Integrated Vehicle-Based Safety System

Heavy Truck Driver-Vehicle Interface (DVI) Specifications

(Final Version)

Developed under
U.S. Department of Transportation
Cooperative Agreement DTNH22-05-H-01232

by
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Revision date October 22, 2007

This report was prepared in connection with the U.S. Department of Transportation,
National Highway Traffic Safety Administration, Office of Vehicle Safety Research,
1200 New Jersey Avenue, SE, West Building, Washington, D.C. 20590

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTRI-2008-27		

4. Title and Subtitle	5. Report Date
Integrated Vehicle-Based Safety System Heavy Truck Driver-Vehicle Interface (DVI) Specifications (Final Version)	October 2007
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
James Brown, Marvin McCallum, John Campbell, and Christian Richard	
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Battelle, Center for Human Performance and Safety 1100 Dexter Ave. Seattle, WA 98109	11. Contract or Grant No. Cooperative Agreement DTNH22-05-H-01232
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation National Highway Traffic Safety Administration 1200 New Jersey Avenue, SE Washington, DC 20590	14. Sponsoring Agency Code Office of Human Vehicle Performance Research – Intelligent Technologies Research Division, NVS-332

15. Supplementary Notes

This report was prepared by Battelle, Center for Human Performance and Safety, for UMTRI under contract to the U.S. DOT.

16. Abstract

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.

This report provides detailed specifications (presentation characteristics and functional characteristics) for a DVI design that will meet the objectives of the program.

17. Key Words	18. Distribution Statement
IVBSS, driver-vehicle interface, DVI, vehicle safety research, crash avoidance research, verification testing, collision avoidance, crash warning systems, warnings	Document is available to the public through the University of Michigan Transportation Research Institute, Ann Arbor, Michigan

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	73	

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Acknowledgments

This research was sponsored by the National Highway Transportation Safety Administration (NHTSA), U. S. Department of Transportation, through cooperative agreement DTNH22-05-H-01232. The material contained herein does not necessarily reflect the opinions or policies of NHTSA.

Jack Ference is the contracting officer's technical representative at NHTSA. Wassim Najm and Sandor Szabo lead efforts at the Volpe National Transportation Systems Center and the National Institutes for Standards and Technology, respectively, to support NHTSA.

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List of Acronyms and Abbreviations

CWS ..... Collision Warning System
dB ..... Decibel
dBA ..... Decibel (A-Weighted)
DIU ..... Driver Interface Unit
DVI ..... Driver Vehicle Interface
FCW ..... Forward Collision Warning
FOT ..... Field Operational Test
IVBSS ..... Integrated Vehicle-based Safety Systems
GIS ..... Geographic Information System
GPS ..... Global Positioning System
HT ..... Heavy Truck
Hz ..... Hertz
KHz ..... Kilohertz
LCD ..... Liquid Crystal Display
LCM ..... Lane Change Merge
LDU ..... Lateral Display Unit
LDW ..... Lateral Drift Warning
LED ..... Light Emitting Diode
ms ..... millisecond
RDCW ..... Road Departure Collision Warning
rms ..... Root Mean Square
SV ..... Subject Vehicle
TBD ..... To Be Determined

Introduction

The overall goal of the Integrated Vehicle-based Safety Systems (IVBSS) program is to integrate several collision warning systems (CWSs) 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. This document provides detailed specifications for a DVI design that will meet the objectives of the program.

The specification is organized into two sections as follows:

1. **Presentation Characteristics:** This section specifies how the auditory and visual warnings should be presented in order to maximize effectiveness without being overly annoying.

2. **Functional Characteristics of the DVI:** This section specifies DVI functionality, including specifications related to system functions (operations, menus, system failures, etc.); warning conditions (when warnings should be available, suppressed, initiated, and terminated); nuisance warning mitigation; multi-warning integration; and training, help, and systems functions.

Appendix A provides a taxonomy of threat permutations, which lists each possible combination of alerts. This table identifies potential sources of conflict between warning displays when simultaneous collision warnings are initiated and specifies the appropriate warning presentation for each combination.

Presentation Characteristics

This section describes the individual audio and visual display presentation characteristics that have been defined to meet project objectives.

1 Audio Display Characteristics

1.1 Overview

As part of the basic strategy of minimizing the number of excessive warnings presented to the driver by the IVBSS displays, a decision has been made to **restrict auditory warnings to signal only highly urgent or imminent collision conditions**. Thus, cautionary warnings or graded warning levels that represent less urgent collision conditions will not be signaled through the audio system. While it is recognized that graded/cautionary warnings can provide helpful advanced notice of a developing hazard that may improve a driver's responsiveness to a hazard, these warnings are also prone to produce false alarms. With the

involvement of as many as four CWSs in one vehicle, the cost in false alarm distraction is believed to exceed the benefit in driver response preparation. Therefore, auditory warnings will be presented only for high urgency forward collision warning (FCW) conditions (i.e., FCW-3B and higher) and for imminent LCM-3 (lane change merge) and LDW-L/R (lateral drift warning) conditions. Sections 5.2.5, 5.3.5, and 5.4.5 define the warning levels and their associated visual and auditory displays for the FCW, LDW, and LCM subsystems, respectively.

1.2 Operational Requirements:

This section describes the general operational requirements for auditory warnings used in the IVBSS integrated CWS. Specifications are provided that describe the general characteristics and control of auditory warnings. Detailed descriptions of the specific characteristics for each auditory warning are provided later in the "Warning Presentation" section of each of the warning descriptions: Section 5.2.5 for FCW, Section 5.3.5 for LDW, and Section 5.4.5 for LCM warnings.

1.2.1 Distinctiveness:

The characteristics of the auditory warning signals will be unique and distinguishable for each warning subsystem or other message (i.e., FCW, LCM, LDW, system fault, and volume level adjustment). Table 1 lists the types of auditory signal to be used for each type of auditory warning or message.

Table 1. Auditory signal types and filenames for each auditory message

Warning/Message	Type of Auditory Signal	Filename
FCW-3	Tone sequences	FCW-3_5000.wav
FCW-4	Tone sequences	FCW-4_5000.wav
FCW-5, -6, and -7	Tone sequences	FCW-5_5000.wav
LCM-L/R	Lateralized "Horn-Honk" auditory icon	Horn_Honk_2_5000.wav
LDW-L/R	Lateralized "Rumble Strip" auditory icon	WarningSetA_LDW_5000.wav
System Fault	Two-tone sequential chime	Fault2_5000.wav
Volume Adjustment	Single sustained tone	Vol_30_triangle_1000_5K.wav

Detailed specifications for presentation of these signals are given in the *Warning Presentation* section of each respective subsystem: Section 5.2.5 for FCW, Section 5.3.5 for LDW, and Section 5.4.5 for LCM.

1.2.2 Loudness:

Loudness refers to the intensity of auditory signals. For IVBSS, the auditory displays should be loud enough to overcome masking sounds from road noise and other equipment. For

nominal audibility, the IVBSS warning signal should be at least 15-25 dB above the masked threshold. However, warning levels should not exceed 90 dB. Alternatively, warning signals should exceed background levels by at least 10 dBA[1].

Audio sound level from the radio could mask warning sounds unless radio attenuation can be supported. Ideally, the driver interface unit (DIU) will attenuate the radio output before presenting auditory warnings. See section 1.2.4 for specifications related to presentation of auditory warnings.

The mounting location of the DIU can affect the loudness of its internal speaker, which provides centrally localized auditory signals for FCW warnings. Some means to offset the effect of mounting position on speaker volume should be provided.

1.2.3 Pitch:

Ideally, the audio system should support a signal frequency range of 500 Hz to at least 5 KHz. The Nyquist-Shannon sampling theorem requires that the signal must be limited in bandwidth and that the output must be sampled at a rate that is at least twice the highest output signal frequency in order to prevent aliasing artifacts. Thus, the DIU should provide an output sampling rate of at least 10 KHz in order to present 5 KHz frequency components. Warnings should be limited to frequency components no higher than 3.6 KHz in order to allow headroom in the antialiasing filter.

In practice, the current Vorad VS-400 cannot meet these ideal specifications. The maximum supported sampling rate of the VS-400 is 5 KHz with 8-bit dynamic range. Furthermore, the -3dB cutoff frequency of the antialiasing filter limits the highest useful frequency component to 2.2 KHz. In addition, the small size of the internal speaker limits the ability of the DIU to produce low-frequency sounds with sufficient volume to be useful in the noisy environment of the heavy vehicle (HV) cab. Therefore, the usable frequency range may be 500-2200 Hz. While within the desired range for the pitch fundamental, there is little room to manipulate timbre using higher order harmonics. These limitations may be particularly pertinent to the use of auditory icons because they are likely to be comprised of many higher order harmonics and/or overtones, which would be removed by the antialiasing filter. Finally, there may be some limitation on digitally balancing the sound volume: it may to be difficult to digitally balance a sine wave and more complex sounds based on rms output. For these reasons, sounds should offer the best compromise between the desired signal characteristics and the DIU capabilities. The recommended sounds and their filenames are listed in Section 1.2.1.

1.2.4 Duration and repetition:

Sounds will be presented in bursts of no more than 2 seconds in duration; repetitions of bursts may also be required. Presentation of an auditory warning message will be limited to a maximum number of three repetitions for a given hazard condition in order to reduce the level of nuisance warnings.

[1] The Eaton Vorad VS-400 volume ranges from 70±3 dB to 89±3 dB.

Sections 5.2.5, 5.3.5, and 5.4.5 describe specific characteristics of the auditory signals for FCW, LDW, and LCM subsystems.

1.2.5 Directional audio presentation for lateralized warnings:

Sounds that are paired with LDWs and LCM warnings should be lateralized so that the sound indicates the direction of the threat or lane excursion. Lateralization will be achieved using two audio channels situated so that the sound can be localized by the driver to either the left or right direction. Directional sound will be provided through the left and right speakers (either side-mounted or headliner-mounted) provided in the cab.

To produce more sophisticated auditory spatial cues, stereo channels would be required. However, the use of virtual speakers—sounds that seemingly emanate from between two physical speakers—is discouraged. Sound images that are generated using virtual speakers tend to be associated with poorer localization acuity, particularly with low-bandwidth signals under high noise conditions (Ericson, Bolia, & Nelson, 1999; Tan & Lerner, 1996).

Ideally, the radio should be muted when an auditory warning is presented. A method for muting the radio is as follows: when any IVBSS auditory warning is initiated, the IVBSS system will: (1) send a signal to the vehicle's sound system to reduce the radio volume to a fixed percentage of the current radio volume, (2) play the IVBSS auditory message, (3) after a delay of 0.5 seconds, resume the system state (i.e., mode, volume, channel, etc.) that was interrupted by the IVBSS. A schematic for this approach is shown below in Figure 1.

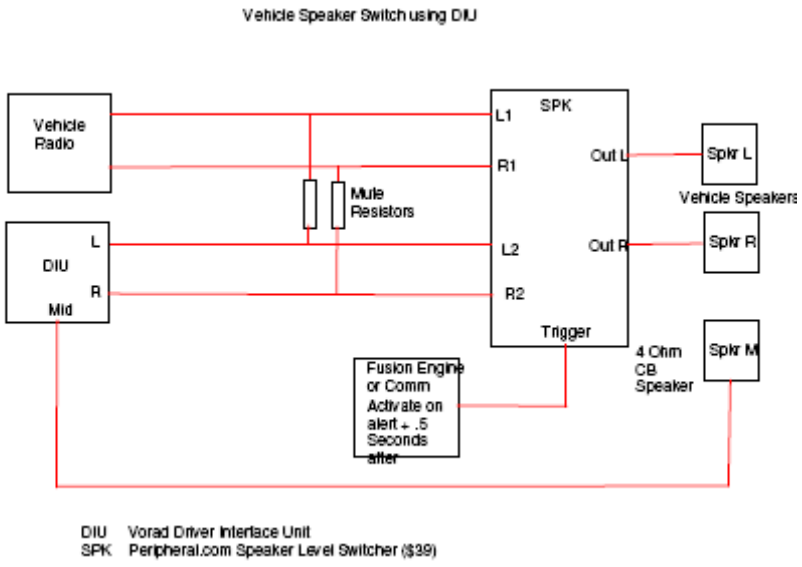

Figure 1. Schematic of IVBSS auditory warning approach.

1.2.6 Audio channels:

Auditory warnings will be presented to drivers using three speakers/audio channels: one front speaker located external to the DIU for FCWs; and two side-mounted (or headliner-mounted) speakers to indicate side-collision warnings and lateral drifts (LCM and LDW).

1.2.7 Other sounds:

If non-urgent informational material is automatically presented on the DIU display, then the driver may be alerted to its appearance by a brief, non-repeating auditory chime or tone. The frequency of the signal will be range of 300-500 Hz in order to convey a low sense of urgency. Other characteristics of auditory warnings that convey low urgency are found in *Crash Warning System Interfaces: Human Factors Insights and Lessons Learned, Final Report* (Campbell, Richard, Brown and McCallum, 2006).

1.2.8 Control

This section provides general requirements related to control of the presentation of warnings. These requirements include specifications for maximum latency in auditory presentation and preemption, general conditions for preemption, and termination of warning repetitions.

1.2.8.1 Latency:

Sound output should commence in less than 100 ms of threat detection—that is, from the time the Fusion Engine determines that an auditory warning should be presented to the time the sound is produced.

1.2.8.2 Preemption and suppression:

In some circumstances, when a higher priority threat is detected and a prior auditory warning is still active, preemption of the first auditory warning may be required: that is, the DIU will interrupt the current warning and initiate the higher priority warning. Likewise, in some cases it may be appropriate for the DIU to suppress the presentation of the second auditory warning until the currently active auditory message has completed. Section 7.4 describes the recommended strategies for presentation of the various pairings of auditory alerts.

When one auditory message either preempts or is suppressed by another, as described in Section 7.4, the two messages shall be separated by a 100 ms gap of silence in order to make them more distinctive. The 100 ms gap should include any latency incurred in the process of loading or playing the sound; the maximum time between messages must not exceed 100 ms in order to prevent a significant reduction in time available for the driver to respond to the warning. Figure 2 is an example that illustrates the timing of preemptive warnings. In the figure, the initial warning is partially presented and then interrupted when presentation of a higher priority warning is required. After a 100 ms gap of silence, the second warning is presented in full.

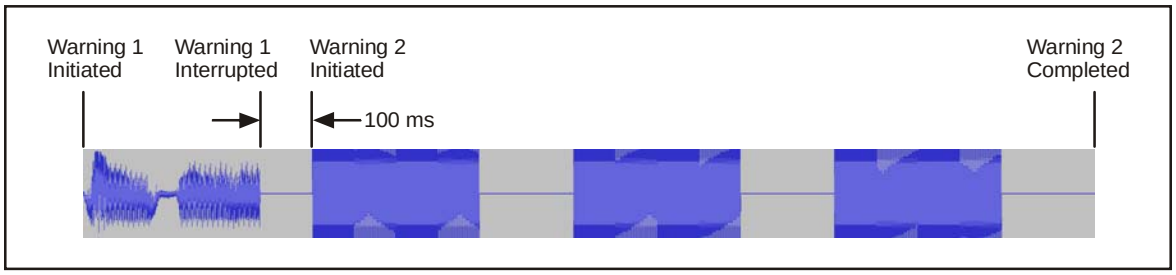

Figure 2. Time series showing an example of warning preemption timing

When an initial auditory message is preempted by a second auditory message, the initial message will *not* resume after the second message has finished being presented.

The DIU will have the capability to preempt auditory warnings within no more than 30 ms of receiving the command to present the new auditory message.

1.2.8.3 Repetition:

Warning repetition may be determined both by preset parameters and by driver action—that is, a particular auditory warning may be repeated a maximum number of three cycles or until a driver applies the brake or initiates an evasive steering action.

2 Visual Interface

2.1 Overview:

The IVBSS visual display will provide a supporting role in supplying a driver with information about collision threats. In no circumstances will the visual interface serve as the sole source of information about an imminent collision, although it will function to support or clarify the circumstances of imminent collision, as well as provide advanced warning of a potential collision. As an example, while an imminent FCW is signaled by an auditory warning, the visual display should also reflect the warning and could perhaps depict the closing range between the vehicle and the collision object. While an imminent collision is pending, the visual interface should continue to reflect this state until the condition is resolved.[2]

The visual display may also be used to depict cautionary warning states—e.g., forward-headway limit or side-object detection; display system status information—e.g., component failure, system availability; display configuration settings—e.g., volume control; and provide general information about system operation—e.g., tutorial material.

Because drivers must glance away from the road to view the display, no significant content should be displayed too briefly on the display screen. Brief display durations encourage

[2] Note that while an imminent *auditory* warning may be terminated when a driver initiates a remedial action (reducing a source of distraction), the visual interface should continue to depict the imminent warning information.

drivers to turn their gaze off the roadway in order to avoid missing the display. Warning messages will be displayed for 10 seconds, unless a higher priority message preempts the current warning message. However, the appropriate display duration should be refined during pilot testing. Therefore, a method shall be provided for researchers to adjust the duration of display presentation during pilot testing.

It is critical that drivers are aware of the functional status of the system in the event of a subsystem malfunction. Hard fault malfunctions generally are not transient in nature but are likely to persist until a repair or other intervention has been performed. In order to ensure that drivers are aware of the hard fault failures, visual status messages related to these failures should remain on the display until the driver acknowledges the message by pressing the "OK" button.

Status messages may be interrupted by higher-priority warning messages. Section 4.5.1.2 describes how to handle preemption of status messages. Section 4.5 provides details related to the general topic of system error and status indication, and Section 7 provides rules determining arbitration of messages, including failure mode messages.

Transient failures, such as inability for LDW to determine lane position due to insufficient lane marking data, are not considered hard faults and are displayed using the LDW availability icon as discussed in Section 5.3. LDW failures caused by a dirty windshield and FCW failures caused by mud, ice, or snow on the sensor should *not* be treated as transient failures because these types of faults require driver or maintenance crew intervention to restore full functionality to the subsystem; these failures should be treated as hard faults (see Sections 4.5.2.2 and 4.5.2.3). However, it is acceptable to provide individual failure status messages for dirty windshield and radar faults (rather than presenting a General Failure status message) because the driver may be able to resolve the problem without assistance from a maintenance crew (see Sections 4.5.2.2 and 4.5.2.3).

2.2 Operational Requirements

2.2.1 Eaton VORAD primary forward display unit:

Figure 3 below shows the DIU.

Figure 3. Vorad Driver Interface Unit (DIU).

The liquid crystal display (LCD) unit resolution is 128 x 48 pixels. Update rate is 50-100 ms/frame.

2.2.1.1 Primary display unit placement:

The display unit should be mounted in a driver's forward visual field, not more than 30 degrees (ideally, no more than 15 degrees) of horizontal visual angle and no more than 30 degrees of vertical visual angle with respect to the forward line of sight.

The display unit must also be within easy reach of the driver so that pushbuttons can be operated without changing seated position.[3]

The DIU shall be mounted at a vertical and horizontal angle such that the face of the DIU display is orthogonal to the driver's gaze when looking at the center of the LCD display. This mounting angle will apply to the driver of average height and distance from the DIU. In order to accommodate the full range of driver heights and seating positions, it may be desirable to mount the DIU on an adjustable stand.

2.2.1.2 Legibility requirements of primary display screen:

Each text character should be clearly legible and subtend a minimum of 24 minutes of arc at normal viewing distance (assuming a black/white display[4]).

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[3] Analyses of viewing angle and reach based on the proposed location for the DVI indicate that the driver will likely be required to lean to reach controls, although the display is located within International's recommended reach difficulty curve. The same analyses indicated that the proposed location would require a range of look-down angles (relative to straight ahead view) of 19 to 32 degrees (small female to large male).]

Width-to-height ratios of displayed text characters should be between 0.6:1 and 0.8:1. Stroke width to character height should be between 1:12.5 and 1:6.25. A lower ratio should be used for most important displayed information.

The DIU currently employs a set of three monospaced fonts that are 6 x 8, 8 x 12, and 14 x 20 pixels in size (small-, medium-, and large-size font respectively). In addition, text can be drawn graphically in any size or font as needed. The font size used for messages of a given type should be consistent across all of the messages of that type. In addition, the largest font size that will allow all messages of that type to fit the display should be used. For example, if all but one of the system fault status messages can be displayed in the medium-size font, the odd message should be shortened so that it can fit within the display using the medium-size font. Alternatively, all system fault messages could be displayed in the small-size font to ensure consistency of size; however, this course is not recommended because all system fault messages would be too small to meet the minimum viewing angle requirement (see Footnote 4). In general, the following font sizes should be used for presenting textual messages:

Table 2. Recommended font sizes for textual messages

Warning/Message	Font Size
Status messages	Medium-size
FCW-1, -2, -3, and -4	Medium-size or graphical equivalent to medium-size
FCW-5, -6, and -7	Large-size or graphical equivalent to large-size
LDW-L/R	Medium-size or graphical equivalent to medium size or larger
"OK" box (bottom right-hand side of display)	Medium-size preferred. Small-size ok.[5]
Simplified IVBSS logo	Large graphical font

Luminance contrast between foreground and background display elements should be sufficiently legible in daylight, with a minimum contrast ratio of 3:1 and a desired contrast ratio of 7:1. Minimum nighttime contrast should be 2:1.

2.2.1.3 Bar graph displays

The displays for setting auditory warning volume and LCD background luminance levels incorporate a bar graph to assist the driver in determining the current relative setting for

[4] The smallest font size in the Vorad font set subtends less than 24 minutes of arc for the average sized individual (average between 95th percentile male and female) when the Vorad is placed at the currently proposed position on the wing. The small-size font may still be useful for status messages from the menu because they are available only when the vehicle is not moving. However, if possible, messages should be designed to avoid the smallest font set.

[5] Although the small-size font does not meet the specified minimum visual angle requirements, the placement and function of this message is consistent throughout all screens in which it is used, and its purpose should be easily recognized and learned.

those functions. Figure 4 illustrates the recommended orientation and size of the bar graph display.

Figure 4. Example of bar graph display

The horizontal dimension of each block that represents an incremental change in setting should subtend a visual angle that is sufficient for the driver to perceive the change. A 9 x 9 pixel block should provide adequate visual angle[6] while fitting the space on the LCD panel. A solid bar that is 9 x 90 pixels (when the setting level is adjusted to maximum) is recommended. This size will accommodate 10 levels of adjustment with 9 pixels per level.

2.2.1.4 Default presentation mode:

The Default Presentation Mode shall consist of the FCW-0 display at times when no other higher priority warning, menu, or other display is presented (see Section 5.2.5, Table 6 for the FCW-0 display). If the FCW-0 subsystem has failed, the main LCD display of the DIU will show a simplified IVBSS logo, similar to the one shown in Figure 5. Note that the LDW availability icon is presented in both displays.

Figure 5. Default Display (with LDW availability icon).

2.2.2 Lateral display units:

The presence of side objects will be indicated on two lateral displays (left and right) as depicted in Figure 6. Section 5.4.1.2 contains information related to how warnings will be presented on these displays.

[6] A 9 pixel block subtends a visual angle of approximately 15 minutes of horizontal arc for the 95th percentile male driver.

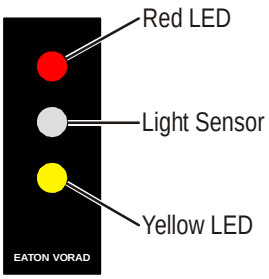


Figure 6. Side sensor display unit.

2.2.2.1 Lateral display placement:

The lateral displays will be located nearby the driver and passenger side rear-view mirrors (e.g., the displays may be attached to the A-pillars on the vehicle). The visual angle subtended by the distance from the center of the left or right side-view mirror to the lateral display light emitting diodes (LEDs) shall be no more than 15 degrees[7] at normal viewing distance.

2.2.2.2 Visibility requirements:

The indicator LEDs should be clearly visible and, ideally, subtend a minimum of 20 minutes of arc at normal viewing distance.

Luminance contrast between foreground and background display elements should be sufficiently legible in daylight, with a minimum contrast ratio of 3:1 and a desired contrast ratio of 7:1. Minimum nighttime contrast should be 2:1.

2.2.2.3 Brightness control:

The current interface supports automatic brightness control of LED indicators using an ambient light sensor.

3 Haptic Interface

Haptic displays will not be used in the IVBSS HV Field Operational Test (FOT).

[7] This specification is analogous to the requirement that the forward display be no more than 30 degrees (and ideally 15 degrees) from the forward line of sight. The rationale is that the lateral displays should be clearly visible when the driver checks the side mirrors.

Functional Characteristics of the DVI

4 System Functions

4.1 Overview

The DVI will provide the following functions:

- A start-up mode
- A menu operation mode
- Indications of system errors and system status
- System settings (temporary mute, luminance, volume)

The following section contains graphical images depicting various IVBSS messages presented on the DIU. These images are intended to be conceptual in nature and do not represent finalized bitmaps of these messages. Although the wording of these messages has been chosen to ensure that the messages will fit within the display space using the appropriate font size, the representations in the following sections may not reflect the actual spacing or appearance of the text.

The visibility of the LCD panel may be slightly limited due to occlusion by the DIU bezel. If the DIU is mounted in the cab in an orientation that prevents the driver's gaze from being perpendicular to the surface of the LCD panel, the bezel may occlude the top and/or left-hand 2 rows of pixels[8]. Therefore, a two pixel boundary along the top and left-hand edges of the active area of the display should be provided when preparing bitmaps for the DIU screens.

4.2 Basic keypad operations

Many of the DIU functions require the driver to enter input, such as volume and brightness settings and acknowledgement of system messages, through a three-key keypad. Available keys will include an "Up" arrow key, a "Down" arrow key, and an "OK" key. Table 3 comprises a summary of all of the key closures and their associated responses when the vehicle/DIU is in a given state.

Note that for the purposes of the table, a "quiescent" state means the DIU is either in default presentation mode or a non-imminent warning is being presented, specifically: FCW-0, -1, -2, -3a, -4a; LCM-0, -1, -2; and LDW-0. Also for the purposes of the table, imminent warnings comprise any warning that includes an auditory component, specifically: FCW-3b, -4b, -5, -6, -7; LCM-3; and LDW-L/R.

[8] Assumes a worst-case viewing angle of 32 degrees (vertical) and 22 degrees (horizontal) from perpendicular.

Table 3. Summary of keypad operations and their associated responses.

Key	Action	Vehicle State	DIU State	Result	Section
OK	Press*	Stationary Moving	System Fault	Clear status message and 1) display next fault message if multiple faults; or 2) return to appropriate display for conditions.	4.4.4.4 4.5.2
	Press < 0.5 sec	Stationary Moving	Quiescent	Enter Luminance Adjustment Mode	4.6.2
	Press < 0.5 sec	Moving	Imminent Warning	Button press ignored	4.6.2
	Press and hold ≥ 0.5 sec	Stationary	Any state except System Fault	Enter Menu Mode	4.4.1
	Press and hold ≥ 0.5 sec	Moving	Any state except System Fault	Enter Temporary Mute Mode	4.6.1
	Press	Moving	Temporary Mute Mode	Add 120 seconds to current count up to 6 minutes total time. Additional button presses are ignored after 6 minutes has been entered.	4.6.1
Up arrow	Press	Stationary Moving	Any state except Luminance Adjustment Mode	Increase volume by 1 unit	4.4.4.1 4.6.3
	Press	Stationary Moving	Luminance Adjustment Mode	Increase display luminance by 1 unit	4.4.4.2 4.6.2
	Press	Stationary Moving	Multiple System Faults	Scroll to previous fault display. Ignore if current display is first failure display	4.3 4.5.2.6
Down arrow	Press	Stationary Moving	Any state except Luminance Adjustment Mode	Decrease volume by 1 unit	4.4.4.1 4.6.3
	Press	Stationary Moving	Luminance Adjustment Mode	Decrease display luminance by 1 unit	4.4.4.2 4.6.2
	Press	Stationary Moving	Multiple System Faults	Scroll to next fault display. Ignore if current display is last failure display	4.3 4.5.2.6

* "Press" indicates that the action produces one instance of the result regardless of duration of key closure. For example, pressing and holding the "Up" arrow key while in Volume Adjustment Mode increments the volume by one unit regardless of how long the button is pressed.

4.3 Start-up mode

During power-up or system reset, the DIU will perform a self-test of all subsystem components and indicate the functional status of all subsystems on the DIU display. Failure indications will only distinguish between the subsystems (FCW, LDW, and LCM) and will not report component failures. If a failure is detected, the system failure auditory alert will sound, the orange LED will flash at a rate of 2.5 Hz, and the display will present a message indicating which subsystem has failed. The warning message will remain on the DIU display until the driver acknowledges the failure by pressing the "OK" button.

The start-up sequence will proceed as follows:

1. **Initialization period:** All LEDs on the DIU will activate and the main display will present the initialization message, shown in Figure 7, for approximately 3 seconds.

Figure 7. Display for initialization message.

After the 3-second period, the following will occur:

a. The LEDs on the DIU will extinguish, and the LDW availability icon will change to "unavailable" (both half-moons hollow). However, the initialization display will remain otherwise unchanged.

b. The red and yellow LEDs on the lateral displays will illuminate as presented in the LCM-X1 description found in Table 8. The left and right channels will be presented individually to give the driver the opportunity to turn and view the presentation of each display.

The IVBSS initialization screen shall remain on the DIU until the Fusion Engine sends a message indicating it is ready. If the DIU does not receive messages within 60 seconds, the DIU will present a General System Failure status message (Section 4.5.2.5).

2. **Trailer setup display:** After the initialization period, the DIU shall display the "Trailer Setup" screen (as if selected via menu). The last selected configuration (from non-volatile memory) shall be highlighted (see Section 4.4.4.3). The driver will press the up/down arrow keys to highlight a different configuration, if required. The driver will press the "OK" button to select the highlighted configuration.

The trailer setup display shall remain active until the driver presses the "OK" button, or until the vehicle begins to move.

3. **System status display:** After initialization, the DIU will display the system status as follows.

    a. **Fault detected:** If a fault is detected in one or more of the subsystems, the system failure auditory alert will sound, the orange LED will flash at a rate of 2.5 Hz[9], and the display will present a message indicating which subsystem has failed (see Section 4.5.1.2 below for failure mode messages). For example, if a failure is detected in the FCW subsystem, the screen shown in Figure 8 will be displayed:

Figure 8. Display for failure detected in the FCW subsystem.

If a fault is detected in more than one subsystem, scroll arrows will be presented to the right of the failure message as shown below. Pressing the up/down arrows will cause the screen to scroll up/down to display each warning failure. Scrolling will display *complete* failure messages page-by-page rather than line-by-line. Pressing the "Up" button will display the entire next failure message, and pressing the "Down" button will display the entire previous failure message.

Figure 9. Display for multiple subsystem faults with scroll arrows.

[9] Some standards mandate 2 Hz as a maximum blink rate to avoid the risk of initiating photosensitive epileptic seizures. The flash rate definitions of the current DIU software specifications divided the LED on/off times into 100 ms segments. That is, the time an LED is on or off is a multiple of 100 ms. A 2 Hz flash rate is not achievable using the current flash rate definitions, assuming the LEDs flash with a 50% duty cycle. However, a 2 Hz flash rate is achievable using a 60% duty cycle—300 ms on and 200 ms off. A 1.67 Hz flash rate is the fastest the DIU can achieve at 50% duty cycle that will meet the 2 Hz standard.

The driver must press the "OK" button for each failure message in order to continue to the next step. After pressing "OK" for each failure message the orange LED will stop flashing and will be continuously active.

b. **No fault detected:** If all subsystems are functioning normally (i.e., no system faults are detected in any of the subsystems) at the end of the self-test, the screen[10] shown in Figure 10 will be presented for 5 seconds.

Figure 10. Display indicating all subsystems are functioning normally.

4. **Menu Mode:** After the warning status has been displayed for 5 seconds (no fault detected) or after the driver has acknowledged a fault or faults by pressing the "OK" button (fault detected) for each failure message, the DIU will enter the Menu Mode, as described below, with the default menu selection of "Volume." If the driver does not select a menu option by within 30 seconds, the DIU will revert to Default Presentation Mode (see Section 2.2.1.3).

4.4 Menu Mode

4.4.1 Menu availability

Menu Mode may be entered at any time the vehicle is stationary (i.e., vehicle speed is 0 mph) by pressing and holding the "OK" button for ≥ 0.5 seconds. **Menu Mode will not be available at times when the vehicle is moving**.

4.4.2 Menu Mode termination

Any menu-based activities that are being performed when the vehicle begins to move will terminate, the system will revert to the Default Presentation Mode, and the Menu Mode will not be available until the vehicle has again stopped. If the driver is in the process of adjusting system settings (e.g., volume or brightness) when the vehicle starts to move, the settings will be fixed at the state they are in at the instant of forward velocity, and Menu Mode will terminate as described.

[10] The Eaton Vorad VS400 status display includes a pass/fail message for each subsystem rather than a single message that indicates that all warnings are functioning. However, the complexity of the IVBSS system may require more subsystem status messages than will fit on one screen. The use of a single message stating that all warnings are functional will keep the display as simple as possible and avoid the need to scroll. (Although the driver may still have to scroll when multiple failures are detected, scrolling is not required for the default "All warnings OK" message.)

4.4.3 Menu presentation and operation

Menu items will be shown in positive contrast (black letters on a white background). Highlighted menu items will be shown in negative contrast (white letters on a black background).

Pressing the “Up” arrow key will highlight the menu selection above the currently highlighted option, and pressing the “Down” arrow key will highlight the menu selection below the currently highlighted option.

Scrolling through the menu will be bounded between the first and last item on the list: if the current menu selection is the first item on the list, pressing the “Up” arrow key will have no effect. Similarly, if the current menu selection is the last item in the list, pressing the “Down” arrow key will have no effect.

Pressing the “OK” button will activate the functionality of the highlighted menu item.

4.4.4 Menu options

The top-level menu in Menu Mode will contain the following selections, which will appear in a scrollable window. Each of these selections is discussed in the associated section of this document, as shown in Table 4.

Table 4. Top-level menu selections.

Menu Operation	Section
Volume	4.4.4.1 (see also 1.2.2)
Brightness	4.4.4.2 (see also 2.2.2.3)
Trailer Setup	4.4.4.3 (see also 4.3)
System Status	4.5 (see also 4.2)
Demo	8.1

The following sections describe the menu interactions that are used to operate each of the menu selections in Menu options.

4.4.4.1 Volume

Selecting “Volume” from the main menu will display the screen shown in Figure 11.

Figure 11. Display for volume when selected from the main menu.

The driver will use the up and down arrow buttons to change the volume to louder and quieter, respectively. Pressing the "OK" button will exit this menu item.

The bar graph shown above represents the volume relative to the minimum and maximum settings. Adjusting the bar graph to its maximum extreme will set the volume level to 90 dBA; adjusting the bar graph to its minimum extreme will set the volume level to 70 dBA. The recommended size and orientation of the bar are specified in Section 2.2.1.3.

Each press of an "Up" or "Down" arrow button will execute a change in the volume setting and store the new setting in the DIU. The driver will not be required to take any other action to activate or confirm the setting.

To provide auditory feedback related to the volume level setting, a single tone will be presented to the driver at the new volume level after each "Up" or "Down" arrow button press. The tone will have the following characteristics:

- 1000 Hz triangle wave
- 0.5 sec duration
- 30 ms linear attack and 30 ms exponential decay

4.4.4.2 Brightness

Selecting "Brightness" from the main menu will display the screen shown in Figure 12.

Figure 12. Display for brightness when selected from the main menu.

The driver will use the up and down arrow buttons to change the LCD backlighting, LED brightness, and button backlighting. Pressing the "OK" button will exit this menu item.

The bar graph shown above represents the brightness relative to the minimum and maximum settings. Adjusting the bar graph to its maximum extreme sets the brightness level to the

maximum brightness generated by the display; adjusting the bar graph to its minimum extreme sets the brightness level to the minimum brightness generated by the display. The recommended size and orientation of the bar are specified in Section 2.2.1.3.

Each press of an “Up” or “Down” arrow button will execute a change both in the visible brightness of the display and in the corresponding setting stored in the DIU. The driver will not be required to take any additional action to activate or confirm the setting.

4.4.4.3 Trailer setup

Selecting “Trailer setup” from the main menu will display a submenu with the options shown in Table 5.

Table 5. Trailer setup submenu options

Menu Operation
No Trailer
Single 40'
Single 45'
Single 48'
Single 53'
Double 2-28'

The DIU shall store the last selected trailer configuration in non-volatile memory. When the DIU restarts, this value shall be used as the default value, offered to the driver for selection. For a new DIU (trailer configuration never selected) the default value in non-volatile memory shall be “No Trailer”

4.4.4.4 System Status

Selecting “System Status” from the main menu will display a screen similar to the one shown in Figure 13.

Figure 13. Display for system status when selected from the main menu.

This screen will show the current operational status of the warning subsystems as described in Section 4.2 above. If no failure has been detected in any of the subsystems, the display will present the “All warnings OK” message. If a failure has been detected in any of the

subsystems at any time, a message will be presented that indicates which system is faulty. See Section 4.5.1.2 for a table of fault mode messages.

The status of the lateral display health will be presented simultaneously with the DIU system status. The red and yellow LEDs on the lateral displays will illuminate as presented in the LCM-X1 description found in Table 4, and the lateral display startup tone will be presented (See Section 4.2 for a description of the startup tone). The left and right channels will be presented individually to give the driver the opportunity to turn and view the presentation of each display.

Pressing the "OK" button will exit this menu item.

4.4.4.5 Demo mode

The purpose of Demo mode is to provide help and/or training to novice users. Detailed information about the menu structure and usage of Demo mode are described in Section 8.1.

4.5 System error/status indication

4.5.1 Hard fault detection and notification

During operation, the DIU will test the functional status of all subsystem components at a rate of at least four tests per minute. The following sections describe how the system will behave in the event of fault detection and how the driver will be notified of system failures.

4.5.1.1 Detection

All functioning subsystems will remain activated in the event that a hard fault is detected in one of the subsystems.

Several policies have been suggested regarding management of fault detection. For example, when a fault is detected, drivers may be advised to "…*use the system with caution.*" This might be easier said than done. Whenever a component fails in a way that affects the core functionality of a warning subsystem, the behavior of the subsystem may become difficult for the driver to predict. If a subsystem attempts to continue operating with reduced functionality, the system is effectively operating in another (and likely unfamiliar) mode. The potential benefit of the partial subsystem operation may not offset the cost of confusion to the driver. Unless warning subsystem fault modes are easily distinguished, they should be minimized to either a fault (not working) state or a no-fault (working) state. For example, if one of the two FCW radar units fails, the entire FCW subsystem should be considered not-working, instead of managing with a diminished field of view.

A failure in one of the IVBSS subsystems (i.e., FCW, LDW, or LCM) does not necessitate signaling failures on the other systems. The majority of the IVBSS scenarios depend on sensing in single zones to determine whether to trigger an alert; in the case of FCW, most scenarios require only the forward sensors to activate the warning. Therefore, the FCW will remain active if a fault is detected in one of the lateral sensors.

In the case of lateralized warnings, it is suggested that a driver may easily comprehend that the left-side and the right-side systems are relatively independent of each other. Also, the majority of IVBSS scenarios that rely on lateral sensing require functioning sensors on only one side of the vehicle. For these reasons, if a fault is detected on one side of a lateral system, the other side should continue to operate.

In scenarios that require integrated sensing (e.g., forward + right side or forward + left side, etc.), overall system functionality may be reduced by the loss of sensing in one zone, but some benefit may still be realized by retaining the availability of the remaining subsystems. Because the sensing for warnings are independent for many of the scenarios, and scenarios with integrated sensing may still benefit from warnings generated by the still-functioning sensors, all functioning subsystems will remain activated in the event that a hard fault is detected in one of the subsystems.

4.5.1.2 Notification

Hard fault detection, during both power-up/reset and running self-test, will be signaled by a two-tone sequential chime auditory tone, a pulsing orange LED that flashes at a rate of 2.5 Hz, and a message on the display screen. The auditory tone will be presented once at the onset of failure detection. The LED will continue to pulse and the screen message will continue to be displayed until the driver acknowledges the warning by pressing the "OK" button. This will clear the display and change the pulsing LED to a steady light, which will remain lit for the duration of the drive.

The system failure auditory tone will be common to all subsystem failures (i.e., unique auditory presentations will *not* be presented for individual subsystem failures). The tone should be easily distinguishable from auditory collision warning presentations. Although it should be attention-getting, it should convey a lower level of urgency than a collision warning auditory alarm.

The fault display can be preempted by any collision warning display according to the warning integration rules in Section 7; however, a visual fault display that has been preempted by a collision warning display should be re-displayed once the collision warning conditions are no longer valid. The driver will then be required to press the "OK" button to clear the system fault message.

4.5.2 Failure mode messages

While traveling, drivers will be notified of all subsystem failures (except lateral display unit failures[11]) via messages on the DIU. The following behavior will be common to all failure messages:

[11] The lack of bidirectional communication between the lateral display units (LDUs) and the DIU precludes the ability to monitor the health of the LDUs. One suggested solution for providing indication that each LDU is functioning is to hard wire an LED to the LDUs power line. However, this solution only indicates that the LDU has power, not that the LDU is functioning. Alternatively, it is possible that a lack of LCM warnings in the presence of lateral vehicles may be a sufficient cue to drivers that the display is not functioning, making an indicator unnecessary, particularly if drivers have been informed of this scenario during training.

1. The system failure auditory alert will sound.

2. The orange LED will flash at a rate of 2.5 Hz (see Footnote 9 above).

3. The display will present the fault message.

4. The fault message will remain on the display until the driver presses the "OK" button.

5. After the "OK" button is pressed, the orange LED will stop flashing and display continuously.

6. The DIU will replace the fault message with the default display (see Section 2.2.1.3) or a display that is appropriate for the current warning conditions.

