Final Report

Phase II Driver Survey Report: Volvo Intelligent Vehicle Initiative Field Operational Test

Prepared for

U.S. Department of Transportation
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by

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The Business of Innovation

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

List of Tables

List of Figures

Page

EXECUTIVE SUMMARY

Introduction

The United States Department of Transportation (USDOT) established an Intelligent Vehicle Initiative (IVI) as a major component of the Intelligent Transportation System (ITS) program. The intent of the IVI is to improve significantly the safety and efficiency of motor vehicle operations by reducing the probability of motor vehicle crashes. These safety improvements could also show secondary benefits such as increased transportation mobility, productivity, or other operational improvements. USDOT entered into a cooperative agreement on September 29, 1999 with Volvo Trucks North America, Inc., in partnership with U.S. Xpress, to test and evaluate a radar-based collision warning system (Vorad®), an adaptive cruise control system (SmartCruise), and an advanced electronic braking system (AdvBS).

The USDOT selected a Battelle-led team to perform an independent evaluation of the technologies being tested by Volvo and U.S. Xpress. The primary evaluation goal of the FOT is to determine the potential safety benefits of advanced Intelligent Vehicle Safety Systems (IVSS). Specifically, how many crashes, injuries, and fatalities could be avoided if vehicles were equipped with these technologies? It is also important to understand how these technologies affect driver performance. For example, do drivers drive more safely? And, how do these technologies affect driver stress level and workload? The secondary goals of these evaluations include the estimation of other benefits (mobility, efficiency, productivity, and environmental quality), evaluation of system performance, and assessments of other factors that affect development and deployment of these technologies. These factors include user acceptance, product maturity, manufacturability, and institutional and legal issues.

This report presents findings from an analysis of the data collected through driver surveys conducted at both the beginning and the end of the evaluation period. The first survey (Phase I) focused on driver expectations for the new safety technologies installed on selected Volvo trucks and the second survey (Phase II) focused on driver experiences using the technologies.

Background

The three safety systems under evaluation have been developed to reduce the occurrence and severity of rear-end crashes as well as lane change/merge crashes. These include a forward sensor and a side sensor[1]. The forward sensor sends a radar beam out from the front bumper to measure the following distance between the host (or subject) vehicle and the lead (or target) vehicle while the side sensor sends a radar beam into the right side blind spot of the tractor to check for vehicles that enter the driver's blind spot on the right side of the truck. SmartCruise maintains a fixed distance, dependent on road speed, between the host vehicle and the target vehicle ahead. When there is no detected vehicle ahead, SmartCruise maintains a given pre-set speed similar to conventional cruise control. The AdvBS, which includes air disc brakes and Electronically Controlled Braking Systems (EBS or ECBS), was designed to enhance the tractor's braking capabilities.

U.S. Xpress leased 100 Volvo VN770 tractors for their normal revenue generating service, beginning in January 2001. Fifty of these vehicles were equipped with the three safety systems (test vehicles) and 50 served as control vehicles. The control vehicles were broken down further

[1] Due to restrictions in the vehicle set-up, the side CWS could not be evaluated in this FOT.

into two groups. One was planned to have no IVSS technology activated for the first six months (20 baseline vehicles) and only the Eaton® VORAD® radar active for the remaining time (control vehicles). The other control group had the SmartCruise operational for the entire FOT (30 control vehicles). As it turned out, the control vehicles were not fully converted until about 18 months later. All vehicles, both test and control units, were instrumented for data collection by the Aberdeen Test Center (ATC).

Objectives

The USDOT (1999) suggested five goal areas along with some generic objectives for each goal. These objectives were to be tailored to meet the needs of each IVI FOT. The evaluation goals covered (1) safety, (2) user acceptance and human factors, (3) IVSS performance potential, (4) product maturity, and (5) institutional and legal issues. Goal 2, Assess user acceptance and human factors, is the subject of this report, and it includes four objectives, as follows:

Objective 1: Determine usability of the IVSS technologies

Objective 2: Determine how IVSS affects perceived stress and workload of drivers

Objective 3: Determine perceived impact on driver risk and vigilance

Objective 4: Determine perception of product quality and maturity

This goal area focuses on understanding if and how human factors may play a role in the eventual acceptance and deployment of the systems. The evaluation of this goal was covered in two survey phases. Phase I largely focused on driver expectations for the performance of the IVSS technologies, while Phase II focused on driver perceptions, behaviors, and recommendations for changes based on extensive experience using the technologies. This report presents an overview of what was learned from the drivers who responded to each of these surveys.

Methods

The method for collecting data was to conduct telephone interviews with drivers using a survey questionnaire to guide the interviews. Drivers were notified to call in to an 800 number, and trained interviewers were available to conduct the interviews. The answers to the survey questions were entered into a computer using a Computer-Aided Telephone Interview (CATI) system. This allowed automated checks for the validity of responses and transfer into a database for further analysis. Further details on the interview process are described in Appendix B of this report.

Findings

Driver Expectations from Phase I. Findings on drivers' expectations for the IVSS from Phase I are summarized below:[2]

- Most of the drivers in the baseline, control, and test groups expressed positive attitudes toward each of the IVSS technologies (Vorad®, SmartCruise, and AdvBS). Those drivers who had not yet tried these technologies were positive about their likely benefits, and those who already had driving experience with any of them reported that the benefits outweighed any drawbacks.

[2] See Interim Report for details on the Phase I evaluation results (References p. 50: Battelle 2002b).

- Many drivers reported that they had limited or no training in the use of Vorad®. Those drivers who did have training and who thought the training was useful tended to be more positive about the value of the technology. Therefore, emphasis on training could lead to greater benefits to be derived from these technologies, coupled with greater support from the drivers.
- Drivers in the initial Phase I survey said they believed that these technologies would help avoid front-end collisions, that they would be better off with these systems in their trucks than without them, and that the benefits are likely to vary depending on driving conditions.
- The research expectation at the end of Phase I was that driver attitudes toward each of these technologies would improve with experience using them, based on comparing responses between *baseline* drivers (with no experience with any of the three systems), *control* drivers (experienced only with Vorad®) and *test* drivers (experienced with all the systems). Drivers in the first survey believed that these technologies would help avoid front-end collisions, that drivers are better off with these systems on their trucks, and that the benefits are likely to be greater in some driving condition (such as poor visibility) than in others (such as heavy traffic).

Driver Experiences from Phase II. Findings on drivers' experiences with the IVSS from Phase II are organized according to the hypotheses that were described in the Evaluation Plan for Objective 2. The drivers interviewed in Phase II reported a substantial amount of experience both with truck driving and driving with each of the IVSS technologies. This level of experience, shown in table 1, is more than sufficient for providing informed judgments about each of the three safety technologies.

Table 1. Average driving experience driving trucks and driving with IVSS (years).

Average Driving Experience (Years)	Truck Driving Overall	Driving with Vorad®	Driving with SmartCruise	Driving with AdvBS
Mean*	11.9	3.1	1.1	1.5
Median**	8.5	3.0	1.0	1.0

*The arithmetic average.
**The mid-point such that half the drivers have more years and half have less years.

Objective 1. Determine the usability of the IVSS technologies

This objective focuses on how IVSS are used and understood by the drivers. In particular the drivers' understanding of signals and information; perceptions of consistency and robustness of signals; how the information is integrated and presented to the driver; and the ease of learning, use, and control.

The evaluation asked drivers to indicate their perceptions of the ease of learning the IVSS and the adequacy of training they may have received. The results are summarized in table 2.

Table 2. Objective 1: Training and learning.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers find the IVSS and components easy to learn.	👍👍	About half of the drivers reported receiving Vorad® training (54%), and only 24% and 19% received training in SmartCruise and AdvBS respectively. Almost all the drivers said the training they received was "very" or "somewhat" helpful. The majority (between two-thirds and three-quarters) of the drivers said they learned these systems by trial and error. Trial and error was rated more helpful than learning with a manual or from informal discussions with other drivers. However, drivers did recommend more training as one possible improvement.
Drivers believe that they are adequately trained to use these systems.	👍	

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

The evaluation asked drivers to indicate their perceptions of the understandability of the IVSS visual and audible alerts. The results are summarized in table 3.

Table 3. Objective 1: Understandability.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers understand the IVSS capabilities.	👍👍	When asked to express in their own words the meaning of the visual and audible alerts from Vorad®, drivers showed that they had a general understanding of these different warnings, but most did not understand the meanings in specific terms (distance to object or time left to react). They had a more accurate understanding of the visual warnings than the audible warnings. Most drivers knew that a double beep represented a more dangerous situation than a single beep, but they were not aware of the exact level of urgency or nature of the situation.
Drivers understand the signals and controls.	👍	

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

The evaluation asked drivers to indicate their perceptions of the ease of use of the IVSS, including how easy the alerts are to see and hear, and distinguish from other warnings in their truck. The results are summarized in table 4.

