Evaluation of the Full and Half Barrier Faces in Oblique Frontal Offset Tests

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NHTSA
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

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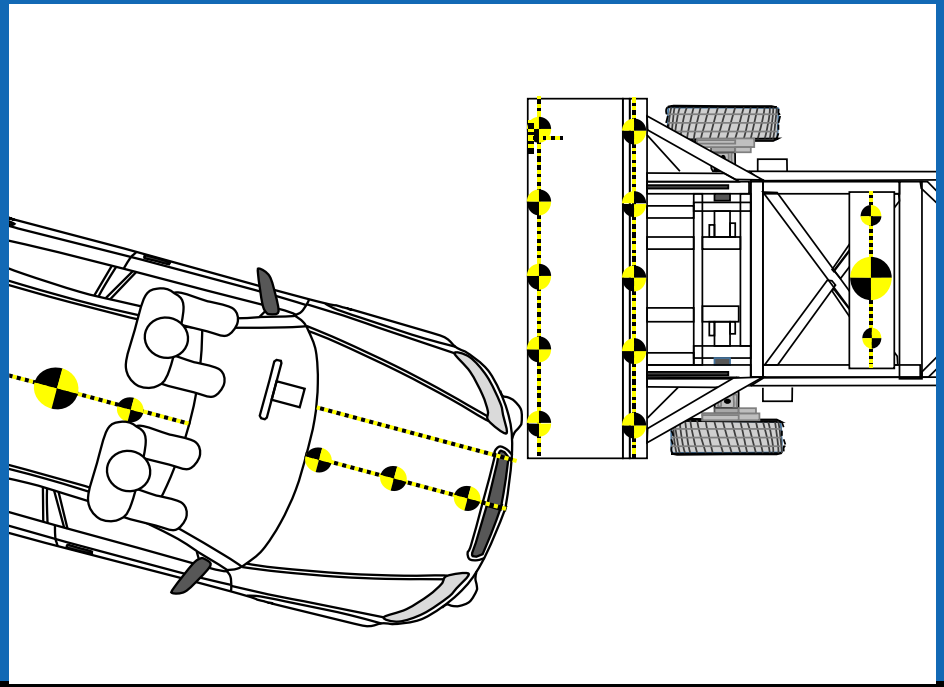
Test Setup

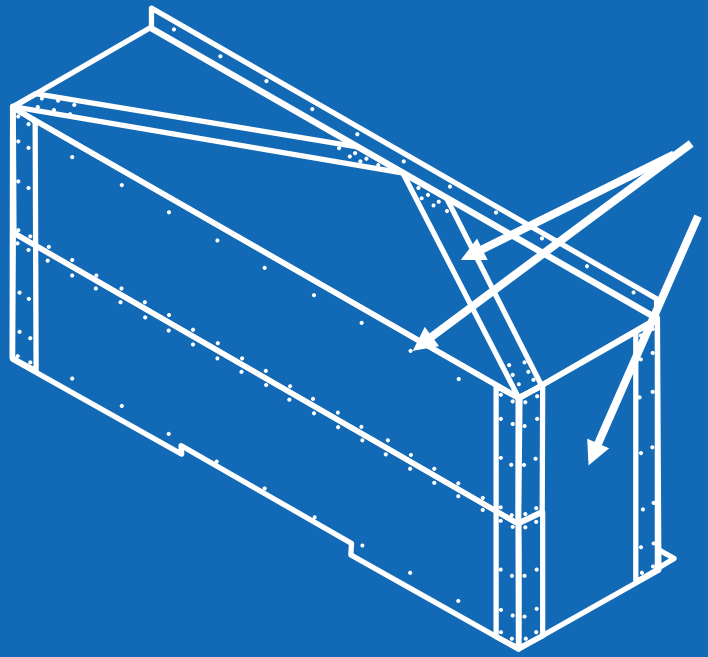
THOR-50M in driver and right front passenger seat



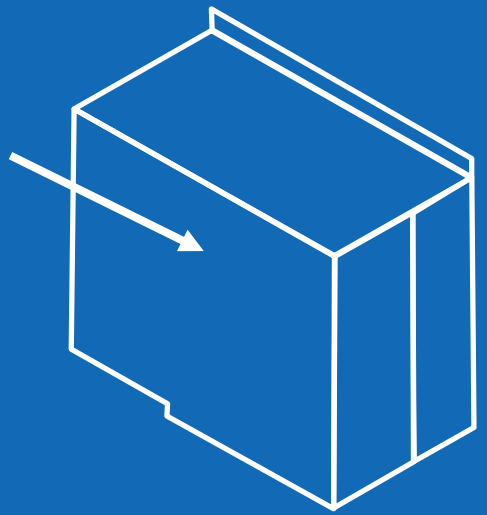
OMDB
-Weight=2500 kg
-Impact Velocity
=90 kph
-35% overlap

Vehicle
-Stationary
-Rotated 15 degrees

Honeycomb Definition

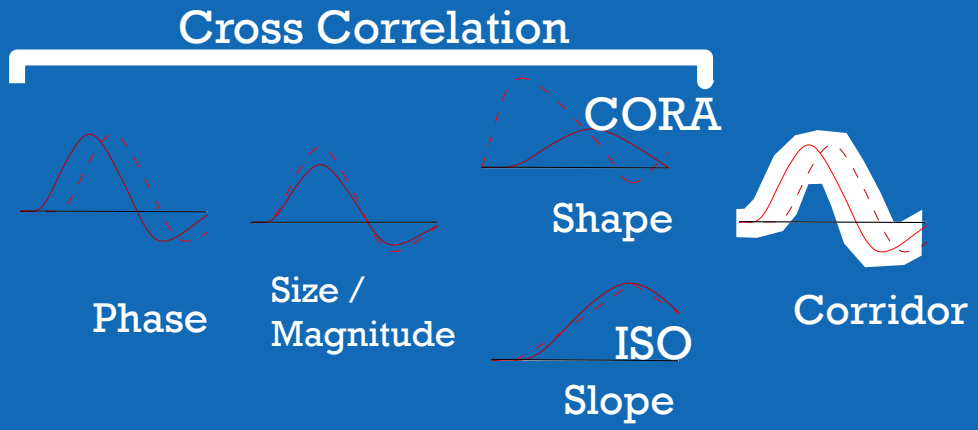


- Width slightly > 50%
- Materials the same
- Removed straps and rivets
- Removed side cladding
- Outer cladding one piece



Methodology

- Calculate correlation between time-histories
  - CORrelation and Analysis (CORA) *
  - ISO 18571 *
  - Percent Difference (Percent)
- Percent difference from peaks
  - $\text{Percent} = 1 - \frac{Full - Half}{Full}$



* CORAplus Release 4.04 User's Manual

CORA and ISO Setup

- Used examples from CORAPlus download
  - Only changed curve data
- Time range
  - OMDB and vehicle 0-100 ms
  - THOR 0-150 ms
- Data sampled at 0.1 ms

Methodology (continued)

- ISO 18572 grades *
  - Divides final score up into 4 grades (excellent, good, fair, and poor)
  - For this analysis combined excellent and good
- CORA and Percent do not have a grades for their final score
  - To be able to make a comparison between three methods ISO grades are assumed

Good	R>0.80
Fair	0.58<R<=0.80
Poor	R<=0.58

Vehicle Selection

- Different weight classes
- IIHS Top Safety Pick
- NHTSA 5 stars

	NHTSA Test #	
	Half	Full
Small	10134	10133
Mid-size	10072	10154
Large PU	10119	10099

Nomenclature

OMDB	
OMDBCGaccRes	OMDB CG resultant acceleration (xy)
OMDBCGvelRes	OMDB CG resultant velocity(xy)
OMDBCGav	OMDB CG angular velocity z-direction
OMDBCGang	OMDB CG rotation z-direction

Vehicle	
VehLRaccRes	Veh left rear resultant acceleration (xy)
VehLRvelRes	Veh left rear resultant velocity(xy)
VehRRaccRes	Veh right rear resultant acceleration (xy)
VehRRvelRes	Veh right rear resultant velocity(xy)
VehCGaccRes	Veh CG resultant acceleration (xy)
VehCGvelRes	Veh CG resultant velocity(xy)
VehCGav	Veh CG angular velocity z-direction
VehCGang	Veh CG rotation z-direction

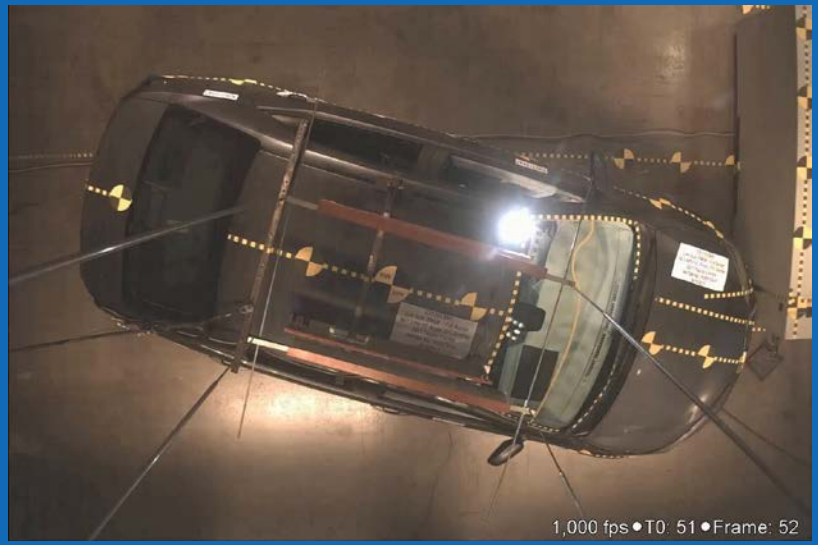
Nomenclature (continued)

Upper Body	
HeadACRes	Head resultant acceleration
HeadAVx	Head angular velocity x-direction
HeadAVy	Head angular velocity y-direction
HeadAVz	Head angular velocity z-direction
NeckFz	Upper neck force z-direction
NeckMy	Upper neck moment y-direction
ChestRL	Resultant chest displacement right lower
ChestLU	Resultant chest displacement left upper
ChestRU	Resultant chest displacement right upper

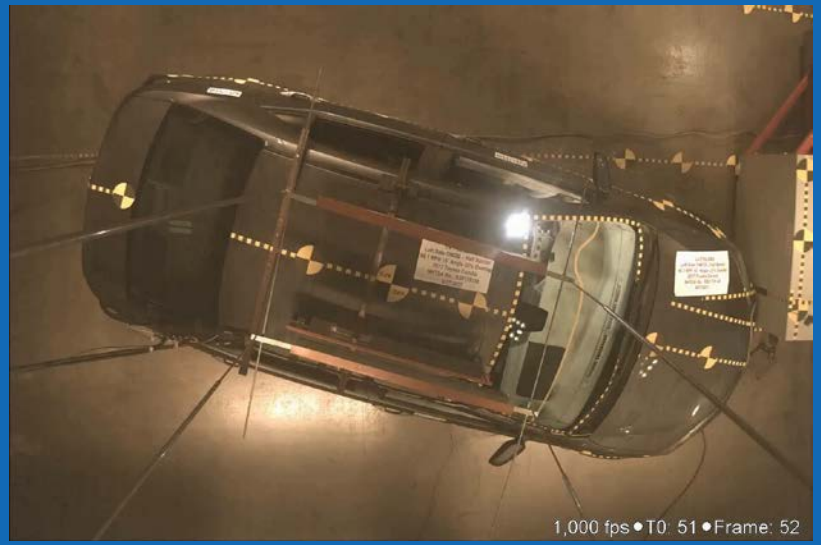
Lower Body	
AcetabRIRes	Resultant right accetabalum force
AcetabLERes	Resultant left accetabalum force
FemurLE	Left femur axial force
FemurRI	Right femur axial force
TibiaRUFz	Right upper tibia force z-direction
TibiaRUMomRes	Right upper resultant tibia moment (xy)
TibiaRLFz	Right lower tibia force z-direction
TibiaRLMomRes	Right lower resultant tibia moment (xy)
TibiaLUFz	Left upper tibia force z-direction
TibiaLUMomRes	Left upper resultant tibia moment (xy)
TibiaLLFz	Left lower tibia force z-direction
TibiaLLMomRes	Left lower resultant tibia moment (xy)

Overhead View Comparison

Full



Half



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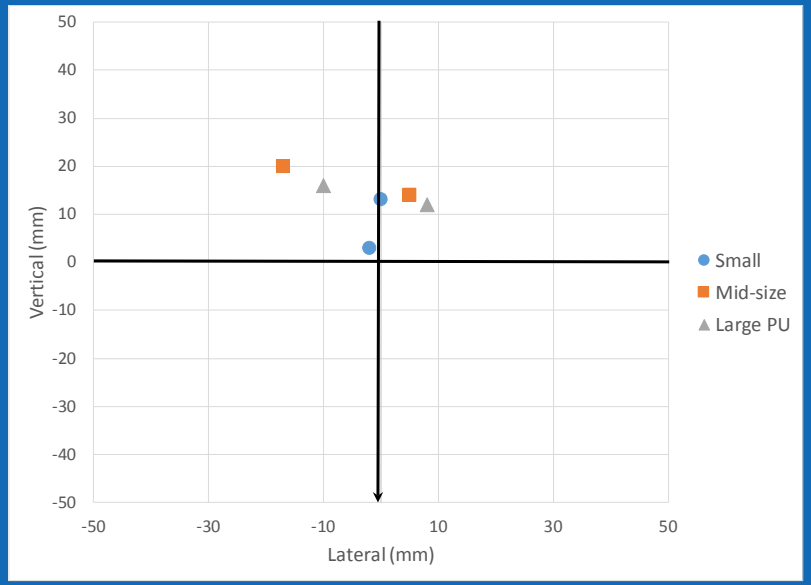
Impact Point