4.5.2.1 Display characteristics for failure message presentation

4.5.2.1.1 Visual display characteristics

In order to provide clear distinction between failure messages and warning messages, failure mode messages will be presented in reverse contrast, with white letters or symbols on a black background[12].

Because of the small screen size and coarse resolution of the DIU screen, adequate textual messages may be difficult to produce clearly on the screen. Alternatively, messages that use icons may be used instead of textual messages if they can be reproduced faithfully enough that their meaning is easily recognized.

4.5.2.1.2 Auditory display characteristics

The auditory signal for failure message presentation shall be comprised of a two-tone-chime auditory icon. The recommended characteristics of this icon include the following:

- First chime tone with fundamental frequency of approximately 450 Hz
- Second chime tone a perfect fifth musical interval below the first chime tone (i.e., fundamental frequency of approximately 300 Hz).
- First tone duration approximately 100 ms
- Second tone duration approximately 400 ms followed by 750 ms of reverberative decay

4.5.2.2 FCW failure message presentation

The FCW failure message will be presented on the DIU as shown in Figure 14.

[12] The Eaton Vorad VS-400 displays system fault warnings using white letters on a black background.

Figure 14. Display for FCW failure.

In the event that the forward-looking radar's antenna becomes blocked while the vehicle is moving (due to snow, mud, ice, tampering, etc.), the "Radar Blocked" failure message will be presented on the DIU as shown in Figure 15. Note that the System Fault auditory warning will be presented because the fault likely will not self-correct and will require active intervention to clear the blockage.

Figure 15. Display for FCW "Radar Blocked" failure.

The fault message will remain on the screen until the driver presses the "OK" button, which will cause the orange LED to stop flashing and display continuously. At this time, the DIU will replace the system status message screen with a display that is appropriate for existing warning conditions.

4.5.2.3 LDW failure message presentation

If a fault is detected in the LDW subsystem, the system failure auditory alert will sound, the orange LED will flash at a rate of 2.5 Hz, and the display will present the message[13] shown below in Figure 16.

Figure 16. Display indicating a fault in the LDW subsystem.

[13] Although the textual message will not indicate which side has failed, that information will be available via the LDW availability icon after the driver has pressed the "OK" button.

A “Dirty Windshield” fault message will be presented when the LDW determines that it cannot reliably determine lane position due to a dirty windshield, as shown below in Figure 17. Note that the System Fault auditory warning will be presented because the fault likely will not self-correct and will require active intervention to clean the windshield.

Figure 17. Display indicating windshield is too dirty for LDW subsystem to reliably determine lane position.

The fault message will remain on the screen until the driver presses the “OK” button, which will cause the orange LED to stop flashing and display continuously. At this time, the DIU will replace the system status message screen with a display that is appropriate for existing warning conditions, and the LDW availability icons will be displayed as unavailable on the DIU.

4.5.2.4 LCM failure message presentation

If a fault is detected in the LCM subsystem, the system failure auditory alert will sound, the orange LED will flash at a rate of 2.5 Hz, and the display will present a status message. If the left-side channel is faulty, the message shown in Figure 18 will be presented:

Figure 18. Display for left-side channel fault detected in the LCM subsystem.

A right-side fault will result in a similar message, shown below in Figure 19.

Figure 19. Display for right-side channel fault detected in the LCM subsystem.

If hard faults are detected in both channels, a general LCM failure warning will be presented, as shown in Figure 20.

Figure 20. Display for channel fault detected in both sides of the LCM subsystem.

The fault message will remain on the screen until the driver presses the "OK" button, which will cause the orange LED to stop flashing and display continuously. At this time, the DIU will replace the system status message screen with a display that is appropriate for existing warning conditions.

4.5.2.5 General system failure message presentation

The general system failure message will be presented if the DIU determines that communications with the Fusion Engine have failed. This message also will be displayed when any other system failure that is not related to the individual collision warning subsystems is detected (i.e., when none of the failure messages listed above are appropriate). The general system failure message will be presented in a manner that is consistent with the collision warning subsystem failure messages as shown in Figure 21.

Figure 21. Display for general system fault message.

The fault message will remain on the screen until the driver presses the "OK" button, which will cause the orange LED to stop flashing and display continuously. At this time, the DIU will replace the system status message screen with a display that is appropriate for existing warning conditions.

4.5.2.6 Multiple failure presentation

If a fault is detected in more than one subsystem, scroll arrows will be presented to the right of the failure message as shown in Figure 22. Pressing the up/down arrows will cause the screen to scroll up/down to display each warning failure. Scrolling will display *complete* failure messages page-by-page rather than line-by-line. Pressing the "Up" button will

display the entire next failure message, and pressing the "Down" button will display the entire previous failure message.

Figure 22. Example of a scroll bar, which allows the driver to view multiple system failure screens.

Upon pressing the "OK" button, the currently displayed failure message will be replaced with the next failure message. The driver must press the "OK" button for each individual failure message until all failures have been acknowledged. When all failures have been acknowledged, the orange LED will cease flashing and display continuously, and the DIU will revert to a display that is appropriate for existing warning conditions.

4.5.3 Warning system activation criteria

4.5.3.1 Vehicle speed activation

All warning systems are inactive when the host vehicle is stationary.

In order to provide hysteresis in the activation-deactivation speed (to prevent intermittent changes in activation state when driving at or near the threshold speed), individual subsystems may become active or inactive using different minimum and maximum speed criteria and/or vehicle modes. For example, an FCW warning system may become active at a minimum speed of 25 mph when accelerating, and 20 mph when decelerating. Alternatively, a delay may be introduced before warning activation and/or deactivation when using a common speed threshold. However hysteresis is achieved, the activation rules should not be made so complicated that a driver would find it difficult to predict system availability. The presence of multiple collision warning systems only magnifies this problem. As a general guideline, the number of conditions that affect whether a system is or is not active should be minimized. The specifications presented in Sections 5.2.1.1, 5.3.1.1, and 5.4.1.1—for FCW, LDW, and LCM, respectively—provide protocols for activation and deactivation of warnings in a way that should not confuse drivers.

4.5.3.2 Environmental factors (e.g., presence/absence of lane markings)

LDW Availability: Under certain environmental conditions, the LDW subsystem may withdraw availability if lane markings are not reliable. Availability will be determined independently on the left or right side of the vehicle. In normal operation, LDW availability can change repeatedly during a driving session. This behavior is notably different from a fault detection which is assumed to be rare and, once detected, unlikely to change state. Consequently, LDW availability should be indicated to a driver in a manner that is immediately visible without requiring menu navigation (see Section 5.3).

In the Road Departure Collision Warning (RDCW) field test, drivers referred to the availability display in order to confirm that LDW warnings were omitted because of temporary unavailability of the system. A portion of the DIU display will be reserved to depict LDW availability.

4.5.4 Power Indication

The system will be powered automatically when the ignition key is on. The IVBSS power-on status will be indicated by the illumination of the LCD display: dark when the system is not powered, and lighted when the system is powered on. In addition, the Default Presentation Mode includes a constant message and LDW availability icons, so a message will be present at all times when the DIU is powered.

4.6 System settings

4.6.1 Temporary warning mute function

In some road conditions (such as work zones), drivers may find that the IVBSS auditory warnings need to be temporarily muted for a short period of time. Therefore, the IVBSS Heavy Truck (HT) system will provide the driver with the means to mute[14] or disable ALL IVBSS warning sounds for a fixed period of time after the button-press. Visual warnings will not be disabled.

This capability should be designed to discourage frequent use and should therefore be implemented as a duration-based button-press of the "OK" button on the DIU interface such that a long-duration press ($\geq$ 0.5 sec) invokes the mute function, and a short-duration button-press (< 0.5 sec) invokes one of two functions: 1) the menu screen when the vehicle is stationary (i.e., when the menu is available); or 2) the luminance control function when the vehicle is moving (see Section 4.6.2).

When the mute function is invoked, a count-down in the form of a bar-gauge display will be displayed on the DIU LCD display. A single disable button-press will disable the auditory warnings for a period of 120 seconds[15]. Successive "OK" button-presses of short duration (< 0.5 seconds) will add an additional 120 seconds to the count down time, up to a maximum of 6 minutes[16]. A method shall be provided for researchers to adjust the durations during field testing.

[14] A possible addition to this function might be to record the GPS location(s) associated with frequent initiations of the mute function and automatically trigger the function; however, the benefits of automating snooze might be outweighed by the decreases in the driver's ability to predict system behavior.

[15] The goal is to provide enough time to get through the work zone or other driving situation that might be associated with an unacceptable rate of false or nuisance alarms, yet not be so long that the warning is muted after leaving the work zone. If the muting time is too short, the driver may become annoyed by the need to repeatedly press the mute button. If the time is too long, the auditory warning may not be available after the work zone or other situation has ended.

A count-down bar-gauge on the DIU display will indicate the time remaining by decreasing (to the left) the solid portion of the gauge. In addition to the bar-gauge, the time remaining will be shown numerically. Time remaining will be updated once per second. The DIU will display the time remaining until the total time entered has elapsed, after which the DIU will revert to a display that is appropriate for conditions. The yellow and red FCW indicator LEDs shall continue to provide headway and imminent collision information while the Mute display is active. Figure 23 illustrates the count-down display.

Figure 23. Display for indicating the time remaining for the temporary mute function.

A system failure status message (both visual and auditory) shall preempt the count-down display. In the background, the DIU should continue to count down the time remaining; however, the time remaining should not be displayed until after the driver acknowledges the system failure by pressing the "OK" button. If there is still time remaining after the driver acknowledges the failure, the display will revert to the count-down display; otherwise, the DIU will present a message that is appropriate for existing warning conditions.

4.6.2 Luminance Control (Luminance Adjustment Mode)

The luminance levels on the DIU shall be driver adjustable, from 100 percent maximum luminance down to the luminance associated with minimum contrast levels[17]. The initial default intensity level shall be 100 percent maximum luminance.

(continued from previous page)
In a study of work zone activity, Wunderlich & Hardesty (2003) determined that, in 2001, the median length of work zones was four miles. It takes four minutes to traverse the four-mile work zone at 60 mph and eight minutes at 30 mph. At 60 mph, the driver would have to press the mute button twice to traverse the work zone without nuisance alerts. At 30 mph the driver must press the button three times to the maximum of six minutes and then once again at the end of the six-minute period. Alternatively, the driver could press the button four times, once at the end of each two-minute period. The two-minute intervals and six-minute maximum appear to offer a reasonable compromise between providing adequate time to traverse the work zone and maximizing warning availability. The same 120 second value was chosen for both the initial and subsequent button-presses to make the operation as simple as possible for the driver.

[16] COMSIS (1996) guidelines recommend transient manual override of three to five minutes for driver alertness monitors. No specific guidance for duration of override is given related to other warnings. At 45 mph the driver would traverse the four mile work zone within the six-minute maximum period in these specifications.

[17] Contrast levels in both daytime and nighttime driving will need to be determined to fully specify the minimum absolute luminance level.

The luminance control function shall be available when the vehicle is in motion. Luminance also can be modified by following a menu-driven procedure when the vehicle is stopped (see Section 4.4.4.2).

The luminance control function shall be activated by pressing the "OK" button for less than 0.5 seconds, except when an imminent warning is currently being presented. The luminance control function may also be accessed through menu selection when the vehicle is stopped (see Section 4.4.4.2). Once the luminance control function has been activated, subsequent presses of these keys will adjust the luminance. Pressing the "Up" arrow will increase the luminance by 10 percent of its range until the maximum luminance level is reached. Pressing the "Down" arrow will decrease the luminance by 10 percent of its range until the minimum luminance level reached. However, the incremental difference in luminance from one setting to the next must be detectable; if the driver cannot perceive a difference in brightness with each button press, a higher percent change per button press may be required.

Each press of an "Up" or "Down" arrow button will execute a change in the luminance setting and store the new setting in the DIU. The driver will not be required to take any other action to activate or confirm the setting.

A visual display will be presented to the driver on the DIU that represents the current luminance setting after each "Up" or "Down" arrow button press to provide visual feedback. In addition, the actual luminance of the display corresponding to the setting will be displayed. See Section 4.4.4.2 for further details about the characteristics of the luminance adjustment display.

Figure 24. Display for luminance when adjusting with up- and down-arrow keys.

The luminance control function shall be deactivated if more than 5 seconds elapses after the last button press or by pressing the "OK" button, after which the DIU will revert to a display that is appropriate for conditions.

Luminance control adjustment will be preempted by any message that also includes an auditory warning: FCW-3B, FCW-4B, FCW-5, -6, and -7; LDW-L, LDW-R; LCM-3; and System Fault status messages. "Up" or "Down" arrow button presses will have no effect on DIU luminance while these messages are being displayed. When conditions devolve such that warnings are no longer presented, the DIU will enter the Default Presentation Mode (see Section 2.2.1.3).

The yellow and red FCW indicator LEDs shall continue to provide headway and imminent collision information while the luminance control adjustment display is active.

Upon shutdown or reset, the DIU will retain the last luminance level set by the driver. Upon startup, the DIU will set the luminance level to this last setting.

4.6.3 Volume Control (Volume Adjustment Mode)

The volume levels on the DIU shall be driver adjustable from a maximum of 90 dBA down to 70 dBA[18]. The initial default volume level shall be 90 dBA.

The volume control function shall be available when the vehicle is in motion. The IVBSS audible warning volume also can be modified by following a menu-driven procedure when the vehicle is stopped (see Section 4.4.4.1).

The default function of the "Up" and "Down" arrow buttons on the DIU will be to adjust volume whenever menu displays are not presented. Pressing the "Up" arrow will increase the volume by 2 dB until the maximum volume level of 90 dBA is reached. Pressing the "Down" arrow will decrease the volume by 2 dB until the minimum volume level of 70 dBA is reached.

Each press of an "Up" or "Down" arrow button will execute a change in the volume setting and store the new setting in the DIU. The driver will not be required to take any other action to activate or confirm the setting.

To provide auditory feedback related to the volume level setting, a single tone will be presented to the driver at the new volume level after each "Up" or "Down" arrow button press. The tone will have the following characteristics:

- 1000 Hz triangle wave
- 0.5 sec duration
- 30 ms linear attack and 30 ms exponential decay

A visual display will be presented to the driver on the DIU to represent the current volume setting after each "Up" or "Down" arrow button press to provide visual feedback. The visual display will persist for 5 seconds after the last button press, after which it will revert to the display that is appropriate for conditions. See Section 4.4.4.1 for further details about the characteristics of the volume adjustment display.

[18] Ideally, the background level should be monitored so that the volume level of the DIU can be dynamically limited to 10 dB above this level. In practice dynamic limiting may not be simple to implement because background levels may change rapidly due to transient roadway noise, dynamic changes in the volume of radio output, bursts of sound from CB radios, etc. It is suggested that methods be explored for assessing background levels in a way that will compensate for these challenges (e.g., background level averaging or other technique).

Figure 25. Display for volume when adjusting with up- and down-arrow keys.

Volume control adjustment will be preempted by any message that also includes an auditory warning: FCW-3B, FCW-4B, FCW-5, -6, and -7; LDW-L, LDW-R; LCM-3; and System Fault status messages. “Up” or “Down” arrow button presses will have no effect on DIU volume while these messages are being displayed. When conditions devolve such that warnings are no longer presented, the DIU will enter the Default Presentation Mode (see Section 2.2.1.3).

The volume control function shall be deactivated if more than 5 seconds elapses after the last button press or by pressing the “OK” button, after which the DIU will revert to a display that is appropriate for conditions.

The yellow and red FCW indicator LEDs shall continue to provide headway and imminent collision information while the volume control adjustment display is active.

Upon shutdown or reset, the DIU will retain the last volume level set by the driver. Upon startup, the DIU will set the volume level to this last setting.

4.6.4 Sensitivity Control

Sensitivity control of the IVBSS warning subsystems will not be directly provided to drivers.

5 Warning Conditions

5.1 Overview

This section describes the conditions under which the FCW, LDW, and LCM subsystems are activated and when the warnings are initiated or suppressed. The terms “Activation,” “Initiation,” and “Suppression” as used in this specification are defined as follows:

- **Activation** of a warning subsystem means that the subsystem is “turned on” and available to provide warning messages based on sensor data. When a subsystem is inactive, the sensors and decisions from the fusion engine are still active, but messages related to that subsystem are not presented to the driver.

- **Initiation** refers to the actual presentation of a subsystem warning. When the subsystem is in an active state, and the rules for presenting a warning are satisfied, the warning is initiated by presenting it on the DIU.

- **Suppression** refers to conditions in which a warning normally would be presented, but mitigating circumstances require that it should not be displayed. A warning may be suppressed only prior to the warning presentation—not after presentation has begun.

5.2 Forward Collision Warnings (FCW)

The FCW system includes both a headway warning system and an imminent collision detection system. The headway warning system provides drivers with graded cautionary warnings when headway time to a forward object drops below four established threshold levels. The FCW system provides collision warnings whenever a significant risk of collision is detected.

5.2.1 Availability

Availability refers to the state in which the subsystem is active and its sensors are functioning properly. The FCW subsystem generally is unavailable only if it is inactive due to system fault or because the vehicle is traveling below the minimum activation speed.

5.2.1.1 Conditions

The FCW shall be available when the vehicle is in the following state:

1. No faults are detected in FCW components (see also section 4.1).
2. The vehicle is traveling at or above a speed threshold of 25 mph.[19]
3. Insufficient remedial driver action is detected.
4. On curves, the turn radius must exceed 500 m[20]; otherwise forward collision warnings are not presented.

The FCW system shall not be available when:

1. The subject vehicle is traveling below a speed threshold of 20 mph.

A method shall be provided for researchers to calibrate the speed threshold and time delay in conditions 2, 3, and 4 during field testing.

[19]From "Global Function Behavior and Assumptions A3" in *ScenarioClassification_031706_HT.xls* spreadsheet.
[20] From LeBlanc, Nowak, Tang, & Pomerleau (2007, p. 6)

5.2.1.2 Availability presentation

No dedicated indicators are required to indicate the availability of headway warnings and collision warnings.

5.2.2 Suppression conditions

FCW warning output can be suppressed prior to onset when conditions suggest that a warning is likely to represent a false alarm or a nuisance alarm. The following general conditions are associated with warning onset suppression.

1. If the subject vehicle has been very recently started.

2. If there is a strong indication that the driver is actively engaged in an avoidance maneuver, as evidenced by either:

    a. Very recent braking; or

    b. Rapid change in steering angle, yaw rate, or lateral acceleration.

3. If there is a strong indication that the driver is engaging in an intended maneuver and there is not an indication of an imminent collision, as evidenced by either:

    a. Very recent use of the turn signal toward an adjacent lane without an indication of a hard object adjacent (from LCM subsystem) or imminent collision ahead (from FCW subsystem) of the subject vehicle; and

    b. Lateral acceleration toward the unoccupied adjacent lane.

Section 7 provides detailed specifications regarding suppression of FCW warnings when multiple warning conditions exist.

5.2.3 Initiation conditions

5.2.3.1 Headway Warnings

Headway warnings are produced when the headway time decreases past four threshold times: 3, 2, 1, and 0.5 second[21]. The DIU indicates increased urgency for each stage using a mix of auditory and/or visual displays for each level as specified in Table 6 below. Auditory warnings are disabled if the foundation brake is pressed and are reinstated on transition back into each state when the brakes are no longer applied.

[21] A collision avoidance detection algorithm is also under consideration that is based on time-to-collision, which should be used if it is shown that a time-to-collision algorithm will likely be more effective at reducing collisions than headway algorithms.

5.2.3.2 Collision Warnings:

The collision warning display (row 6 of Table 6 below) is also activated when a slow moving object (20 percent slower than the truck) enters the vehicle's path, or when a stopped vehicle is detected in the vehicle's path.

5.2.4 Warning termination conditions

5.2.4.1 Audio termination

Auditory warnings shall be terminated after three cycles of repetition. Also, auditory warnings should terminate if:

1. The driver performs an evasive maneuver by braking or steering away; or
2. Warning conditions no longer exist. See also 5.2.2 above.

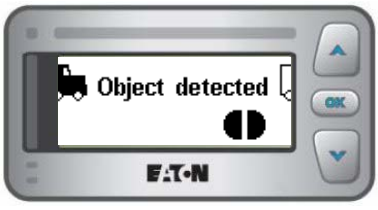
5.2.4.2 Visual display termination

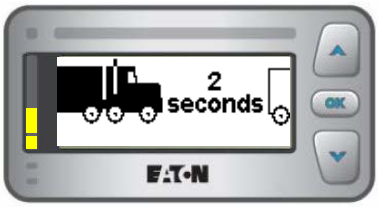
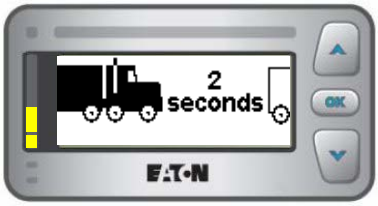
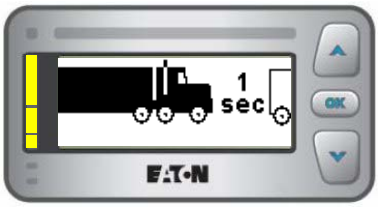
Warning displays are based on measured range and are maintained until the range to the forward object is increased outside of the threshold conditions.

