FINAL REPORT

Evaluating Forward Crash Warning on the NADS for CWIM

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<td>ACWS</td>
<td>Advanced Crash Warning Systems</td>
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<td>AMTCC</td>
<td>Adjusted Minimum Time-To-Collision</td>
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<td>CIB</td>
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<td>Statement of Work</td>
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UI       The University of Iowa
USDOT   United States Department of Transportation
TOM     Task Order Manager
VRTC    Vehicle Research Test Center
1 EXECUTIVE SUMMARY

NHTSA has initiated the Crash Warning Interface Metrics (CWIM) program to develop a set of standard metric and test procedures to assess the Driver-Vehicle Interface (DVI) of Advanced Crash Warning Systems (ACWS). This document reports the work done by the National Advanced Driving Simulator (NADS). The NADS study closely mirrors test track work that has been done on ACWS at the Vehicle Research and Test Center (VRTC).

Of interest in this study were two types of ACWS for the detection of potential forward collisions. Passive warnings issue visual, auditory, and/or haptic stimuli to call a driver’s attention to a conflict, and are referred to as forward collision warnings (FCW) in this report. Active warnings provide some degree of automatic control of a vehicle’s behavior through steering or braking and are usually accompanied by a passive warning. This type of warning is referred to as a forward collision countermeasure (FCC) in this report.

These studies compare the relative effectiveness and acceptability of active and passive warnings for distracted drivers. The goals of this study were: 1) to understand driver response to forward collision warnings and countermeasures when the driver’s vehicle encounters a rear-end crash threat from a decelerating or stopped vehicle in its path, and 2) to make initial recommendations for a confirmation test protocol that can apply to both passive and active forward collision warnings, including metrics, rating scale, and pass-fail criteria.

A total of 48 participants were included in the study, eight of which comprised a pilot study. Independent variables were the system type (FCW, FCC, baseline), and gender (male, female).

Scenarios were adapted from the CWIM, Part 2, Task 5 Research Plan for NADS Study of Active and Passive Lane Departure Warning Systems (Contract ID# DTNH22-05-D-01002, Task Order #15). The three simulated events were a decelerating lead vehicle, a stopped lead vehicle, and a false alarm event. The last consisted of a stopped vehicle that was not actually in the driver’s lane of traffic.

The passive FCW utilized an audio alert (pulsing tone) from a Mercedes E350 and a visual alert (flashing LED strip) from a Volvo S80. The active FCC consisted of a brake pulse that decelerated the car momentarily at a level of approximately 0.22 G. There was no visual or auditory component to the FCC alert.

Several metrics were utilized to rate the systems under study using the developed protocol. Several metrics were developed that would require only the instrumentation of the vehicle to collect. The only failure criterion in this protocol was the occurrence of collisions; however, since all metrics but collisions are continuous in nature, they may be used to rate the systems on a continuous scale.

The limitations in the study were mainly due to its small size. Other FCW alert modalities, such as haptic systems that use the seat belt tensioner, were not included in the treatments. Additionally, the modalities were studied independently. In reality, each
warning is a piece of a larger alert scheme that may include audio/visual, haptic, and active alerts occurring at differing stages from early to collision-imminent.

Overall, the protocol was effective at getting the drivers’ attention off of the road long enough to initiate a forward collision event. Although both warning conditions produced a faster response, the brake pulse appeared to produce a more rapid response that resulted in a lower peak deceleration with equivalent safety outcomes.

It is recommended that design guidelines consider not only system performance but also driver preference. When nuisance warnings are likely to occur, greater weight should be given to driver acceptance; however, for imminent warnings driver acceptance may not align with optimal response to a crash situation. Design guidelines should also consider how false or nuisance alarms will impact the driver and the potential for secondary crashes. Even with two systems tested in this study, there were subtle differences in how drivers responded to warnings to null events that could result in unexpected crashes if the driver responds abruptly to an absent threat.
2 INTRODUCTION

NHTSA has initiated the Crash Warning Interface Metrics (CWIM) program to develop a set of standard metric and test procedures to assess the Driver-Vehicle Interface (DVI) of Advanced Crash Warning Systems (ACWS). This document reports the work the NADS has done in response to the Statement of Work (SOW) described in NHTSA’s “Evaluating Forward Crash Warning on the NADS for CWIM.” The experimental plan is documented, and results and conclusions are presented. The NADS study closely mirrors test track work that has been done on ACWS at the Vehicle Research and Test Center (VRTC).

2.1 Terminology

Today’s vehicles increasingly provide advanced technologies to alert drivers about emerging hazardous situations. These technologies are referred to as Advanced Crash Warning Systems (ACWS). Among these ACWS are those that detect when the vehicle is about to collide with the vehicle in front of it. Such systems are the focus of this research study.

The project also distinguishes two broad categories of forward collision systems, here termed “active” and “passive.” Consistent with the project’s SOW, we are using the terms “active” and “passive” to distinguish systems that provide some direct control of the vehicle’s dynamic behavior (active) from those that provide only warnings to alert the driver (passive). We proceed from the following definitions:

- A passive warning is the issuing of visual, auditory, and/or haptic stimuli to call a driver’s attention to a conflict.
- For an active warning, there is automatic partial control of a vehicle’s behavior (e.g., direction, speed) through steering/braking; this is usually accompanied by a passive warning.

Per the SOW, the passive type of forward collision system is termed forward collision warning (FCW), while the active version of the system is referred to as forward collision countermeasure (FCC).

Other terminology has been used in the literature, such as collision warning system (CWS), in-vehicle collision avoidance warning system (IVCAWS), and rear end crash avoidance system (RECAS). Furthermore, individual manufacturers may use their own terminologies for FCW. For example, Acura uses the term collision mitigation braking system (CMBS), Mercedes’ system is called Pre-Safe, and Volvo uses collision warning with auto brake (CWAB). Forward collision warning systems are commonly paired with adaptive cruise control (ACC) systems, due to the common sensor and algorithm requirements.

For purposes of clarity, this document will specifically limit its terminology to the use of FCW to refer to passive collision warning systems, and FCC to refer to active collision warning systems. Where forward collision warning systems in general are discussed, no acronym has been used to avoid confusion.
3 RATIONALE

3.1 Research Objectives

The purpose of the work on forward collision countermeasures at the NADS has been to complement studies at the VRTC to provide results that support the creation of standards, such as NCAP protocols, using DVI metrics. These studies compare the relative effectiveness and acceptability of active and passive warnings for distracted drivers. Whereas passive warnings vary in modality, intensity, and characteristics related to their urgency, active warnings vary in the strength of the intervention and the extent to which autonomy is delegated to the vehicle. For example, some active warning systems may enhance the driver’s braking actions, whereas others brake autonomously. An objective of the present research is to develop metrics that permit evaluation of the relative effectiveness and acceptability of FCC that vary in these characteristics.

The goals of this study were: 1) to understand driver response to forward collision countermeasures when the driver’s vehicle encounters a rear-end crash threat from a decelerating or stopped vehicle in its path, and 2) to make initial recommendations for a confirmation test protocol that can apply to both passive and active forward collision counter measures, including metrics, rating scale, and pass-fail criteria.

Because of the unique demands of creating realistic forward collision events in a safe and repeatable manner, the study was conducted with the NADS. The NADS-1 driving simulator is one of the world’s most advanced driving simulators, with unique capabilities for recreating motion. It provides an ideal platform both for inducing subjectively convincing forward collision events and for replicating the dynamics of FCW and FCC systems.

Previous studies have documented the effectiveness of RECAS warnings (Lee, Reyes, McGehee, & Brown 2000; Lee, McGehee, Brown, & Reyes 2002), as well as pointing out that cognitive distractions are in fact comparable to structural distractions. This study will include both types of distraction tasks and include active countermeasures as an additional condition.

3.2 Research Questions

This effort seeks to understand the range of driver response to forward collision warnings within the context of two situations—a decelerating lead vehicle and a stopped lead vehicle—in order to create initial recommendations for a confirmation test protocol that applies to both passive and active forward collision warning systems, including metrics, rating scale, and pass-fail criteria.

Question 1: Do distracted drivers using a vehicle equipped with an FCW system or an FCC system respond to potential forward collisions differently than drivers using a vehicle that does not have a forward collision warning system?
With regard to their initial response to the warning or forward collision event?
With regard to collision avoidance?
With regard to inappropriate behaviors (i.e., acceleration, looking in the wrong direction, etc.)?

Question 2: Do distracted drivers with an FCC system respond to potential forward collisions more effectively than drivers with an FCW system?

With regard to their initial response to the warning or forward collision event?
With regard to collision avoidance?
With regard to inappropriate behaviors (i.e., acceleration, looking in the wrong direction, etc.)?

Question 3: After driving for a limited time in a vehicle with a forward collision warning system and experiencing some potential forward collision events, do drivers find the technology to be acceptable and helpful?

Is system acceptance higher for passive or active systems?
4 EXPERIMENTAL DESIGN

4.1 Forward Collision Systems

4.1.1 Algorithm

Previous studies have developed zone-based kinematic algorithms (Burgett, Carter, Miller, Najm, & Smith, 1998; McGehee, 1995; McGehee & Brown, 1998). The three zones are: Zone I, where the lead vehicle is stopped at the time of the warning; Zone II, where the lead vehicle stops before the following vehicle stops; and Zone III, where the following vehicle stops before the lead vehicle stops (Burgett et al., 1998). In Zones II and III, the equations assume that the vehicles are initially traveling at the same speed. Different algorithms apply for each of the three zones. Brown (Brown, Lee, & McGehee, 2001) concluded that the kinematics-based algorithm provided more intuitive and linear results than a similar algorithm based on time-to-collision.

A kinematics-based algorithm was used in a RECAS/ACC system developed by John Hopkins for NHTSA (Brunson, Kyle, Phamdo, & Prezioi, 2002). ACC functionality was handled by a separate mode of operation, and all alerts were inhibited when the subject vehicle (SV) velocity was less than 25 mph. Details about the algorithm are available in the report.

The details of OEM collision algorithms are not known; however, it was decided that the algorithm and warnings for the NADS study should resemble, as closely as possible, the systems tested at VRTC. The focus was also placed on early warnings, rather than on collision imminent warnings, because the available reaction time for the driver to avoid collision in the latter case is severely restricted.

In fact, the procedure at VRTC was to bypass some functionality of the OEM systems and trigger warnings using their own controller. The details of their implementation were arrived at after extensive testing of several OEM systems, and the NADS algorithm is based on the VRTC procedure.

Early warnings are issued when the time-to-collision \( (ttc) \) falls below a threshold of 3.5 seconds. Time to collision can be calculated from the kinematic equation

\[ ttc = \frac{-range}{\text{range rate}} \]

4.1.2 Warning Modes

The passive FCW utilized an audio alert from a Mercedes E350 and a visual alert from a Volvo S80. The audio alert is a beeping tone with a period of 400 ms, a 50% duty cycle, and a total length of four seconds. The visual alert is delivered through a heads-up display (HUD) LED light strip. The LED flashes with a pulse train of period 200 ms, 50% duty cycle, and total length of four seconds.

The active FCC consisted of a brake pulse that decelerated the car momentarily at a level of approximately 0.22 G. There was no visual or auditory component to the FCC alert. Once the alerts triggered, they followed their specified profile in time and expired.
naturally, as long as the alert conditions in the algorithm were no longer met. The profile of the brake pulse is shown in Figure 1.

![Brake Pulse Profile](image)

**Figure 1** FCC brake pulse profile

The FCC was implemented in the Simulink modeling environment. In fact, the entire NADSDyna brake subsystem was ported to Simulink, and then functionality was added for the brake pulse. This implementation allowed for faster and easier design and test iterations. A top-level diagram of the Simulink brake subsystem is shown in Figure 2 above.

![Simulink Implementation](image)

**Figure 2** Simulink implementation of brake subsystem
5 METHODOLOGY

This section discusses the driving scenarios and road environment, forward collision alert modes, and distraction tasks. It also provides an overview of the experimental design and protocol.

5.1 Driving Scenarios

Scenarios were adapted from the CWIM, Part 2. Task 5 Research Plan for NADS Study of Active and Passive Lane Departure Warning Systems (Contract ID# DTNH22-05-D-01002, Task Order #15). The roadway is a two-lane bidirectional rural highway with standard 3 m lanes and 1 m shoulders. This roadway type was representative of the most common roadway departure crash scenarios used for the LDW study (Najm et al., 2002). The roadway is suitable for the inclusion of braking events; however, it does not have built-in intersections or on/off ramps, which would have been ideal locations for stopped vehicles. Detailed scenario information is available in Appendix A.

5.1.1 Decelerating Lead Vehicle

The SV is following a lead vehicle traveling at constant speed between 45-60 mph when lead vehicle suddenly decelerates (in daylight, clear weather, on a straight and level road). This scenario represents 23.4% of rear-end crashes (Najm & Smith, 2007; Ference, Szabo, and Najm, 2007; Lee, Llaneras, Klauer, and Sudweeks, 2007).

5.1.2 Stopped Lead Vehicle

The SV is traveling at constant speed between 35-55 mph and encounters a stopped lead vehicle (in daylight, clear weather, on a straight and level road). This scenario represents 50.4% of rear-end crashes (Najm & Smith, 2007; Ference, Szabo, and Najm, 2007; Lee, Llaneras, Klauer, and Sudweeks, 2007)

5.1.3 False Warning

The SV encounters a construction zone with rerouted lane markings. A stopped construction vehicle is in the line of sight of the SV, but not in the path of the lane. The forward collision warning system, if present, will erroneously trigger a warning as the SV enters the construction zone.

5.2 Scenario Ordering

The order of the forward collision scenarios were varied independently with the forward collision warning system condition resulting in two simulator drives with two orders of
forward collision events, with the false alarm always presented as the final event (see Table 1).

Table 1 Driving scenario event orders

<table>
<thead>
<tr>
<th>Scenario Orders</th>
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<tbody>
<tr>
<td>Decelerating Lead Vehicle…</td>
</tr>
<tr>
<td>Stopped Lead Vehicle…</td>
</tr>
<tr>
<td>False Warning</td>
</tr>
<tr>
<td>Stopped Lead Vehicle…</td>
</tr>
<tr>
<td>Decelerating Lead Vehicle…</td>
</tr>
<tr>
<td>False Warning</td>
</tr>
</tbody>
</table>

5.3 Roadway Environment Database

The database is the same as that used in the CWIM-LDW experiment and was of sufficient length to allow for 35 minutes of driving at 35-60 mph. The roadway is a two-lane bidirectional rural highway with standard 3 m lanes and 1 m shoulders. Several straight road segments and curves exist in the database. The forward collision scenario events were placed on straight road segments of sufficient length and with appropriate posted speed for each event. The false alarm event occurred in the last straight road segment in both drive orders.

5.4 Forward Collision Alert Modes

The project utilized two types of forward collision systems. Details on the algorithm and warning modalities are given in Sections 4.1.1 and 4.1.2 above.

