

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

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ACKNOWLEDGMENTS

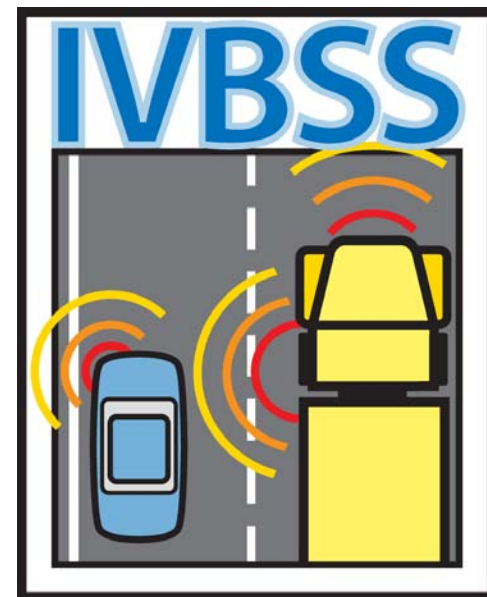
Michael Nowak, Michael Lesher, and John Kovacich of Eaton Corporation;

Dean Pomerleau and Matt Troup of Cognex;

Lenora Hardee of International Truck and Engine Corporation;

John Sullivan and Jim Sayer of UMTRI;

Jack Ference is the NHTSA COTR.



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

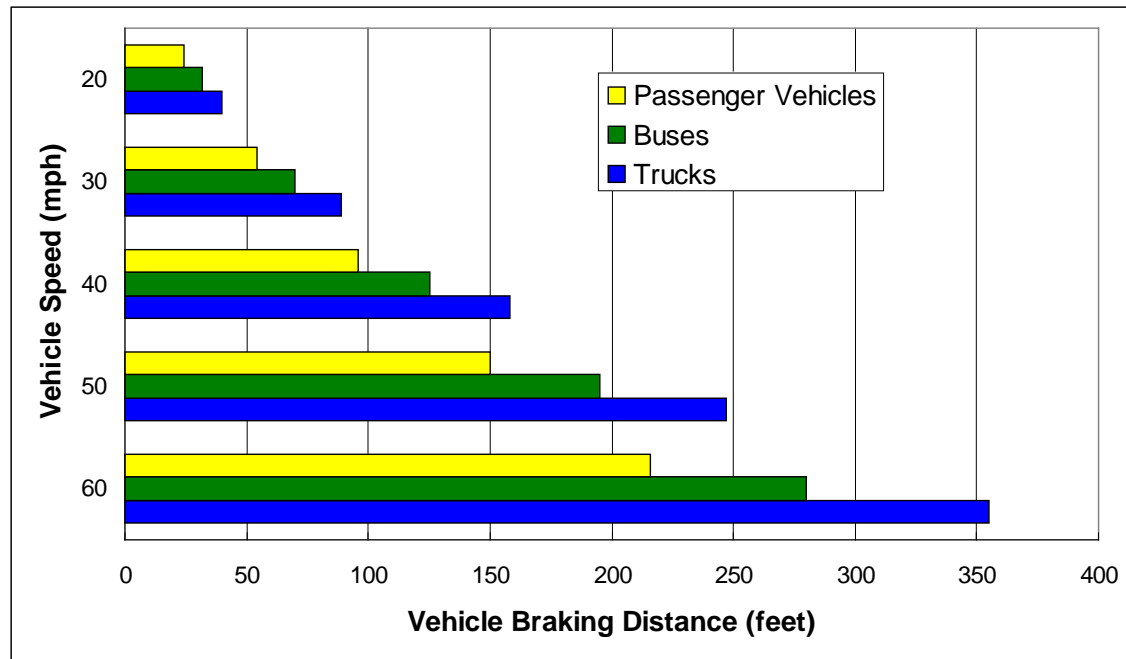
- Forward Collision Warning (FCW)
- Lane-Change/Merge Warning (LCM-L/R)
- Lane Departure Warning (LDW-L/R)