5.2.5 Warning presentation

The stages operate as shown below in Table 6.

Table 6. Headway warning levels.

Condition Code	Initiation Condition	Visual Display	Auditory Display
FCW-0	No forward object detected		None
FCW-1	Forward object detected (range < 106 m)		None

Condition Code	Initiation Condition	Visual Display	Auditory Display
FCW-2A	Forward object < 3 sec headway and opening or constant	 Yellow LEDs steady illumination	None
FCW-2B	Forward object < 3 sec headway and closing	 Yellow LEDs steady illumination	None
FCW-3A	Forward object < 2 sec headway and opening or constant	 Yellow LEDs steady illumination	None
FCW-3B	Forward object < 2 sec headway and closing	 Yellow LEDs steady illumination	Short alert – 1800 Hz; 80 ms 600 Hz; 80 ms
FCW-4A	Forward object < 1 sec headway and opening or constant	 Yellow LEDs steady illumination	None
FCW-4B	Forward object < 1 sec headway and closing	 Yellow LEDs steady illumination	Double alert – 1800 Hz; 80 ms 600 Hz; 80 ms 1800 Hz; 80 ms 600 Hz; 80 ms

Condition Code	Initiation Condition	Visual Display	Auditory Display
FCW-5	Forward object < 0.5 seconds headway (opening, closing, or constant)	 Red LEDs steady illumination	Repeating alert: 1800 Hz; 80 ms 600 Hz; 80 ms 1800 Hz; 80 ms 600 Hz; 80 ms Pause 180 ms; Repeat…
FCW-6	Stationary vehicle/object within 220 feet (67 m) and less than 3 seconds away	 Red LEDs steady illumination	Repeating alert: 1800 Hz; 80 ms 600 Hz; 80 ms 1800 Hz; 80 ms 600 Hz; 80 ms Pause 180 ms; Repeat…
FCW-7	Slow moving vehicle ahead moving 20% slower than subject vehicle and within 220 feet (67 m)	 Red LEDs steady illumination	Repeating alert: 1800 Hz; 80 ms 600 Hz; 80 ms 1800 Hz; 80 ms 600 Hz; 80 ms Pause 180 ms; Repeat…
FCW-X	FCW hard fault	See Section 4.5.2.2 for presentation of FCW hard failure messages on the DIU.	

The auditory signals for each of the various levels of FCW alerts shall be comprised of patterns of pure-tone sinusoids (with no harmonics) as described in Table 6 above.

5.3 Lateral Drift Warnings (LDW)

5.3.1 Availability

Availability refers to the state in which the subsystem is active and its sensors are functioning properly. The LDW subsystem may be active but temporarily unavailable due to lack of sufficient confidence in the sensor data, such as when lane markers are unclear or non-existent. This section defines the conditions under which the LDW subsystem is and is not available

5.3.1.1 Conditions

The LDW shall be available when all of the following conditions exist:

1. No faults are detected in LDW components (see also section 4.1).

2. The vehicle is traveling at or above threshold speed of 25 mph.[22]

The LDW system shall not be available when any of the following conditions exist:

1. The subject vehicle is traveling below a speed threshold of 20 mph.

3. The system cannot detect either the right or left lane boundary with adequate confidence (resulting in partial or full unavailability as discussed below).

4. The turn signal is active and indicating the direction of lateral travel.

5. The vehicle exhibits high lateral velocity.

6. The brake has been applied within the past 5 seconds[23]

7. The outer edge of the vehicle is still more than 0.5 m within the lane.[24] Earlier crash alerts may be presented if there is a perceived object at, or beyond, the lane boundary that may constitute a crash threat. However, these alerts shall not occur until the outer edge of the vehicle is less than 0.75 m from the lane boundary.

A method shall be provided for researchers to calibrate the activation speed and lateral speed thresholds during field testing.

The availability of left- and right-side warnings shall be independent; that is, the LDW shall continue to operate for one side of the lane when it cannot track the other side. Section 5.3.1.2 below provides details for presentation of availability status in the case of unilateral functionality.

5.3.1.2 Availability presentation

The LDW availability display is a status message that indicates whether the LDW subsystem has sufficient confidence in the data from roadway markings and edges to determine whether the vehicle is in the lane. It does not indicate a hard fault in the LDW subsystem.

LDW availability involves both sides of the vehicle and shall be indicated by two (2) half-moon icons colored black to indicate "available" or hollow with black outline to indicate "unavailable." Examples of this approach are shown in Figure 26 below. The left half-moon icon shall indicate left-side availability, and the right half-moon shall indicate right-side availability. The lower left or lower right locations on the DIU are good candidate locations for these symbols. When the LDW can only track one side of the lane, the half moon icon

[22] From "Global Function Behavior and Assumptions A3" in *ScenarioClassification_031706_HT.xls* spreadsheet

[23] Application of the brake implies that the driver is alert and engaged in some active maneuver. From LeBlanc et al., (2006, pp. 3-11 to 3-12).

[24] See Section 2.4.1.2.3 of LeBlanc, Nowak, Tang, & Pomerleau (2007, p. 11).

for that side shall turn black to show its availability, while the unavailable side's half moon icon shall remain grey.

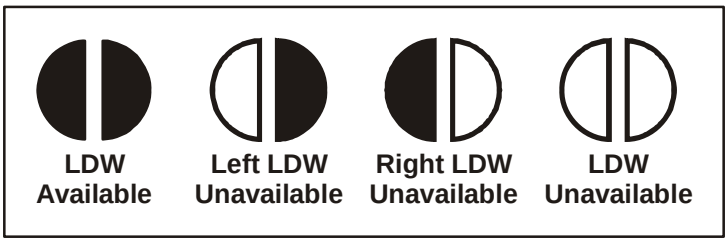


Figure 26. Examples of LDW "availability" icons for presentation on the DIU.

Because the LDW availability icon is a status message, it should be suppressed when higher priority messages are presented or when it could add confusion or additional, unnecessary cognitive workload. However, suppression must be balanced with the driver's need to be aware of the functional status of the LDW subsystem during critical situations. Therefore, the LDW availability icon will be displayed at all times *except* when a high priority message is presented on the DIU. Specifically, the LDW availability icon will be suppressed for any warning or status message that is accompanied by an auditory alert: FCW-3B, FCW-4B, FCW-5, -6, and 7; LDW-L, LDW-R; LCM-3; System Fault status messages; and volume/luminance adjustment displays.

The LDW availability icon will be displayed as "Unavailable" when the system is inactive (i.e., when the vehicle is stopped, the DIU is in Menu mode, or an LDW system fault has been detected).

5.3.2 Suppression conditions

LDW warning output can be suppressed prior to onset when conditions suggest that a warning is likely to represent a false alarm or a nuisance alarm. The following general conditions are associated with warning onset suppression.

1. If the subject vehicle has been very recently started.

2. If the vehicle is still well within its lane.

3. If there is a strong indication that the driver is actively engaged in an avoidance maneuver, as evidenced by either:

    a. Current braking; or

    b. Very recent (last 2 sec) and substantial lateral velocity (greater than 1 m/sec) away from the side to be warned.

4. If there is a strong indication that the driver is engaging in an intended maneuver and there is not an indication of an imminent collision, as evidenced by either:

a. Very recent use of the turn signal toward the lane being incurred upon without an indication of a hard object adjacent (from LCM subsystem) or ahead (from FCW subsystem) of the subject vehicle; or

b. The subject vehicle has very recently completed a lane change.

Section 7 provides detailed specifications regarding suppression of LDW warnings when multiple warning conditions exist.

5.3.3 Initiation conditions

Departures across solid or dashed lane markings without use of a turn signal will produce an LDW.

Warning conditions based solely upon a projected lane excursion that *do not* involve the additional indication of a potential collision by FCW or LCM are limited to the left- and right-lane excursion warnings, as described in Section 5.3.5.

Additional warning conditions that include FCW or LCM warning initiation conditions are addressed in the Multi-Warning Integration section (Section 7).

5.3.4 Warning termination conditions

Warning termination refers to suppression of auditory and visual warnings prior to being presented, usually when conditions suggest that a warning is likely to represent a false alarm or a nuisance alarm. An LDW may also be terminated when a higher priority warning takes precedence (see arbitration rules in Section 7). The following general conditions are associated with warning termination.

1. If there is a strong indication that the driver is actively engaged in an avoidance maneuver in response to the warning and there is not an indication of an imminent collision, as evidenced by either:

    a. Braking initiation subsequent to the warning and no indication of an imminent collision; or

    b. Substantial lateral velocity (greater than 1 m/sec) away from the warned side and no indication of an imminent collision.

An auditory warning that is currently in progress will not be truncated prior to completion when terminating warnings because conditions suggest that the warning is likely to represent a false or nuisance alarm—the warning tone, tone pattern, or auditory icon will always be presented in its entirety. However, a higher priority auditory warning may interrupt a lower priority auditory warning as defined in the warning arbitration rules in Section 7.

5.3.5 Warning presentation

Table 7 indicates the visual and auditory warnings associated with various conditions for the LDW system.

Table 7. Lateral Drift Warnings (LDWs).

Condition Code	Initiation Condition	Visual Display	Auditory Display
LDW-0	Vehicle in lane	 (Default Presentation Mode)	None
LDW-L	Left lateral drift in the absence of an indication of an imminent crash into a hard object in the left lane, as indicated by the FCW or LCM subsystems		Left channel lane excursion warning (i.e., rumble strip)
LDW-R	Right lateral drift in the absence of an indication of an imminent crash into a hard object in the right lane, as indicated by the FCW or LCM subsystems		Right channel lane excursion warning (i.e., rumble strip)
LDW-X	LDW hard fault. Note: does not include temporary unavailability due to environmental factors, etc.	See Section 4.5.2.3 for presentation of LDW hard failure messages on the DIU.	

The auditory signal for the LDW alert shall be comprised of a rumble strip auditory icon. The recommended characteristics of this icon include the following:

- 2 sets of 5 square wave pulses separated by 40 ms between sets
- Fundamental frequency of 400 Hz
- 25 ms pulse duration
- 100 ms silence between pulses
- Sound lateralized in the direction of the threat

5.4 Lane Change Merge (LCM) Warnings

5.4.1 Availability

Availability refers to the state in which the subsystem is active and its sensors are functioning properly. The LCM subsystem generally will be unavailable only if it is inactive due to a system fault or because the vehicle is traveling below the minimum activation speed.

5.4.1.1 Conditions

The LCM shall be available when the all of the following conditions apply:

1. No faults are detected in LCM components.

2. The vehicle is traveling at or above a speed threshold of 25 mph.

The LCM shall not be available when:

1. The subject vehicle is traveling below a speed threshold 20 MPH.

A method shall be provided for researchers to calibrate the speed threshold and time delay in conditions 2, 3, and 4 during field testing.

The availability of left- and right-side warnings shall be independent; that is, the LCM shall continue to operate for one side of the vehicle when it cannot monitor the other side. Section 5.4.1.2 below provides details for presentation of availability status in the case of unilateral functionality.

5.4.1.2 Presentation of Availability

No dedicated indicators are required on the DIU to indicate the availability of LCM warnings. That is, there is no persistent indication that the LCM is available; only the system failure warning, which indicates when the LCM is *not* available. Upon detection of fault in the LCM subsystem (i.e., the system is not available), the system failure warning tone will be presented and a text message indicating the LCM failure will be presented on the DIU. The failure message will remain on the DIU display until the driver acknowledges the fault by pressing the "OK" button.

During start-up/reset the side indicator red and yellow LEDs will flash briefly to indicate that the system is in self-test and that the system is available. The taxonomy of warnings for LCM in Section 5.4.5 illustrates the LCM display activity at start-up/reset.

5.4.2 Suppression conditions

LCM warning output can be suppressed prior to onset when conditions suggest that a warning is likely to represent a false alarm or a nuisance alarm. The following general conditions are associated with warning onset suppression.

1. If the subject vehicle has been very recently started.

2. If the vehicle is still well within its lane, as indicated by LDW with high confidence.

3. If there is a strong indication that the driver is actively engaged in an avoidance maneuver, as evidenced by either:

    a. Very recent braking; or

    b. Very recent (last 2 sec) and substantial lateral velocity (greater than 1 m/sec) away from the side to be warned.

4. If there is a strong indication that the driver is engaging in an intended maneuver and there is not an indication of an imminent collision, as evidenced by:

    a. Very recent use of the turn signal toward the lane being incurred upon; without an indication of a hard object in the adjacent zone or ahead (from FCW subsystem) of the subject vehicle; and

    b. The subject vehicle has very recently completed a lane change.

Section 7 provides detailed specifications regarding suppression of LCM warnings when multiple warning conditions exist.

5.4.3 Initiation conditions

LCM notifications are produced when a vehicle is detected in an adjacent lane; vehicle detection is a binary operation—either the vehicle is detected or it is not. The decision to initiate an LCM warning depends on whether the system determines that the driver intends to change lanes when a vehicle has been detected.

The lower priority LCM-2 warning indicates that a vehicle is in the adjacent lane when the driver shows intent to change lanes by activating the turn signal but the driver is not currently performing the lane change maneuver. The following criteria are used to initiate the LCM-2 warnings:

1. Vehicle is detected in the adjacent zone; *and*

2. LDW or other side-looking sensors[25] determine that the time to collision between the subject vehicle (SV) and adjacent vehicle is less than 1.35s; *and*

3. Corresponding turn signal is active.

The higher priority LCM-3 warning indicates that a vehicle is in the adjacent lane when the driver is performing the lane change maneuver in the direction of the adjacent vehicle. In

[25] Rear sensors or other side-looking sensors that are capable of determining lateral range and range rate at an adequate sampling rate may also be used to determine intent to change lanes. Specifications for adequate sample rate and sensor resolution and accuracy will need to be determined.

this warning, the auditory alert is presented to bring attention to the critical character of the maneuver. This warning is initiated when an adjacent vehicle is detected and lateral travel data indicate that the driver DOES intend to change lanes.

The following criteria are used to initiate the LCM-3 warning:

1. Vehicle is detected in the adjacent zone; *and*

    a. LDW or other side-looking sensors**Error! Bookmark not defined.** determine that the time to collision between the SV and adjacent vehicle is less than 1.35s;

    or

    b. If LDW or other side-looking sensors**Error! Bookmark not defined.** cannot provide reliable lateral velocity, range, or range-rate information, intent to change lanes is assumed when the corresponding turn signal is active. In this event, the LCM-3 warning will be initiated in the presence of a detected vehicle when the turn signal is active.

Table 8 in Section 5.4.5 below specifies the different conditions that shall initiate the LCM warnings.

Left- and right-side warnings shall be independent; warnings on both sides of the SV may be displayed simultaneously if vehicles are detected in the lanes on both sides.

5.4.4 Warning Termination conditions

5.4.4.1 Audio termination

Auditory warnings shall be terminated after 3 cycles of repetition of the auditory warning.

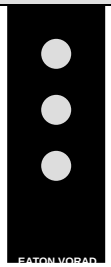
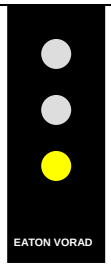
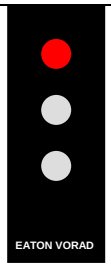
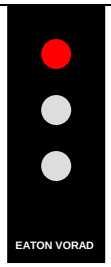
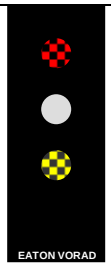
5.4.4.2 Visual Display termination

Visual warnings shall be maintained until the side object is outside the threshold conditions.

5.4.5 Warning presentation

Table 8 indicates the visual and auditory warnings associated with various conditions for the LCM system. Note that the LCM-X2 fault warning is presented on the DIU rather than on the side displays; consequently, the potential exists for conflicts between the LCM-X2 and other warning displays. Section 7 provides rules for arbitration of warnings that resolve these potential conflicts.

Table 8. Lane Change Merge (LCM) Warnings.

Condition Code	Initiation Condition	Visual Display		Auditory Display
LCM-0	No vehicle detected in the adjacent zone	Red OFF Yellow OFF		None
LCM-1	Vehicle detected in the adjacent zone (use caution)	Red OFF Yellow ON		None
LCM-2	Vehicle detected in the adjacent zone *and* corresponding turn signal is active *and* lateral travel data indicates that the driver *does not* intend to change lanes	Red ON Yellow OFF		None
LCM-3	Vehicle detected in adjacent zone *and* (1) lateral travel data indicate that the driver *does* intend to change lanes *or* (2a) lateral data are not available *and* (2b) corresponding turn signal is active	Red ON Yellow OFF		"Horn Honk" auditory icon
LCM-X1	Startup self-test	Red ON Briefly, then OFF Yellow ON Briefly, then OFF		None
LCM-X2	LCM hard fault	See Section 4.5.2.4 for presentation of LCM hard failure messages on the DIU.		

The auditory signal for the LCM alert shall be comprised of a "Horn-Honk" auditory icon. The recommended characteristics of this icon include the following:

- 2 bursts of "horn-honk"
- Initial burst duration of 150 ms
- Second burst duration of 300 ms
- 50 ms between bursts
- Sound lateralized in the direction of the threat
- Horn-honk should sound artificial enough that the driver will not confuse the sound with an actual horn-honk from a neighboring vehicle.

6 Nuisance warning mitigation

6.1 Overview

6.1.1 Definition

False alarms or warnings refer to those IVBSS messages that are triggered in the absence of an appropriate stimulus. For example, a false alarm occurs when the system provides an FCW when there are no cars in front of the driver's vehicle, or provides one based on an out-of-path vehicle or roadside object such as a guardrail or a light post. Nuisance warnings include a subjective component. They refer to warnings that are caused by an appropriate stimulus, but are perceived by the driver to be inappropriate due to some aspect of their implementation such as their frequency, timing, intensity, or modality.

6.2 Mitigation Specifications and Strategies[26]

Ideally, for FCW devices, false alarms for FCW-5, FCW-6, and FCW-7 conditions should be limited to less than once per week for in-path and once per week for out-of-path alarms. In practice, this rate is likely to be unachievable. However, the actual false alarm rate should be minimized to the greatest extent possible.

For LCM devices, drivers are less likely to consider even relatively high rates of "nuisance" alarms annoying, as long as the warnings are unobtrusive and presented via the visual modality only.

Key strategies for minimizing the frequency and impact of false/nuisance warnings include:

- Deactivate a warning device automatically when it is not needed during a particular driving situation.

- Allow the driver to reduce detection sensitivity to a restricted limit that minimizes false/nuisance warnings without significantly affecting the target detection capability of the device.

[26] The topic of false/nuisance alarms has not been extensively studied for heavy vehicles. While these specifications probably reflect the "best available" evidence for heavy vehicles/buses, they should be used cautiously and may be most useful as issues to be evaluated during future IVBSS activities.

- Present a warning only after a target or critical situation has been detected as continuously present for some specified minimum time.

- Mitigate the annoyance of false/nuisance warnings by allowing the driver to reduce warning intensity or volume within the bounds described in Section 4.6.3.

- Change warning modality as the severity of the situation increases (e.g., warn first visually, then add auditory component as severity increases).

- The IVBSS system can be integrated so that the system determines whether or not a driver has already begun to initiate a crash avoidance maneuver (by steering away, releasing the accelerator, or braking) and then use this information to decide whether or not to initiate a warning.

- The IVBSS system can be integrated into a Global Positioning System (GPS) tied to a Geographic Information System (GIS) that can use adjacent roadway information to improve the percentage of "True Positive" alerts.

7 Multi-Warning Integration

7.1 Overview

Warning integration refers to the merging of individual IVBSS components into a comprehensive, understandable, and interoperable system.

The topic of "integration" is associated with a number of design issues, including:

- Overall management and prioritization of all information presented to the driver.

- The implementation of distributed vs. centralized visual displays.

- The implementation of distributed vs. centralized system controls.

- The presentation of hazard-specific visual/auditory/haptic warnings vs. master warnings, especially in situations where multiple hazards are detected and the potential exists for multiple warnings to be presented to the driver simultaneously (or near-simultaneously).

7.2 Functional requirements

- The goal of warnings integration is to provide the driver with information that he/she can perceive, recognize, interpret, and—ultimately—respond to in a manner that improves driving performance and increases safety.

- The driver should perceive the warning: if multiple messages are presented simultaneously, any perceptual conflicts or masking of the messages should be avoided.

- The driver should recognize the information being presented in the warning: if multiple messages are presented simultaneously, the driver must still be able to identify/recognize individual messages.

- The driver should understand the warning: if multiple messages are presented simultaneously, the driver should not confuse the meanings of individual messages or misinterpret the combined set of messages, especially alerts or warnings.

- The presentation of the warning should support a timely and appropriate response from the driver: if multiple messages are presented simultaneously, drivers should not be confused regarding the relative priorities of desired responses.

- Efforts to integrate IVBSS warnings should aid the driver's development of an accurate and functional mental model of how the system works; key elements of this approach will include ease-of-use, adherence to and exploitation of population stereotypes, transparency in the design approach, and—where appropriate—design consistency.

