



Integrated Vehicle-Based Safety System

Heavy Truck Driver Vehicle Interface (DVI)

Stage 1 Jury Drive Summary

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16. Abstract <p>The Integrated Vehicle-Based Safety Systems (IVBSS) program is a four-year, two phase cooperative research program conducted by an industry team led by the University of Michigan Transportation Research Institute (UMTRI). The program goal is to integrate several collision warning systems into one vehicle in a way that alerts drivers to potential collision threats with an effective driver vehicle interface (DVI), while minimizing the number of excessive warnings presented to the driver. Basic program strategies for meeting this objective include systematically managing and prioritizing all information presented to the driver, minimizing the number of system false alarms, and restricting auditory alarms to higher urgency collision conditions.</p> <p>This document presents key objectives and results of the stage 1 jury drives, a discussion of these results, and recommendations associated with the stage 1 jury drives for the IVBSS heavy-truck platform. The focus of this document is the DVI aspects of the jury drive experience.</p>			
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List of Acronyms and Abbreviations

DIU Driver Interface Unit
DVI Driver Vehicle Interface
FCW Forward Collision Warning
IVBSS Integrated Vehicle-based Safety Systems
HT Heavy Truck
LCM Lane Change Merge
LDU Lateral Display Unit

Introduction

This document presents key results, a discussion of these results, and recommendations associated with the Stage 1 Jury Drives for the Integrated Vehicle-Based Safety Systems (IVBSS) Heavy Truck (HT). The focus of this document is the driver vehicle interface (DVI) aspects of the Jury Drive experience.

During the Jury Drives, drivers were asked to drive the IVBSS-equipped heavy vehicle on both a test track and on public roadways over the course of several hours. On the test track, drivers were exposed to higher-urgency warnings (e.g., FCW 5, 6, & 7 alerts) under realistic conditions. On the public roadways, drivers were free to select their own driving routes, but were asked to drive in such a way that the remaining, lower-urgency alerts would be triggered on multiple occasions. Across both types of drives, they were exposed to virtually all of the auditory and visual warnings associated with the DVI, and then asked to provide feedback on the understandability, timing, appropriateness, perceived urgency, and general operability/usability of specific aspects of the DVI.

This document reflects both driver responses to specific questions about the DVI, as well as the detailed observations of the facilitator/observer that was present during all aspects of the Jury Drives for all five (5) of the Jury Drive participants.

Objectives

From the DVI perspective, the objectives of the Stage 1 Jury Drives were: (1) to determine if revisions needed to be made to the HT DVI Specification and (2) to identify questions or DVI topics that should be included in the data collection protocol for the Stage 2 Jury Drives.

Threshold for Making Changes to the DVI Specification. With regard to possible changes to the DVI Specification that reflected the Stage 1 Jury Drive results, we have adopted a relatively conservative approach to the question of how to determine if a DVI revision is warranted. In particular, we are looking for a consensus among the Jury Drive participants about specific DVI design parameters that could be changed in order to improve driver performance or driver acceptance. This approach has been taken after considering that:

- The current DVI specification reflects a considerable body of past DVI research, experience with similar systems like the Eaton Vorad, as well as a number of analyses conducted in support of the IVBSS program
- Only five (5) drivers participated in the Stage 1 Jury Drives; such a small sample size limits the generalizeability of the findings and allows the results of a single driver to be given undue weight in the overall data
- The HT IVBSS team will have other opportunities to evaluate the IVBSS DVI before the planned Phase 2 Field Operational test, including the Stage 2 Jury Drives that will be

conducted as part of Phase 2 and the pilot testing that will be conducted as part of Phase 1 in October, 2007.

Results and Discussion

To analyze the data, the mean and standard deviation were calculated for each question in the IVBSS Warnings and Alerts Review and the Self-Administered Driver Questionnaire. Based on these results, the questions were divided into three categories: no concern at this time, possible concern, and likely concern. The criterion for the “no concern at this time” category was a mean of 70 or greater for questions where 100 represented the best rating (this was reversed for questions where the highest rating was 0). The criteria for the “possible concern” category was a mean less than 70 with at least one score below 50 for questions where 100 represented the best rating (again, this was reversed for questions where the highest rating was 0). The criteria for the “likely concern” category was a mean less than 70, and two individual scores below 50, for the questions where the highest rating was 100.

Table 1 shows the questionnaire items and responses that fell into the “likely concern” and “possible concern” categories for the IVBSS Warnings and Alerts Review. Table 2 shows the “likely concern” and “possible concern” responses from the Self-Administered Driver Questionnaire.

Table 1. Results from the IVBSS Warnings and Alerts Review.

