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

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Contents

• Test Setup
• Methodology
• Vehicle selection
• Nomenclature
• Results
• Examination of rating methods
• Observations
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
  - Percent = 1 - \( \frac{\text{Full-Half}}{\text{Full}} \)

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

<table>
<thead>
<tr>
<th>Grade</th>
<th>R Range</th>
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<tbody>
<tr>
<td>Good</td>
<td>R &gt; 0.80</td>
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<tr>
<td>Fair</td>
<td>0.58 &lt; R &lt;= 0.80</td>
</tr>
<tr>
<td>Poor</td>
<td>R &lt;= 0.58</td>
</tr>
</tbody>
</table>
Vehicle Selection

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

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<tr>
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<tr>
<td>Large PU</td>
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</table>
## Nomenclature

<table>
<thead>
<tr>
<th>OMDB</th>
<th>Vehicle</th>
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<tbody>
<tr>
<td>OMDBCGaccRes</td>
<td>OMDB CG resultant acceleration (xy)</td>
</tr>
<tr>
<td>OMDBCGvelRes</td>
<td>OMDB CG resultant velocity(xy)</td>
</tr>
<tr>
<td>OMDBCGav</td>
<td>OMDB CG angular velocity z-direction</td>
</tr>
<tr>
<td>OMDBCGang</td>
<td>OMDB CG rotation z-direction</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
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</table>
### Nomenclature (continued)

<table>
<thead>
<tr>
<th><strong>Upper Body</strong></th>
<th><strong>Lower Body</strong></th>
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<tbody>
<tr>
<td>HeadACRes</td>
<td>AcetabRIRes Resultant right acetabulum force</td>
</tr>
<tr>
<td>HeadAVx</td>
<td>AcetabLERes Resultant left acetabulum force</td>
</tr>
<tr>
<td>HeadAVy</td>
<td>FemurLE Left femur axial force</td>
</tr>
<tr>
<td>HeadAVz</td>
<td>FemurRI Right femur axial force</td>
</tr>
<tr>
<td>NeckFz</td>
<td>TibiaRUFz Right upper tibia force z-direction</td>
</tr>
<tr>
<td>NeckMy</td>
<td>TibiaRUMomRes Right upper resultant tibia moment (xy)</td>
</tr>
<tr>
<td>ChestRL</td>
<td>TibiaRLFz Right lower tibia force z-direction</td>
</tr>
<tr>
<td>ChestLU</td>
<td>TibiaRLMomRes Right lower resultant tibia moment (xy)</td>
</tr>
<tr>
<td>ChestRU</td>
<td>TibiaLUFz Left upper tibia force z-direction</td>
</tr>
<tr>
<td></td>
<td>TibiaLUMomRes Left upper resultant tibia moment (xy)</td>
</tr>
<tr>
<td></td>
<td>TibiaLLFz Left lower tibia force z-direction</td>
</tr>
<tr>
<td></td>
<td>TibiaLLMomRes Left lower resultant tibia moment (xy)</td>
</tr>
</tbody>
</table>
Overhead View Comparison

Full

Half
Impact Point

Max difference is 37 mm
Energy Absorbed by OMDB

- Small PU
- Mid-size PU
- Large PU Full
- Large PU Half

Energy (KJ)
Interior Intrusions

![Graphs showing resultant intrusion for Small, Mid-size, and Large PU vehicles.](image-url)
<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Mid-size</th>
<th>Large PU</th>
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</thead>
<tbody>
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<td></td>
<td>CORA</td>
<td>ISO</td>
<td>Percent</td>
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# Vehicle Results

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<td>ISO</td>
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<td>0.91</td>
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<td>0.99</td>
<td>0.97</td>
<td>0.81</td>
<td>0.94</td>
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<td>VehRRaccRes</td>
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<td>0.92</td>
<td>0.97</td>
<td>0.90</td>
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<td>VehRRvelRes</td>
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<td>0.96</td>
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<td>0.88</td>
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<td>ND</td>
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<td>0.65</td>
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<td>0.87</td>
<td>0.84</td>
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<td>0.93</td>
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<tr>
<td>VehCGang</td>
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<td>0.74</td>
<td>0.92</td>
<td>0.69</td>
<td>0.84</td>
</tr>
</tbody>
</table>

Acceleration rating “fair” but velocity is rated “good”
### Driver Upper Body Results

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Mid-size</th>
<th>Large-PU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CORA</td>
<td>ISO</td>
<td>Percent</td>
</tr>
<tr>
<td>HIC</td>
<td>0.67</td>
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<tr>
<td>BRIC</td>
<td>0.79</td>
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<td>0.95</td>
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<tr>
<td>HeadACRes</td>
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<td>0.83</td>
<td>0.97</td>
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<tr>
<td>HeadAVx</td>
<td>0.74</td>
<td>0.76</td>
<td>0.90</td>
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<tr>
<td>HeadAVy</td>
<td>0.90</td>
<td>0.86</td>
<td>0.82</td>
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<tr>
<td>HeadAVz</td>
<td>0.81</td>
<td>0.81</td>
<td>0.96</td>
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<tr>
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<td>NeckMy</td>
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<td>0.89</td>
</tr>
<tr>
<td>ChestLL</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>ChestRL</td>
<td>0.93</td>
<td>0.85</td>
<td>0.90</td>
</tr>
<tr>
<td>ChestLU</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>ChestRU</td>
<td>0.94</td>
<td>0.90</td>
<td>0.99</td>
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</table>