- In general, efforts to integrate IVBSS warnings should seek to avoid: overwhelming the driver, interfering with the driving task, contributing to errors and annoyance, or confusing/overloading the driver.

7.3 General design specifications

The IVBSS approach for arbitrating warnings in multiple-warning scenarios adopts a strategy of displaying as much as possible as long as it does not interfere with the driver's making the best safety response. Table 9 presents a set of rules that was developed to implement this strategy. These rules provide general high-level guidance for determining which warnings to present in the event of multiple warning conflicts. The application of these rules is presented in Appendix A for each identified scenario in which a potential warning conflict may occur.

Table 9 consists of the following fields:

Rule: Defines the conditions under which visual and/or auditory warnings are preempted or suppressed either by other warnings or by activities such as turn signal activation.

Justifications: Rationale and/or logic behind the rule.

Confidence: Strength of confidence in the data that support the justification for the rule. Confidence levels may be reduced if the quality or quantity of available data cannot adequately support the rationale behind the rule

Exceptions: Likelihood that exceptions to the rule may be applicable.

Table 9. Integration rules.

	Rule[27]	Justification	Confidence[28]	Exceptions[29]
1	No overrides in specified "No Conflict" conditions	Multiple concurrent displays that are not expected to distract or disrupt the driver's perception and processing of important driving information will not be suppressed.	High	Unlikely
	This includes the following display combinations: FCW-1 – LCM-0, FCW-1 – LCM-1, FCW-1 – LCM-2, FCW-1 – LCM-3, FCW-2a – LCM-0, FCW-2a – LCM-1, FCW-2a – LCM-2, FCW-2a – LCM-3, FCW-2b – LCM-0, FCW-2b – LCM-1, FCW-2b – LCM-2, FCW-2b – LCM-3, FCW-3a – LCM-0, FCW-3a – LCM-1, FCW-3a – LCM-2, FCW-3a – LCM-3, FCW-3b – LCM-0, FCW-3b – LCM-1, FCW-3b – LCM-2, FCW-4a – LCM-0, FCW-4a – LCM-1, FCW-4a – LCM-2, FCW-4a – LCM-3, FCW-4b – LCM-0, FCW-4b – LCM-1, FCW-4b – LCM-2, FCW-5 – LCM-0, FCW-5 – LCM-1, FCW-5 – LCM-2, FCW-6 – LCM-0, FCW-6 – LCM-1, FCW-6 – LCM-2, FCW-7 – LCM-0, FCW-7 – LCM-2, LCM-0 – LDW-R/L, and LCM-1 – LDW-R/L.			

[27] Note that "overrides" indicates that the Fusion Engine should suppress the lower priority message(s). It may be the case that this suppression is temporary; i.e., that the message is only delayed. Conditions under which a message should be delayed and not completely suppressed will be defined after further analyses.

[28] "Confidence" reflects our level of certainty that the rule is valid as described

[29] The likelihood that sub-rules will have to be developed to accommodate special circumstances

Rule[1]		Justification	Confidence[2]	Exceptions[3]
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.	Med-High	Possible
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.	High	Unlikely
2b	Visual and auditory LCM-X2 overrides visual (and auditory) FCW-3a & FCW-3b	The same logic as the previous rule (2a) applies here. In almost all FCW-3a or FCW-3b situations, even if there is an escalation to the next warning severity level while drivers are responding to the LCM-X2, drivers should have enough time to respond the FCW.	High	Unlikely
2c	Visual and auditory LCM-X2 overrides visual and auditory FCW-4b	The same logic as the previous rule (2a) applies here. Note, however, that if the FCW-4b warning is suppressed, there is an increased likelihood that the driver will have insufficient time to respond to an escalation to FCW-5 and still completely avoid a crash. Acknowledging the LCM-X2 can distract the driver, however, drivers have 2.5 seconds to do so before an FCW-4b condition can escalate to a FCW-5. Also, kinematic analysis indicates that under worse-case conditions (high speeds & slow deceleration level), drivers should still have at least 1.5 sec of available RT following the onset of the FCW-5 (driver's first notice if FCW-4b is suppressed) to avoid a potentially serious crash with the lead vehicle (more than 10 mph relative speed). On the other hand, if there is an unidentified LCM conflict, it has a greater potential to lead to higher severity crashes (e.g., driving the side vehicle into oncoming traffic etc), and consequently should be given priority.	High	Possible
2d	Visual and auditory LCM-X2 overrides visual and auditory LDW-L/R	The assumption here is that the LCM-X2 warning will advise drivers to remain in their lane, which implicitly provides warning about the LD. Exceptions are likely if the LD can lead to immediate high-severity conflicts (i.e., with shoulder hazards or oncoming traffic), or if the driver is asleep or unalert and not responding to either the LCM-X2 warning or the LD hazard.	High	Possible

Rule[1]		Justification	Confidence[2]	Exceptions[3]
2e	Visual LCM-X2 overrides visual FCW-4a (there is no auditory component)	Although this situation can be associated with a shorter headway than occurs in the rule 2c situation (possibly as little as 0.6 sec), it is likely that the driver is aware of the FC hazard, because the FCW-4a follows a response to an FCW-4b that halts closing. Also, the SV driver's response to the FCW-4b may involve a lane change, so the LCM-X2 could provide safety-critical information (see rule 2c).	Med-High	Possible
3	Visual and auditory FCW-5, 6, & 7 override visual and auditory LDW	Avoiding conflicts with a FC hazard is the highest priority, and the LDW is most likely to arise from the driver's evasive maneuver.	High	Unlikely
4	Visual LDW overrides visual FCW-1, FCW-2a, and FCW-2b	FCW-1, FCW-2a, and FCW-2b represent low-severity conditions that are not likely to require an immediate driver response, whereas the LD condition may require an immediate driver response if it is associated with encroachment into oncoming traffic or the shoulder.	High	Unlikely
5	Auditory LCM-3 overrides auditory FCW-3b	FCW-3b is uncommon and most likely to occur concurrently with LCM-3 while the driver is passing a lead vehicle that has a slower relative speed. In this case, the driver is likely to be aware of the reduced headway, which reduces the usefulness of the FCW-3b information. In contrast, the LCM conflict has a higher severity, and requires more immediate action to avoid.	High	Unlikely
5a	Auditory LCM-3 overrides auditory FCW-4b	FCW-4b is uncommon and most likely to occur concurrently with LCM-3 while the driver is passing a lead vehicle that has a slower relative speed. In this case, the driver is likely to be aware of the reduced headway, which reduces the usefulness of the FCW-4b information. Note, however, that if the FCW-4b warning is suppressed, there is an increased likelihood that the driver will have insufficient time to respond to an escalation to FCW-5 and still completely avoid a crash. Kinematic analysis indicates that under worse-case conditions (high speeds & slow deceleration level), drivers should still have at least 1.5 sec of available RT time following the onset of the FCW-5 (driver's first notice if FCW-4b is suppressed) to avoid a potentially serious crash with the lead vehicle (more than 10 mph relative speed). The LCM conflict has a greater potential to lead to higher severity crashes (e.g., driving the side vehicle into oncoming traffic etc) under these conditions, and consequently should be given priority.	High	Possible

Rule[1]		Justification	Confidence[2]	Exceptions[3]
6	Auditory FCW-3b & 4b overrides auditory LDW	FCW-3b & 4b are uncommon and most likely to occur concurrently with LDW while the driver is 1) passing a lead vehicle that has a slower relative speed, or 2) asleep or distracted and maintaining a higher relative speed. In case 1, it is unlikely that there is a lateral hazard/risk (and the LDW is self-evident to an alert driver), therefore the FCW-3b & 4b auditory warnings provide the most useful information. In case 2, there is an increase in potential for a run-off-road incident, and the LDW may to take precedence in some scenarios.	Med	Likely
7	Visual FCW-3b & 4b override visual LDW	The applicable scenarios in this case are the same as for Rule 6; the purpose of Rule 7 is to maintain overall display consistency with Rule 6. The reason for making Rule 7 separate from Rule 6 is to leave open the possibility of reversing Rule 7 and giving priority to the LDW on the DIU. In particular, FCW headway information is already presented via the auditory warning in addition to being available on the DIU left-side LED bar. In some situations, it may be beneficial to present the LDW on the DIU instead of the FCW. Note that providing LDW information comes at the expense of display consistency. At this time it is unknown if this mixing of messages can lead to driver confusion, so this approach is not currently recommended. However, this is an esoteric issue, since an alert driver making a lane change is unlikely to look at the DIU during this maneuver anyway, and sleeping/distracted drivers need auditory, not visual, warnings to prompt them into a more alert state.	Med	Likely
8	Auditory FCW-5, 6, & 7 override auditory LCM-3	The FCW-5, 6, & 7 capture high-severity hazard situations that drivers must be initially alerted about above all other hazards. Also, LCM-3 auditory warnings should be suppressed if they have the potential to interfere with drivers making an optimal emergency response. However, it may be necessary to provide a LCM-3 auditory warning once the driver has unambiguously acknowledged the FC hazard, and if the side-vehicle hazard poses a fatality risk (e.g., if the side vehicle will be driven into oncoming traffic by the driver's emergency maneuver)	Med-High	Very Likely
9	LCM-3 cancels LDW	Under all the scenarios in which these warnings can occur concurrently, a roadway departure is unlikely to present a hazard because the adjacent space is drivable by an adjacent vehicle. Consequently, only the LCM-3 provides meaningful information.	High	Unlikely

Rule[1]		Justification	Confidence[2]	Exceptions[3]
10	LDW is canceled if same-side turn signal is activated	The assumption here is that this situation represents an intentional lane departure, and no LDW should be provided.	High	Possible
11	If LDW indicates LD in direction of LCM-1, an auditory LCM-3 warning should be thrown under all conditions except FCW-5,6,7 (LDW is also canceled)	This represents LCM-3 conditions even though a turn signal is not activated. In this case, the LCM-1 alert plus auditory should function in the same way as a LCM-3 warning. Rules 5, 8, & 9 would also apply. Note that this particular sensory combination may not be possible because the conditions are the same as the definition for an LCM-3. This rule is included for completeness.	High	Possible
12	DIU display should not be changed while a LCM-3 is in progress, except for FCW-5, 6, or 7 (LCM-3 overrides visual FCW-1,2,3, & 4 and visual LDW-L/R)	A DIU display change produces a conspicuous visual event that has the potential to capture the driver's attention and interfere with the driver immediately attending to the visual LCM-3 information. The defining assumption is that drivers have enough time to recover from the conditions associated with the suppressed warning after they have responded to the LCM-3 situation. Note that whether or not this rule applies to FCW-3 & 4 is still being determined.	Med-High	Possible
13	LDW overrides FCW-3a	Headway is long enough in this situation to provide drivers with sufficient time to respond to an FCW-3b message that would occur if P1 started closing again.	High	Possible
14	LDW overrides FCW-4a	Although the headway (and corresponding safety margin) is relatively small in this situation, the FC is not an immediate threat and the driver is a likely to be aware of it, since the FCW-4a is the result of some response (although not necessarily from the driver) to an earlier FCW-4b warning. Also, a driver's response to the LDW warning should not directly lead to an escalation of the FC threat (the driver would have to accelerate for this to be true). However, responding to the LDW could delay the driver's response to the FC threat if conditions change suddenly. Nevertheless, driver will still get an FCW-4b warning if this happens, which would override the LDW alert and give the driver the needed information.	Med-High	Possible

Rule[1]		Justification	Confidence[2]	Exceptions[3]
15	LDW-X overrides FCW-1 & FCW-2A/B	FCW-1 and FCW-2a/b are low priority warnings, and the interruption from the LDW-X system is unlikely to impact safety. Also, these FCW are likely to occur for a significant proportion of the driving time, so waiting until the FCW-1 & 2 alerts are over would unnecessarily delay the presentation of the LDW failure information.	Med-High	Possible
16	FCW-3A, FCW-3AB, FCW-4A FCW-3A, B, FCW-567 override LDW-X	All these FCW alert conditions represent imminent or evolving crash risks and should have priority over the LDW-X alert, which is not inherently associated with driving risks.	High	Unlikely
17	LDW-RL overrides FCW-X	The occurrence of an FCW system failure at the same time as an impending FC crash risk is probably a very unlikely event. This means that most of the time, the LDW alert will represent a higher crash risk than forward case, and should have priority.	High	Possible
18	LCM-X2 overrides FCW-X & LDW-X	Of the information represented by each system, information about adjacent vehicles is the most difficult for an SV driver to maintain awareness of because it is not directly available in the forward field of view. Therefore, an alert that the LCM system has failed provides the most useful information to the driver. Note that presenting LCM-X2 failure information is not likely to be as critical under these conditions relative to other LCM-X2 arbitration situations (e.g., co-occurrence with FCW-3b/4b conditions), because it is less likely that the SV driver will be making a lane change in response to the conflicting alert information (in contrast, a lane change is a reasonable response to an FCW-4b alert).	High	Unlikely
19	Auditory FCW-X & LDW-X are overridden by all auditory alerts	All other auditory alerts are triggered during driving conditions that have some degree of associated crash risk, whereas this would only be true with FCW-X and LDW-X situations under exceptional circumstances.	High	Unlikely

* Assumption – LCM-3 warnings only occur in the direction of the turn signal. If the lane change side is clear but there is a POV on the other side, an LCM-3 warning will not occur.

7.4 Arbitration of concurrent auditory warnings

7.4.1 Overview

This section describes the recommended approach for determining when to present an auditory alert that is generated by one warning subsystem while a previous auditory alert associated with another subsystem is still active.

7.4.2 Recommended strategies for presentation of the various pairings of auditory alerts

Four strategies have been identified for arbitration of concurrent auditory warning messages. When an auditory message must be presented on the DIU (Message 2), but an earlier message is currently being played (Message 1), the first message may be preempted, or the second message may be suppressed, delayed, or canceled. The appropriate strategy for each 2-alert combination depends on warning priority, duration of Message 1, and the time available before the driver must react to Message 2. Table 10 defines these strategies.

Table 10. Definitions of the presentation strategies for concurrent auditory messages

Strategy	Presentation Logic	Comment
Preemption	Message 1 is halted, and Message 2 is played at the first opportunity.	The first message is interrupted and some masking/sound confusion could theoretically occur. This potential problem is left unaddressed at this time because the severity of this problem is unknown, and requires further investigation.
Suppression	Message 2 is not immediately played. If the Message 2 triggering conditions are still present when Message 1 is complete (including the Message 1 "silence" interval), then Message 2 is played	This is the preferred presentation approach for most message combinations. It is only with very high priority messages (Preemption) or very low priority messages (Delay) is a different approach recommended.
Delay	Message 2 is not played. Instead a 20 second count-down is initiated, and if the conditions associated with Message 1 have not escalated (they may still persist or have improved since then), then Message 2 is played.	The purpose of this presentation approach is to let the conditions associated with Message 1 evolve before presenting these very-low priority messages.
Cancel	Message 2 is not played, even when Message 1 conditions are no longer present (even if Message 2 conditions still are)	This situation should not occur for straight pre-emption, because these combinations should be eliminated by Fusion Engine arbitration. This option is included to provide a default action if this combination slips through for whatever reason.

Table 11 below indicates the recommended presentation strategy for the following 2-alert combinations. It is unknown at the present time whether additional combinations are possible (e.g., LDW-L followed by LDW-R), but those can be added as needed.

Note that although strategies are specified for the Fault messages (as Message 2), these combinations will not occur under the current arbitration rules because LDW and FCW fault alerts are overridden by all the other warning conditions that have an auditory component.

Table 11. The recommended presentation strategy for 2-alert warning combinations. Note that Message 1 is the initial message and Message 2 is the second message that overlaps in time with the presentation of Message 1.

		Message 2						
		FCW3	**FCW4**	**FCW567**	**LCM3**	**LDW**	**LCMX2**	**Fault**
Message 1	**FCW3**		M2 is Suppressed	M2 Preempts	M2 Preempts	M2 is Suppressed	M2 is Suppressed	M2 is Delayed
	FCW4	M2 is Suppressed		M2 Preempts	M2 Preempts	M2 is Suppressed	M2 is Suppressed	M2 is Delayed
	FCW567	M2 is Suppressed	M2 is Suppressed		M2 is Cancelled	M2 is Cancelled	M2 is Cancelled	M2 is Delayed
	LCM3	M2 is Suppressed	M2 is Suppressed	M2 Preempts		M2 is Cancelled	M2 is Suppressed	M2 is Delayed
	LDW	M2 is Suppressed	M2 Preempts	M2 Preempts	M2 Preempts		M2 Preempts	M2 is Delayed
	LCMX2	M2 is Suppressed	M2 is Suppressed	M2 Preempts	NA*	M2 is Suppressed		M2 is Delayed
	Fault	M2 is Suppressed	M2 Preempts	M2 Preempts	M2 Preempts	M2 is Suppressed	M2 is Suppressed	

**NA:* The second message should not occur because of system failure

8 Training, help, and systems functions

8.1 Demonstration mode

Selecting “Demo” from the main menu will start a demonstration mode that shows the various lights, display screens, and sounds produced by the DIU. Screen demonstrations will be presented using in the same manner as described in Appendix C of the Eaton Vorad VS-400 CWS/SmartCruise specification document (Eaton, 2007, pp. 33–35). Each display will be preceded by an introductory message identifying the upcoming screen.

Because of the complexity of the IVBSS, sub-menus will be used to navigate to demos for each warning type. Specifically, four sub-menus will provide selections for the following functions:

1. System Operation
2. FCW
3. LDW
4. LCM

The system operation sub-menu shall have screens describing general operations that are not specific to warning subsystems, such as how to enter mute mode, how to adjust

volume and brightness, etc. Navigation of the Demo Mode displays should be the first item in the System Operation sub-menu.

The warning subsystem sub-menus should describe the warning displays from least to most imminent and the system fault messages. LCD displays, auditory displays, and LED indicator lights corresponding to each stage, warning level, and/or failure mode will be displayed for the appropriate selection.

The scroll symbol should be indicated on each description screen to indicate navigation options: pressing the down arrow key will advance the demonstration to the next screen, and pressing the up arrow key moves to the preceding screen. Pressing the “OK” key will cause the DIU to revert to the main Demo Mode menu.

Demonstration mode will be available to drivers only while the vehicle is not moving; that is when the vehicle speed is 0 mph; demonstration mode will terminate if the vehicle begins to move.

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Appendix A. Multiple threat permutations

This appendix comprises a taxonomy of threat permutations and the application of the arbitration rules in Table 9 (Section 7.3) to each warning display conflict. This table lists each possible combination of alerts generated by the three IVBSS warning subsystems in conjunction with application of the turn signal. Corresponding display outputs are given based on the application of the associated rule or rules.

The table is organized into six sections as follows:

1. Input: All possible combinations of FCW, LCM, and LDW warnings.
2. Output: The resulting visual and auditory outputs associated with each input combination. Outputs are given for the DIU, right lateral, and left lateral visual displays and for the auditory displays.
3. Conflict Source: Lists the types of displays (auditory, DIU) associated with each input combination for which warning display conflicts exist.
4. Sensor inputs: Indicates the subsystem alerts, in combination with the turn signal, that result in presentation conflicts.
5. Rule: Indicates the arbitration rule or rules from Table 9 that applies to the input combination.
6. Display Outputs: Indicates which visual and auditory displays should be presented for each input combination.

Many of the input combinations do not result in a conflict between warning presentations, while other combinations are not possible or are highly unlikely, such as concurrent LDW-R and LCM-L. For each of these combinations, the fields in the Conflict Source, Sensor Inputs, Rule, and Display Output sections are left blank. However, display outputs for all combinations that may directly affect safety have been included.

Highlighted rows indicate combinations that, based on kinematic and other analyses, are likely to require exceptions to the arbitration rules.

Table A - 1 Multiple threat permutations and rule applications.
Note: Side-specific sensor conditions are identified with the R (Right) and L (Left) suffixes (R/L means that the logic applies to both sides).