Warning	Type of Warning	Question	Results
Likely Concern			
FCW-3B ¹	Auditory	To what extent do the particular sound characteristics of this audio alert result in you feeling annoyed at its onset?	Mean=40 SD=44.58
Possible Concern			
FCW-2	Visual	How appropriate is the timing of the onset of this warning in providing you a timely warning and sufficient time to assess and respond to the situation?	Mean=69 SD=38.47
FCW-4A	Visual	How appropriately does this message convey the actual urgency of the situation?	Mean=61 SD=32.86
FCW-4A	Visual	How appropriate is the timing of the onset of this warning in providing you a timely warning and sufficient time to assess and respond to the situation?	Mean=61 SD=32.86
FCW-5, 6, 7	Visual	How appropriately does this message convey the actual urgency of the situation?	Mean=61 SD=34.71
FCW-5, 6, 7	Visual	How appropriate is the timing of the onset of this warning in providing you a timely warning and sufficient time to assess and respond to the situation?	Mean=55 SD=27.84
LCM-2	Visual	How appropriate is the timing of the onset of this warning in providing you a timely warning and sufficient time to assess and respond to the situation?	Mean=62 SD=32.71

Note: SD=Standard Deviation

The one response categorized as a “likely concern” indicated that the FCW-3B auditory warning tended to make the drivers feel annoyed at its onset. This result does not indicate whether the drivers were annoyed at the sound of the warning or the timing of the warning. The FCW sounds consist of essentially the same basic set of tones that is repeated as the urgency of the threat increases (i.e., the same basic sound that is used in FCW 4B, 5, 6, & 7). The use of this tone is consistent with the current Vorad offering, in which an auditory tone is presented when headway is <2 seconds and the vehicle is closing, in order to encourage drivers to drive with greater headway. This issue should also be examined further during the Stage 2 Jury Drives. It may be useful to include additional follow-up questions that allow the Stage 2 drivers to identify specific concerns or aspects of the warnings that contributed to negative ratings.

¹ In the Jury Drive protocol, this was labeled “FCW-3A”, not “FCW-3B.” These 2 alerts share an identical visual display; however, FCW-3B has an auditory component to indicate that the forward object has < 2 sec headway and is **closing** (not constant or opening).

One interesting observation about the FCW alerts - which appeared to be consistent across most drivers - was that the FCW alerts for stopped objects may have been presented too late for an inattentive driver to react. This could explain the low mean responses for some of the FCW warning messages. For example, there was one driver that tended to give lower scores than the other drivers for many aspects of the FCW system. After following-up with this driver, it became clear that he felt that the FCW collision warnings (FCW-5, 6, 7) were given too late. He said that he based his opinion of the overall system on this specific observation, therefore giving a low score for most of the FCW visual warnings.

It was observed during the jury drives that the LCM side displays were not working properly. The yellow LED indicator would pick up adjacent vehicles, but would only very occasionally turn red when the turn signal was activated. This could explain the low mean rating for the LCM-2 warning, when asked about the appropriateness of the timing of the warning onset.

Table 2. Results from the Self-Administered Driver Questionnaire.

Component	Characteristic	Question	Results
Likely Concern			
DIU	Display Visibility	During operation of the system, to what extent do you have a direct, unobstructed, and normal line of sight to the Driver Interface Unit (DIU) on the dash?	Mean=33 SD=40.87
LDU	Display Visibility	During operation of the system, to what extent do you have a direct, unobstructed, and normal line of sight to the Lateral Display Unit (LDU) on the side pillars?	Mean=34 SD=44.5
Possible Concern			
LDU	Fit and Finish	To what extent does the fit between the components and the finish of the materials of the LDU on the side pillars represent superior quality?	Mean=69 SD=33.62
DIU	LCD Legibility Adequacy	How adequately does the size and design of image components and symbols in the DIU on the dash allow you to easily identify them from a normal viewing distance?	Mean=69 SD=28.81

Note: SD= Standard Deviation

The exact source or concern associated with the (DIU) visibility is unclear. The DIU was located on top of the wing panel (above the instrument panel), in between the center of the instrument panel and the center console. We should re-examine this display location and should certainly include questions about DIU visibility in the survey developed for the Stage 2 Jury Drives.

For the LDU display visibility question, there was a score of 100 from one driver, indicating that the participant felt there was extensive line of sight blockage. It is unclear if this was possibly a misunderstanding of the scale (he may have believed that 100 was the highest rating, indicating no line of sight blockage, due to the fact that the scale was often reversed in other questions).

For both the questions about DIU and LDU visibility, it is possible that the original questions associated with this topic was phrased poorly, with drivers interpreting the question as a reference to the visibility of the displays when their head/eyes are oriented towards the roadway ahead.

Summary of Recommendations

- For the FCW-3B warning: (1) reconsider whether or not an auditory alert is needed for this level of urgency, (2) be sure and re-examine driver acceptance associated with this warning during the Stage 2 Jury Drives.
- Re-examine the timing of FCW 5, 6, & 7 alerts with an eye towards determining if they are perhaps presented too late for most drivers to take effective action. Consider the safety benefits associated with triggering these alerts sooner vs. the possible increase in the number of perceived nuisance alerts associated with an earlier alert. Several of the warning messages received low scores for timing and appropriateness of the warning. However, it was unclear whether the participants felt the warning was provided too early or too late. In general, we recommend that during the Stage 2 Jury Drives, if a score of 50 or below is given for any question, a follow-up question should be asked to obtain more specific information.
- Re-examine the driver lines-of-sight to both the DIU and the LDU to determine if there are alternate display locations within the vehicle cab that are both: (1) feasible from an overall engineering perspective and (2) more likely to be more visible to drivers under representative driving conditions. For the Stage 2 Jury Drives, change the wording of the questions about DIU and LDU visibility to avoid the confusions that may be been associated with the Stage 1 Jury Drives.
- In order to improve display visibility/legibility of the DIU, consider: (1) adding a hood to the DIU in order to minimize glare effects and, (2) adding a swivel to the DIU so that drivers could rotate (even slightly) the face of the display to the left and right.