- FCW - a passive warning consisting of visual and auditory alerts to call a driver’s attention to a conflict. The interface to be used was based on the visual warning from the Volvo S80 and the audio warning from the Mercedes E350.
- FCC - an active warning consisting of automatic partial control of a vehicle’s behavior through braking. The specifications for the active system are based on a brake pulse with a duration of about 300 ms.

5.5 Distraction Tasks

To support this research, it was necessary to take the driver’s eyes off the road prior to the forward collision events. Although there are many distracters that can achieve this, it was necessary to choose a task that could reliably and repeatedly ensure that the driver’s eyes were off road for several seconds. Because drivers are able to use peripheral vision to monitor the roadway, it was essential that the driver’s gaze be directed well away from the forward view. It was also desired that the primary task be continuous so that when the driver removed his or her attention from the road, their attention would remain off the road until the forward collision event was triggered. A simulated insect task was developed to meet the needs of the project and was utilized as the primary distracter and tied to the planned forward collision events discussed in the scenario section.

This task requires that the participant turn and reach into the back seat to trace the path of the insect on a touch screen display. The insect buzzes to start the task and continues to
buzz until the participant successfully catches it. The insect is designed to ensure that it cannot be caught until the forward collision event has been triggered. The insect is designed in such a way as to provide variable lengths of the distracter task depending upon the needs of a particular scenario. The insect is controlled by an algorithm that moves it away from the participant’s finger in random directions at varying speeds.

Secondary distracter tasks include a trivia game task and a CD changing task. They are included to mask the importance of the planned forward collision events associated with the primary distracter task, the insect task. The secondary distracter tasks are not associated with planned forward collision events.

The trivia game task takes place on a touch screen mounted on the cab console with an interface that is instrumented so that screen touches are recorded into the raw data stream. This task involves the participant receiving an audio prompt that the task is about to begin. A second audio message contains the trivia question. The participant chooses an answer by touching the touch screen.

The radio task involves selecting a CD from a group of CDs stored in the cab, placing it in the radio, and then advancing it to a particular track before returning it to the storage location (on the driver’s overhead sun visor). The task is designed to last at least 10 seconds and to require several glances away from the roadway.
OVERVIEW OF STUDY

This section summarizes the general research design and procedure. Greater detail on specific aspects is in the sections that follow.

The basic experimental design is a factorial design with three factors: forward collision warning system, forward collision event scenario, and gender. The forward collision warning system is a between-groups variable. There were three forward collision warning conditions, so there were three groups of participants, each experiencing a different forward collision warning system condition:

1. FCW warning – passive visual and audio warning
2. FCC warning – active partial control of vehicle through braking
3. Control group – no forward collision warning system

The forward collision event scenario is a within-subjects variable, with three events:

1. Braking lead vehicle
2. Stopped lead vehicle
3. False warning

Thus each participant experienced the forward collision warning under three distinct scenarios.

For each forward collision event, data were recorded for a variety of dependent measures (discussed in Section 7.1 below). These included measures of initial vehicle control response, inappropriate responses, and lane recovery. After completion of the entire simulator drive, data were also collected on driver acceptance of the forward collision warning system and other subjective response measures.

The experimental session comprises five segments. These are:

1. Pre-familiarization with vehicle features. Participants received instructions and background information before entering the simulator, by watching a training presentation. This included exposure to either FCW or FCC, but also other display and control features (e.g., infotainment system) and vehicle cab aspects (e.g., seat design, seat belt). The point was to ensure familiarity with the ACWS alert without focusing participant attention specifically on crash warnings. Participants were also trained on the distracter tasks in this phase.

2. Initial portion of drive. Participants engaged in a short practice drive to adapt to the vehicle before actual data trials began. This primarily involved low speed and local roads with minimal traffic in order to avoid uncontrolled (participant-initiated) forward collision situations; however, participants were instructed to intentionally approach a lead vehicle to activate either FCW or FCC, to experience the system. Once the participant was comfortable with the vehicle, the distracter tasks were introduced and briefly practiced while driving.
3. **Forward collision data collection portion of drive.** Participants engaged in an extended drive during which distracter tasks periodically occurred. Potential forward collisions were implemented during the “primary” distracter task, but not every time.

4. **False alarm scenario.** At the end of the drive, after completion of forward collision scenarios, a false alarm condition occurred. The setting was a work zone lane shift, where the forward collision warning system detected a vehicle within the work zone and activated, even though the driver’s lane actually detoured around. A mild distraction task was in effect during this event. This allowed comparison of driver response to the forward collision warning systems when there was a false alarm.

5. **Post-drive information.** Following the simulator trip, information was collected on driver acceptance, perceived problems, etc.

### 6.1 Protocol

A total of 48 participants were included in the study. Sixteen participants experienced a passive FCW system with a visual and auditory alert, sixteen experienced an active FCC system, and sixteen did not experience a forward collision system (baseline condition). All participants were paid $40 for completing the study and pro-rated compensation was provided for participants who did not complete the study. Figure 3 shows how the participants were allocated to each study condition.

![Figure 3 Experimental conditions](image)

### 6.1.1 Inclusion/Exclusion Criteria

Potential participants had to be between 35 and 55 years of age and in good general health. Participants had to hold a valid driver’s license, have been a licensed driver for at least two years, and drive a minimum of 10,000 miles per year. Restrictions on any
participant’s driver’s license had to be limited to vision, and participants could not require the use of any special equipment to drive, such as pedal extensions, hand brake or throttle, spinner wheel knobs, or other non-standard equipment that would limit interpretation of accelerator pedal, brake pedal, or steering inputs. Participants were to have no prior experience with NADS during the last year or in any of its studies associated with collision avoidance or active safety systems. By self-report of the make and model of their current vehicle, participants could not currently own a vehicle equipped with a forward collision warning system. Participants who never engage in distracting tasks while driving were excluded in the pre-study screening by answering “no” when asked “do you ever engage in behavior that may be distracting while driving such as talking on your cell phone, sending or receiving text messages, eating, sending or receiving emails, or reading?”

6.1.2 Recruitment Methods
The primary recruitment tool was the NADS database that contains over 5,500 names of potential participants that are interested in participating in driving studies conducted at NADS. A database query of the prospective age groups was first completed. From this query, a list of names was generated, and potential participants were either emailed or called with information about the study. For those interested, a phone screening was conducted to determine if potential participants met final study criteria.

If there were any recruitment problems with the primary method of recruitment, secondary methods could be applied and implemented depending on needs for recruitment prior to study start dates. Newspaper and flyer distribution were the secondary methods for recruitment. Additionally, a mass email could be sent to University of Iowa staff, students and alumni. A wide variety of Eastern Iowa recruitment resources are used to target the Iowa City/Coralville and Cedar Rapids areas. Community recruitment resources consist of local media outlets, community centers, newsletters, entertainment centers, local businesses, and volunteer organizations.

6.1.3 Briefing
To prevent participants from becoming fixated on the forward collision warning system, they were told during screening and briefing that they would experience a vehicle with a number of innovative design features rather than that they would be evaluating the forward collision warning system. During briefing, participants completed an informed consent document (Appendix B), a video release statement (Appendix C), a payment voucher, and questions about demographics, driving history, current driving practices, and medical issues (Appendix D). To assure familiarity with the forward collision warning system without focusing the participant’s attention specifically on the forward collision warning system, participants watched a PowerPoint Presentation (Appendix E) that identified the purpose of the study, introduced them to the simulator cab, trained
them on FCW or FCC, trained them on a variety of display and control features (i.e., infotainment system), provided them information on the drives, and trained them on the distracter tasks.

Three different PowerPoint options were created, one for each of the three warning modalities. Only the PowerPoint for the correct modality was shown to each participant. The explanation of the warning modality was consistent with the type of information provided in a vehicle’s owner’s manual. It provided the information necessary to allow the participants to understand what the warning looked like, sounded like, and/or felt like. Pictures, videos, and audio sounds were also incorporated.

6.1.4 Drive
Participants experienced an initial drive to familiarize them with the test vehicle. Immediately prior to this drive, while in the vehicle, they were given instructions (Appendix F). In order to avoid uncontrolled (participant-initiated) forward collision events, the initial drive included minimal traffic. To develop participants’ experience with the feel of the test system, participants were asked to make an intentional activation of the forward collision system. Once the participant was comfortable with the vehicle, the distracter tasks were then introduced and briefly practiced while driving.

During the main portion of the drive, participants were asked to drive as they normally would. The forward collision scenarios were implemented during the “primary” distracter task, but did not occur during every such task. After completion of both forward collision events, a false alarm event occurred. The setting for the false alarm condition was a work zone lane shift where the forward collision warning system detected a vehicle within the work zone and activated, even though the driver’s lane detoured around the work zone. A mild distracter task was in effect during this scenario. This allowed for comparison of driver response to the forward collision warning systems when there was a false alarm. Participants were reminded before each drive that if they needed to stop driving for any reason, they were to tell the researcher and that the researcher would stop the simulation as soon as possible.

6.1.5 Debriefing
During the debriefing process, participants were asked to complete a Wellness survey (Appendix G) to assess how participants physically felt after driving in the simulator, a realism questionnaire to assess participants’ view of realism of simulator and simulated environment (Appendix H), the SART (Taylor, 1989) (Appendix I) to assess situational awareness, and an acceptance survey (Appendix J and K) to assess user acceptance of the technology. After the completion of the acceptance survey, a debriefing statement (Appendix L) that revealed the true purpose of the study was provided. This debriefing statement also stated that the participant should refrain from discussing specific details about the study, including the experimental drives, until data collection was completed.
After reading the disclosure script, participants were thanked and paid for their time and were free to leave.
METRICS, MEASURES, AND ANALYSIS

7.1 Dependent Measures

The dependent measures for this study can be divided to address the three research questions: initial response measures, outcome measures, and inappropriate behavior measures. Table 2 describes the dependent measures that are of interest in this study.

<table>
<thead>
<tr>
<th>Type of Measure</th>
<th>Dependent Measure</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Response</td>
<td>Braking Response</td>
<td>0 for no braking response. 1 for braking response.</td>
<td>binary</td>
</tr>
<tr>
<td>Initial Response Time</td>
<td>The time elapsed from event onset to when a braking response has been initiated.</td>
<td>seconds</td>
<td></td>
</tr>
<tr>
<td>Response Time from Alert</td>
<td>The time elapsed from the onset of the forward collision alert to initial brake pedal depression.</td>
<td>seconds</td>
<td></td>
</tr>
<tr>
<td>Minimum Acceleration</td>
<td>The minimum acceleration (maximum deceleration) during the event.</td>
<td>meters/second²</td>
<td></td>
</tr>
<tr>
<td>Maximum Brake Pedal Force</td>
<td>The maximum force exerted on the brake pedal during the event.</td>
<td>Newtons</td>
<td></td>
</tr>
<tr>
<td>Accelerator Release</td>
<td>Accelerator pedal position reaches the fully released position in response to the forward collision event.</td>
<td>binary</td>
<td></td>
</tr>
<tr>
<td>Time to Accelerator Release</td>
<td>Time from the start of the event onset until the driver begins to release the accelerator prior to the full release of the accelerator.</td>
<td>seconds</td>
<td></td>
</tr>
<tr>
<td>Warning Issued</td>
<td>Whether or not the FCW or FCC system issued an alert.</td>
<td>binary</td>
<td></td>
</tr>
<tr>
<td>Time to eyes back on road</td>
<td>Time from event onset until the driver ends the distraction task and looks toward the forward scene.</td>
<td>seconds</td>
<td></td>
</tr>
<tr>
<td>Time to collision at time of initial braking response</td>
<td>The time to collision when the brake pedal is first depressed following event onset.</td>
<td>meters</td>
<td></td>
</tr>
<tr>
<td>Type of Measure</td>
<td>Dependent Measure</td>
<td>Description</td>
<td>Units</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td>Outcome</td>
<td>Adjusted Minimum Time-To-Collision (AMTTC)</td>
<td>The amount of spare time the driver had based on the avoidance response chosen. In the case of a collision, returns a negative number indicating the time a driver had to avoid the collision.</td>
<td>seconds</td>
</tr>
<tr>
<td></td>
<td>Relative Velocity at Collision</td>
<td>The difference between the participant and lead vehicle velocities at the time of collision</td>
<td>meters/second</td>
</tr>
<tr>
<td></td>
<td>Minimum Time Headway</td>
<td>The minimum time it would take the participant’s vehicle to travel the distance between the participant and lead vehicles given the participant vehicle’s current velocity.</td>
<td>seconds</td>
</tr>
<tr>
<td></td>
<td>Collision</td>
<td>Driver's vehicle collides with another vehicle in the driving environment during the event.</td>
<td>binary</td>
</tr>
<tr>
<td>Inappropriate Response</td>
<td>Location of first glance</td>
<td>The location in the world where the driver first attends to after the forward collision warning: 0 to forward scene. 1 any other location.</td>
<td>binary</td>
</tr>
<tr>
<td></td>
<td>Steering Response</td>
<td>0 for no steering response 1 for steering response.</td>
<td>binary</td>
</tr>
<tr>
<td></td>
<td>Acceleration Response</td>
<td>Whether or not the participant accelerated in response to a forward collision alert: 0 for no increase in speed. 1 for increase in speed.</td>
<td>binary</td>
</tr>
</tbody>
</table>

### 7.2 Data Reduction Plan

The scientific data from the NADS is saved in DAQ files. When each of these files is written from temporary storage to long-term storage, a report is generated. This report contains the name and size of the DAQ file. DAQ files are reduced as frequently as possible during main data collection, on a daily basis if possible.

MATLAB is used to perform the data reduction. During data reduction, each DAQ file indicated in a control spreadsheet is individually opened, and the required variables are read into the MATLAB workspace. Some raw values, e.g., lane deviation, need to be cleaned in order to calculate the specified dependent measures. Once the raw data is cleaned for the entire file, dependent measures are calculated for each of the scenario events and saved into a data reduction spreadsheet.

Eye tracker data is recorded in two ways. First, it is sent via the SCRAMNet network to the DAQ, where it is logged, along with all the other engineering data, to a DAQ file. Second, all eye data is also locally logged to a file on the eye tracker machine. These log files are copied to the DAQ file store along with the DAQ files for data reduction and analysis processing.
7.3 Data Analysis Plan

Data from this study were reviewed for consistency. This process started with an automated review that looked for data problems daily. Any issues that arose were addressed immediately. After the data were reduced to the dependent measures, the data were reviewed for outliers to identify any additional potential data issues. Each extreme outlier was investigated to determine if it accurately represented the driver’s performance. Problems were addressed and any necessary changes to the data reduction process were made.

After the review of the data, it was analyzed using the general linear models procedure in SAS to examine the univariate relationships between the levels of the independent measures. Separate analyses were performed for each experimental question. Where more than two levels were present for a variable, a post-hoc test was performed. Simple effects tests were used to examine interaction effects.

The analysis of this experiment compared the three forward collision warning conditions in terms of speed and effectiveness of responding, frequency of inappropriate driver actions, and driver subjective response. The analysis included consideration of the warning system by scenario event interaction. This was important for determining whether specific forward collision warning system approaches may perform well in one scenario but not the other. Based on the analyses, specific recommendations were derived for the design of forward collision warning systems in particular, and to the extent possible, provided suggestions for ACWS in general.
8 RESULTS

Results are grouped into four primary areas: general system effectiveness, differences in effectiveness related to events, response to false alarm, and driver acceptance.

Parametric data were analyzed using an Analysis of Variance (ANOVA) in the SAS General Linear Models Procedure. The statistical model included the following independent variables and their interactions:

- Condition
  - Auditory/Visual
  - Brake Pulse
  - Baseline
- Event
  - Stopping
  - Stopped
- Sequence
  - Stopping event first
  - Stopped event first
- Subject

Data were dropped for drivers when they began to brake prior to the time the warning would have been provided. The following table provides details on the data points used for the overall analysis.

<table>
<thead>
<tr>
<th></th>
<th>Stopping</th>
<th>Stopped</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Auditory</td>
<td>Brake Pulse</td>
</tr>
<tr>
<td>Total Collected</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Braking before warning</td>
<td>-6</td>
<td>-8</td>
</tr>
<tr>
<td>Analyzed</td>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>

8.1 System Effectiveness

Table 3 provides the dependent measures that were analyzed for this analysis as well as the level of significance for the main effect of condition. The highlighted rows indicate where statistically significant differences were found. Due to the limited sample size, both statistically significant differences and trends will be discussed.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Condition Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Accelerator</td>
<td>Time from task engagement (ex: first button press) to a partial throttle release. Partial release is defined as dropping below 85% of the value at task engagement.</td>
<td>F(2,27) = 2.93, p = 0.0705</td>
</tr>
</tbody>
</table>
### Accelerator Reaction

**Time**

Time from when the FCW alert was issued (or would have been issued in the baseline condition) until the driver releases the accelerator measured in seconds.

| F(2,27) = 2.16 | p=0.1347 |

### Time to Brake Press

Time from task engagement to a brake pedal depress measured in seconds.

| F(2,30) = 2.46 | p=0.1024 |

### Peak Brake Force

The maximum brake pressure applied during the avoidance response measured in foot-pounds.

| F(2,30) = 5.08 | p=0.0126 |

### Peak Acceleration

The peak acceleration in the opposite direction of vehicle motion (deceleration) during the avoidance response measured in meters per second squared.

| F(2,30) = 4.75 | p=0.0162 |

### Minimum Distance

The minimum bumper to bumper distance between the driver’s vehicle and the lead vehicle measured in meters.

| F(2,30) = 2.51 | p=0.0985 |

### Adjusted Minimum Time-To-Collision

The amount of spare time the driver had to avoid colliding. In the case of no collision, this is positive and is measured purely as the minimum time to contact. In the case of a collision, this is negative and calculated based on collision speed and deceleration. This is measured in seconds.

| F(2,30) = 2.88 | p=0.0718 |

### Startle

The peak rate of deceleration measured in meters per second cubed.

| F(2,16) = 2.13 | p=0.1514 |

The first area of interest is in driver reactions to the alert. All drivers applied the brakes. A total of 10 participants released the accelerator prior to the warning. The breakdown is provided in the following figure. As can be seen, drivers in the Auditory/Visual warning condition were least likely to release the accelerator before the warning threshold, whereas drivers in the brake pulse condition were most likely to release the accelerator early.
Figure 4 Participant split on releasing the accelerator prior to the warning

There were no statistical differences in response time, although there was a clear trend across reaction time measures. When looking at initial response to the event, drivers in the baseline condition took longer to release the accelerator than drivers in the warning conditions relative to the initial engagement in the distraction task.
There were also trends towards faster responses for response relative to the time the alert was issued. On average, drivers responded by releasing the accelerator and applying the brakes 375 ms sooner with a warning than without.

Figure 5 Time to accelerator release between conditions

Figure 6 Accelerator reaction time to alert threshold
When applying the brakes, there were significant differences in both the level of braking and the maximum deceleration achieved by the driver. Peak brake pedal force was towards less forceful braking for drivers with the brake pulse than for drivers in the baseline and auditory/visual warning condition. In fact these drivers achieved a maximum brake pressure that was 36% less than was achieved in the other conditions. Correspondingly, for drivers in the brake pulse condition, they achieved a peak deceleration level that was 15% less than for drivers in the other two conditions.
Figure 8 Peak brake force

Figure 9 Peak longitudinal acceleration
With significant differences in magnitude of braking, the issue of impact on outcome is important to consider. Overall, there were no differences in collisions between the conditions for either the stopped or stopping event.

<table>
<thead>
<tr>
<th></th>
<th>Stopping</th>
<th></th>
<th>Stopped</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Auditory</td>
<td>Brake</td>
<td>Baseline</td>
<td>Auditory</td>
</tr>
<tr>
<td>Collision</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>No Collision</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>

There were, however, safety-related trends, relative to minimum distance and Adjusted Minimum TTC. The minimum distance was greater for the brake pulse condition than for the baseline and auditory/visual warning. For the Adjusted Minimum TTC, both warning conditions showed greater safety margins compared to the baseline condition with no warning.

![Minimum Distance](image)

Figure 10 Minimum distance from the lead vehicle
The last variable of interest was the startle response, which permits us to look at the rate at which the driver begins to decelerate. In this case, there was a trend toward a more aggressive response for the brake pulse warning condition compared to the auditory/warning condition and the baseline condition.
Overall, the brake pulse warning appeared to provide a more rapid braking response that required a lower peak level of deceleration to achieve similar outcomes to the auditory/visual warning. Both performed better than the baseline condition. This type of response, if generalizable, has the potential to prevent secondary front-to-rear-end crashes.

8.2 Events

Although there were differences on the measures between the dependent measure, there was only one case where there was an interactive effect of any note. For Peak Acceleration, there was a trend ($F(2,15) = 2.11, p = 0.1555$) with the peak decelerations being less for the stopping vehicle than for the stopped vehicle, although the difference was minimal for the brake pulse condition.

![Peak Acceleration](image)

Figure 13 Peak longitudinal acceleration

8.3 Response to False Alarm
Table 4 provides the dependent measures that were analyzed to understand driver response to a false alarm as well as the level of significance for the main effect of condition. The highlighted rows indicate where statistically significant differences were found. Due to the limited sample size, both statistically significant differences and trends will be discussed.
Table 4 Effect of system on response to false alarm

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Condition Effect</th>
</tr>
</thead>
</table>
| Peak Brake Force   | The maximum brake pressure applied during the avoidance response measured in foot-pounds. | $F(2,43) = 6.17$  
                      |                                                                             | $p=0.0044$       |
| Peak Acceleration  | The peak acceleration in the opposite direction of vehicle motion (deceleration) during the avoidance response measured in meters per second squared. | $F(2,43) = 21.74$  
                      |                                                                             | $P<0.0001$       |
| Time to Peak       | The time from the onset of the event to the point where the driver’s vehicle reaches the peak acceleration in the opposite direction of vehicle motion (deceleration) measured in seconds. | $F(2,43) = 12.19$  
                      | Acceleration                                                              | $P<0.0001$       |
| Delta V            | The change in velocity over the event measured in meters per second.          | $F(2,43) = 2.61$  
                      |                                                                             | $P=0.0849$       |

When first considering the response to the false alarm event, it will be noted that all drivers, both those with and without a FCW alert, released the accelerator and applied the brakes upon approach to the event area in anticipation of the upcoming lane shift. As such, differences in timing of accelerator and brake pedal response are not examined.

There were significant differences in the response of the drivers in the three warning conditions in their response to the false alarm event. Although all drivers applied the brakes, there was significantly more brake pressure applied. Drivers in the baseline and brake pulse condition applied significantly less brake pressure than did drivers in the auditory/visual warning condition (see Figure 14). The 6.7 ft-lbs difference in brake pressure between the baseline and brake pulse conditions was not statistically significant.

Although the auditory/visual warning condition had the greatest brake pressure, that did not result in the greatest level of deceleration. There were significant differences between all three warning conditions with the greatest level of deceleration for drivers who had the brake pulse warning (see Figure 15). Drivers in the auditory/visual conditions had decelerations that were 3.8 times greater than drivers who did not receive the false alarm (baseline condition), whereas drivers with the brake pulse warning had decelerations that were 5.3 times as great as the baseline condition.

When considering the timing of the peak deceleration, there were significant differences between when drivers who received a warning reached peak deceleration. Both the drivers who received the brake pulse and the auditory/visual warnings reached peak deceleration later in the false alarm events than did drivers who did not get a warning (see Figure 16). This difference in timing helps to demonstrate the effect of the warning.

Drivers without a warning reach their peak deceleration approximately 3 seconds into the event on approach to the lane shift, whereas drivers in the warning condition reached
their peak deceleration between 9.3 and 10.3 seconds into the event. This time to peak deceleration indicates that drivers in these warning conditions did indeed have a secondary deceleration in response to the alert after they initially adjusted speed for the lane shift.

The total velocity shed during the event also provides insight into the effects of the warning. The trend in the data indicates that the alerts resulted in a greater shedding of velocity over the false alarm event (see Figure 17). Drivers without a warning shed 1.4 m/s over the event, whereas drivers with the auditory/visual warning shed 3.3 m/s and drivers with the brake pulse warning shed 1.9 m/s.

![Figure 14 Brake force applied during false alarm event](image)

![Figure 15 Peak deceleration during false alarm event](image)
Overall, drivers who had warnings had a significantly different response to the false alarm event than did drivers with warnings. Drivers with the warning applied greater brake pressure and had a greater level of deceleration. Moreover, the results indicate that drivers with the brake pulse applied sharper and shorter brake inputs that caused less of a change in speed. On the other hand, drivers with the FCW pressed the brake more gradually, but for more time, such that more speed was dropped. This braking strategy actually produced a smaller peak deceleration even though more brake pedal force was ultimately developed.
8.4 Acceptance

Finally, the acceptance of the systems by the participants was analyzed. The only question to show significance was the ability to interpret the information presented by the alert. The passive system was less difficult to interpret than the active system (p=0.0343).

![Graph showing ease of warning interpretation](image)

Figure 18 Ease of warning interpretation

Participants with both alerts reported that they easily understood why the alert was presented, that the system successfully caught their attention, and the alert was easy to see and hear/feel.
However, both types of alerts were found to be slightly distracting, and the alert timing to be a little too late.
As shown below, drivers reported fairly neutral responses to the intensity of the alert, the helpfulness of the system for identifying vehicles in front of driver, and the effect the alert had on their driving.
Figure 23 Alert intensity

The intensity of the alert was...

<table>
<thead>
<tr>
<th>Level</th>
<th>All</th>
<th>Audio/Visual</th>
<th>Brake Pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too Strong</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Too Weak</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 24 Alert effectiveness

The forward collision warning affected my driving...

<table>
<thead>
<tr>
<th>Effect</th>
<th>All</th>
<th>Audio/Visual</th>
<th>Brake Pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positively</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Negatively</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Participants reported moderate responses with respect to their trust in the system, the reliability of the system, and their confidence and level of comfort with system, while indicating that they would rely on it only slightly.

87.5% of drivers in the active condition stated that they would want a forward collision warning system in their next vehicle, while 71.4% of participants in the passive condition want a FCW in their next vehicle. Conversely, drivers in the passive condition are willing to pay more for the system than drivers in the active condition.
9 DISCUSSION

Overall, both systems appeared to provide a positive benefit in terms of performance; however, the participants had a preference for the auditory/visual warning modality. The discussion of warning effectiveness will be divided into four portions of the response: time to response, response initiation, actual response, and outcome.

For the time to response, there was no difference between the two modalities of alerts in releasing the accelerator or applying the brakes. In both cases, drivers with an alert responded prior to drivers without an alert.

For response initiation, there was a difference between the auditory/visual warning and the brake pulse warning. Drivers with the brake pulse exhibited a more startled response than did drivers with the auditory/visual warning. The startle response represents approximately a 50% increase in change in deceleration over time. There was no difference in startle response between the auditory/visual warning and the no warning condition.

For actual response, drivers with the brake pulse had smaller maximum brake pedal force and deceleration than did drivers with the auditory/visual warning or no warning. For peak brake pedal force, the drivers with the brake pulse only applied the brakes at 2/3 the force of the other drivers, and had approximately 15% less peak deceleration.

For the outcome, there were no differences in crash outcomes across conditions; however, there were differences in minimum distance and adjusted minimum time to collision. The minimum distance was greater for the brake pulse warning mode compared to both the auditory/visual condition and the no warning condition. The adjusted minimum time-to-collision was greatest for the auditory/visual condition, and both warning conditions were better than the no warning condition.

From a performance standpoint, it appears that drivers with the brake pulse warning responded more abruptly initially but then required a less extreme response to complete their maneuver, whereas drivers with the auditory/visual warning had a more extreme response in terms of peak deceleration to achieve similar outcomes. This points to an interesting tradeoff associated with how these systems are evaluated from a performance standpoint. Namely, is a safer response one that produces a more stable initiation or one that provides a reduction in the maximum response? This issue would seem to be closely related to the design tradeoff of designing later versus earlier warnings to control the occurrence of false alerts, except that in this study both the FCW and FCC warnings were triggered at the same time; only the warning modality changed.

The data concerning the acceptance of the systems is relatively straightforward. Drivers expressed a clear preference for the auditory/visual warning over the brake pulse warning. It is not clear, however, what the basis for this preference is and how well it would generalize to different warning implementations in those same modes or to other active and passive warnings. It could be that drivers are more comfortable with more
traditional warning implementations that utilize the auditory and visual channels and therefore rate them better. Further research would be required to generalize the acceptance results beyond the implementations tested in this study.
10 CONCLUSIONS AND RECOMMENDATIONS

A protocol for testing safety systems has been developed at NADS and applied to FCW and FCC warnings (as well as LDW warnings in a previous study). The large motion base driving simulator has provided a unique environment in which to provide varying levels of visual and cognitive distraction to drivers while placing them in situations with the potential for collisions. Forty-eight participants were run through a pilot and main study with a control condition, and significant differences were observed between the control and warning conditions.

Several metrics were utilized to rate the systems under study using the developed protocol. These metrics are reviewed in the following table and require only the instrumentation of the vehicle to collect. The only failure criterion in this protocol is the occurrence of collisions; however, since all metrics but collisions are continuous in nature, they may be used to rate the systems on a continuous scale.

Table 5 Performance metrics

<table>
<thead>
<tr>
<th>Collisions</th>
<th>Time to throttle release</th>
<th>Throttle reaction time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum distance</td>
<td>Time to brake press</td>
<td>Peak brake pedal force</td>
</tr>
<tr>
<td>Adjusted minimum TTC</td>
<td>Peak acceleration</td>
<td>Startle</td>
</tr>
</tbody>
</table>

Several general conclusions can be drawn from these results:
- Overall, the protocol was effective at getting the driver’s attention off of the road long enough to initiate a forward collision event.
- A simple TTC-based algorithm proved sufficient to represent the salient characteristics of more complicated safety systems and study differences between alternative DVI designs.
- Although both warning conditions produced a faster response, the brake pulse appeared to produce a more rapid response that resulted in a lower peak deceleration with equivalent safety outcomes.

From the standpoint of the effectiveness of this protocol to assess the effect of active and passive FCW systems, a few key lessons have been identified:
- Longer glances are needed to successfully initiate a braking event, and the bug task seemed to keep the driver’s attention sufficiently long enough for the braking event to be triggered while the driver was inattentive to the road.
- A small adjustment from the LDW experiment to the FCW experiment, which pushed the display further away from the driver and required a longer reach, seemed to better draw the driver’s eyes off the road.
- Less data processing was needed to clean the data for the FCW study than for the LDW study. The data produced fewer outliers and there was less ambiguity concerning which data were applicable for the analysis.
Drivers were still reluctant to look away for long periods of time, and 38% of the data had to be removed because the driver had begun responding prior to reaching the alert threshold.

There were limitations in the reported work, mainly due to the small size of the study. Other attractive FCW alert modalities, such as haptic systems that use the seat belt tensioner, were not included in the treatments. Additionally, the modalities were studied independently. In reality, each warning is a piece of a larger alert scheme that may include audio/visual, haptic, and active alerts occurring at differing stages from early to collision-imminent.

It is recommended that design guidelines need to consider not only system performance but also driver preference. When nuisance warnings are likely to occur, greater weight should be given to driver acceptance; however, for imminent warnings, driver acceptance may not align with optimal response to a crash situation. Design guidelines should also consider how false or nuisance alarms will impact the driver and the potential for secondary crashes. Even with two systems tested in this study, there were subtle differences in how drivers responded to warnings to null events that could result in unexpected crashes if the driver responds abruptly to an absent threat.

The potential for particular interfaces to provide equivalent safety benefits without requiring the same degree of response magnitude should be further investigated due to the potential impact on secondary crashes. Additionally, additional experimental conditions could be run to include other conditions, such as haptic seat belts and combinations of warnings.
REFERENCES


APPENDIX A: SCENARIO SPECIFICATION

This section describes the layout of this study’s scenarios. A scenario consists of driving tasks that combine to form an experimental drive approximately 25 minutes duration. All scenarios occur on a two lane rural roadway. Within these 25 minutes are 12 different task events and a false alarm. The same events occur in every drive in three different orders. Event orders and logstream information can be found in …
Table 6 Scenario 1 order of events

<table>
<thead>
<tr>
<th>Scenario #1 Event</th>
<th>Description</th>
<th>Logstream 3 Event Order</th>
<th>Logstream 4 Event Number</th>
<th>Logstream 5 Curve ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bug (practice)</td>
<td>Buzzz (easy catch)</td>
<td>1</td>
<td>2331</td>
<td>1</td>
</tr>
<tr>
<td>Trivia #1</td>
<td>&quot;What famous document contains the sentence: we hold these truths to be self evident; that all men are created equal&quot;</td>
<td>2</td>
<td>8981</td>
<td>1</td>
</tr>
<tr>
<td>CD #1</td>
<td>&quot;Advance to track 6 on the Aerosmith CD&quot;</td>
<td>3</td>
<td>231</td>
<td>3</td>
</tr>
<tr>
<td>Trivia #2</td>
<td>&quot;What color does acid turn when applied to litmus paper&quot;</td>
<td>4</td>
<td>8982</td>
<td>5</td>
</tr>
<tr>
<td>Bug (Stopping)</td>
<td>Buzzz (double lead vehicle brake when bug screen touched)</td>
<td>5</td>
<td>2332</td>
<td>6</td>
</tr>
<tr>
<td>Trivia #3</td>
<td>&quot;Who blinks more-men or women?&quot;</td>
<td>6</td>
<td>8983</td>
<td>7</td>
</tr>
<tr>
<td>CD #2</td>
<td>&quot;Advance to track 9 on the Toby Keith CD&quot;</td>
<td>7</td>
<td>232</td>
<td>8</td>
</tr>
<tr>
<td>CD #3</td>
<td>&quot;Advance to track 11 on the Frank Sinatra CD&quot;</td>
<td>8</td>
<td>233</td>
<td>8</td>
</tr>
<tr>
<td>Bug (curve)</td>
<td>Buzzz</td>
<td>9</td>
<td>2334</td>
<td>9</td>
</tr>
<tr>
<td>CD #4</td>
<td>&quot;Advance to track 13 on the Michael Jackson CD&quot;</td>
<td>10</td>
<td>234</td>
<td>9</td>
</tr>
<tr>
<td>Trivia #4</td>
<td>&quot;What is the largest freshwater lake in the world?&quot;</td>
<td>11</td>
<td>8984</td>
<td>10</td>
</tr>
<tr>
<td>Bug (Stopped)</td>
<td>Buzzz (Vehicle comes to stop when bug screen touched. Deer in front of stopped vehicle)</td>
<td>12</td>
<td>2333</td>
<td>11</td>
</tr>
<tr>
<td>Trivia #5</td>
<td>&quot;Which of the following animals cannot jump?&quot;</td>
<td>13</td>
<td>8985</td>
<td>13</td>
</tr>
<tr>
<td>False Alarm</td>
<td>Construction zone that causes a Forward Collision False alarm</td>
<td>13</td>
<td>NA</td>
<td>13</td>
</tr>
</tbody>
</table>
Table 7 Scenario 2 Order of events

<table>
<thead>
<tr>
<th>Scenario #2 Event</th>
<th>Description</th>
<th>Logstream 3 Event Order</th>
<th>Logstream 4 Event Number</th>
<th>Logstream 5 Curve ID</th>
</tr>
</thead>
<tbody>
<tr>
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<td>2331</td>
<td>1</td>
</tr>
<tr>
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<td>8981</td>
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</tr>
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<td>CD #1</td>
<td>&quot;Advance to track 6 on the Aerosmith CD&quot;</td>
<td>3</td>
<td>231</td>
<td>3</td>
</tr>
<tr>
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<td>&quot;What color does acid turn when applied to litmus paper&quot;</td>
<td>4</td>
<td>8982</td>
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</tr>
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</tr>
<tr>
<td>CD #3</td>
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<td>13</td>
</tr>
<tr>
<td>False Alarm</td>
<td>Construction zone that causes a Forward Collision False alarm</td>
<td>13</td>
<td>NA</td>
<td>13</td>
</tr>
</tbody>
</table>
Event Specifications

This section describes each event in detail. The order of the events will change across the three CWIM2 scenarios.
Scenario Initialization

<table>
<thead>
<tr>
<th>SCENARIO INITIALIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>RATIONALE</td>
</tr>
<tr>
<td>ROAD NETWORK REQUIREMENTS</td>
</tr>
<tr>
<td>PREPARATION</td>
</tr>
<tr>
<td>START CONDITIONS</td>
</tr>
<tr>
<td>ACTUAL EVENT</td>
</tr>
<tr>
<td>END CONDITIONS</td>
</tr>
<tr>
<td>CLEANUP</td>
</tr>
<tr>
<td>PERFORMANCE MEASURES</td>
</tr>
</tbody>
</table>

Bug Task1

<table>
<thead>
<tr>
<th>BUG TASK 1: EVENT ID 2331</th>
</tr>
</thead>
<tbody>
<tr>
<td>RATIONALE</td>
</tr>
<tr>
<td>ROAD NETWORK REQUIREMENTS</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>PREPARATION</td>
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<td></td>
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</tbody>
</table>
**END CONDITIONS**

When the driver resumes stability and continues driving along the road and AUX_Display2_ReceiveFrom=0.

**CLEANUP**

The speeding violation message is reengaged. The appropriate value (0) is sent to Reset AUX_Display_SendTo.

**PERFORMANCE MEASURES**

This event has no specific measures associated with it.

---

**FCW/Baseline Practice**

**TRYFCW/FCWBASLINE: EVENT IDS 8791, 8792**

**RATIONALE**

To allow participants the opportunity to experience the FCW alert or the brakes.

**ROAD NETWORK REQUIREMENTS**

- Speed limit (in mph): 55
- Overall length/distance needed to support event (in feet): 3,200 (from hearing instruction to catching vehicle and forcing warning to activate or braking by subject.)
- Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder
- Intersection type: none
- Time of Day/Date: day

**PREPARATION**

The participant drives along a 2 lane rural road with narrow shoulders.

The speed limit is 55 mph.

The “Speeding Violation” message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time.

Lead vehicle LV1 is created 2500 feet from ownship with activation delay of 5 seconds.

Forced velocity is set to 30 mph.

**START CONDITIONS**

Driving along road when driver crosses road pad trigger.

**ACTUAL EVENT**

The TRYFCW/Baseline message plays in curve; “Slow moving vehicle ahead. Approach the vehicle at 55 mph until the forward collision warning activates, then respond.” or “Slow moving vehicle ahead. Approach the vehicle at 55 mph and brake when you feel it is necessary.” This is caused by writing ID # 8791/2 to the SCC_Audio_Trigger Cell. Driver approaches slow moving vehicle on straight road at 55mph until warning activates or driver brakes.

The event ID is written to LogStream 4 (8791-FCW 8792-Baseline)

**END CONDITIONS**

The alert activates when SCC_Warning_Lights > 63(alert condition) or brake pedal is pressed with force>5. LV1 velocity is forced to 65 mph with acceleration of 3 m/s squared. The driver returns to normal driving along the road.

**CLEANUP**

The speeding violation message is reengaged.

**PERFORMANCE MEASURES**

This event has no specific measures associated with it.

---

**Try Speed**

**TRY SPEED: EVENT ID 8793**

**RATIONALE**

To allow participant the opportunity to experience the speed violation warning.
**Try Speed: Event ID 8793**

| ROAD NETWORK REQUIREMENTS | Speed limit (in mph): 55  
|                           | Overall length/distance needed to support event (in feet): 2,400 (1,200 to hear message, 1,200 to respond)  
|                           | Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder  
|                           | Intersection type: none  
|                           | Time of Day/Date: day  
| PREPARATION               | The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds  
|                           | The speed limit is 55 mph.  
| START CONDITIONS          | Driving along road when driver crosses road pad trigger.  
| ACTUAL EVENT              | The “Speeding up to 65 miles per hour to experience the speed violation warning then return to the posted speed limit” message plays. This is caused by writing 8793 to the SCC_Audio_Trigger Cell.  
|                           | The event ID 8793 is written to LogStream 4.  
| END CONDITIONS            | Driver receives warning and decreases speed to speed limit  
| CLEANUP                   | None  
| PERFORMANCE MEASURES      | This event has no specific measures associated with it.  

**Trivia Tasks**

**TRIVIA TASKS: EVENT IDS 8981, 8982, 8983 AND 8984**

| RATIONALE | The Trivia Tasks are secondary distracter tasks, and they are not associated with any planned braking events. They are included to mask the importance of the planned braking events associated with the primary distracter tasks.  
| ROAD NETWORK REQUIREMENTS | Speed limit (in mph): 55  
|                           | Overall length/distance needed to support event (in feet): 2,400 feet (1,200 to hear message, 1,200 to respond)  
|                           | Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder  
|                           | Intersection type: none  
|                           | Time of Day/Date: day  
| PREPARATION               | The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds  
|                           | The speed limit is 55 mph  
|                           | The “Speeding Violation” message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time.  
| START CONDITIONS          | Driving along road when driver crosses road pad trigger.
**TRIVIA TASKS: EVENT IDS 8981, 8982, 8983 AND 8984**

| Actual Event | The Trivia message task plays. This is caused by writing the appropriate ID # (8981, 8982, 8983, 8984, or 8985) to the SCC_Audio_Trigger Cell.  
The event ID (8981, 8982, 8983, or 8984, 8985) is written to LogStream 4.  
The event order number (2, 4, 7, 11, or 13) is written to LogStream 3.  
The appropriate value (1, 2, 3, 4, or 5) is sent to the AUX_Display1_SendTo Cell. This determines which Trivia task to start. |
---|---|
**END CONDITIONS** | Participant answers question and returns to normal driving. |
**CLEANUP** | The speeding violation message is reengaged. |
**PERFORMANCE MEASURES** | This event has no specific measures associated with it. |

**Nav11**

**Nav11: No Event ID**

| Rationale | To provide driver with information on direction to follow when approaching intersection. |
---|---|
**Road Network Requirements** | Speed limit (in mph): 55  
Overall length/distance needed to support event (in feet): 2,400 feet  
(80 seconds - 80 feet/sec at 55 mph)  
Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder  
Intersection type: none  
Time of Day/Date: day |
**Preparation** | The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds  
The speed limit is 55 mph  
The "Speeding Violation" message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time. Message sent 250 feet before Nav11. |
**Start Conditions** | Driving along road when driver crosses road pad trigger. |
**Actual Event** | The Nav11 instruction is played. The message states "continue straight at intersection in one thousand 500 feet". This is caused by writing ID 62811 to the SCC_Audio_Trigger Cell.  
Event begins 900 feet after the start of curve 3.  
No event ID is associated with this event.  
No order event is associated with this event. |
**End Conditions** | Participant continues driving. |
**Cleanup** | The speeding violation message is reengaged. |
### Nav12

**Nav12: NO EVENT ID**

<table>
<thead>
<tr>
<th><strong>Rationale</strong></th>
<th>To provide driver with information on direction to follow when approaching intersection.</th>
</tr>
</thead>
</table>

**Road Network Requirements**

- Speed limit (in mph): 55
- Overall length/distance needed to support event (in feet): 2,400 feet
- (30 seconds - 80 feet/sec at 55 mph)
- Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder
- Intersection type: none
- Time of Day/Date: day

**Preparation**

The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds

- The speed limit is 55 mph
- The “Speeding Violation” message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time. Message sent 250 feet before Nav12.

**Start Conditions**

Driving along road when driver crosses road pad trigger.

**Actual Event**

The Nav12 instruction is played. The message states “continue straight”. This is caused by writing ID 62812 to the SCC_Audio_Trigger Cell.

- Event begins 8 seconds before start of intersection between curve 3 and 4
- No event ID is associated with this event.
- No order event is associated with this event.

**End Conditions**

Participant continues driving.

**Cleanup**

The LDW warning is suppressed during the time participant crosses intersection. Logstream 1 set to 2. After crossing through intersection, LDW reengaged. The speeding violation message is reengaged.

---

### CD Tasks

**CD Tasks: Event IDs 231, 232, 233, AND 234**

<table>
<thead>
<tr>
<th><strong>Rationale</strong></th>
<th>These are secondary distracter tasks. They are not associated with a planned road departure. They are included to mask the importance of the planned lane departures associated with the primary distracter tasks.</th>
</tr>
</thead>
</table>

**Road Network Requirements**

- Speed limit (in mph): 55
- Overall length/distance needed to support event (in feet): 2,400 feet
- (30 seconds - 80 feet/sec at 55 mph)
- Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder
- Intersection type: none
- Time of Day/Date: day
<table>
<thead>
<tr>
<th>CD TASKS: EVENT IDs 231, 232, 233, AND 234</th>
</tr>
</thead>
</table>
| **PREPARATION** | The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds  
- The speed limit is 55 mph  
- The “Speeding Violation” message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time. |
| **START CONDITIONS** | Driving along road when driver crosses road pad trigger. |
| **ACTUAL EVENT** | The CD task message plays. This is caused by writing the appropriate ID # (231, 232, 233, or 234) to the SCC_Audio_Trigger Cell.  
- The event ID (231, 232, 233, or 234) is written to LogStream 4.  
- The event order number (3, 6, 8, or 10) is written to LogStream 3. |
| **END CONDITIONS** | Participant returns CD to visor and returns to normal driving. |
| **CLEANUP** | The speeding violation message is reengaged. |
| **PERFORMANCE MEASURES** | This event has no specific measures associated with it. |

**Nav21**

<table>
<thead>
<tr>
<th>NAV21: NO EVENT ID</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RATIONALE</strong></td>
</tr>
</tbody>
</table>
| **ROAD NETWORK REQUIREMENTS** | Speed limit (in mph): 55  
- Overall length/distance needed to support event (in feet): 2,400 feet  
  (80 seconds - 80 feet/sec at 55 mph)  
- Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder  
- Intersection type: none  
- Time of Day/Date: day |
| **PREPARATION** | The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds  
- The speed limit is 55 mph  
- The “Speeding Violation” message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time. Message sent 420 feet before Nav21. |
| **START CONDITIONS** | Driving along road when driver crosses road pad trigger. |
**Nav21: NO EVENT ID**

<table>
<thead>
<tr>
<th>ACTUAL EVENT</th>
<th>The Nav21 instruction is played. The message states &quot;continue straight at intersection in one thousand 500 feet&quot;. This is caused by writing ID 62821 to the SCC_Audio_Trigger Cell. Event begins at the end of curve 6 as approaching intersection. No event ID is associated with this event. No order event is associated with this event.</th>
</tr>
</thead>
<tbody>
<tr>
<td>END CONDITIONS</td>
<td>Participant continues driving.</td>
</tr>
<tr>
<td>CLEANUP</td>
<td>The speeding violation message is reengaged.</td>
</tr>
</tbody>
</table>

**Nav22**

**Nav22: NO EVENT ID**

<table>
<thead>
<tr>
<th>RATIONALE</th>
<th>To provide driver with information on direction to follow when approaching intersection.</th>
</tr>
</thead>
</table>
| ROAD NETWORK REQUIREMENTS | Speed limit (in mph): 55  
Overall length/distance needed to support event (in feet): 2,400 feet  
(30 seconds - 80 feet/sec at 55 mph)  
Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder  
Intersection type: none  
Time of Day/Date: day |
| PREPARATION | The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds  
The speed limit is 55 mph  
The "Speeding Violation" message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time. Message sent 475 feet after Nav21. The LDW warning is suppressed 160 ft prior to Nav22 and continues as participant crosses intersection. Logstream 1 set to 2. |
| START CONDITIONS | Driving along road when driver crosses road pad trigger. |
| ACTUAL EVENT | The Nav22 instruction is played. The message states "continue straight". This is caused by writing ID 62822 to the SCC_Audio_Trigger Cell. Event begins 8 seconds before intersection after curve 6. No event ID is associated with this event. No order event is associated with this event. |
| END CONDITIONS | Participant continues driving. |
| CLEANUP | The speeding violation message is reengaged. The LDW is reengaged 65 feet after crossing through intersection; Logstream 1 set to 1 |
## Bug Task-Stopping

### Bug Task-Stopping: Scenario 1(2nd Bug) or Scenario 2(4th bug) 2332

<table>
<thead>
<tr>
<th>RATIONALE</th>
<th>This is a primary distracter task that is associated with a planned road departure to the left while driving straight with an oncoming vehicle present. The oncoming semi is set to match the velocity of the driver so that they interact with it at approx the same location in relation to the event.</th>
</tr>
</thead>
</table>
| ROAD NETWORK REQUIREMENTS | Speed limit (in mph): 55  
Overall length/distance needed to support event (in feet): 1,000-1,500 feet (from Buzz... message to end of event)  
Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder 
Intersection type: none  
Time of Day/Date: day |
| PREPARATION | The participant drives along a 2 lane rural road with narrow shoulders. Three oncoming vehicles approaching. The lead vehicle in the group has a match ownship velocity.  
**Scenario 1 (2nd Bug):** LeadVehicle2 (LV2) is created with creation radius of X feet in Curve 2. It crosses a road pad trigger to set a gap with LV1 of 5 seconds, min speed of 35 and max speed of 75. This continues until LV1 turns right at y intersection. After Y intersection, LV2 crosses road pad trigger to maintain 5 second gap with ownship vehicle; low speed of 40, max speed of 80. 380 feet before Curve 4, LV2 crosses road pad trigger increasing the gap changes to 4.5 seconds with min speed of 50 and max speed of 80. After Curve 4, LV2 crosses road pad trigger increasing the gap to 4 seconds, min and max speeds stay the same. After Curve 5, the Gap size decrease to 3.5 seconds. After Curve 6, the Gap size decreases to 3 seconds, min speed 48, max 80.  
Bug2_StoppingVehicle is triggered to turn onto road when ownship vehicle crosses roadpad trigger about 1750 feet from intersection. Bug2_StoppingVehicle crosses a roadpad trigger and maintains a gap with LV2 of 3.5 seconds, max speed 80 and min speed of 35.  
**Scenario 2 (4th Bug):** LeadVehicle3_02 (LV3_02) is triggered to accelerate to 66mph with acceleration of 0.4 g when ownship is 1600 feet away from vehicle. LV3_02 crosses roadpad trigger about 550 feet before Curve 7 to maintain gap of 6 seconds with ownship, min speed 45, max 80. Gap charged to 5.5 seconds after Curve 7, min 45, max 50. Gap decreases again to 5 seconds, min 45, max 80 when LV3_02 crosses roadpad trigger 5005 feet from intersection 3.  
Bug4_StoppingVehicle is triggered to turn onto road when ownship crosses roadpad trigger about 1750 feet from intersection. About 3500 feet after Curve 9, Bug4_StoppingVehicle maintains gap with LV3_02 of 5 seconds. About 3000 feet later, LV3_02 crosses roadpad to decrease gap with ownship to 4.5 seconds, min 50, max 80. About 350 feet before Curve 10, gap decreases again to 4 seconds. About 150 feet after Curve 10 gap decreases to 3.5 seconds. About 170 feet before Curve 11, LV3_02 and Bug4_Stopping gap size decreases to 3.5 seconds. After Curve 11, LV3_02 and ownship gap decreases a final time to 3 seconds, min 48, max 80.  
The speed limit is 55 mph  
The “Speeding Violation” message is suppressed during the time that the participant receives the message to begin bug task, so that not to hear two messages at the same time. |
| START CONDITIONS | Driving along road and cross a road pad to trigger bug event. |
**ACTUAL EVENT**

Event is located 3500 feet after second intersection in Scenario 1, and 4750 feet after curve B in Scenario 2

The event ID, 2332, is written to LogStream 4.

The appropriate event order (5, 12) is written to LogStream 3.

3 additional bug task 1 Triggers are created:

- Scenario 01: B2S2 Initial audio, B2S2 Delete initial audio, B2S2 Final Audio
- Scenario 02: B4S2 Initial audio, B4S2 Delete initial audio, B4S2 Final Audio

The event initiates when the appropriate value (1) is sent to the AUX_Display2_SendTo Cell. This cell transmits (via several steps) to the AUX computer in the cab and drives the messages to be displayed. The bug task begins when SCC_Audio_Trigger changes to 2331 and plays while AUX_Display2_ReceiveFrom=1.

When participant touches bug screen, initiate both vehicles to brake to 20 mph with a deceleration of 0.85 g for duration of 2.25 seconds. Vehicles will drive at 20 mph for 5 seconds. Bug is set to be impossible to catch until the cell SCC.Warning_Lights > 63.

**END CONDITIONS**

When the driver resumes driving along the road and AUX_Display2_ReceiveFrom=0.

Scenario 1: Bug2_StoppingVehicle will accelerate to 65 mph and LV2 will maintain gap with owner ship vehicle of 4 seconds, min speed 40, and max speed 80.

Scenario 2: Bug4_StoppingVehicle will accelerate to 70 mph and LV3_02 will maintain gap with owner ship vehicle of 4 seconds, min speed 40, max speed 80.

**CLEANUP**

The speeding violation message is reengaged. 0 is sent to Reset AUX_Display_SendTo.

Scenario 1: Bug2_StoppingVehicle will pass roadpad triggers to increase forced velocity 12 mph greater than ownership than another of 15 mph greater. LV2 will cross roadpad trigger to reset gap and force velocity of 12 mph greater than ownership (250 feet before Curve B) then to 18 mph greater (1500 feet after Curve B).

Scenario 2: Bug4_StoppingVehicle will accelerate to 70 mph and LV3_02 will maintain gap with ownership vehicle of 4 seconds, min speed 40, max speed 80. About 425 feet from Curve 13, LV3_02 and Bug4_Stopping cross roadpad triggers to increase velocity to 10(LV3_02) and 12 mph greater than ownership. 250 feet after Curve 12, both vehicles speed increase to 15 mph greater than ownership. 300 feet after Curve 13, velocity for both increase to 18 mph greater than ownership.

**PERFORMANCE MEASURES**

See Dependent Measures Table in section 1.2 of this document.

---

**Bug Task-Stopped**

**BUG TASK Stopped: 4th Bug (Scenario 1) or 2nd Bug (Scenario 2) EVENT ID 2333**

**RATIONALE**

This is a primary distracter tasks that is associated with a planned road departure to the right while driving straight.
**PERFORMANCE MEASURES**

| ROAD NETWORK REQUIREMENTS | Speed limit (in mph): 55  
|                          | Overall length/distance needed to support event (in feet): 1,000-1,500 feet (from Buzz... message to end of event)  
|                          | Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder  
|                          | Intersection type: none  
|                          | Time of Day/Date: day  
| PREPARATION | The participant drives along a 2 lane rural road with narrow shoulders. Three oncoming vehicles approaching. The lead vehicle in the group has a match ownership velocity.  
|              | 
| Scenario 1 (Bug): LeadVehicle3 (LV3) is triggered to turn when ownership crosses roadpad trigger about 1850 feet from intersection. After Curve 9, LV3 crosses roadpad trigger to maintain 4 second gap with ownership vehicle with min speed of 40, max of 70. After Curve 10, gap increases to 5.75 with min speed of 50 and max of 85. After Curve 11, gap increases to 7 seconds with min of 50 and max of 85.  
|              | 
| Scenario 2 (Bug): LeadVehicle2_02 (LV2_02) is created with creation radius of X feet in curve x. It crosses a road pad trigger to set a gap with LV1 of 5 seconds, min speed of 35 and max speed of 75. This continues until LV1 turns right at y intersection. After Y intersection, LV2_02 crosses road pad trigger to maintain 4 second gap with ownership vehicle; low speed of 40, max speed of 80. After Curve 4, LV2_02 crosses road pad trigger increasing the gap changes to 4.5 seconds with min speed of 50 and max speed of 80. After Curve 5, LV2_02 crosses road pad trigger increasing the gap to 5.75 seconds, min and max speeds stay the same. After Curve 6, the Gap size increases to 7 seconds.  
|              | The speed limit is 55 mph  
|              | The “Speeding Violation” message is suppressed during the time that the participant receives the message to begin bug task, so that not to hear two messages at the same time.  
| START CONDITIONS | Driving along road and cross a road pad to trigger bug event.  
| ACTUAL EVENT | Event is located at 4000 feet before third intersection in Scenario 1, 4041 feet before curve 12 in Scenario 2, and 1902 feet after second intersection in Scenario 3.  
|              | The event ID, 2333, is written to LogStream 4.  
|              | The appropriate event order (5, 12, 9) is written to LogStream 3.  
|              | Create 3 additional bug task 1 Triggers:  
|              | · Scenario 01: B4S2 Initial audio, B4S2 Delete initial audio, B4S2 Final Audio  
|              | · Scenario 02: B2S2 Initial audio, B2S2 Delete initial audio, B2S2 Final Audio  
|              | The event initiates when the appropriate value (1) is sent to the AUX_Display2_SendTo Cell. This cell transmits (via several steps) to the AUX computer in the cab and drives the messages to be displayed. The bug task begins when SCC_Audio_Trigger changes to 2331 and plays while AUX_Display2_ReceiveFrom=1.  
|              | When participant touches bug screen, initiate LV3 to come to a complete stop with a decal of 2 g. Deer created and placed 18 feet in front of vehicle. Bug is set to be impossible to catch until the cell SCC_Warning_Lights > 63.  
| END CONDITIONS | When the driver resumes stability and continues driving along the road and AUX_Display2_ReceiveFrom=0.  
| CLEANUP | The speeding violation message is reengaged. 0 is sent to Reset AUX_Display_SendTo.  
| PERFORMANCE MEASURES | See Dependent Measures Table in section 1.2 of this document.
Nav31

**NAV31: NO EVENT ID**

<table>
<thead>
<tr>
<th>RATIONALE</th>
<th>To provide driver with information on direction to follow when approaching intersection.</th>
</tr>
</thead>
</table>
| **ROAD NETWORK REQUIREMENTS** | Speed limit (in mph): 55  
Overall length/distance needed to support event (in feet): 2,400 feet  
(30 seconds - 80 feet/sec at 55 mph)  
Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder  
Intersection type: none  
Time of Day/Date: day |
| **PREPARATION** | The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds  
The speed limit is 55 mph  
The “Speeding Violation” message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time. Message sent 355 feet before Nav31. |
| **START CONDITIONS** | Driving along road when driver crosses road pad trigger. |
| **ACTUAL EVENT** | The Nav31 instruction is played. The message states “continue straight at intersection in one thousand 500 feet”. This is caused by writing ID 62831 to the SCC_Audio_Trigger Cell.  
Event begins 1600 feet before intersection before curve 9.  
No event ID is associated with this event.  
No order event is associated with this event. |
| **END CONDITIONS** | Participant continues driving. |
| **CLEANUP** | The speeding violation message is reengaged. |

Nav32

**NAV32: NO EVENT ID**

<table>
<thead>
<tr>
<th>RATIONALE</th>
<th>To provide driver with information on direction to follow when approaching intersection.</th>
</tr>
</thead>
</table>
| **ROAD NETWORK REQUIREMENTS** | Speed limit (in mph): 55  
Overall length/distance needed to support event (in feet): 2,400 feet  
(30 seconds - 80 feet/sec at 55 mph)  
Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder  
Intersection type: none  
Time of Day/Date: day |
**NAV32: NO EVENT ID**

**PREPARATION**
The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds.
The speed limit is 55 mph.
The “Speeding Violation” message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time. Message sent 500 feet after Nav31.

**START CONDITIONS**
Driving along road when driver crosses road pad trigger.

**ACTUAL EVENT**
The Nav32 instruction is played. The message states “continue straight”. This is caused by writing ID 62832 to the SCC_Audio_Trigger Cell.
Event begins 8 seconds before intersection after curve 6.
No event ID is associated with this event.
No order event is associated with this event.

**END CONDITIONS**
Participant continues driving.

**CLEANUP**
The speeding violation message is reengaged.

---

**Bug Task3-Curve**

**BUG TASK 3-CURVE EVENT ID 2334**

**RATIONALE**
This bug is to allow participant another opportunity to catch the bug easily, as to mask the intent of events occurring with every bug.

**ROAD NETWORK REQUIREMENTS**
- Speed limit (in mph): 55
- Overall length/distance needed to support event (in feet): approximately 2,400 feet (from Buzz... message to end of task)
- Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder
- Intersection type: none
- Time of Day/Date: day

**PREPARATION**
The participant drives along a 2 lane rural road with narrow shoulders. There is assorted oncoming traffic at the rate of about 1 vehicle every 60 seconds.
The speed limit is 55 mph.
The “Speeding Violation” message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time.

**START CONDITIONS**
Driving along road and cross a road pad to trigger bug event.
ACTUAL EVENT

Event is located at the start of Curve 9.
The event ID, 2334, is written to LogStream 4.
The appropriate event order 9 is written to LogStream 3.
Create 3 additional bug task 1 Triggers:
  - B3S2 Initial audio, B3S2 Delete initial audio, B3S2 Final Audio

The event initiates when the appropriate value (1) is sent to the AUX_Display2_SendTo Cell. This cell transmits (via several steps) to the AUX computer in the cab and drives the messages to be displayed.
The bug task begins when SCC_Audio_Trigger changes to 2331 and plays while AUX_Display2_RecieveFrom=1.

END CONDITIONS

When the driver resumes driving along the road and AUX_Display2_RecieveFrom=0.

CLEANUP

The speeding violation message is reengaged. 0 is sent to Reset AUX_Display_SendTo.

PERFORMANCE MEASURES

See Dependent Measures Table in section 1.2 of this document.

False Alarm/Trivia Task #5

FALSE ALARM: EVENT ID NOT APPLICABLE

RATIONALE

To provide participant with a false alarm FCW. During the event, trivia task #5 is given.

ROAD NETWORK REQUIREMENTS

Speed limit (in mph): 55
Overall length/distance needed to support event (in feet): 1400 feet (from first road construction sign to outside road construction zone)
Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder that contains road construction.
Intersection type: none
Time of Day/Date: day
The right lane veers to right. Old lane markings are faint and new white solid road marking is visible.
Road construction barrels in front of cement truck that is in oncoming lane. Another truck is parked on left shoulder surrounded by additional barrels. Road construction ahead sign with lower speed of 45 mph present at about 950 feet before cement truck. Road veers to right sign located 430 feet after first road construction sign.

PREPARATION

The participant drives along a 2 lane rural road with narrow shoulders. The speed limit is 55 mph but drops to 45 near road construction area.
The "Speeding Violation" message is suppressed during the time that the participant receives the message, so that he does not hear two messages at the same time.
Scenario 02 about 590 feet before cement truck lane offset is road pad trigger for the two lead vehicles involved in stopping event to veer right. 470 feet after cement truck another lane offset trigger forces lead vehicles back to left.

START CONDITIONS

Driving along road and veers to right.
FALSE ALARM: EVENT ID NOT APPLICABLE

ACTUAL EVENT

The Trivia 5 message task plays. This is caused by writing the appropriate ID # 8985 to the SCC_Audio_Trigger Cell.

The event ID 8985 is written to LogStream 4.

The event order number 13 is written to LogStream 3.

The appropriate value 7 is sent to the AUX_Display1_SendTo Cell. This determines which Trivia task to start.

As driver approaches cement truck the FCW will activate when the cell SCC_Warning_Lights > 63.

END CONDITIONS

No special conditions, the driver continues driving along the road.

CLEANUP

None.

PERFORMANCE MEASURES

This event has no specific measures associated with it.

END OF DRIVE

RATIONAL

Ends the drive.

ROAD NETWORK REQUIREMENTS

Speed limit (in mph): 55

Overall length/distance needed to support event (in feet): 2,400 feet

(30 seconds - 80 feet/sec at 55 mph)

Road type (lanes, surface): 2 driving lanes, paved surface, normal shoulders, ditch just beyond shoulder

Intersection type: none

Time of Day/Date: day

PREPARATION

The speed limit is 55 mph.

START CONDITIONS

Driver crosses road pad trigger.

ACTUAL EVENT

The end of drive file plays. This is caused by writing 1009 to the SCC_Audio_Trigger Cell.

END CONDITIONS

Drive ends

There is no event ID number associated with this event.

CLEANUP

None.

PERFORMANCE MEASURES

This event has no specific measures associated with it.
APPENDIX B: CWIM_FCW INFORMED CONSENT

INFORMED CONSENT DOCUMENT

Project Title: Driver Perceptions of New Vehicle Technology

Principal Investigator: Timothy Brown, Ph.D.

Research Team Contact: Timothy Brown (319-335-4785)

This consent form describes the research study to help you decide if you want to participate. This form provides important information about what you will be asked to do during the study, about the risks and benefits of the study, and about your rights as a research subject.

- If you have any questions about or do not understand something in this form, you should ask the research team for more information.
- You should discuss your participation with anyone you choose such as family or friends.
- Do not agree to participate in this study unless the research team has answered your questions and you decide that you want to be part of this study.

WHAT IS THE PURPOSE OF THIS STUDY?

This is a research study. We are inviting you to participate in this research study because you are between the ages of 35-55 and have held a valid driver’s license for at least 2 years. In addition, you drive at least 10,000 miles per year, you do not use any special equipment to help you drive, and you are in good health.

The purpose of this research study is to evaluate several new in-vehicle equipment designs and technologies.

HOW MANY PEOPLE WILL PARTICIPATE?

Approximately 84 people will participate in this study at the University of Iowa.

HOW LONG WILL I BE IN THIS STUDY?

If you agree to take part in this study, your involvement will last for approximately 90 minutes.

WHAT WILL HAPPEN DURING THIS STUDY?

Upon arrival at the National Advanced Driving Simulator (NADS) at the University Research Park (formerly the Oxidation Campus), study staff will verbally review this document with you, answer any questions you may have about the study, and provide you time to read this document. If you agree to participate you will be asked to sign this document. You will receive a copy of the signed Informed Consent Document.

Next, you will be asked to show your driver’s license to confirm you have a valid U.S. driver’s license and then fill out a payment form which asks for your social security number. Next, you will be asked to complete a questionnaire that covers some general demographic and driving information that includes...
questions about your driving history including the type of vehicles you drive, your license history, driving violations and accidents, and driving habits. We will also ask for your birthdate, gender, ethnicity, marital status, highest level of education completed, employment information, and participation in other driving studies. This questionnaire also asks you several health-related questions including medication, drug and alcohol use, and history of motion sickness.

Next you will be asked to watch a PowerPoint presentation on the computer that gives you an overview of the simulator cab and drive, the purpose of the study, the systems installed in the vehicle, and the tasks you may be asked to complete while driving. The tasks that you may be asked to complete involve catching a virtual bug and inserting a CD into the given track.

Prior to entering the simulator, temporary stickers will be applied to your face so that we may trace your eye and head movements while you drive. These stickers are commercially manufactured and are the same type of stickers that are given to children at doctor’s offices. The eye tracking cameras are mounted on the vehicle dashboard and will record your head and eye movements during the drive by following the movement of the stickers. If you are allergic to latex, please inform study staff and we will use temporary tattoos in place of stickers containing latex. If tattoos are used, a damp cloth will be pressed upon the tattoo that is applied to your face for about 30 seconds after which the damp cloth and tattoo backing will be removed leaving the tattoo. If tattoos are used instead of stickers, you will be asked to remove the tattoos before leaving, using your choice of several available over the counter cleansers. The stickers will be removed at the end of the study drives.

Then you will be escorted into the simulator and asked to drive for approximately 20 minutes. During the test drive you will experience a number of innovative vehicle design features and be asked to complete a number of tasks. After the drive, you will be asked to complete a questionnaire about how you feel.

You will be escorted back to the waiting room and asked to complete a questionnaire evaluating how real you viewed the simulator. Then you will be asked to complete a questionnaire about your driving experience and an additional questionnaire regarding your opinions about the new technology you experienced. A member of the research team will complete your payment form and you will be free to go.

You may skip any questions that you do not wish to answer on the questionnaire.

The simulator contains sensors that measure vehicle operation, vehicle motion, and your driving actions. The system also contains video cameras that capture images of you while driving (e.g., driver’s hand position on the steering wheel, forward road scene). These sensors and video cameras are located in such a manner that they will not affect you or obstruct your view while driving. The information collected using these sensors and video cameras are recorded for analysis by research staff and may be used as described in the Confidentiality section below.

SOCIAL SECURITY NUMBER (SSN) USAGE

You will be asked to provide your social security number on the payment form that is then entered into the University of Iowa’s Account Payable computer system. The payment form is shredded once your
name, address, and social security number has been entered. The collection of your social security number is to be used only for payment of your time and effort for participating in this research study.

I do not allow you to collect or use my social security number for the purposes outlined above.

(Initial your choice above)

**WHAT ARE THE RISKS OF THIS STUDY?**

You may experience one or more of the risks indicated below from being in this study. In addition to these, there may be other unknown risks, or risks that we did not anticipate, associated with being in this study.

The risk involving driving the simulator is possible discomfort associated with simulator disorientation. Some participants in driving simulator studies reported feeling uncomfortable during or after the simulator drive. These feelings were usually mild to moderate and consisted of slight dizziness, warm, or eyes strain. These effects typically last for only a short time, usually 10-15 minutes, after leaving the simulator. You may quit driving at any time if you experience any discomfort.

If you ask to quit driving as a result of discomfort, you will be allowed to quit at once. If you ask to quit driving due to discomfort, you will be escorted to a room, asked to sit and rest, and offered a beverage and snack. A trained staff member will determine if you will be allowed to leave. If you show few or any signs of discomfort, you will be able to go home or transportation will be arranged if you feel you are unable to drive home. If you experience anything other than slight effects, a follow-up call will be made to you 24 hours later to ensure you’re not feeling ill effects.

In the rare event that normal exiting of the simulator is not available, you will need to exit the simulator through an alternative path. You will be assisted down a small ladder and escorted to a participant waiting room. This could pose a minimal risk if you have difficulty negotiating the ladder or walkway in the simulator bay.

An experimenter will be in the back seat of the simulator cab to ensure your safety while you drive.

Risks associated with latex stickers can be dryness, itching, burning, scaling, and lesions of the skin.

Risks associated with temporary tattoos can be mild skin irritation during removal.

**WHAT ARE THE BENEFITS OF THIS STUDY?**

You will not benefit from being in this study. However, we hope that, in the future, other people might benefit from this study because information gained about how the public perceives and reacts to the vehicle innovations will contribute to improved vehicles in the future.
WILL IT COST ME ANYTHING TO BE IN THIS STUDY?

You will not have any costs for being in this research study.

WILL I BE PAID FOR PARTICIPATING?

You will be paid for being in this research study. You will need to provide your social security number (SSN) in order for us to pay you. You may choose to participate without being paid if you do not wish to provide your social security number (SSN) for this purpose. You may also need to provide your address if a check will be mailed to you. If your social security number is obtained for payment purposes only, it will not be retained for research purposes.

You will be paid $40 for your time. You will be paid with a check sent to your home address that you provided on the payment voucher.

You may quit the study at any time, however if you choose to quit before completion of the study your compensation will be pro-rated based on the length of time you participated. You will then be compensated $4 for every 9 minutes you participated.

WHO IS FUNDING THIS STUDY?

The National Highway Traffic Safety Administration is funding this research study. This means that the University of Iowa is receiving payments from the National Highway Traffic Safety Administration to support the activities that are required to conduct the study. No one on the research team will receive a direct payment or increase in salary from the National Highway Traffic Safety Administration for conducting this study.

WHAT ABOUT CONFIDENTIALITY?

We will keep your participation in this research study confidential to the extent permitted by law. However, it is possible that other people such as those indicated below may become aware of your participation in this study and may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

- federal government regulatory agencies,
- auditing departments of the University of Iowa, and
- the University of Iowa Institutional Review Board (a committee that reviews and approves research studies)

To help protect your confidentiality, you will be assigned a study number which will be used instead of your name to identify all data collected for the study. The list linking your study number and name will be stored in a secure location and will be accessible only to the researchers at the University of Iowa. All records and data containing confidential information will be maintained in locked files or on a secure password-protected computer system that are accessible to the researchers, the study sponsor, and its agents. It is possible that persons viewing the video data may be able to identify you. Study documents will be kept in a locked cabinet within a secure building that can only be entered by research personnel. After completion of analysis, all hard copies except the Informed Consent Documents will be scanned.
placed on a CD and placed into the NADS archival room that has limited access by designated archival personnel. The original Informed Consent Documents will be stored in the NADS archival room that has limited access by designated archival personnel.

The **engineering data** collected and recorded in this study (including any performance scores based on these data) will be analyzed along with data gathered from other participants. These data may be publicly released in final reports or other publications or media for scientific (e.g., professional society meetings), regulatory (e.g., to assist in regulating devices), educational (e.g., educational campaigns for members of the general public), outreach (e.g., nationally televised programs highlighting traffic safety issues) legislative (e.g., data provided to the U.S. Congress to assist with law-making activities), or research purposes (e.g., comparison analysis with data from other studies). Engineering data may also be released individually or in summation with that of other participants, but will not be presented publicly in a way that permits personal identification, except when presented in conjunction with video data.

The **video data** (video image data recorded during your drive) recorded in this study includes your video-recorded likeness and all in-vehicle audio including your voice (and may include, in some views, superimposed performance information). Video and in-vehicle sounds will be used to examine your driving performance and other task performance while driving. Video image data (in continuous video or still formats) and associated audio data may be publicly released, either separately or in association with the appropriate engineering data for scientific, regulatory, educational, outreach, legislative, or research purposes (as noted above).

The **simulator data** is captured and stored on hard drives located within a limited access area of the NADS facility. Access to simulator data is controlled through permissions established on a per-study basis.

If we write a report or article about this study, or share the study data set with others, we typically describe the study results in a summarized manner so that you cannot be identified by name.

**IS BEING IN THIS STUDY VOLUNTARY?**

Taking part in this research study is completely voluntary. You may choose not to take part at all. If you decide to be in this study, you may stop participating at any time. If you decide not to be in this study, or if you stop participating at any time, you won’t be penalized or lose any benefits for which you otherwise qualify.

**Can Someone Else End my Participation in this Study?**

Under certain circumstances, the researchers might decide to end your participation in this research study earlier than planned. This might happen if you fail to operate the research vehicle in accordance with the instructions provided, or if there are technical difficulties with the driving simulator.
WHAT IF I HAVE QUESTIONS?

We encourage you to ask questions. If you have any questions about the research study itself, please contact Timothy Brown, 319-335-4785. If you experience a research-related injury, please contact Timothy Brown, 319-335-4785.

If you have questions, concerns, or complaints about your rights as a research subject or about research related to injury, please contact the Human Subjects Office, 340 College of Medicine Administration Building, The University of Iowa, Iowa City, Iowa, 52242, (319) 335-0564, or e-mail hr@uiowa.edu.

General information about being a research subject can be found by clicking “Info for Public” on the Human Subjects Office website, http://research.uiowa.edu/info. To offer input about your experiences as a research subject or to speak to someone other than the research staff, call the Human Subjects Office at the number above.

This Informed Consent Document is not a contract. It is a written explanation of what will happen during the study if you decide to participate. You are not waiving any legal rights by signing this Informed Consent Document. Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subject's Name (printed):

Do not sign this form if today's date is on or after expiration date: 10/21/13.

(Signature of Subject) (Date)

Statement of Person Who Obtained Consent

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative. It is my opinion that the subject understands the risks, benefits, and procedures involved with participation in this research study.

(Signature of Person who Obtained Consent) (Date)
APPENDIX C: VIDEO RELEASE_FCW_CWIM

CONSENT FOR RELEASE OF VIDEO IMAGE AND AUDIO DATA

I, the undersigned, have agreed to participate in a research project to be conducted at the University of Iowa entitled “Driver Perceptions of New Vehicle Technology”. The purpose of the study is to evaluate several new in-vehicle equipment designs and technologies. As part of the informed consent form I have signed for that study, I have agreed to allow the University, the study sponsor, and those acting pursuant to its authority, to record and use for research purposes video image data (including my video-recorded likeness) and audio data (including my voice), as well as, in some views, superimposed performance information (referred to below as “the Recording”). This Consent for Release of Video Image and Audio Data pertains to the following non-research purposes the University, the study sponsor, and those acting pursuant to its authority propose for my video image data (in continuous video or still formats) and associated audio data, either separately or in association with the appropriate engineering data:

1) Public release for regulatory purposes (e.g., to assist in regulating devices);
2) Public release for educational purposes (e.g., to assist with educational campaigns for members of the general public);
3) Public release for outreach purposes (e.g., to nationally-televised programs highlighting traffic safety issues);
4) Public release for legislative purposes (e.g., to assist the U.S. Congress with law-making/rule-making activities).

Engineering or simulator data may also be released individually or in summary with that of others participating in the study, but will not be presented publicly in a way that permits personal identification, except when presented in conjunction with video image data.

I hereby authorize the University of Iowa, the study sponsor, and those acting pursuant to its authority, to use my recorded video image and audio data, with or without related engineering or simulator data, for the non-research purposes specified above.

I transfer and assign to the University of Iowa and the study sponsor any right, title, and interest I may have in and to the Recording, including the copyright, and in and to all works based upon, derived from, or incorporating the recorded data.

I irrevocably waive any right to inspect, edit, or approve said Recording in any of its forms.

I irrevocably release the University of Iowa and the study sponsor, and any of their employees, agents, and assigns, from any and all claims that I may have at any time arising out of, or related to, the Recording or use of the Recording, including, but not limited to, any claims based on the right of privacy, libel, or defamation.

________________________________________________
Name of Participant

________________________________________________
Signature of Participant

________________________________________________
Date
Appendix D: FCW_NADS Driving Survey

As part of this study, it is useful to collect information describing each participant. The following questions ask about you, your health, and your driving patterns. Please read each question carefully. If something is unclear, ask the researcher for help. Your participation is voluntary and you have the right to omit questions if you choose. Please remember that all of your answers will be kept confidential.

Background Information

1) What is your birth date? ______/_____/______

2) What age are you today? ______

3) What is your gender?
   - Male
   - Female

4) What is your marital status? (Check only one)
   - Single, never married
   - Married
   - Domestic Partnership
   - Separated or Divorced
   - Widowed

5) What was your total household income last year? (Check only one)
   - $0 - $24,999
   - $25,000 - $29,999
   - $30,000 - $34,999
   - $35,000 - $39,999
   - $40,000 - $49,999
   - $50,000 - $59,999
   - $60,000 - $69,999
   - $70,000 - $79,999
   - $80,000 - $89,999
   - $90,000 - $99,999
   - $100,000 or more

6) What is your present employment status? (Check only one)
   - Unemployed
   - Retired
   - Work part-time
   - Work full-time
   - None of the above

7) What type of work do you do (e.g., teacher, homemaker)? __________________________

8) How many children do you have? ______

9) How many children under the age of 18 live at home? ______
10) How many children under the age of 14 live at home? ________

11) Of which ethnic origin(s) do you consider yourself? (Check all that apply)
   - American Indian/Alaskan Native
   - Asian
   - Black/African American
   - Hispanic/Latino
   - Native Hawaiian/Other Pacific Islander
   - White/Caucasian
   - Other

12) What is the highest level of education that you have completed? (Check only one)
   - Primary School
   - High School Diploma or equivalent
   - Technical School or equivalent
   - Some College or University
   - Associate’s Degree
   - Bachelor’s Degree
   - Some Graduate or Professional School
   - Graduate or Professional Degree

Driving Experience

13) How old were you when you started to drive (including driving before license)? ________

14) How old were you when you got your FIRST driver’s license? ________

15) How often do you drive? (Check the most appropriate category)
   - Less than once weekly
   - At least once weekly
   - At least once daily

16) Approximately how many miles do you drive per year? (Check only one)
   - Under 2,000
   - 2,000 - 7,999
   - 8,000 - 12,999
   - 13,000 - 19,999
   - 20,000 or more
17) Is any driving you do work-related? (Check only one)
   - No (Go to question # 16)
   - Yes (please complete question 17a below)

17a) How many work-related miles do you drive per year? (Check only one)
   - Under 2,000
   - 2,000 - 7,999
   - 8,000 - 12,999
   - 13,000 - 19,999
   - 20,000 or more

18) How frequently do you drive in the following environments? (Check only one for each environment)

<table>
<thead>
<tr>
<th>Environment</th>
<th>Never</th>
<th>Yearly</th>
<th>Monthly</th>
<th>Weekly</th>
<th>Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business District</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural Highway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interstate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel Roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

19) What speed do you typically drive in a residential area when the speed limit is 25? _________ mph

20) What speed do you typically drive in a business district when the speed limit is 35? _________ mph

21) What speed do you typically drive on a rural highway when the speed limit is 55? _________ mph

22) What speed do you typically drive on the Interstate when the speed limit is 65? _________ mph

23) What speed do you typically drive on a gravel road? _________ mph

24) Have you ever had to participate in any driver improvement courses due to moving violations?
   - No
   - Yes (Please describe) ________________________________________________________________

69
25) When driving, how frequently do you perform each of the following tasks/maneuvers?

(Check the most appropriate answer for each task/maneuver)

<table>
<thead>
<tr>
<th>Task/Maneuver</th>
<th>Never</th>
<th>Rarely</th>
<th>Occasionally</th>
<th>Frequently</th>
<th>Always</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change lanes on Interstate or freeway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keep up with traffic in town</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keep up with traffic on two-lane highway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keep up with traffic on Interstate or freeway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass other cars on Interstate or freeway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exceed speed limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wear a safety belt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make left turns at uncontrolled intersections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

26) How comfortable do you feel when you drive in the following conditions or perform the following maneuvers? (Check the most appropriate answer for each condition)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Very Uncomfortable</th>
<th>Slightly Uncomfortable</th>
<th>Slightly Comfortable</th>
<th>Very Comfortable</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway/freeway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After drinking alcohol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-traffic volume</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passing other cars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing lanes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making left turns at uncontrolled intersections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

27) How often do you engage in the following behaviors while driving?

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Never</th>
<th>Rarely</th>
<th>Occasionally</th>
<th>Frequently</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talk on cell phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read text or email</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Send text or email</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vioaltions

28) Within the past five years, how many tickets have you received for the following?
(Please check a response for each ticket)

<table>
<thead>
<tr>
<th>Violation</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speeding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Going too slowly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failing to yield right of way</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disobeying traffic lights</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disobeying traffic signs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improper passing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improper turning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reckless driving</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Following another car too closely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating While Intoxicated (DWI) or Driving Under the influence (DUI)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify type and frequency of violation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Accidents

29) In the past five years, how many times have you been the driver of a car involved in an accident?

- 0 (Go to question # 30 on page 7)
- 1
- 2
- 3
- 4 or more

Please provide the following information for each accident below and on the next page.

Accident 1

<table>
<thead>
<tr>
<th>Question</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was another vehicle involved?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was a pedestrian involved?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Were you largely responsible for this accident?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you go to driver’s rehabilitation?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weather Conditions:  

Description:  

---

Page 5

71
<table>
<thead>
<tr>
<th>Health Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>30) How often do you experience motion sickness? (Circle only one)</td>
</tr>
<tr>
<td>Never</td>
</tr>
<tr>
<td>Always</td>
</tr>
<tr>
<td>31) How severe are your symptoms when you experience motion sickness (Circle only one)</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Severe</td>
</tr>
</tbody>
</table>
32) Have you taken any medication in the past 48 hours? (Check only one)

☐ No
☐ Yes (Please list all)

33) Have you consumed any alcohol or other drugs in the past 24 hours? (Check only one)

☐ No
☐ Yes (Please list all)

34) What is your normal bedtime hour of the day? ______________________

Other Studies

35) Have you participated in other driving studies?

☐ No (End of questionnaire)
☐ Yes (please provide details for each study you have participated in below)

Study 1
What vehicle was used for this study? (Check only one)

☐ Actual car - only
☐ Another simulator - only
☐ National Advanced Driving Simulator (Motion Simulator)
☐ National Advanced Driving Simulator (Elastic Simulator)
☐ Both - actual car and another simulator
☐ Both - actual car and the National Advanced Driving Simulator (Motion Simulator)

Brief Description: ________________________________________________________

Study 2
What vehicle was used for this study? (Check only one)

☐ Actual car - only
☐ Another simulator - only
☐ National Advanced Driving Simulator (Motion Simulator)
☐ National Advanced Driving Simulator (Elastic Simulator)
☐ Both - actual car and another simulator
☐ Both - actual car and the National Advanced Driving Simulator (Motion Simulator)

Brief Description: ________________________________________________________
APPENDIX E: CWIMFCW_TRAINING PRESENTATION WITH AUDIO_ALL
Pre-Drive Information for Study Participants

Please press the space bar or use the ↑ keys to advance to a new slide.
Instructions

Each slide will play on its own. Listen to each slide then go to the next slide when you are ready. You may ask questions at any time or at the end.
Purpose of the Study

You will be experiencing several new in-vehicle technologies during your drive today. The vehicle in our driving simulator has been fitted with these new features. After the drive, we will ask for your opinion about the technologies you experienced.
Making it Realistic

In order to ensure that the new technologies are experienced in a way that is realistic, we will occasionally ask you to perform some tasks that mimic the distractions, and even misbehaviors, that sometimes occur while driving.
<table>
<thead>
<tr>
<th>Getting Ready</th>
</tr>
</thead>
<tbody>
<tr>
<td>The next few slides go through the procedures for entering the simulator and preparing for your drive.</td>
</tr>
</tbody>
</table>
Advanced Concept Car
Interior
Steering Wheel Adjustments
Resting Position
Eye Tracking Cameras

Face straight ahead
MIRRORS

You may adjust the mirrors by using the control panel on the door. Set the side mirrors in much the same way as you would set the mirrors on your car. Wait to adjust the mirrors until after the eye tracking cameras have been calibrated. The control panel should be pressed firmly. If you need assistance, please ask the researcher in the simulator for help.
Intercom System

The car has an intercom system which allows the researchers to hear you. It is already adjusted for the drive today. If for any reason you want to stop driving, please tell us. The operator will hear you and can end the drive in just a few seconds.
Reviewing the New Technologies and Distraction Tasks

After you have made all necessary adjustments and are comfortable in the vehicle, a researcher will review what your drive will be like, show you the new technologies, and practice the distraction tasks with you.
The Drive

The drive starts with your car parked on a suburban road. When told to begin, press on the brake, shift into drive, and begin to drive.

The beginning portion of your drive today is designed to help you get used to the simulator. During this time you should become familiar with driving at the posted speed limit, the feel of the simulator, and some of the new technologies.

You will leave the suburban town and drive into a rural area between towns. This rural road is a two lane street. The speed limit is 55 mph.
New Technologies

You will be experiencing several new in-vehicle technologies during your drive today. After the drive, we will ask for your opinion about the technologies you experienced. The next few slides will give you information about these new technologies.

- Auditory-Only Navigation System
- Forward Collision Warning System
- Speed Warning Alert System
- In-Vehicle Computer System
New Technology:
Auditory-Only Navigation System

As you approach intersections during your drive, you may or may not hear an auditory navigation system inform you of which direction you should take in order to arrive at your desired destination. There is no visual navigation screen included, this is an auditory only navigation system. To hear a sample of the auditory alert click on the icon below.
New Technology:
Forward Collision Warning

NOTE: this slide is only presented to the participants who have this condition.

During your drive, if a collision threat is detected with a vehicle in front of you, a warning will alert you of this threat. The warning will include a series of flashing lights displayed on a heads-up display and an auditory tone.

Click the image below to see a sample of the alert.
New Technology:
Forward Collision Warning

During your drive, if a collision threat is detected with a vehicle in front of you, a warning will alert you of this threat by applying the brakes. This limited braking is meant to alert you to adjust the car speed before a collision occurs, not to stop the car for you.
New Technology: Speed Warning System

If your speed exceeds 10mph over the posted speed limit, you will hear a warning alerting you that you are committing a "speeding violation." Click the icon to hear a sample of the warning.
New Technology: In-Vehicle Computer System

The in-vehicle computer system has many programs that offer advantages to the driver. The application program you will experience today is a trivia game.

When you hear the prompt, the computer has selected a trivia question for you to keep you from becoming bored while driving. Click below to hear the prompt.

Three possible answers will appear on the touch screen computer mounted in the vehicle. Choose the answer you believe is correct by touching it with your finger. The goal is to get as many correct answers as possible to increase your score. You will hear your score after finishing the game.
Distraction Tasks

In order to ensure that the new technologies are experienced in a way that is realistic, we will ask you to perform distraction tasks while driving. There are two tasks you will be asked to perform:

1. Task 1: CD Player
2. Task 2: Bug Catching

These tasks are described in detail on the following slides.
Task 1: CD Player Task

At several points in your drive you will be asked to locate a specific CD from a collection of CDs located on the driver's side visor and insert it into the CD player.

Please familiarize yourself with the location of the CD slot.
Task 1: CD Player Task

You will then be asked to advance to a specific track on the CD. To change the CD track, move the selection lever up to go to a higher numbered track and down to go to a lower numbered track.

Move the selection lever up or down once for each track. For example, to change the CD from track 2 to track 5 you should move the selection lever up three times.

Do not turn the SOURCE dial.
Do not press the MODE button.
Task 1: CD Player Task

After finding the requested track, you will need to eject the CD and return it to its appropriate sleeve on the visor of the vehicle.

To eject the CD, press the eject button and wait for the CD to come out of the CD slot.
CD Task Prompt

A voice prompt will play asking you to begin the CD Player Task. Click the icon below to hear an example of the prompt.
Task 2: Bug Catching Task

At several points in your drive you will be asked to locate and catch a bug that is flying in the backseat of the vehicle. The bug represents an URGENT task that should be dealt with immediately.

This virtual bug will appear on a touch screen located behind the passenger seat.
Task 2: Bug Catching Task

Once you have located the bug attempt to “catch” it by placing your finger on the touch screen where the bug is located and try hard to keep in contact with it as it moves around.

While maintaining contact with the screen, follow the path of the bug by tracing its path until you no longer hear it buzzing in the car.

Once you begin this task you must continue to follow the path of the bug until the buzz noise stops. DO NOT remove your finger from the screen until the task is complete. Remember the bug represents an URGENT task that should be dealt with immediately.
Task 2: Bug Catching Task

You will see a RED glow around your finger if you are not doing a good job tracing the path of the bug.

You will see a GREEN glow around your finger if you are doing a good job tracing the path of the bug.

Your goal in this task is to maintain a green glow until you catch the bug. When you have successfully caught it, the buzz noise will stop and the bug will flash. Remember the bug represents an URGENT task that should be dealt with immediately.
Bug Task Prompt

A buzz sound will play prompting you to begin the Bug Catching Task. Click the icon to hear an example of the prompt.
Summary

• You will drive in a simulator vehicle in your normal manner on rural roads.

• At times during the drive, you will experience some new technology features.

• At times during the drive, you will engage in some tasks that mimic various behaviors drivers sometimes do.

• After the drive, we will ask for your opinions about the technologies you experienced.
Conclusion

This concludes the briefing presentation. We can answer any questions you may have at this time.
APPENDIX F: IN-CAB PRE-DRIVE INSTRUCTIONS

After the participant is comfortable in the driver’s seat, the bug catching screen is adjusted so that the participant is able to reach all four corners of the screen. Then the in-cab researcher will provide instructions for practicing the bug catching task:

“We will now practice the Bug Catching Task. The bug catching task is considered an URGENT task that should be dealt with immediately. When you hear the buzz noise you should locate the bug on the screen, then place your finger on the screen and try to catch the bug by tracing it with your finger. It is important that you keep your finger on the screen until the buzz noise stops and the bug begins to flash which indicates that you caught the bug and the task is complete. Remember, if you see a red glow while you follow the bug, it indicates that you are NOT doing a good job whereas a green glow indicates that you are doing a good job. Please maintain the green glow and do not allow it to turn red. Do you have any questions?” Following the practice, the researcher will tell participant “Please remember that this is an URGENT task that should be dealt with immediately. You need to catch and kill the bug. Do your best to maintain the green glow.”

After completing the bug catching practice the researcher will point out the location of the CDs and the CD player and the buttons needed to complete the CD changing task. When time to practice the researcher will read aloud “We will now practice the CD changing task. First I need you to look above at the CDs and list them for me. When you hear the prompt to select a track on a CD, select the appropriate CD from the visor, put it into the CD player, advance to the appropriate track, wait to hear the music, then eject the CD and return it to the appropriate slot on the visor. As soon as you hear the music start playing, it is important that eject the CD and return it to the visor. Do you have any questions?”

As the simulator’s motion is turned on, the ride-along experimenter tells the participant that they will hear some instructions as the simulator starts up. The control room researcher then plays the Simulator Motion audio clip: “The simulator is moving towards its start position. During this time, you may hear rumbling and feel vibrations. This is perfectly normal. There are microphones in the cab so the Simulator Operator can hear you at all times. If, for any reason, you wish to stop driving, please let us know. The Operator can bring you to a stop in just a few seconds.”

While moving out to the starting position, the researcher will provide instructions for the trivia game practice. “We will now proceed to the Trivia game practice. You will hear a sound indicating that there is a trivia question for you to answer. The computer will read you the trivia question and the answers will appear on this touch screen. Touch the answer you feel is correct. You accumulate points for correct answers. I am able to provide you with the correct answers for the trivia game after the drive but not during your drive. Do you have any questions?” At this time the control room researcher initiates practice trivia file of “What was the original name of Mickey Mouse?”

Data Collection Drive

The ride-along researcher reads the following instructions to each participant before the start of the drive: “The drive starts with your car parked on a suburban road. When told to
begin, press on the brake, shift into drive, and begin to drive. The first few minutes of your drive today is designed to help you get used to the simulator. During this time you should become familiar with driving at the posted speed limit, the feel of the simulator, and some of the new technologies. You will leave the suburban town and drive onto a two-lane highway. For data collection purposes, please keep communication with me to a minimum. I am here to answer questions or address concerns if needed. Please standby until you are told to begin. Do you have any questions?”

After the first bug catching task the researcher will tell the participant, “Good Job. Please remember that this is an URGENT task that should be dealt with immediately. You need to catch and kill the bug. Do your best to maintain the green glow.”
APPENDIX G: CWIM-FCW_WELLNESS QUESTIONNAIRE

Study/Participant: CWIM-FCW

Date:_______

WELLNESS SURVEY

Directions: Circle one option for each symptom to indicate whether that symptom applies to you right now.

2. Fatigue ................. None .......... Slight .......... Moderate .......... Severe
7. Sweating .......... None .......... Slight .......... Moderate .......... Severe
D. **"Fullness of the Head" .......... None .......... Slight .......... Moderate .......... Severe
II. Blurred Vision .......... None .......... Slight .......... Moderate .......... Severe
15. ***Stomach Awareness .......... None .......... Slight .......... Moderate .......... Severe
B. Other .......... None .......... Slight .......... Moderate .......... Severe

* Fullness of the head is an awareness of pressure in the head.
**Vertigo is experienced as loss of orientation with respect to vertical upright.
***Stomach awareness is a feeling of discomfort which is just short of nausea.
## APPENDIX H: FCW_REALISM_SURVEY

### Study/Participant: CWB-L-FCW

### Date: 

### REALISM SURVEY

For each of the following items, circle the number that best indicates how closely the simulator resembles an actual car in terms of appearance, sound, and response. If an item is not applicable, circle NA.

<table>
<thead>
<tr>
<th>General Driving</th>
<th>Not at all realistic</th>
<th>Somewhat realistic</th>
<th>Completely realistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response of the seat adjustment levers</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response of the mirror adjustment levers</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response of the door locks and latches</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response of the fans</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response of the gear shift</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response of the brake pedal</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response of the accelerator pedal</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response of the speedometer</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response of the steering wheel while driving straight</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feel when accelerating</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feel when braking</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to read road and warning signs</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of car interior</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of signs</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of roads and road markings</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of rural scenery</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of intersections</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of other vehicles</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of rear-view mirror image</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound of the car</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound of other vehicles</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall feel of the car when driving</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall similarity to real driving</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Appearance of driving scenes</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Situational Driving</td>
<td>Not at all</td>
<td>Somewhat</td>
<td>Very</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>------------</td>
<td>----------</td>
<td>------</td>
</tr>
<tr>
<td>Feel of driving straight while going 25 mph</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feel of driving straight while going 55 mph</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feel of driving on a curved road while going 25 mph</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feel of driving on a curved road while going 55 mph</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feel of accelerating from a stopped position</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feel of braking to a stop</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to stop the vehicle</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to respond to other vehicles</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to keep straight in your lane</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to respond at intersections</td>
<td>0 1 2 3 4 5 6 NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX I: FCW_SART

Study/Participant: 
Date: 

Situational Awareness

The following questions ask about your study drive. Please read each question carefully. If something is unclear ask the research assistant for help. Your participation is voluntary, and you have the right to omit questions you choose not to answer.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instability of situation</td>
<td>During your drive, how likely was the situation to change suddenly?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variability of situation</td>
<td>During the drive, how many variables which required your attention were changing at once?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexity of situation</td>
<td>How complicated were the situations in the drive?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td>What was the level of mental stimulation during the drive?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spare Mental Capacity</td>
<td>How much mental capacity did you have to spare during the drive?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration</td>
<td>How much could you concentrate your attention to important tasks during the drive?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division of Attention</td>
<td>Were you able to divide your attention between several relevant sources during the drive?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information Quality</td>
<td>How good (useful) was the information you obtained in the drive?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information Quantity</td>
<td>How much useful information was provided from the available sources in the drive?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Familiarity</td>
<td>How familiar were you with the different elements and events in the drive?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unexpected events, things you react to: No unexpected events, simulation went as expected: 1 | 2 | 3 | 4 | 5 | 6 |

A lot of things changing at once: 1 | 2 | 3 | 4 | 5 | 6 |

Difficult to navigate: Easy route: 1 | 2 | 3 | 4 | 5 | 6 |

Scenario was engaging: Bored during the scenario: 1 | 2 | 3 | 4 | 5 | 6 |

Could not comfortably perform other tasks: Could perform other tasks: 1 | 2 | 3 | 4 | 5 | 6 |

Distracted by non-essential tasks: Able to focus on the important tasks: 1 | 2 | 3 | 4 | 5 | 6 |

Focused on one source of information: Able to scan between relevant information sources: 1 | 2 | 3 | 4 | 5 | 6 |

Information is poorly depicted, useless, or difficult to understand: Information is easy to comprehend and very useful: 1 | 2 | 3 | 4 | 5 | 6 |

Insufficient amounts of necessary information to perform the task: A lot of useful information to complete the task: 1 | 2 | 3 | 4 | 5 | 6 |

Uncomfortable, no familiarity: Comfortable, very familiar: 1 | 2 | 3 | 4 | 5 | 6 |
APPENDIX J: CWIM-FCW
ACCEPTANCE_QUESTIONNAIRE_WARNING

Study:  
Participant:  
Date:  

Forward Collision Warning Post Drive Acceptance Questionnaire

The following questions address ONLY the ALIRF issued by the Forward Collision Warning System. This is the only system you will be asked to evaluate. The alert activated when there was a potential collision with a vehicle in front of you. Please read each question carefully and circle 1-7 for each question. If something is unclear ask the research assistant for help. Your participation is voluntary, and you have the right to omit questions you choose not to answer.

<table>
<thead>
<tr>
<th></th>
<th>The alert...</th>
<th>Did not catch my attention</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Caught my attention</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The alert was...</td>
<td>Very Distracting</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>Not Distracting</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>My ability to hear/feel the alert was...</td>
<td>Very Difficult</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>Very Easy</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>The intensity of the alert was...</td>
<td>Too Weak</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>Too Strong</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>The timing of the alert was...</td>
<td>Too Early</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>Too Late</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Rate how helpful the forward collision warning was in identifying vehicles in front of you...</td>
<td>Not Helpful</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>Very Helpful</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>The forward collision warning affected my driving...</td>
<td>Negatively</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>Positively</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>My ability to interpret the information presented by the alert was...</td>
<td>Very Difficult</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>Very Easy</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>My ability to understand why the alert was presented was...</td>
<td>Very Difficult</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>Very Easy</td>
<td>7</td>
</tr>
</tbody>
</table>

The following questions address ONLY the ALIRF issued by the Forward Collision Warning System. Please check the appropriate answer and describe your reasoning.

10. To what extent did you trust the forward collision warning system?

☐ Not at all
☐ Slightly
☐ Moderately
☐ Very Much
☐ Extremely

What factors led to this degree of trust?

________________________________________________________________________

________________________________________________________________________
11. To what extent did you rely on the forward collision warning system?

☐ Not at all
☐ Slightly
☐ Moderately
☐ Very much
☐ Extremely

What factors led to this degree of reliance?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

12. How would you rate your level of comfort with the forward collision warning system alert sound and visual warning/causing the vehicle to brake?  
   (*Note: and one of these will be shown to the participant depending on trial conditions*)

☐ Not at all comfortable
☐ Slightly comfortable
☐ Moderately comfortable
☐ Very comfortable
☐ Extremely comfortable

What affected your level of comfort?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

13. How reliable was the forward collision warning system?

☐ Not at all reliable
☐ Slightly reliable
☐ Moderately reliable
☐ Very reliable
☐ Extremely reliable

What about the forward collision warning system’s operation influenced how you rated its reliability?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
14. What was your level of confidence in the forward collision warning system?

- Not at all confident
- Slightly confident
- Moderately confident
- Very confident
- Extremely confident

What about the forward collision warning system influenced how you rated your confidence in its operation?

________________________________________________________________________

________________________________________________________________________

15. Would you want a forward collision warning system in your next vehicle?

- Yes
- No

Why would/wouldn't you want a forward collision warning system in your next vehicle?

________________________________________________________________________

________________________________________________________________________

16. How much would you be willing to pay for a forward collision warning system?

$________

17. What was your degree of self-confidence to handle vehicles slowing in front of you?

- Not at all confident
- Slightly confident
- Moderately confident
- Very confident
- Extremely confident

Suggestions for improving the alert of the forward collision warning system:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
APPENDIX K: CWIM-FCW_ACCEPTANCE_QUESTIONNAIRE_NO WARNING

Study: CWIM-FCW
Participant: 
Date: 

Forward Collision Post Drive Acceptance Questionnaire
(No Warning)

The following question asks about your study drive and about your opinions related to the potential collisions with a vehicle in front of you. Please read each question carefully. If something is unclear ask the research assistant for help. Your participation is voluntary, and you have the right to omit questions you choose not to answer.

1. What was your degree of self confidence to handle potential collisions with another vehicle in front of you?
   - Not at all confident
   - Slightly confident
   - Moderately confident
   - Very confident
   - Extremely confident
Debriefing Statement
Thank you so much for participating in this study. Your participation was very valuable to us.
We know you are very busy and appreciate the time you devoted to participating in this study.

There was some information about the study that we were unable to discuss with you prior to the study, because doing so may have impacted your actions and thus skewed the study results.

In this study, we were interested in understanding your reactions to different forward collision warnings while distracted. You were told that several new technologies were being tested; however, in reality, forward collisions were simulated while you were distracted and data about your reaction to the warning modality was collected.

We hope this clarifies the purpose of the research, and the reason why we could not tell you all of the details about the study prior to your participation.

It is very important that you do not discuss this study with anyone else until the study is complete. Our efforts will be greatly compromised if participants come into the study knowing its true purpose and how their reactions are being examined. To this end, we would ask that you not discuss any of the details of the study until November 1, 2010.