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
01-FCW-0	1-LCM-0	1-LDW-0	None	None	None	None										
01-FCW-0	1-LCM-0	2-LDW-R	LDWR	LDWR	None	None	None	--	LCM-0 R/L	LDW-R	OFF	1	LDW-R	LCM-0	LCM-0	LDW-R
01-FCW-0	1-LCM-0	3-LDW-L	LDWL	LDWL	None	None	None	--	LCM-0 R/L	LDW-L	OFF	1	LDW-L	LCM-0	LCM-0	LDW-L
01-FCW-0	1-LCM-0	4-LDW-X	LDWX	Fault	None	None										
01-FCW-0	2-LCM-1R	1-LDW-0	None	None	LCM1	None										
01-FCW-0	2-LCM-1R	2-LDW-R	LDWR	LDWR	LCM1	None	AUD	--	LCM-1R	LDW-R	OFF	9	None	LCM-0	LCM-3*	LCM-3*
01-FCW-0	2-LCM-1R	3-LDW-L	LDWL	LDWL	LCM1	None	None	--	LCM-1R	LDW-L	OFF	1	LDW-L	LCM-0	LCM-1	LDW-L
01-FCW-0	2-LCM-1R	4-LDW-X	LDWX	Fault	LCM1	None										
01-FCW-0	3-LCM-2R	1-LDW-0	None	None	LCM2	None										
01-FCW-0	3-LCM-2R	2-LDW-R	LDWR	LDWR	LCM2	None										
01-FCW-0	3-LCM-2R	3-LDW-L	LDWL	LDWL	LCM2	None										
01-FCW-0	3-LCM-2R	4-LDW-X	LDWX	Fault	LCM2	None										
01-FCW-0	4-LCM-3R	1-LDW-0	None	LCMR	LCM2	None										
01-FCW-0	4-LCM-3R	2-LDW-R	LDWR	LCMR	LCM2	None	AUD	--	LCM-3R	LDW-R	OFF	*9*	None	LCM-0	LCM-3	LCM-3
01-FCW-0	4-LCM-3R	3-LDW-L	LDWL	LCMR	LCM2	None										
01-FCW-0	4-LCM-3R	4-LDW-X	LDWX	LCMR	LCM2	None										
01-FCW-0	5-LCM-1L	1-LDW-0	None	None	None	LCM1										
01-FCW-0	5-LCM-1L	2-LDW-R	LDWR	LDWR	None	LCM1	None	--	LCM-1L	LDW-R	OFF	*1*	LDW-R	LCM-1	LCM-0	LDW-R
01-FCW-0	5-LCM-1L	3-LDW-L	LDWL	LDWL	None	LCM1	AUD	--	LCM-1L	LDW-L	OFF	*9*	None	LCM-3*	LCM-0	LCM-3*
01-FCW-0	5-LCM-1L	4-LDW-X	LDWX	Fault	None	LCM1										
01-FCW-0	6-LCM-2L	1-LDW-0	None	None	None	LCM2										
01-FCW-0	6-LCM-2L	2-LDW-R	LDWR	LDWR	None	LCM2										
01-FCW-0	6-LCM-2L	3-LDW-L	LDWL	LDWL	None	LCM2										
01-FCW-0	6-LCM-2L	4-LDW-X	LDWX	Fault	None	LCM2										

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
01-FCW-0	7-LCM-3L	1-LDW-0	None	LCML	None	LCM2										
01-FCW-0	7-LCM-3L	2-LDW-R	LDWR	LCML	None	LCM2										
01-FCW-0	7-LCM-3L	3-LDW-L	LDWL	LCML	None	LCM2	AUD	--	LCM-3L	LDW-L	OFF	*9*	None	LCM-3	LCM-0	LCM-3
01-FCW-0	7-LCM-3L	4-LDW-X	LDWX	LCML	None	LCM2										
01-FCW-0	8-LCM-X2	1-LDW-0	LCX2	Fault	None	None										
01-FCW-0	8-LCM-X2	2-LDW-R	LCX2	Fault	None	None	DIU	--	LCM-X2 R/L	LDW-R	OFF	2d	LCM-X2	None	None	LCM-X2
01-FCW-0	8-LCM-X2	3-LDW-L	LCX2	Fault	None	None	DIU	--	LCM-X2 R/L	LDW-L	OFF	2d	LCM-X2	None	None	LCM-X2
01-FCW-0	8-LCM-X2	4-LDW-X	LCX2	Fault	None	None										
01-FCW-0	9-LCM-1LR	1-LDW-0	None	None	LCM1	LCM1										
01-FCW-0	9-LCM-1LR	2-LDW-R	LDWR	LDWR	LCM1	LCM1										
01-FCW-0	9-LCM-1LR	3-LDW-L	LDWL	LDWL	LCM1	LCM1										
01-FCW-0	9-LCM-1LR	4-LDW-X	LDWX	Fault	LCM1	LCM1										
02-FCW-1	1-LCM-0	1-LDW-0	FCW1	None	None	None	None	FCW-1	LCM-0 R/L	--	L, R, OFF	1	FCW-1	LCM-0	LCM-0	None
02-FCW-1	1-LCM-0	2-LDW-R	LDWR	LDWR	None	None	DIU	FCW-1	LCM-0 R/L	LDW-R	OFF	*4*	LDW-R	LCM-0	LCM-0	LDW-R
02-FCW-1	1-LCM-0	3-LDW-L	LDWL	LDWL	None	None	DIU	FCW-1	LCM-0 R/L	LDW-L	OFF	*4*	LDW-L	LCM-0	LCM-0	LDW-L
02-FCW-1	1-LCM-0	4-LDW-X	LDWX	Fault	None	None										
02-FCW-1	2-LCM-1R	1-LDW-0	FCW1	None	LCM1	None	None	FCW-1	LCM-1R	--	OFF	1	FCW-1	LCM-0	LCM-1	None
02-FCW-1	2-LCM-1R	2-LDW-R	LDWR	LDWR	LCM1	None	DIU	FCW-1	LCM-1R	LDW-R	OFF	*4,11,12*	FCW-1[#]	LCM-0	LCM-3*	LCM-3*
02-FCW-1	2-LCM-1R	3-LDW-L	LDWL	LDWL	LCM1	None	DIU	FCW-1	LCM-1R	LDW-L	OFF	*4*	LDW-L	LCM-0	LCM-1	LDW-L
02-FCW-1	2-LCM-1R	4-LDW-X	LDWX	Fault	LCM1	None	None	FCW-1	LCM-1R	Unavail	OFF	1	FCW-1	LCM-0	LCM-1	None
02-FCW-1	3-LCM-2R	1-LDW-0	FCW1	None	LCM2	None	None	FCW-1	LCM-2R	--	R	1	FCW-1	LCM-0	LCM-2	None
02-FCW-1	3-LCM-2R	2-LDW-R	LDWR	LDWR	LCM2	None										
02-FCW-1	3-LCM-2R	3-LDW-L	LDWL	LDWL	LCM2	None										
02-FCW-1	3-LCM-2R	4-LDW-X	LDWX	Fault	LCM2	None										
02-FCW-1	4-LCM-3R	1-LDW-0	FCW1	LCMR	LCM2	None										
02-FCW-1	4-LCM-3R	2-LDW-R	LDWR	LCMR	LCM2	None	DIU, AUD	FCW-1	LCM-3R	LDW-R	OFF	*9*	FCW-1	LCM-0	LCM-3	LCM-3R
02-FCW-1	4-LCM-3R	3-LDW-L	LDWL	LCMR	LCM2	None	None	FCW-1	LCM-3R	Unavail	OFF	1	FCW-1	LCM-0	LCM-3	LCM-3R[†]
02-FCW-1	4-LCM-3R	4-LDW-X	LDWX	LCMR	LCM2	None	None	FCW-1	LCM-3R	Unavail	RIGHT	1	FCW-1	LCM-0	LCM-3	LCM-3R

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
02-FCW-1	5-LCM-1L	1-LDW-0	FCW1	None	None	LCM1	None	FCW-1	LCM-1L	--	OFF	1	FCW-1	LCM-1	LCM-0	None
02-FCW-1	5-LCM-1L	2-LDW-R	LDWR	LDWR	None	LCM1	DIU	FCW-1	LCM-1L	LDW-R	OFF	*4*	LDW-R	LCM-1	LCM-0	LDW-R
02-FCW-1	5-LCM-1L	3-LDW-L	LDWL	LDWL	None	LCM1	DIU	FCW-1	LCM-1L	LDW-L	OFF	*4,11,12*	FCW-1[#]	LCM-3*	LCM-0	LCM-3*
02-FCW-1	5-LCM-1L	4-LDW-X	LDWX	Fault	None	LCM1	None	FCW-1	LCM-1L	Unavail	OFF	1	FCW-1	LCM-1	LCM-0	None
02-FCW-1	6-LCM-2L	1-LDW-0	FCW1	None	None	LCM2	None	FCW-1	LCM-2L	--	L	1	FCW-1	LCM-2	LCM-0	None
02-FCW-1	6-LCM-2L	2-LDW-R	LDWR	LDWR	None	LCM2										
02-FCW-1	6-LCM-2L	3-LDW-L	LDWL	LDWL	None	LCM2										
02-FCW-1	6-LCM-2L	4-LDW-X	LDWX	Fault	None	LCM2										
02-FCW-1	7-LCM-3L	1-LDW-0	FCW1	LCML	None	LCM2										
02-FCW-1	7-LCM-3L	2-LDW-R	LDWR	LCML	None	LCM2										
02-FCW-1	7-LCM-3L	3-LDW-L	LDWL	LCML	None	LCM2	DIU, AUD	FCW-1	LCM-3L	LDW-L	OFF	*9*	FCW-1	LCM-3	LCM-0	LCM-3L
02-FCW-1	7-LCM-3L	4-LDW-X	LDWX	LCML	None	LCM2	None	FCW-1	LCM-3L	Unavail	OFF	1	FCW-1	LCM-3	LCM-0	LCM-3L[†]
02-FCW-1	8-LCM-X2	1-LDW-0	LCX2	Fault	None	None	DIU	FCW-1	LCM-X2 R/L	--	L, R, OFF	2a	LCM-X2	None	None	LCM-X2
02-FCW-1	8-LCM-X2	2-LDW-R	LCX2	Fault	None	None										
02-FCW-1	8-LCM-X2	3-LDW-L	LCX2	Fault	None	None										
02-FCW-1	8-LCM-X2	4-LDW-X	LCX2	Fault	None	None										
02-FCW-1	9-LCM-1LR	1-LDW-0	FCW1	None	LCM1	LCM1										
02-FCW-1	9-LCM-1LR	2-LDW-R	LDWR	LDWR	LCM1	LCM1										
02-FCW-1	9-LCM-1LR	3-LDW-L	LDWL	LDWL	LCM1	LCM1										
02-FCW-1	9-LCM-1LR	4-LDW-X	LDWX	Fault	LCM1	LCM1										
03-FCW-2	1-LCM-0	1-LDW-0	FCW2	None	None	None	None	FCW-2b	LCM-0 R/L	--	L, R, OFF	1	FCW-2b	LCM-0	LCM-0	None
03-FCW-2	1-LCM-0	2-LDW-R	LDWR	LDWR	None	None	DIU	FCW-2b	LCM-0 R/L	LDW-R	OFF	*4*	LDW-R	LCM-0	LCM-0	LDW-R
03-FCW-2	1-LCM-0	3-LDW-L	LDWL	LDWL	None	None	DIU	FCW-2b	LCM-0 R/L	LDW-L	OFF	*4*	LDW-L	LCM-0	LCM-0	LDW-L
03-FCW-2	1-LCM-0	4-LDW-X	LDWX	Fault	None	None										
03-FCW-2	2-LCM-1R	1-LDW-0	FCW2	None	LCM1	None	None	FCW-2b	LCM-1R	--	OFF	1	FCW-2b	LCM-0	LCM-1	None
03-FCW-2	2-LCM-1R	2-LDW-R	LDWR	LDWR	LCM1	None	DIU	FCW-2b	LCM-1R	LDW-R	OFF	*4,11,12*	FCW-2b[#]	LCM-0	LCM-3*	LCM-3*
03-FCW-2	2-LCM-1R	3-LDW-L	LDWL	LDWL	LCM1	None	DIU	FCW-2b	LCM-1R	LDW-L	OFF	*4*	LDW-L	LCM-0	LCM-1	LDW-L
03-FCW-2	2-LCM-1R	4-LDW-X	LDWX	Fault	LCM1	None	None	FCW-2b	LCM-1R	Unavail	OFF	1	FCW-2b	LCM-0	LCM-1	None

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
03-FCW-2	3-LCM-2R	1-LDW-0	FCW2	None	LCM2	None	None	FCW-2b	LCM-2R	--	R	1	FCW-2b	LCM-0	LCM-2	None
03-FCW-2	3-LCM-2R	2-LDW-R	LDWR	LDWR	LCM2	None										
03-FCW-2	3-LCM-2R	3-LDW-L	LDWL	LDWL	LCM2	None										
03-FCW-2	3-LCM-2R	4-LDW-X	LDWX	Fault	LCM2	None										
03-FCW-2	4-LCM-3R	1-LDW-0	FCW2	LCMR	LCM2	None										
03-FCW-2	4-LCM-3R	2-LDW-R	LDWR	LCMR	LCM2	None	DIU, AUD	FCW-2b	LCM-3R	LDW-R	OFF	*9*	FCW-2b	LCM-0	LCM-3	LCM-3R
03-FCW-2	4-LCM-3R	3-LDW-L	LDWL	LCMR	LCM2	None										
03-FCW-2	4-LCM-3R	4-LDW-X	LDWX	LCMR	LCM2	None	None	FCW-2b	LCM-3R	Unavail	OFF	1	FCW-2b	LCM-0	LCM-3	LCM-3R[†]
03-FCW-2	5-LCM-1L	1-LDW-0	FCW2	None	None	LCM1	None	FCW-2b	LCM-1L	--	OFF	1	FCW-2b	LCM-1	LCM-0	None
03-FCW-2	5-LCM-1L	2-LDW-R	LDWR	LDWR	None	LCM1	DIU	FCW-2b	LCM-1L	LDW-R	OFF	*4*	LDW-R	LCM-1	LCM-0	LDW-R
03-FCW-2	5-LCM-1L	3-LDW-L	LDWL	LDWL	None	LCM1	DIU	FCW-2b	LCM-1L	LDW-L	OFF	*4,11,12*	FCW-2b[#]	LCM-3*	LCM-0	LCM-3*
03-FCW-2	5-LCM-1L	4-LDW-X	LDWX	Fault	None	LCM1	None	FCW-2b	LCM-1L	Unavail	OFF	1	FCW-2b	LCM-1	LCM-0	None
03-FCW-2	6-LCM-2L	1-LDW-0	FCW2	None	None	LCM2	None	FCW-2b	LCM-2L	--	L	1	FCW-2b	LCM-2	LCM-0	None
03-FCW-2	6-LCM-2L	2-LDW-R	LDWR	LDWR	None	LCM2										
03-FCW-2	6-LCM-2L	3-LDW-L	LDWL	LDWL	None	LCM2										
03-FCW-2	6-LCM-2L	4-LDW-X	LDWX	Fault	None	LCM2										
03-FCW-2	7-LCM-3L	1-LDW-0	FCW2	LCML	None	LCM2										
03-FCW-2	7-LCM-3L	2-LDW-R	LDWR	LCML	None	LCM2										
03-FCW-2	7-LCM-3L	3-LDW-L	LDWL	LCML	None	LCM2	DIU, AUD	FCW-2b	LCM-3L	LDW-L	OFF	*9*	FCW-2b	LCM-3	LCM-0	LCM-3L
03-FCW-2	7-LCM-3L	4-LDW-X	LDWX	LCML	None	LCM2	None	FCW-2b	LCM-3L	Unavail	OFF	1	FCW-2b	LCM-3	LCM-0	LCM-3L[†]
03-FCW-2	8-LCM-X2	1-LDW-0	LCX2	Fault	None	None	DIU	FCW-2b	LCM-X2 R/L	--	L, R, OFF	2a	LCM-X2	None	None	LCM-X2
03-FCW-2	8-LCM-X2	2-LDW-R	LCX2	Fault	None	None										
03-FCW-2	8-LCM-X2	3-LDW-L	LCX2	Fault	None	None										
03-FCW-2	8-LCM-X2	4-LDW-X	LCX2	Fault	None	None										
03-FCW-2	9-LCM-1LR	1-LDW-0	FCW2	None	LCM1	LCM1										
03-FCW-2	9-LCM-1LR	2-LDW-R	LDWR	LDWR	LCM1	LCM1										
03-FCW-2	9-LCM-1LR	3-LDW-L	LDWL	LDWL	LCM1	LCM1										
03-FCW-2	9-LCM-1LR	4-LDW-X	LDWX	Fault	LCM1	LCM1										

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
04-FCW-3A	1-LCM-0	1-LDW-0	FCW3	None	None	None	None	FCW-3a	LCM-0 R/L	--	L, R, OFF	1	FCW-3a	LCM-0	LCM-0	None
04-FCW-3A	1-LCM-0	2-LDW-R	LDWR	LDWR	None	None	DIU	FCW-3a	LCM-0 R/L	LDW-R	OFF	*13*	LDW-R	LCM-0	LCM-0	LDW-R
04-FCW-3A	1-LCM-0	3-LDW-L	LDWL	LDWL	None	None	DIU	FCW-3a	LCM-0 R/L	LDW-L	OFF	*13*	LDW-L	LCM-0	LCM-0	LDW-L
04-FCW-3A	1-LCM-0	4-LDW-X	FCW3	Fault	None	None										
04-FCW-3A	2-LCM-1R	1-LDW-0	FCW3	None	LCM1	None	None	FCW-3a	LCM-1R	--	OFF	1	FCW-3a	LCM-0	LCM-1	None
04-FCW-3A	2-LCM-1R	2-LDW-R	LDWR	LDWR	LCM1	None	DIU, AUD	FCW-3a	LCM-1R	LDW-R	OFF	*9,11*	FCW-3a	LCM-0	LCM-3*	LCM-3*
04-FCW-3A	2-LCM-1R	3-LDW-L	LDWL	LDWL	LCM1	None	DIU	FCW-3a	LCM-1R	LDW-L	OFF	*13*	LDW-L	LCM-0	LCM-1	LDW-L
04-FCW-3A	2-LCM-1R	4-LDW-X	FCW3	Fault	LCM1	None	None	FCW-3a	LCM-1R	Unavail	OFF	1	FCW-3a	LCM-0	LCM-1	None
04-FCW-3A	3-LCM-2R	1-LDW-0	FCW3	None	LCM2	None	None	FCW-3a	LCM-2R	--	R	1	FCW-3a	LCM-0	LCM-2	None
04-FCW-3A	3-LCM-2R	2-LDW-R	LDWR	LDWR	LCM2	None										
04-FCW-3A	3-LCM-2R	3-LDW-L	LDWL	LDWL	LCM2	None										
04-FCW-3A	3-LCM-2R	4-LDW-X	FCW3	Fault	LCM2	None										
04-FCW-3A	4-LCM-3R	1-LDW-0	FCW3	LCMR	LCM2	None										
04-FCW-3A	4-LCM-3R	2-LDW-R	LDWR	LCMR	LCM2	None	DIU, AUD	FCW-3a	LCM-3R	LDW-R	OFF	*9*	FCW-3a	LCM-0	LCM-3	LCM-3R
04-FCW-3A	4-LCM-3R	3-LDW-L	LDWL	LCMR	LCM2	None										
04-FCW-3A	4-LCM-3R	4-LDW-X	FCW3	LCMR	LCM2	None	None	FCW-3a	LCM-3R	Unavail	OFF	1	FCW-3a	LCM-0	LCM-3	LCM-3R[†]
04-FCW-3A	5-LCM-1L	1-LDW-0	FCW3	None	None	LCM1	None	FCW-3a	LCM-1L	--	OFF	1	FCW-3a	LCM-1	LCM-0	None
04-FCW-3A	5-LCM-1L	2-LDW-R	LDWR	LDWR	None	LCM1	DIU	FCW-3a	LCM-1L	LDW-R	OFF	*13*	LDW-R	LCM-1	LCM-0	LDW-R
04-FCW-3A	5-LCM-1L	3-LDW-L	LDWL	LDWL	None	LCM1	DIU, AUD	FCW-3a	LCM-1L	LDW-L	OFF	*9,11*	FCW-3a	LCM-3*	LCM-0	LCM-3*
04-FCW-3A	5-LCM-1L	4-LDW-X	FCW3	Fault	None	LCM1	None	FCW-3a	LCM-1L	Unavail	OFF	1	FCW-3a	LCM-1	LCM-0	None
04-FCW-3A	6-LCM-2L	1-LDW-0	FCW3	None	None	LCM2	None	FCW-3a	LCM-2L	--	L	1	FCW-3a	LCM-2	LCM-0	None
04-FCW-3A	6-LCM-2L	2-LDW-R	LDWR	LDWR	None	LCM2										
04-FCW-3A	6-LCM-2L	3-LDW-L	LDWL	LDWL	None	LCM2										
04-FCW-3A	6-LCM-2L	4-LDW-X	FCW3	Fault	None	LCM2										
04-FCW-3A	7-LCM-3L	1-LDW-0	FCW3	LCML	None	LCM2										
04-FCW-3A	7-LCM-3L	2-LDW-R	LDWR	LCML	None	LCM2										
04-FCW-3A	7-LCM-3L	3-LDW-L	LDWL	LCML	None	LCM2	DIU, AUD	FCW-3a	LCM-3L	LDW-L	OFF	*9*	FCW-3a	LCM-3	LCM-0	LCM-3L
04-FCW-3A	7-LCM-3L	4-LDW-X	FCW3	LCML	None	LCM2	None	FCW-3a	LCM-3L	Unavail	OFF	1	FCW-3a	LCM-3	LCM-0	LCM-3L[†]

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
04-FCW-3A	8-LCM-X2	1-LDW-0	LCX2	Fault	None	None	DIU	FCW-3a	LCM-X2 R/L	--	L, R, OFF	2b	LCM-X2	None	None	LCM-X2
04-FCW-3A	8-LCM-X2	2-LDW-R	LCX2	Fault	None	None										
04-FCW-3A	8-LCM-X2	3-LDW-L	LCX2	Fault	None	None										
04-FCW-3A	8-LCM-X2	4-LDW-X	LCX2	Fault	None	None										
04-FCW-3A	9-LCM-1LR	1-LDW-0	FCW3	None	LCM1	LCM1										
04-FCW-3A	9-LCM-1LR	2-LDW-R	LDWR	LDWR	LCM1	LCM1										
04-FCW-3A	9-LCM-1LR	3-LDW-L	LDWL	LDWL	LCM1	LCM1										
04-FCW-3A	9-LCM-1LR	4-LDW-X	FCW3	Fault	LCM1	LCM1										
05-FCW-3B	1-LCM-0	1-LDW-0	FCW3	FC3B	None	None	None	FCW-3b	LCM-0 R/L	--	L, R, OFF	1	FCW-3b	LCM-0	LCM-0	FCW-3b
05-FCW-3B	1-LCM-0	2-LDW-R	FCW3	FC3B	None	None	DIU, AUD	FCW-3b	LCM-0 R/L	LDW-R	OFF	*6,7*	FCW-3b	LCM-0	LCM-0	FCW-3b
05-FCW-3B	1-LCM-0	3-LDW-L	FCW3	FC3B	None	None	DIU, AUD	FCW-3b	LCM-0 R/L	LDW-L	OFF	*6,7*	FCW-3b	LCM-0	LCM-0	FCW-3b
05-FCW-3B	1-LCM-0	4-LDW-X	FCW3	FC3B	None	None										
05-FCW-3B	2-LCM-1R	1-LDW-0	FCW3	FC3B	LCM1	None	None	FCW-3b	LCM-1R	--	OFF	1	FCW-3b	LCM-0	LCM-1	FCW-3b
05-FCW-3B	2-LCM-1R	2-LDW-R	FCW3	FC3B	LCM1	None	DIU, AUD	FCW-3b	LCM-1R	LDW-R	OFF	*5,9,11*	FCW-3b	LCM-0	LCM-3*	LCM-3*
05-FCW-3B	2-LCM-1R	3-LDW-L	FCW3	FC3B	LCM1	None	DIU, AUD	FCW-3b	LCM-1R	LDW-L	OFF	*6,7*	FCW-3b	LCM-0	LCM-1	FCW-3b
05-FCW-3B	2-LCM-1R	4-LDW-X	FCW3	FC3B	LCM1	None	None	FCW-3b	LCM-1R	Unavail	OFF	1	FCW-3b	LCM-0	LCM-1	FCW-3b
05-FCW-3B	3-LCM-2R	1-LDW-0	FCW3	FC3B	LCM2	None	None	FCW-3b	LCM-2R	--	R	1	FCW-3b	LCM-0	LCM-2	FCW-3b
05-FCW-3B	3-LCM-2R	2-LDW-R	FCW3	FC3B	LCM2	None										
05-FCW-3B	3-LCM-2R	3-LDW-L	FCW3	FC3B	LCM2	None										
05-FCW-3B	3-LCM-2R	4-LDW-X	FCW3	FC3B	LCM2	None										
05-FCW-3B	4-LCM-3R	1-LDW-0	FCW3	LCMR	LCM2	None										
05-FCW-3B	4-LCM-3R	2-LDW-R	FCW3	LCMR	LCM2	None	DIU, AUD	FCW-3b	LCM-3R	LDW-R	OFF	*5,9*	FCW-3b	LCM-0	LCM-3	LCM-3R
05-FCW-3B	4-LCM-3R	3-LDW-L	FCW3	LCMR	LCM2	None										
05-FCW-3B	4-LCM-3R	4-LDW-X	FCW3	LCMR	LCM2	None	AUD	FCW-3b	LCM-3R	Unavail	OFF	5	FCW-3b	LCM-0	LCM-3	LCM-3R[†]
05-FCW-3B	5-LCM-1L	1-LDW-0	FCW3	FC3B	None	LCM1	None	FCW-3b	LCM-1L	--	OFF	1	FCW-3b	LCM-1	LCM-0	FCW-3b
05-FCW-3B	5-LCM-1L	2-LDW-R	FCW3	FC3B	None	LCM1	DIU, AUD	FCW-3b	LCM-1L	LDW-R	OFF	*6,7*	FCW-3b	LCM-1	LCM-0	FCW-3b
05-FCW-3B	5-LCM-1L	3-LDW-L	FCW3	FC3B	None	LCM1	DIU, AUD	FCW-3b	LCM-1L	LDW-L	OFF	*5,9,11*	FCW-3b	LCM-3*	LCM-0	LCM-3*
05-FCW-3B	5-LCM-1L	4-LDW-X	FCW3	FC3B	None	LCM1	None	FCW-3b	LCM-1L	Unavail	OFF	1	FCW-3b	LCM-1	LCM-0	FCW-3b

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
05-FCW-3B	6-LCM-2L	1-LDW-0	FCW3	FC3B	None	LCM2	None	FCW-3b	LCM-2L	--	L	1	FCW-3b	LCM-2	LCM-0	FCW-3b
05-FCW-3B	6-LCM-2L	2-LDW-R	FCW3	FC3B	None	LCM2										
05-FCW-3B	6-LCM-2L	3-LDW-L	FCW3	FC3B	None	LCM2										
05-FCW-3B	6-LCM-2L	4-LDW-X	FCW3	FC3B	None	LCM2										
05-FCW-3B	7-LCM-3L	1-LDW-0	FCW3	LCML	None	LCM2										
05-FCW-3B	7-LCM-3L	2-LDW-R	FCW3	LCML	None	LCM2										
05-FCW-3B	7-LCM-3L	3-LDW-L	FCW3	LCML	None	LCM2	DIU, AUD	FCW-3b	LCM-3L	LDW-L	OFF	*5,9*	FCW-3b	LCM-3	LCM-0	LCM-3L
05-FCW-3B	7-LCM-3L	4-LDW-X	FCW3	LCML	None	LCM2	AUD	FCW-3b	LCM-3L	Unavail	OFF	5	FCW-3b	LCM-3	LCM-0	LCM-3L[†]
05-FCW-3B	8-LCM-X2	1-LDW-0	LCX2	Fault	None	None	DIU, AUD	FCW-3b	LCM-X2 R/L	--	L, R, OFF	2b	LCM-X2	None	None	LCM-X2
05-FCW-3B	8-LCM-X2	2-LDW-R	LCX2	Fault	None	None										
05-FCW-3B	8-LCM-X2	3-LDW-L	LCX2	Fault	None	None										
05-FCW-3B	8-LCM-X2	4-LDW-X	LCX2	Fault	None	None										
05-FCW-3B	9-LCM-1LR	1-LDW-0	FCW3	FC3B	LCM1	LCM1										
05-FCW-3B	9-LCM-1LR	2-LDW-R	FCW3	FC3B	LCM1	LCM1										
05-FCW-3B	9-LCM-1LR	3-LDW-L	FCW3	FC3B	LCM1	LCM1										
05-FCW-3B	9-LCM-1LR	4-LDW-X	FCW3	FC3B	LCM1	LCM1										
06-FCW-4A	1-LCM-0	1-LDW-0	FCW4	None	None	None	None	FCW-4a	LCM-0 R/L	--	L, R, OFF	1	FCW-4a	LCM-0	LCM-0	None
06-FCW-4A	1-LCM-0	2-LDW-R	LDWR	LDWR	None	None	DIU, AUD	FCW-4a	LCM-0 R/L	LDW-R	OFF	*14*	LDW-R	LCM-0	LCM-0	LDW-R
06-FCW-4A	1-LCM-0	3-LDW-L	LDWL	LDWL	None	None	DIU	FCW-4a	LCM-0 R/L	LDW-L	OFF	*14*	LDW-L	LCM-0	LCM-0	LDW-L
06-FCW-4A	1-LCM-0	4-LDW-X	FCW4	Fault	None	None										
06-FCW-4A	2-LCM-1R	1-LDW-0	FCW4	None	LCM1	None	None	FCW-4a	LCM-1R	--	OFF	1	FCW-4a	LCM-0	LCM-1	None
06-FCW-4A	2-LCM-1R	2-LDW-R	LDWR	LDWR	LCM1	None	DIU, AUD	FCW-4a	LCM-1R	LDW-R	OFF	*9,11*	FCW-4a	LCM-0	LCM-3*	LCM-3*
06-FCW-4A	2-LCM-1R	3-LDW-L	LDWL	LDWL	LCM1	None	DIU	FCW-4a	LCM-1R	LDW-L	OFF	*14*	LDW-L	LCM-0	LCM-1	LDW-L
06-FCW-4A	2-LCM-1R	4-LDW-X	FCW4	Fault	LCM1	None	None	FCW-4a	LCM-1R	Unavail	OFF	1	FCW-4a	LCM-0	LCM-1	None
06-FCW-4A	3-LCM-2R	1-LDW-0	FCW4	None	LCM2	None	None	FCW-4a	LCM-2R	--	R	1	FCW-4a	LCM-0	LCM-2	None
06-FCW-4A	3-LCM-2R	2-LDW-R	LDWR	LDWR	LCM2	None										
06-FCW-4A	3-LCM-2R	3-LDW-L	LDWL	LDWL	LCM2	None										
06-FCW-4A	3-LCM-2R	4-LDW-X	FCW4	Fault	LCM2	None										

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
06-FCW-4A	4-LCM-3R	1-LDW-0	FCW4	LCMR	LCM2	None										
06-FCW-4A	4-LCM-3R	2-LDW-R	LDWR	LCMR	LCM2	None	DIU, AUD	FCW-4a	LCM-3R	LDW-R	OFF	*9*	FCW-4a	LCM-0	LCM-3	LCM-3
06-FCW-4A	4-LCM-3R	3-LDW-L	LDWL	LCMR	LCM2	None										
06-FCW-4A	4-LCM-3R	4-LDW-X	FCW4	LCMR	LCM2	None	AUD	FCW-4a	LCM-3R	Unavail	OFF	1	FCW-4a	LCM-0	LCM-3	LCM-3R†
06-FCW-4A	5-LCM-1L	1-LDW-0	FCW4	None	None	LCM1	None	FCW-4a	LCM-1L	--	OFF	1	FCW-4a	LCM-1	LCM-0	None
06-FCW-4A	5-LCM-1L	2-LDW-R	LDWR	LDWR	None	LCM1	DIU	FCW-4a	LCM-1L	LDW-R	OFF	*14*	LDW-R	LCM-1	LCM-0	LDW-R
06-FCW-4A	5-LCM-1L	3-LDW-L	LDWL	LDWL	None	LCM1	DIU, AUD	FCW-4a	LCM-1L	LDW-L	OFF	*9,11*	FCW-4a	LCM-3*	LCM-0	LCM-3*
06-FCW-4A	5-LCM-1L	4-LDW-X	FCW4	Fault	None	LCM1	None	FCW-4a	LCM-1L	Unavail	OFF	1	FCW-4a	LCM-1	LCM-0	None
06-FCW-4A	6-LCM-2L	1-LDW-0	FCW4	None	None	LCM2	None	FCW-4a	LCM-2L	--	L	1	FCW-4a	LCM-2	LCM-0	None
06-FCW-4A	6-LCM-2L	2-LDW-R	LDWR	LDWR	None	LCM2										
06-FCW-4A	6-LCM-2L	3-LDW-L	LDWL	LDWL	None	LCM2										
06-FCW-4A	6-LCM-2L	4-LDW-X	FCW4	Fault	None	LCM2										
06-FCW-4A	7-LCM-3L	1-LDW-0	FCW4	LCML	None	LCM2										
06-FCW-4A	7-LCM-3L	2-LDW-R	LDWR	LCML	None	LCM2										
06-FCW-4A	7-LCM-3L	3-LDW-L	LDWL	LCML	None	LCM2	DIU, AUD	FCW-4a	LCM-3L	LDW-L	OFF	*9*	FCW-4a	LCM-3	LCM-0	LCM-3
06-FCW-4A	7-LCM-3L	4-LDW-X	FCW4	LCML	None	LCM2	None	FCW-4a	LCM-3L	Unavail	OFF	1	FCW-4a	LCM-3	LCM-0	LCM-3L†
06-FCW-4A	8-LCM-X2	1-LDW-0	LCX2	Fault	None	None	DIU	FCW-4a	LCM-X2 R/L	--	L, R, OFF	2c	LCM-X2	None	None	LCM-X2
06-FCW-4A	8-LCM-X2	2-LDW-R	LCX2	Fault	None	None										
06-FCW-4A	8-LCM-X2	3-LDW-L	LCX2	Fault	None	None										
06-FCW-4A	8-LCM-X2	4-LDW-X	LCX2	Fault	None	None										
06-FCW-4A	9-LCM-1LR	1-LDW-0	FCW4	None	LCM1	LCM1										
06-FCW-4A	9-LCM-1LR	2-LDW-R	LDWR	LDWR	LCM1	LCM1										
06-FCW-4A	9-LCM-1LR	3-LDW-L	LDWL	LDWL	LCM1	LCM1										
06-FCW-4A	9-LCM-1LR	4-LDW-X	FCW4	Fault	LCM1	LCM1										
07-FCW-4B	1-LCM-0	1-LDW-0	FCW4	FC4B	None	None	None	FCW-4b	LCM-0 R/L	--	L, R, OFF	1	FCW-4b	LCM-0	LCM-0	FCW-4b
07-FCW-4B	1-LCM-0	2-LDW-R	FCW4	FC4B	None	None	DIU, AUD	FCW-4b	LCM-0 R/L	LDW-R	OFF	*6,7*	FCW-4b	LCM-0	LCM-0	FCW-4b
07-FCW-4B	1-LCM-0	3-LDW-L	FCW4	FC4B	None	None	DIU, AUD	FCW-4b	LCM-0 R/L	LDW-L	OFF	*6,7*	FCW-4b	LCM-0	LCM-0	FCW-4b
07-FCW-4B	1-LCM-0	4-LDW-X	FCW4	FC4B	None	None										

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
07-FCW-4B	2-LCM-1R	1-LDW-0	FCW4	FC4B	LCM1	None	None	FCW-4b	LCM-1R	--	OFF	1	FCW-4b	LCM-0	LCM-1	FCW-4b
07-FCW-4B	2-LCM-1R	2-LDW-R	FCW4	FC4B	LCM1	None	DIU, AUD	FCW-4b	LCM-1R	LDW-R	OFF	*5a,9,11*	FCW-4b	LCM-0	LCM-3*	LCM-3*
07-FCW-4B	2-LCM-1R	3-LDW-L	FCW4	FC4B	LCM1	None	DIU, AUD	FCW-4b	LCM-1R	LDW-L	OFF	*6,7*	FCW-4b	LCM-0	LCM-1	FCW-4b
07-FCW-4B	2-LCM-1R	4-LDW-X	FCW4	FC4B	LCM1	None	None	FCW-4b	LCM-1R	Unavail	OFF	1	FCW-4b	LCM-0	LCM-1	FCW-4b
07-FCW-4B	3-LCM-2R	1-LDW-0	FCW4	FC4B	LCM2	None	None	FCW-4b	LCM-2R	--	R	1	FCW-4b	LCM-0	LCM-2	FCW-4b
07-FCW-4B	3-LCM-2R	2-LDW-R	FCW4	FC4B	LCM2	None										
07-FCW-4B	3-LCM-2R	3-LDW-L	FCW4	FC4B	LCM2	None										
07-FCW-4B	3-LCM-2R	4-LDW-X	FCW4	FC4B	LCM2	None										
07-FCW-4B	4-LCM-3R	1-LDW-0	FCW4	LCMR	LCM2	None										
07-FCW-4B	4-LCM-3R	2-LDW-R	FCW4	LCMR	LCM2	None	DIU, AUD	FCW-4b	LCM-3R	LDW-R	OFF	*5a,9*	FCW-4b	LCM-0	LCM-3	LCM-3
07-FCW-4B	4-LCM-3R	3-LDW-L	FCW4	LCMR	LCM2	None										
07-FCW-4B	4-LCM-3R	4-LDW-X	FCW4	LCMR	LCM2	None	AUD	FCW-4b	LCM-3R	Unavail	OFF	5	FCW-4b	LCM-0	LCM-3	LCM-3R[†]
07-FCW-4B	5-LCM-1L	1-LDW-0	FCW4	FC4B	None	LCM1	None	FCW-4b	LCM-1L	--	OFF	1	FCW-4b	LCM-1	LCM-0	FCW-4b
07-FCW-4B	5-LCM-1L	2-LDW-R	FCW4	FC4B	None	LCM1	DIU, AUD	FCW-4b	LCM-1L	LDW-R	OFF	*6,7*	FCW-4b	LCM-1	LCM-0	FCW-4b
07-FCW-4B	5-LCM-1L	3-LDW-L	FCW4	FC4B	None	LCM1	DIU, AUD	FCW-4b	LCM-1L	LDW-L	OFF	*5a, 9,11*	FCW-4b	LCM-3*	LCM-0	LCM-3*
07-FCW-4B	5-LCM-1L	4-LDW-X	FCW4	FC4B	None	LCM1	None	FCW-4b	LCM-1L	Unavail	OFF	1	FCW-4b	LCM-1	LCM-0	FCW-4b
07-FCW-4B	6-LCM-2L	1-LDW-0	FCW4	FC4B	None	LCM2	None	FCW-4b	LCM-2L	--	L	1	FCW-4b	LCM-2	LCM-0	FCW-4b
07-FCW-4B	6-LCM-2L	2-LDW-R	FCW4	FC4B	None	LCM2										
07-FCW-4B	6-LCM-2L	3-LDW-L	FCW4	FC4B	None	LCM2										
07-FCW-4B	6-LCM-2L	4-LDW-X	FCW4	FC4B	None	LCM2										
07-FCW-4B	7-LCM-3L	1-LDW-0	FCW4	LCML	None	LCM2										
07-FCW-4B	7-LCM-3L	2-LDW-R	FCW4	LCML	None	LCM2										
07-FCW-4B	7-LCM-3L	3-LDW-L	FCW4	LCML	None	LCM2	DIU, AUD	FCW-4b	LCM-3L	LDW-L	OFF	*5a,9*	FCW-4b	LCM-3	LCM-0	LCM-3
07-FCW-4B	7-LCM-3L	4-LDW-X	FCW4	LCML	None	LCM2	AUD	FCW-4b	LCM-3L	Unavail	OFF	5a	FCW-4b	LCM-3	LCM-0	LCM-3L[†]
07-FCW-4B	8-LCM-X2	1-LDW-0	LCX2	Fault	None	None	DIU, AUD	FCW-4b	LCM-X2 R/L	--	L, R, OFF	2c	LCM-X2	None	None	LCM-X2
07-FCW-4B	8-LCM-X2	2-LDW-R	LCX2	Fault	None	None										
07-FCW-4B	8-LCM-X2	3-LDW-L	LCX2	Fault	None	None										
07-FCW-4B	8-LCM-X2	4-LDW-X	LCX2	Fault	None	None										

