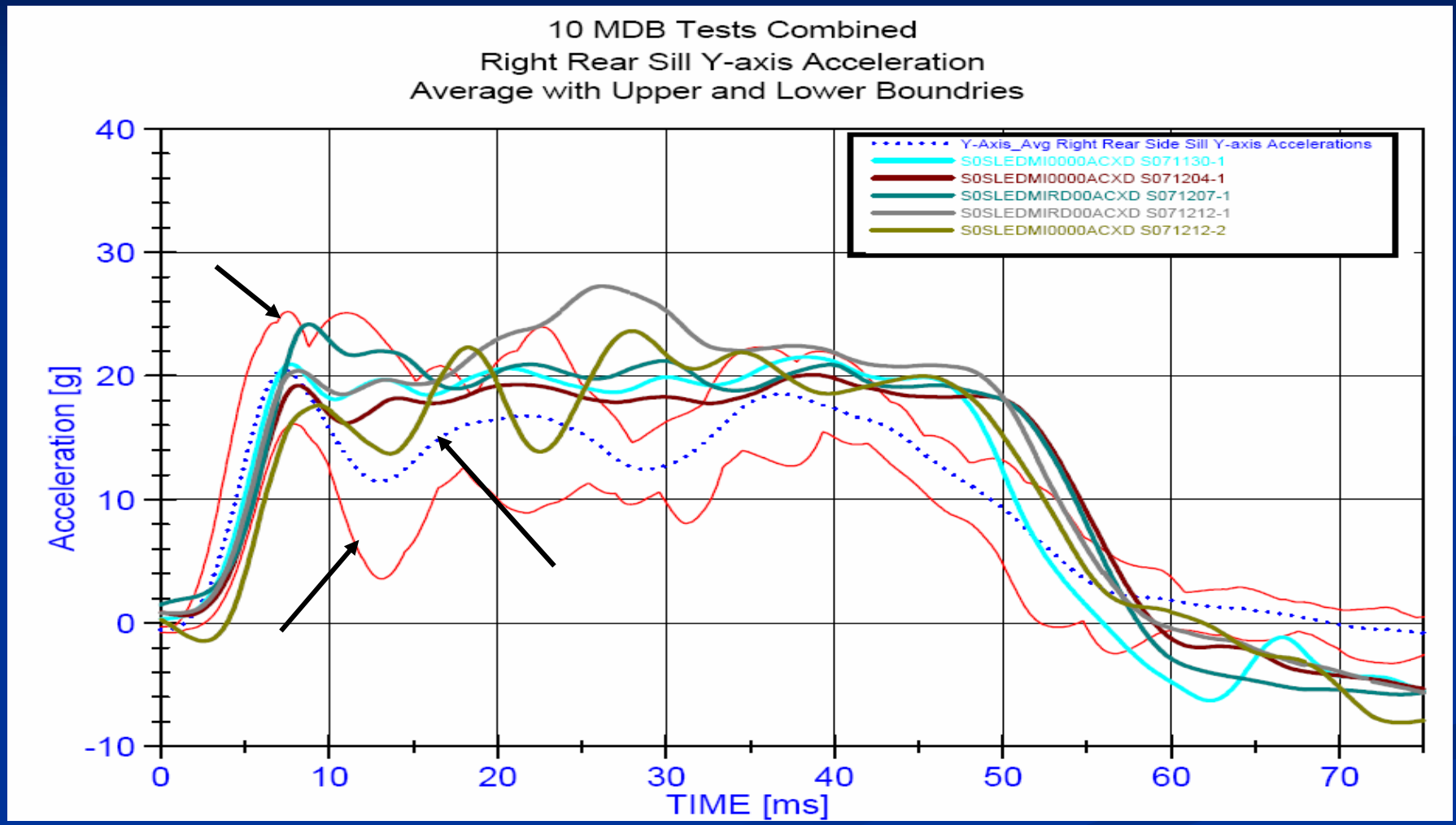
- For kids 0-8 years old (FARS 1991-2000)
  - 276 fatalities (front passenger or 2nd row seats) per year in side impacts
    - Near side - 170 fatalities/year (43 known CRS use)
    - Far side - 56 fatalities/year (13 known CRS use)
    - Middle - 50 fatalities/year (12 known CRS use)