Table 4. Objective 1: Usability.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers find the IVSS and components easy to use and control.	👍👍	Most of the drivers reported that the visual and audible signals from Vorad® are "always" easy to see (87%) and hear (93%). Drivers were asked how easily they could distinguish the different warnings in their truck (forward, side, visual, auditory, and other non-IVSS warning systems). Most of the drivers (64%) said they could "always" distinguish IVSS alerts from one another, but sometimes they could be confused (for example, when the driver is tired, or is focusing on a particular driving situation). Drivers rarely reported problems distinguishing IVSS warnings from those provided by other systems in the truck, but 38% of the drivers said they have other, potentially competing, systems in their truck anyway. Drivers said that Vorad® is more useful in low visibility conditions such as fog (78%), heavy rain/snow (61%), or night (52%) and more likely to be distracting in heavy traffic. Driver comments on related questions indicate that they think SmartCruise is generally useful in all conditions other than climbing hills or in heavy traffic, and AdvBS is useful in all conditions.
Drivers perceive that the IVSS signals are recognizable and easy to see or hear.	👍👍	
Drivers understand how to use information from the IVSS.	👍	
Drivers believe that the IVSS messages are unambiguous and clearly understood.	👍	
Drivers have reasons for using the IVSS under specific, if not all, driving conditions (e.g., drivers might not use SmartCruise under congested traffic conditions).	👍👍	

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

Objective 2. Determine how IVSS technologies affect the perceived stress or workload of drivers

This objective focuses on how the IVSS affect the driving environment. Of particular interest are the effects of false alarms and the impacts on driver workload. Specific hypotheses tested are shown in the following tables.

Drivers were asked to indicate their perceptions of distractions due to the use of the IVSS, including the nuisance effects of false alarms. The results are summarized in table 5.

Table 5. Objective 2: Distraction and false alerts.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers perceive that IVSS do not distract them or interfere with their other tasks.	👍	Most drivers said the Vorad® visual (78%) and auditory (84%) warnings "rarely" or "never" drew their attention away from their driving tasks. Some drivers said they should not have to look away from the road to see what the alert means. On average drivers reported that they received Vorad® alerts when there was no apparent cause 4.7 times out of every 10 alerts (about half the time). Only 8% of the drivers reported no false positive alerts and 7% reported every alert was a false positive. False negative alerts are reported much less frequently, averaging less than 1 out of every 10 times drivers thought that an alert should have been provided, and 72% of the drivers said they never receive a false negative alert. 59% of the drivers said false alerts were a nuisance.
Drivers perceive that IVSS false positive[3] alarms are a nuisance.	👍👍	
Drivers perceive that IVSS false negative[4] alarms degrade their confidence in the systems.	👎👎	

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

Drivers were asked to indicate whether they thought the IVSS had the effect of reducing or increasing their levels of driving stress and fatigue compared with driving without these systems. The results are summarized in table 6.

Table 6. Objective 2: Stress and fatigue.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers perceive that IVSS reduce their levels of stress or fatigue.	👍	Drivers report driving is "somewhat" or "a lot" less stressful and tiring with Vorad® (49%), Smart-Cruise (38%) and AdvBS (56%). Some said these IVSS can increase stress and fatigue "somewhat" or "a lot" (23.6%, 17%, and 7% respectively). About one-third of the drivers (33.7%, 38.2% and 37.0% respectively) said that the Vorad®, SmartCruise and AdvBS did not affect their stress and fatigue.

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

Drivers were asked to rate the amount of mental workload they experienced on a scale from 1 (lowest) to 10 (highest). Mental workload refers to the amount of mental effort (level of concentration or degree of mental focus) it takes to drive their truck under various conditions. The results are summarized in table 7.

[3] A "false positive" alert occurs when Vorad® issues an alert when in reality there was no cause for the alert.
[4] A "false negative" occurs when Vorad® should have given a warning but failed to do so.

Table 7. Objective 2: Driver workload.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers perceive that IVSS reduce their driving workload.	👍👍	Without IVSS, perceived driving workload increases from driving a truck under good conditions, to heavy traffic, to low visibility, from an average score of 5.7 to 8.7 (up 53%). With IVSS, workload increased less, from 4.8 to 6.9, from good conditions up to the most demanding conditions (low visibility). The important point is that **the IVSS serve to lower perceived workload** under each of these conditions, between 14% and 21%.

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

If truck drivers do not find new safety technologies acceptable and useful, then they will either not use them or they will use them reluctantly, thereby not gaining full benefit. As a measure of acceptance, drivers were asked whether they preferred to drive a truck equipped with each of these technologies or one not equipped. They also were asked to indicate what they liked most and least about these systems. The results are summarized in table 8.

Table 8. Objective 2: Driver satisfaction.

Evaluation Hypotheses	Test Outcome*	Findings
IVSS increase job satisfaction of drivers.	👍	About 81% of the drivers said they would rather drive a truck equipped with Vorad® than without it. Benefits included safety, helpfulness and awareness. About 53% of drivers prefer to drive with SmartCruise and 44% prefer to drive without it. Benefits included safety and stress reduction. Almost all drivers (93%) preferred driving with AdvBS. Drivers dislike Vorad®'s false alarm tendency as well as excessive alarm noise.
Drivers trust the IVSS and perceive that they are useful.**	👍👍	
Drivers perceive that the IVSS are effective under specific (if not all) driving conditions (to be determined).	👍👍	

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

** This hypothesis was included under Objective 1 in the Evaluation Plan.

Objective 3. Determine the perceived impacts on driver risk and vigilance

Driver perceptions about how the use of IVSS affects the risk of an accident, and whether or not use of IVSS has resulted in any change in driving behaviors are summarized under this objective. The intent of IVSS is to enhance driving safety and reduce the risks of an accident; however, the opposite effect might occur if drivers begin to rely on IVSS and reduce their driving vigilance, or if they feel they can take greater driving risks because IVSS will warn them of potentially dangerous situations with time to respond. Driving behavior effects are summarized in table 9.

Table 9. Objective 3: Driver behaviors.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers are aware that they modify their driving behavior (speed, following distance, braking, turn signal usage) for particular reasons (to be determined) in response to the IVSS.	👍👍	Drivers were more likely to say their driving had changed "somewhat" or "a lot" with Vorad® (62%) than with SmartCruise (41%) or AdvBS (44%). Drivers who said their driving had changed talked about increasing following distances and being more aware.

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

Drivers were asked whether they thought the likelihood of an accident or a near-accident situation had been affected (reduced, increased, or no change) by the use of any of the three safety technologies. The drivers were asked to briefly explain in their own words how each of the IVSS affects the likelihood of accidents or near-accident situations. Risk taking effects are summarized in table 10.

Table 10. Objective 3: Risk taking.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers with the CWS and ACC systems are aware that they are more vigilant in their following distance behavior than those without the system, because of the feedback provided by the system.	👍👍	Most drivers (77%) said they thought Vorad® reduced the risk of an accident because it helps them maintain a safe following distance, increases reaction time, helps in low visibility, and increases awareness if they are distracted. 52% said SmartCruise reduces accident risks by keeping safe following distances and increasing reaction time. 18% thought it increased risk due to reduced attentiveness and driver control. 78% said AdvBS reduced the risk of an accident by reducing stopping distances.

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

Objective 4. Determine perceptions of product quality, maturity, etc.

Information on the perceived quality, value, and maturity of the IVSS from the perspective of the drivers were obtained. The evaluation addressed driver perceptions of system performance and functionality, and solicited driver recommendations for any changes that could improve the systems or make them easier to use and learn how to use. The results are summarized in table 11.

Table 11. Objective 4: Recommended changes.

Evaluation Hypotheses	Test Outcome*	Findings
Drivers have recommendations for changes that might make it easier to use or learn how to use the IVSS.	👍👍	Most drivers did not have recommendations for improvements, but of those who did (38%) some wanted more detailed information on Vorad® indicators (e.g. actual distances), volume controls for alerts, and better training or simpler manuals. A few drivers suggested improved SmartCruise training. Few drivers reported performance problems--Vorad® 39%; SmartCruise (21%); AdvBS (19%), and those who did said they experienced more downtime with Vorad® than the other two systems, but reports of frequent downtime were rare.
Drivers have recommendations for changes that might improve the performance or functionality of the IVSS.	👍	

* 👍👍 = Supported; 👍 = Partially supported; 👎👎 = Not supported.

Conclusions

The two surveys of drivers regarding their expectations and experiences associated with three truck safety technologies—Vorad®, SmartCruise and AdvBS—suggest that drivers understand and appreciate the benefits that these technologies can provide. These are highly experienced drivers who take great pride in their driving skills, and they can be expected to want to be convinced of the merits of technology before accepting the need for it in their trucks. The surveys reflected a range of positive and negative reactions to various aspects of these technologies, but the drivers believe these technologies help avoid or reduce accidents, and most prefer to have them installed on their trucks. The evaluation hypotheses that could be tested with the survey data were generally supported. The perceived benefits of each technology outweigh the drawbacks and depend mainly on driving conditions (particularly visibility and traffic density) and system performance (false alerts and distraction or annoyance factors). The results from these surveys lend support to the further refinement and deployment of these technologies throughout truck fleets to enhance driver safety, performance and satisfaction.

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1. INTRODUCTION

The United States Department of Transportation (USDOT) has established an Intelligent Vehicle Initiative (IVI) as a major component of the Intelligent Transportation System (ITS) program. The intent of the IVI is to improve the safety and efficiency of motor vehicle operations significantly by reducing the probability of motor vehicle crashes. These safety improvements could also show secondary benefits such as increased transportation mobility, productivity, or other operational improvements.

