Australian Government

Department of Infrastructure and Transport

PSI-01-15

Australian Pole Side Impact Research 2010

A summary of recent oblique, perpendicular and offset perpendicular pole side impact research with WorldSID 50th

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1st Meeting - GRSP Informal Group on Pole Side Impact

Bonn, Germany, 16-18 November 2010

Acknowledgements

- Suzanne Tylko – Transport Canada
- PMG Technologies
- NSW RTA Crashlab

Objectives

- Evaluate WorldSID 50^{th} male responses for three different pole side impact test methods.
- Use RibEye multipoint sensing to study the affect of pole impact angle and alignment on WorldSID 3-dimensional rib deflection response.
- Investigate response of current and previous generation vehicles, including impact detection and countermeasure performance, for each test method.

Summary of Tests

- Two vehicle makes / models
- Six full-scale vehicle-to-pole side impact tests
- Left-hand impact
- Three test methods investigated / conducted for each vehicle model
  - Oblique
  - Perpendicular
  - Offset Perpendicular

Test Methods

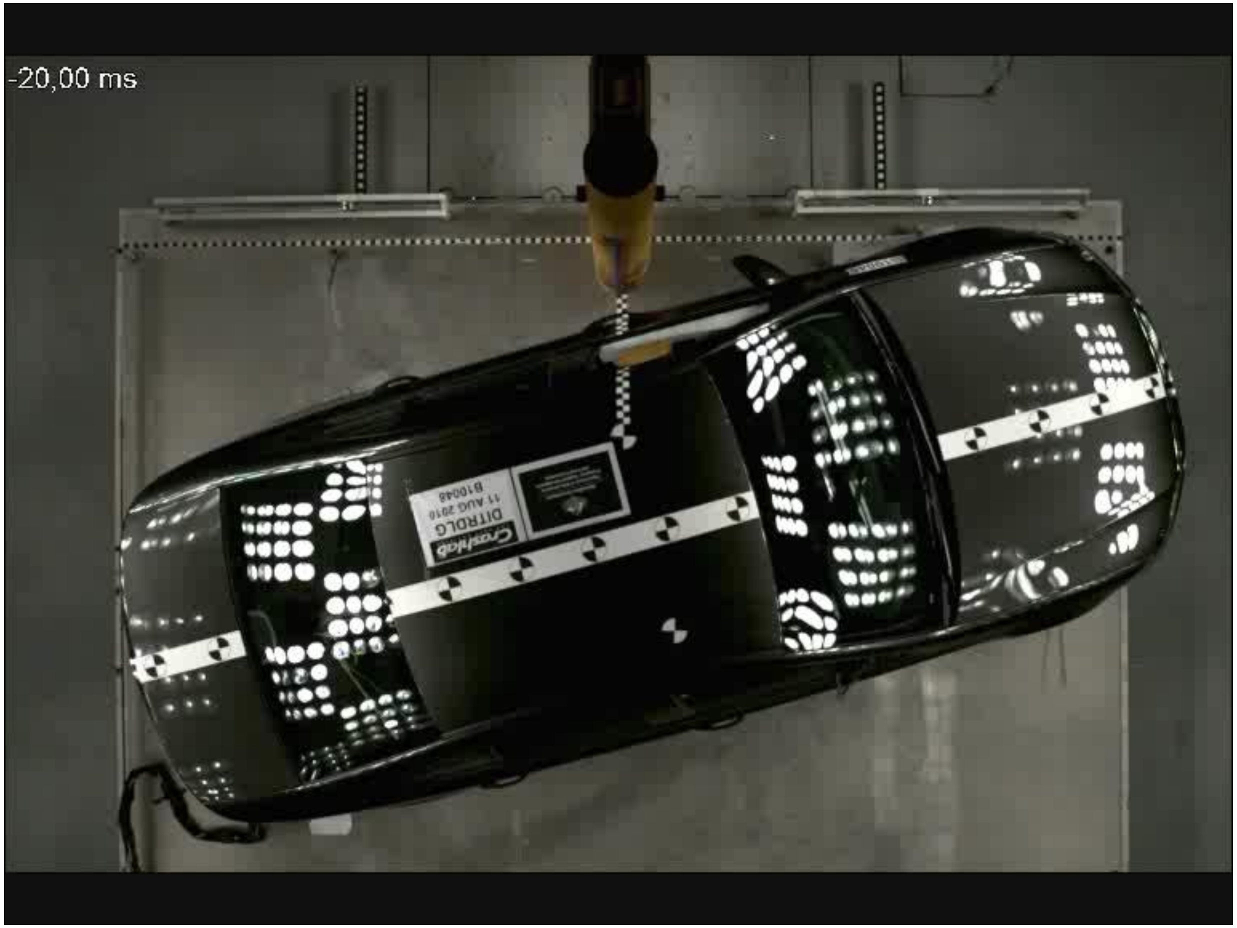
Test	Impact Angle (Degrees)	Pole Impact Alignment	Target Impact Speed (km/h)	Pole Diameter (mm)
Oblique*	75	At head centre of gravity	32	254
Perpendicular†	90	At head centre of gravity	32	254
Offset Perpendicular††	90	100mm forward of head centre of gravity	32	254

* Based on FMVSS 214 pole test method.

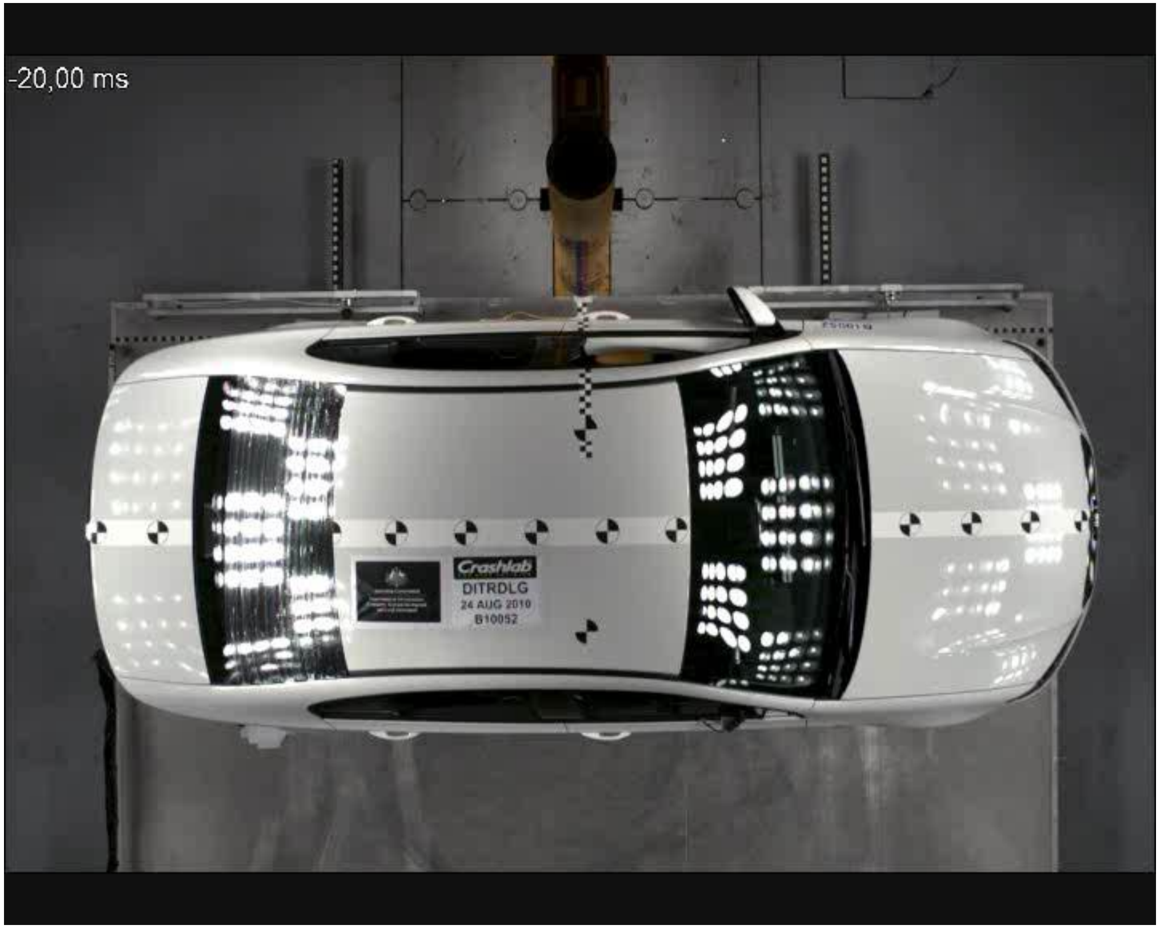
† Based on EuroNCAP/ANCAP test method .
(note: a higher speed and different seating procedure are used)

†† Based on test method recommended in APROSYS SP11-0086 'An Evaluation of the Side Impact Pole Test Procedure'.

Oblique Test Method



Perpendicular Test Method



Offset Perpendicular Test Method

Anthropometric Test Devices

- Struck / near / passenger / left side
  - WorldSID 50th male with RibEye
- Non-struck / far / driver / right side
  - WorldSID 50th male with IRTRACC

Test Vehicles

Both large Australian made passenger sedans

Model A

- Previous generation (2005/06 model year)
- 1803kg test mass (FMVSS 214 test mass)
- UNECE R95 certified vehicle

Model B

- Current generation (2010 model year)
- 1925kg test mass (FMVSS 214 test mass)
- 5* ANCAP rating (2 points ANCAP Pole Test)

Model B: ANCAP Results

Side Impact Test Performance

- EuroNCAP Pole Side Impact Protocol
  - ES-2 struck side dummy
  - 29.2 km/h actual test speed
- EuroNCAP Side Impact Protocol v4.1
  - ES-2 struck side dummy
  - 50 km/h MDB test speed

Injury Criteria	Pole Test Result	MDB Test Result
HIC36	140	117
3ms Head Acceleration (g)	37.4	50.9
Upper Thorax Rib Deflection (mm)	38.3	20.3 (max)
Middle Thorax Rib Deflection (mm)	34.4	
Lower Thorax Rib Deflection (mm)	33.6	
Total Abdominal Force (kN)	1.39	0.74
Pubic Symphysis Force (kN)	1.95	1.61

Repeatability
Impact Speed & Alignment

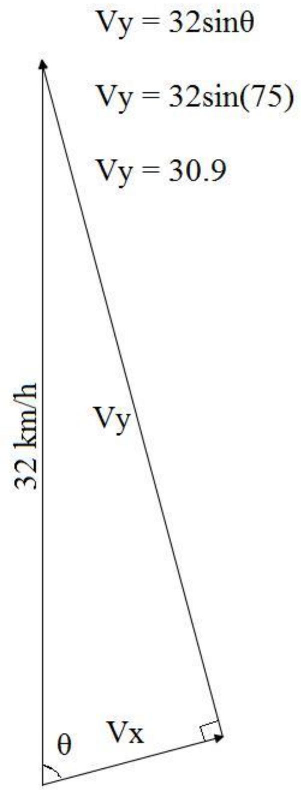
Target Impact Speed: 32 ± 0.5 km/h
Target Impact Alignment: ± 38 mm (x positive forward)

Test	Actual Impact Speed (km/h)	Actual Impact Alignment (mm)
Model A		
Oblique	32.13	-2
Perpendicular	32.28	+2
Offset Perpendicular	32.20	-4
Model B		
Oblique	32.17	-5
Perpendicular	32.23	0
Offset Perpendicular	32.21	-3

Velocity & Energy Considerations

- All tests conducted at 32 km/h target impact speed
- Impact energy is therefore the same for each test method
- Lateral (vehicle y-axis) component of oblique test impact velocity is 30.9 km/h

Oblique Impact Vector Diagram

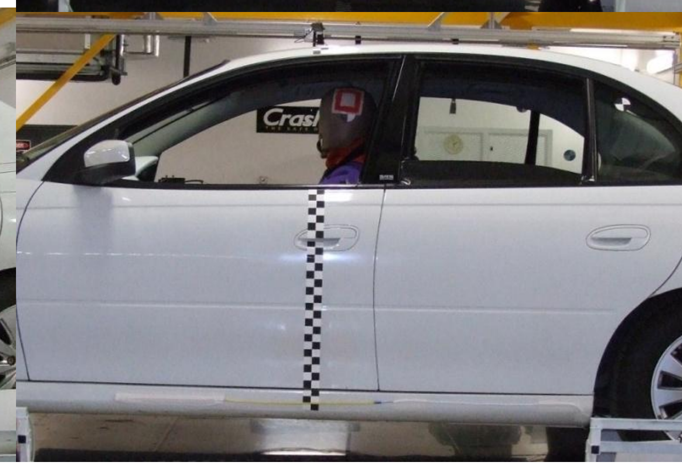


Impact Alignment

Model A:

Clockwise from top right: perpendicular, offset perpendicular, and oblique target impact alignment.