Max difference is 37 mm

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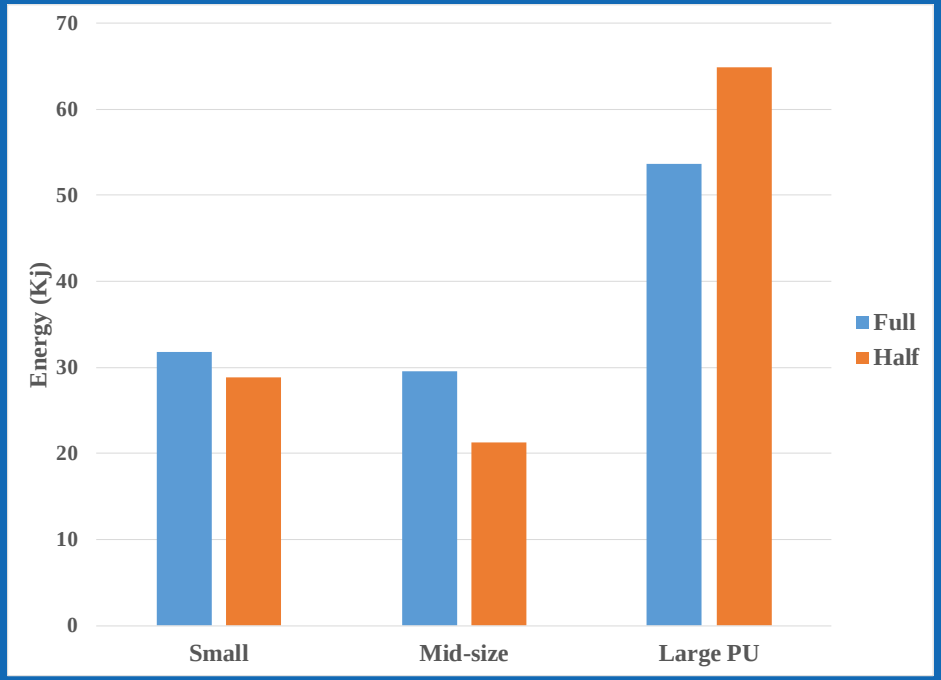
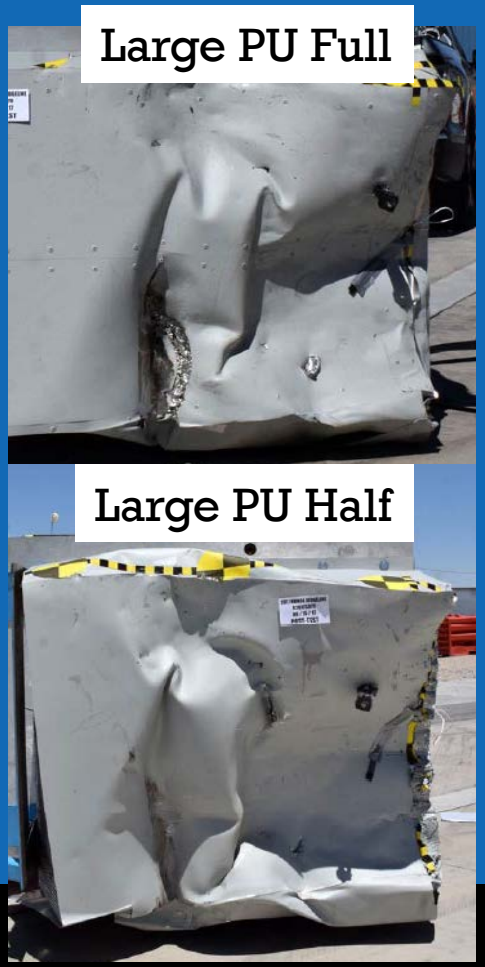
Energy Absorbed by OMDB





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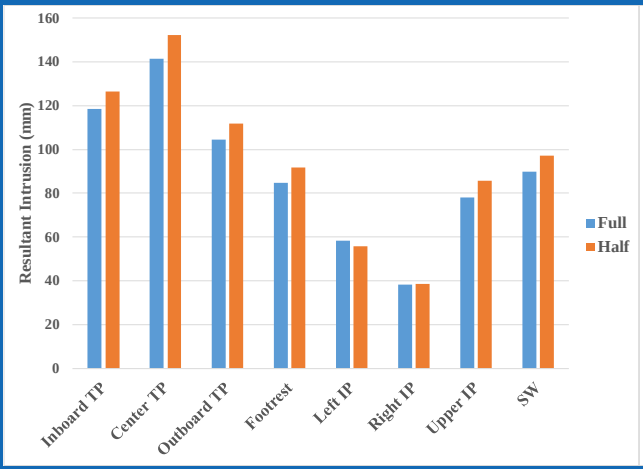
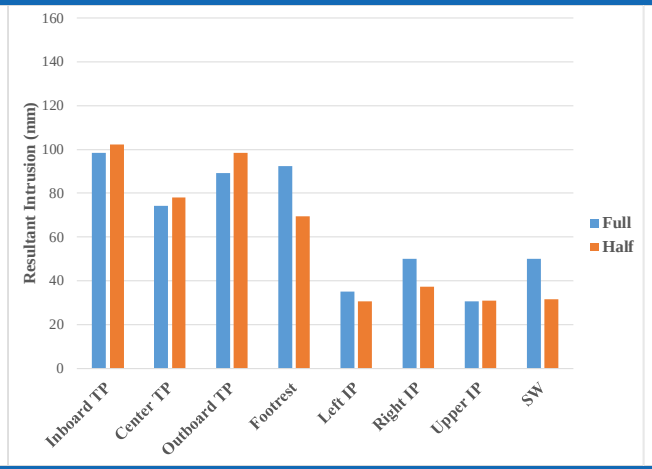
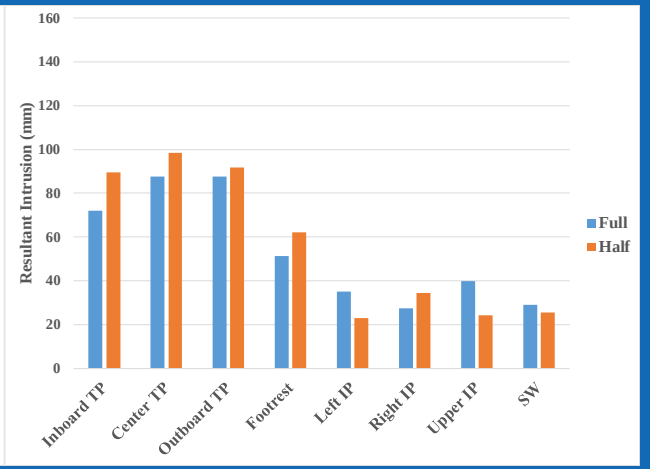
Interior Intrusions