USDOT entered into cooperative agreements on September 29, 1999 with four partnerships to conduct Generation 0 Field Operational Tests (FOTs) of advanced intelligent vehicle safety systems (IVSS). Although the scope of the IVI Generation 0 FOT program includes light passenger vehicles and transit vehicles, USDOT selected one FOT involving specialty vehicles and three FOTs involving commercial trucks. As part of this effort, the USDOT selected a Battelle-led team to work with each partner to perform an independent evaluation of the technologies tested. This report covers the test involving Volvo Trucks North America, Inc., in partnership with U.S. Xpress, of a forward collision warning system, an adaptive cruise control, and an advanced electronic braking system for commercial vehicles.

The primary evaluation goal of the FOT was to determine the potential safety benefits of IVSS. The secondary goals of these evaluations included the estimation of other benefits (mobility, efficiency, productivity, and environmental quality), evaluation of system performance, and assessments of other factors that affect development and deployment of these technologies. These factors included user acceptance, product maturity, manufacturability, and institutional and legal issues.

This report presents the evaluation of user acceptance with the analysis of the data collected through driver surveys at both the beginning and the end of the evaluation period. The first survey (Phase I) focused on driver expectations for the new safety technologies being installed and the second survey (Phase II) focused on driver experiences using the technologies.

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2. THE VOLVO IVI FIELD OPERATIONAL TEST

2.1 PARTNERSHIP

The USDOT signed a Cooperative Agreement on September 29, 1999 with Volvo Truck North America (VTNA), in partnership with U.S. Xpress Enterprises, Inc., (U.S. Xpress) to evaluate Generation 0 advanced safety systems. The supplier participants assisting the Volvo partnership include Eaton® VORAD®, Eaton® Bosch, and the US Army Aberdeen Test Center (ATC).

VTNA is part of the Volvo Group. U.S. Xpress Enterprises, Inc., is the fifth largest publicly owned truckload carrier in the United States and specializes in time-definite and expedited service. The company provides truckload and dedicated services throughout North America, with regional capabilities in the West, Midwest, and Southeastern United States. Its fleet approaches 4,800 trucks and 9,500 dry van trailers. More than 6,500 of the 8,000 employees are drivers. U.S. Xpress utilizes one of the largest team-operated fleets in the industry, with more than 1,000 teams of drivers.

2.2 TECHNOLOGIES UNDER EVALUATION

Three commercially available systems are under evaluation:

1. A collision warning system (CWS or Vorad®),
2. An adaptive cruise control (ACC or SmartCruise), and
3. An advanced braking system (AdvBS).

These systems have been developed to reduce the occurrence and severity of rear-end crashes as well as lane change/merge crashes. The CWS includes a forward sensor and a side sensor. The forward sensor sends a radar beam out from the front bumper to measure the following distance between the following vehicle and the lead vehicle while the side sensor sends a radar beam into the right side blind spot of the tractor to check for vehicles that enter the driver's blind spot on the right side of the truck.[5] ACC maintains a fixed distance, dependent on road speed, between the host vehicle and the target vehicle ahead. When there is no detected vehicle ahead, ACC maintains a given pre-set speed similar to conventional cruise control (CCC). The AdvBS, which includes air disc brakes and Electronically Controlled Braking Systems (EBS or ECBS), was designed to enhance the tractor's braking capabilities. Further details on the technologies are included in appendix A.

2.3 RESEARCH PLAN

U.S. Xpress leased 100 Volvo VN770 tractors for their normal revenue generating service, beginning in January 2001. Fifty of these vehicles were equipped with the three safety systems (test vehicles) and 50 served as control vehicles. The control vehicles were broken down further into two groups. One had no IVSS technologies activated for the first 18 months (20 "baseline" vehicles) and only the Eaton® VORAD® CWS active for the remaining time (control vehicles), approximately 50 months. The other control group had the CWS operational for the entire FOT (30 control vehicles). All vehicles were instrumented for data collection by the Aberdeen Test Center (ATC). The trailers were not instrumented. Hereafter, the unit refers to the tractor.

[5] The side sensor configuration was changed during production and had to be hard wired. This was not accomplished in time for this evaluation, and therefore the evaluation was not able to cover the side sensor.

Table 12 details the specifications of the IVI technologies on each group of units. Table 13 shows the schedule.

Table 12. Specifications of IVI technologies for each group of units.

		SYSTEMS INSTALLED ON UNITS		
		Collision Warning System	**Cruise Control**	**Braking Systems**
BASELINE UNITS	Conventional units	On / NO driver display	Conventional	Conventional[1]
CONTROL UNITS	Conventional units + CWS	On	Conventional	Conventional[1]
TEST UNITS	Units with all IVS Systems	On	Adaptive	Advanced[2]

[1] Drum brakes + ABS
[2] Air disc brakes + EBS

Table 13. Schedule for data collection.

	Year 1	Year 2	Year 3
20 units	**Baseline units**		**Control units**
30 units	**Control units**		
50 units	**Test units**		

The vehicles were placed in normal revenue generating service. All 100 vehicles were traveling over a nationwide service area, with USX drivers. The average yearly mileage of a U.S. Xpress truck is 120,000 miles. During the course of the FOT, test trucks traveled approximately 30 million miles. U.S. Xpress facilities are located in Tunnel Hill, GA; Dayton, OH; Lincoln, NB; Oklahoma City, OK; Salt Lake City, UT; Fontana, CA; and Colton, CA.

According to VTNA's original schedule, the project duration was 4 years, but was extended to 5 years, including 8 months for the design/manufacture of the vehicles and 30 months for the FOT. The evaluation is aimed at a shorter program and assumed that adequate data would be gathered in 24 months of road testing.

U.S. Xpress conducted driver assignments according to their operational needs and procedures, except for the "baseline" vehicles. Indeed, since the CWS had been in use for several years at U.S. Xpress, USX drivers had experience with the system prior to the start of the FOT. Since the system was expected to change driving behavior on a long-term basis, if experienced drivers are

used, the data collected during the "baseline" tests would have been biased and not representative. As such, to the extent possible, new hires, with no previous experience with the CWS at U.S. Xpress, were assigned to the "baseline" vehicles. The total number of drivers involved in the FOT exceeded 1,000 as a result of:

- The U.S. Xpress driver turnover rate which exceeds 100 percent per year.
- The way drivers and leased tractors are assigned. Typically, a vehicle is assigned to a driver team until it reaches ~150,000 miles, at which time, single drivers are assigned to the unit until the end of the three-year lease. This technique for driver assignments enables U.S. Xpress to optimize the use of leased vehicles under the warranty period.

Traditional driver training takes place over several days and consists of formal in-class training, followed by in-truck training. The extent of training varies according to drivers' experience and driver records. Since only a small percentage of all U.S. Xpress drivers were involved in the FOT, U.S. Xpress conducted special training for the IVI systems. The IVI systems training consisted of one-on-one discussions between the driver and a knowledgeable U.S. Xpress staff member.

2.4 USER ACCEPTANCE STUDY

As part of the evaluation of the Volvo IVI FOT, drivers were surveyed to seek information on user acceptance. Drivers assigned to a U.S. Xpress IVI vehicle were expected to be interviewed at least once at the beginning and once at the end of the evaluation period.

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3. GOALS, OBJECTIVES AND HYPOTHESES

The Volvo Evaluation Plan (Battelle 2001) described the goals and objectives that guided the evaluation of the Volvo Partnership Intelligent Vehicle Initiative (IVI) Generation 0 Field Operational Test (FOT). The evaluation goals are:

Goal 1: Achieve an in-depth understanding of the benefits of intelligent vehicle safety systems (IVSS).

Goal 2: Assess user acceptance, and human factors.

Goal 3: Assess IVSS performance and capability potential.

Goal 4: Assess product maturity for deployment.

Goal 5: Address institutional and legal issues that might impact deployment.

Goal area 2 focuses on how IVSS technologies affect the driving environment and the acceptability of the systems by the drivers and fleet managers, as well as understanding if and how human factors may play a role in the eventual acceptance and deployment of the systems.

Under Goal 2, four study objectives relating to the assessment of user acceptance and human factors issues of the IVSS were identified:

Objective 1. Determine the usability of the IVSS technologies.

Objective 2. Determine how IVSS technologies affect the perceived stress or workload of drivers.

Objective 3. Determine the perceived impacts on driver risk and vigilance.

Objective 4. Determine perceptions of product quality and maturity.

Objective 1: Determine the usability of the IVSS technologies. This objective focuses on how IVSS are used and understood by the drivers. In particular the drivers' understanding of signals and information; perceptions of consistency and robustness of signals; how the information is integrated and presented to the driver; and the ease of learning, use, and control. Specific hypotheses tested are:

1-1 Drivers have reasons for using the IVSS under specific, if not all, driving conditions (e.g., drivers might not use ACC under congested traffic conditions).

1-2 Drivers find the IVSS and components easy to learn.

1-3 Drivers believe that they are adequately trained to use these systems.

1-4 Drivers find the IVSS and components easy to use and control.

1-5 Drivers understand the IVSS capabilities.

1-6 Drivers understand the signals and controls.

1-7 Drivers perceive that the IVSS signals are recognizable and easy to see or hear.

1-8 Drivers trust the IVSS and perceive that they are useful.[6]

1-9 Drivers understand how to use information from the IVSS.

1-10 Drivers believe that the IVSS messages are unambiguous and clearly understood.

[6] This hypothesis is moved under Objective 2 for purposes of this analysis.