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

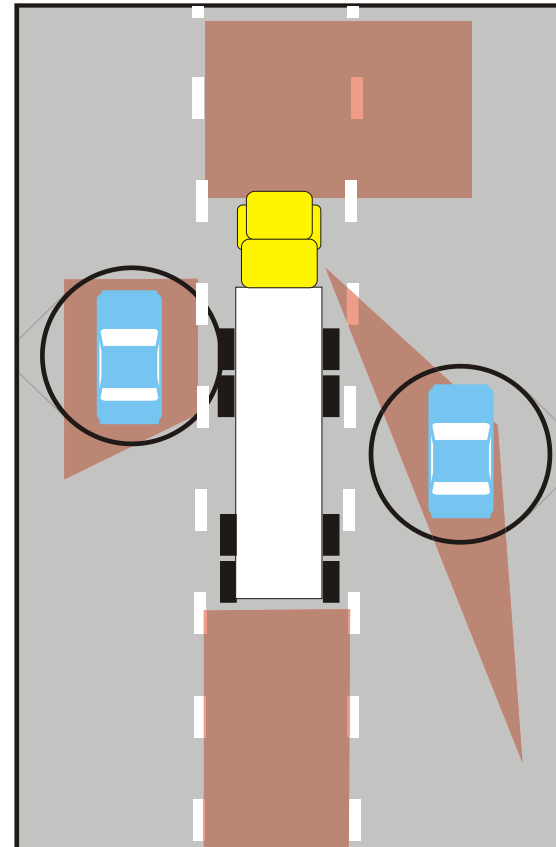


- Minimum stopping distances ⁵ for buses and trucks from FMVSS 121

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

* From: Robinson, G., Casali, J., and Lee, S. (1997).

The Role of Hearing in Commercial Motor Vehicle Operation:

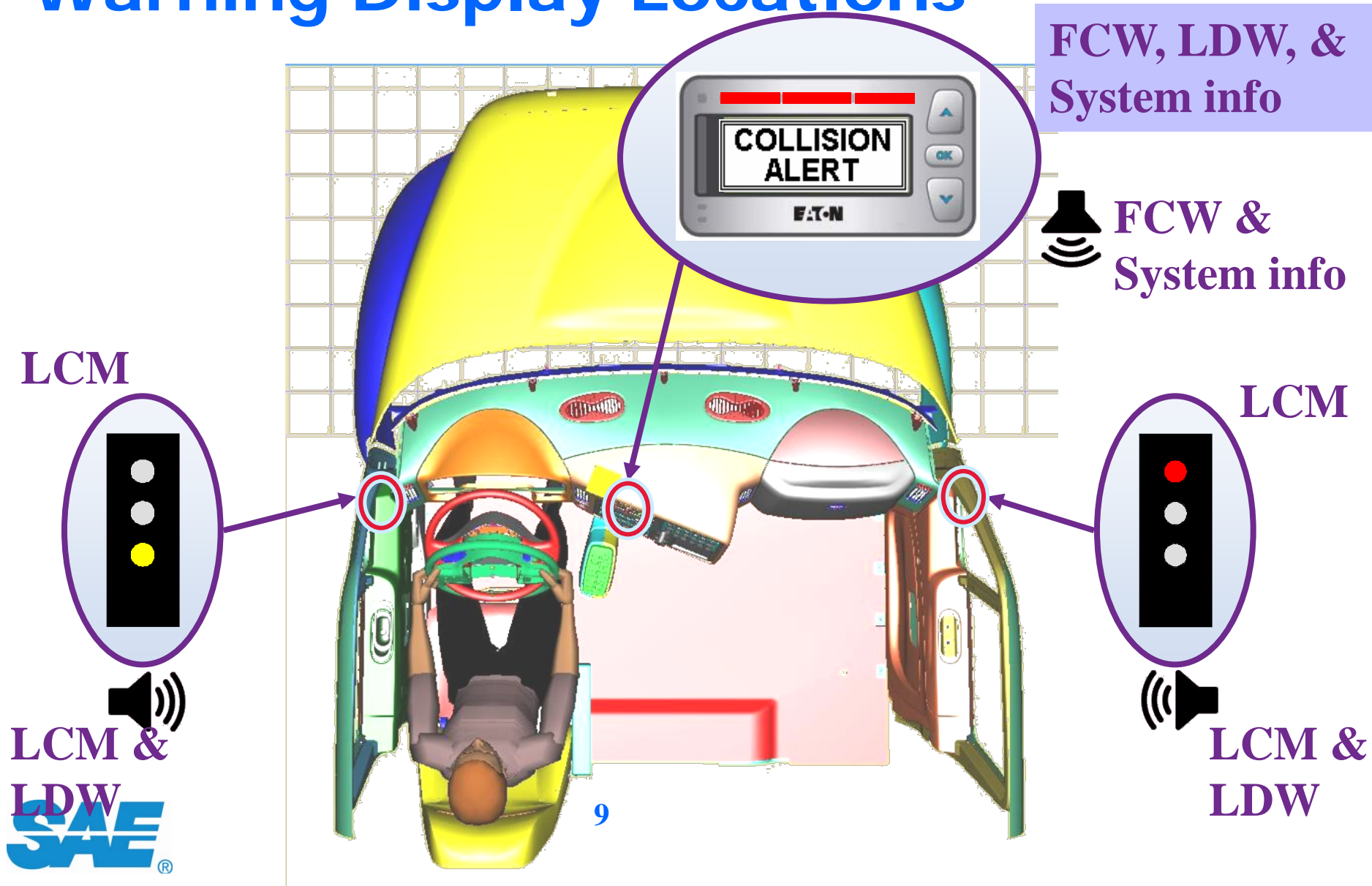
An Evaluation of the FHWA Hearing Requirement, Final Report. Blacksburg, VA.