Test Conditions

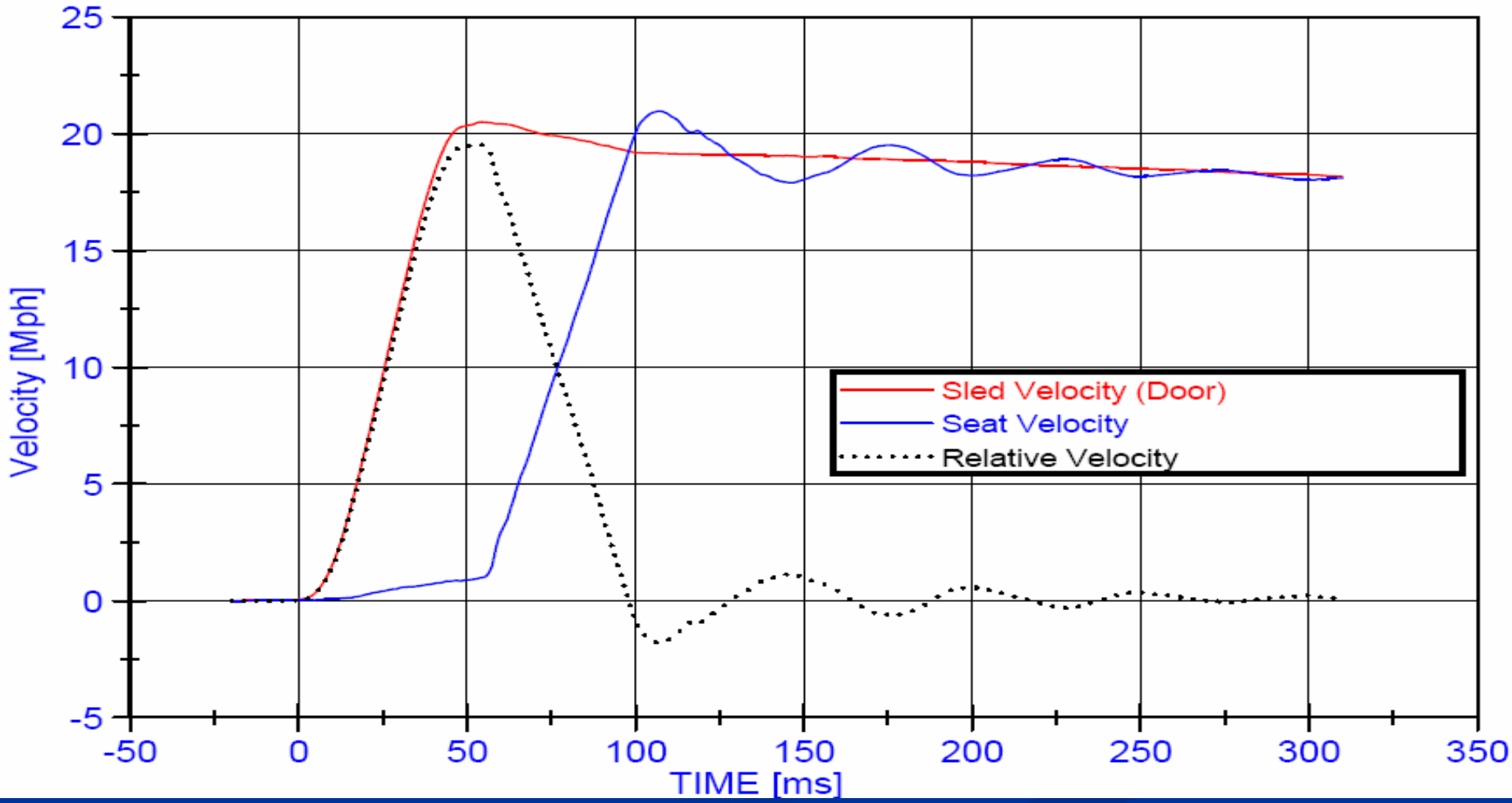
Sled Test Pulse Inputs

- Sliding seat acceleration ~ 20 g's
  - based on right rear sill accelerometers from 10 FMVSS 214 tests of small vehicles
- Sled (Door) velocity ~ 20 mph
  - based on door accelerometers from 5 FMVSS 214 tests of small vehicles
- Sled pulse – ½ sine
  - shape not critical; reach velocity in 250 mm
- Resultant sled pulse:
  - ½ sine wave with peak of 28 g's and velocity of ~20 mph with a duration of ~50 ms.

Sliding Seat Acceleration Pulse

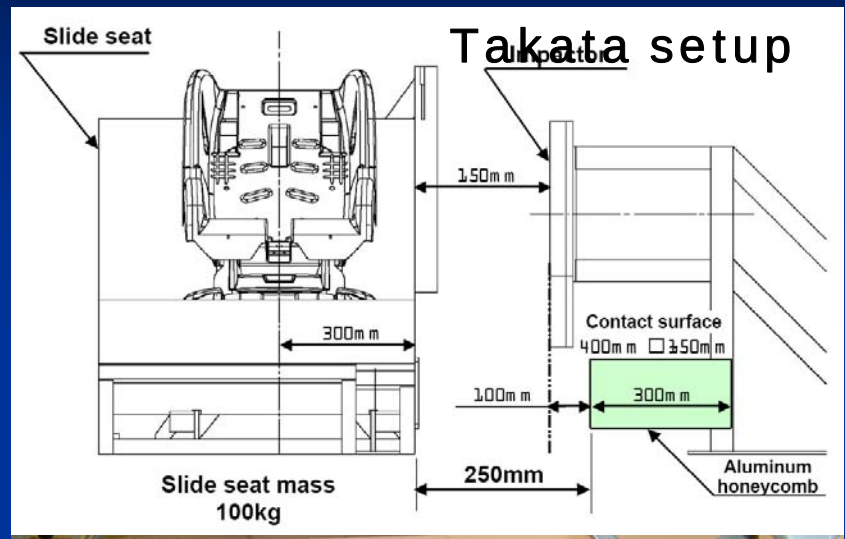


Sled and Sliding Seat Velocity



Side Impact Sled Variables

- Honeycomb stiffness
- Door padding stiffness
  - Takata's foam (stiffer)
  - Ethafoam type (softer)
- Seat cushion foam
- Lateral (0°) impact angle; option to change impact angle



CRS Tested

U.S. Models	Graco SafeSeat Step 2 Toddler			
	Evenflo Triumph Advance DLX			
	Safety 1st All-in-One Convertible			
European Models	Maxi-Cosi Priori (SIP)			
	Graco Logico M (SIP) (does not meet FMVSS 213)			Doesn't have LATCH

CRS SI Sled Test Series

- **Series #1:**
  - Sliding seat
  - Q3s dummy
  - 0° and 10° impact angles
- **Series #2:**
  - Locked seat
  - Q3s dummy
  - 0° and 10° impact angles

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Series # 1: Sliding Seat, 0° vs. 10° Impact Angle

- Q3s dummy
- Original sliding seat fixture
- 0° and 10° impact angles
  - 10° based on FMVSS 214 crash data
  - Performed repeat tests with 5 CRS models at 0°
- Door padding - 2" foam thickness
    - Takata's foam (stiffer)
    - Ethafoam type (softer) – 0° tests only
      - no apparent differences observed between Takata and Ethafoam in 0° series

Safety 1st All-in-One, 0° vs. 10° Impact

0° impact

10° impact

Safety 1st All-in-One, 0° vs. 10° Impact

0° impact

10° impact

Sliding Seat, 0° vs 10° Impact Angle Summary

- Takata sled exhibited good repeatability
- Able to distinguish between carseat models using injury levels
  - No significant differences between European (2 models) and U.S. seats (3 models) tested
- Two "door" foams used did not appear to affect results
- Minimal differences observed between 0° and 10° impact angles for 5 CRS models tested
  - Significantly higher neck tensions during 10° test for 2 CRS

CRS SI Sled Test Series

- **Series #1:**
  - Sliding seat
  - Q3s dummy
  - 0° and 10° impact angles
- **Series #2:**
  - Locked seat
  - Q3s dummy
  - 0° and 10° impact angles

Series # 2: Sliding vs. Locked Seat

- Q3s Dummy
- Locked seat fixture
  - initial position dependent on width of CRS tested (approximately 2" from edge of CRS to padded wall)
- 0° and 10° Impact angles