- Perpendicular pole impact centerline approx. 50mm forward of airbag sensor.
- Oblique and offset perpendicular initial impact location relative to vehicle and dummy seating position were very similar.

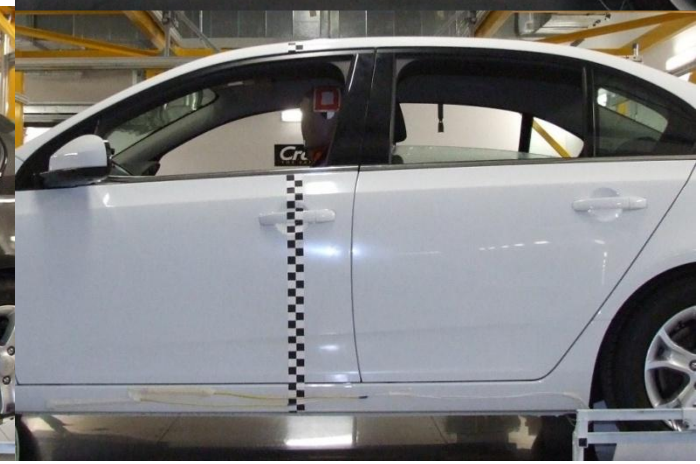


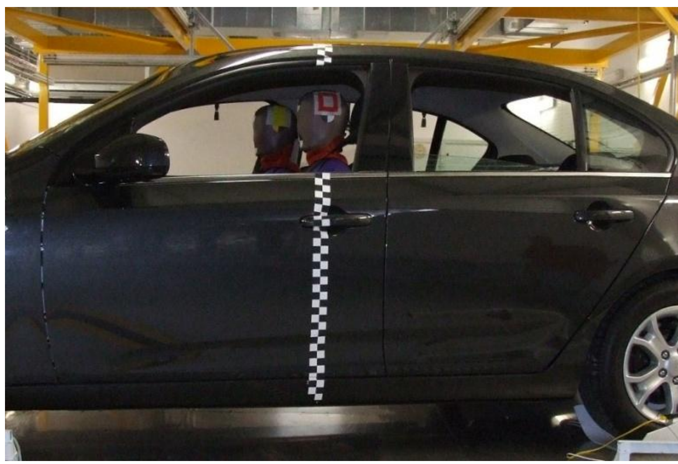
Impact Alignment

Model B:

Clockwise from top right: perpendicular (post test), offset perpendicular, and oblique target alignment.

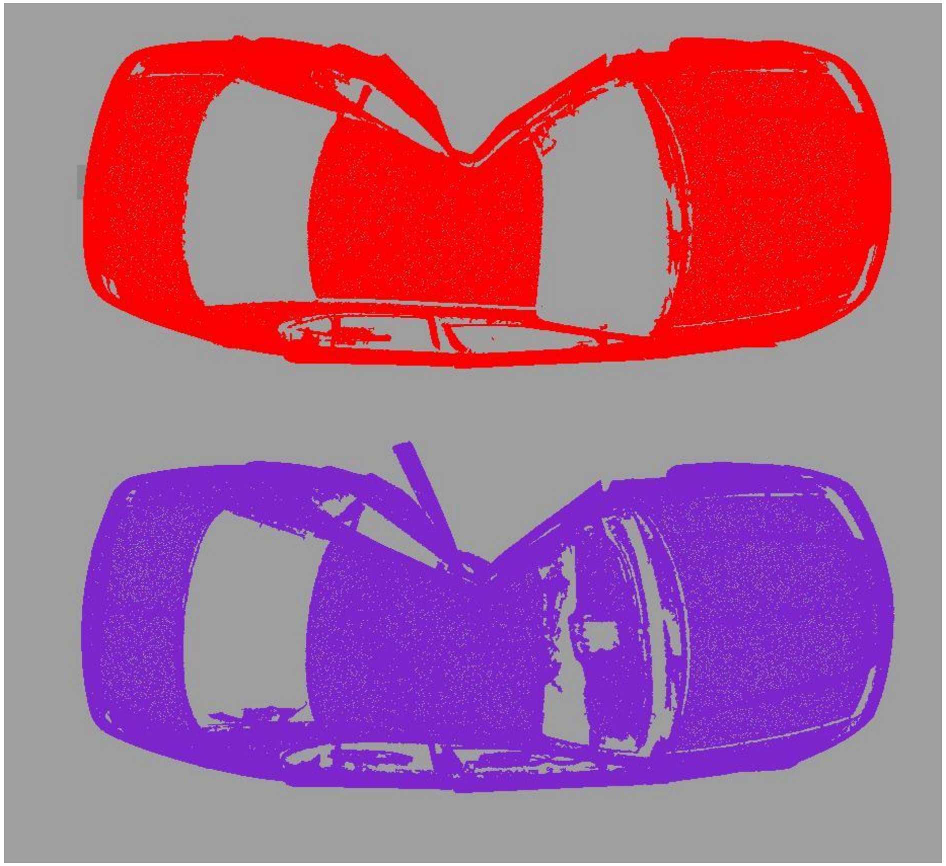
- Perpendicular pole impact closely aligned with lower b-pillar.
- Oblique and offset perpendicular tests had the most similar initial impact locations relative to vehicle and dummy seating position.





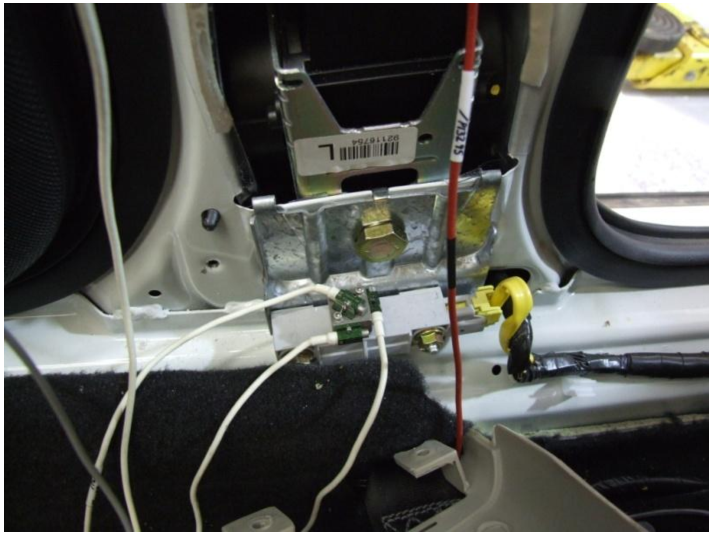
Structural Deformation

- Post crash laser scanning of perpendicular and oblique test vehicles (Model A only)
- Difficult for accident investigators to accurately code small differences in impact angle



Side Impact Detection

Model A: Lower B-pillar Acceleration Sensor



Model B: Pressure Sensor and C-pillar Accel. Sensor

Airbag Deployment Method

Model A

- Airbags manually fired 7ms after first contact with pole
  - previous generation vehicle and uncertain of pole side impact performance
  - anticipated unreliable / variable airbag firing could make comparisons difficult
  - time chosen to avoid later fire than vehicle would otherwise have achieved
  - represents performance of vehicle **if** airbag sensing highly optimized for a test

Model B

- Airbags fired by vehicle airbag ECU
  - current generation vehicle with 5* ANCAP rating
  - expected to fire/deploy airbags consistently for all 3 test methods

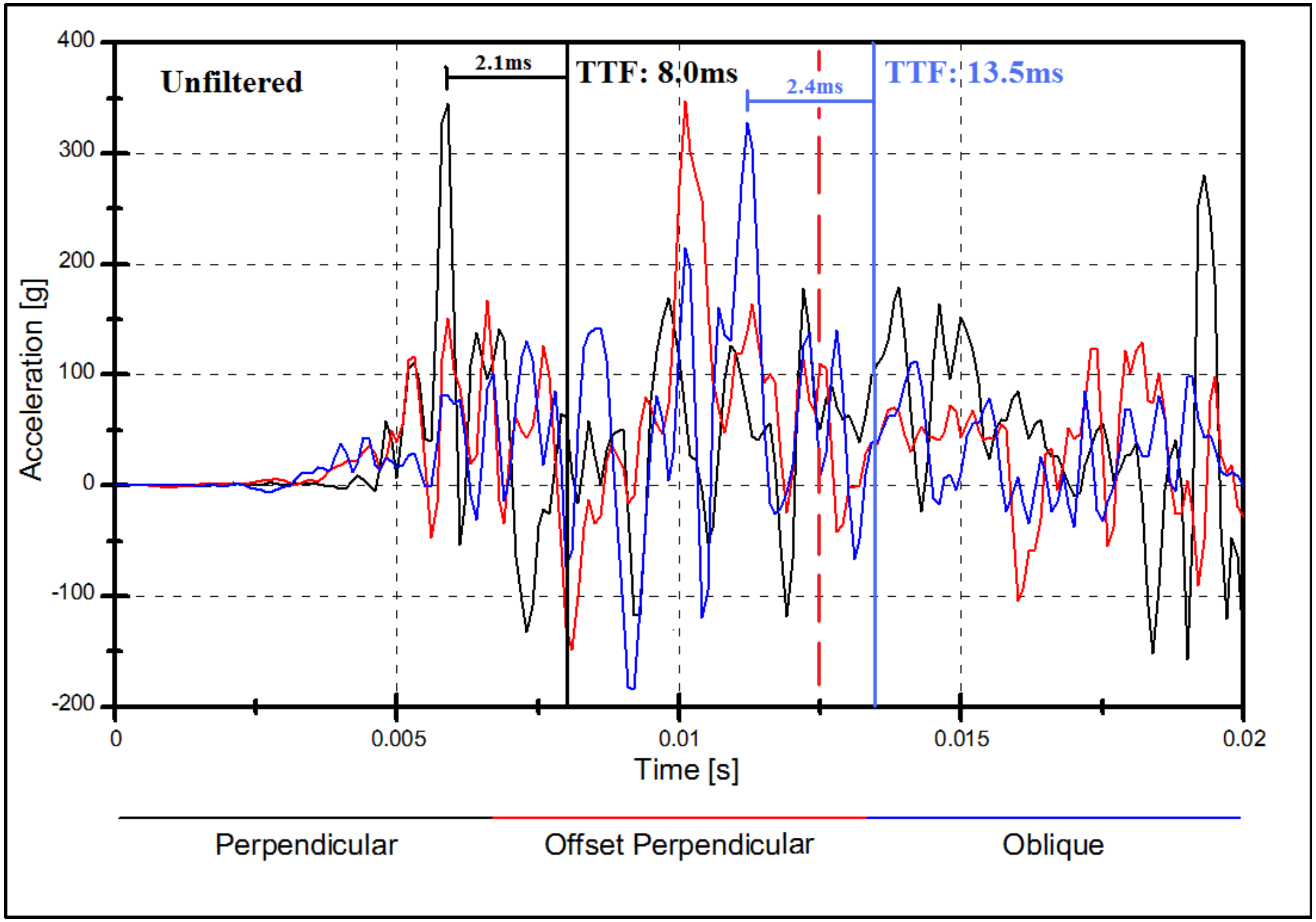
Measurement of Airbag Deployment Time

Model A

- A “dummy” resistor was used to simulate airbag resistance to airbag ECU
- Voltage across “dummy” resistor was measured and used to determine airbag ECU fire time

Model B

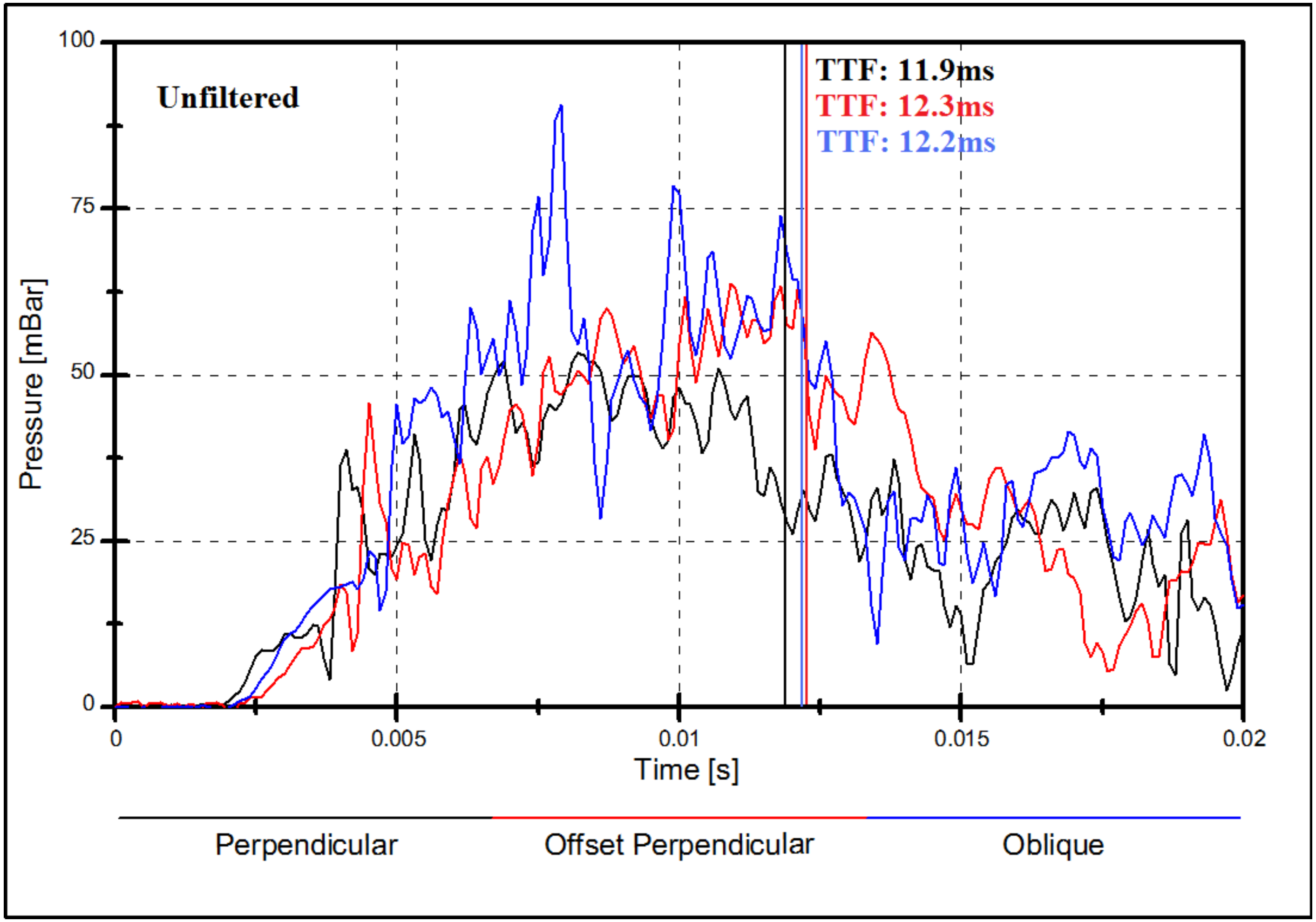
- Current clamp used to measure airbag fire time



Model A – Airbag Sensor: Y-axis Acceleration

ECU would have fired airbag at 8.0ms in perpendicular test and 13.5ms in oblique test.

Note: An airbag ECU fire signal was not detected for the offset perpendicular test – comparison of acceleration responses suggests ECU should have fired airbag around 12.5ms after first contact with pole.



Model B: Door Cavity Pressure

ECU fired airbag at 11.9ms in perpendicular test, 12.3ms in offset perpendicular test, and 12.2ms in oblique test (measured from first contact of door handle with pole).

Note: First contact of door handle with pole is up to 2.6ms before first contact of outer door panel with pole.

Side Airbags

Model A: Head/Thorax Combination

Model B: Head/Thorax Combination

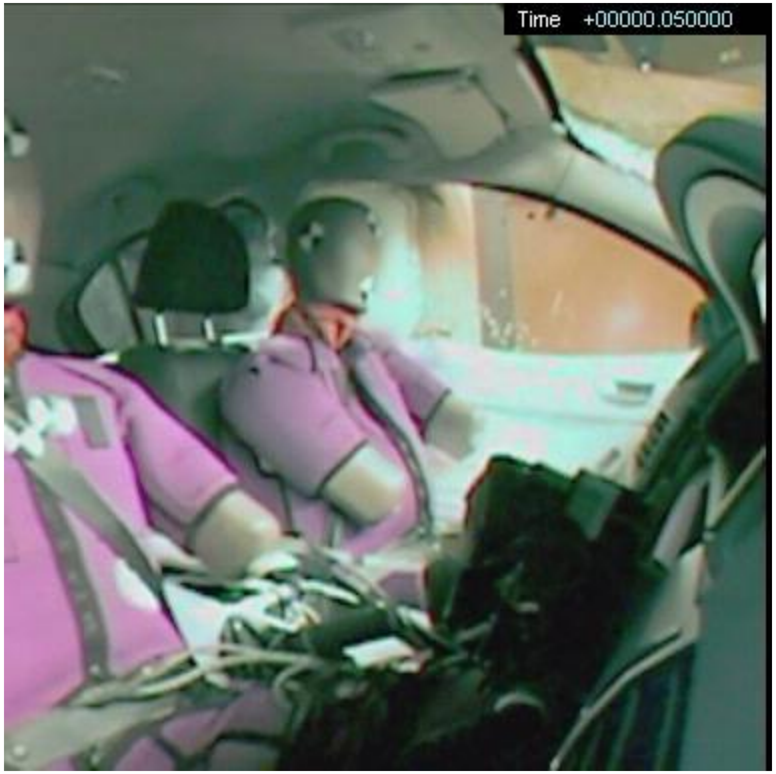
- Low cost countermeasure
- Expected to provide less thorax protection than a separate head curtain / thorax airbag system
- Exercise thorax of dummy enough to show any differences between tests and thoroughly reach/explore likely injury criteria limits of dummy

Airbag Width

Are these combo airbags wide enough for oblique impact?

Model A

Model B



Abdomen Rib-to-Armrest Interaction

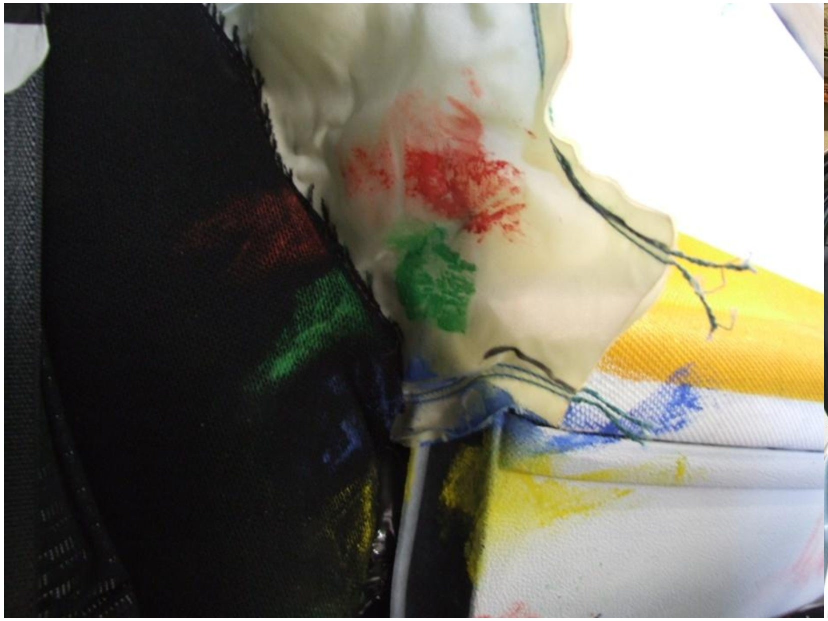
Model A (oblique impact shown)

Abdominal rib 1 (red) impact distributed across lower airbag seam and armrest

Abdominal rib 2 (blue) impacted armrest underneath airbag

Abdomen Rib-to-Armrest Interaction

Model B (oblique impact shown)



Abdominal rib 1 (blue) impact distributed across lower airbag seam and armrest

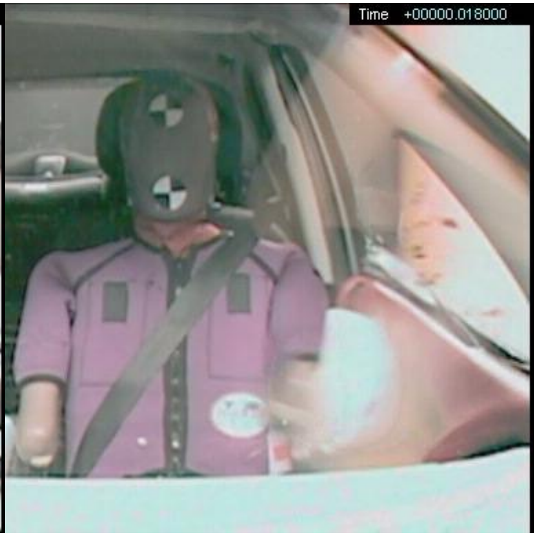
Abdominal rib 2 (yellow) impacted armrest underneath airbag

Airbag Deployment (Model A)

Oblique

Offset

Perpendicular



B-pillar has much lower stiffness / strength than many current generation vehicles

Airbag entrapment was more likely with:

1. Higher lateral impact velocity (note: oblique test lateral component is 30.9 km/h)
2. Closer alignment of pole to point of dummy shoulder (a vehicle specific conclusion)

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Airbag Design

Model A

- Deploys upwards from lower thorax
- Better thorax coverage

Model B

- Deploys in both directions from shoulder
- More reliable head protection

Hypothesis: Perhaps airbag entrapment in Model A (as occurred in perpendicular and offset perpendicular tests) could be avoided and more reliable head protection achieved by making a small change to the way in which the airbag deploys?

Head-to-Pole Impact (Model A)

Does the offset pole alignment reduce the severity of the interaction between the pole and the dummy head?

Perpendicular

Offset Perpendicular

Dummy Positioning

- WorldSID seating procedure draft 5.2
- Struck side seat base moved 2 positions rearward of mid-track (both vehicles)
- Struck side seat base heights non adjustable
- Non-struck side seat base heights adjustable
- Non-struck side seat base heights and track positions were matched to struck side positions
- Model A: Nominal 23-degree manikin torso angle
- Model B: Manufacturer specified 25-degree manikin torso angle

Repeatability
Struck Side Dummy H-Point

As measured in each manufacturer's vehicle coordinate system

Test	X (mm)	Z (mm)
Model A		
Oblique	2329.4	-33.3
Perpendicular	2328.7	-33.6
Offset Perpendicular	2329.4	-32.0
Model B		
Oblique	3025.2	738.3
Perpendicular	3030.1	743.1
Offset Perpendicular	3034.5	739.5

Repeatability
Struck Side Dummy Head COG

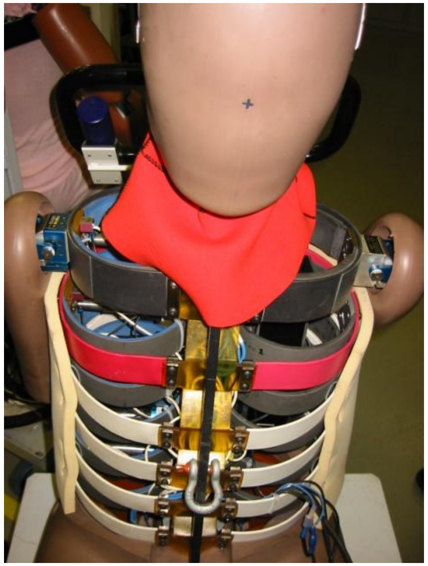
As measured in each manufacturer's vehicle coordinate system