Development of the DVI: Warning Arbitration Goals

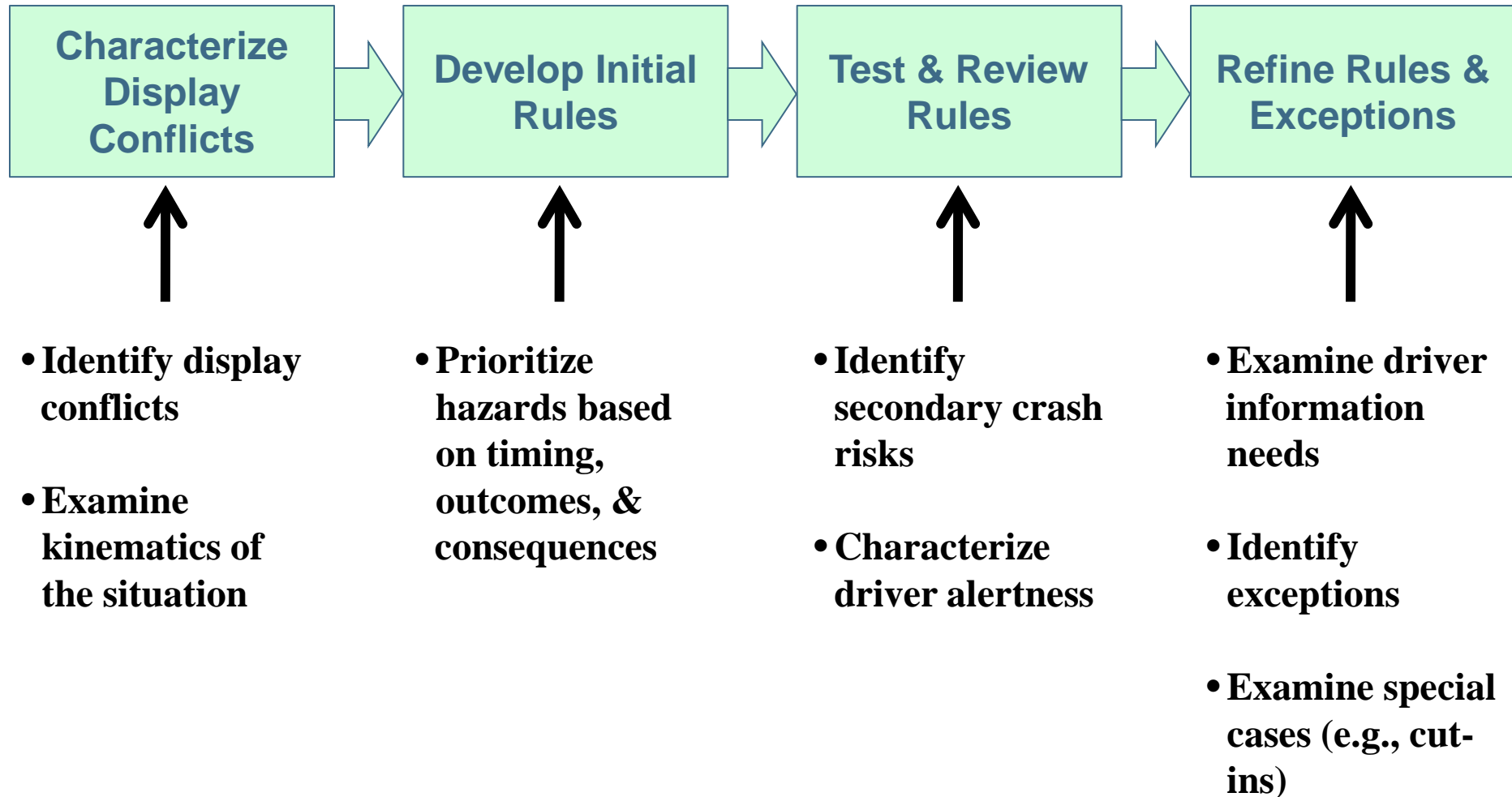
Support a timely and appropriate response from the driver

Support the development of an accurate and functional mental model of the IVBSS by the driver

Development of the DVI: Warning Display Locations



Development of the DVI: Process for Generating Prioritization Rules



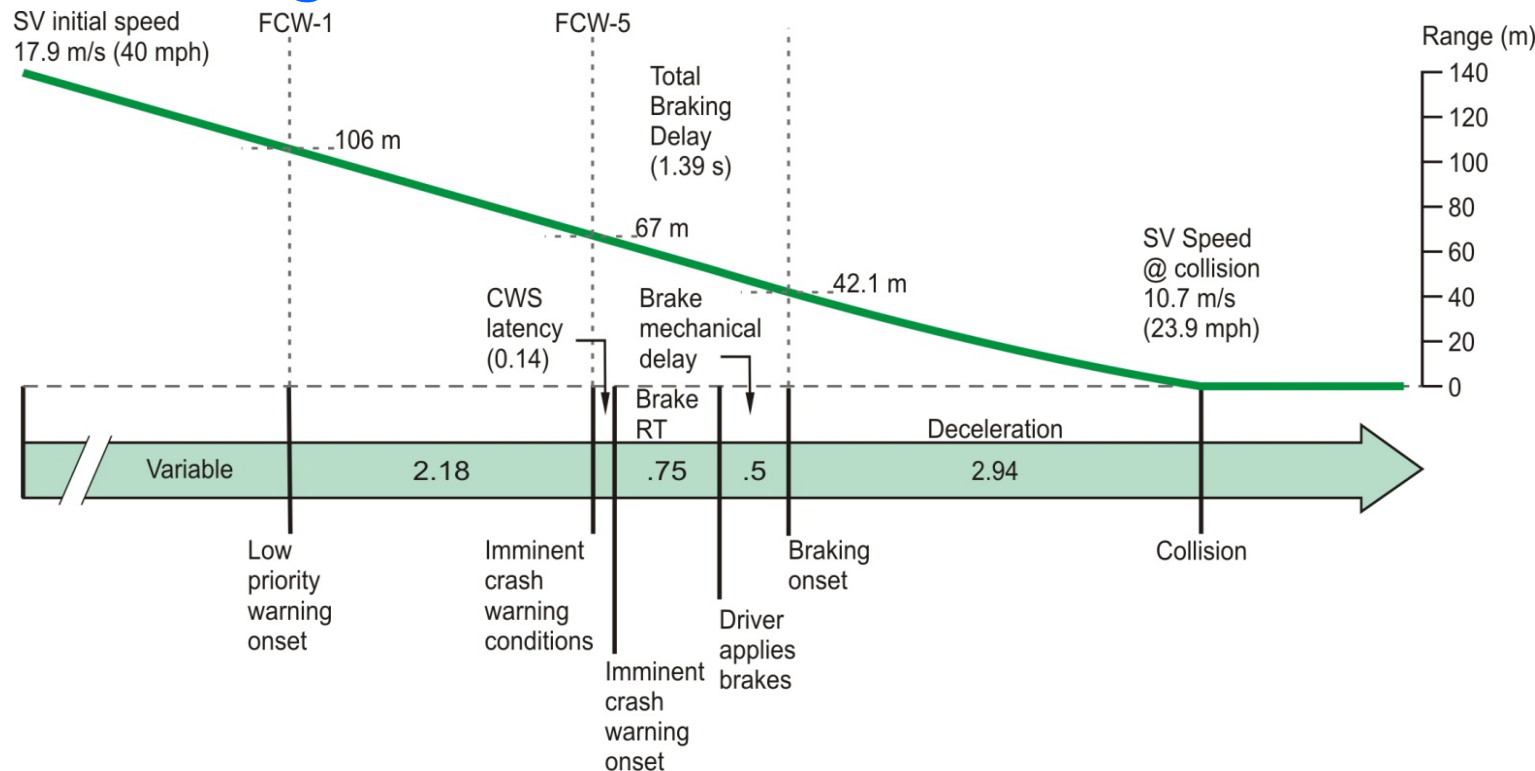
Development of the DVI: Display Conflict Matrix

| | FCW-1 V | FCW-2 V | FCW-3 V | FCW-3 A | FCW-4 V | FCW-4 A | FCW-5 V | FCW-5 A | FCW-6 V | FCW-6 A | FCW-7 V | FCW-7 A | LCM-1 V | LCM-2 V | LCM-3 V | LCM-3 A | LCM-X2 V | LCM-X2 A | LDWL V | LDWL A | LDWR V | LDWR A |
|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|--------|--------|--------|--------|
| FCW-1 V | | | | | | | | | | | | | | | | | * | | * | | * | |
| FCW-2 V | | | | | | | | | | | | | | | | | * | | * | | * | |
| FCW-3 V | | | | | | | | | | | | | | | | | * | | * | | * | |
| FCW-3 A | | | | | | | | | | | | | | | | * | | * | | * | | * |
| FCW-4 V | | | | | | | | | | | | | | | | | * | | * | | * | |
| FCW-4 A | | | | | | | | | | | | | | | | * | | * | | * | | * |
| FCW-5 V | | | | | | | | | | | | | | | | | * | | * | | * | |
| FCW-5 A | | | | | | | | | | | | | | | | * | | * | | * | | * |
| FCW-6 V | | | | | | | | | | | | | | | | | * | | * | | * | |
| FCW-6 A | | | | | | | | | | | | | | | | * | | * | | * | | * |
| FCW-7 V | | | | | | | | | | | | | | | | | * | | * | | * | |
| FCW-7 A | | | | | | | | | | | | | | | | | * | | * | | * | |
| LCM-1 V | | | | | | | | | | | | | | | | | | | | | | |
| LCM-2 V | | | | | | | | | | | | | | | | | | | | | | |
| LCM-3 V | | | | | | | | | | | | | | | | | | | | | | |
| LCM-3 A | | | | | | | | | | | | | | | | | | | | | | |
| LCM-X2 V | | | | | | | | | | | | | | | | | | | | | | |
| LCM-X2 A | | | | | | | | | | | | | | | | | | | | | | |
| LDWL V | | | | | | | | | | | | | | | | | | | | | | |
| LDWL A | | | | | | | | | | | | | | | | | | | | | | |
| LDWR V | | | | | | | | | | | | | | | | | | | | | | |
| LDWR A | | | | | | | | | | | | | | | | | | | | | | |