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
07-FCW-4B	9-LCM-1LR	1-LDW-0	FCW4	FC4B	LCM1	LCM1										
07-FCW-4B	9-LCM-1LR	2-LDW-R	FCW4	FC4B	LCM1	LCM1										
07-FCW-4B	9-LCM-1LR	3-LDW-L	FCW4	FC4B	LCM1	LCM1										
07-FCW-4B	9-LCM-1LR	4-LDW-X	FCW4	FC4B	LCM1	LCM1										
08-FCW-5	1-LCM-0	1-LDW-0	FCW5	FCW5	None	None	None	FCW-5	LCM-0 R/L	--	L, R, OFF	1	FCW-5	LCM-0	LCM-0	FCW-5
08-FCW-5	1-LCM-0	2-LDW-R	FCW5	FCW5	None	None	DIU, AUD	FCW-5	LCM-0 R/L	LDW-R	OFF	*3*	FCW-5	LCM-0	LCM-0	FCW-5
08-FCW-5	1-LCM-0	3-LDW-L	FCW5	FCW5	None	None	DIU, AUD	FCW-5	LCM-0 R/L	LDW-L	OFF	*3*	FCW-5	LCM-0	LCM-0	FCW-5
08-FCW-5	1-LCM-0	4-LDW-X	FCW5	FCW5	None	None										
08-FCW-5	2-LCM-1R	1-LDW-0	FCW5	FCW5	LCM1	None	None	FCW-5	LCM-1R	--	OFF	1	FCW-5	LCM-0	LCM-1	FCW-5
08-FCW-5	2-LCM-1R	2-LDW-R	FCW5	FCW5	LCM1	None	DIU, AUD	FCW-5	LCM-1R	LDW-R	OFF	*3,8*	FCW-5	LCM-0	LCM-3*	FCW-5
08-FCW-5	2-LCM-1R	3-LDW-L	FCW5	FCW5	LCM1	None	DIU, AUD	FCW-5	LCM-1R	LDW-L	OFF	*3*	FCW-5	LCM-0	LCM-1	FCW-5
08-FCW-5	2-LCM-1R	4-LDW-X	FCW5	FCW5	LCM1	None	None	FCW-5	LCM-1R	Unavail	OFF	1	FCW-5	LCM-0	LCM-1	FCW-5
08-FCW-5	3-LCM-2R	1-LDW-0	FCW5	FCW5	LCM2	None	None	FCW-5	LCM-2R	--	R	1	FCW-5	LCM-0	LCM-2	FCW-5
08-FCW-5	3-LCM-2R	2-LDW-R	FCW5	FCW5	LCM2	None										
08-FCW-5	3-LCM-2R	3-LDW-L	FCW5	FCW5	LCM2	None										
08-FCW-5	3-LCM-2R	4-LDW-X	FCW5	FCW5	LCM2	None										
08-FCW-5	4-LCM-3R	1-LDW-0	FCW5	FCW5	LCM2	None										
08-FCW-5	4-LCM-3R	2-LDW-R	FCW5	FCW5	LCM2	None	DIU, AUD	FCW-5	LCM-3R	LDW-R	OFF	*3,8*	FCW-5	LCM-0	LCM-3	FCW-5
08-FCW-5	4-LCM-3R	3-LDW-L	FCW5	FCW5	LCM2	None										
08-FCW-5	4-LCM-3R	4-LDW-X	FCW5	FCW5	LCM2	None	AUD	FCW-5	LCM-3R	Unavail	OFF	8	FCW-5	LCM-0	LCM-3	FCW-5[†]
08-FCW-5	5-LCM-1L	1-LDW-0	FCW5	FCW5	None	LCM1	None	FCW-5	LCM-1L	--	OFF	1	FCW-5	LCM-1	LCM-0	FCW-5
08-FCW-5	5-LCM-1L	2-LDW-R	FCW5	FCW5	None	LCM1	DIU, AUD	FCW-5	LCM-1L	LDW-R	OFF	*3*	FCW-5	LCM-1	LCM-0	FCW-5
08-FCW-5	5-LCM-1L	3-LDW-L	FCW5	FCW5	None	LCM1	DIU, AUD	FCW-5	LCM-1L	LDW-L	OFF	*3,8*	FCW-5	LCM-3*	LCM-0	FCW-5
08-FCW-5	5-LCM-1L	4-LDW-X	FCW5	FCW5	None	LCM1										
08-FCW-5	6-LCM-2L	1-LDW-0	FCW5	FCW5	None	LCM2	None	FCW-5	LCM-2L	--	L	1	FCW-5	LCM-2	LCM-0	FCW-5
08-FCW-5	6-LCM-2L	2-LDW-R	FCW5	FCW5	None	LCM2										
08-FCW-5	6-LCM-2L	3-LDW-L	FCW5	FCW5	None	LCM2										
08-FCW-5	6-LCM-2L	4-LDW-X	FCW5	FCW5	None	LCM2										

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
08-FCW-5	7-LCM-3L	1-LDW-0	FCW5	FCW5	None	LCM2	None	FCW-5	LCM-1L	Unavail	OFF	1	FCW-5	LCM-1	LCM-0	FCW-5
08-FCW-5	7-LCM-3L	2-LDW-R	FCW5	FCW5	None	LCM2										
08-FCW-5	7-LCM-3L	3-LDW-L	FCW5	FCW5	None	LCM2	DIU, AUD	FCW-5	LCM-3L	LDW-L	OFF	*3,8*	FCW-5	LCM-3	LCM-0	FCW-5
08-FCW-5	7-LCM-3L	4-LDW-X	FCW5	FCW5	None	LCM2	AUD	FCW-5	LCM-3L	Unavail	OFF	8	FCW-5	LCM-3	LCM-0	FCW-5[†]
08-FCW-5	8-LCM-X2	1-LDW-0	FCW5	FCW5	None	None	DIU	FCW-5	LCM-X2 R/L	--	L, R, OFF	2	FCW-5	None	None	FCW-5
08-FCW-5	8-LCM-X2	2-LDW-R	FCW5	FCW5	None	None										
08-FCW-5	8-LCM-X2	3-LDW-L	FCW5	FCW5	None	None										
08-FCW-5	8-LCM-X2	4-LDW-X	FCW5	FCW5	None	None										
08-FCW-5	9-LCM-1LR	1-LDW-0	FCW5	FCW5	LCM1	LCM1										
08-FCW-5	9-LCM-1LR	2-LDW-R	FCW5	FCW5	LCM1	LCM1										
08-FCW-5	9-LCM-1LR	3-LDW-L	FCW5	FCW5	LCM1	LCM1										
08-FCW-5	9-LCM-1LR	4-LDW-X	FCW5	FCW5	LCM1	LCM1										
09-FCW-6	1-LCM-0	1-LDW-0	FCW5	FCW5	None	None	None	FCW-6	LCM-0 R/L	--	L, R, OFF	1	FCW-6	LCM-0	LCM-0	FCW-6
09-FCW-6	1-LCM-0	2-LDW-R	FCW5	FCW5	None	None	DIU, AUD	FCW-6	LCM-0 R/L	LDW-R	OFF	*3*	FCW-6	LCM-0	LCM-0	FCW-6
09-FCW-6	1-LCM-0	3-LDW-L	FCW5	FCW5	None	None	DIU, AUD	FCW-6	LCM-0 R/L	LDW-L	OFF	*3*	FCW-6	LCM-0	LCM-0	FCW-6
09-FCW-6	1-LCM-0	4-LDW-X	FCW5	FCW5	None	None										
09-FCW-6	2-LCM-1R	1-LDW-0	FCW5	FCW5	LCM1	None	None	FCW-6	LCM-1R	--	OFF	1	FCW-6	LCM-0	LCM-1	FCW-6
09-FCW-6	2-LCM-1R	2-LDW-R	FCW5	FCW5	LCM1	None	DIU, AUD	FCW-6	LCM-1R	LDW-R	OFF	*3,8*	FCW-6	LCM-0	LCM-3*	FCW-6
09-FCW-6	2-LCM-1R	3-LDW-L	FCW5	FCW5	LCM1	None	DIU, AUD	FCW-6	LCM-1R	LDW-L	OFF	*3*	FCW-6	LCM-0	LCM-1	FCW-6
09-FCW-6	2-LCM-1R	4-LDW-X	FCW5	FCW5	LCM1	None	None	FCW-6	LCM-1R	Unavail	OFF	1	FCW-6	LCM-0	LCM-1	FCW-6
09-FCW-6	3-LCM-2R	1-LDW-0	FCW5	FCW5	LCM2	None	None	FCW-6	LCM-2R	--	R	1	FCW-6	LCM-0	LCM-2	FCW-6
09-FCW-6	3-LCM-2R	2-LDW-R	FCW5	FCW5	LCM2	None										
09-FCW-6	3-LCM-2R	3-LDW-L	FCW5	FCW5	LCM2	None										
09-FCW-6	3-LCM-2R	4-LDW-X	FCW5	FCW5	LCM2	None										
09-FCW-6	4-LCM-3R	1-LDW-0	FCW5	FCW5	LCM2	None										
09-FCW-6	4-LCM-3R	2-LDW-R	FCW5	FCW5	LCM2	None	DIU, AUD	FCW-6	LCM-3R	LDW-R	OFF	*3,8*	FCW-6	LCM-0	LCM-3	FCW-6
09-FCW-6	4-LCM-3R	3-LDW-L	FCW5	FCW5	LCM2	None										
09-FCW-6	4-LCM-3R	4-LDW-X	FCW5	FCW5	LCM2	None	AUD	FCW-6	LCM-3R	Unavail	OFF	8	FCW-6	LCM-0	LCM-3	FCW-6[†]

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
09-FCW-6	5-LCM-1L	1-LDW-0	FCW5	FCW5	None	LCM1	None	FCW-6	LCM-1L	--	OFF	1	FCW-6	LCM-1	LCM-0	FCW-6
09-FCW-6	5-LCM-1L	2-LDW-R	FCW5	FCW5	None	LCM1	DIU, AUD	FCW-6	LCM-1L	LDW-R	OFF	*3*	FCW-6	LCM-1	LCM-0	FCW-6
09-FCW-6	5-LCM-1L	3-LDW-L	FCW5	FCW5	None	LCM1	DIU, AUD	FCW-6	LCM-1L	LDW-L	OFF	*3,8*	FCW-6	LCM-3*	LCM-0	FCW-6
09-FCW-6	5-LCM-1L	4-LDW-X	FCW5	FCW5	None	LCM1	None	FCW-6	LCM-1L	Unavail	OFF	1	FCW-6	LCM-1	LCM-0	FCW-6
09-FCW-6	6-LCM-2L	1-LDW-0	FCW5	FCW5	None	LCM2	None	FCW-6	LCM-2L	--	L	1	FCW-6	LCM-2	LCM-0	FCW-6
09-FCW-6	6-LCM-2L	2-LDW-R	FCW5	FCW5	None	LCM2										
09-FCW-6	6-LCM-2L	3-LDW-L	FCW5	FCW5	None	LCM2										
09-FCW-6	6-LCM-2L	4-LDW-X	FCW5	FCW5	None	LCM2										
09-FCW-6	7-LCM-3L	1-LDW-0	FCW5	FCW5	None	LCM2										
09-FCW-6	7-LCM-3L	2-LDW-R	FCW5	FCW5	None	LCM2										
09-FCW-6	7-LCM-3L	3-LDW-L	FCW5	FCW5	None	LCM2	DIU, AUD	FCW-6	LCM-3L	LDW-L	OFF	*3,8*	FCW-6	LCM-3	LCM-0	FCW-6
09-FCW-6	7-LCM-3L	4-LDW-X	FCW5	FCW5	None	LCM2	AUD	FCW-6	LCM-3L	Unavail	OFF	8	FCW-6	LCM-3	LCM-0	FCW-6[†]
09-FCW-6	8-LCM-X2	1-LDW-0	FCW5	FCW5	None	None	DIU	FCW-6	LCM-X2 R/L	--	L, R, OFF	2	FCW-6	None	None	FCW-6
09-FCW-6	8-LCM-X2	2-LDW-R	FCW5	FCW5	None	None										
09-FCW-6	8-LCM-X2	3-LDW-L	FCW5	FCW5	None	None										
09-FCW-6	8-LCM-X2	4-LDW-X	FCW5	FCW5	None	None										
09-FCW-6	9-LCM-1LR	1-LDW-0	FCW5	FCW5	LCM1	LCM1										
09-FCW-6	9-LCM-1LR	2-LDW-R	FCW5	FCW5	LCM1	LCM1										
09-FCW-6	9-LCM-1LR	3-LDW-L	FCW5	FCW5	LCM1	LCM1										
09-FCW-6	9-LCM-1LR	4-LDW-X	FCW5	FCW5	LCM1	LCM1										
10-FCW-7	1-LCM-0	1-LDW-0	FCW5	FCW5	None	None	None	FCW-7	LCM-0 R/L	--	L, R, OFF	1	FCW-7	LCM-0	LCM-0	FCW-7
10-FCW-7	1-LCM-0	2-LDW-R	FCW5	FCW5	None	None	DIU, AUD	FCW-7	LCM-0 R/L	LDW-R	OFF	*3*	FCW-7	LCM-0	LCM-0	FCW-7
10-FCW-7	1-LCM-0	3-LDW-L	FCW5	FCW5	None	None	DIU, AUD	FCW-7	LCM-0 R/L	LDW-L	OFF	*3*	FCW-7	LCM-0	LCM-0	FCW-7
10-FCW-7	1-LCM-0	4-LDW-X	FCW5	FCW5	None	None										
10-FCW-7	2-LCM-1R	1-LDW-0	FCW5	FCW5	LCM1	None	None	FCW-7	LCM-1R	--	OFF	1	FCW-7	LCM-0	LCM-1	FCW-7
10-FCW-7	2-LCM-1R	2-LDW-R	FCW5	FCW5	LCM1	None	DIU, AUD	FCW-7	LCM-1R	LDW-R	OFF	*3,8*	FCW-7	LCM-0	LCM-3*	FCW-7
10-FCW-7	2-LCM-1R	3-LDW-L	FCW5	FCW5	LCM1	None	DIU, AUD	FCW-7	LCM-1R	LDW-L	OFF	*3*	FCW-7	LCM-0	LCM-1	FCW-7
10-FCW-7	2-LCM-1R	4-LDW-X	FCW5	FCW5	LCM1	None	None	FCW-7	LCM-1R	Unavail	OFF	1	FCW-7	LCM-0	LCM-1	FCW-7

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
10-FCW-7	3-LCM-2R	1-LDW-0	FCW5	FCW5	LCM2	None	None	FCW-7	LCM-2R	--	R	1	FCW-7	LCM-0	LCM-2	FCW-7
10-FCW-7	3-LCM-2R	2-LDW-R	FCW5	FCW5	LCM2	None										
10-FCW-7	3-LCM-2R	3-LDW-L	FCW5	FCW5	LCM2	None										
10-FCW-7	3-LCM-2R	4-LDW-X	FCW5	FCW5	LCM2	None										
10-FCW-7	4-LCM-3R	1-LDW-0	FCW5	FCW5	LCM2	None										
10-FCW-7	4-LCM-3R	2-LDW-R	FCW5	FCW5	LCM2	None	DIU, AUD	FCW-7	LCM-3R	LDW-R	OFF	*3,8*	FCW-7	LCM-0	LCM-3	FCW-7
10-FCW-7	4-LCM-3R	3-LDW-L	FCW5	FCW5	LCM2	None										
10-FCW-7	4-LCM-3R	4-LDW-X	FCW5	FCW5	LCM2	None	AUD	FCW-7	LCM-3R	Unavail	OFF	8	FCW-7	LCM-0	LCM-3	FCW-7[†]
10-FCW-7	5-LCM-1L	1-LDW-0	FCW5	FCW5	None	LCM1	None	FCW-7	LCM-1L	--	OFF	1	FCW-7	LCM-1	LCM-0	FCW-6
10-FCW-7	5-LCM-1L	2-LDW-R	FCW5	FCW5	None	LCM1	DIU, AUD	FCW-7	LCM-1L	LDW-R	OFF	*3*	FCW-7	LCM-1	LCM-0	FCW-6
10-FCW-7	5-LCM-1L	3-LDW-L	FCW5	FCW5	None	LCM1	DIU, AUD	FCW-7	LCM-1L	LDW-L	OFF	*3,8*	FCW-7	LCM-3*	LCM-0	FCW-7
10-FCW-7	5-LCM-1L	4-LDW-X	FCW5	FCW5	None	LCM1	None	FCW-7	LCM-1L	Unavail	OFF	1	FCW-7	LCM-1	LCM-0	FCW-7
10-FCW-7	6-LCM-2L	1-LDW-0	FCW5	FCW5	None	LCM2	None	FCW-7	LCM-2L	--	L	1	FCW-7	LCM-2	LCM-0	FCW-7
10-FCW-7	6-LCM-2L	2-LDW-R	FCW5	FCW5	None	LCM2										
10-FCW-7	6-LCM-2L	3-LDW-L	FCW5	FCW5	None	LCM2										
10-FCW-7	6-LCM-2L	4-LDW-X	FCW5	FCW5	None	LCM2										
10-FCW-7	7-LCM-3L	1-LDW-0	FCW5	FCW5	None	LCM2										
10-FCW-7	7-LCM-3L	2-LDW-R	FCW5	FCW5	None	LCM2										
10-FCW-7	7-LCM-3L	3-LDW-L	FCW5	FCW5	None	LCM2	DIU, AUD	FCW-7	LCM-3L	LDW-L	OFF	*3,8*	FCW-7	LCM-3	LCM-0	FCW-7
10-FCW-7	7-LCM-3L	4-LDW-X	FCW5	FCW5	None	LCM2	AUD	FCW-7	LCM-3L	Unavail	OFF	8	FCW-7	LCM-3	LCM-0	FCW-7[†]
10-FCW-7	8-LCM-X2	1-LDW-0	FCW5	FCW5	None	None	DIU	FCW-7	LCM-X2 R/L	--	L, R, OFF	2	FCW-7	None	None	FCW-7
10-FCW-7	8-LCM-X2	2-LDW-R	FCW5	FCW5	None	None										
10-FCW-7	8-LCM-X2	3-LDW-L	FCW5	FCW5	None	None										
10-FCW-7	8-LCM-X2	4-LDW-X	FCW5	FCW5	None	None										
10-FCW-7	9-LCM-1LR	1-LDW-0	FCW5	FCW5	LCM1	LCM1										
10-FCW-7	9-LCM-1LR	2-LDW-R	FCW5	FCW5	LCM1	LCM1										
10-FCW-7	9-LCM-1LR	3-LDW-L	FCW5	FCW5	LCM1	LCM1										
10-FCW-7	9-LCM-1LR	4-LDW-X	FCW5	FCW5	LCM1	LCM1										

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
11-FCW-X	1-LCM-0	1-LDW-0	FCWX	Fault	None	None										
11-FCW-X	1-LCM-0	2-LDW-R	LDWR	LDWR	None	None										
11-FCW-X	1-LCM-0	3-LDW-L	LDWL	LDWL	None	None										
11-FCW-X	1-LCM-0	4-LDW-X	FCWX	Fault	None	None										
11-FCW-X	2-LCM-1R	1-LDW-0	FCWX	Fault	LCM1	None										
11-FCW-X	2-LCM-1R	2-LDW-R	LDWR	LDWR	LCM1	None										
11-FCW-X	2-LCM-1R	3-LDW-L	LDWL	LDWL	LCM1	None										
11-FCW-X	2-LCM-1R	4-LDW-X	FCWX	Fault	LCM1	None										
11-FCW-X	3-LCM-2R	1-LDW-0	FCWX	Fault	LCM2	None										
11-FCW-X	3-LCM-2R	2-LDW-R	LDWR	LDWR	LCM2	None										
11-FCW-X	3-LCM-2R	3-LDW-L	LDWL	LDWL	LCM2	None										
11-FCW-X	3-LCM-2R	4-LDW-X	FCWX	Fault	LCM2	None										
11-FCW-X	4-LCM-3R	1-LDW-0	FCWX	LCMR	LCM2	None										
11-FCW-X	4-LCM-3R	2-LDW-R	LDWR	LCMR	LCM2	None										
11-FCW-X	4-LCM-3R	3-LDW-L	LDWL	LCMR	LCM2	None										
11-FCW-X	4-LCM-3R	4-LDW-X	FCWX	LCMR	LCM2	None										
11-FCW-X	5-LCM-1L	1-LDW-0	FCWX	Fault	None	LCM1										
11-FCW-X	5-LCM-1L	2-LDW-R	LDWR	LDWR	None	LCM1										
11-FCW-X	5-LCM-1L	3-LDW-L	LDWL	LDWL	None	LCM1										
11-FCW-X	5-LCM-1L	4-LDW-X	FCWX	Fault	None	LCM1										
11-FCW-X	6-LCM-2L	1-LDW-0	FCWX	Fault	None	LCM2										
11-FCW-X	6-LCM-2L	2-LDW-R	LDWR	LDWR	None	LCM2										
11-FCW-X	6-LCM-2L	3-LDW-L	LDWL	LDWL	None	LCM2										
11-FCW-X	6-LCM-2L	4-LDW-X	FCWX	Fault	None	LCM2										
11-FCW-X	7-LCM-3L	1-LDW-0	FCWX	LCML	None	LCM2										
11-FCW-X	7-LCM-3L	2-LDW-R	LDWR	LCML	None	LCM2										
11-FCW-X	7-LCM-3L	3-LDW-L	LDWL	LCML	None	LCM2										
11-FCW-X	7-LCM-3L	4-LDW-X	FCWX	LCML	None	LCM2										

Input			Output				Conflict Source	Sensor Inputs				Rule	Display Outputs			
FCW	LCM	LDW	DIU	Aud	RSD	LSD		Subsystem Alerts			Turn Signal		DIU Visual Display	Left SSD Visual Display	Right SSD Visual Display	Auditory Display
11-FCW-X	8-LCM-X2	1-LDW-0	LCX2	Fault	None	None										
11-FCW-X	8-LCM-X2	2-LDW-R	LCX2	Fault	None	None										
11-FCW-X	8-LCM-X2	3-LDW-L	LCX2	Fault	None	None										
11-FCW-X	8-LCM-X2	4-LDW-X	LCX2	Fault	None	None										
11-FCW-X	9-LCM-1LR	1-LDW-0	FCWX	Fault	LCM1	LCM1										
11-FCW-X	9-LCM-1LR	2-LDW-R	LDWR	LDWR	LCM1	LCM1										
11-FCW-X	9-LCM-1LR	3-LDW-L	LDWL	LDWL	LCM1	LCM1										
11-FCW-X	9-LCM-1LR	4-LDW-X	FCWX	Fault	LCM1	LCM1										

^ There is no conflict involving an LDW display because the LDW is suppressed by the turn signal activation.

* LCM-3 is the most appropriate warning, even though a turn signal is not activated, because the sensor data indicate that it is the same as an LCM-3 situation. It is unclear whether this sensor combination is even possible, given the definition of the LCM-3 alarm, however, it is included for completeness.

The assumption here is that the FCW-1 display appears before the LCM-3 conditions, otherwise the FCW-1 display would also be suppressed as per rule 12.

† It is unclear if this permutation is possible with the LDW unavailable (can the LCM system still throw an LCM-3?).