Sliding vs. Locked Seat

Evenflo Triumph

Graco SafeSeat

Maxi Cosi Priori

Safety 1st All-in-One

Method to Lock Seat

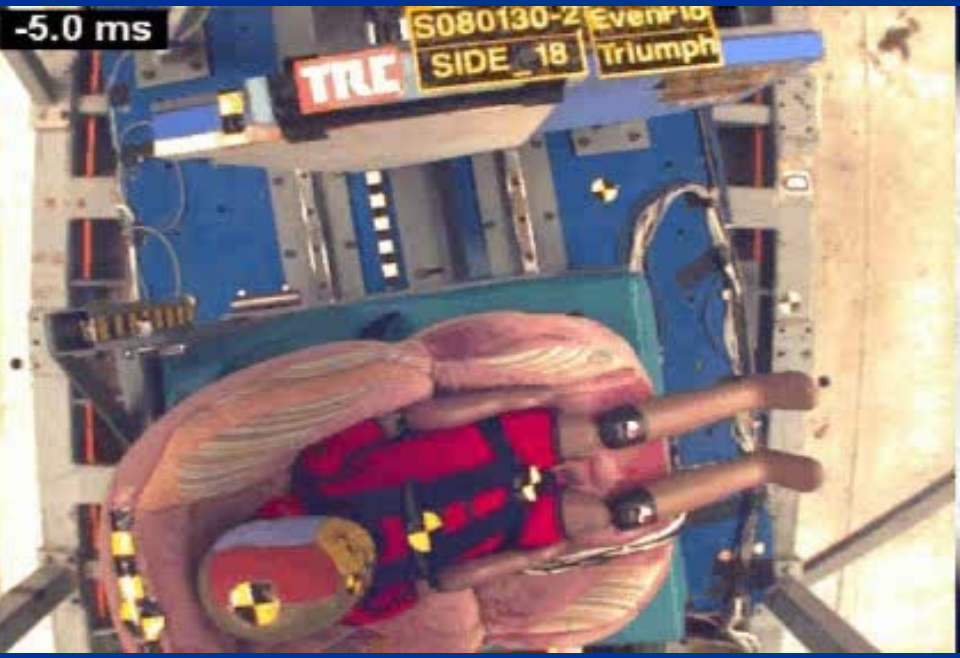
Rigid bar with removable shims

Sliding vs. Locked Seat
10° impact

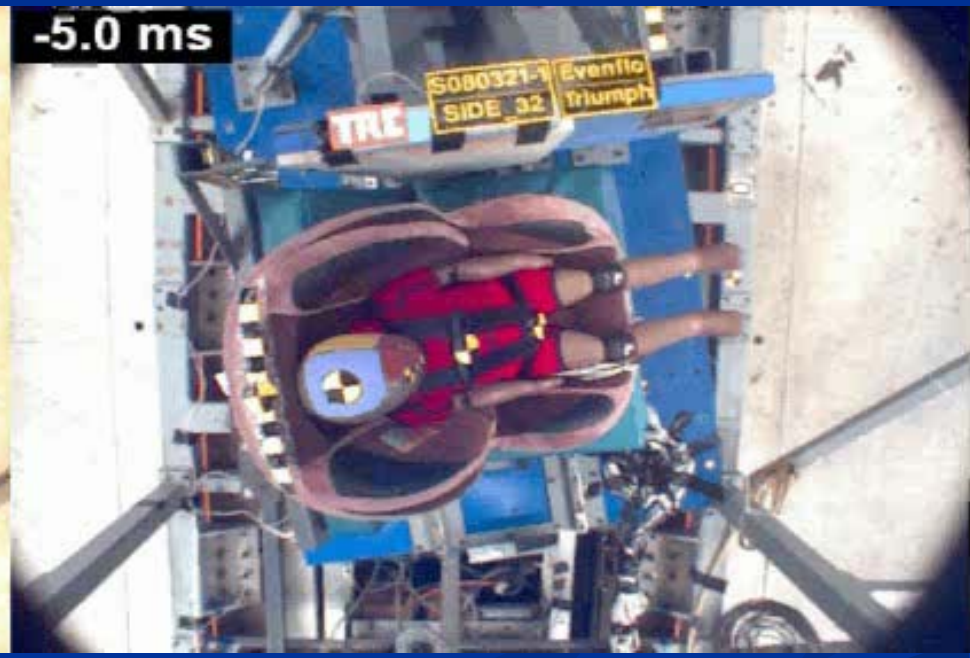
Sliding seat

Locked seat

Sliding vs. Locked Seat
10° impact



Sliding seat



Locked seat

Sliding vs. Locked Seat Summary

- Sliding Seat Configuration
  - better real-world simulation
  - sliding seat configuration repeatable
- Locked Seat Configuration
  - simpler to fabricate
  - have not conducted repeatability tests
  - generally resulted in higher injury values
    - reducing velocity could compensate for difference in values
- Unknown if both sled configurations will produce same outcome/countermeasures
  - Mixed outcomes of observed trends

NHTSA's Future CRS Side Impact Research

- Continue test procedure development and evaluation
  - Wall padding stiffness
  - Buck angle
  - Seat cushion stiffness
  - CRS fleet performance
  - Other CRS types and child size dummies
- Continue Q3s development and evaluation
- Continue development of viable IARV's

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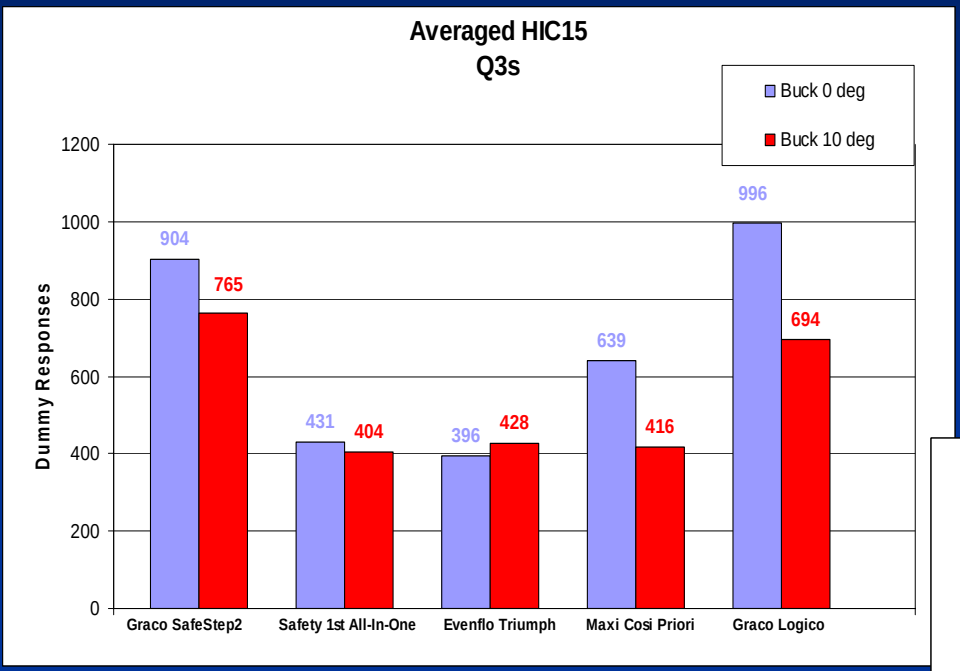
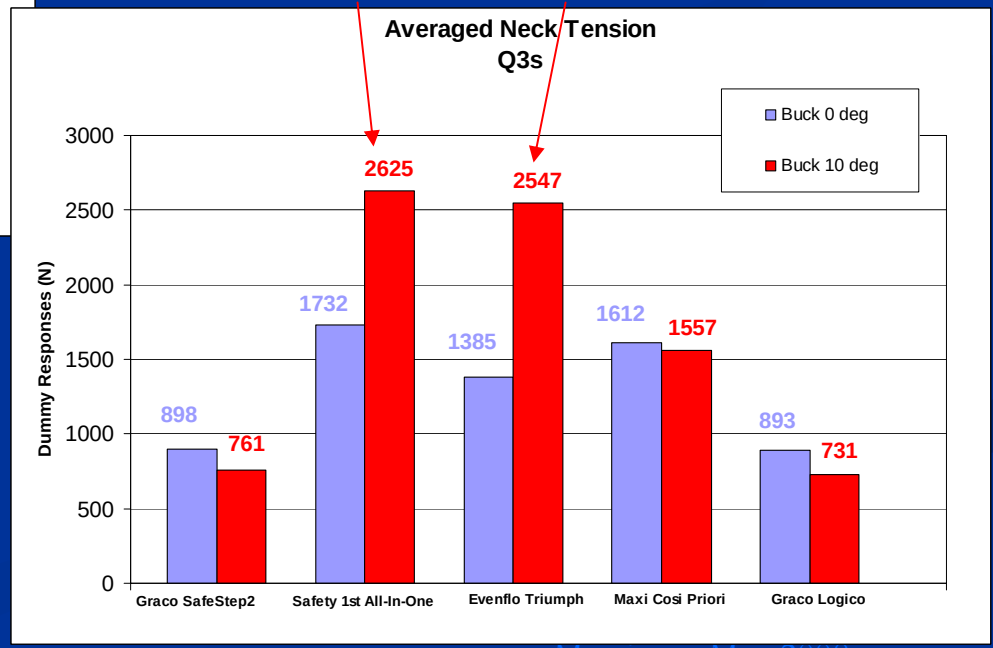
Thank You

0º vs 10º Impact Angle



HIC response similar trend for all CRS (generally higher at 0º than at 10º)

High neck tensions in All-in-One and Triumph at 10º appear due to CRS wing designs



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Series # 1: 0º Angle, Sliding Seat