| Color | Rule # | Rule Description |
|-------|--------|---|
| | 2 | Visual and auditory FCW-5, 6, & 7 |
| | 2a-2d | Visual LCM-X2 overrides visual FCW-5, 6, & 7 Visual and auditory LCM-X2 overrides visual FCW-5, 6, & 7 Visual and auditory LCM-X2 overrides auditory FCW-5, 6, & 7 Visual and auditory LCM-X2 overrides auditory FCW-5, 6, & 7 |
| | 3 | Visual and auditory FCW-5, 6, & 7 |
| | 4 | Visual LDW overrides visual FCW-5, 6, & 7 |
| | 5-5a | Auditory LCM-3 overrides auditory FCW-5, 6, & 7 Auditory LCM-3 overrides auditory FCW-5, 6, & 7 |

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

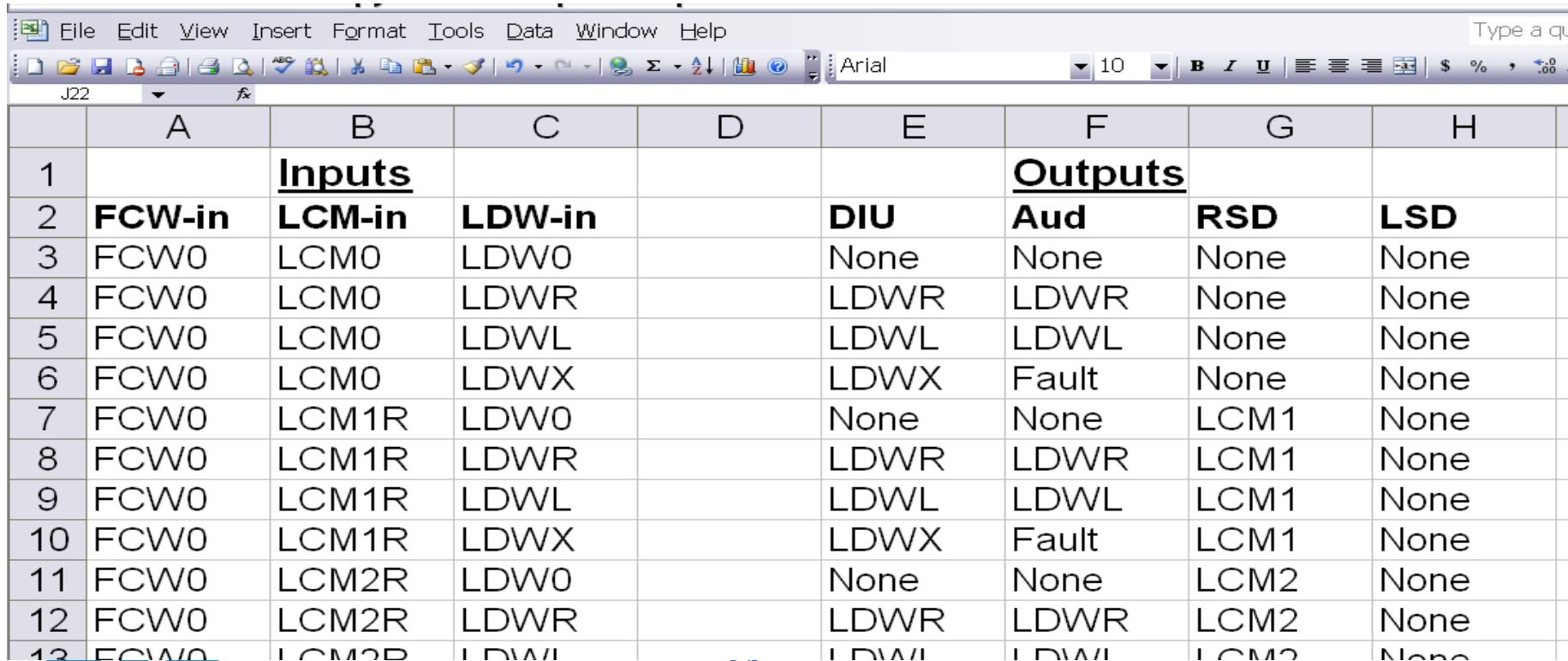
Final Rule table had 19 separate arbitration rules, including:

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

| Rule | | Justification |
|------|---|--|
| 2 | Visual and auditory FCW-5, 6, & 7 override visual and auditory LCM-X2 | In FCW-5, 6, 7 scenarios, the driver must respond quickly, and suppressing the LCM-X2 will eliminate the chance that the LCM-X2 display itself—or the required driver response to acknowledge it—interferes with the driver response to the FCW-5,6, or 7. |
| 2a | Visual LCM-X2 overrides visual FCW-1, FCW-2a, & FCW-2b | Because the SSD failure-mode display is the same as the LCM-0 display, the potential exists for a side-vehicle conflict if the driver interprets the “failed” SSD display as a LCM-0 display. This means that the priority of the LCM-X2 warning should be similar to that of a LCM-3 warning and override the FCW-1, FCW-2a, and FCW-2b especially since the FCW situations do not indicate imminent conflicts. |

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



| | A | B | C | D | E | F | G | H |
|----|---------------|----------------------|---------------|---|------------|-----------------------|------------|------------|
| 1 | | <u>Inputs</u> | | | | <u>Outputs</u> | | |
| 2 | FCW-in | LCM-in | LDW-in | | DIU | Aud | RSD | LSD |
| 3 | FCW0 | LCM0 | LDW0 | | None | None | None | None |
| 4 | FCW0 | LCM0 | LDWR | | LDWR | LDWR | None | None |
| 5 | FCW0 | LCM0 | LDWL | | LDWL | LDWL | None | None |
| 6 | FCW0 | LCM0 | LDWX | | LDWX | Fault | None | None |
| 7 | FCW0 | LCM1R | LDW0 | | None | None | LCM1 | None |
| 8 | FCW0 | LCM1R | LDWR | | LDWR | LDWR | LCM1 | None |
| 9 | FCW0 | LCM1R | LDWL | | LDWL | LDWL | LCM1 | None |
| 10 | FCW0 | LCM1R | LDWX | | LDWX | Fault | LCM1 | None |
| 11 | FCW0 | LCM2R | LDW0 | | None | None | LCM2 | None |
| 12 | FCW0 | LCM2R | LDWR | | LDWR | LDWR | LCM2 | None |
| 13 | FCW0 | LCM2R | LDWL | | LDWL | LDWL | LCM2 | None |

For Further Information

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Reports can be found at UMTRI IVBSS webpage including this report:
Integrated Vehicle-Based Safety System Arbitration of Heavy Truck Driver-Vehicle Interface (DVI) Warnings [PDF], Battelle, Center for Human Performance and Safety. Sponsored by U.S. Department of Transportation, May 2007, UMTRI-2008-24.

UMTRI IVBSS webpage:

<http://www.umtri.umich.edu/divisionPage.php?pageID=249>