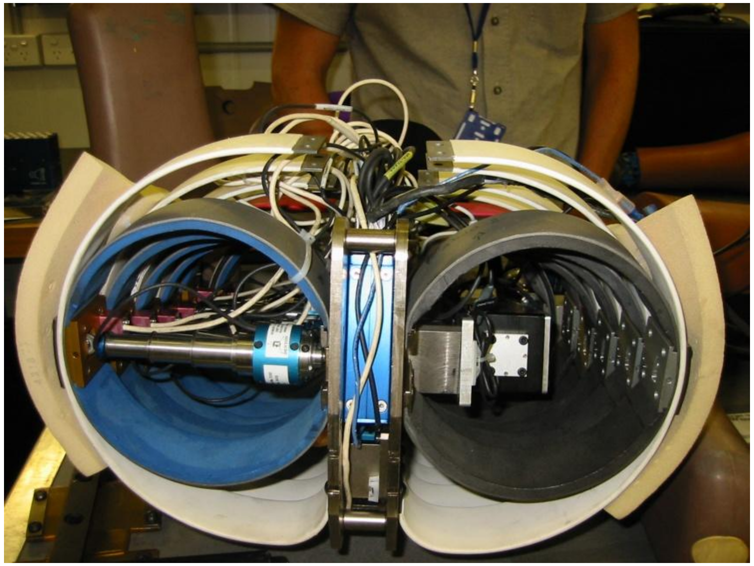
Test	X (mm)	Z (mm)
Model A		
Oblique	2133.5	623.1
Perpendicular	2132.6	621.7
Offset Perpendicular	2132.4	624.4
Model B		
Oblique	3207.6	1392.9
Perpendicular	3207.6	1395.6
Offset Perpendicular	3207.4	1395.2

WorldSID 50th with IRTRACC

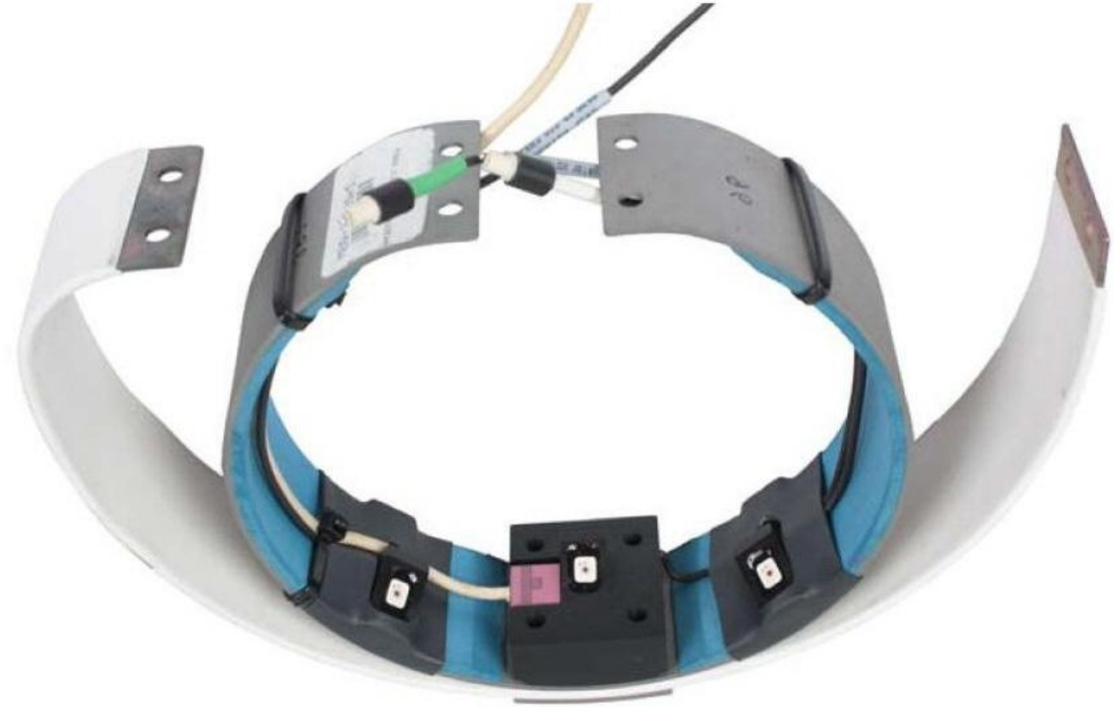
Infra**R**ed **T**elescoping **R**od for **A**ssessment of **C**hest **C**ompression

- Ribs capable of deflection in multiple directions and from both sides
- 1D IRTRACC provides point-to-point rib deflection measurement





RibEye LED Mounting



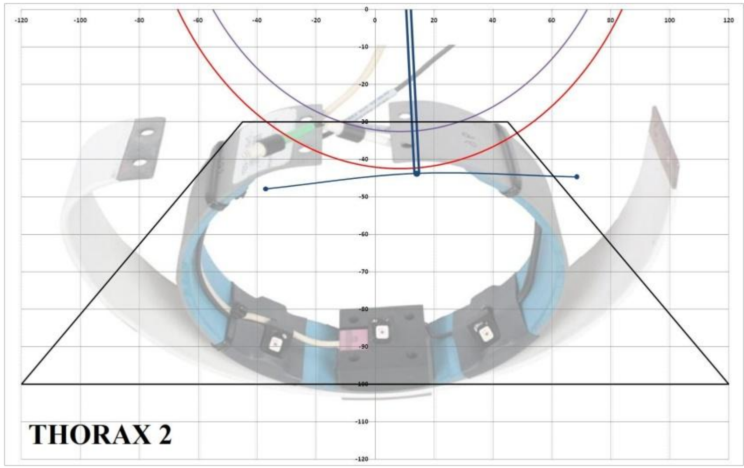
- Rear / Middle / Front LEDs mounted inside each inner rib
- Front and rear LEDs mounted using double sided tape / shrink fit
- Middle LED mounted to rib at IRTRACC pivot point location

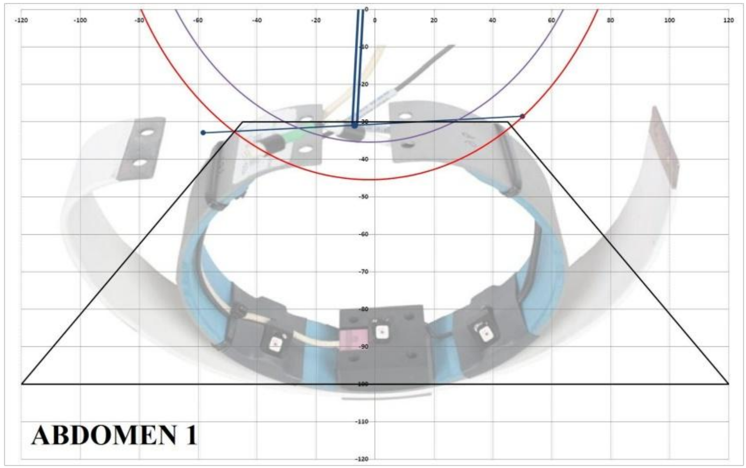
RibEye Optical Sensors

- Two sensor sets (right) mounted in a vertical orientation at spine box inside the inner ribs
- Top sensor set monitors X-Y-Z position of front/middle/rear LEDs mounted to shoulder, thorax rib 1, and thorax rib 2 (nine LEDs)
- Bottom sensor set monitors X-Y-Z position of front/middle/rear LEDs mounted to thorax rib 3, abdomen rib 1, and abdomen rib 2 (nine LEDs)
- LED coordinates are reported relative to the middle sensor (centre right) in each sensor set