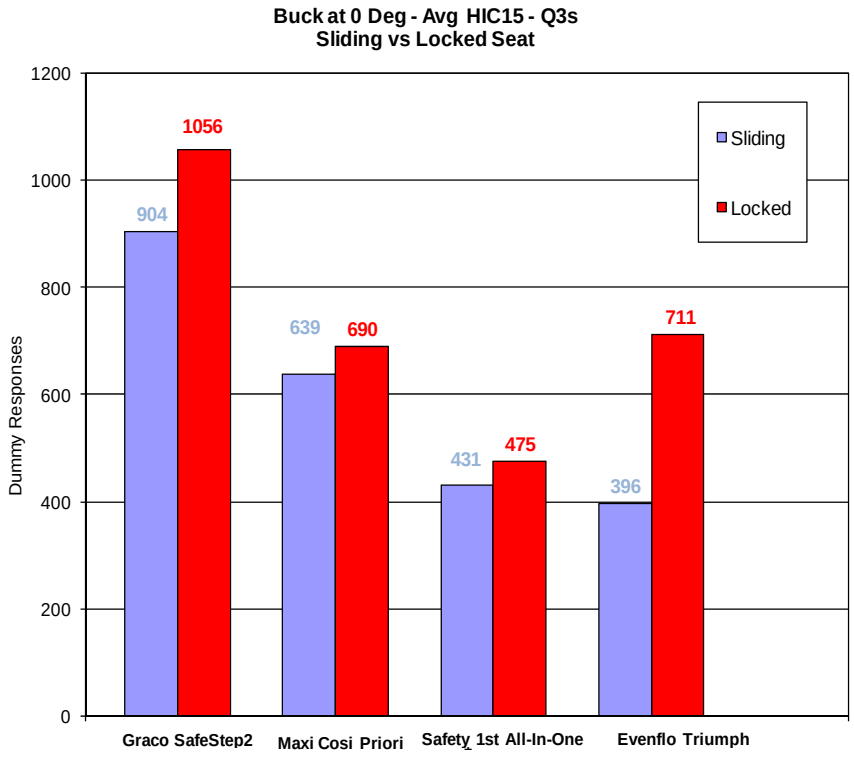
Number	Car Seat	HIC15	HIC36	Neck Tension (+FZ)	Neck Comp. (-Fz)	Shoulder Y defl (mm)	Chest Defl (mm)	Spine Y (G)	Pelvis Y (G)	Pubic ForceY (N)
Side_002	Graco SafeStep2	957	957	949	-24	-21.2	-27.3	88.2	119.7	295.8
Side_003	Graco SafeStep2	948	949	957	-54	-22.4	-23.9	91.1	124.1	325.2
Side_004	Graco SafeStep2	915	915	856	-25	-21.8	-23.9	94.1	107.3	379.1
Side_005	Graco SafeStep2	818	818	840	-28	-20.2	-24.3	99.7	106.9	273.4
Side_006	Evenflo Triumph Deluxe	416	467	1382	-22	-21.6	-24.8	120.9	142.0	430.2
Side_007	Evenflo Triumph Deluxe	375	436	1387	-30	-22.2	-26.3	119.3	152.6	451.5
Side_008	Maxi-Cosi Priori	649	649	1685	-14	-23.3	-26.3	73.3	98.1	342.5
Side_009	Maxi-Cosi Priori	629	629	1539	-15	-20.5	-22.0	85.0	99.5	360.7
Side_010	Safety 1st All-in-One	400	400	1686	-16	-22.6	-27.8	120.5	119.2	490.3
Side_011	Safety 1st All-in-One	451	460	1767	-22	-24.3	-21.1	138.0	112.6	432.4
Side_012	Graco SafeStep2 (Takata foam)	988	988	860	-30	-22.8	-23.7	127.7	106.2	287.1
Side_013	Graco SafeStep2 (Takata foam)	798	798	925	-87	-19.7	-24.7	129.2	102.6	338.1
Side_014	Safety 1st All-in-One (Takata Foam)	431	454	1730	-16	-22.7	-23.8	169.6	122.0	527.2
Side_015	Safety 1st All-in-One (Takata Foam)	443	464	1746	-16	-22.5	-22.0	163.9	114.7	595.0
Side_022	Graco Logico M (Takata Foam)	959	959	893	-52	-24.1	-31.1	96.0	112.5	216.7
Side_023	Graco Logico M (Takata Foam)	1033	1033	894	-133	-23.1	-25.8	111.8	101.7	306.1

Side_011 & Side_012: Q3s jacket was removed

Series # 1: 10° Angle, Sliding Seat

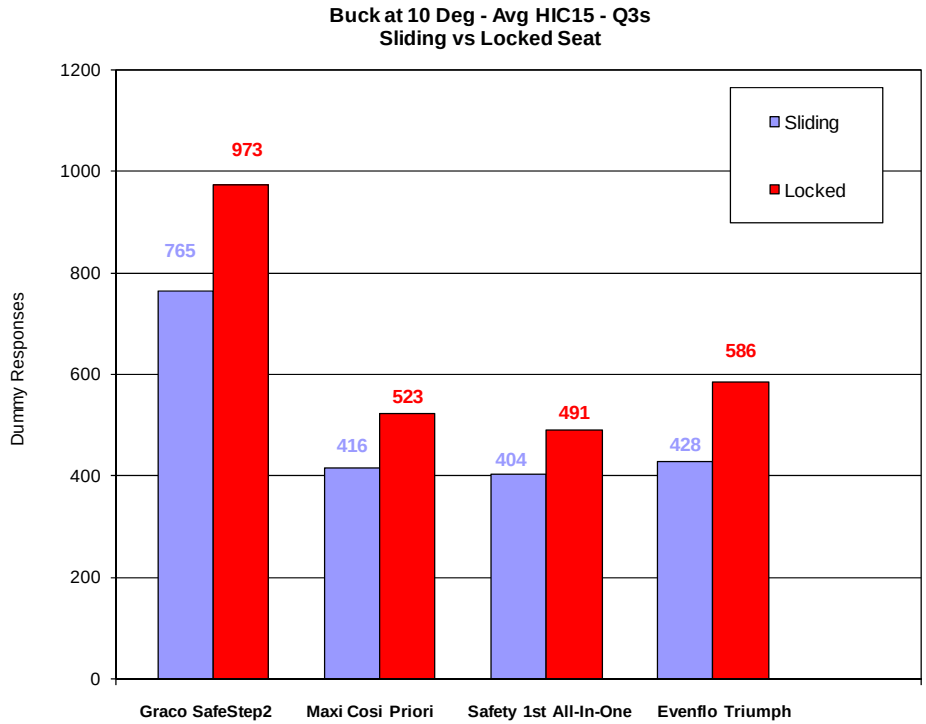
Number	Car Seat	HIC15	HIC36	Neck Tension (+FZ)	Neck Comp. (-Fz)	Shoulder Y defl (mm)	Chest Defl (mm)	Spine Y (G)	Pelvis Y (G)	Pubic ForceY (N)
Side_016	Graco Logico M (Eurpean)	694	694	731	-33	-21.9	-28.6	126.7	78.5	183.3
Side_017	Graco SafeStep2	773	773	837	-18	-21.6	-29.5	87.3	91.3	303.1
Side_021	Graco SafeStep 2	756	756	685	-64	-23.8	-30.4	77.9	89.7	299.6
Side_018	Evenflo Triumph Deluxe	428	456	2547	-49	-21.5	-26.2	94.4	107.2	464.4
Side_019	Safety 1st All-in-One	404	420	2625	-28	-20.3	-25.6	136.0	104.8	336.8
Side_020	Maxi Cosi Priori (European)	416	419	1557	-36	-22.2	-27.4	75.7	89.9	295.8