Objective 2: Determine how IVSS technologies affect the perceived stress or workload of drivers. This objective focuses on how the IVSS affect the driving environment. Of particular interest are the effects of false alarms and the impacts on driver workload. Specific hypotheses tested are:

2-1 Drivers perceive that the IVSS are effective under specific (if not all) driving conditions.

2-2 Drivers perceive that IVSS reduce their driving workload.

2-3 Drivers perceive that IVSS reduce their levels of stress or fatigue.

2-4 Drivers perceive that IVSS do not distract them or interfere with their other tasks.

2-5 Drivers perceive that IVSS false positive alarms are a nuisance.

2-6 Drivers perceive that IVSS false negative alarms degrade their confidence in the systems.

2-7 IVSS increase job satisfaction of drivers.

Objective 3: Determine the perceived impacts on driver risk and vigilance. Specific hypotheses tested include:

3-1 Drivers with the CWS and ACC systems are aware that they are more vigilant in their following distance behavior than those without the system, because of the feedback provided by the system.

3-2 Drivers are aware that they modify their driving behavior (speed, following distance, braking, turn signal usage) for particular reasons in response to the IVSS.

Objective 4: Determine perceptions of product quality, maturity, etc. Information on the perceived quality, value, and maturity of the IVSS from the perspective of the users (drivers, managers, and other fleet personnel) will be obtained. Specific hypotheses addressed include:

4-1 Drivers have recommendations for changes that might improve the performance or functionality of the IVSS.

4-2 Drivers have recommendations for changes that might make it easier to use or learn how to use the IVSS.

4-3 Fleet managers understand the potential benefits of IVSS and, depending on costs, are willing to deploy these technologies in their fleets.[7]

[7] This hypothesis is not related to driver acceptance and therefore was not tested in this evaluation.

4. SURVEY METHODS

4.1 INTERVIEW PLAN

As shown in figure 1 below, there were two driver survey questionnaires implemented under the evaluation program. To the extent possible, drivers assigned to a U.S. Xpress IVI vehicle were expected to be interviewed at least once at the beginning and once at the end of the evaluation period. However, all drivers did not remain assigned to IVI vehicles during the whole evaluation period. Only a small number of drivers remained assigned to their IVI truck for the full evaluation period and were available to participate in both surveys, providing initial baseline data on expectations and additional data on experiences with the technologies. The total number of drivers who participated in *both* the Phase I and Phase II interviews is 25 (14 test drivers, 6 control drivers and 5 baseline drivers). As a result of the small number of respondents responding to both surveys, comparisons that might have been made on an individual driver-by-driver basis between Phase I and Phase II responses were not examined as they were not expected to result in statistically significant effects.

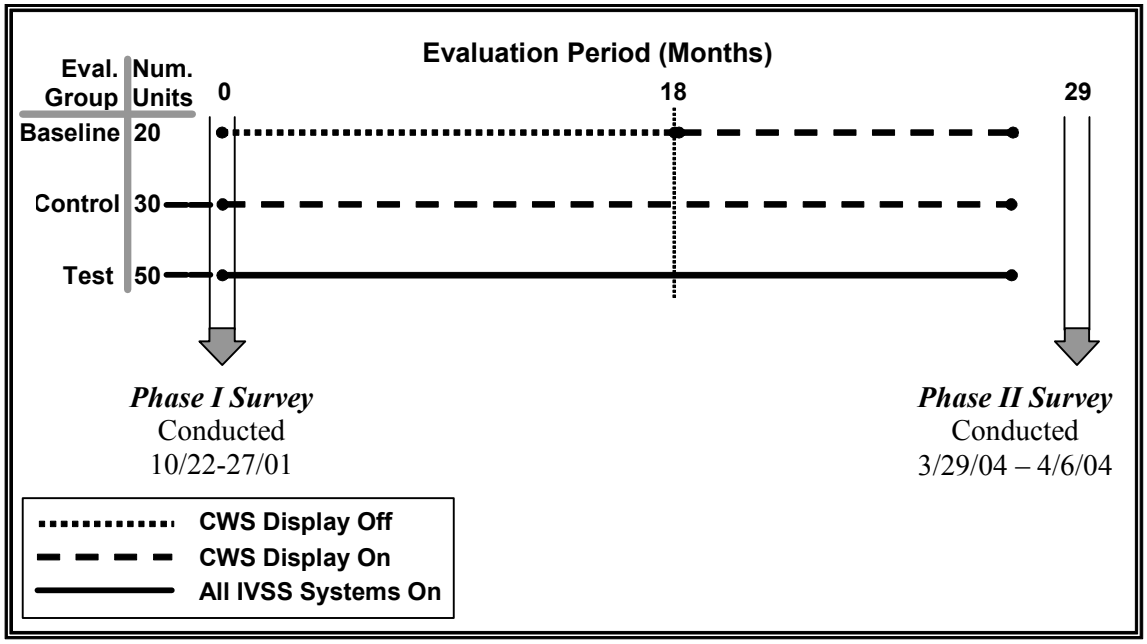

Figure 1. Driver survey design and timing of data collection.

4.2 DRIVER GROUPS

In support of the comprehensive evaluation design, drivers participating in the IVI Volvo FOT were organized into three separate groups for Phase I:

- The drivers of "*baseline*" units (up to 40 drivers). For an extended period of time, these vehicle units had the driver display unit (DDU) of the Collision Warning System (CWS, also known as Vorad®) turned off. The display became fully functional as the evaluation progressed but none of the other technologies under evaluation were operating in these trucks.

- The drivers of *"control"* units (up to 60 drivers). These drivers had a variable amount of experience with Vorad® prior to their IVI unit assignment, and they continued to have an operational Vorad® in their vehicle unit for the duration of the evaluation. However, they did not have exposure under this program to the other two technologies, the Adaptive Cruise Control system (ACC or SmartCruise) and Advanced Braking System (AdvBS). Thus, these drivers also served as control drivers.
- The drivers of *"test"* units (up to 100 drivers). These drivers had experience with the Vorad® prior to their assignment to one of the IVI units. Their trucks were equipped from the start with all three new IVI technologies, including Vorad®, ACC, and AdvBS.

Phase II interviews were conducted after trucks were pulled out of service. Therefore, drivers were selected based on whether or not they drove one of the three types of units in the past three years, not because they were assigned to the units at the time of the interviews (as in Phase I). In support of US Xpress's operations, many drivers were assigned to the 100 vehicles during the 3-year evaluation period, with driving experience on these trucks ranging from 1 day up to 852 days. Details on assignments for the vehicles were obtained from US Xpress, including start, finish and duration of assignment. From the list of 1,176 drivers, 344 drivers were selected based on the length of their assignments to the vehicles, which reflects their exposure to the technologies, as well as based on the last date of the assignments. The US Xpress driver turn-over rate is high, and out of the 344 selected candidates, only 165 were still working at US Xpress at the time of the Phase II interviews. As a result of this selection process, the drivers interviewed in Phase II have had varying exposures to the technologies, with that exposure occurring at different times during the evaluation period.

To assess results of the Phase II interviews, respondents can be categorized in one of two groups:

1. Drivers exposed to Vorad® only (equivalent with Phase I "control" drivers).
2. Drivers exposed to Vorad®, SmartCruise and AdvBS (equivalent to Phase I "test" drivers).

Any differences in driver responses that might have been due to different exposure to these technologies by the baseline and control drivers is assumed to be no longer detectable given the timing of the Phase II interviews. Thus, for the purposes of evaluating driver responses to the Phase II survey, all Vorad®-related questions were addressed by all respondents, while SmartCruise and AdvBS questions were addressed by drivers who reported driving a truck equipped with these technologies. Specifically, 34 drivers self-reported having driven a truck equipped with SmartCruise and 27 drivers said they drove trucks with AdvBS in the period between the Phase I and Phase II surveys. Information obtained from US Xpress shows that, out of the 87 drivers who responded (53% of the 165 active drivers who were contacted), 47 were test drivers and should have been exposed to all three of the technologies (see table 2).

4.3 INTERVIEW DETAILS

Because it would not have been logistically feasible to contact all the U.S. Xpress drivers in person for interviews, a Computer Aided Telephone Interview (CATI) approach was used (Battelle, 2001). Drivers were notified over their satellite-based truck communication system and requested to call an 800 number at specified times to answer survey questions. The call-in times were staggered over a period of six to nine days. Non-respondents were contacted daily encouraging them to call in for their interview. No incentives were offered to the drivers for

participating in the telephone interviews. Trained interviewers conducted the interviews over the CATI system that automatically recorded the results in a database. The data were later cleaned and formatted for data analysis and report preparation.

The Phase I survey was conducted between October 22 and 27, 2001. The Phase II survey was conducted between March 29 and April 6, 2004. A complete discussion of the methods and procedures of driver notification and data collection for Phase II is presented in appendix B. The survey questionnaire used for Phase II interviews is presented in appendix C. Details for Phase I were presented in the Phase I Interim Report (Battelle 2002b).

Table 14 lists the number of drivers who were notified to participate in the interviews, the number of drivers who responded, and the corresponding response rates for Phases I and II. When trucks were driven by a team of drivers, each driver was asked to complete a telephone interview.

Table 14. Summary of survey response rates.