Small



Mid-size



Large PU

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OMDB Results

	Small			Mid-size			Large PU		
	CORA	ISO	Percent	CORA	ISO	Percent	CORA	ISO	Percent
OMDBCGaccRes	0.99	0.93	0.99	0.97	0.67	0.97	0.94	0.86	0.97
OMDBCGvelRes	1.00	0.99	0.99	1.00	0.82	0.92	0.99	0.96	0.99
OMDBCGav	0.96	0.83	0.98	0.90	0.72	0.81	0.96	0.89	0.93
OMDBCGang	0.96	0.98	0.97	0.94	0.85	0.69	0.98	0.99	0.97

Vehicle Results

	Small			Mid-size			Large PU		
	CORA	ISO	Pecent	CORA	ISO	Pecent	CORA	ISO	Pecent
VehLRaccRes	0.97	0.91	1.00	0.91	0.63	0.73	0.80	0.78	0.85
VehLRvelRes	1.00	0.98	0.99	0.97	0.81	0.94	0.99	0.94	0.97
VehRRaccRes	0.97	0.92	0.97	0.90	0.63	0.92	0.86	0.80	0.79
VehRRvelRes	1.00	0.99	0.96	0.90	0.83	0.88	0.99	0.96	0.98
VehCGaccRes	0.98	0.94	0.96	ND	ND	ND	0.83	0.77	0.99
VehCGvelRes	1.00	0.99	0.98	ND	ND	ND	0.98	0.95	0.92
VehCGav	0.65	0.63	0.87	0.84	0.58	0.93	0.90	0.79	0.92
VehCGang	0.81	0.77	0.74	0.92	0.69	0.84	0.99	0.97	0.99

Explain latter

Acceleration rating "fair" but velocity is rated "good"

Driver Upper Body Results

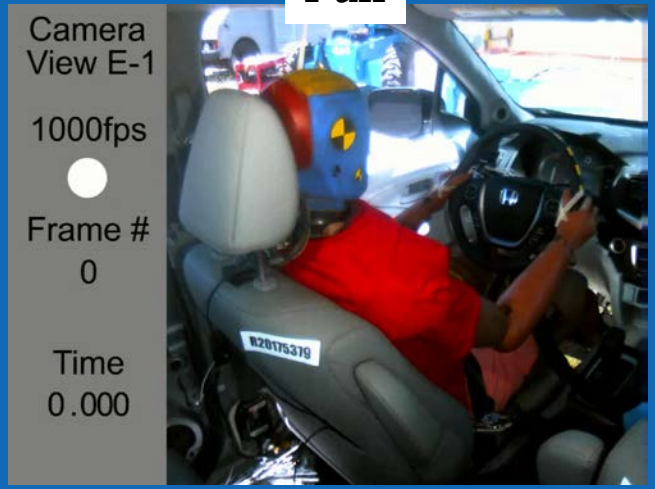
	Small			Mid-size			Large-PU		
	CORA	ISO	Percent	CORA	ISO	Percent	CORA	ISO	Percent
HIC			0.67			0.96			0.86
BRIC			0.79			0.95			0.74
HeadACRes	0.93	0.83	0.97	0.94	0.71	0.96	0.89	0.78	0.87
HeadAVx	0.74	0.76	0.90	0.91	0.69	0.92	0.65	0.67	0.57
HeadAVy	0.90	0.86	0.82	0.92	0.74	0.98	0.71	0.68	0.90
HeadAVz	0.81	0.81	0.96	ND	ND	ND	0.51	0.61	0.62
NeckFz	0.87	0.81	0.98	0.87	0.65	0.94	0.85	0.82	0.96
NeckMy	0.80	0.77	0.89	0.66	0.53	0.61	0.72	0.71	0.89
ChestLL	ND	ND	ND	0.64	0.51	0.53	0.75	0.64	0.85
ChestRL	0.93	0.85	0.90	0.53	0.40	0.64	0.68	0.63	0.76
ChestLU	ND	ND	ND	0.66	0.42	0.83	0.83	0.80	0.83
ChestRU	0.94	0.90	0.99	0.62	0.54	0.79	ND	ND	ND

Head Kinematics different (see next slide)

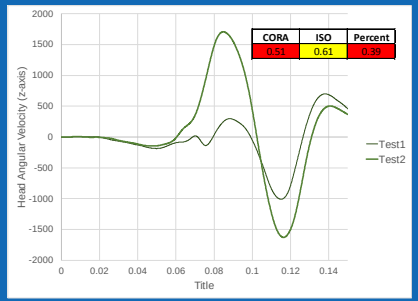
63 mm difference in SW displacement in the z-direction and difference in dummy position

Large PU Driver Head Kinematics

Full



Half



Full barrier test head rotates about the z-axis
Half barrier head slides relative to the bag causing less z-axis rotation

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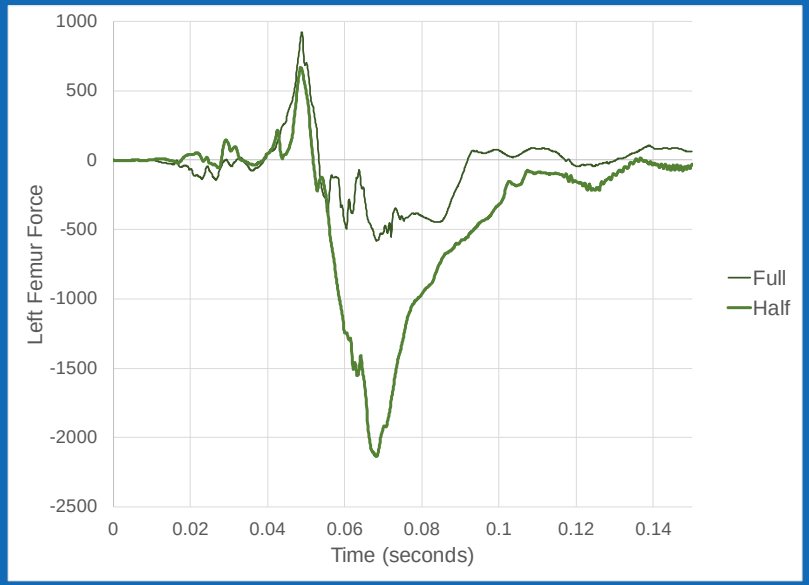
Driver Lower Body Results