Sliding vs Locked Seat, 0º and 10º Angles

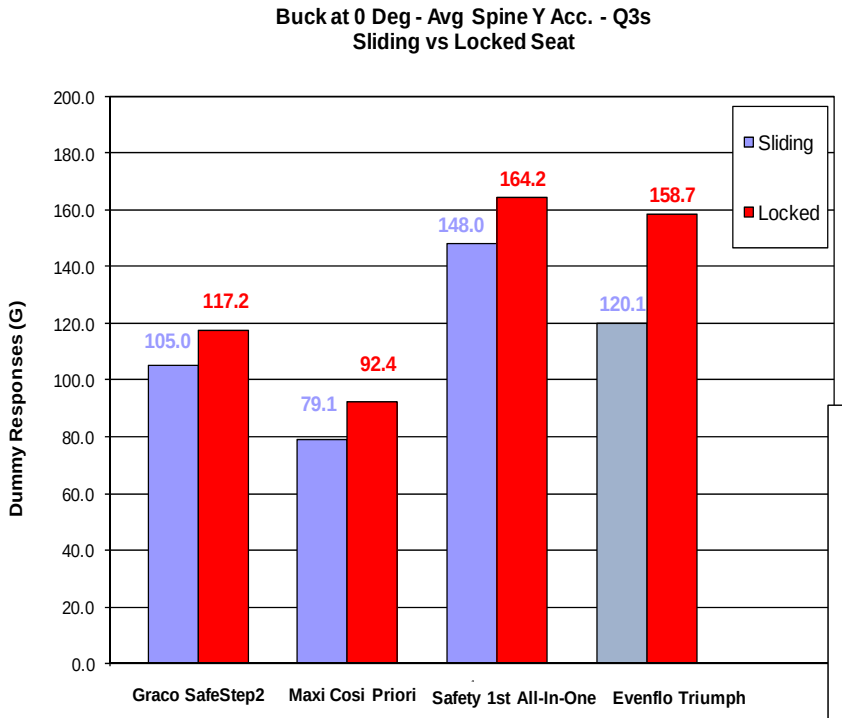


HIC responses follow similar trends for both 0º and 10º test conditions

HIC responses follow similar trends for both sliding and locked seat conditions

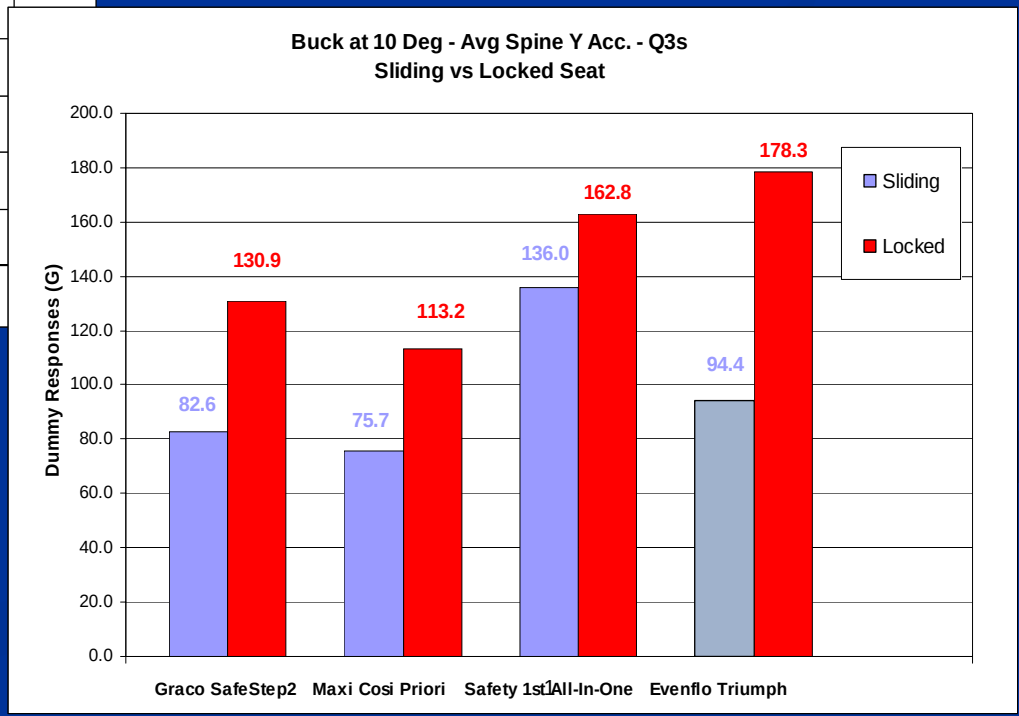


Sliding vs Locked Seat, 0° and 10° Angles



For 0° test condition, dummy responses show similar trends

For 10° test condition, dummy response trends not as similar



Series # 3: 0° and 10° Angle, Locked Seat

Number	Car Seat	HIC15	HIC36	Neck Tension (+FZ)	Neck Comp. (-Fz)	Shoulder Y defl (mm)	Chest Defl (mm)	Spine Y (G)	Pelvis Y (G)	Pubic ForceY (N)
Side_32	Evenflo Triumph (Takata foam) Buck angled 10 deg Veh. seat locked	586	586	1872.35	-45.74	-21.32	-29.55	178.3	131.69	736.6
Side_033	Graco SafeStep2 (Takata foam) Buck angled 10 deg Veh. seat locked	918	918	1459.59	-7.55	-18.66	-25.56	121.67	119.48	716.82
Side_034	Graco SafeStep2 (Takata foam) Buck angled 10 deg Veh. seat locked	1027	1027	1572.04	-56.10	-18.02	-23.58	140.12	114.31	555.02
Side_035	Maxi Cosi Priori (Takata foam) Buck angled 10 deg Veh. seat locked	523	523	2459.52	-34.07	-19.11	-19.94	113.18	108.71	742.48
Side_036	Safety 1st All-in-One (Takata foam) Buck angled 10 deg Veh. seat locked	491	501	2306.25	-43.55	-18.86	-24.77	162.82	121.52	590.73
Side_037	Safety 1st All-in-One (Takata foam) Buck angled 0 deg Veh. seat locked	475	490	2427.59	-36.87	-19.59	-12.60	164.23	119.76	416.47
Side_038	Graco SafeStep2 (Takata foam) Buck angled 0 deg Veh. seat locked	1056	1056	1424.27	-244.53	-19.95	-26.34	117.24	113.63	370.87
Side_039	MaxiCosi Priori (Takata foam) Buck angled 0 deg Veh. seat locked	690	690	2129.00	-24.08	-21.37	-23.48	92.44	117.85	630.41
Side_040	Evenflo Triumph (Takata foam) Buck angled 0 deg Veh. seat locked	737	737	1547.82	-10.71	-22.02	-27.65	150.92	139.49	649.89