	Phase I				Phase II		
	Baseline	**Control**	**Test**	**Total**	**Control**	**Test**	**Total**
# of drivers notified	38	49	87	174	62	103	165
# of respondents	27	31	59	117	40	47	87
Response rate	*71.1%*	*63.3%*	*67.8%*	*67.6%*	*64.5%*	*45.6%*	*52.7%*

The analysis of the Phase I baseline data was primarily descriptive, providing a characterization of the three driver groups with regard to their expectations and any preliminary experiences associated with the main IVI truck safety technology systems. The results of the analysis were presented in the Phase I Interim Report (See References p. 50: Battelle 2002b). The analysis of the Phase II data allow for an assessment of driver perceptions and behaviors after gaining experience using the three safety technologies.

Questions relating to Objectives 2.1 to 2.3 were asked in the Phase I baseline survey, as well as background questions to get a measure of the drivers' early experiences with the technologies in general and with the Volvo® IVSS technologies specifically. Questions pertaining to perceptions of product quality (Objective 2.4) were asked only in Phase II because, in Phase I, the drivers had not had sufficient hands-on experience with the systems in their trucks to adequately form an opinion of the quality of the product.

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5. RESULTS

Phase I results (Battelle, 2002b), and Phase II results are organized according to the four study objectives under Goal 2: Driver Acceptance and Human Factors. The complete frequency and percentage distributions of the responses to questions in the survey are contained in appendix D.

5.1 BACKGROUND

The Phase I driver survey included a series of questions to gain an understanding of how experienced, knowledgeable, and comfortable drivers were with regard to technology in general, as background to assessing their eventual use and acceptance of the IVI technologies. These initial questions also covered their general satisfaction with their truck's performance, and their history of driving trucks equipped with any of the newer technologies. The results of these background topics were reported in detail in the Interim Report (Battelle, 2002b).

The Phase II survey focuses on driver self-reported experiences with truck driving and with each of the technologies. Results are presented in table 31[8] and figures 2, 3 and 4.

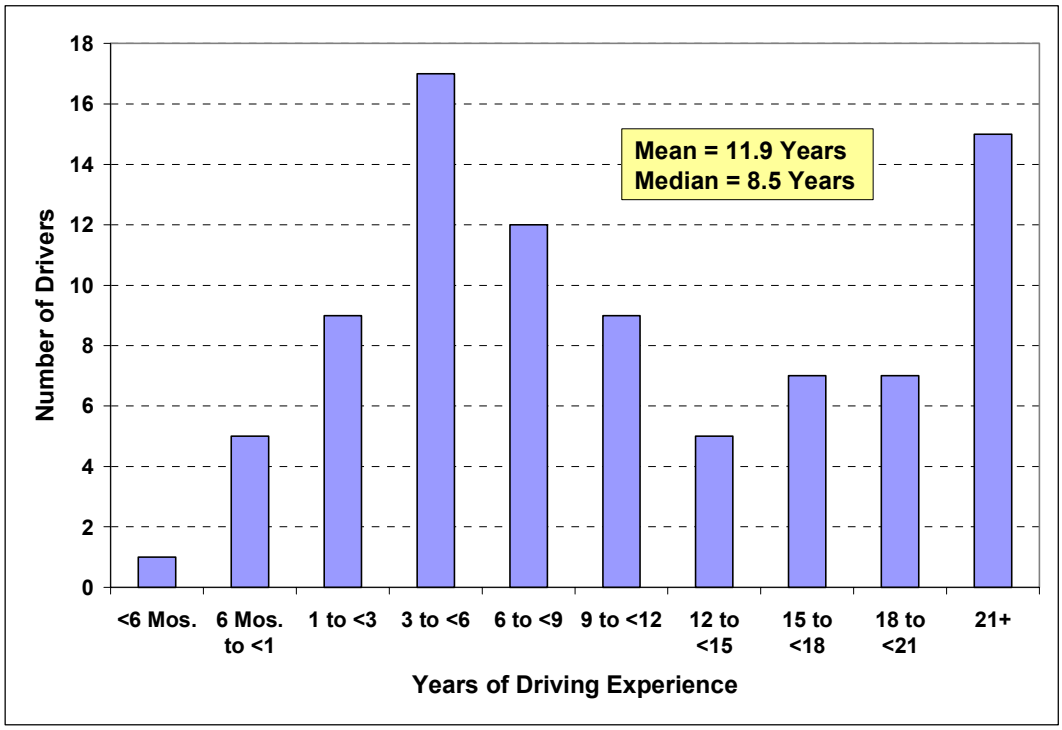

Figure 2. Distribution of Volvo drivers by years of driving experience.

[8] Survey data frequency distributions are provided in appendix D.

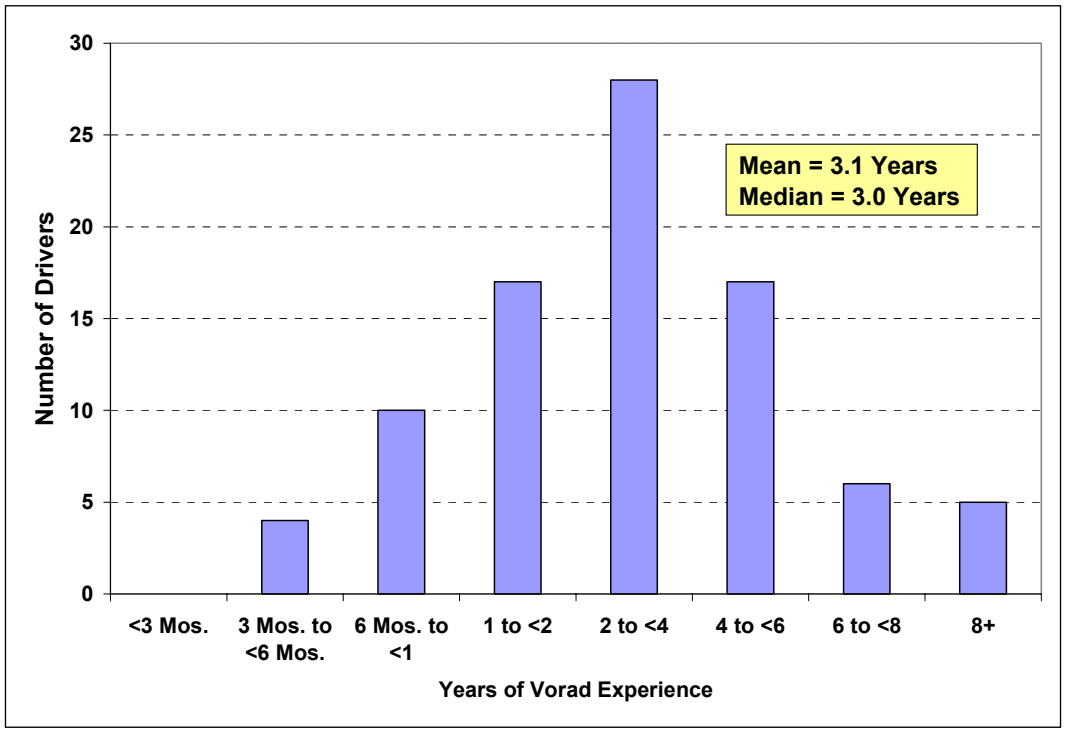

Figure 3. Distribution of Volvo drivers by years of driving experience with Vorad®.

- **Truck driving:** All drivers interviewed in Phase II are very experienced truck drivers, with on average 11.9 years of driving experience. Only one driver had less than 6 months of driving experience, and five had between 6 months and 1 year.
- **Vorad®:** Phase II drivers reported having driven a truck with Vorad® active for an average of 3 years, compared to an average of 1.5 years in Phase I. About 84 percent of the respondents to the Phase II survey reported a year or more experience driving with Vorad®, which is more than adequate to provide an experienced and informed sample of drivers for the evaluation of driver response to this technology. Only four drivers had less than 6 months experience with Vorad®.
- **SmartCruise:** 34 out of 87 (39%) drivers said they have driven a truck equipped with SmartCruise. The average experience they report is 1.1 years (figure 4).
- **AdvBS:** 34 out of 87 (31%) drivers said they have driven a truck equipped with AdvBS. The average experience they report is 1.5 years (figure 4).

Because Vorad® has been operational for several years, this level of driver experience is not unexpected. Many drivers apparently had experience using the system prior to the Field Operational Test (FOT). However, most drivers only had the opportunity to use the SmartCruise and Advanced Braking System during this FOT, since both technologies were not widely deployed prior to the FOT.

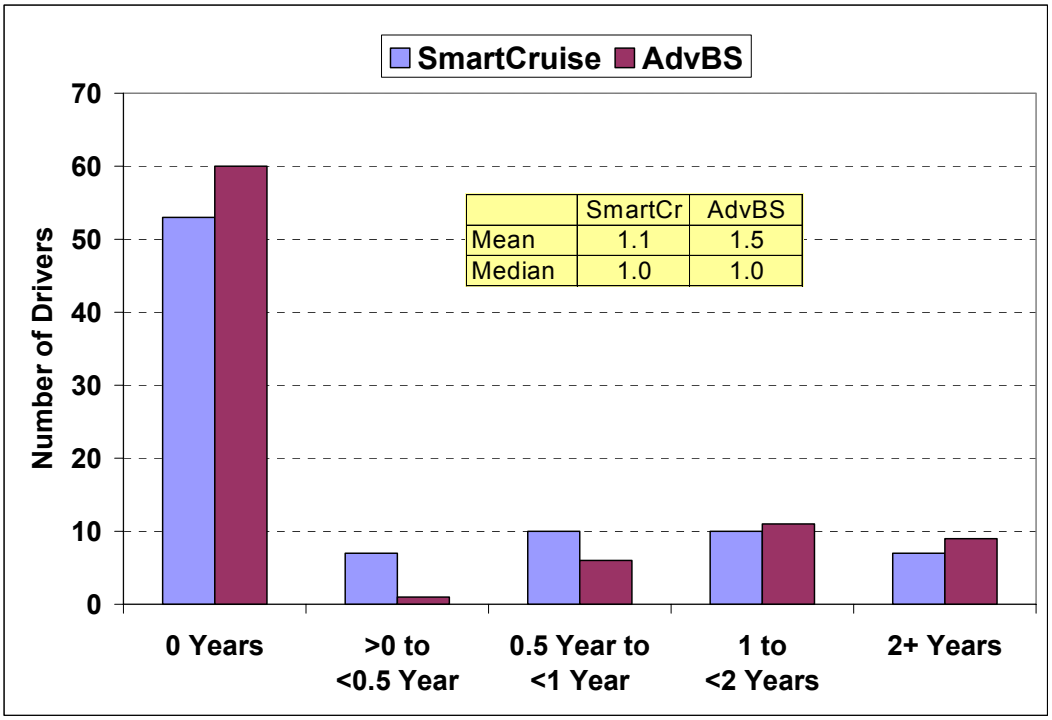

Figure 4. Distribution of Volvo drivers who have driving experience with SmartCruise (N=34) and AdvBS (N=27), by years of experience.

The small sample size for the data regarding driver response to SmartCruise and AdvBS (only about one-third of the drivers reported that they had driven trucks with the technology operating) reduces the likelihood of detecting statistically significant effects.

5.2 USABILITY OF IVSS TECHNOLOGIES (OBJECTIVE 1)

This chapter focuses on how the IVSS are used and understood by the drivers. First, it looks at training and learning processes, then it investigates the ease of use and control, and finally focuses on driver understanding of the visual and audible warnings that are provided by each system under various driving conditions.

The Evaluation Plan identified 10 hypotheses under Objective 1, as shown in table 15. These hypotheses were tested with the data from the driver surveys and the outcome of each test is shown in table 15 and discussed in more detail in this chapter.

Table 15. Use of IVSS technologies: Outcome of hypothesis tests.

Evaluation Hypotheses	Test Outcome	Sections
Drivers find the IVSS and components easy to learn.	Supported	5.2.1 Training and Learning
Drivers believe that they are adequately trained to use these systems.	Partially Supported	
Drivers find the IVSS and components easy to use and control.	Supported	
Drivers understand the IVSS capabilities.	Supported	5.2.1 Understandability
Drivers understand the signals and controls.	Partially Supported	
Drivers perceive that the IVSS signals are recognizable and easy to see or hear.	Supported	5.2.2 Usability
Drivers understand how to use information from the IVSS.	Partially Supported	
Drivers believe that the IVSS messages are unambiguous and clearly understood.	Partially Supported	
Drivers have reasons for using the IVSS under specific, if not all, driving conditions (e.g., drivers might not use SmartCruise under congested traffic conditions).	Supported	
Drivers trust the IVSS and perceive that they are useful.	Supported	

5.2.1 Training and Learning

Tables 16 and 17 address driver training, ease of learning and preferred method of learning to use the technology.

Table 16. Driver training.

Question	Response Category	Phase I Survey Control	Phase I Survey Test			Phase II Survey		
		Vorad® N=31	Vorad® N=59	ACC N=59	AdvBS N=59	Vorad® N=87	ACC N=34	AdvBS N=27
Did you receive training in the use of _____?	Yes	**54.8%**	**52.5%**	32.8%	25.9%	**54.0%**	**23.5%**	**19.2%**
	No	45.2%	47.5%	67.2%	74.1%	46.0%	76.5%	80.8%
How helpful was _____ training for you? Would you say it was…	Very helpful	**29.4%**	**48.4%**	63.2%	53.5%	**42.6%**	**62.5%**	**100.0%**
	Somewhat helpful	**53.0%**	**45.2%**	31.6%	40.0%	53.2%	**37.5%**	**0.0%**
	Not at all helpful	17.6%	6.5%	5.3%	6.7%	4.3%	0.0%	0.0%

As in Phase I, Phase II drivers were asked whether or not they received training, and, if so, how helpful they thought it was.

- **Vorad®:** About half the respondents, 47 out of 87 (54.0%), reported having received training in the use of Vorad®. Of those who said they have received training, almost half the drivers reported that the Vorad® training was "very helpful". Approximately the same percentage of drivers reported having received training in Phase I, and between one-third (control drivers) and half (test drivers) found it very helpful. In both Phases I and II, the majority of the drivers found training to be "very helpful" or "somewhat helpful", and very few said it was not helpful at all.
- **SmartCruise/AdvBS:** Much smaller portions of drivers in both surveys reported having received training in either SmartCruise or AdvBS systems: 8 out of 34 (23.5%) drivers reported having experience with SmartCruise and 5 out of 27 (18.5%) drivers reported having experience with AdvBS. Of those, all of them said the training was "somewhat" or "very" helpful.

In Phase II, drivers also were asked to indicate how helpful various alternative ways of learning each of these systems was to them. The results are similar across each of the three technologies, as shown in table 17.

- The majority of drivers report learning the systems by trial and error.
- More than half of the drivers either think that informal discussions with other drivers are "not at all" helpful, or report that they do not have informal discussions about the technologies with other drivers. Only 20 percent or less of the drivers report informal discussions help "a lot" to learn how to use the system.
- About half of the drivers think that the Vorad® manual helps "somewhat" or "a lot." Nearly half of the drivers report not having a SmartCruise or AdvBS manual.

Table 17. Reported helpfulness of learning approaches.

Question	Response Category	Phase II Survey		
		Vorad®	SmartCruise	AdvBS
How much would you say explanations in the driver's manual help you learn _____?	A lot	**32.6%**	15.2%	7.4%
	Somewhat	**23.3%**	12.1%	25.9%
	Not at all	26.7%	30.3%	18.5%
	Don't have a manual	17.4%	**42.4%**	**48.1%**
How much would you say informal discussions with other drivers help you learn _____?	A lot	14.9%)	20.6%	18.5%
	Somewhat	27.6%	14.7%	7.4%
	Not at all	**27.6%**	**29.4%**	**25.9%**
	Don't talk about this	**29.9%**	**35.3%**	**48.1%**
How much would you say that just using it and trial and error help you learn _____?	A lot	**66.3%**	**70.6%**	**77.8%**
	Somewhat	25.6%	17.6%	7.4%
	Not at all	8.1%	11.8%	14.8%

In Phase I, drivers were asked whether or not it was/would be easy to learn how to use Vorad®, SmartCruise and AdvBS. There was little disagreement on the ease of learning to use these systems. The vast majority (80% to 95%) of the drivers in Phase I said that Vorad®, SmartCruise and AdvBS are or would be easy to use. In Phase II, drivers were asked to recommend changes to the system to make it easier to use or to learn how to use Vorad® or SmartCruise, and these results are presented in chapter 6 "Product Quality and Maturity." Although drivers did provide suggestions to make it easier to learn how to use Vorad® or SmartCruise, their answers indicated that they perceived the systems as easy to learn.

In Phase II, drivers were asked about the meaning of various warnings in order to assess whether or not they have learned how to use to system. Specifically, drivers were asked about the meaning of all three lights illuminated, of one single beep and of double beeps.

- **Three illuminated lights:** Nearly all drivers recognized that all three Vorad® lights illuminated simultaneously is an indication that they are "real close", or "too close to someone". While a few drivers knew exactly that this was an indication that the time gap was less than 1 second, a few other drivers did not know what it meant and others thought that it was only the system self-check.
- **Single beep:** Drivers' understanding of the system is not quite as good when it comes to single beeps. Although some drivers did report that a single beep was indicative of a closing distance, most drivers' responses were either not correct ("object was there and now not there"), vague ("we are a certain distance away"), or incomplete ("when I pass an overpass, that's what it does"). Many drivers reported that a single beep was sounded when driving under an overpass, near a post or other roadside furniture.
- **Double beep:** Most drivers recognized that the double beep is indicative of a dangerous situation ("entering danger zone") and that something must be done ("you are getting very close to an object, and you need to slow down") but they are not aware of the exact level of urgency ("it's getting closer"), or nature of the situation.

5.2.2 Usability

This section covers driver responses to questions about their perception of the visual and audible aspects of Vorad® (ease-of-use related questions do not readily apply to SmartCruise and AdvBS). Are they easy to see and hear? Can the drivers easily and unambiguously distinguish warnings from each other and from other systems in their truck? Do they work properly, and, if not, how frequently do they fail? Recommendations for improving the ease of use of these systems are addressed in chapter 6 "Product Quality and Maturity."

Ease of Seeing and Hearing Vorad® Warnings

Table 18 summarizes the data on ease of seeing and hearing the Vorad® warnings (detailed data are in table 35).

Table 18. Seeing and hearing Vorad® warnings.