	Small			Mid-size			Large-PU		
	CORA	ISO	Percent	CORA	ISO	Percent	CORA	ISO	Percent
AcetabRIRes	0.93	0.85	0.95	0.91	0.73	0.83	0.80	0.75	0.96
AcetabLERes	0.81	0.73	0.86	0.85	0.67	0.72	0.91	0.84	0.72
FemurLE	0.81	0.74	0.92	0.47	0.43	0.73	0.77	0.75	0.78
FemurRI	0.97	0.90	0.95	0.88	0.72	0.74	0.63	0.58	0.61
TibiaRUFz	0.93	0.85	0.93	0.79	0.63	0.90	0.67	0.66	0.85
TibiaRUMomRes	0.90	0.81	0.86	0.70	0.61	0.84	0.73	0.64	0.95
TibiaRLFz	0.96	0.90	0.98	0.87	0.65	0.84	0.59	0.59	0.59
TibiaRLMomRes	0.88	0.85	0.87	0.78	0.69	0.88	0.79	0.79	0.98
TibiaLUFz	0.79	0.77	0.80	0.65	0.57	0.50	0.29	0.36	0.34
TibiaLUMomRes	0.79	0.75	0.93	0.81	0.65	0.71	0.89	0.84	0.85
TibiaLLFz	0.85	0.77	0.90	0.77	0.66	0.80	ND	ND	ND
TibiaLLMomRes	0.72	0.71	0.80	0.80	0.68	0.68	0.78	0.78	0.67