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**

<table>
<thead>
<tr>
<th>Camera View E-1</th>
<th>Full</th>
<th>Half</th>
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<tr>
<td>Time</td>
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<td>0.000</td>
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</tbody>
</table>

Full barrier test head rotates about the z-axis
Half barrier head slides relative to the bag causing less z-axis rotation
## Driver Lower Body Results

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Mid-size</th>
<th>Large-PU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CORA</td>
<td>ISO</td>
<td>Percent</td>
</tr>
<tr>
<td>AcetabRIRes</td>
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<td>0.85</td>
<td>0.95</td>
</tr>
<tr>
<td>AcetabLERes</td>
<td>0.81</td>
<td>0.73</td>
<td>0.86</td>
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<td>0.81</td>
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<td>TibiaLUFz</td>
<td>0.79</td>
<td>0.77</td>
<td>0.80</td>
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<td>TibiaLUMomRes</td>
<td>0.79</td>
<td>0.75</td>
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<td>TibiaLLFz</td>
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<tr>
<td>TibiaLLMomRes</td>
<td>0.72</td>
<td>0.71</td>
<td>0.80</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Mid-size</th>
<th>Large-PU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CORA</td>
<td>ISO</td>
<td>Percent</td>
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<tr>
<td></td>
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<td>ISO</td>
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<td>HIC</td>
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<tr>
<td>BRIC</td>
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<td>0.94</td>
</tr>
<tr>
<td>HeadACRes</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<tr>
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<td>0.74</td>
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<td>HeadAVy</td>
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<td>HeadAVz</td>
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<tr>
<td>ChestLU</td>
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<td>0.92</td>
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</tr>
<tr>
<td>ChestRU</td>
<td>0.71</td>
<td>0.85</td>
<td>ND</td>
</tr>
</tbody>
</table>

**Magnitude small compared to other chest displacement**
Mid-size Passenger Head Angular Velocity (z)
### Passenger Lower Body

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th></th>
<th>Mid-size</th>
<th></th>
<th>Large-PU</th>
<th></th>
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<td>ISO</td>
<td>Percent</td>
<td>CORA</td>
<td>ISO</td>
<td>Percent</td>
</tr>
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<td>AcetabRIRes</td>
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</tr>
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<td>0.72</td>
<td>0.88</td>
<td>0.68</td>
<td>0.98</td>
</tr>
</tbody>
</table>

- Similar up to 65 ms
- Phase shift
- Higher magnitude for 10 ms
Comparison of time-history methods

<table>
<thead>
<tr>
<th>Method</th>
<th>CORA</th>
<th>ISO</th>
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<tbody>
<tr>
<td>Corridor</td>
<td>0.956</td>
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<tr>
<td>Phase</td>
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<td>Size (Magnitude)</td>
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<tr>
<td>Cross correlation (Slope)</td>
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<td>0.795</td>
</tr>
<tr>
<td>Overall rating</td>
<td>0.968</td>
<td>0.938</td>
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</tbody>
</table>

() ISO naming convention

<table>
<thead>
<tr>
<th>Method</th>
<th>CORA</th>
<th>ISO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corridor</td>
<td>0.959</td>
<td>0.599</td>
</tr>
<tr>
<td>Phase</td>
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<tr>
<td>Overall rating</td>
<td>0.968</td>
<td>0.672</td>
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</tbody>
</table>

() ISO naming convention
Remove Bias in Curves

The bias at time 0 effects ISO rating

Score with bias

<table>
<thead>
<tr>
<th>Method</th>
<th>CORA</th>
<th>ISO</th>
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</thead>
<tbody>
<tr>
<td>Corridor</td>
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<tr>
<td>Phase</td>
<td>1.000</td>
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<tr>
<td>Overall rating</td>
<td>0.968</td>
<td>0.672</td>
</tr>
</tbody>
</table>

Score with bias removed

<table>
<thead>
<tr>
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<th>CORA</th>
<th>ISO</th>
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<tr>
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<td>0.952</td>
<td>0.981</td>
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<tr>
<td>Phase</td>
<td>1.000</td>
<td>0.962</td>
</tr>
<tr>
<td>Size (Magnitude)</td>
<td>0.971</td>
<td>0.973</td>
</tr>
<tr>
<td>Cross correlation (Slope)</td>
<td>0.965</td>
<td>0.745</td>
</tr>
<tr>
<td>Overall rating</td>
<td>0.964</td>
<td>0.929</td>
</tr>
</tbody>
</table>

() ISO naming convention
ISO Eye test

![Graph showing correlations between ISO and CORA values]

- [ ] ISO Meets Eye Test
- [ ] ISO Does Not Meet Eye Test
- [ ] ISO Questable Meets Eye Test
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
EVALUATION OF THE FULL AND HALF BARRIER FACES IN OBLIQUE FRONTAL OFFSET TESTS