Question	Response Category	Vorad® (N = 87)	
		Lights / See	Beeps / Hear
The warning _____ from the Vorad® forward radar are easy to _____.	Always	**87.4%**	**93.1%**
	Most of the time	8.0%	6.9%
	Some of the time	1.1%	0.0%
	Rarely	1.1%	0.0%
	Never	1.1%	0.0%

- Most of the drivers (87.4%) report that the Vorad® warning lights are always easy to see. Drivers who reported "most of the time" or less said that "glare from the sun" sometimes made the lights hard to see, or that the positioning of the display required them to "look away from the road to see which light is on" because "it is not in a direct line of sight."
- Similarly, most drivers (93%) report that the Vorad® audible alerts are most of the time easy to hear. Six of the drivers said the alerts were easy to hear "most of the time," and none reported less than that. Those six drivers said the Vorad® sounds can be confused with, be masked by or blend with "other sounds in [their] truck," specifically quoting "radio," "CB," and "phone." Two drivers stated that they "turned down the alert volume" or "taped the speaker."

Ease of Distinguishing Alerts from Each Other and from Other Sounds

It is important for drivers to be able to distinguish the various types of Vorad® alerts from one another in order to fully benefit from the system. Drivers were asked how often they can successfully distinguish among these warnings. Frequency results are shown in table 36, and summary results are shown in table 19.

Table 19. Ease of distinguishing among different Vorad® alerts.

Question	Response Category	Vorad® (N = 87)	
		the warnings given by the **forward** Vorad®	the warnings given by the **side** Vorad®
The various Vorad® warnings given by the forward sensor, including single beeps, double beeps and visual alerts, are easily distinguished from _____.	Always	64.4%	62.1%
	Most of the time/ Some of the Time	29.8%	23.0%
	Rarely/ Never	3.4%	11.5%
	Don't know	2.3%	3.4%

- About two-thirds of the drivers (64.4%) said they could "always" distinguish the different alerts from one another.

- Thirty percent (30%) said they can distinguish the alerts "some" or "most of the time."
- Only three drivers said they could "rarely" or "never" distinguish them (3.4%).
- A few of the drivers who said they could not easily distinguish the warnings all the time explained that the "tone is same more or less" or that "they basically sound about the same." A couple of drivers said that they would have to "look down to tell them apart," and that they are "not looking at the lights when someone is too close." Another driver specifically refers to the fact that "other noises in the cab can blend together with tones, that the truck itself has tones and sometimes they harmonize with Vorad®," thereby making Vorad® alerts hard to distinguish.

The drivers were asked whether they could easily distinguish the Vorad® forward warnings from the Vorad® side warnings (table 19).

- Two-thirds of the respondents (62.1%) reported that they could "always" distinguish between the forward and side warnings.
- Twenty-three percent (23%) said they can distinguish the alerts "some" or "most of the time."
- Ten drivers (12%) said they could "rarely" or "never" distinguish them.
- When asked to explain why they could not "always" distinguish the forward and side warnings, several drivers said that the front and side audible alerts "are too similar," "of the same quality," or that they "could not tell the difference" because "sounds are alike." Two of drivers said that sounds are hard to distinguish because "the sound from Vorad® comes from the same location regardless if coming from the front or the side." On the other hand, these drivers said "the lights when they flash show up in two different areas and are thereby easily distinguished." One driver said that he "is not aware of the side alarm because he does not get as many off the side as he does off the front."

It is important to understand what other systems in the truck cab may potentially compete with Vorad® for the driver's attention and the ability of the driver to distinguish similar sounds coming from these various systems.

First, drivers were asked whether their truck was equipped with warning or beeping systems other than Vorad® (table 20).

- A little over one-third of the drivers (37.9%) said they did have such systems in their vehicles.
- When asked how consistently they could distinguish the warnings from these systems apart from the Vorad® warnings, most of those drivers said they could tell the difference every time (78.8% said "always"). The rest said "most of the time," though one driver said "rarely."
- When asked why warnings from Vorad® and these others systems were hard to distinguish, one driver said "sometimes when I'm tired the two sounds kind of sound alike." Another said when several systems "go off" at the same time and he is concentrating on his driving, he has to look to see if it is the Vorad® or something else, particularly if the radio is on at the same time. Another driver said that the warning tones from the different systems in the cab, while not identical, can sound very similar.

Table 20. Distinguishing Vorad® warnings from other system warnings.

Question	Response Category	Vorad® N = 87
Is your truck equipped with warning or beeping systems other than the Vorad® forward or side radar?	Yes	37.9%
	No	62.1%
The various Vorad® warnings (forward and side) are easily distinguished from other systems' warnings.	Always	78.8%
	Most of the time	18.2%
	Some of the time	0.0%
	Rarely	3.0%
	Never	0.0%

In conclusion, most drivers do not appear to have problems distinguishing the feedback provided by the Vorad® system.

Driver Response to Vorad® Alerts

Drivers were asked about the meaning of several warnings, namely, all three lights illuminated, a single beep, and a double beep, in an attempt to assess whether or not they have learned how to use to system. This question investigates whether or not they know how to respond, or what to do to react to these various levels of warnings: three illuminated lights, a single beep or a double beep.

When the three lights illuminate, a target vehicle is within 1 second of the truck. A tone will sound if the distance between the target is closing (i.e., slow moving, braking or stationary vehicle). A double tone will sound if the distance between the target and the truck continues to close and the target is within a half second of the truck.

- Nearly all drivers recognized that each of these three warnings indicates a potential danger, and that they needed to make adjustments. Some drivers said that they "perk up" or "become very alert to what is around." Many drivers said that they assessed the situation: "look around and make sure it is safe," or "focus [their] attention to the front of the truck to check to see if an object is within unsafe distance." Finally, the majority of the drivers reported that they needed to take action to "increase the distance between the vehicle in front or beside you," by "slowing down," "backing off on speed," "backing off the accelerator," "starting to hit the brakes," "applying the brakes to get away from the vehicle," or "changing lanes." Some drivers (7 out of 87) reported that "nothing" needed to be done, that they "assume that there is a problem with the Vorad®," and that they "ignore it" because they "do what they need to do without looking at Vorad®."
- Drivers' responses to what to do when a single beep sounds were identical to those in response of the three illuminated lights.
- Drivers' responses to what to do when a double beep sounds were also identical to those in response of the three illuminated lights or the single beep, with nine drivers specifically recognizing the increased level of danger by reporting that they "slow down even more," "are on the brake more" or "increase the distance, but with greater haste and

more diligence." Two drivers said they respond by "turning the cruise control off." Six still stated that "nothing" needed to be done, or that they "pay no attention to the beeps."

5.3 DRIVER STRESS AND WORKLOAD (OBJECTIVE 2)

Objective 2 focuses on how the IVSS affect the driving environment. This chapter examines how drivers perceive how each of the safety technologies affects their driving behavior, driving stress and fatigue, and workload, based on their driving experience. The Phase I survey asked comparable questions early in the program to understand driver expectations and reactions of drivers with limited experience with the technologies. Phase II provides insights from drivers with much more extensive experience with each of the IVSS.

The Evaluation Plan identified seven hypotheses under Objective 2, as shown in table 21. These hypotheses were tested with the data from the driver surveys. The outcome of each test is shown in table 21 and discussed in more detail in this chapter.

Table 21. Perceived stress and workload: Outcome of hypothesis tests.

Evaluation Hypotheses	Test Outcome	Sections
Drivers perceive that IVSS do not distract them or interfere with their other tasks.	Partially supported	5.3.1 Driver Distraction and False Alerts
Drivers perceive that IVSS false positive alarms are a nuisance.	Supported	
Drivers perceive that IVSS false negative alarms degrade their confidence in the systems.	Not supported	
Drivers perceive that the IVSS reduce their levels of stress or fatigue.	Partially supported	5.3.2 Stress and Fatigue
Drivers perceive that IVSS reduce their driving workload.	Supported	5.3.3 Driver Workload
IVSS increase job satisfaction of drivers.	Indirectly supported	5.3.4 Driver Acceptance
Drivers trust the IVSS and perceive that they are useful.	Supported	
Drivers perceive that the IVSS are effective under specific (if not all) driving conditions (to be determined).	Supported	

5.3.1 Driver Distraction and False Alerts

Distraction from Driving Tasks

Drivers were asked whether the visual or auditory warnings provided by Vorad® drew their attention away from their driving tasks. Full results are shown in table 38 and summarized in table 22.

Table 22. Stress and workload: IVSS distraction effects.