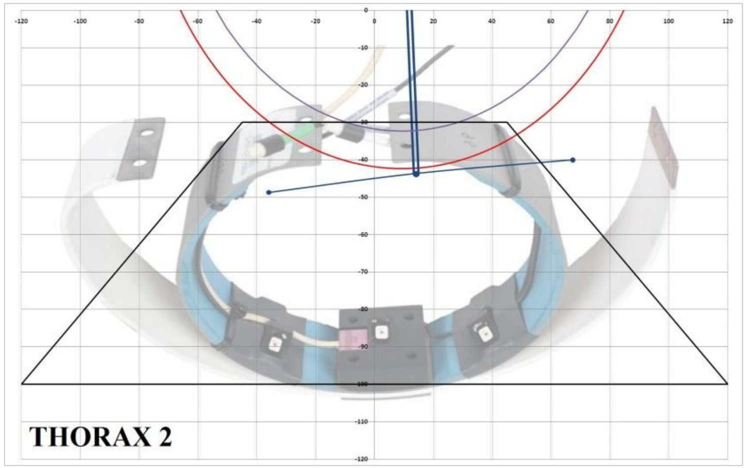
Oblique Test: RibEye Movies

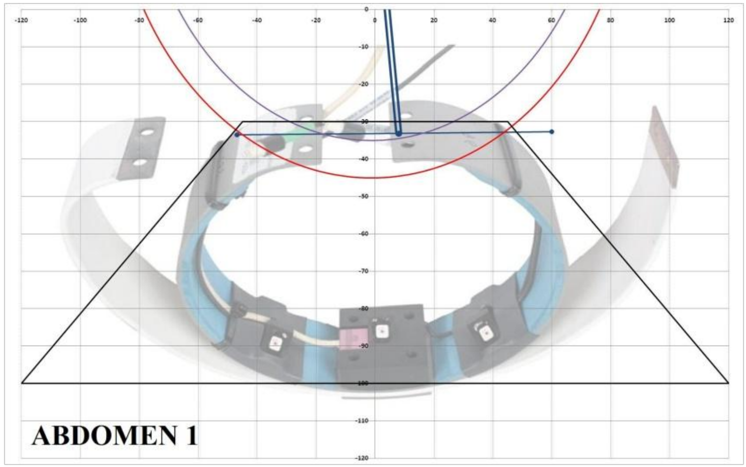
Model B





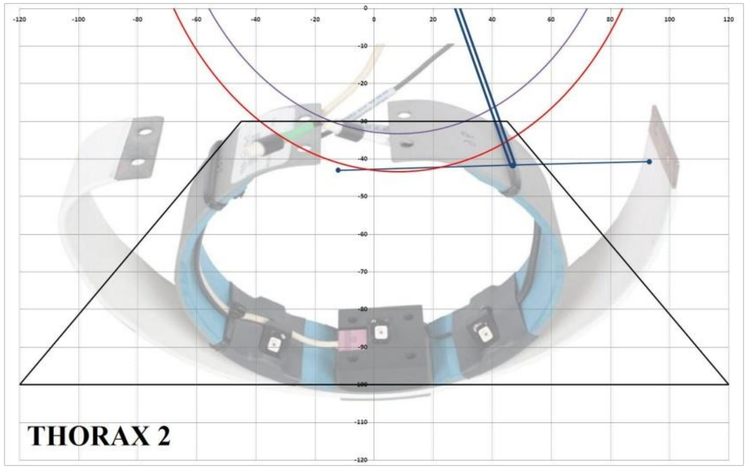
Model A

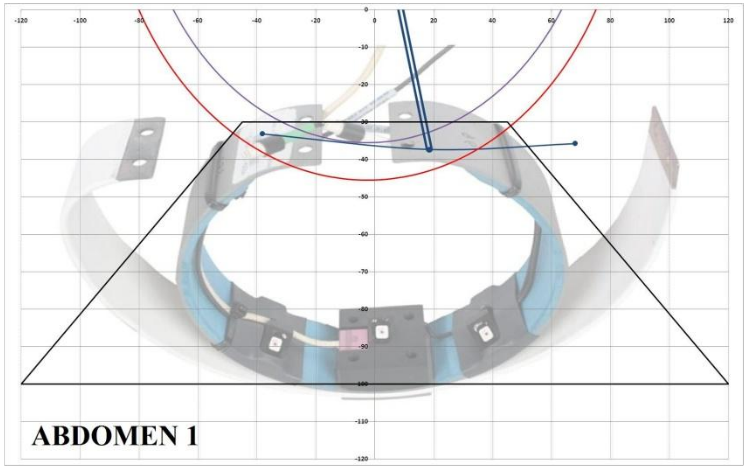




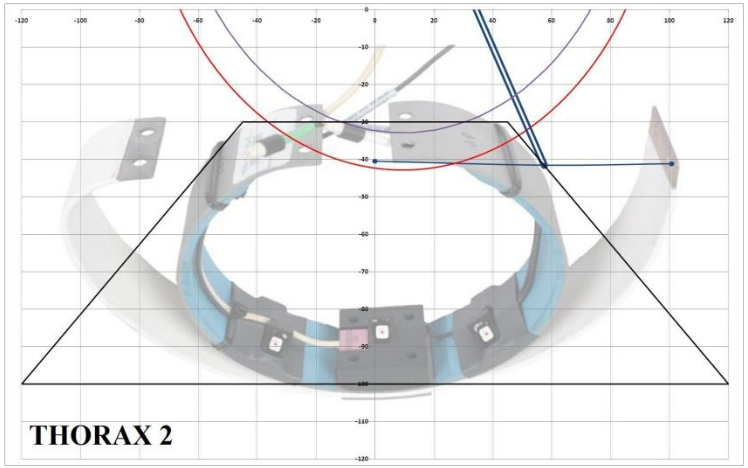
Perpendicular Test: RibEye Movies

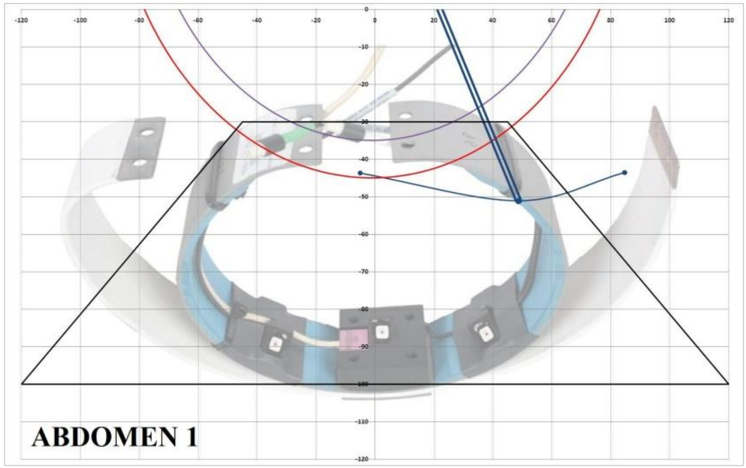
Model B





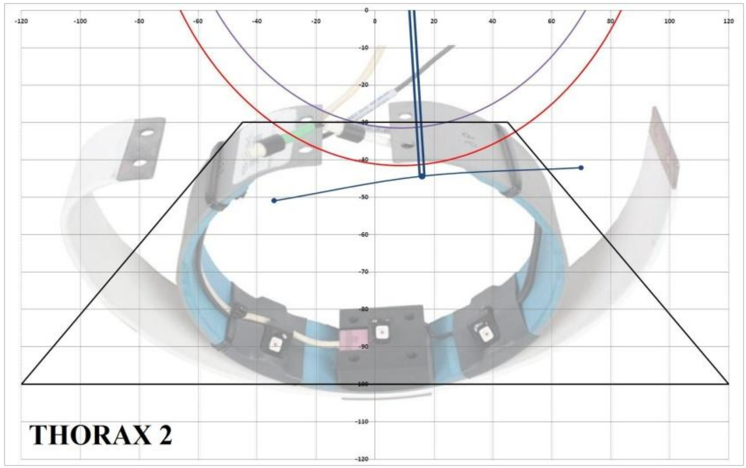
Model A

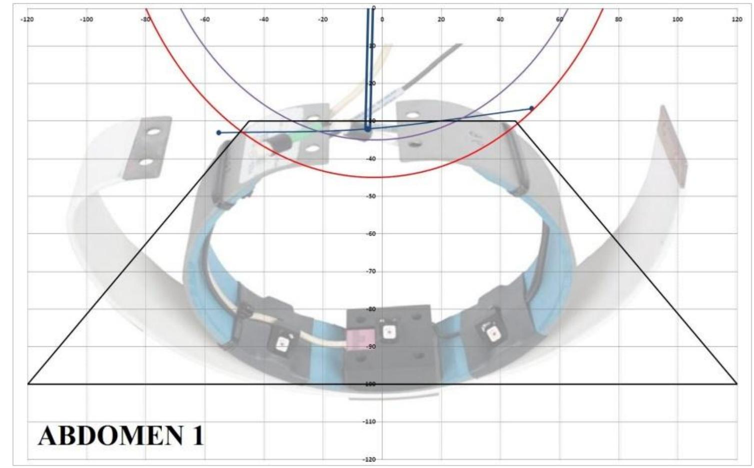




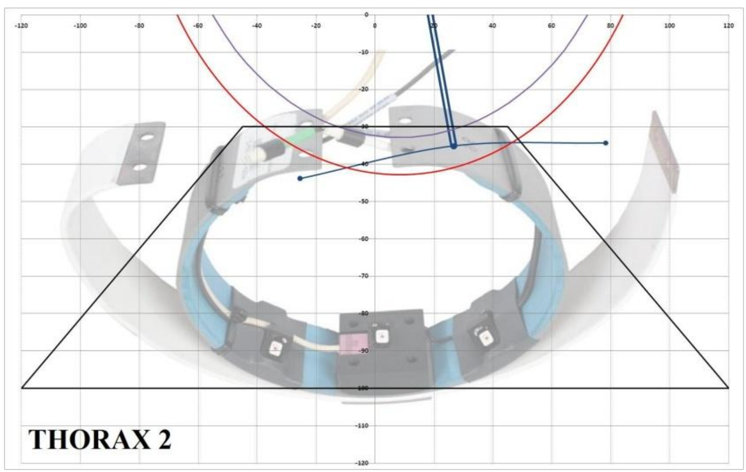
Offset Test: RibEye Movies

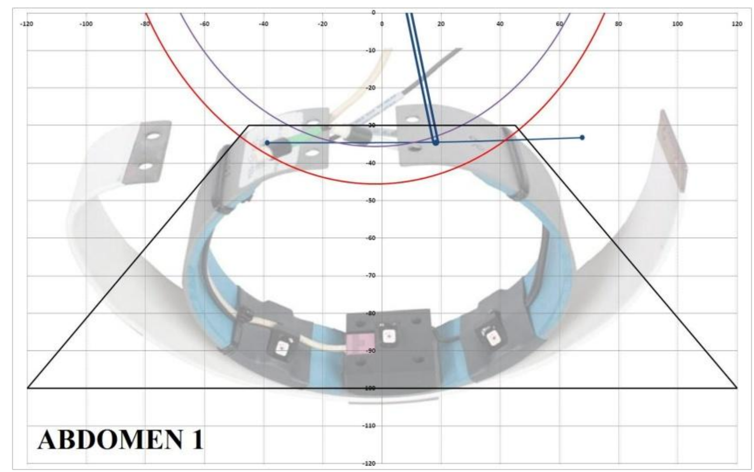
Model B



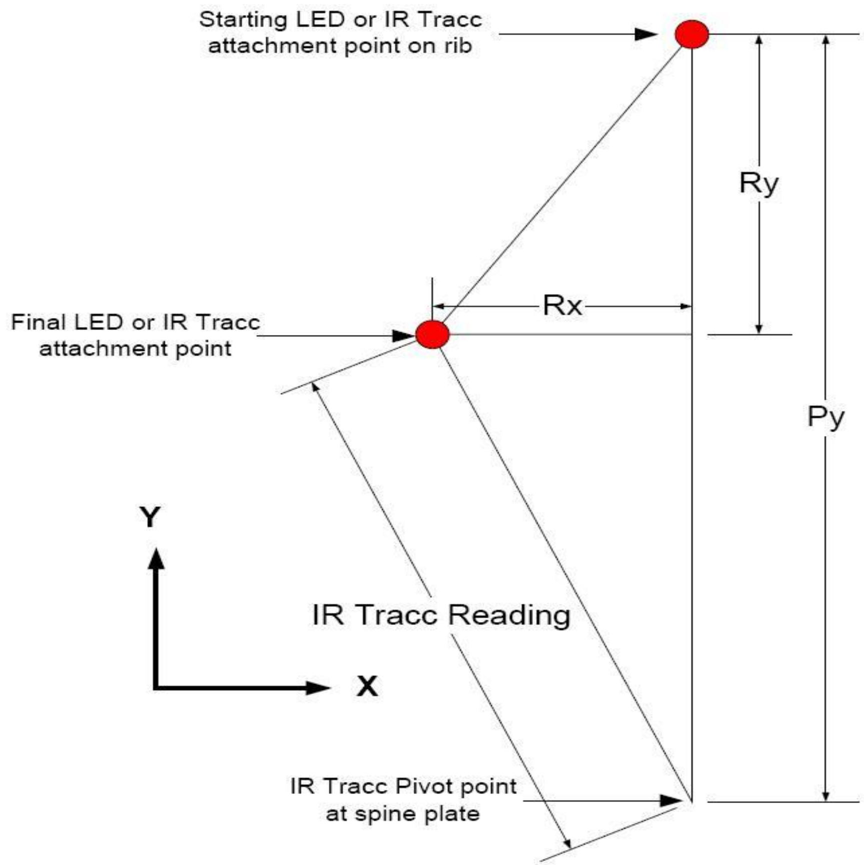


Model A





Theoretical IRTRACC Deflection



Py = IR-TRACC pivot-to-pivot dimension of an unloaded rib

Rx = Ribeye centre LED position change in the X direction

Ry = Ribeye centre LED position change in the Y direction

Rz = Ribeye centre LED position change in the Z direction

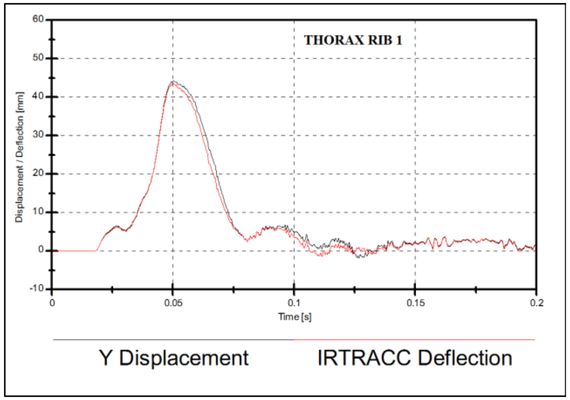
IRTRACC Deflection = $Py - \text{sqrt}[(Py - |Ry|)^2 + Rx^2 + Rz^2]$

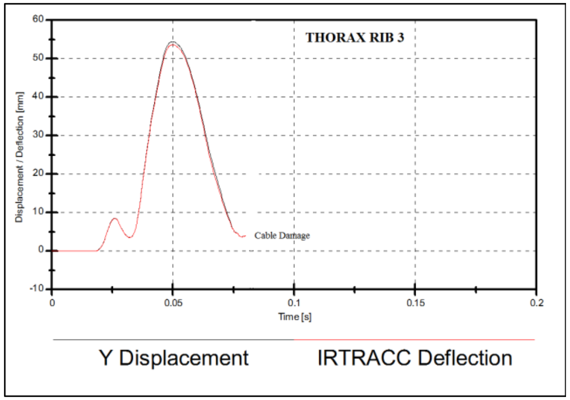
Source: Denton / Boxboro Systems, Hardware Users Manual RibEye™ Multi-Point Deflection Measurement System 3-Axis Version for the WorldSID 50th ATD, July 2009, pg 22.

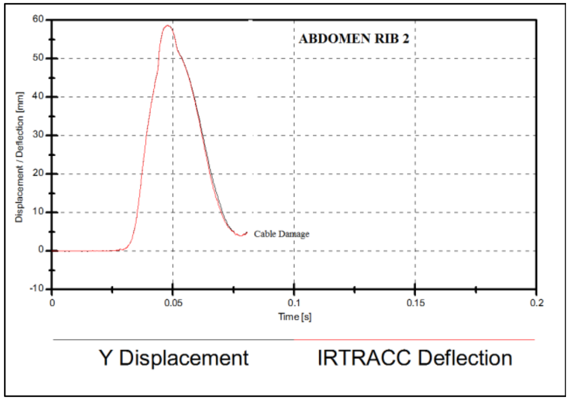
Oblique Test: Rib Responses

Centre LED Y-axis Displacement vs. Theoretical IRTRACC Deflection

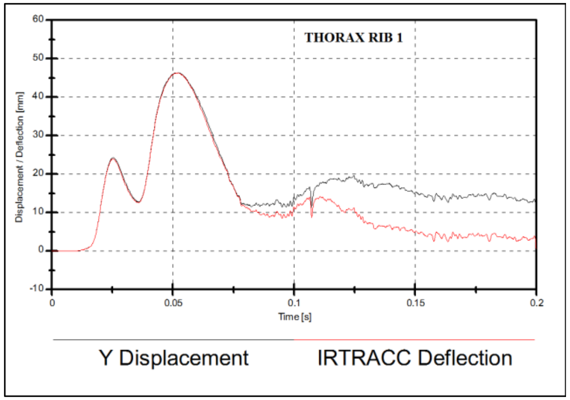
Model B

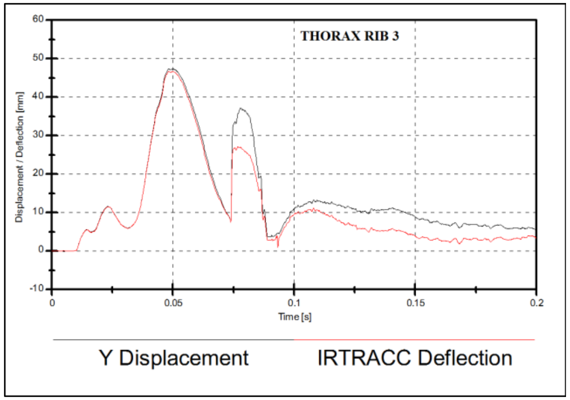


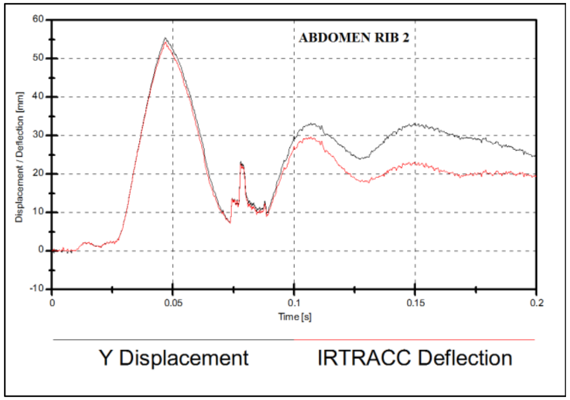




Model A



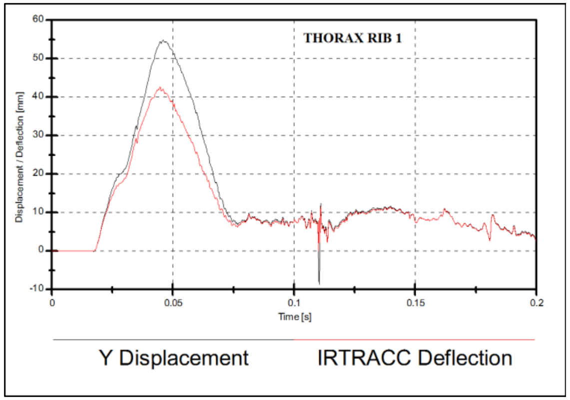


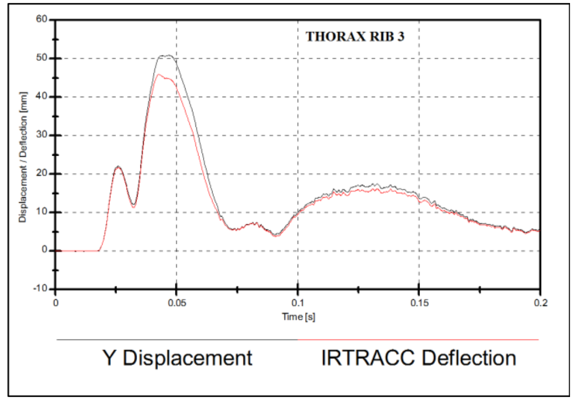


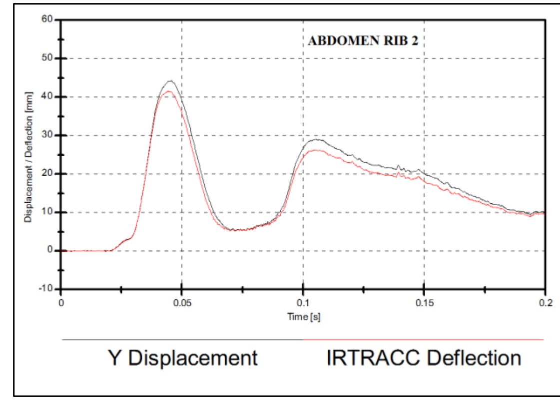
Perpendicular Test: Rib Responses

Centre LED Y-axis Displacement vs. Theoretical IRTRACC Deflection

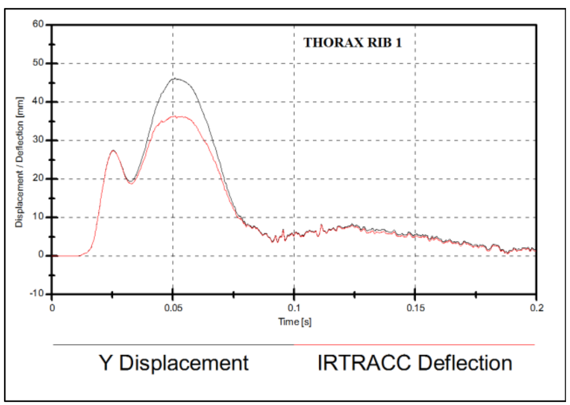
Model B

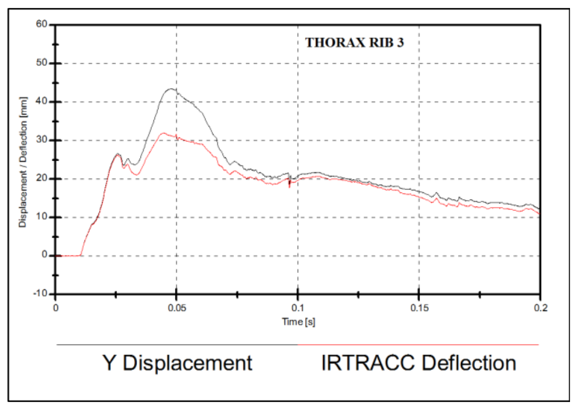


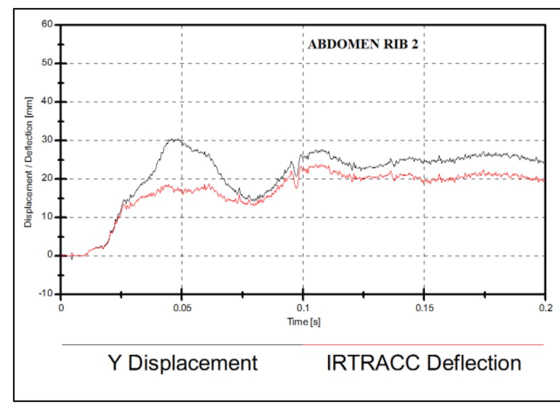




Model A



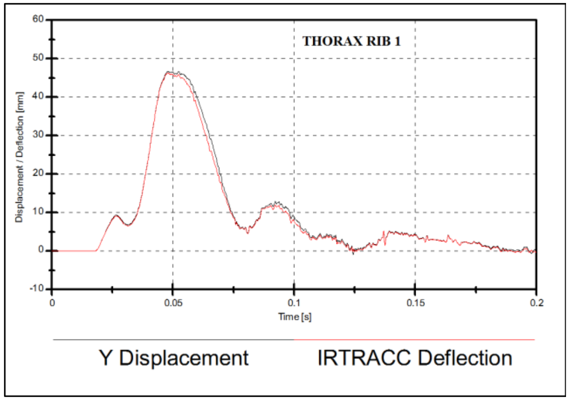


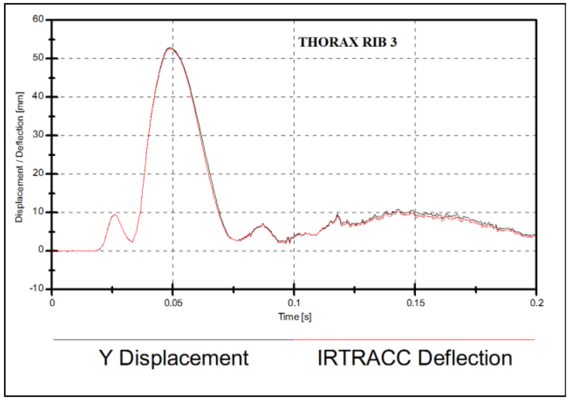


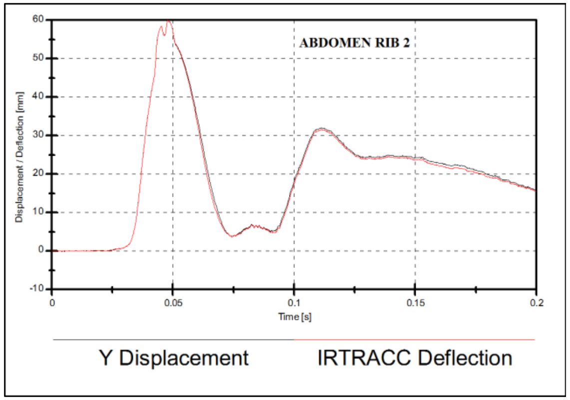
Offset Test: Rib Responses

Centre LED Y-axis Displacement vs. Theoretical IRTRACC Deflection

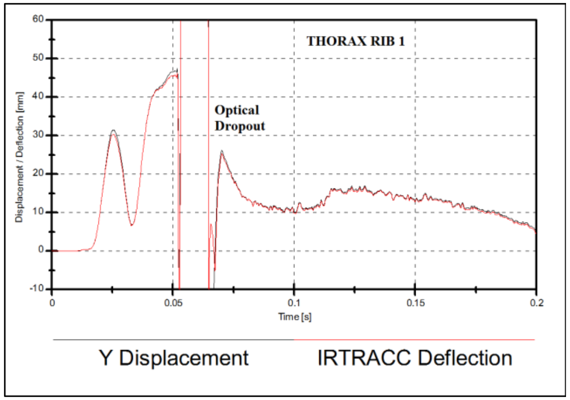
Model B

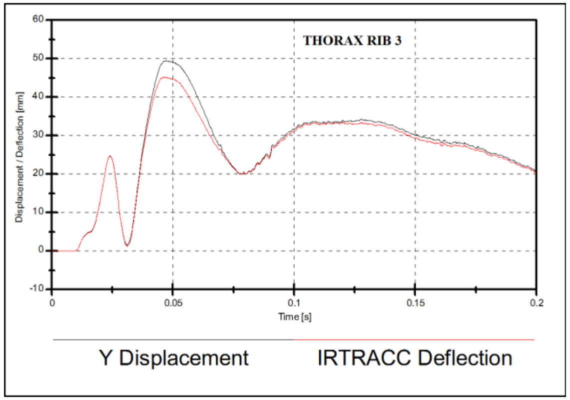


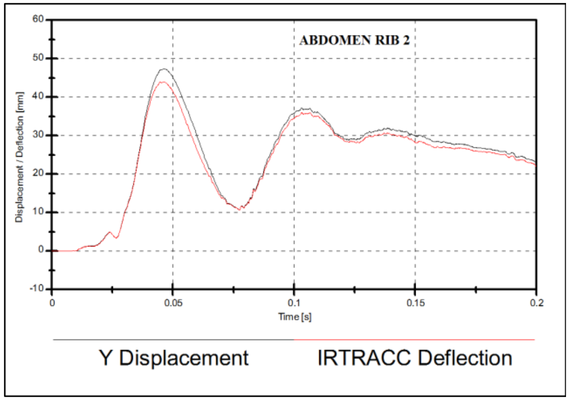




Model A







Struck Side Injury Response

Model A: Summary of Struck Side Injury Criteria Performance

IARVs as per proposed limits presented by Louden (NHTSA) Feb 2009

Exceeds Proposed IARV → Within 10% of Proposed IARV → Less than 90% of Proposed IARV

BODY REGION	INJURY CRITERIA	OBLIQUE	PERPENDICULAR	OFFSET
Head	HIC36	275	5667	5944
	3ms Head Acceleration (g)	60.2	103.6	84.7
Thorax	Thorax Rib 1 Deflection (mm)	46.3	36.4	> 46
	Thorax Rib 1 Viscous Criterion (m/s)	0.74	0.4	-
	Thorax Rib 2 Deflection (mm)	43.4	35.5	50.9
	Thorax Rib 2 Viscous Criterion (m/s)	0.68	0.54	0.95
	Thorax Rib 3 Deflection (mm)	46.7	32	45.3
	Thorax Rib 3 Viscous Criterion (m/s)	0.89	0.32	0.62
Abdomen	Abdomen Rib 1 Deflection (mm)	56	28.7	53.4
	Abdomen Rib 1 Viscous Criterion (m/s)	0.82	0.19	0.82
	Abdomen Rib 2 Deflection (mm)	54.2	23.8	43.9
	Abdomen Rib 2 Viscous Criterion (m/s)	0.83	0.43	0.65
Lower Spine	Resultant T12 Acceleration (g)	57.7	49.1	63.1
Pelvis	Resultant Pelvis Acceleration (g)	72.3	49.1	73.9
	Pubic Symphysis Force (kN)	1.23	0.74	1.19

