Human Factors for the Integrated Vehicle-Based Safety Systems (IVBSS) Program

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Discussion Topics

• Project Objectives
• Key Driver-Vehicle Interface (DVI) Challenges
• Development of the DVI
**Project Objectives**

IVBSS project involves integrating multiple safety systems for heavy trucks

- Forward Collision Warning (FCW)
- Lane-Change/Merge Warning (LCM-L/R)
- Lane Departure Warning (LDW-L/R)

**Key objective for the DVI:** Prioritize messages from 3 systems in a way that addresses conflicts and maximizes safety benefits.
Key Driver-Vehicle Interface Challenges

Longer stopping distances
- 30-40% greater than PVs
- A key factor in collision warning design

- Minimum stopping distances for buses and trucks from FMVSS 121
Key Driver-Vehicle Interface Challenges

More blind spots

- Greater than on PVs
- Non-symmetrical
- Requires unique visual scanning strategies

Key Driver-Vehicle Interface Challenges

Greater noise levels

- Greater levels of road & engine noise
- Average noise levels of 89 dBA*

Haptic alerts may not be as effective

- Presence of masking vibration

Support a timely and appropriate response from the driver.

Support the development of an accurate and functional mental model of the IVBSS by the driver.
Development of the DVI: Warning Display Locations

FCW, LDW, & System info

LCM

FCW & System info

LCM & LDW

LCM & LDW

LCM

SAE
Development of the DVI: Process for Generating Prioritization Rules

1. Characterize Display Conflicts
   - Identify display conflicts
   - Examine kinematics of the situation

2. Develop Initial Rules
   - Prioritize hazards based on timing, outcomes, & consequences

3. Test & Review Rules
   - Identify secondary crash risks
   - Characterize driver alertness

4. Refine Rules & Exceptions
   - Examine driver information needs
   - Identify exceptions
   - Examine special cases (e.g., cut-ins)
# Development of the DVI: Display Conflict Matrix

<table>
<thead>
<tr>
<th>Color</th>
<th>Rule #</th>
<th>Rule Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>Visual and auditory FCW-5, 6, &amp; 7 override</td>
</tr>
<tr>
<td></td>
<td>2a-2d</td>
<td>Visual LCM-X2 overrides visual FCW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Visual and auditory LCM-X2 override</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Visual and auditory FCW-5, 6, &amp; 7 override</td>
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<tr>
<td></td>
<td>4</td>
<td>Visual LDW overrides visual FCW</td>
</tr>
<tr>
<td></td>
<td>5-5a</td>
<td>Auditory LCM-3 overrides auditory</td>
</tr>
</tbody>
</table>
Development of the DVI: Kinematic Analysis

1) Validate warning timing

2) Provides some information about the severity of potential crashes → important for prioritizing.
Development of the DVI: Arbitration Rule Table

Final Rule table had 19 separate arbitration rules, including:

- Several “maintenance” rules for completeness
- 6 exceptions (e.g., 2a-e)

<table>
<thead>
<tr>
<th>Rule</th>
<th>Justification</th>
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<tbody>
<tr>
<td>2</td>
<td>Visual and auditory FCW-5, 6, &amp; 7 override visual and auditory LCM-X2</td>
</tr>
<tr>
<td>2a</td>
<td>Visual LCM-X2 overrides visual FCW-1, FCW-2a, &amp; FCW-2b</td>
</tr>
</tbody>
</table>
Arbitration Logic for Integration Engine

The end result was a simple spreadsheet that indicated the appropriate display warning combinations for a set of sensor states.

<table>
<thead>
<tr>
<th></th>
<th>Inputs</th>
<th>Outputs</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>1</td>
<td>FCW-in</td>
<td>LCM-in</td>
</tr>
<tr>
<td>2</td>
<td>FCW0</td>
<td>LCM0</td>
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<tr>
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<td>LCM0</td>
</tr>
<tr>
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<td>LCM0</td>
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<tr>
<td>5</td>
<td>FCW0</td>
<td>LCM0</td>
</tr>
<tr>
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<td>FCW0</td>
<td>LCM1R</td>
</tr>
<tr>
<td>7</td>
<td>FCW0</td>
<td>LCM1R</td>
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<tr>
<td>12</td>
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<td>LCM2R</td>
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For Further Information

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Reports can be found at UMTRI IVBSS webpage including this report:

UMTRI IVBSS webpage: