Driver Acceptance of Collision Warning Applications Based on Heavy-Truck V2V Technology

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16. Abstract

Battelle conducted a series of driver acceptance clinics (DACs) with heavy-truck drivers to gauge their acceptance of collision-warning applications using vehicle-to-vehicle (V2V) communication technology. This report describes the results from Volpe's independent analysis of DAC data, in particular data generated from intersection collision warnings (intersection movement assist, or IMA), forward collision warnings (FCW), blind spot/lane change warnings (BSW/LCW), and emergency electronic brake light (EEBL) warnings of hard braking by one or more vehicles ahead. A total of 112 subjects drove trucks towing 53-foot semitrailers through scripted maneuvers on closed courses and rated their impressions in surveys.

The results indicated high acceptance in each of five criteria used to define driver acceptance; usability, perceived safety benefits, understandability, desirability, and security and privacy. The majority of subjects viewed the system as no more distracting to use than a car radio, but nonetheless thought it would result in drivers paying somewhat less attention to the road. There was no effect of age on acceptance. Warnings had both auditory and visual components and the combination of the two was preferred to either the visual or auditory components alone (although, for the visual component, some subjects felt uneasy with having to take their eyes off the road to see the screen).

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List of Acronyms

ANOVA	analysis of variance
BSW/LCW	blind spot warning/lane change warning
CCV	connected commercial vehicle
CDL	commercial driver license
DAC	Driver Acceptance Clinic
DSRC	dedicated short range communications
EEBL	emergency electronic brake light
EOBR	electronic on-board recorder
ESC	electronic stability control
FCW	forward collision warning
IAA	Intra-Agency Agreement
IMA	intersection movement assist
LDW	lane departure warning
P&D	pick-up and delivery
SPMD	Safety Pilot Model Deployment
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle

Foreword

Volpe National Transportation Systems Center, is supporting the National Highway Traffic Safety Administration by conducting an independent analysis of collision warning applications. The analysis is based on vehicle-to-vehicle and vehicle-to-infrastructure communication using data collected from the Safety Pilot Model Deployment field test and the driver acceptance clinics. As a Federal agency, Volpe is considered to be independent since it is not involved in the development of technology and does not financially benefit from commercialization of future products based on the technology.

This report documents the approach used and results of the independent analysis. A related intra-agency agreement between Volpe and NHTSA is also in place to conduct an independent evaluation of light-vehicle collision warning applications using data from the SPMD field test. Volpe and the Intelligent Transportation Systems Joint Program Office also have an IAA in place to conduct an independent evaluation of transit bus collision warning applications using data from the SPMD field test.

In addition to this DAC report, there are companion reports on the results from the independent evaluation of light vehicle and transit bus collision warning applications.

Executive Summary

This report presents the methods used and the results of the independent analysis of subjective data to gauge heavy truck driver acceptance of collision warning applications based on vehicle-to-vehicle communication technology during several driver acceptance clinics for heavy trucks. V2V technology is used to transmit vehicle information—such as current vehicle location, size, and speed—between vehicles, using dedicated short-range communications at 5.9 GHz radio frequency. Using this information, the V2V safety application can predict impending collisions and warn the driver. The DACs are part of a series of tests of V2V technology conducted by the U.S. Department of Transportation as part of the SPMD program. The vision of the SPMD is to test V2V and vehicle-to-infrastructure safety applications in real-world driving scenarios to determine their effectiveness at reducing crashes, and to verify that the technology does not cause unintended consequences.

The SPMD consists of two parts; DACs (light vehicles and heavy trucks) and the model deployment. The model deployment is a large-scale field test conducted on the streets of Ann Arbor, Michigan, in which volunteer drivers use vehicles with fully integrated V2V applications in their regular day-to-day driving. The DACs were conducted before the model deployment. NHTSA will use data generated from the DACs and the model deployment as input when making potential agency decisions related to V2V technology.

Volpe conducted the independent analysis of the subjective DAC data. In the context of this report, Volpe is considered independent since it is not involved in the development of technology, and do not financially benefit from commercialization of future products based on the technology.

Goal and Objectives

This analysis of the DAC subjective data supports the goal of the SPMD subjective data analysis; to assess driver acceptance based on the compatibility between subjects' expectations of the technology and its performance, and the degree to which subjects express interest in having the technology in their vehicles.

The objectives of the DAC data analysis are to determine driver acceptance based on the following five criteria.

1. **Usability:** Do subjects think that the V2V safety applications are easy to use?
2. **Perceived Safety Benefits:** Do subjects think that V2V technology will contribute to their driving safety?
3. **Understandability:** Are the V2V safety applications easy to understand and learn to use?
4. **Desirability:** Do subjects want to have and use V2V safety applications in their truck?
5. **Security and Privacy:** How do subjects feel about the security and privacy issues raised by V2V technologies?

Of particular interest is the risk of unintended consequences, including overreliance or distraction caused by the V2V technology, which falls under the second objective of perceived safety benefits. There is also the possibility that drivers will ignore the application or find a way to deactivate it if they find it annoying or untrustworthy.

Methodology

During the clinics, 112 subject volunteers drove truck tractors towing 53-foot semitrailers through scripted maneuvers on closed courses. The maneuvers were designed to generate different types of warnings through interactions with other vehicles piloted by professional drivers. The four different warnings consisted of a warning for an oncoming vehicle from a lateral direction while the truck was crossing an intersection (intersection movement assist, or IMA), a forward collision warning, a blind

spot/lane change warning, and an emergency electronic brake light warning that alerts the driver to hard braking several vehicles ahead. Subjects were given surveys asking their opinions of the different safety applications before the demonstrations, in the vehicle immediately after each demonstration, and after the demonstrations ended.

Findings

- *High acceptance rate:* The results showed a very high acceptance rate in each of the five criteria used to define driver acceptance; usability, perceived safety benefits, understandability, desirability, and security and privacy. Nearly 95 percent of subjects strongly agreed with the statement "I would like to have this Vehicle-to-Vehicle Communication safety feature on my truck." (In the survey, safety applications were referred to as "safety applications.")

- *Rating order:* Among the different safety applications, the in-vehicle surveys showed that the BSW/LCW was usually rated highest, followed by the EEBL, the FCW, and the IMA. Since this is the inverse of the order in which subjects experienced the safety applications, these preferences may be influenced by an order effect. In fact, when asked in the post-drive survey to rank the applications relative to one another in terms of usefulness, the order was different, with the IMA ranked higher than the FCW.

- *Distractibility:* The majority regarded the application to be no more distracting to use than a car radio, but nonetheless thought that it would result in drivers paying less attention to the road to some degree.

- *Impact of age:* There was no effect of age on acceptance.

- *Route experience:* There was suggestive evidence that drivers with only pick-up and delivery experience rated the effectiveness of the EEBL and the understandability of the BSW/LCW slightly lower than did drivers experienced in both line haul and pick-up and delivery routes.

- *Audio and visual warnings:* Subjects preferred the combination of the audio and visual warning to either the visual or auditory components alone. However, with the visual component, some drivers were uneasy with having to take their eyes off the road to see the screen.

1 Introduction

Findings from a 2014 Battelle report analyzing the subjective data from a series of driver acceptance clinics for light vehicles showed high driver acceptance of collision warning systems [1]. This report of collision warning applications is a similar analysis, describing the methodology used and results of a series of DACs for heavy trucks.

The DACs are part of a series of tests of V2V technology conducted by the U.S. DOT as part of the SPMD program. V2V technology is used to transmit vehicle information—such as current vehicle location, size, and speed—between vehicles, using Dedicated Short Range Communications at 5.9 GHz radio frequency. Using this information the V2V safety application can predict impending collisions and warn the driver. The SPMD program is intended to establish vehicle communications for the surface transportation system; communications that will support applications to enhance safety and mobility. SPMD consists of two parts; DACs and the SPMD. The SPMD is a large-scale field test conducted on the streets of Ann Arbor, in which volunteer drivers use vehicles with fully-integrated V2V applications in their regular day-to-day driving. The vision of the SPMD is to test V2V and vehicle-to-infrastructure safety applications in real-world driving scenarios to determine their effectiveness at reducing crashes, and to verify that the technology does not cause unintended consequences. The DACs were conducted before the SPMD. NHTSA will use data generated from the DACs and the SPMD when making potential agency decisions related to V2V technology.

Volpe conducted the independent analysis of the DAC data. In the context of this report, Volpe is considered independent since it is not involved in the development of the technology, and do not financially benefit from commercialization of future products based on the technology.

1.1 Goal and Objectives

This analysis of the DAC subjective data supports the goal of the SPMD subjective data analysis; to assess driver acceptance based on the compatibility between subjects' expectations of the technology and its performance, and the degree to which subjects express interest in having the technology in their vehicles.

"Driver acceptance" is a complex combination of several different factors that influence whether drivers will want the technology and how well it will work for them. However, these factors may vary independently of one another and should be analyzed separately to gain a more detailed understanding of why and how drivers do or do not accept a technology. For this study, driver acceptance is based on the following five criteria that are the objectives of the data analysis.

1. **Usability:** Do subjects think that the V2V safety applications are easy to use?
2. **Perceived Safety Benefits:** Do subjects think that V2V technology will contribute to their driving safety?
3. **Understandability:** Are the V2V safety applications easy to understand and learn to use?
4. **Desirability:** Do subjects want to have and use V2V safety applications in their truck?
5. **Security and Privacy:** How do subjects feel about the security and privacy issues raised by V2V technologies?

Of particular interest is the risk of unintended consequences, including overreliance or distraction caused by the V2V technology, which falls under the second objective of perceived safety benefits. There is also the possibility that drivers will ignore the application or find a way to deactivate it if they find it annoying or untrustworthy.

Even though the primary goal of the analysis is to summarize driver acceptance data in the heavy truck DACs, the data can also be used as a pilot experiment to identify patterns in the responses, which can then

be tested statistically during the SPMD. In addition, analysts can further refine the V2V technology before the SPMD begins.

The heavy truck DAC data may also be used in conjunction with the SPMD data to analyze the SPMD. Even though this is outside the scope of this document, the DAC data provides comparative data, reflecting different levels of experience with the vehicles and different levels of instruction and demonstration of scenarios.

Multiple Comparisons

The approach of using DAC analysis results as a pilot for the SPMD has the added benefit of reducing the problem of "multiple comparisons," which frequently occurs in statistical analyses using a large array of tests in a single study. With multiple comparisons the usual cut-off point (p-value) used to determine statistical significance is 0.05, i.e., the null hypothesis is rejected if the probability that the observed results could have been acquired with the null hypothesis being true is less than 5 percent. But if 20 tests are conducted, the likelihood of at least one of those tests being statistically significant by random chance becomes far more likely. When the key questions being asked in a study are planned ahead of time, this effect is usually ignored. However, when there is a statistically significant result in one of a large number of tests to explore the dataset, and key questions are not planned ahead of time ("fishing expeditions") the result cannot be considered evidence. These results can still be used to identify interesting effects, and any such results that reoccur in a subsequent test—i.e., the SPMD—can then be confirmed as evidence of a real effect. The problem of multiple comparisons is thus reduced in this analysis of DAC data by treating the DAC analysis as a pilot study to identify patterns that can be confirmed (or not confirmed) later using the SPMD data.

1.2   Methodology

To support potential agency decisions on heavy vehicles, U.S. DOT has contracted with a CCV team led by Battelle, and including Mercedes-Benz Research and Development North America, Daimler Trucks North America, Denso, Meritor WABCO, and the University of Michigan Transportation Research Institute. The CCV team has developed the connected vehicle on-board equipment and safety applications on selected Class 8 commercial vehicles and has also built vehicles for research and testing activities to provide the data needed to assess safety benefits and support NHTSA agency decisions. The heavy-truck DACs are some of the many tests and demonstrations of heavy vehicle connected vehicle technology during this project.

The Battelle team conducted the heavy-truck driver clinics in 2012 at two test tracks, the Transportation Research Center in East Liberty, Ohio, from July 10 to 26, and at the former Alameda Naval Air Station in Oakland, California, on August 22 and 23. In both clinics, volunteers were asked to drive V2V-equipped vehicles using scripted interactions with other vehicles driven by professional drivers. These interactions were designed to demonstrate different types of collision warnings.

After volunteer drivers checked in, the Battelle team provided an overview of the study and an orientation of the vehicle and course. For each type of collision warning, before the demonstration began, a test conductor sitting in the passenger seat described how to drive and what would happen during the demonstration. Volunteer drivers then sat behind the wheel and took part in the demonstrations. Their participation ended when they were debriefed and paid. Drivers spent approximately 90 minutes in the vehicle, a third of this time driving and following the scenarios, and the remaining time listening to the test conductor explaining each scenario and completing surveys.

Figure 1 illustrates the two vehicles demonstrating the V2V technology. Both were Freightliner Cascadia Class 8 trucks and were purchased specifically for the DAC. The white truck had a high-roof sleeper body and the red truck had a mid-roof sleeper. Both towed empty 53-foot van semitrailers (with one exception at the California clinic, where the red truck towed a 48-foot trailer).

Source: Battelle

Figure 1. Demonstration Trucks Used in the DACs

1.2.1 Safety Applications

The trucks were equipped with four safety applications, each designed to provide warnings about a specific collision scenario. Driver warnings consisted of visual icons displayed on an iPad mounted on the center of the dashboard and auditory beeps emitted from speakers mounted at roof height on both sides of the truck cab interior. Figure 2 shows the iPad placement in the cab. The device on top of the iPad is a lock.

Source: Battelle

Figure 2. Placement of the iPad in the Truck Cab

1.2.2   Visual Icons

The visual icons displayed on the screen were different for each safety application. The auditory warnings were different for "cautionary" and "imminent" warnings, but did not differ between safety applications. The following safety applications are described in the order in which they were demonstrated to drivers:

1. **Intersection Movement Assist:** Warns the driver of a vehicle approaching from the side while entering an intersection (Figure 3). In this scenario, the subject driving the truck (illustrated by the blue icon) was instructed to release the brakes and roll into an intersection as a passenger vehicle approached from the left at a constant speed. A single-unit truck (the green icon) was parked at the corner to obstruct the subject's view of the approaching passenger car (the red icon), which represented the threat. On the right side of Figure 3 are the visual icons displayed to the driver; on top is the cautionary warning and below is the imminent warning. The application first issued a cautionary alert followed by an "imminent" alert.

   After the IMA demonstration and before the FCW demonstration, subjects were asked to accelerate and to practice hard braking.
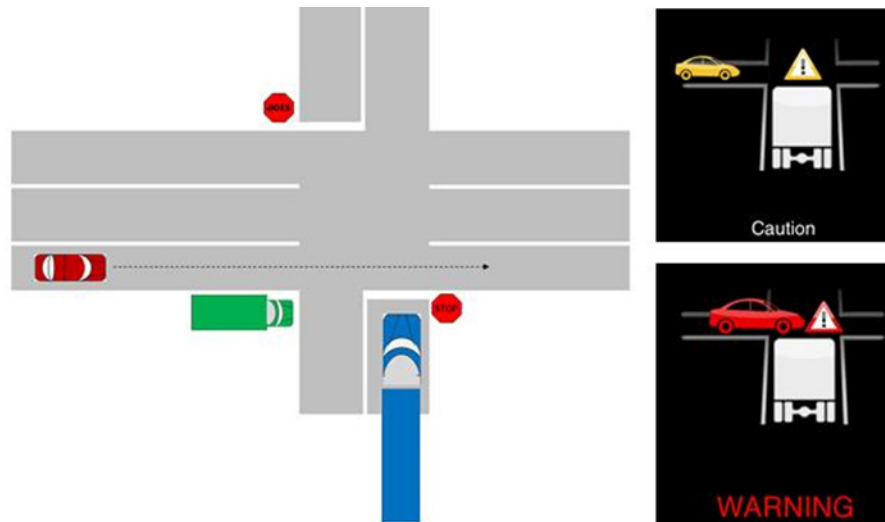
Figure 3. Intersection Movement Assist Scenario With Associated Cautionary and Imminent Warning Displays

2. **Forward Collision Warning:** Warns drivers if they are approaching stopped or slower lead vehicles (Figure 4). In this scenario, the application issued a cautionary and then imminent alert as the subject's vehicle approached a stopped passenger vehicle. The subject drove the truck (blue icon) toward a stopped passenger car (red icon). Figure 4 also shows the visual icons displayed to the driver; on the left is the cautionary warning and on the right is the imminent warning.
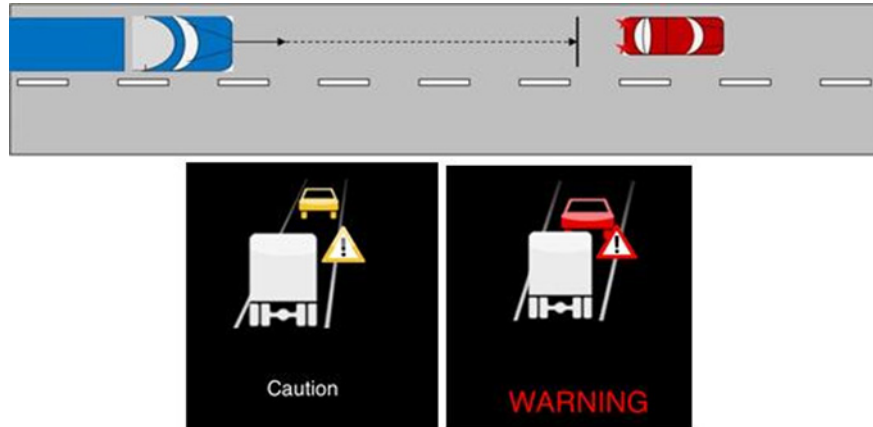
Figure 4. Forward Collision Warning Scenario With Associated Cautionary and Imminent Warning Displays

3. **Emergency Electronic Brake Light Warning:** Warns the driver if there is hard braking by one or more vehicles ahead in the traffic queue (Figure 5). In this scenario, the subject drove the truck (blue icon) behind two vehicles, including a single-unit truck (green icon) in front of the subject's truck that blocked the subject's view of a passenger car (red icon) farther ahead. The driver of the passenger car then abruptly applied the brakes. The truck in front of the subject's truck did not brake. If the vehicles were in an adjacent lane, the application would issue a cautionary warning. If they were in the same lane, an imminent warning would be issued. In this scenario, the alert did not depend on the intermediate vehicle braking (single-unit truck), but instead provided information on traffic farther ahead. For this safety application only, there was no audio for the cautionary warning (but there was for the imminent warning). Figure 5 also shows the visual icons displayed to the driver; on the left is the cautionary warning and on the right is the imminent warning.

Figure 5. Emergency Electronic Brake Light Scenario With Associated Cautionary and Imminent Warning Displays

4. **Blind Spot/Lane Change Warning:** Warns driver there is a vehicle in their blind spots (Figure 6). In this scenario, the subject (blue icon) was driving down a road at a constant speed of 35 mph. When a passenger car (red icon) entered the subject's blind spot in the adjacent lane, the application issued a cautionary alert (the BSW). When the subject activated their turning indicator in the direction of the lane where the passenger car was driving, the application issued an imminent alert (the LCW). Figure 6 also shows the visual icons displayed to the driver; on the left is the BSW and on the right is the LCW warning.
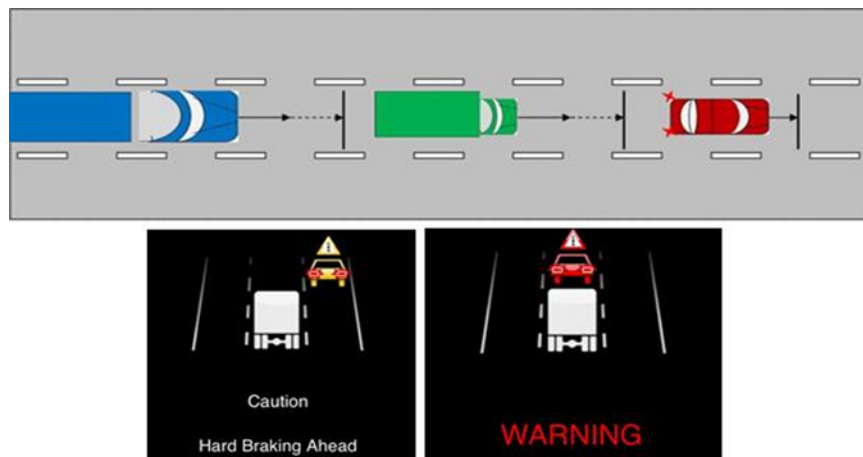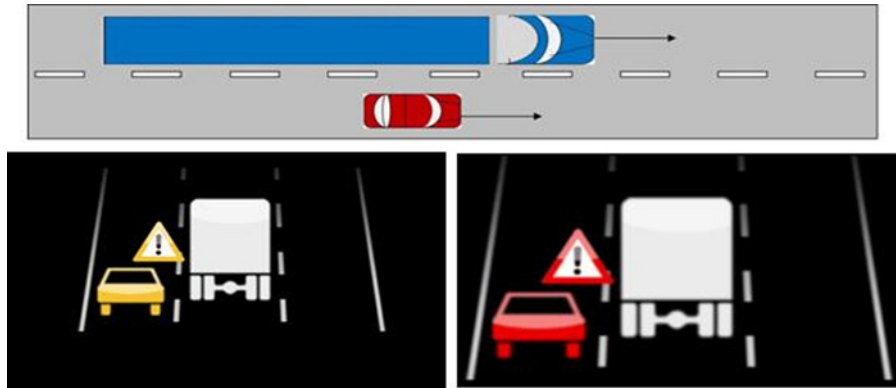

Figure 6. Blind Spot Warning Scenario and Associated Cautionary and Imminent Warning Displays

2 Data Analysis

The following section describes the statistical techniques and analysis methodology used by Volpe to analyze data from the DACs.

2.1 Surveys

Subjects filled out three surveys; a "pre-drive" survey before the demonstrations; an "in-vehicle" survey for each safety application after experiencing the application; and a "post-drive" survey after completing the demonstration and leaving the vehicle.

The surveys consisted of open-ended questions (e.g., "Do you have any concerns, ideas for improvement, or other comments for the blind spot warning?") and questions answered using a Likert scale. The Likert-scale items consisted of questions or statements that subjects rated their agreement with using a numeric scale. For example:

"How useful do you think this blind spot warning would be in the real world?"

1	2	3	4	5	6	7
Not at all useful			Moderately useful			Extremely useful
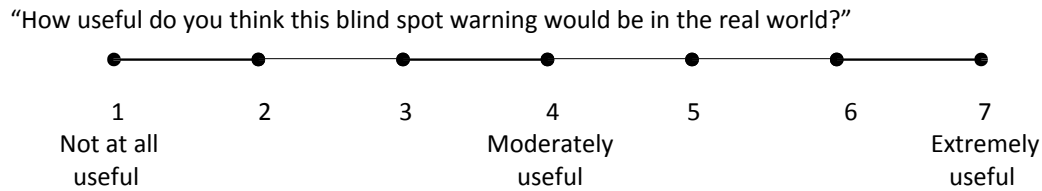
Appendix A contains samples of each of the three surveys.

A total of 112 individuals from local trucking fleets, independent owner-operators, and respondents to advertisements placed online and in local truck stops volunteered to participate in the DACs. The breakdown was 64 subjects in the Ohio clinic and 48 in the California clinic. In addition to other criteria, volunteers had to be at least 21 years of age, possess a valid Class-A commercial driver license (CDL-A), currently drive a tractor trailer, and not have had more than two moving violations in the last 3 years or have caused an injury or crash in the last 3 years. The goal was to represent demographics of professional truck drivers currently on the road. This meant subjects were not equally balanced by gender (most were male) or age.

For more details on the experimental design refer to Battelle's final technical report on the driver clinics test and safety plan [1].

2.2 Likert-Scale Responses

A downside to answering survey questions using a scale of one to seven is the built-in subjectivity: one subject's five might be equivalent to another's seven. To remove some of that subjectivity, Volpe converted scores to one of three bins: "negative," "neutral," or "positive" (the actual names of these bins varied from question to question depending on the wording of the question). The bins were divided using a system of 12-345-67, i.e., with scores of one and two as "negative," three through five as "neutral," and six and seven as "positive." Volpe used this 12-345-67 breakdown instead of a 123-4-567 breakdown because it is more conservative and because so many of the responses were strongly positive. The chance of finding meaningful changes in the results is higher if the upper responses are separated from the middle ones—otherwise the results would likely be almost exclusively "positive."

2.3   Open-Ended Responses

Volpe summarized open-ended responses based on the overarching or dominant concerns and issues raised. Open-ended responses were also used to clarify unusual responses (such as outliers) and to illustrate concerns or trends seen in the numerical Likert-scale responses. Finally, all responses were checked for anything related to security and privacy to determine whether subjects raised concerns about those issues.

2.4   Statistical Approach

Parametric statistics, such as *t*-tests and analysis of variance, assume that the data are collected on an interval scale. These sorts of tests are generally considered inappropriate for data collected on a Likert scale because the magnitude of the difference between, for example, a four and a five, cannot be assumed to be the same as the magnitude of the difference between a five and a six. Consequently, Volpe used non-parametric tests, such as Mann-Whitney and Kruskal-Wallis, instead. The same reasoning lies behind using medians instead of means to describe central tendencies. When conducting correlation analyses using responses on a Likert scale, Volpe used Spearman tests since they are non-parametric.

2.5   Analyses Conducted

Volpe conducted the following analyses. Section 3 provides results by type of analysis (with the relevant subsection identified below).

- **Effect of driver clinic.** Before pooling the data from the two clinics, Volpe conducted tests to check for consistent differences in responses between the clinics that could have been caused by the demographics of the subjects, environmental conditions at the time, or local conditions at any of the clinics. (Section 3.1)

- **Responses grouped by objective.** The distribution of the responses to each question was quantified by percentage using the 12-345-67 breakdown and graphed using bar charts. For multiple-choice responses not on a Likert scale, responses were characterized for each multiple-choice option. These results were grouped in subsections based on the five objectives for the analysis; usability, perceived safety benefits, understandability, desirability, and security and privacy. (Section 3.2)

- **Environmental conditions.** Subjects were asked under which environments and conditions each safety application would provide the most benefit. (Section 3.3)

- **Effect of age.** Several analyses were conducted to determine whether the responses varied as a function of age. To preserve as much data as possible, raw scores (not broken down into 12-345-67 bins) were analyzed. (Section 3.4)

- **Effect of previous driving route experience.** In the real world, the driving experience differs between those driving local pick-up and delivery routes and those driving line haul. These differences may affect driver acceptance of the safety applications. Past driver experience with routes was therefore used to divide subjects into three groups (line haul, pick-up and delivery, and both) and the groups were compared based on their responses to the survey questions. (Section 3.5)

- **Effect of previous experience with safety applications**. Drivers were divided into two categories; "experience" and "no experience," based on whether or not they had one of six non-V2V collision warning devices installed in their primary truck. Survey question responses were then compared between the two groups. Volpe conducted a second analysis comparing V2V acceptance between drivers who rated such non-V2V devices desirable versus those who did not. (Section 3.6)

- **Outlier analysis:** Outlier and extreme responses were identified and analyzed. Experience has shown that responses at technology demonstrations are often strongly positive, possibly due to the technology being demonstrated under ideal circumstances. For example, the only outliers in the light-vehicle DACs occurred at the negative end of the spectrum since the median response was the most positive available [2]. Analyzing outliers is useful in identifying critical concerns that may otherwise be hidden by overwhelmingly positive responses. (Section 3.7)

3   Results

This section presents the results from Volpe's analysis of the heavy-truck DAC subjective data. The total number of subjects (n) answering each question varies in some cases because subjects occasionally left questions blank.

3.1   Effect of Driver Clinic

Even though the two clinics—one in Ohio and one in California—were administered by the same staff, it is possible that the subject responses on the surveys were affected by some other variables that differed between the two locations. For example, differences in the layout of the track, the background scenery, or weather conditions, could have influenced driver acceptance of the technology. For each question answered using a Likert scale (a total of 26 questions), Volpe compared the percent of scores that were positive (a score of six or seven) between clinics. There were no significant differences between clinics. The pattern of the scores was similar, as indicated by a significant positive correlation between both clinics (Pearson's $r = 0.9$, $n = 26$, $p < 0.001$, two-tailed). The magnitude of the scores was also similar, as shown by a small mean difference (1.4 percentage points, 95% confidence interval between 1.0 and 3.8 percentage points) and no significant difference between clinics (paired t-test, $t = 1.2$, df $= 25$, $p = 0.24$, two-tailed) (Figure 7). Based on these similarities, the responses from the two clinics were pooled for all subsequent analyses.
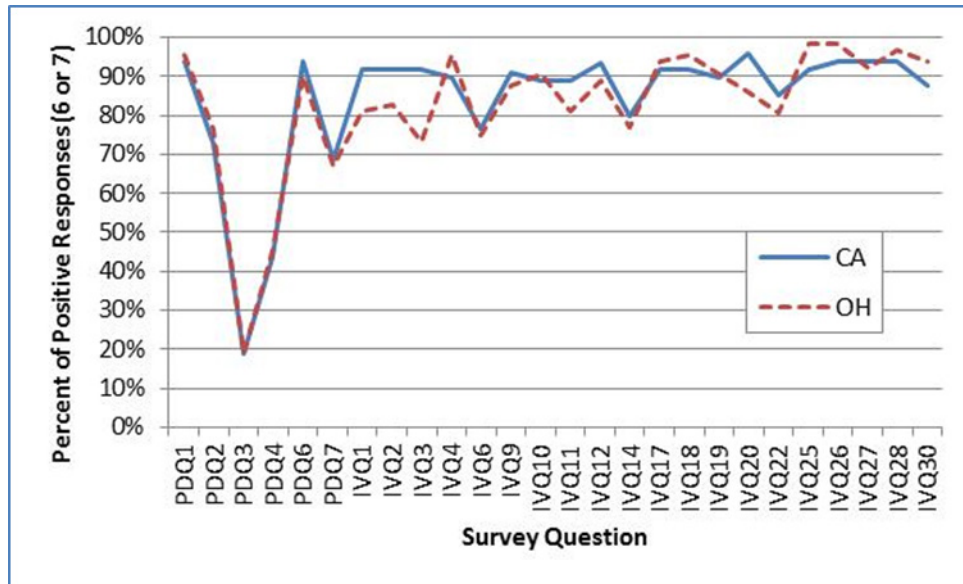
Figure 7. Percent of Responses to Likert-Scale Survey Questions That Were Positive (Score of Six or Seven)

The questions (listed on the horizontal axis) are from either the post-drive survey or the in-vehicle survey. Refer to Appendix A for the wording of each question.

3.2   Responses Grouped by Objective

The following stacked bar charts show the results from all three surveys (pre-drive, in-vehicle, and post-drive), grouped by analysis objective. The charts illustrate the percentage of responses that fell into each of the three score bins (split according to 12-345-67). The number of respondents in each bin is listed in each bar.

Usability

The majority of subjects rated all safety applications effective (Figure 8). However, there may have been an order effect, since the order in which subjects experienced the safety applications was the same for all subjects and corresponds with the relative effectiveness rating below. The last-experienced safety application (BSW/LCW) was rated highest and the first-experienced safety application (IMA) was rated lowest.
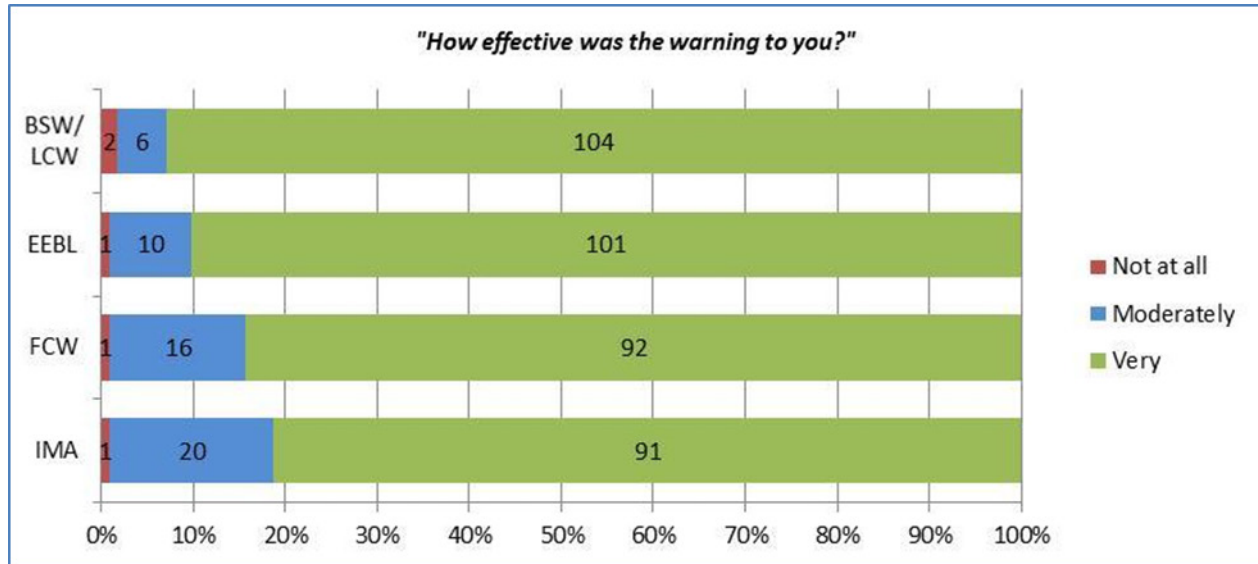
Figure 8. Effectiveness of the Different Safety Applications Rated in

Questions 3, 11, 19, and 27 of the In-Vehicle Survey

One factor impacting effectiveness is whether alerts are auditory only, visual only, or both. For each safety application, subjects were asked which presentation they preferred. For the demonstration, all subjects experienced simultaneous auditory and visual warnings (although they may not have always noticed both). The results showed most subjects wanted the alert to include both a visual and an auditory component (Figure 9) and considered the visual warnings to be "clear and obvious" (Figure 10). Unlike the other questions on a seven-point scale, this question allowed an answer of zero for those who did not notice a visual warning at all). For subjects who preferred to receive only an auditory warning, most expressed a desire not to take their eyes off the road during an emergency situation in order to look at the display. This concern was raised in the open-ended answers multiple times, with subjects stating a preference for a heads-up display on the windshield, or stating their unease with looking away from the road.

11
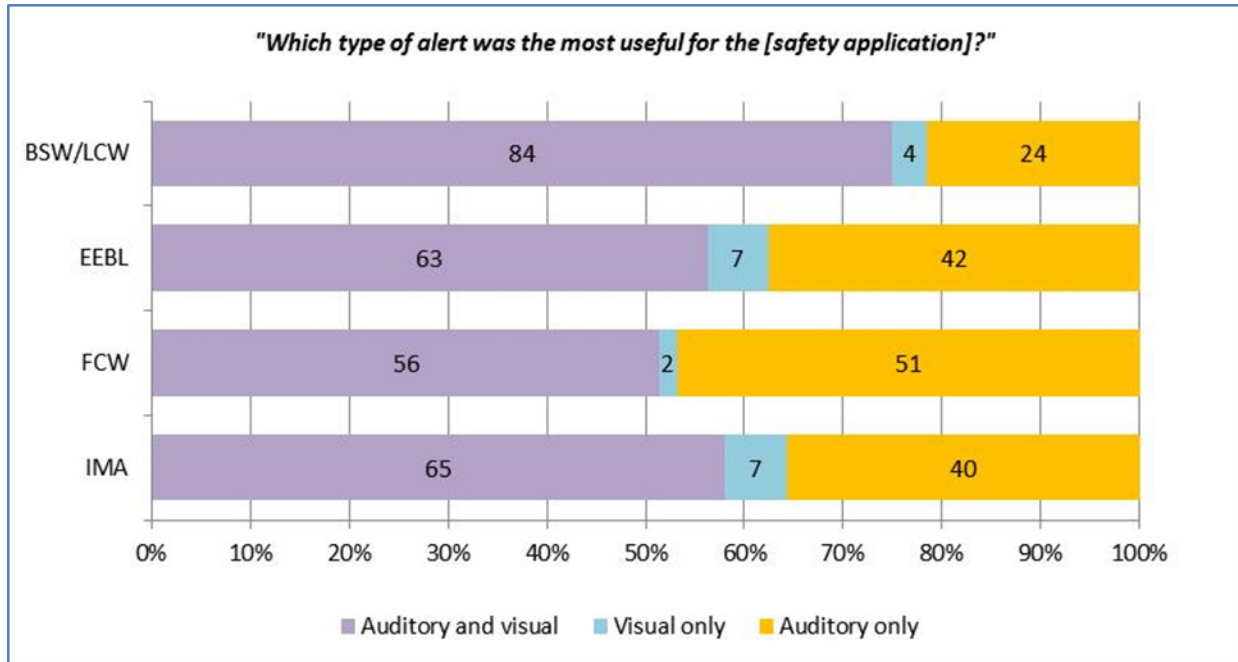
Figure 9. Usefulness of Alerts Presented as Auditory, Visual, or Both for Each Safety Application Rated in Questions 5, 13, 21, and 29 of the In-Vehicle Survey
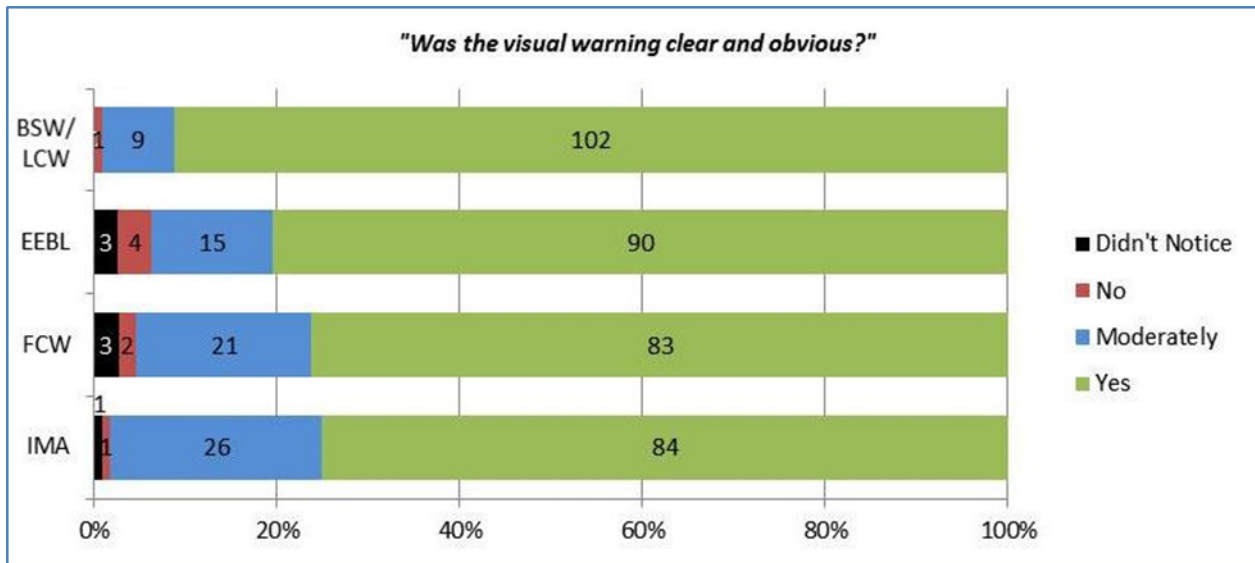
Figure 10. Clarity of Visual Warnings for Each Safety Application Rated in Questions 6, 14, 22, and 30 of the In-Vehicle Survey

Perceived Safety Benefits

Subjects gave very high approval rates to the perceived safety benefits provided by each safety application overall during the in-vehicle surveys (Figure 11). The BSW/LCW received the highest ratings of usefulness, followed by the EEBL, and the FCW. The IMA received the lowest number of high ratings (although it did not receive any "not useful" ratings).
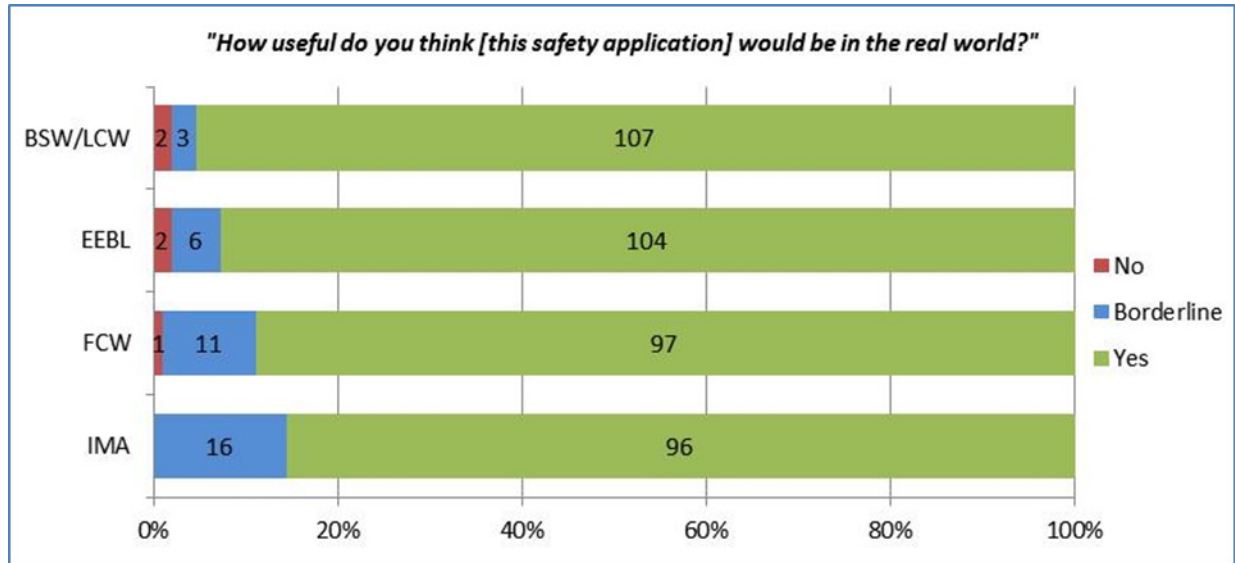
Figure 11. Rated "Real-World" Usefulness for Each Safety Application Rated in Questions 1, 9, 17 and 25 of the In-Vehicle Survey

Again, the above relative preferences between safety applications may be affected by the order in which the applications were experienced, since the order is the same as the inverse of the order of preference, with the application rated most useful being experienced last and the least useful being experienced first. That this may be an order effect is directly addressed by Table 1, in which subjects ranked the safety applications in a slightly different order when considering them all together and after the fact.

Table 1. Mean Ranks in Answer to Question 20 of the Post-Drive Survey

Safety Application	Mean Rank
BSW/LCW	2.1
EEBL	2.2
IMA	2.7
FCW	3.0

The following two questions from the post-drive survey looked at subjects' opinions of the potential for driver distraction caused by the safety applications. The answers reveal an overall perception that even though 75 percent of subjects estimate the degree of distraction caused by the applications to be comparable to operating a car radio (the same percentage found in the report on the light-vehicle DACs; [2]) (Figure 12), 81 percent believed there was some likelihood of drivers becoming dependent on the warning applications to alert them to danger (Figure 13).
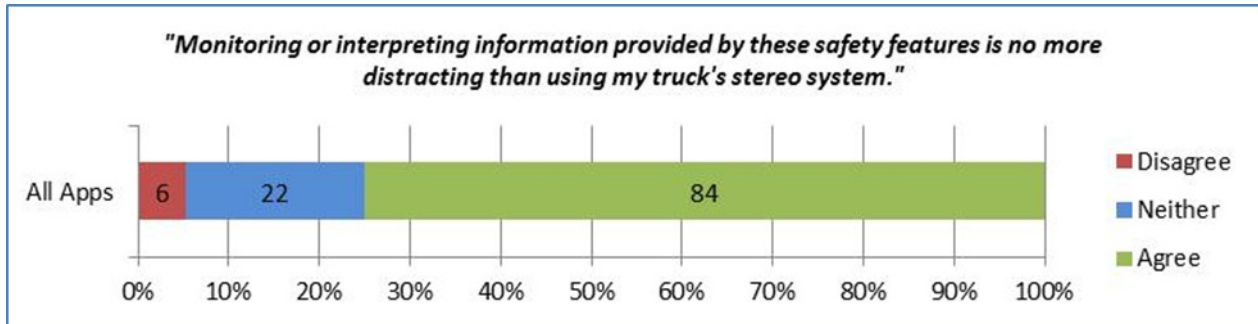
Figure 12. Distraction Potential (Question 2 of the Post-Drive Questionnaire)
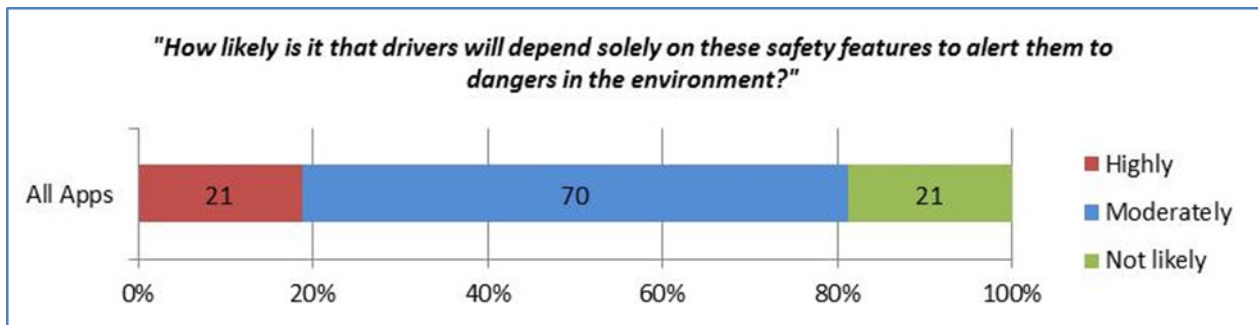
Figure 13. Likelihood of Overreliance on Safety Applications (Question 3 of the Post-Drive Survey)

Several drivers expressed further concern for unintended consequences in Question 21 of the post-drive survey:

- "Each driver must learn not to rely on these safety devices. Still no substitute for driver looking and staying alert."
- "The only con of all these things that I can see in the future is that some of the future drivers may begin to rely on this technology too much and pay less attention to the actual road."
- "Warning not to depend on system. Must be used with SAFE driving practices. There are (maybe) legal implications for ignoring warning system. Driver should be made aware."
- "I think this is helpful and useful. My only reservation is that I believe these systems would hamper drivers in developing instincts. I am a million-mile safe driver and I feel the instincts I have built over the years have been good to me. But if I had the choice in a vehicle with or without this system, I would use the warning system."

Question 6 of the Post-Drive survey indirectly relates to the issue of overreliance. Subjects were told, "It is possible that the Vehicle-to-Vehicle Communication safety [application] may become temporarily unavailable, and not warn you when it otherwise would. With that in mind, please answer the following." They were asked whether or not they would want to be notified when the application was unavailable. The overwhelming majority answered affirmatively (Figure 14). This question relates to overreliance, since needing to know when the application is online implies that drivers may act differently when the application is on or off.
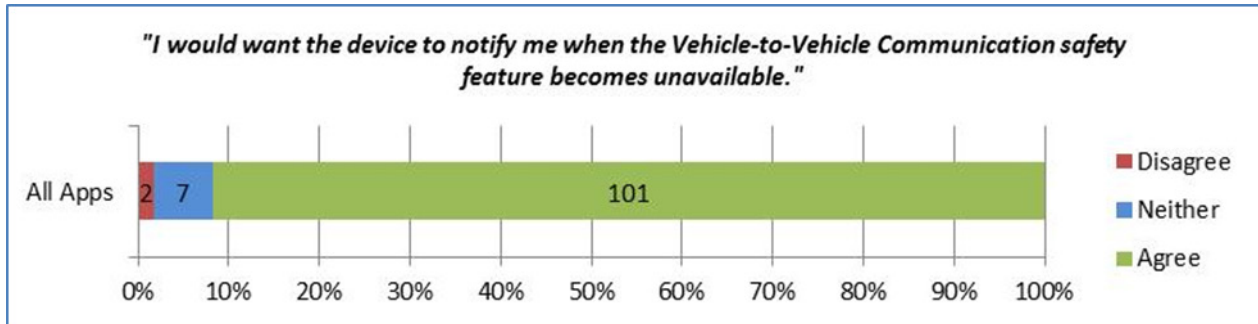
Figure 14. Notification When the V2V Application Is Unavailable (Question 6 of the Post-Drive Survey)

Understandability

During the in-vehicle survey when asked if a given safety application was easy to understand, the large majority of subjects rated their understanding as high for each application (Figure 15).
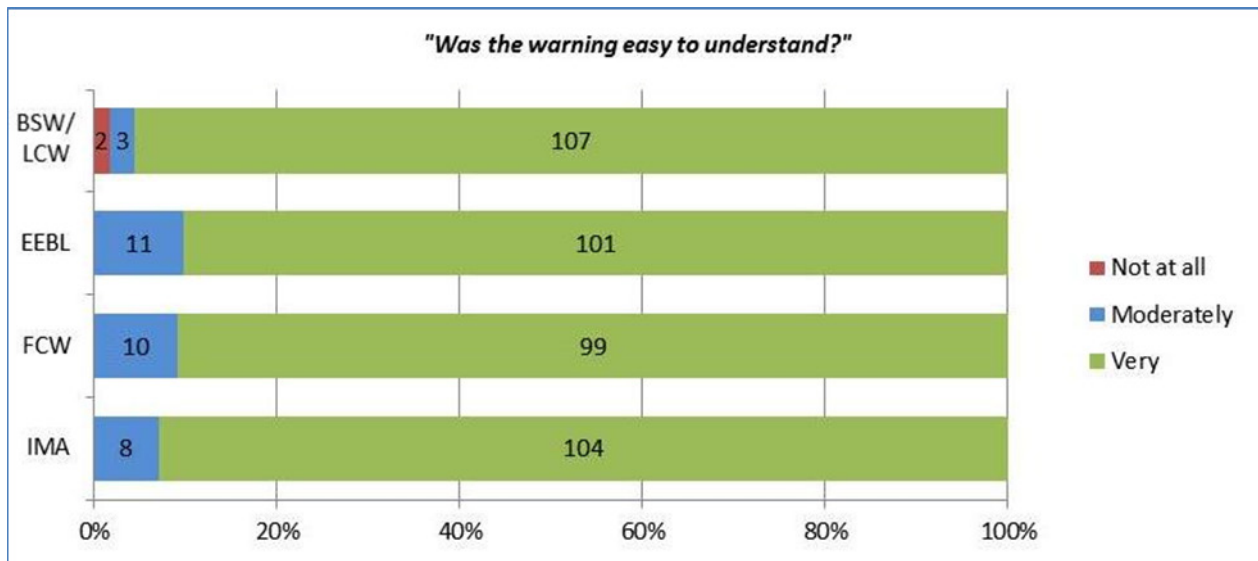
Figure 15. Understanding of the Safety Applications (Questions 4, 12, 20, and 28 of the In-Vehicle Survey)

In the post-drive survey, a large number of subjects reported feeling that there would be some confusion in identifying which safety applications (referred to as "features" in the survey) provided which warnings (Figure 16).
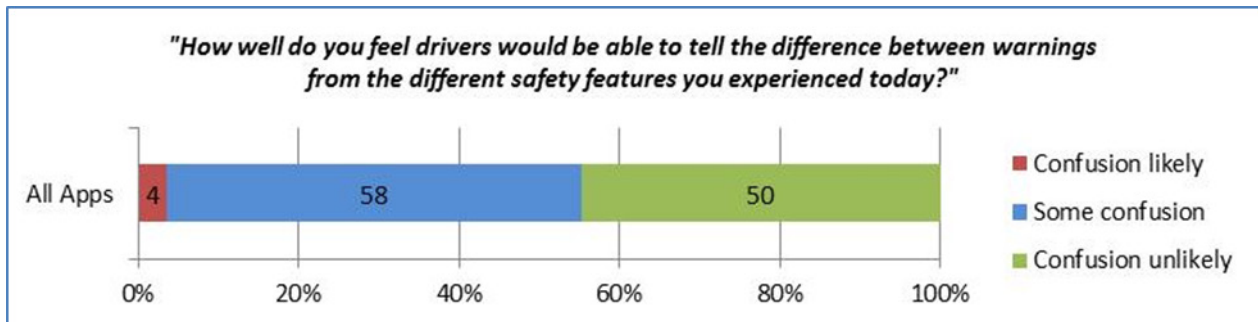
Figure 16. Potential for Confusing the Safety Applications (Question 4 of the Post-Drive Survey)

After completing the demonstration subjects were asked how well they understand the technology (for all applications) and how it works. The question was multiple choice and subjects were asked to check only one of the three options. From the wording of the question, it was unclear whether positive responses indicated an understanding of the application's basic logic, e.g., "the application beeps when I'm in danger of hitting someone," or an understanding of how the technology works on a more fundamental level, e.g., vehicle information being broadcast and received via shortwave radio. Most subjects stated "full comprehension" of the technology, with only one driver saying they didn't understand (Figure 17).
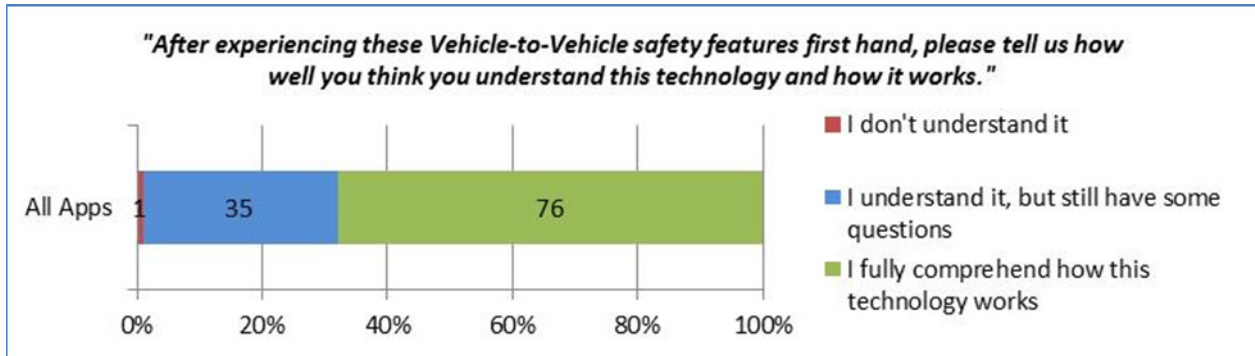
Figure 17. Understanding of "how [V2V] technology works" (Question 7 of the Post-Drive Survey)

Desirability

The following questions from the post-drive survey indicate that the vast majority of subjects would like to have V2V applications (referred to as "features" in the survey) on their truck (Figure 18).
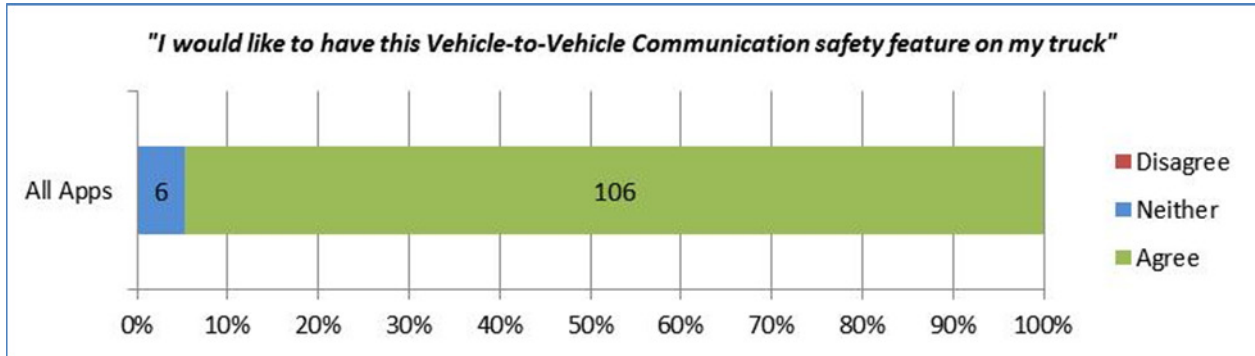
Figure 18. Desirability of the Combined Package of All Four Safety Applications (Question 1 of the Post-Drive Survey)

When broken down by individual safety application in the in-vehicle surveys, the IMA was the least strongly rated—but as before, it was still rated overwhelmingly positive, with over 87 percent of respondents giving it a six or seven (Figure 19).
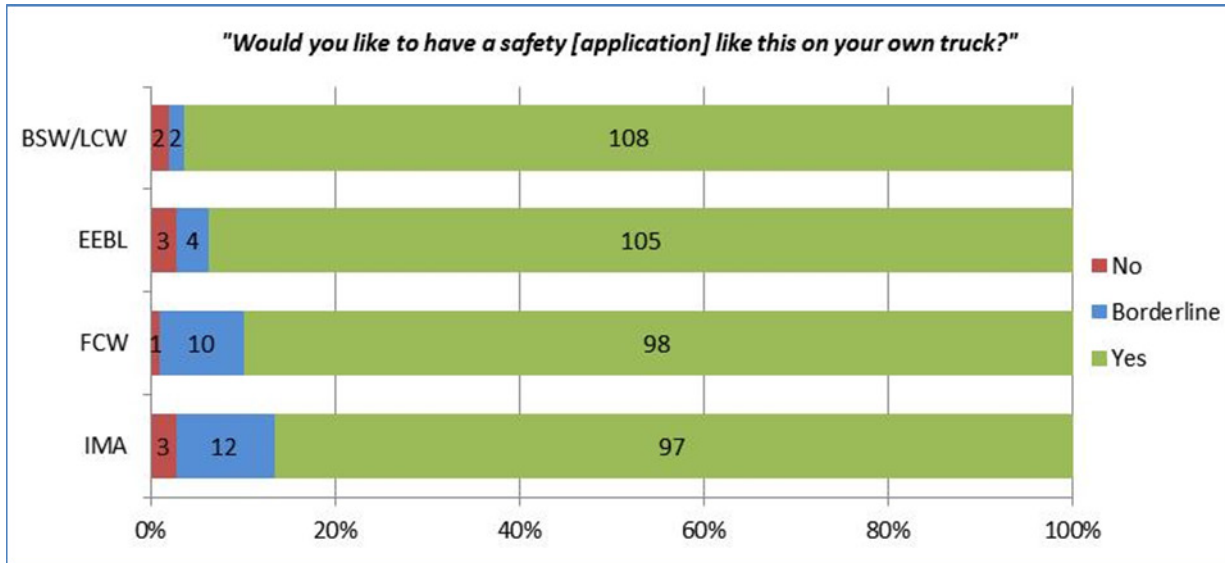
Figure 19. Desirability of the Individual Safety Applications (Questions 2, 10, 18, and 26 of the In-Vehicle Survey)

After experiencing the technology, subjects ranked their desire for V2V technology in comparison with other options for vehicle systems. In order—from most to least desirable—subjects ranked V2V first, followed by FCW (via Eaton Vorad or Meritor OnGuard), adaptive cruise control, stability control systems, GPS, and finally tire-pressure monitoring systems. Table 2 shows the mean rankings for different vehicle systems in response to the question, "Please rank the following options in terms of overall desirability, with 1 being the MOST preferred and 6 being the LEAST. Use numbers 1-6 only once." Row order is the same as it was in the in-vehicle survey. Note that even though not all subjects may have experienced all of these systems, all of them recently experienced V2V technology.

Table 2. Mean Rankings for Different Vehicle Systems

Available Option	Mean Rank
Adaptive Cruise Control (slows down when somebody is in front of you)	3.8
Forward Collision Warning Application (Eaton Vorad or Meritor OnGuard)	2.7
GPS Navigation System	4.2
Roll Stability Control or Electric Stability Control	4.0
Tire Pressure Monitoring System	4.5
Vehicle-to-Vehicle Warnings (All of the safety applications you experienced today)	1.8

Security and Privacy

There were no questions asking subjects directly about security and privacy concerns (it could be argued this could be construed as asking a leading question, thus creating driver concerns rather than checking to see if drivers had initial concerns). Consequently, Volpe checked responses to the open-ended questions to see if drivers raised security or privacy-related concerns on their own. Question 21 of the post-vehicle survey, which asked "any final thoughts or comments on your overall experience today that you would

like to provide?" was the most relevant. Only one of the 112 subjects raised an issue relating to either security or privacy, namely, "can someone rig something to send false info to mess with a driver?"

3.3   Environmental Conditions

For each safety application in the post-drive survey, subjects were asked "under what environments and conditions do you feel the safety [application] would provide the most benefit? (Circle all that apply)." Since subjects were able to circle all that apply, there may be as many as 112 responses for each answer, which is the total number of subjects.

Volpe compiled the number of drivers who circled the option for each safety application, in addition to the qualitative answers to "other, please specify" subjects may have written in by hand (only redundant or non-relevant answers were omitted). Overall, subjects picked all options with high frequency for each safety application (Figure 20). From to 16 subjects provided an answer for a given safety application under "other." For the IMA warning, poor visibility and obstructed views were the most widely chosen (Figure 20). For FCW, all options except daytime driving were commonly picked (Figure 21). The responses for EEBL (Figure 22) and BSW/LCW (Figure 23) were similar. Representative written-in responses to the "other" option are provided below each chart. "Heavy traffic," "rush hour," and "distracted/tired" drivers were common answers for all safety applications. Situations obstructing views were listed for the IMA and factors causing vehicles to suddenly stop were listed for the FCW and EEBL alerts. Several drivers cited "motorcycles passing on the right" as a use for the BSW/LCW safety application.

Figure 20. Environments and Conditions Providing the Most Benefit – IMA Safety Application

Based on Question 10 in the post-drive survey, subjects wrote down the following under the IMA "other" option.

- "city driving"
- "helps keep you focused"
- "driving in fog," "fog"
- "when pulling from driveways or blind intersection"
- "tired drivers/distracted drivers," "could save a tired driver from making a mistake he wouldn't normally make"
- "highway driven rush hour," "heavy traffic"

- "trees and signs block trucks a lot"
- "over the hill"
- "any application," "help at everything," "helps keep you focused and lessens chance of collision"
- "a stoplight on a four-lane highway. The light changes for you, but the driver in the outside lane doesn't stop. This warning would be very helpful," "busy intersections"

FCW

Condition	Number of Responses
Nighttime driving	95
Daytime driving	79
Driving on slippery roads	94
Driving under poor visibility conditions	105
Driving on unfamiliar roadways	85
Driving when view of road ahead is partially blocked	99
other	13

Figure 21. Environments and Conditions Providing the Most Benefit – FCW Safety Application

Based on Question 13 in the post-drive survey, subjects wrote down the following under the FCW "other" option.

- "stop-and-go traffic," "heavy traffic conditions," "during rush-hour traffic in large cities," "highway driven rush hour," "heavy traffic or stopping traffic"
- "two-lane country roads"
- "tired drivers / distracted drivers," "when thinking or daydreaming," "fatigued or tired driver not paying attention," "tired or distracted driving"
- "cars stopped due to an accident or break down"
- "any application I could imagine this system would be helpful"
- "fog"
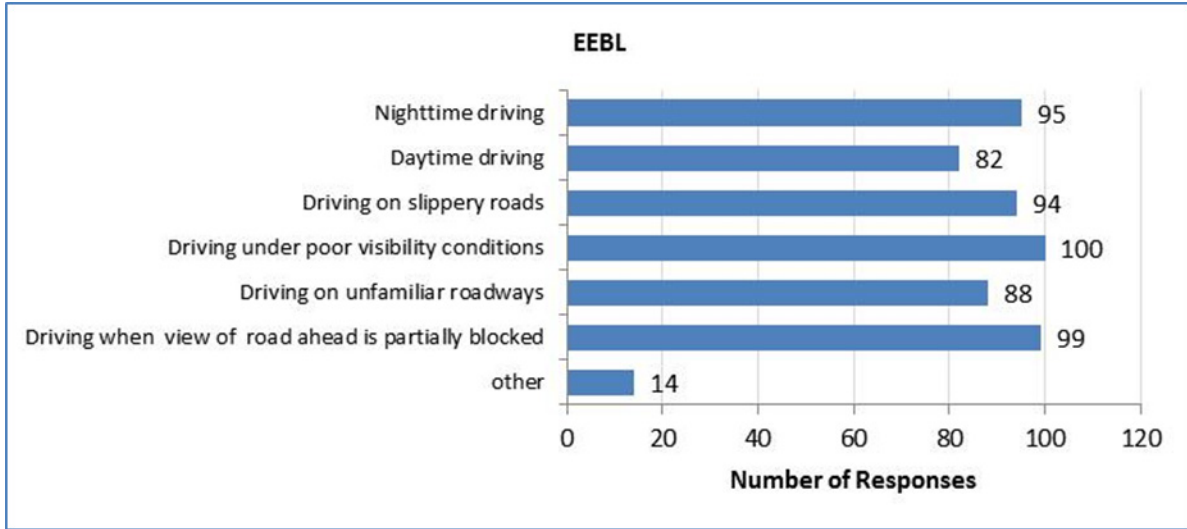
Figure 22. Environments and Conditions Providing the Most Benefit – EEBL Safety Application

Based on Question 16 in the post-drive survey, subjects wrote down the following under the EEBL "other" option.

- "commuter traffic, heavy," "city traffic," "rush hour," "stop-and-go traffic, like rush hour traffic when vehicles are close together," "highway driven rush hour," "heavy traffic," "city driving"
- "freeway or highway driving"
- "stalled vehicles in lane"
- "tired drivers/distracted drivers"
- "heavy traffic/downhill"
- "fog"
- "animals running across the road causing a car to slam on the brakes"
- "a warning for stopped traffic that might be on the other side of a hill such as mountain back-up going down the other side"
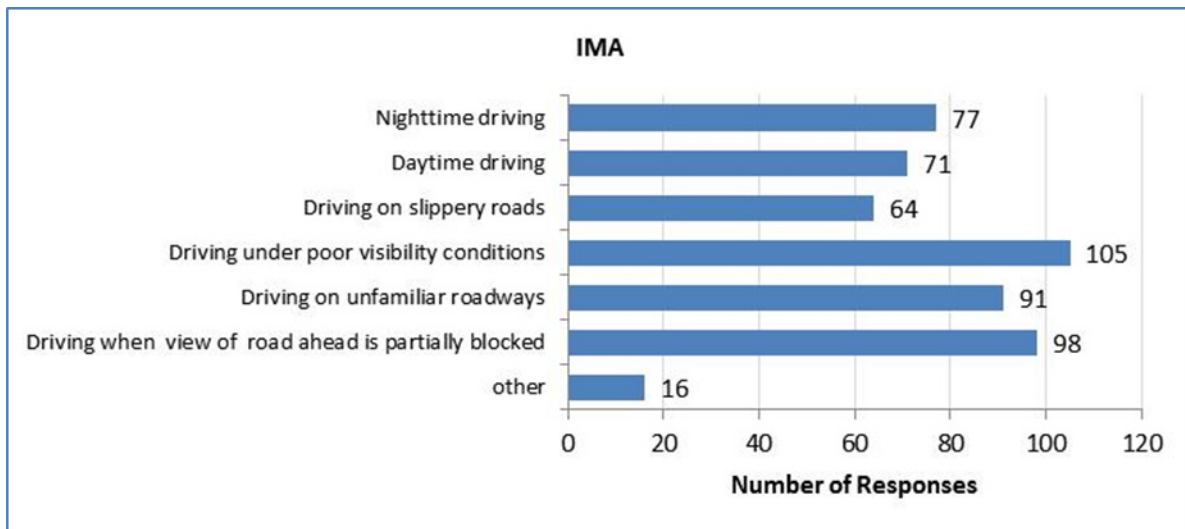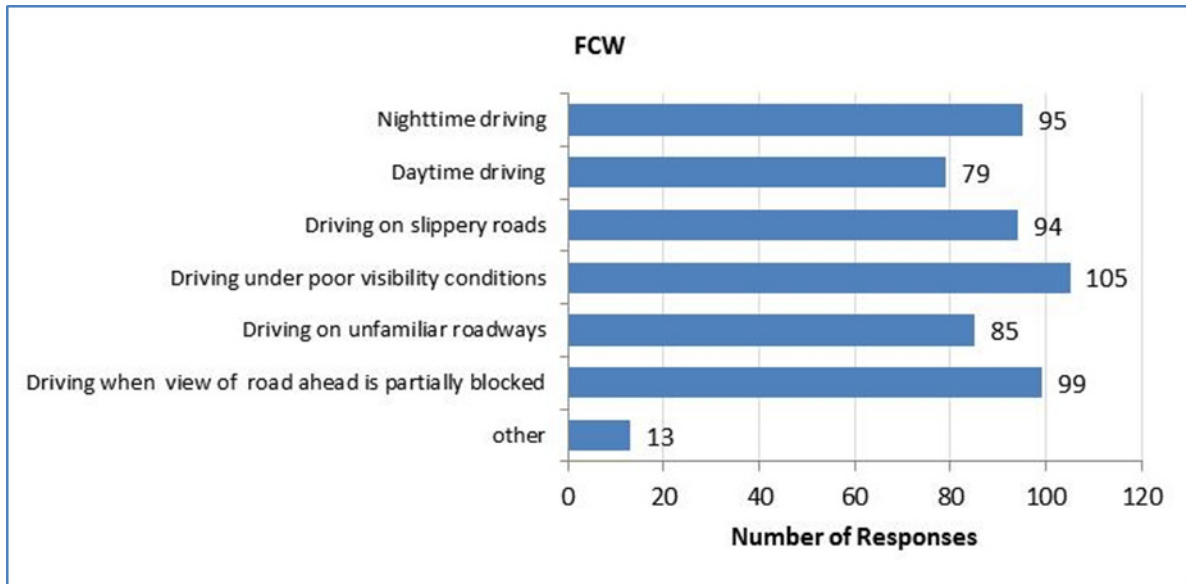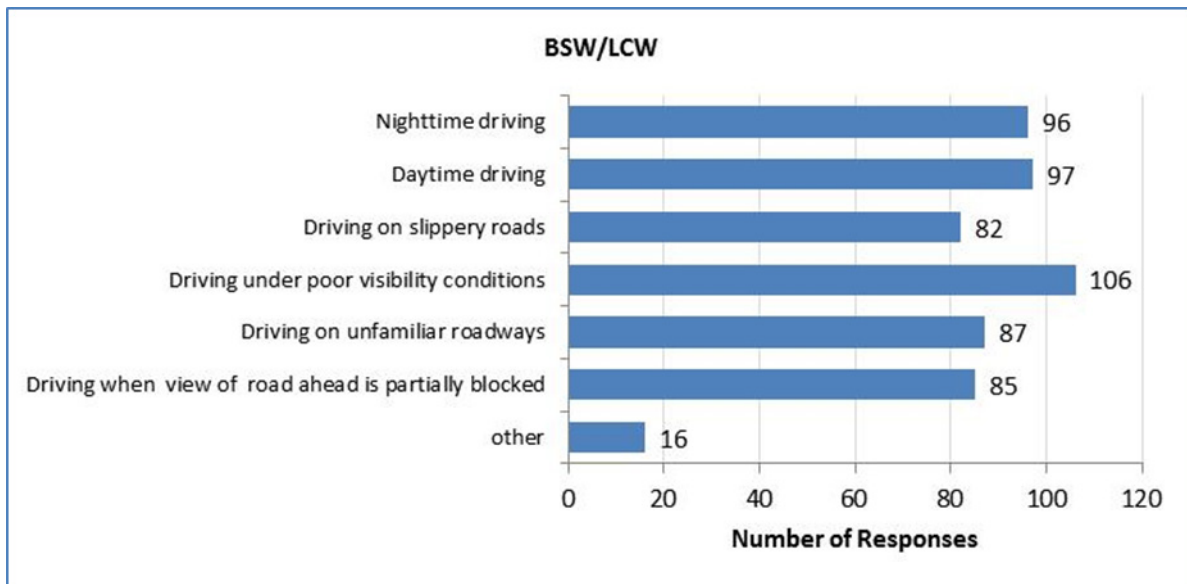

Figure 23. Environments and Conditions Providing the Most Benefit – BSW/LCW Safety Application

Based on Question 19 in the post-drive survey, subjects wrote down the following under the BSW/LCW "other" option.

- "making right turns"
- "motorcycle riders that pass on right"
- "rush-hour traffic" (3), "highway driven rush hour," "heavy traffic" (3), "city driving"
- "two-lane country roads"
- "when driving in lots"
- "tired drivers/distracted drivers," "when driver's been on the road for a while"
- "city traffic, leaving or entering toll booth"

3.4 Effect of Age

The ages of the 112 volunteers who took part in the clinics ranged from 28 to 66 years old. The mean age was 47.2 years old, with a standard deviation of 9.3 years.

Correlation Analysis

Volpe conducted Spearman correlation tests to test for relationships between responses to Likert-scale survey questions and years of age. There were a couple of statistically significant correlations (p-values < 0.05), which is not unusual given the large sample size, which ranged from 108 to 111. However, the most important measure in such correlations is not the degree of significance, but the magnitude of the correlations. For this measure, nothing was found; all of the correlation coefficients (r_s) were between 0.2 and -0.1 and were therefore very weak or non-existent. In other words, there did not appear to be any non-weak linear relationships between survey responses and age. This was true for both the individual safety applications as well as the combined system. As an example, in Figure 24 the combined application is graphed in a scatter plot in which no clear pattern is visible and most subjects, regardless of age, gave scores of sevens. In this case, the results of the correlation test were: $r_s = 0.06$, $n = 111$, $p = 0.5$, two-tailed.
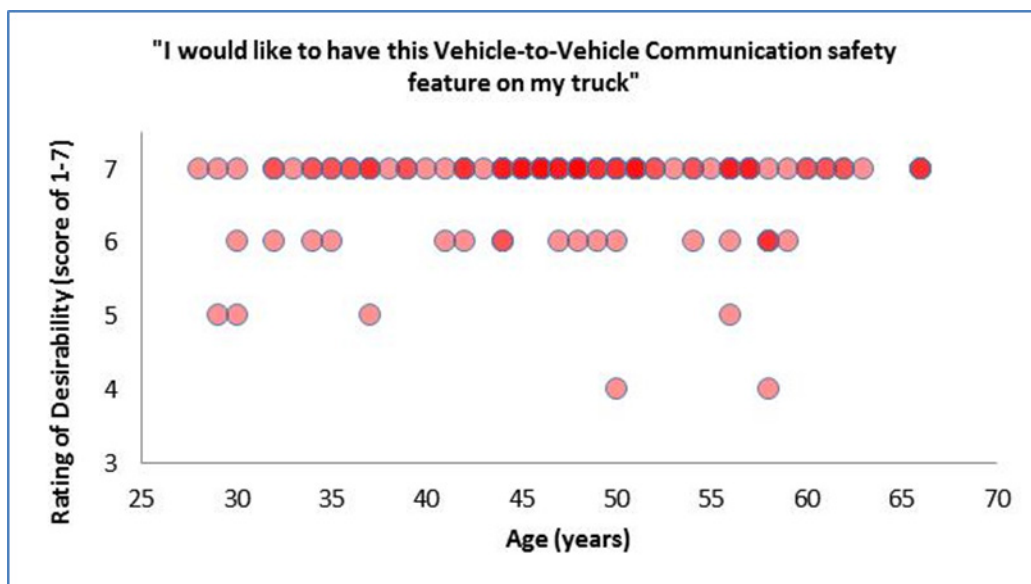
Figure 24. Ratings of Desirability as a Function of Age

Ratings are from Question 1 of the post-drive survey. The red circles are partly transparent so that when multiple data points fall on the same spot, the stack darkens, indicating how frequently an answer was given by a certain age. The two variables are not statistically correlated.

Analysis Comparing "Age Bins"

Volpe also divided the subjects into subgroups ("bins") by age and compared the ratings using non-parametric between-subject tests. The analysis focused on Likert-scale questions related to driver acceptance, specifically questions 1-4 on the post-drive survey and questions 1-3, 4-6, 9-12, 14, 17-20, 22, 25-28, and 30 on the in-vehicle survey (refer to the Appendix for the wording of each question). Since the age distribution was mostly random and not created *a priori* based on any plan to capture interesting age ranges, it was not clear how to divide the range into bins.

Consequently, Volpe used two different division strategies. In the first, ages were divided into two groups: 28-50 and 50-66. In the second, three groups were used: 28-39, 40-49, and 50-66. Since analyses following either strategy yielded the same results, only the results from the second strategy are shown since the trends are better illustrated with three bins. Kruskal-Wallis omnibus tests were used to compare all three age bins between subjects. There were no significant differences between age groups (in all cases $p > 0.05$).

3.5   Effect of Previous Driving Route Experience

When asked to report the number of years with a CDL-A license, the mean response was 18.6 years, with a standard deviation of 11.7 years. The least amount of time was five months and the longest 41 years. For the number of years of experience driving a tractor trailer, the mean response was 17.7 years, with a standard deviation of 11.8 years. The least amount of time was again five months and the longest 41 years.

To determine whether there was a difference in the acceptance of V2V technology between route types, subjects were divided into three groups: those who had driven only local "pick-up & delivery" (P&D), those who had driven only line haul, and those who had driven both. This division was based on the survey question in which drivers were asked "What types of routes do you have experience driving?" Subjects had five answers to select from:

     a. Local,
     b. Over the road,
     c. City driving,
     d. Truckload, and
     e. Less than truckload.

Answers to (a) and (c) were considered P&D, and (b) was considered line haul. The majority of drivers have experience with both types of routes and no driver had experience with neither (Figure 25).
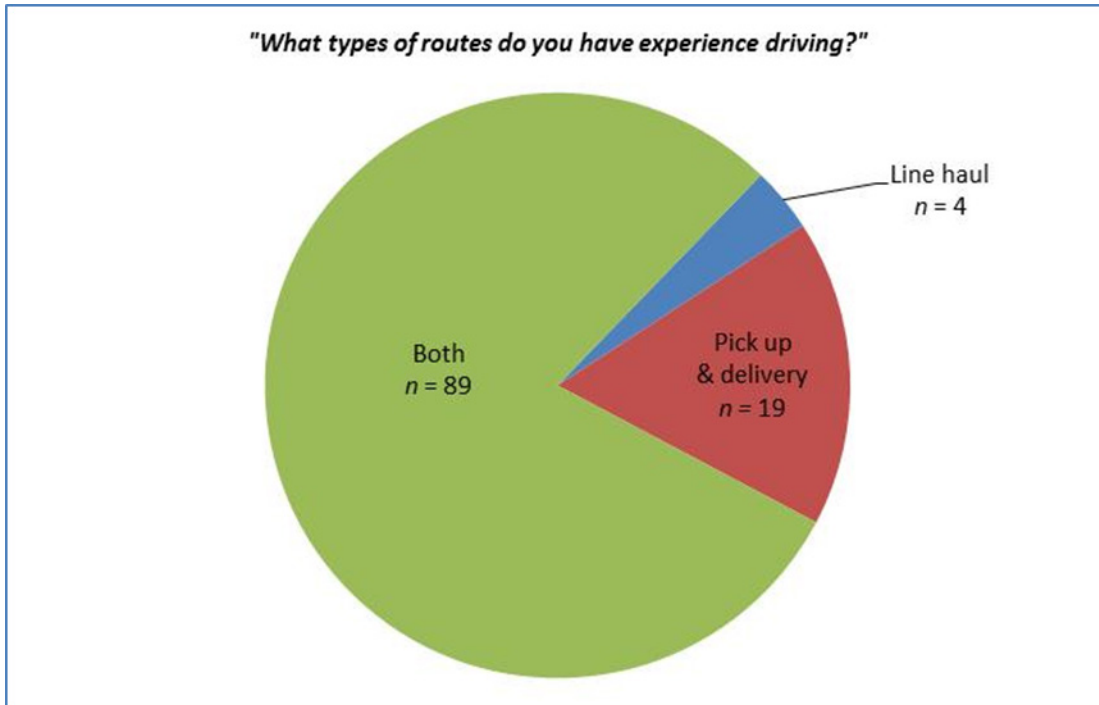
Figure 25. Reported Route Experience Based on Line Haul, Pick-Up and Delivery, or Both Route Types (Question 4 of the Pre-Drive Survey)

Unfortunately, there were too few drivers with only line-haul experience to include them in statistical analyses, so the following tests compared those with P&D experience to those with P&D experience as well as line-haul experience.

Out of the 24 questions compared for these two groups (the same 24 questions used in the age-effect analysis above), only two showed significant differences. Drivers with experience in both types of routes tended to give higher ratings for the effectiveness of the EEBL warning than those with only experience with P&D (Mann-Whitney test, $U = 660$, $n_{both} = 89$, $n_{P\&D} = 19$, $p = 0.045$, two-tailed). Drivers with experience in both routes also rated understandability of the BSW/LCW warning higher ($U = 681$, $n_{both} = 89$, $n_{P\&D} = 19$, $p = 0.011$, two-tailed) (Figure 26). Since 24 tests were conducted in this particular analysis, the risk is that there will be a significant result by random chance. Furthermore, the sample size for the P&D group was much smaller than the "both" group (19 compared with 89) and was considered more "volatile" and prone to large changes in proportions with small changes in numbers. Similar to the age-effect analysis, these results should be considered suggestive.
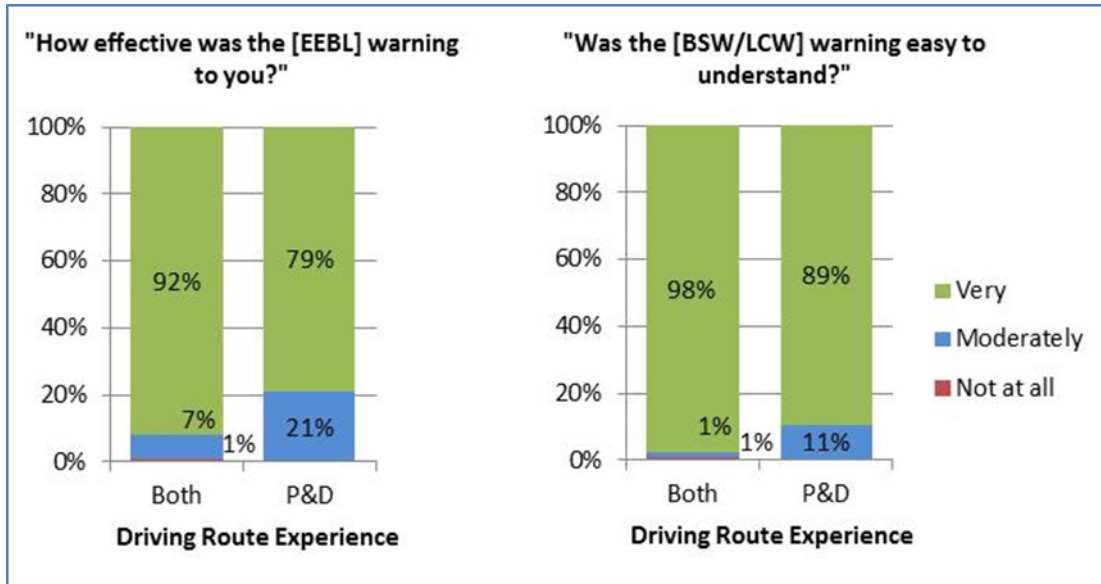
Figure 26. Comparison of Responses Between Drivers With Line Haul and Pick-Up and Delivery Experience and Drivers With Pick-Up and Delivery Experience Only (Based on Questions 19 and 28 of the In-Vehicle Survey)

3.6 Effect of Previous Experience with Safety Applications

Although collision warning applications based on V2V communication are a new technology, collision warning applications based on other technologies, such as onboard radar or cameras, are already in use. To determine whether prior experience with other types of warning applications may have affected subjects' acceptance of V2V-based technology, the pre-drive survey included two questions about other types of warning application. The first asked drivers, "Which of the following devices are installed or available to you in your primary truck?" (Question 9). The second asked, "Which devices would you like to have installed or available in your truck?" (Question 10). For both questions a range of devices were then listed, next to which subjects could check one of three columns; Question 9: "installed"/"don't know"/ "not installed"; and Question 10: "desirable"/"don't know"/"not desirable." Of the 21 devices listed (see the Appendix for the full list), the following six included audio or visual warnings for impending collision capabilities similar to the V2V safety applications used in the DACs: Cadec, Eaton Vorad, FCW, LDW, OnGuard, and Wingman.

Table 3 shows the responses to device possession and desire, grouped by device. There was a large degree of uncertainty about which devices drivers had in their vehicles, although most drivers had none of them. The type of device with the highest installation rate was Cadec. The lane departure warning (LDW) and FCW devices had the lowest rate; they were also the two devices with descriptive rather than brand names and the most desired devices—the rest had a large degree of uncertainty of desirability. For the most part, the devices all received very few "not desirable" ratings. Blank responses were dropped rather than make the assumption these meant "not installed."

Table 3. Number of Drivers With Collision Warning Devices on Their Vehicles and the Number of Drivers Who Wanted the Device on Their Vehicles (Based on Questions 9 and 10 of the Pre-Drive Survey)

Device	Installed in <u>primary</u> truck?			Like to have?		
	Not installed	Don't know	Installed	Not desirable	Don't know	Desirable
Cadec	37	39	9	8	59	12
Eaton Vorad	48	30	4	11	60	13
FCW	71	9	8	3 7	89	
LDW	72	9	3	4	18	76
OnGuard	64	14	5	8	51	31
Wingman	62	17	2	6	64	18

The data in Table 4 is broken down by driver rather than device as shown in Table 3. A total of 25 drivers gave no answer for any of these six devices for either the do-you-have-it-installed or the do-you-want-it-installed questions, and were dropped from the table. Only 19 drivers or 22 percent of the drivers had at least one warning device installed, and of these drivers 89 percent wanted at least one device. Of the 78 percent of drivers who had no devices in their primary trucks, 90 percent wanted to have at least one device.

Table 4. Number of Drivers Who Have and Want at Least One of the Six Collision Warning Devices (Based on Questions 9 and 10 of the Pre-Drive Survey)

		Want installed?		
		At least one	None	Total
Have Installed?	At least one	17	2	19
	None	61	7	68
	Total	78	9	87

When drivers who did or did not *have* at least one of the six collision warning devices installed were compared, their user acceptance ratings were roughly the same. Mann-Whitney between-subject tests found no statistically significant differences ($n_{at\text{-}least\text{-}one\text{-}device}$ = 21-22, $n_{no\text{-}devices}$ = 70, all p-values > 0.05).

When the above comparison was repeated for those who did or did not *want* one of the six non-V2V collision warning devices there were several differences. Out of the 24 questions, the responses to two questions relating to the FCW safety application showed statistically significant differences. In both cases, acceptance of at least one of the six non-V2V-based collision warning devices carried over to the V2V-based FCW safety application. Subjects wanting one of the devices rated the V2V safety application as both more useful (Question 9 on the in-vehicle survey; Mann-Whitney test, U = 346, n_{want} = 92, $n_{don't\text{-}want}$ = 11, p = 0.025, two-tailed) and more desirable (Question 10 on the in-vehicle survey, where "feature" means application; U = 303, n_{want} = 92, $n_{don't\text{-}want}$ = 12, p = 0.001, two-tailed) (Figure 27). Given the large number of tests conducted, there is a chance these two responses were significant by random chance. Furthermore, the strongly unequal sample sizes means the smaller group (in this case "Don't

want") is more volatile or prone to variability. These findings should therefore be considered pilot findings for the SPMD rather than actual evidence.
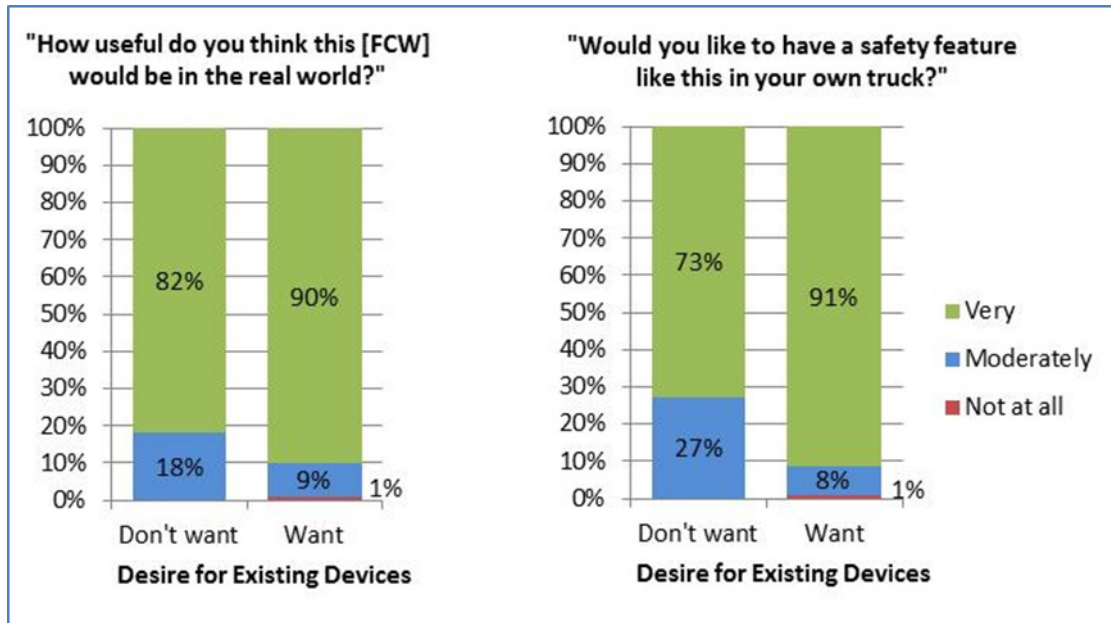
Figure 27. Comparison of Responses for the FCW Safety Application Between Drivers Who Listed at Least One of the Six Non-V2V Devices as Desirable ("Want") and Drivers Who Did Not ("Don't Want")

3.7 Outlier Analysis

Overall, the subjects had a very clear positive response to V2V technology. When asked in the post-drive survey to respond to the statement, "I would like to have this Vehicle-to-Vehicle Communication safety [application] on my truck" (Figure 18), responses were strongly positive. Similar to the light-vehicle DAC results [2], the median response was the maximum response; a seven. During the analysis of the light-vehicle DACs, this question was used to identify negative outliers, which were defined as those who rated agreement three or less times (out of 406 drivers, nine qualified). However, during the heavy truck DACs no drivers gave ratings of less than five, meaning all responses were at least somewhat positive.

Consequently, outliers were identified based on their scores rating the safety applications individually. Subjects were viewed as outliers when, for at least one safety application, they gave a response of less than four to the question, "would you like to have a safety [application] like this on your own truck?" Table 5 shows how those individuals responded to other questions. Note that the column labeled "ALL" is neither the mean nor the sums of the other columns, but is the answer to a separate question referring to the suite of safety applications combined. Scores below four are shaded in red. Dashes indicate that there was no answer for that run.

Table 5. Outlier Analysis Listing Responses to Questions by Subjects Who Rated at Least One Individual Safety Application as Undesirable by Giving a Less-Than-Neutral Score (Less Than Four)

ID	Age	Clinic	Would you like to have it?					How useful would it be?				Warning received			
			IMA	FCW	EEBL	BSW/LCW	ALL	IMA	FCW	EEBL	BSW/LCW	IMA	FCW	EEBL	BSW/LCW
019	58	CA	3	4	1	6	4	4	5	2	5	CI	C-	-I	CI
020	60	CA	7	7	7	1	7	7	7	7	1	CI	C-	IC	CI
036	35	CA	7	-	1	7	7	7	-	2	7	CI	--	-I	CI
040	29	CA	6	5	2	7	5	6	6	4	7	CI	-I	-I	CI
042	47	CA	6	2	7	7	7	6	7	7	7	CI	C-	C-	CI
050	50	OH	3	7	6	7	7	4	6	7	7	CI	-I	-I	CI
054	30	OH	3	7	5	7	5	4	2	5	7	CI	CI	CI	CI
055	48	OH	1	4	7	7	6	4	5	7	7	CI	CI	-I	CI
067	44	OH	2	7	7	7	6	4	7	7	7	CI	-I	-I	CI
085	56	OH	7	7	7	1	7	7	7	7	1	CI	C-	-I	CI
089	35	OH	1	7	6	7	6	4	7	4	7	--	--	--	--

Under the "Warning Received" column, "CI" indicates a cautionary-then-imminent alert, "C" indicates a cautionary alert only, "I" indicates an imminent alert only, and "IC" indicates an inverted imminent-then-cautionary alert order. Under the "Would you like to have it?" column the results for IMA, FCW, EEBL, and BSW/LCW are from in-vehicle survey questions 2, 10, 18, and 26, respectively. "All" results are from post-drive survey Question 1. Under the "How useful would it be?" column, from left to right the results are from in-vehicle survey Questions 1, 9, 18, and 25, respectively.

The last four columns of Table 5 show the warnings received by each driver in each demonstration. Ideally, subjects would receive either a cautionary followed by an imminent warning or, if there was insufficient time before collision for a cautionary, only an imminent warning. In many cases, drivers braked when hearing the cautionary warning and consequently received no imminent warning. In other cases, perhaps due to a technical glitch, the order of the alerts may have been inverted. This raises the question did the 11 outliers give negative ratings because they experienced imperfect demonstrations of the technology? This does not appear to be the case, since the low ratings by the outliers do not correspond to imperfect demonstrations. This fact, combined with the majority of imperfect demonstrations experienced by subjects who rated the application very highly, indicates that problems with the demonstrations are unlikely to be the reason for the outlier's negative ratings.

Overall, for a given safety application, subjects rated usefulness slightly higher than desirability. This finding is consistent with the light-vehicle DAC outlier analysis (the only internally inconsistent answer is Subject 054, who strongly desired the FCW alert, despite giving it a very low rating of usefulness). Likewise, even though subjects may have rated a given safety application undesirable, they tended to rate other safety applications highly, indicating their aversion is relates to the warning rather than warning applications or V2V technology in general.

The following outlier subjects made comments in the open-ended questions that explains why they gave low ratings for some applications.

Comments relating to all safety applications:

- Subject 020: for each safety application, "bigger graphics on screen" and "audio most beneficial."
- Subject 036: use different tones and different visual icons for each warning.
- Subject 042: warn with "more audio than visual [to] keep your eyes on the road."
- Subject 50: "it's better to keep a driver's eyes in the direction of the danger rather than pulling his vision and attention to the dashboard."

- Subject 55: "most would be useful but must be able to adjust. If these are on all the time, driver will not pay attention."
- Subject 089: "the alerts shouldn't sound the same, try to add voices on lane change blind spot."

Comments specific to the IMA:

- Subject 036: "my experience was beneficial because I don't believe I had actually moved prior to the warning going off. So the system was extremely effective in that scenario. I like how I just had to let off the brake."
- Subject 050: "remove the audio, install some kind of heads-up display."
- Subject 055: "as a local T/T driver (city), this [application] would not be useful. Due to high traffic conditions, alerts would be too common."
- Subject 089: "what I would change is the alert reaction time. I would adjust the reaction time because I felt the alert was late."

Comments specific to the FCW:

- Subject 042: would change to include "no visual alert."
- Subject 050: "remove the audio! Install a voice command with a heads-up display on the windshield. Keep the driver's eyes on the danger."
- Subject 055: "this [application] is too slow in reaction, needs more distance, faster warning. If truck used would have been loaded, accident would have happened." Would prefer being able to adjust "distance settings."

Comments specific to the EEBL:

- Subject 050: "remove the beeper… use a voice command with a windshield heads-up display."
- Subject 089: "I didn't feel the benefit of this safety [application]" and "what I would change on this [application] is only to be used 45 mph and under. Two-lane road only, resident, city local driving."

Comments specific to the BSW/LCW:

- Subject 050: the most beneficial aspect was "the visual display because it forced me to look in the direction of my mirror."
- Subject 055: "blind spot alert very useful but in city use this would be on all the time." Would prefer "being able to adjust."
- Subject 089: "I would use a voice that says blind spot."

4 Conclusions

Overall, driver acceptance of the V2V application in heavy trucks was very high, with the vast majority of subjects giving the maximum rating to most safety applications.

4.1 Key Findings

4.1.1 Quantitative Findings

Effect of Clinic Location

There was no detectable effect of clinic location, with those who experienced the Ohio clinics and those who experienced the California clinics giving similar responses.

Usability

Usability was rated very high, with at least 81 percent giving strongly positive ratings. However, there appeared to be an order effect, since acceptance of each safety application increased with the order in which it was demonstrated.

Perceived Safety Benefits

The perceived safety benefits were also rated high, with at least 86 percent giving strongly positive scores, although the relative preferences among the different safety applications again appeared to vary with the same order effect. The presence of an order effect was supported by the fact that when subjects were asked to think back on their ranking of the usefulness of each application, they gave a different order, ranking the IMA above the FCW safety application.

Although 75 percent of subjects rated the distraction potential of the V2V application on par with a car radio, 81 percent said there was at least a moderate chance that drivers will depend "solely" on the safety applications to alert them to dangers on the road. Relatedly, the fact that 92 percent of drivers would want to be notified when the application becomes unavailable raises the concern that drivers might behave differently with the application turned on.

Understandability

At least 90 percent of subjects gave the highest rating for understandability, although 55 percent said there was chance for at least some confusion in differentiating the various safety applications.

Between 50 and 75 percent of subjects wanted alerts to have both a visual and an auditory component. Although at least 75 percent thought the visual displays were "clear and obvious," some expressed concern that they draw one's eyes inside the cabin exactly when attention is most strongly needed outside the cabin. Others voiced concern that auditory alerts could be drowned out by the radio.

Desirability

Desirability was high, with 95 percent of subjects wanting a V2V application on their truck. When safety applications were rated individually, the lowest-rated safety application (IMA) was still desired by 87 percent of subjects, with an additional 11 percent saying they were borderline. Compared to other available options, including adaptive cruise control and GPS, subjects rated V2V the highest.

Security and Privacy

The surveys did not include questions on this topic, but one subject out of 112 raised the issue of security and privacy on their own in the written section of the post-vehicle survey.

Age Effects

There were no age effects observed. This is not surprising given the relatively narrow age range of subjects, which included very few young or old drivers.

Outliers

There were very few outliers at the negative end of the spectrum. No drivers expressed a negative (less than four) rating of agreement with the statement "I would like to have this Vehicle-to-Vehicle Communication safety [application] on my truck," when referring to the combined suite of safety applications. Outliers, therefore, had to be identified by negative ratings of individual safety applications, of which there were very few. Similar to the light-vehicle DACs, outliers rated usefulness slightly higher than desirability. The fact that subjects who rated a given safety application low also tended to rate the other safety applications high suggests that their aversions are to the warning itself and not the idea of V2V-based warning applications in general.

4.1.2 Qualitative Findings

Impact of Previous Experience on V2V Acceptance

There was some evidence to suggest that those who only drive pick-up and delivery routes were less strongly positive in their ratings of EEBL effectiveness or BSW/LCW understandability. Previous experience with six prominent types of non-V2V collision warning systems did not appear to affect ratings of V2V technology. Of those subjects who wanted at least one of the six non-V2V collision warning systems—including most of those who already had a system—most wanted FCW or LDW warnings. This desire for a non-V2V system appeared to carry over to V2V technology, with those drivers rating FCW alerts both as more useful and more desirable. This evidence is only suggestive, but it makes sense if the desire for warning applications is fairly independent of the type of technology that underlies it.

Understanding of the Underlying Technology

Even though 68 percent of the subjects said they "fully comprehend how this technology works," it is unclear what the subjects thought the question referred to—whether it meant just an understanding that alerts would be provided when another vehicle got too close, or whether it referred to principles of the underlying technology. This is important because a good understanding of the underlying principles, especially the fact that V2V technology will be constantly broadcasting your vehicle information to others and receiving information that could be falsified, are both central to whether or not drivers will have security and privacy concerns. If truck drivers resent devices that monitor their activity, this is likely to be an important factor in fleet acceptance, even if was not raised in this DAC.

Order of the Safety Applications

The experimental design did not control the order in which subjects experienced the different safety applications. This appears to have affected their relative impressions of the individual applications; in particular the IMA demonstration. Subject were asked to release the brakes and roll into the path of an oncoming vehicle before they had familiarized themselves with the vehicle—especially its brakes— during a test drive. The slightly lower scores for the IMA relative to other alert types might therefore be partly due to a low comfort level driving an unfamiliar vehicle.

Enthusiasm for the Test Trucks

Many of the drivers admired the brand-new trucks used in the DACs and said they generally operated older vehicles using older technology and less responsive brakes. It is possible that some of the

enthusiasm towards the warning technology for all of the safety applications may have been affected by driver enthusiasm for the truck demonstrating the technology.

Aversion to Technology

There is also a concern that drivers strongly averse to the kind of new technology demonstrated in the DAC are probably less likely to volunteer for such a study in the first place.

High Acceptance Rate

Since the DACs were designed to demonstrate the value of the safety applications under ideal circumstances without any of the variations, false alerts, and nuisance alerts that come into play in the real world, Volpe's expectation was a high acceptance rate. This was proved during the analysis. There is additional information on driver acceptance in the real world from subjects who took part in the heavy truck SPMD.

Additional information on driver acceptance in the real world is presented in Volpe's 2014 report *Independent Evaluation of Heavy Truck Safety Applications Used in the Safety Pilot Model Deployment* [3].

5 References

1 Pape, D., Holdridge, J., & Stephens, D. (2014). *Connected commercial vehicle integrated truck project: Driver, clinics performance tests, and lessons learned* (Report No. FHWA-JPO-13-110). Washington, DC: Federal Highway Administration. Available at http://ntl.bts.gov/lib/51000/51500/51524/FHWA-JPO-13-110_CCV-IT_Driver_Clinic_Final_Report.pdf

2 Svenson, A., Stevens, S., & Guglielmi, J. (2013). Evaluating Driver Acceptance of Heavy-Truck Vehicle-to-Vehicle Safety Applications," in *23rd International Technical Conference on the Enhanced Safety of Vehicles (ESV)*, Seoul, Republic of Korea, May 27-30, 2013.

3 Guglielmi, J., Wilson, B., Stevens, S., Lam, A., Nodine, E., Jackson, C., & Najm, W. G. (2016, January). *Independent evaluation of heavy-truck safety applications based on vehicle-to-vehicle and vehicle-to-infrastructure communications used in the Safety Pilot Model Deployment* (Report No. DOT HS 812 224). Washington, DC: National Highway Traffic Safety Administration. Available at www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2016/812224-HeavyTruckV2VReport.pdf

Appendix: Driver Acceptance Surveys

The following driver acceptance surveys are listed in the order in which they were presented to DAC subjects.

- Connected Commercial Vehicle Driver Clinics: Pre-Drive Questionnaire
- In-vehicle questionnaires:
  - Tractor Orientation
  - Busy Intersection
  - Forward Collision Warning
  - Emergency Electronic Brake Lights
  - Blind Spot Warning
- Connected Commercial Vehicle Driver Clinics: Post-Drive Questionnaire

Note that throughout the surveys, safety applications are referred to as "safety features," but their meaning is the same.

Pre-Drive Questionnaire

1. Age: _____

2. How many years have you had held a CDL-A? _____

3. How many years have you driven a tractor-trailer? _____

4. What types of routes do you have experience driving? (circle all that apply)
   a. Local
   b. Over the road
   c. City driving
   d. Truckload
   e. Less than truckload

5. What types of trucks do you have professional experience driving? (circle all that apply)
   a. Straight truck with no trailer
   b. Tractor with van semitrailer
   c. Tractor with flatbed semitrailer
   d. Tractor with tank semitrailer
   e. Truck with a pull trailer
   f. Tractor with more than one trailer
   g. Vocational (mixer, refuse, etc.)
   h. Class 6 or below
   i. Passenger (bus or motor coach)

6. Do you usually drive as an … ?

   a. Employee driver
   b. Owner-operator

7. What is your primary truck? (circle one)
   a. Freightliner
   b. International
   c. Kenworth
   d. Mack
   e. Mitsubishi Fuso
   f. Peterbilt
   g. Sterling
   h. Volvo
   i. Western Star
   j. Other

8. If you frequently drive another make, what is it?
   a. Freightliner
   b. International
   c. Kenworth
   d. Mack
   e. Mitsubishi Fuso
   f. Peterbilt
   g. Sterling
   h. Volvo
   i. Western Star
   j. Other
   k. I usually drive only the one make.

9. Which of the following devices are installed or available to you in your <u>primary</u> truck? (Some appear under more than one name.)

Electronic Device	Installed	Don't Know	Not Installed
Adaptive Cruise Control			
Cadec			
CB Radio			
Cell Phone			
Cruise Control			
DriveCam or other video camera			
Eaton Vorad			
Electronic Stability Control (ESC)			
Electronic On-Board Recorder (EOBR)			
Electronic Log Book			
Forward Collision Warning			
GPS Navigation System			
Iteris			
Lane Departure Warning			
Navigation System			
OnGuard			
Qualcomm			
Rear Vision Camera			
Roll Stability Control			
Tire Pressure Monitoring			
Wingman			

10. Which devices <u>would you like to have</u> installed or available in your truck?

Electronic Device	Desirable	Don't Know	Not Desirable
Adaptive Cruise Control			
Cadec			
CB Radio			
Cell Phone			
Cruise Control			
DriveCam or other video camera			
Eaton Vorad			
Electronic Stability Control (ESC)			
Electronic On-Board Recorder (EOBR)			
Electronic Log Book			
Forward Collision Warning			
GPS Navigation System			
Iteris			
Lane Departure Warning			
Navigation System			
OnGuard			
Qualcomm			
Rear Vision Camera			
Roll Stability Control			
Tire Pressure Monitoring			
Wingman			

11. Which of the following features have you experienced on a <u>passenger car</u>, either yours or somebody else's?

Feature	Experienced	Have Not Experienced
Adaptive Cruise Control		
Head-Up Display		
Navigation System		
Lane Departure Warning System		
Rear Vision Camera		
Park Assist		
Cross-Traffic Alerting System		
Bluetooth		
Forward Collision Alerts		
Tire Pressure Monitoring		

Thank you!

Please tell the host that you have finished the questionnaire and are ready to drive.

In-Vehicle Questionnaire

Tractor Orientation

When the participant enters the cab, the test conductor will put the participant at ease. The test conductor will allow the participant to adjust the

- Seat
- Mirrors
- Steering Wheel
- Windshield Wipers
- Air Conditioning

The test conductor will cover the following topics using words similar to these.

Safety

Safety is our first priority. To demonstrate the vehicle-to-vehicle communication features, we will put you in realistic driving situations. But these are not intended to be dangerous situations. You will always have plenty of time to brake.

How a situation works

We're going to show you four features of the safety system. It's the same four you saw in the video indoors. The passenger car and moving truck will be working with us. I will always tell you where they are going to be. There are no surprises. I will show you a diagram of what's going to happen. If you have any questions, be sure to ask me before we start driving.

Familiarization drive

Start off by driving down toward this curve (the north loop of the Skid Pad). When you get up to about 35 mph, I'll have you brake so you are familiar with the feel of the brakes. Then I'll have you come to a stop as you leave the curve.

If anybody asks,
The engine is a Detroit Diesel DD13 12.8L 450 HP @ 1800 RPM, 2080 GOV RPM
The transmission is an Eaton Fuller Ultrashift

<u>Busy Intersection</u>

Your first experience will be the Busy Intersection safety feature. It warns you when it is not safe to enter an intersection because somebody else is coming from the cross direction. As you pull forward, one of our helper cars will be driving past. When I tell you, you will begin to pull out. Don't really pull in his path; just pull a foot or so forward like you're starting to enter the intersection. You should get a warning down here on the instrument panel and hear a sound telling you not to enter the intersection.

Imagine that you are stopped at an intersection that you want to drive straight through. It is a 2-way stop; the traffic coming from your left and right have the right of way and do not stop. Also imagine that your view is blocked, for example by a parked truck, making it difficult to see traffic heading toward the intersection. As you release the brake to creep forward, you will receive a warning that the car is headed toward the intersection.

Do you have any questions before we begin?
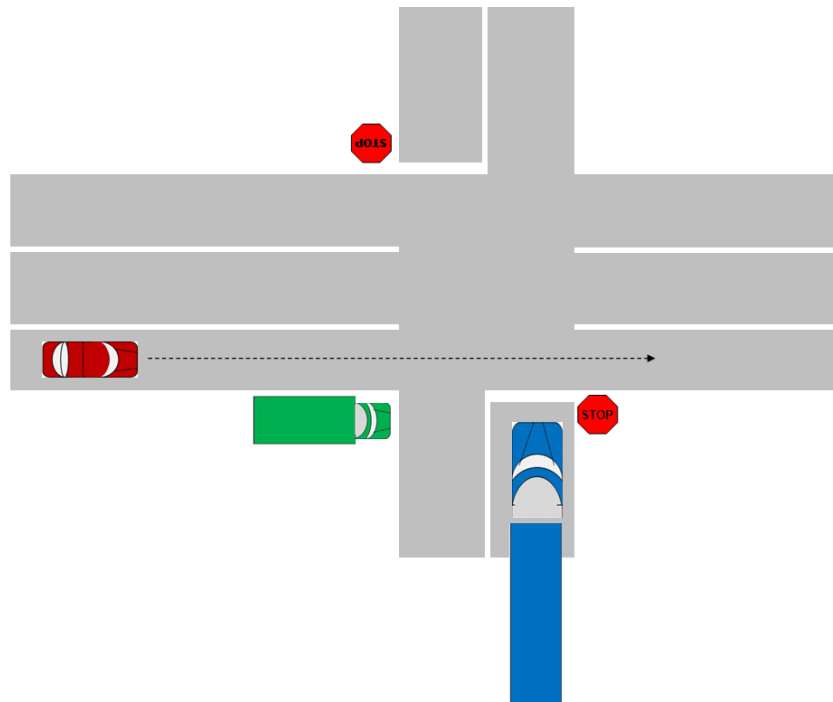

Execution of the "FCW Stopped RV in Same Lane" Scenario

- Confirm the van is in position. Tell RV1 to proceed.
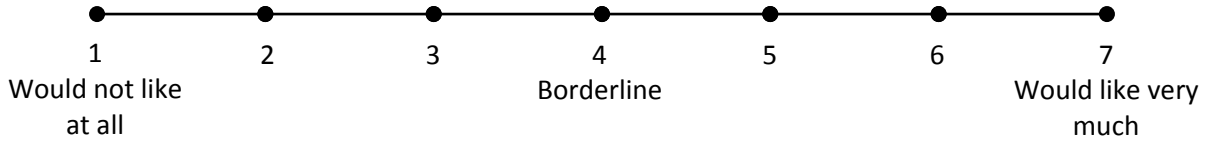- Tell the participant when to release the brake.

Do you have any questions about what you just experienced?

Busy Intersection In-Vehicle Debrief

1. How useful do you think a Busy Intersection warning would be in the real world?

1	2	3	4	5	6	7
Not at All Useful			Moderately Useful			Extremely Useful
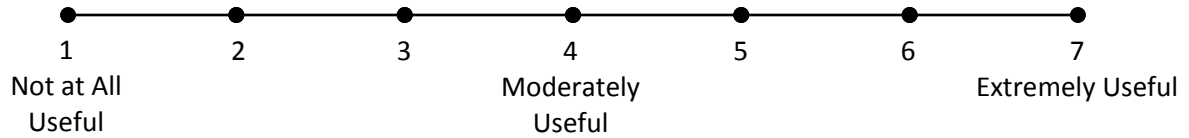
2. Would you like to have a safety feature like this on your own truck?

1	2	3	4	5	6	7
Would not like at all			Borderline			Would like very much

3. How effective was the warning to you?

1	2	3	4	5	6	7
Not at all Effective			Moderately Effective			Extremely Effective

4. Was the warning easy to understand?

1	2	3	4	5	6	7
Not at All Easy to Understand			Moderately Easy to Understand			Very Easy to Understand

    a. If the answer on Question 4 is less than 4 (moderately or less) ask "What about the warning did you find confusing?"

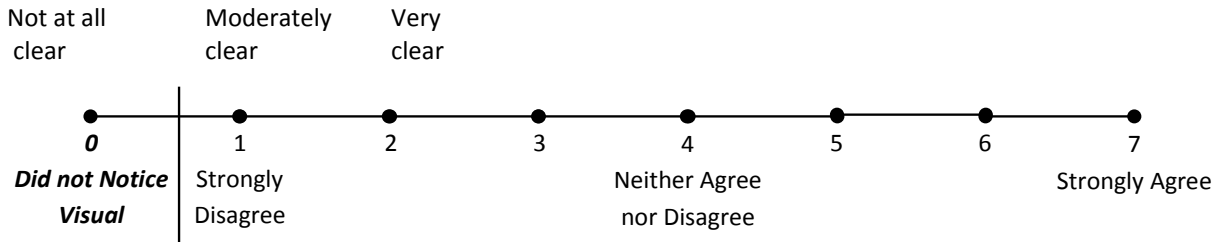5. Which type of alert was the most useful? (choose one, where applicable)
    ☐ Auditory alert only
    ☐ Visual alert only
    ☐ Auditory and visual

6. Was the visual warning clear and obvious?

Not at all clear	Moderately clear	Very clear

0 — 1 — 2 — 3 — 4 — 5 — 6 — 7

Did not Notice
Visual | Strongly
Disagree | Neither Agree
nor Disagree | Strongly Agree
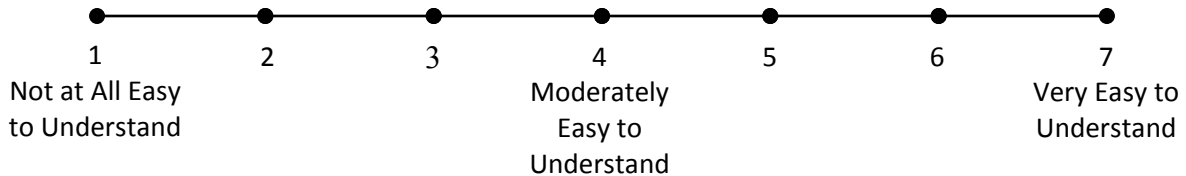
7. Could you describe any concerns, suggestions for improvement, or any other comments you might have for this safety feature?

8. Experimenter Notes

    What warning did the participant receive?

    _____   Caution (yellow) only

    _____   Imminent Warning (red) only

    _____   Yellow then red

    _____   Red then yellow

    _____   Nothing happened.

    _____   Something else happened.

Notes of interest specific to this scenario:

Forward Collision Warning

Now we are ready for the Forward Collision Warning. It warns you when there is a danger of a rear-end collision with a stopped car ahead. It is intended to help you avoid or at the very least reduce the severity of a rear-end collision.

Imagine that somebody is stopped ahead in your lane. The Forward Collision Warning safety feature will tell you about it.

First, we would like you to get up to 35 mph. As you drive, we will approach a stopped car in our path. Try to maintain 35 mph until you get the warning, and then bring our truck to a complete stop within our lane.

Remember that your first priority is driving safely. As a precaution, the driver of that car has gotten out and is standing off to the right in the grass.

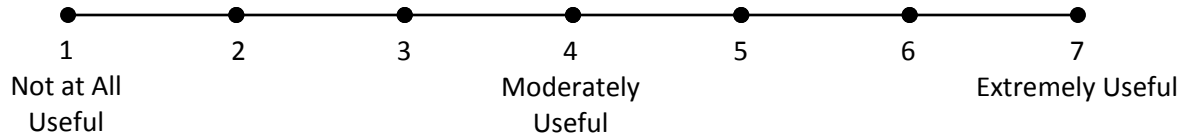*Do you have any questions before we get started?*

Execution of the "FCW Stopped RV in Same Lane" Scenario

- Confirm that RV1 is in position and that the driver is out of the vehicle.
- Provide basic guidance to participant when needed on travel lane, speed
- You may need to instruct participant to stop if FCW is not issued within expected window.
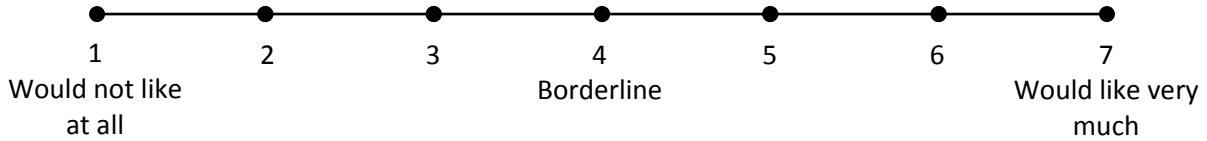
Do you have any questions about what you just experienced?

FCW In-Vehicle Debrief

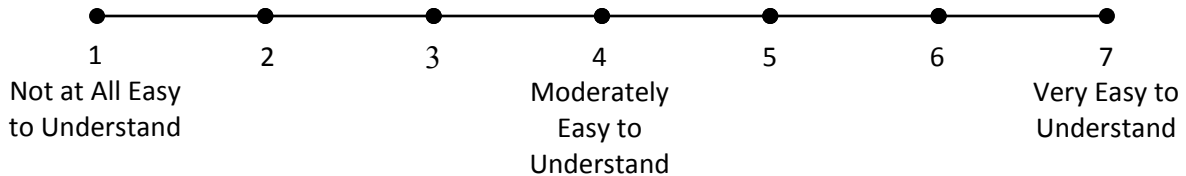1. How useful do you think this forward collision warning would be in the real world?

1	2	3	4	5	6	7
Not at All Useful			Moderately Useful			Extremely Useful

2. Would you like to have a safety feature like this in your own truck?

1	2	3	4	5	6	7
Would not like at all			Borderline			Would like very much

3. How effective was the warning to you?

1	2	3	4	5	6	7
Not at all Effective			Moderately Effective			Extremely Effective

4. Was the warning easy to understand?

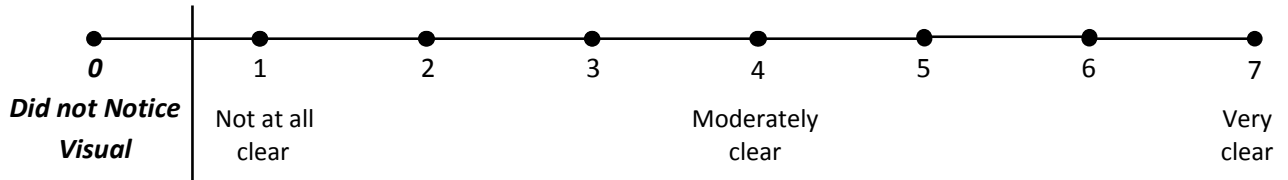|						
1	2	3	4	5	6	7
Not at All Easy to Understand			Moderately Easy to Understand			Very Easy to Understand

    a. If the answer on Question 4 is less than 4 (moderately or less) ask "What about the warning did you find confusing?"

5. Which type of alert was the most useful? (choose one, where applicable)
    ☐ Auditory alert only
    ☐ Visual alert only
    ☐ Auditory and visual

6. Was the visual warning clear and obvious?

0		1	2	3	4	5	6	7
Did not Notice Visual		Not at all clear			Moderately clear			Very clear

7. Could you describe any concerns, suggestions for improvement, or any other comments for the forward collision warning?

8. Experimenter Notes FCW Stopped RV in Same Lane

    What warning did the participant receive?

    _____   Caution (yellow) only

    _____   Imminent Warning (red) only

    _____   Yellow then red

    _____   Red then yellow

    _____   Nothing happened.

    _____   Something else happened.

Notes of interest specific to this scenario:

Emergency Electronic Brake Lights

Next is the Emergency Electronic Brake Lights warning. It warns you of a suddenly slowing car ahead of you. This is useful when your view ahead is blocked by another truck.

Imagine that three vehicles are traveling together in the same lane; your truck is third in the row, and your view of the car is blocked by the other truck you are following. For some reason, like a deer crossing the road or a crash up ahead, the front vehicle brakes rapidly. The Electronic Brake Lights tell you before you see brake lights from the rental truck.

Do you understand? Here's what's going to happen.

The car in front is going to get up to 35 mph. You and that rental truck in front of us are going to follow at a safe distance. When we are all up to speed, the car, will suddenly brake. You won't be able to see its brake lights, but the display here will tell you. This abrupt braking will require both you and the rental truck in front of you to slow to a stop in our lane. Remember that your first priority is driving safely.
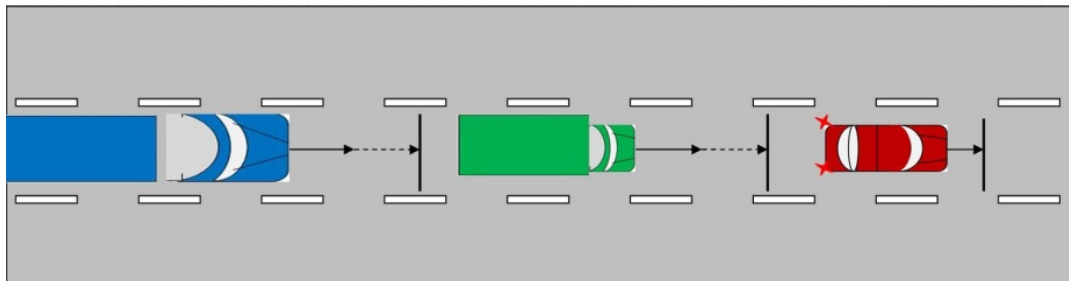
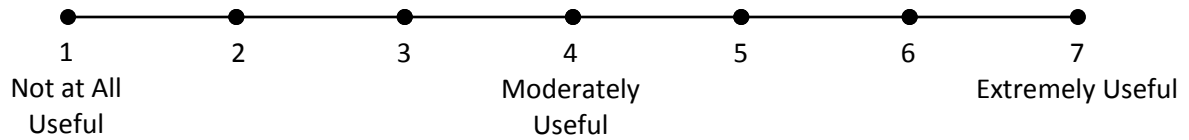*Do you have any questions before we get started?*

Execution of the "EEBL" Scenario

- Communicate to both RVs that HV is ready to proceed
- Provide basic guidance to participant when needed on travel lane and following distance
- When at speed, use the radio to discreetly communicate to RV1 that steady state has been achieved and that the RV1 should execute the braking within approximately 5 seconds by saying, "OK, please hold your speed at 35 mph and continue to follow at a safe distance."
- You may need to instruct the participant to stop if EEBL is not issued within the expected window.
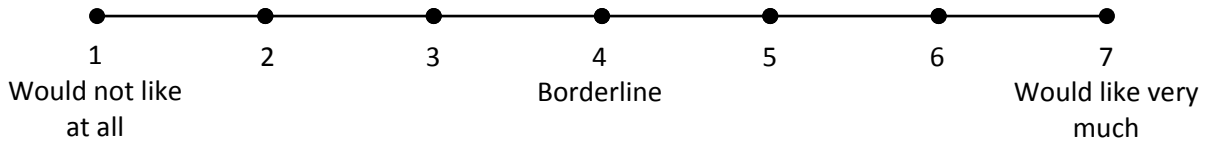
Do you have any questions about what you just experienced?

EEBL In-Vehicle Debrief

1. How useful do you think this emergency brake light warning would be in the real world?
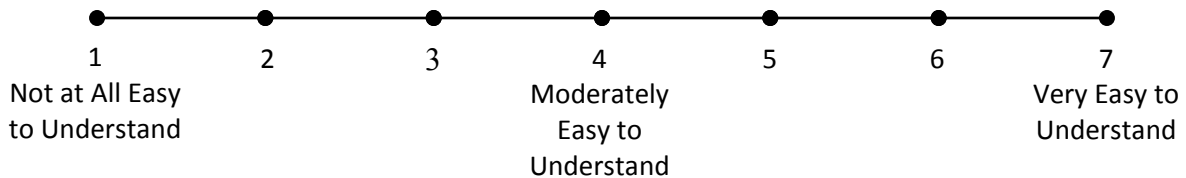
1	2	3	4	5	6	7
Not at All Useful			Moderately Useful			Extremely Useful

2. Would you like to have a safety feature like this in your own truck?

1	2	3	4	5	6	7
Would not like at all			Borderline			Would like very much

3. How effective was the warning to you?

1	2	3	4	5	6	7
Not at all Effective			Moderately Effective			Extremely Effective

4. Was the warning easy to understand?

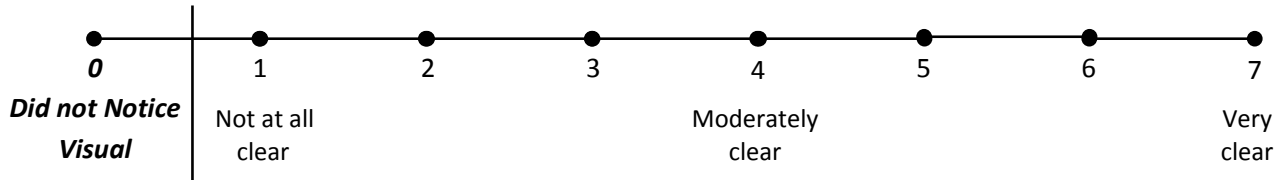| 1	2	3	4	5	6	7
Not at All Easy to Understand			Moderately Easy to Understand			Very Easy to Understand

  a. If the answer on Question 4 is less than 4 (moderately or less) ask "What about the warning did you find confusing?"

5. Which type of alert was the most useful? (choose one, where applicable)
   ☐ Auditory alert only
   ☐ Visual alert only
   ☐ Auditory and visual

6. Was the visual warning clear and obvious?

0	1	2	3	4	5	6	7
Did not Notice Visual	Not at all clear			Moderately clear			Very clear

7. Could you describe any concerns, suggestions for improvement, or any other comments for the emergency brake light warning?

8. Experimenter Notes

   What warning did the participant receive?

   _____   Caution (yellow) only

   _____   Imminent Warning (red) only

   _____   Yellow then red

   _____   Red then yellow

   _____   Nothing happened.

   _____   Something else happened.

Notes of interest specific to this scenario:

<u>Blind Spot Warning</u>

Now we are ready to test the Blind Spot and Lane Change Warning. It warns you when somebody is in your right side blind spot.

Imagine that you are driving and want to make a lane change to the right. There is a car in the lane in your blind spot.

We will have you get up to 35 mph in the left lane. As you drive in your lane, a car will approach us and enter our blind spot in the right lane. A Blind Spot advisory will tell you he's there. Then, I will also ask you to put on your right turn signal, and you will receive another message warning you not to change lanes.

Don't change lanes because there will be a car next to you. Stay in your lane and I'll tell you when to stop.

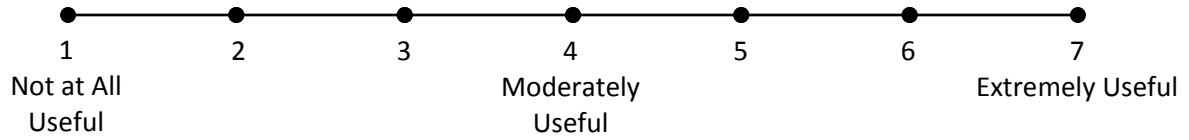*Do you have any questions before we get started?*
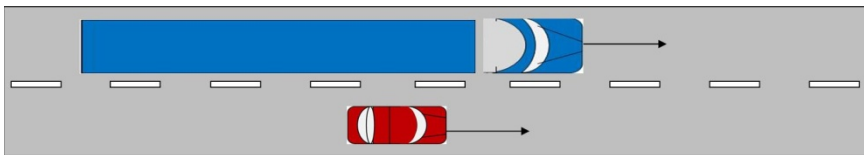
Execution of the BSW Scenario

- Communicate to RV1 that HV is ready to proceed
- Provide basic guidance to participant when needed on travel lane and speed
- When at speed, use the radio to discreetly communicate to RV1 that steady state has been achieved.
- You may need to instruct the participant to stop if BSW is not issued within the expected window.
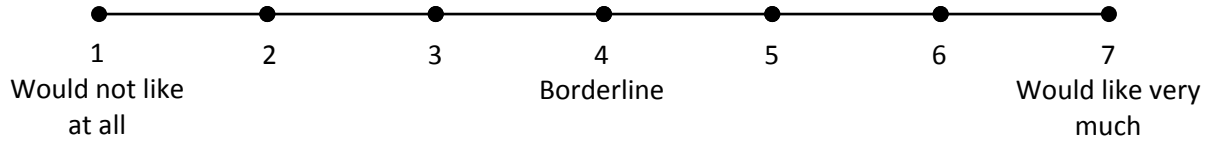
Do you have any questions about what you just experienced?