Rib deflection values are theoretical IRTRACC values

Viscous criterion values calculated according to ECE R94 Directive 96/79/EG from theoretical IRTRACC response

Struck Side Injury Response

Model A: Summary of Struck Side Injury Criteria Performance

Thorax/abdomen/spine/pelvis injury risks as per **survival method** values presented by Petitjean et al., Stapp 2009

Probability AIS 3+ ≥ 50% → 50% > AIS 3+ >25% → Probability AIS 3+ ≤ 25%

BODY REGION	INJURY CRITERIA	OBLIQUE	PERPENDICULAR	OFFSET
Head	HIC36	275	5667	5944
	3ms Head Acceleration (g)	60.2	103.6	84.7
Thorax	Thorax Rib 1 Deflection (mm)	46.3	36.4	> 46
	Thorax Rib 1 Viscous Criterion (m/s)	0.74	0.4	-
	Thorax Rib 2 Deflection (mm)	43.4	35.5	50.9
	Thorax Rib 2 Viscous Criterion (m/s)	0.68	0.54	0.95
	Thorax Rib 3 Deflection (mm)	46.7	32	45.3
	Thorax Rib 3 Viscous Criterion (m/s)	0.89	0.32	0.62
Abdomen	Abdomen Rib 1 Deflection (mm)	56	28.7	53.4
	Abdomen Rib 1 Viscous Criterion (m/s)	0.82	0.19	0.82
	Abdomen Rib 2 Deflection (mm)	54.2	23.8	43.9
	Abdomen Rib 2 Viscous Criterion (m/s)	0.83	0.43	0.65
Lower Spine	3ms T12 Acceleration (g)	55.7	45.9	58.3
Pelvis	3ms Pelvis Acceleration (g)	67.0	44.3	70.1
	Pubic Symphysis Force (kN)	1.23	0.74	1.19

Rib deflection values are theoretical IRTRACC values
Viscous criterion values calculated according to ECE R94 Directive 96/79/EG from theoretical IRTRACC response

Struck Side Injury Response

Model A: Summary of Struck Side Injury Criteria Performance

Thorax/abdomen/spine/pelvis injury risks as per **certainty method** values presented by Petitjean et al., Stapp 2009

Probability AIS 3+ ≥ 50% → 50% > AIS 3+ >25% → Probability AIS 3+ ≤ 25%

BODY REGION	INJURY CRITERIA	OBLIQUE	PERPENDICULAR	OFFSET
Head	HIC36	275	5667	5944
	3ms Head Acceleration (g)	60.2	103.6	84.7
Thorax	Thorax Rib 1 Deflection (mm)	46.3	36.4	> 46
	Thorax Rib 1 Viscous Criterion (m/s)	0.74	0.4	-
	Thorax Rib 2 Deflection (mm)	43.4	35.5	50.9
	Thorax Rib 2 Viscous Criterion (m/s)	0.68	0.54	0.95
	Thorax Rib 3 Deflection (mm)	46.7	32	45.3
	Thorax Rib 3 Viscous Criterion (m/s)	0.89	0.32	0.62
Abdomen	Abdomen Rib 1 Deflection (mm)	56	28.7	53.4
	Abdomen Rib 1 Viscous Criterion (m/s)	0.82	0.19	0.82
	Abdomen Rib 2 Deflection (mm)	54.2	23.8	43.9
	Abdomen Rib 2 Viscous Criterion (m/s)	0.83	0.43	0.65
Lower Spine	3ms T12 Acceleration (g)	55.7	45.9	58.3
Pelvis	3ms Pelvis Acceleration (g)	67.0	44.3	70.1
	Pubic Symphysis Force (kN)	1.23	0.74	1.19

Rib deflection values are theoretical IRTRACC values

Viscous criterion values calculated according to ECE R94 Directive 96/79/EG from theoretical IRTRACC response

Struck Side Injury Response

Model B: Summary of Struck Side Injury Criteria Performance

IARVs as per proposed limits presented by Louden (NHTSA) Feb 2009

Exceeds Proposed IARV → Within 10% of Proposed IARV → Less than 90% of Proposed IARV

BODY REGION	INJURY CRITERIA	OBLIQUE	PERPENDICULAR	OFFSET
Head	HIC36	343	377	355
	3ms Head Acceleration (g)	65	61.5	65.1
Thorax	Thorax Rib 1 Deflection (mm)	43.5	42.6	46.3
	Thorax Rib 1 Viscous Criterion (m/s)	0.82	0.42	0.8
	Thorax Rib 2 Deflection (mm)	43.8	38.7	42.1
	Thorax Rib 2 Viscous Criterion (m/s)	0.66	0.6	0.75
	Thorax Rib 3 Deflection (mm)	53.6	45.9	52.6
	Thorax Rib 3 Viscous Criterion (m/s)	0.83	0.89	0.89
Abdomen	Abdomen Rib 1 Deflection (mm)	59.2	50.6	57.9
	Abdomen Rib 1 Viscous Criterion (m/s)	0.98	1.02	1.04
	Abdomen Rib 2 Deflection (mm)	58.6	41.6	60
	Abdomen Rib 2 Viscous Criterion (m/s)	1.77	0.71	2.22
Lower Spine	Resultant T12 Acceleration (g)	63.7	72.8	64.9
Pelvis	Resultant Pelvis Acceleration (g)	79.4	83.5	86.9
	Pubic Symphysis Force (kN)	1.18	1.07	1.33

Rib deflection values are theoretical IRTRACC values
Viscous criterion values calculated according to ECE R94 Directive 96/79/EG from theoretical IRTRACC response

Struck Side Injury Response

Model B: Summary of Struck Side Injury Criteria Performance

Thorax/abdomen/spine/pelvis injury risks as per **survival method** values presented by Petitjean et al., Stapp 2009

Probability AIS 3+ ≥ 50% → 50% > AIS 3+ >25% → Probability AIS 3+ ≤ 25%

BODY REGION	INJURY CRITERIA	OBLIQUE	PERPENDICULAR	OFFSET
Head	HIC36	343	377	355
	3ms Head Acceleration (g)	65	61.5	65.1
Thorax	Thorax Rib 1 Deflection (mm)	43.5	42.6	46.3
	Thorax Rib 1 Viscous Criterion (m/s)	0.82	0.42	0.8
	Thorax Rib 2 Deflection (mm)	43.8	38.7	42.1
	Thorax Rib 2 Viscous Criterion (m/s)	0.66	0.6	0.75
	Thorax Rib 3 Deflection (mm)	53.6	45.9	52.6
	Thorax Rib 3 Viscous Criterion (m/s)	0.83	0.89	0.89
Abdomen	Abdomen Rib 1 Deflection (mm)	59.2	50.6	57.9
	Abdomen Rib 1 Viscous Criterion (m/s)	0.98	1.02	1.04
	Abdomen Rib 2 Deflection (mm)	58.6	41.6	60
	Abdomen Rib 2 Viscous Criterion (m/s)	1.77	0.71	2.22
Lower Spine	3ms T12 Acceleration (g)	59.6	69.9	61.4
Pelvis	3ms Pelvis Acceleration (g)	66.4	70.2	74.2
	Pubic Symphysis Force (kN)	1.18	1.07	1.33

Rib deflection values are theoretical IRTRACC values
Viscous criterion values calculated according to ECE R94 Directive 96/79/EG from theoretical IRTRACC response

Struck Side Injury Response

Model B: Summary of Struck Side Injury Criteria Performance

Thorax/abdomen/spine/pelvis injury risks as per **certainty method** values presented by Petitjean et al., Stapp 2009

Probability AIS 3+ ≥ 50% → 50% > AIS 3+ >25% → Probability AIS 3+ ≤ 25%

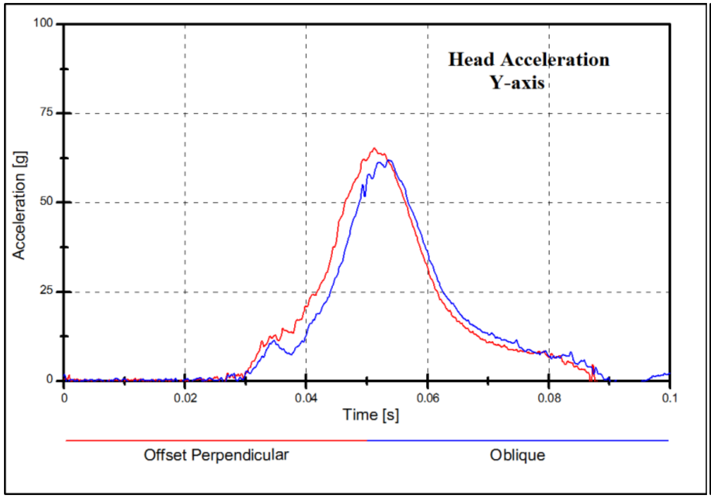
BODY REGION	INJURY CRITERIA	OBLIQUE	PERPENDICULAR	OFFSET
Head	HIC36	343	377	355
	3ms Head Acceleration (g)	65	61.5	65.1
Thorax	Thorax Rib 1 Deflection (mm)	43.5	42.6	46.3
	Thorax Rib 1 Viscous Criterion (m/s)	0.82	0.42	0.8
	Thorax Rib 2 Deflection (mm)	43.8	38.7	42.1
	Thorax Rib 2 Viscous Criterion (m/s)	0.66	0.6	0.75
	Thorax Rib 3 Deflection (mm)	53.6	45.9	52.6
	Thorax Rib 3 Viscous Criterion (m/s)	0.83	0.89	0.89
Abdomen	Abdomen Rib 1 Deflection (mm)	59.2	50.6	57.9
	Abdomen Rib 1 Viscous Criterion (m/s)	0.98	1.02	1.04
	Abdomen Rib 2 Deflection (mm)	58.6	41.6	60
	Abdomen Rib 2 Viscous Criterion (m/s)	1.77	0.71	2.22
Lower Spine	3ms T12 Acceleration (g)	59.6	69.9	61.4
Pelvis	3ms Pelvis Acceleration (g)	66.4	70.2	74.2
	Pubic Symphysis Force (kN)	1.18	1.07	1.33

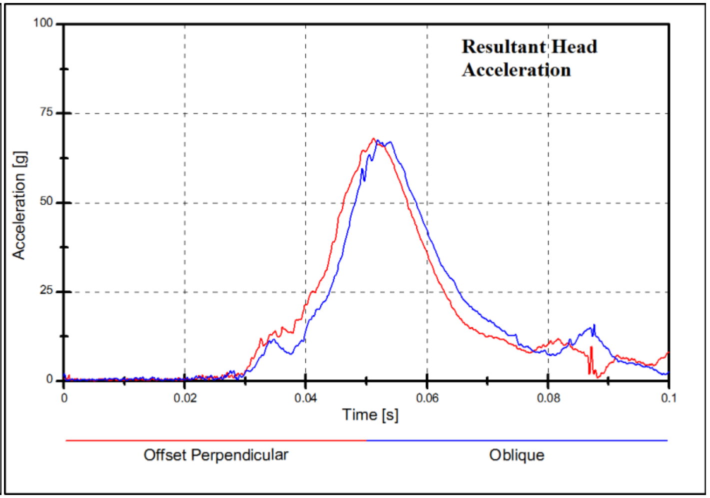
Rib deflection values are theoretical IRTRACC values

Viscous criterion values calculated according to ECE R94 Directive 96/79/EG from theoretical IRTRACC response