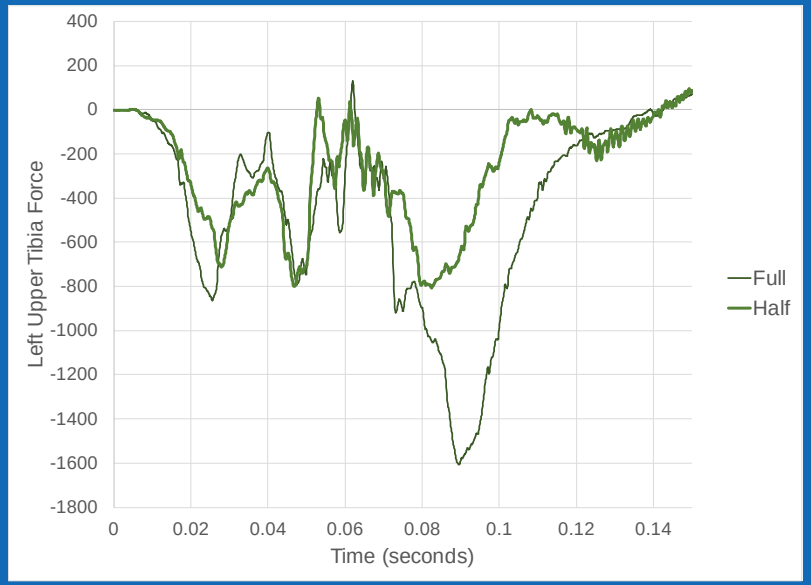
See next slide

Similar up to 50 ms, similar shape just magnitude different after 50 ms

Mid-size Left Femur and Left Upper Tibia Force



Femur similar up to 56 ms



Upper tibia similar for a little longer 70 ms

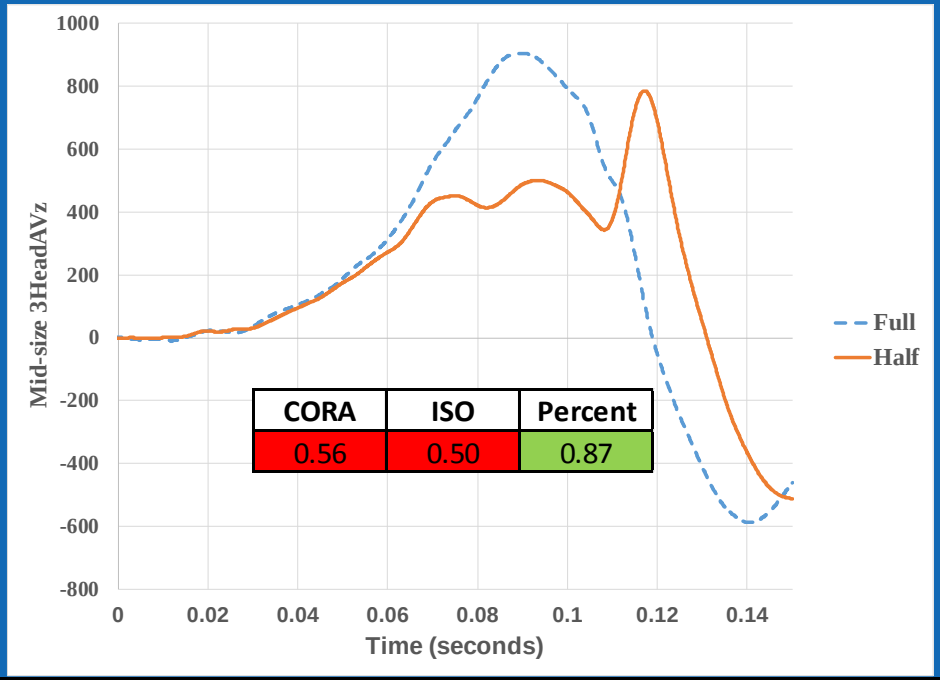
Passenger Upper Body

	Small			Mid-size			Large-PU		
	CORA	ISO	Percent	CORA	ISO	Percent	CORA	ISO	Percent
HIC			0.82			0.76			0.99
BRIC			0.69			0.89			0.94
HeadACRes	ND	ND	ND	0.87	0.69	0.76	0.97	0.90	0.97
HeadAVx	0.74	0.73	0.91	0.77	0.65	0.71	0.96	0.91	0.94
HeadAVy	0.87	0.87	0.85	0.88	0.69	0.94	0.91	0.89	0.99
HeadAVz	0.92	0.92	0.83	0.56	0.50	0.87	0.92	0.90	0.91
NeckFz	0.73	0.68	0.89	0.78	0.63	0.61	0.80	0.78	0.87
NeckMy	0.87	0.80	0.89	0.78	0.60	0.85	0.78	0.78	0.97
ChestLL	0.96	0.93	0.93	0.88	0.69	0.99	0.87	0.83	0.98
ChestRL	0.84	0.79	0.97	0.71	0.55	0.77	0.85	0.81	0.75
ChestLU	0.93	0.89	0.98	0.92	0.72	0.91	ND	ND	ND
ChestRU	0.71	0.63	0.73	0.85	0.63	0.91	0.72	0.67	0.76

See next slide

Magnitude small compared to other chest displacement

Mid-size Passenger Head Angular Velocity (z)



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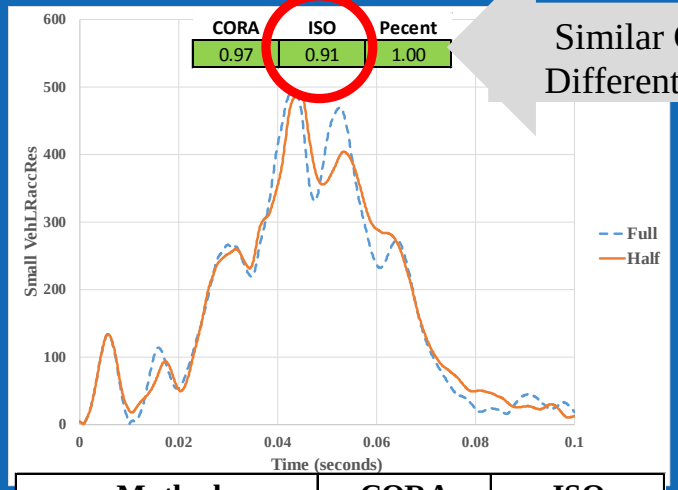
Passenger Lower Body

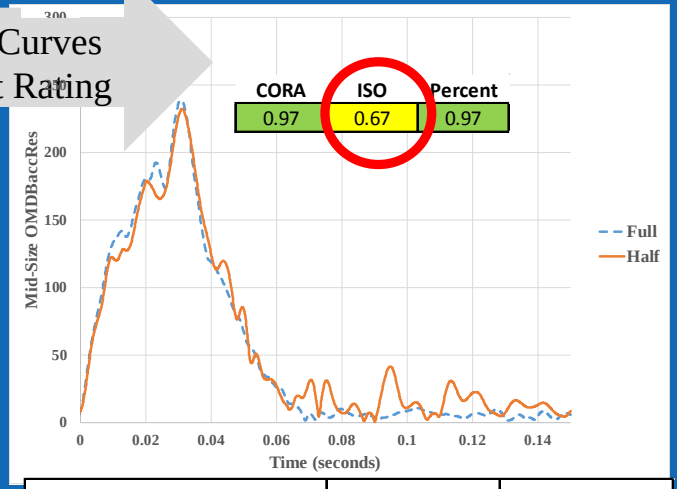
	Small			Mid-size			Large-PU		
	CORA	ISO	Percent	CORA	ISO	Percent	CORA	ISO	Percent
AcetabRIRes	ND	ND	ND	0.89	0.64	0.86	0.78	0.73	0.96
AcetabLERes	0.84	0.75	0.99	ND	ND	ND	0.72	0.68	0.77
FemurLE	0.97	0.90	0.98	0.89	0.63	0.89	0.94	0.86	0.90
FemurRI	0.93	0.87	0.96	0.89	0.71	0.96	0.93	0.86	0.86
TibiaRUFz	0.95	0.87	0.97	0.88	0.64	0.83	0.84	0.75	0.82
TibiaRUMomRes	0.88	0.84	0.98	0.70	0.57	0.96	0.86	0.83	0.87
TibiaRLFz	0.96	0.90	0.96	0.92	0.70	0.99	0.85	0.82	0.96
TibiaRLMomRes	0.79	0.77	0.90	0.89	0.75	0.92	0.85	0.82	0.80
TibiaLUFz	0.93	0.85	0.98	0.90	0.67	0.76	0.73	0.72	0.93
TibiaLUMomRes	0.75	0.73	0.72	0.69	0.53	0.89	0.84	0.80	0.88
TibiaLLFz	0.93	0.88	0.92	0.90	0.69	0.71	ND	ND	ND
TibiaLLMomRes	0.84	0.81	0.72	0.88	0.68	0.98	0.76	0.70	0.67

Similar up to 65 ms Phase shift Higher magnitude for 10 ms

Comparison of time-history methods



Similar Curves
Different Rating



Method	CORA	ISO
Corridor	0.956	0.974
Phase	1.000	0.976
Size (Magnitude)	0.975	0.969
Cross correlation (Slope)	0.973	0.795
Overall rating	0.968	0.938

() ISO naming convention

Method	CORA	ISO
Corridor	0.959	0.599
Phase	1.000	0.530
Size (Magnitude)	0.969	0.949
Cross correlation (Slope)	0.971	0.684
Overall rating	0.968	0.672

() ISO naming convention

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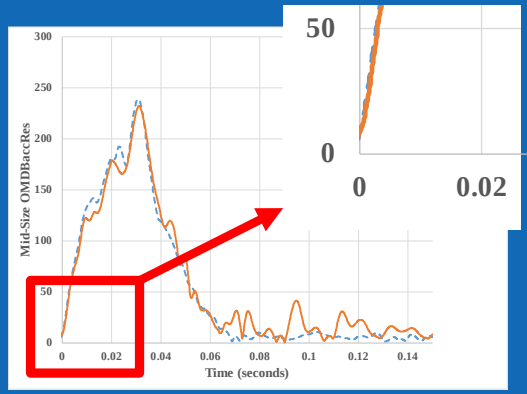
Remove Bias in Curves



The bias at time 0 effects ISO rating

Score with bias

Method	CORA	ISO
Corridor	0.959	0.599
Phase	1.000	0.530
Size (Magnitude)	0.969	0.949
Cross correlation (Slope)	0.971	0.684
Overall rating	0.968	0.672

() ISO naming convention

Score with bias removed

Method	CORA	ISO
Corridor	0.952	0.981
Phase	1.000	0.962
Size (Magnitude)	0.971	0.973
Cross correlation (Slope)	0.965	0.745
Overall rating	0.964	0.929

() ISO naming convention

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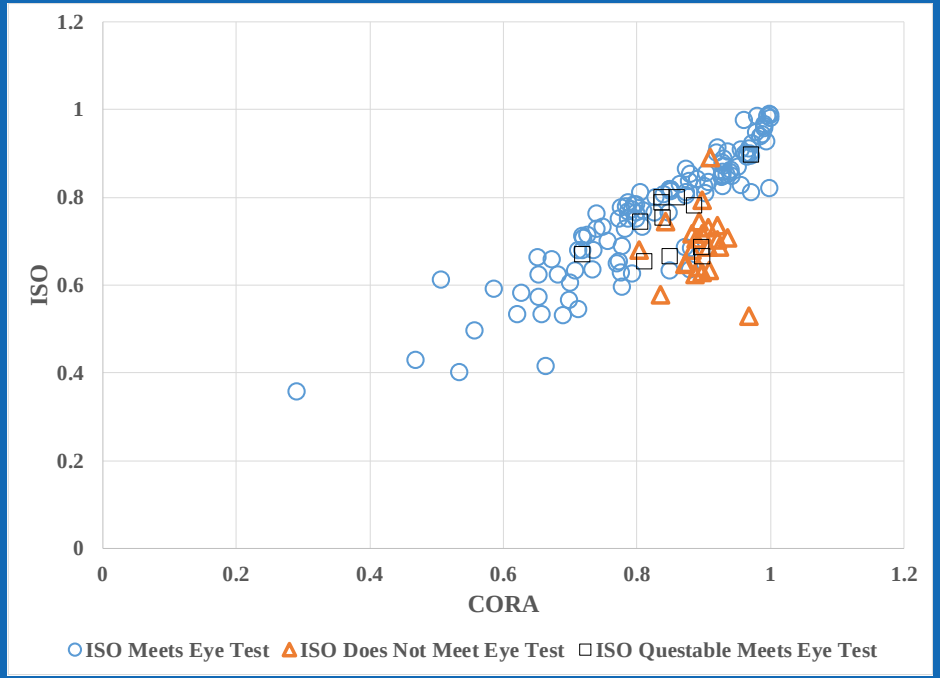
ISO Eye test



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Observations

- Energy absorbed by OMDB not consistent by vehicle type
- OMDB and vehicle performance was overall “good”
- Dummy performance overall acceptable
  - Driver only 16 out of 183 were rated “poor”
  - Passenger only 6 out of 183 were rated “poor”
- ISO method does not always meet the eye test
- These results need to be considered in the context of expected repeatability of the Oblique test in general, analysis of which is underway and will be presented at SAE World Congress

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EVALUATION OF THE FULL AND HALF BARRIER FACES IN OBLIQUE FRONTAL OFFSET TESTS