BSW In-Vehicle Debrief

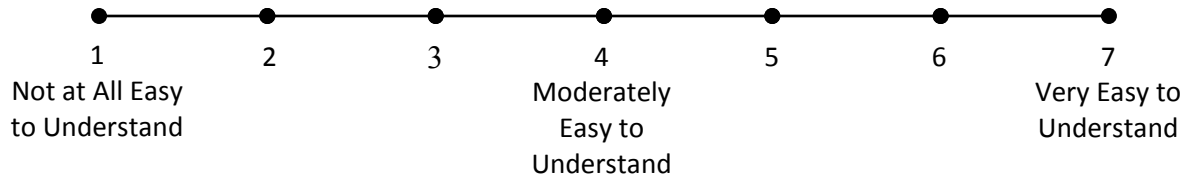1. How useful do you think this blind spot warning would be in the real world?

1	2	3	4	5	6	7
Not at All Useful			Moderately Useful			Extremely Useful

2. Would you like to have a safety feature like this in your own truck?

1	2	3	4	5	6	7
Would not like at all			Borderline			Would like very much

3. How effective was the warning to you?

1	2	3	4	5	6	7
Not at all Effective			Moderately Effective			Extremely Effective

4. Was the warning easy to understand?

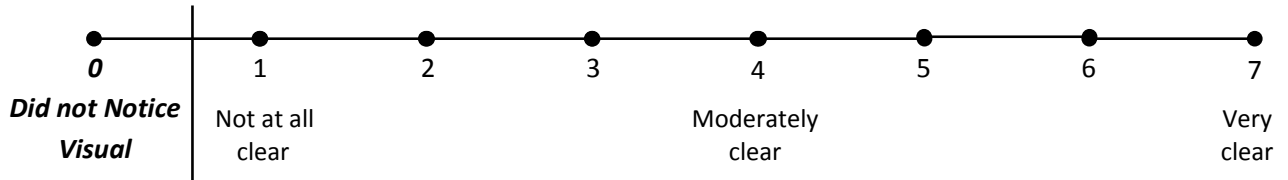| 1	2	3	4	5	6	7
Not at All Easy to Understand			Moderately Easy to Understand			Very Easy to Understand

   a. If the answer on Question 4 is less than 4 (moderately or less) ask "What about the warning did you find confusing?"

5. Which type of alert was the most useful? (choose one, where applicable)
   ☐ Auditory alert only
   ☐ Visual alert only
   ☐ Auditory and visual

6. Was the visual warning clear and obvious?

0		1	2	3	4	5	6	7
Did not Notice Visual		Not at all clear			Moderately clear			Very clear

7. Could you describe any concerns, suggestions for improvement, or any other comments for the blind spot warning?

8. Experimenter Notes

   What warning did the participant receive?

   _____   Caution (yellow) only

   _____   Imminent Warning (red) only

   _____   Yellow then red

   _____   Red then yellow

   _____   Nothing happened.

   _____   Something else happened.

   Notes of interest specific to this scenario:

Post-Drive Questionnaire

Thank you for taking time out of your busy schedule to experience the vehicle-to-vehicle safety features.

This questionnaire is divided into seven sections:

Section 1 – The entire Vehicle-to-Vehicle safety system

Section 2 – Busy Intersection feature

Section 3 – Forward Collision feature

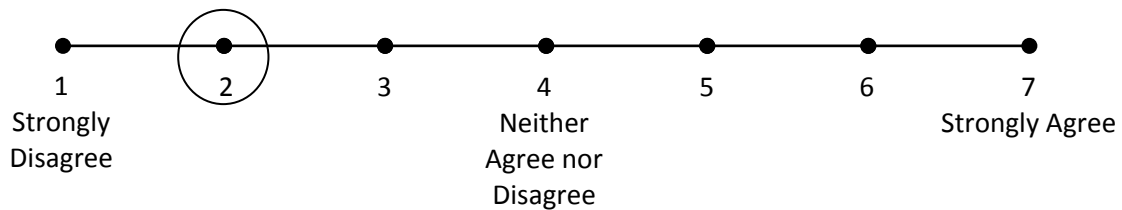Section 4 – Electronic Brake Lights feature

Section 5 – Blind Spot and Lane Change feature

Section 6 – Final Opinions

Thanks again for your feedback.

Circle the number that best represents your opinion for the questions with rating scales.

Example:

| 1	2	3	4	5	6	7
Strongly Disagree			Neither Agree nor Disagree			Strongly Agree

Section 1: Questions related to all safety features you experienced today

Imagine that the safety features you experienced today were grouped together as one Vehicle-to-Vehicle Communication safety package. Please answer the following questions accordingly.
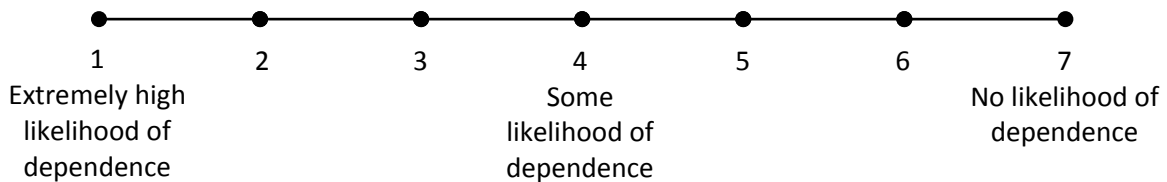
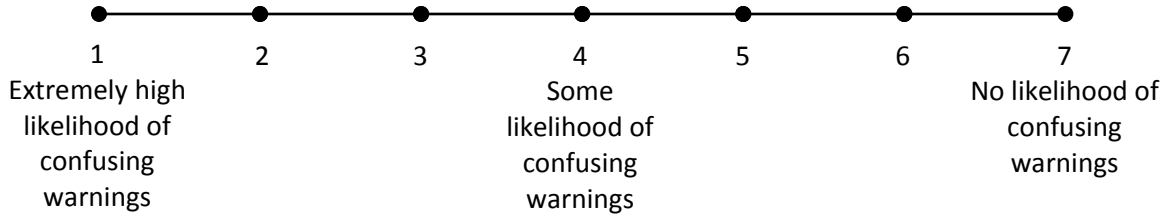1. I would like to have this Vehicle-to-Vehicle Communication safety feature on my truck.

1	2	3	4	5	6	7
Strongly Disagree			Neither Agree nor Disagree			Strongly Agree
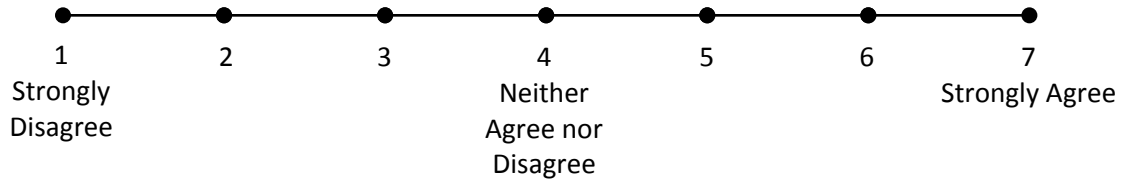
2. Monitoring or interpreting information provided by these safety features is no more distracting than using my truck's stereo system.

1	2	3	4	5	6	7
Strongly Disagree			Neither Agree nor Disagree			Strongly Agree
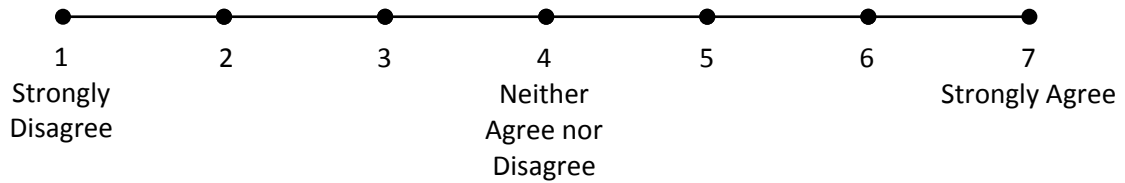
3. How likely is it that drivers will depend solely on these safety features to alert them to dangers in the environment?

| 1	2	3	4	5	6	7
Extremely high likelihood of dependence			Some likelihood of dependence			No likelihood of dependence

4. How well do you feel drivers would be able to tell the difference between warnings from the different safety features you experienced today?

1	2	3	4	5	6	7
Extremely high likelihood of confusing warnings			Some likelihood of confusing warnings			No likelihood of confusing warnings

5. Please rank the following options in terms of overall desirability, with 1 being the MOST preferred and 6 being LEAST. Use numbers 1-6 only once.

Available Option	Rank
Adaptive Cruise Control (slows down when somebody is in front of you)	
Forward Collision Warning System (Eaton Vorad or Meritor OnGuard)	
GPS Navigation System	
Roll Stability Control or Electronic Stability Control	
Tire Pressure Monitoring System	
Vehicle-to-Vehicle Warnings (All of the safety features you experienced today)	

6. It is possible that the Vehicle-to-Vehicle Communication safety feature may become temporarily unavailable, and not warn you when it otherwise would. With that in mind, please answer the following: I would want the device to notify me when the Vehicle-to-Vehicle Communication safety feature becomes unavailable.

| 1	2	3	4	5	6	7
Strongly Disagree			Neither Agree nor Disagree			Strongly Agree
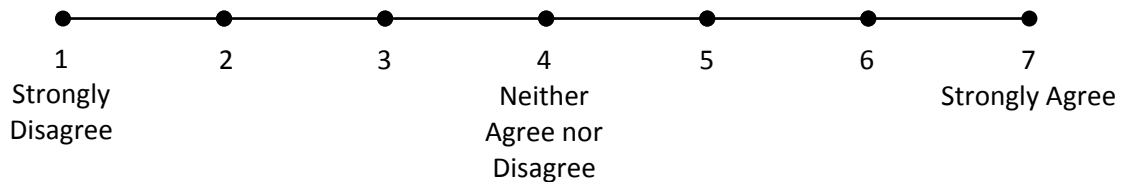
7. After experiencing these Vehicle-to-Vehicle safety features first hand, please tell us how well you think you understand this technology and how it works. (check only one)

___ I don't understand it

___ I understand it, but still have some questions

___ I fully comprehend how this technology works

Section 2: Busy Intersection

The Busy Intersection feature warns drivers when it is not safe to enter an intersection because of a high chance of a collision with crossing vehicles.

During the busy intersection situation, you stopped behind the stop bar at the intersection. You were instructed to release the brake pedal, allowing the vehicle to move forward as if you were about to continue across the intersection, heading straight. The Busy Intersection feature warned you of the approaching car. This situation showed you how the feature might alert you to an unseen crossing vehicle, as you slowly enter the intersection.
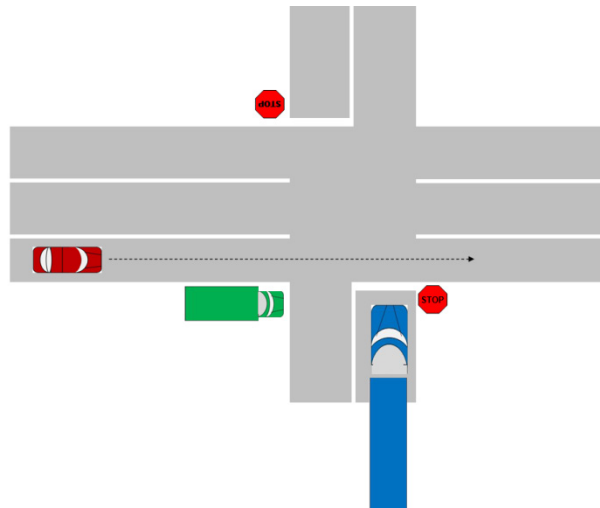
1. What do you feel is the most beneficial aspect of the safety feature?

2. What, if anything, would you change about the safety feature?

3. Under what environments and conditions do you feel the safety feature would provide the most benefit? (circle all that apply)
   a. Nighttime driving
   b. Daytime driving
   c. Driving on slippery roads (rain, ice, snow)
   d. Driving under poor visibility conditions (rain, fog, snow, glare)
   e. Driving on unfamiliar roadways
   f. Driving when your view of the road ahead is partially blocked (by cars, curves, terrain)
   g. Other, please specify:

Section 3: Forward Collision

The Forward Collision feature warns drivers of an impending rear-end collision with the vehicle in front of them, in the same lane and direction of travel. It is intended to help drivers avoid rear-end collisions with other vehicles travelling in the same direction.

During the forward collision situation, you drove your truck up to a stopped car, until you received the warning. Forward Collision warned you that there was a chance of a rear-ender. This situation shows how the feature might work when other vehicles quickly stop in front of you.

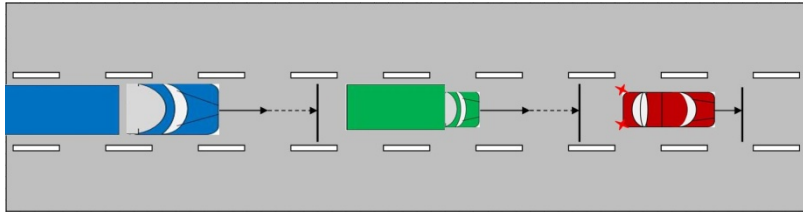1. What do you feel is the most beneficial aspect of the safety feature?

2. What, if anything, would you change about the safety feature?

3. Under what environments and conditions do you feel the safety feature would provide the most benefit? (circle all that apply)

    a. Nighttime driving
    b. Daytime driving
    c. Driving on slippery roads (rain, ice, snow)
    d. Driving under poor visibility conditions (rain, fog, snow, glare)
    e. Driving on unfamiliar roadways
    f. Driving when your view of the road ahead is partially blocked (by cars, curves, terrain)
    g. Other, please specify:

Section 4: Electronic Brake Lights

The Electronic Brake Lights feature alerts a driver when there is a stopped vehicle or vehicle suddenly stopping in their current direction of travel. This can be particularly useful when the driver's forward sightline is blocked, for example by other vehicles or due to low visibility.

During the electronic brake light situation you experienced today, the red vehicle suddenly put on its brakes. Your view of the red car was partially blocked by the green truck, which you were following. This sudden braking required both you and the vehicle in front of you to slow to a stop. Electronic Brake Lights warned you of the red car's sudden stop. This situation showed you how the feature might work when other vehicles or bad weather causes poor visibility of the traffic ahead.

1. What do you feel is the most beneficial aspect of the safety feature?
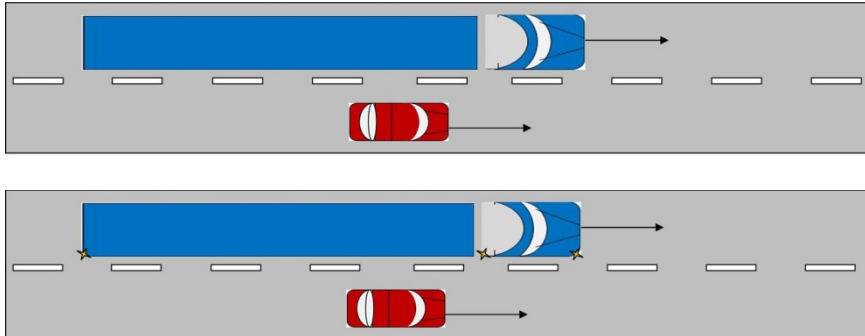

2. What, if anything, would you change about the safety feature?

3. Under what environments and conditions do you feel the safety feature would provide the most benefit? (circle all that apply)

    a. Nighttime driving

    b. Daytime driving

    c. Driving on slippery roads (rain, ice, snow)

    d. Driving under poor visibility conditions (rain, fog, snow, glare)

    e. Driving on unfamiliar roadways

    f. Driving when your view of the road ahead is partially blocked (by cars, curves, terrain)

    g. Other, please specify:

Section 5: Blind Spot and Lane Change

The Blind Spot feature alerts drivers when a vehicle is in their blind spot. The Lane Change feature warns drivers during a lane change attempt if a vehicle traveling in the same direction is about to enter their blind-spot.

During the blind spot situation, the car entered your blind spot in an adjacent lane (see top figure). The feature <u>alerted</u> you to the vehicle, and it <u>warned</u> you when you turned on your signal (bottom figure). This situation showed you the difference between a blind spot alert and a lane change warning.

1. What do you feel is the most beneficial aspect of the safety feature?

2. What, if anything, would you change about the safety feature?

3. Under what environments and conditions do you feel the safety feature would provide the most benefit? (circle all that apply)

    a. Nighttime driving

    b. Daytime driving

    c. Driving on slippery roads (rain, ice, snow)

    d. Driving under poor visibility conditions (rain, fog, snow, glare)

    e. Driving on unfamiliar roadways

    f. Driving when your view of the road ahead is partially blocked (by cars, curves, terrain)

    g. Other, please specify:

Section 6. Final Opinions

1. Rank in order of usefulness of each feature, starting with 1 being the MOST useful to 4 being the LEAST useful.
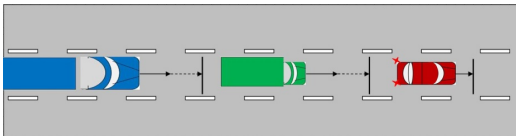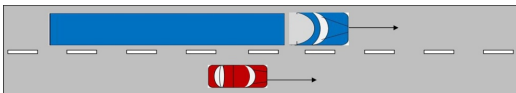
_____ Busy intersection
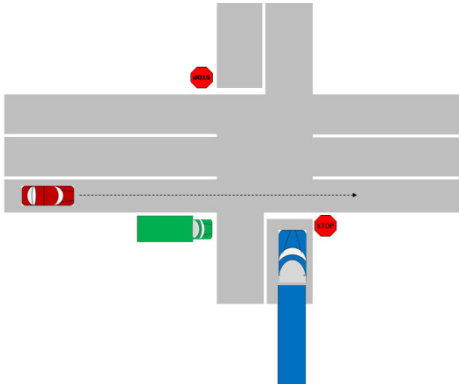
_____ Forward collision

_____ Electronic Brake lights

_____ Blind Spot or Lane Change

2. Any final thoughts or comments on your overall experience today that you would like to provide?

THANK YOU! ☺ Please tell the host you are finished.

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

NHTSA