Development of a crashworthiness evaluation program for rear-seated occupants in frontal crashes

Jessica Jermakian, Marcy Edwards, Sushant Jagtap
Summary of recent IIHS research on rear seat occupants

- Improved front restraint technologies are making the rear less safe by comparison
- High seat belt loads exceeding human tolerances – older occupants at particular risk
- Countermeasures exist but are not widespread
  - Current US regulatory and consumer information crash tests do not drive rear seat belt improvements

Current work:
- Develop rear-seat occupant test protocol in frontal crash test
2019 research testing
Development of rear-seat occupant test protocol

- Initial matrix of 16 tests to inform decisions on
  - Crash configuration
  - Dummy size and type
  - Seat position
  - Performance and injury metrics

- Second matrix of 11 tests with a broader set of vehicles
  - Examine whether initial findings persist across a range of vehicles
  - Focus on potential performance metrics

- Explore effect of potential countermeasures
## Rear seat occupant test protocol development research

| Crash configuration | 40% overlap into deformable barrier at 64 km/h (n=19)  
25% overlap into deformable barrier at 64 km/h (n=8) |
|---------------------|------------------------------------------------------|
| Dummy size and type  | Hybrid III 50th male (n=12)                          
Hybrid III 5th female (n=23)                              
THOR 5th female (n=4)                                    
Hybrid III 10 year-old (without booster) (n=4)          |
| Seat position       | 2nd row left (n=27)                                  
2nd row right (n=16)                                     |
Average percentage change in injury metrics with belt pretensioner and load limiter

Rear-seat occupants in frontal crash tests
Unfavorable occupant kinematics

Submarining behavior
Unfavorable occupant kinematics
Head impact on forward excursion
## Rear seat occupant test protocol development research

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>crash configuration</strong></td>
<td>Dummy injury metrics and kinematics were more challenged in the 40% overlap than 25% overlap</td>
</tr>
<tr>
<td><strong>dummy size and type</strong></td>
<td>Small female represents the broadest range of occupant sizes in the rear seat</td>
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<td>HIII 5&lt;sup&gt;th&lt;/sup&gt; female was able to discriminate between vehicles with and without advanced belt technology in the rear</td>
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<td>THOR 5&lt;sup&gt;th&lt;/sup&gt; female is not finalized for vehicle evaluations</td>
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<tr>
<td><strong>seat position</strong></td>
<td>Dummy injury metrics and kinematics were more challenged on the left side</td>
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### Rear seat occupant test protocol development research

40% overlap into deformable barrier at 64 km/h

<table>
<thead>
<tr>
<th>rear-seat belts</th>
<th>standard belts (n=9)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>load limiter only (n=1)</td>
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<tr>
<td></td>
<td>pretensioner and load limiter (n=10)</td>
</tr>
<tr>
<td>vehicle type</td>
<td>Small car (n=1)</td>
</tr>
<tr>
<td></td>
<td>Midsize car (n=10)</td>
</tr>
<tr>
<td></td>
<td>Small SUV (n=3)</td>
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<tr>
<td></td>
<td>Midsize SUV (n=4)</td>
</tr>
<tr>
<td></td>
<td>Minivan (n=1)</td>
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</tbody>
</table>
## Rear seat occupant test protocol development research

40% overlap into deformable barrier at 64 km/h

<table>
<thead>
<tr>
<th>Vehicles with standard rear-seat belts</th>
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<tbody>
<tr>
<td>Honda Civic</td>
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<tr>
<td>Toyota Camry (previous generation)</td>
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<tr>
<td>Mazda 6</td>
</tr>
<tr>
<td>Chevrolet Equinox</td>
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<tr>
<td>Hyundai Santa Fe</td>
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<tr>
<td>Chrysler Pacifica</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Vehicles with rear-seat load limiters and/or pretensioners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toyota Camry (current generation)</td>
</tr>
<tr>
<td>Nissan Altima</td>
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<tr>
<td>Subaru Forester</td>
</tr>
<tr>
<td>Ford Escape</td>
</tr>
<tr>
<td>Volkswagen Atlas</td>
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<tr>
<td>Volvo XC60</td>
</tr>
<tr>
<td>Volvo XC60 with integrated booster</td>
</tr>
</tbody>
</table>
Head injury
Percent of IARV

standard belt  load limiter + pretensioner  load limiter only

HIC15

Small Car
Midsize Car
Midsize Car2
Small SUV
Midsize Car3
Midsize Car4
Small SUV2
Midsize SUV2
Midsize SUV3
Midsize SUV4

SAE International®
Government/Industry Meeting
Neck injury
Percent of IARV

SAE International®
Government/Industry Meeting
Chest injury
Percent of IARV

- Small Car
- Midsize Car
- Midsize Car2
- Small SUV
- Midsize SUV
- Minivan
- Midsize Car3
- Midsize Car4
- Small SUV3
- Small SUV4
- Midsize SUV2
- Midsize SUV3
- Midsize SUV4
Head excursion
Head excursion and submarining behavior

Percent of IARV

- submarining
- head excursion and submarining behavior
- pretensioner & load limiter
- load limiter only
- standard belt

Excursion
Submarining in vehicles with pretensioners
Next steps
Development of rear-seat occupant test protocol

- Recent crash test data still under review
- Draft protocols expected by early 2020
  - Seating protocol
  - Crash test protocol
- Next round of research tests (early 2020) will focus on potential performance metrics
- Ratings guidelines and first vehicle ratings targeted for 2021
Don’t forget the diversity in rear seat occupants
Thank you

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