Oblique vs Offset Head Responses

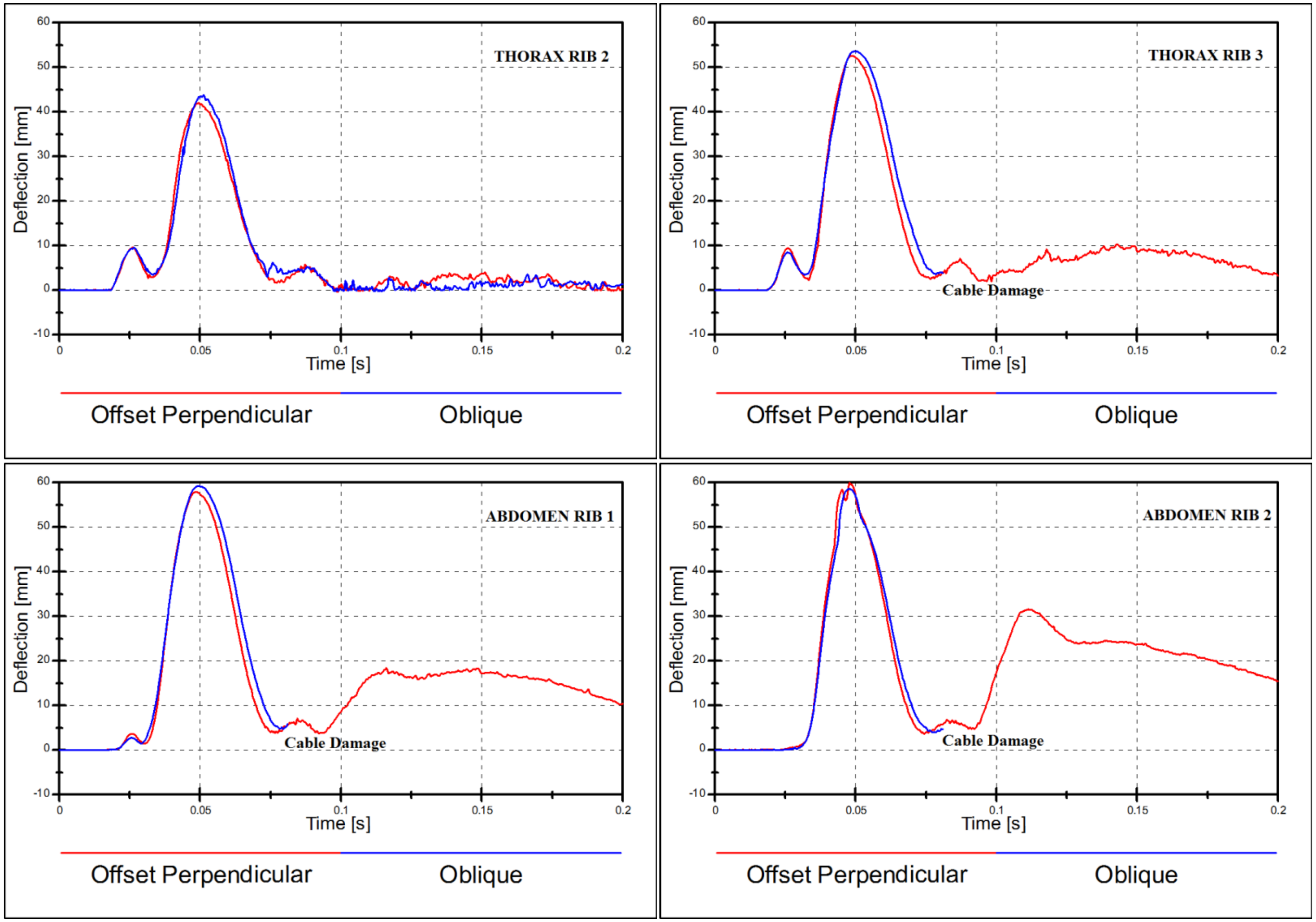
Model B: Y-axis and Resultant Head Acceleration Response Time History





Oblique vs Offset Rib Responses

Model B: Theoretical IRTRACC Deflection (struck side)



Dummy Occupant-to-Occupant Head Injury Risk

Exceeds an Existing IARV → Within 10% of IARV → Less than 90% of IARV

In all but one test, dummy occupant-to-occupant head collisions produced HIC36 results normally associated with a high probability of fatal head injury

Test	Struck Side Dummy		Non-Struck Side Dummy	
	HIC36	3ms Head Acceleration (g)	HIC36	3ms Head Acceleration (g)
Model A				
Oblique	108	26.8	232	44.7
Perpendicular	6242	74.0	6803	85.0
Offset Perpendicular	5767	47.3	6255	92.1
Model B				
Oblique	2561	50.7	2709	56.0
Perpendicular	17979	75.2	18089	76.8
Offset Perpendicular	4252	39.1	4269	58.5

Typical regulatory head injury assessment reference values (IARVs) used (i.e. HIC36 < 1000, 3ms head acc. < 80g)

Centre Console Interactions

Non-struck side dummy interaction with centre console

Model B:

- Oblique Impact:
  - 37mm thorax rib 3 deflection
- Offset Perpendicular Impact:
  - 36mm abdominal rib 1 deflection

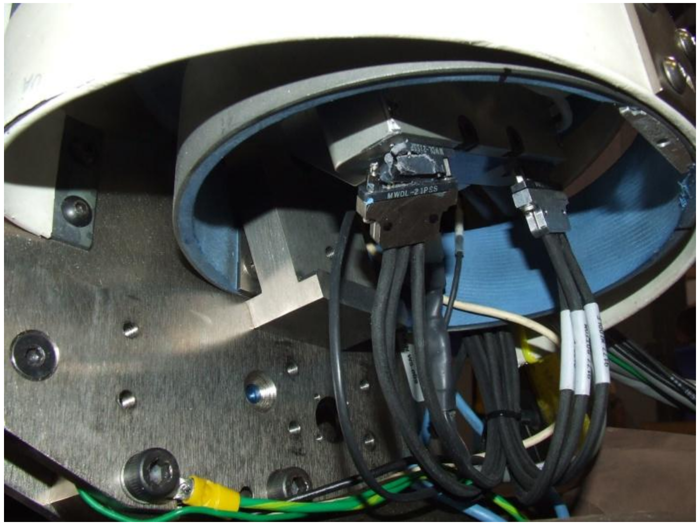
Implied benefit for use of lower thorax and abdomen instrumentation on both sides of struck-side dummy

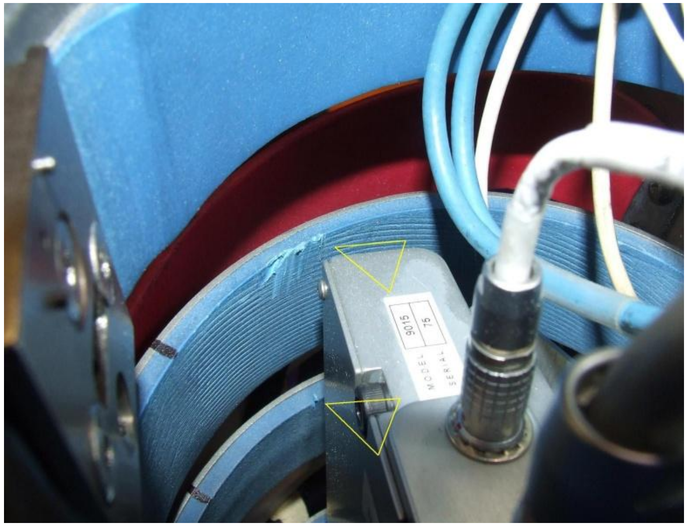
WorldSID ribs can be impacted / instrumented on both sides

Occupant-to-Occupant Interaction and Non-Struck Side Dummy Kinematics

Some examples:

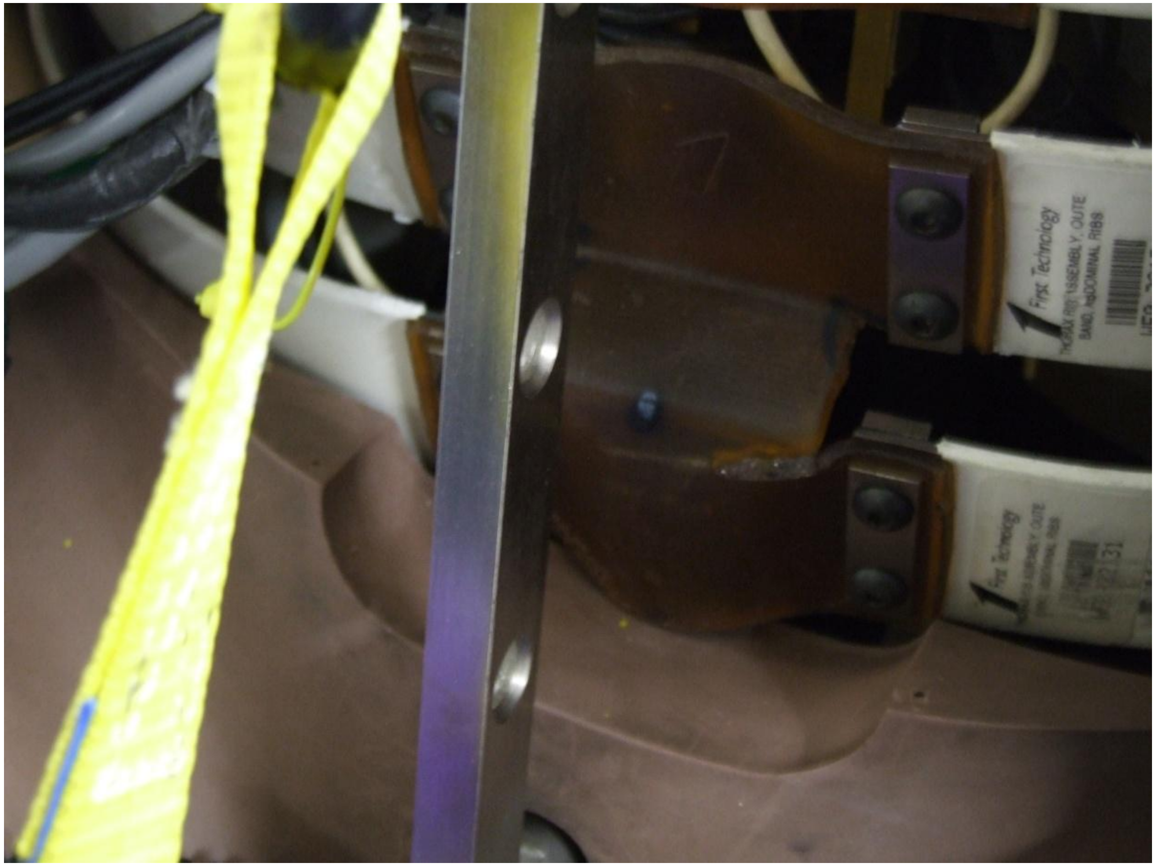
Durability





- Ribeye controller sensor cable connector damage. No internal damage to controller processor board. Field repair successfully performed by test facility.
- Interaction of non-struck side rib damping material with the ribeye controller.

Durability (cont)



Conclusions

Head:

- Airbag entrapment and subsequent bursting occurred in the perpendicular and offset perpendicular pole tests conducted on Model A
  - HIC36 results were therefore much higher than oblique test for this vehicle model.
  - Must be noted airbag deployment would have been much slower for this vehicle in oblique test.
- Attributed to:
  - A higher lateral component of impact velocity; and
  - Closer alignment of pole with point of shoulder.

Conclusions

Head (continued):

- Both combination airbags were wide enough to protect the head in oblique impact (the most forward impact condition).

- Moving pole 100mm forward of head COG was not observed to significantly reduce head injury risk.

- Very similar head injury risks recorded for vehicle where airbag deployed successfully (Model B).

Conclusions

Thorax & Abdomen:

- The peak theoretical IRTRACC deflections of the struck side dummy were predominantly in the lateral (y-axis) direction for both oblique pole tests as well as the offset test conducted with Model B.

- Some forward x-axis movement of ribs occurred for Model A in offset perpendicular test.

- Significant forward x-axis movement of the ribs was recorded in both perpendicular pole tests.

Conclusions

Thorax & Abdomen (continued):

- IRTRACC equivalent thorax rib deflections were higher in oblique and offset perpendicular impact, than in perpendicular impact.
  - perpendicular test may produce comparable or higher y-axis displacement (upper thorax in particular), but forward rib movement generally produces a lower IRTRACC reading.
- Abdomen rib loadings more severe for oblique and offset perpendicular test methods than for perpendicular test method.

Conclusions

General:

- Airbag sensing systems can (in some cases) respond quite differently to different pole impact test methods
  - Will depend on the test vehicle design, including the side impact detection method used.
- Similar dummy responses can be obtained from oblique and offset perpendicular tests.
- Impact velocity and initial pole impact alignment relative to vehicle & dummy are key test parameters.

Thankyou

Questions?