Question	Response Category	Vorad® N = 87	SmartCruise N = 87
The visual Vorad® forward radar warnings draw my attention away from my driving tasks.	Always / Most of the time	**4.5%**	—
	Some of the time	**17.2%**	—
	Rarely / Never	**78.1%**	—
The auditory Vorad® forward radar warnings draw my attention away from my driving tasks.	Always / Most of the time	**2.2%**	—
	Some of the time	**13.8%**	—
	Rarely / Never	**83.5%**	—
The auditory _____ warnings (beeps) get my attention if I get a little tired or bored driving.	Always/ Most of the time	**60.9%**	**20.6%**
	Some of the time	10.3%	26.5%
	Rarely / Never	**28.7%**	**53%**

- Most drivers said visual (78.1%) and auditory (83.5%) warnings "rarely" or "never" drew their attention away from their driving tasks.
- The few drivers who said visual and audible warnings drew their attention away from their driving tasks "some of the time" (17.2% and 13.8%, respectively), "most of the time" or "always" (4.5% and 2.2%, respectively) were asked to explain how.
    - Their explanations for visual distractions focused on the fact that they have to look away from the road to look at the lights:
        - *If someone pulls in front of me, I look at it when I should be looking at the road.*
        - *You are looking to see which sensor is going off instead of watching the road.*
        - *[The visual warning] startles you—want to see what's going on.*
        - *When looking at [warning] lights, you are not looking at the road. Not too much of a problem, but there is a moment of distraction.*
        - *In heavy traffic, particularly in the evening when one has to be visually scanning, Vorad® tends to distract.*
    - Several drivers also noted that the experience of false audible warnings is a source of distraction:
        - *Anything that makes a noise will do this.*
        - *When you hear beeps, you tend to look at the lights.*
        - *Beeps go off for no reason—too many false reasons. Even barrels in construction.*
        - *It's distracting in heavy traffic, and this is stressful.*
        - *Beeps start and you think you are about to hit something but it could be a large rock or tree, and this upsets you a little.*

- *Sometimes it catches you off guard.*
- *When beeping is going on, it draws your attention away from the sounds of traffic, such as someone honking at you.*
- *Distracts me from being focused.*
- *It makes you pay more attention to your surroundings. If the alarm goes off, you check mirrors to make sure nothing is there. It is part of your driving skills.*

Increased Alertness and Awareness

In addition to having the potential of distracting drivers' attention away from their driving tasks, the IVSS auditory warning can have the very positive effect of getting a driver to focus their attention on the driving task when they may be tired or bored.[9] The results are shown in table 22 and in figure 5.

- **Vorad®:** About 61 percent of the drivers said Vorad® audible warnings have the ability to get them more alert and focused "most of the time" or "always," while nearly 30 percent of them said that Vorad® "never" or "rarely" got their attention if they were a little tired or bored. Drivers who reported that the Vorad® auditory warnings get their attention when tired or bored were asked to explain how the system could be attention grabbing:
  - *Each time it goes off you instantly become more alert one higher level.*
  - *Attention grabbing in general. If you don't have the volume turned down, they are very pronounced.*
  - *When you are in stop and go traffic, keeps your attention in check, and at end of driving day it keeps focus.*
  - *When you are tired or something else is distracting you that shouldn't be.*
  - *There is a tendency to fixate, after a long day of driving.*
  - *During long drives it helps keep me alert.*
  - *Near the end of shift when you are tired, it grabs your attention.*
  - *If you are daydreaming, it does this.*
  - *If you are tired and not paying adequate attention to your surroundings, it makes you more alert and you know it is time to part your truck.*
  - *When you are tired and going around a mild curve, that thing will beep and get your attention if you are straying too close along the right side.*
  - *In adverse weather, if you are concentrating too much in one direction, Vorad® pulls your attention back to what is in front of you.*
  - *If I had already looked ahead and it goes off, I look again.*

[9] There is presumably reluctance on the part of drivers to ever admit to being tired or bored on the job, so the results may be subject to bias.

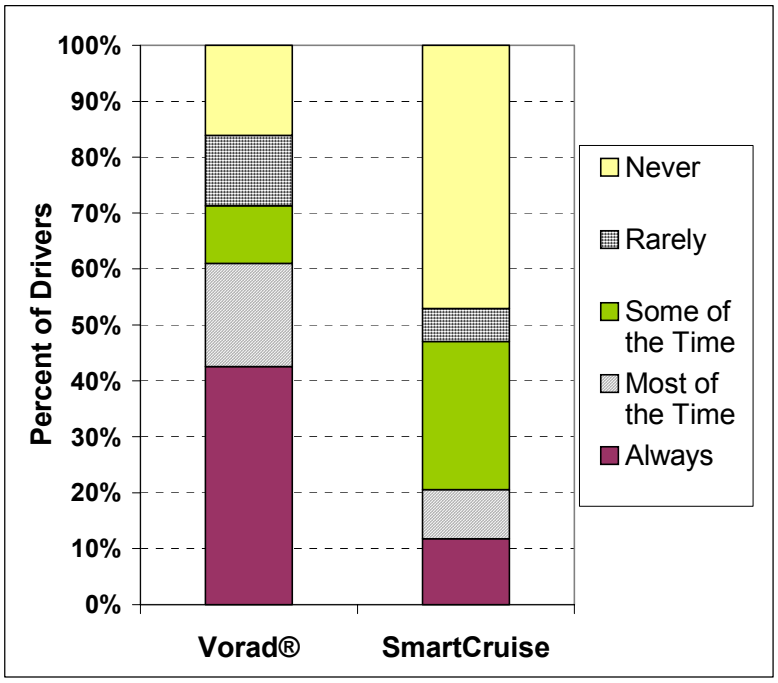

Figure 5. Do the auditory warnings get your attention when you are tired or bored driving?

- **SmartCruise:** Only about 20 percent of the drivers said that SmartCruise causes them to be more alert, while more than half of the drivers (53%) said that SmartCruise never had this effect. There were relatively few drivers who used SmartCruise and reported on how it gets their attention. Those who did offer comments essentially said:
  - It slows their truck automatically (as it is designed to do):
    - *When you are tired, on cruise control, and vehicle slows down.*
  - It serves to raise driving awareness:
    - *If I am singing a song and thinking about the song, the SmartCruise grabs your attention and you get back to driving more alertly.*
    - *Truck automatically slows down which makes me more alert.*
    - *When I've been driving for many hours it alerts you.*
  - In some cases, as one driver commented, it signals that "*fatigue has set in and it is time to stop for a cup of coffee*."

Interference with Driving Tasks

Another aspect of distraction is whether Vorad® and SmartCruise are seen as interfering with driving tasks. Although this issue was touched upon by driver responses to the questions about the distraction effects of the visual and auditory warnings, drivers were also asked if the Vorad® or SmartCruise interferes with their driving tasks. Results are shown in table 39 and figure 6. The drivers who reported interference from either Vorad® or SmartCruise were asked to briefly describe the driving tasks with which the IVSS interfered and how it interfered.

- **Vorad®:** Most of the drivers (77%) said that Vorad® does not interfere. Only 10 percent of them said it interferes "somewhat" or "a lot" with their driving tasks. The

drivers who reported interference mostly cited problems in heavy traffic or construction zones with the alert going off more frequently than necessary, to the point that it became very annoying. One problem noted is that the auditory alert wakes up their partner driver who is trying to sleep.

- *On heavy traffic, it goes off a lot.*
- *In construction, beeps in curvy situations.*
- *In city driving, it is unreal, partner can not sleep with the alarm going off.*
- *Volume too high when partner sleeps.*

- **SmartCruise:** A higher percentage of drivers (44%) reported experiencing interference from SmartCruise to some degree. The drivers who reported interference said that the system lacks power to pass a vehicle or to go uphill, and that the system kicks off too soon and forces the driver to compensate.
  - *Going up hill with a heavy load, and get behind a slow car, it kicks you down automatically and you still need the power to get up top.*
  - *Loose momentum when trying to pass when coming up on a vehicle slower, would go off too soon.*
  - *When you want to pass another vehicle, you have to have enough speed to get past, SmartCruise slows you down sometimes.*
  - *It slows you down a lot. You have to turn the cruise off to get around the car.*

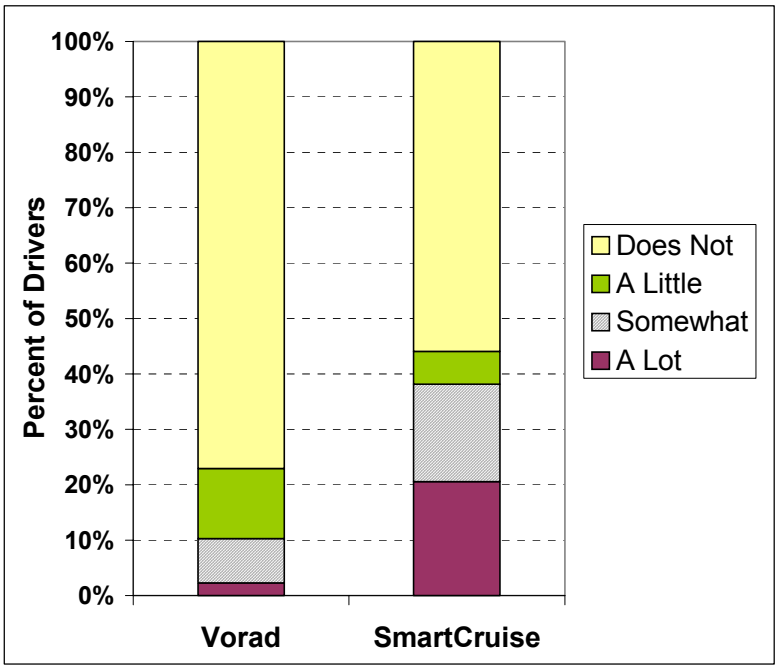

Figure 6. Does the IVSS interfere with your driving tasks?

Effect of Specific Driving Conditions

It is useful to try to understand the conditions under which drivers perceive IVSS technologies to be particularly helpful or alternatively, annoyingly distracting. In adverse driving conditions such as heavy traffic, fog, snow or nighttime, is Vorad® meeting drivers' needs? In Phase I,

drivers were asked whether Vorad® was more helpful or more distracting under specific conditions. In Phase II, drivers were asked to check each of the driving conditions under which the technology was helpful, and then in a separate question, the conditions under which each was distracting. This approach allowed for a more complete understanding of what drivers think about these technologies, without constraining them to choose one response or the other. The results are shown in table 40 and figure 7.

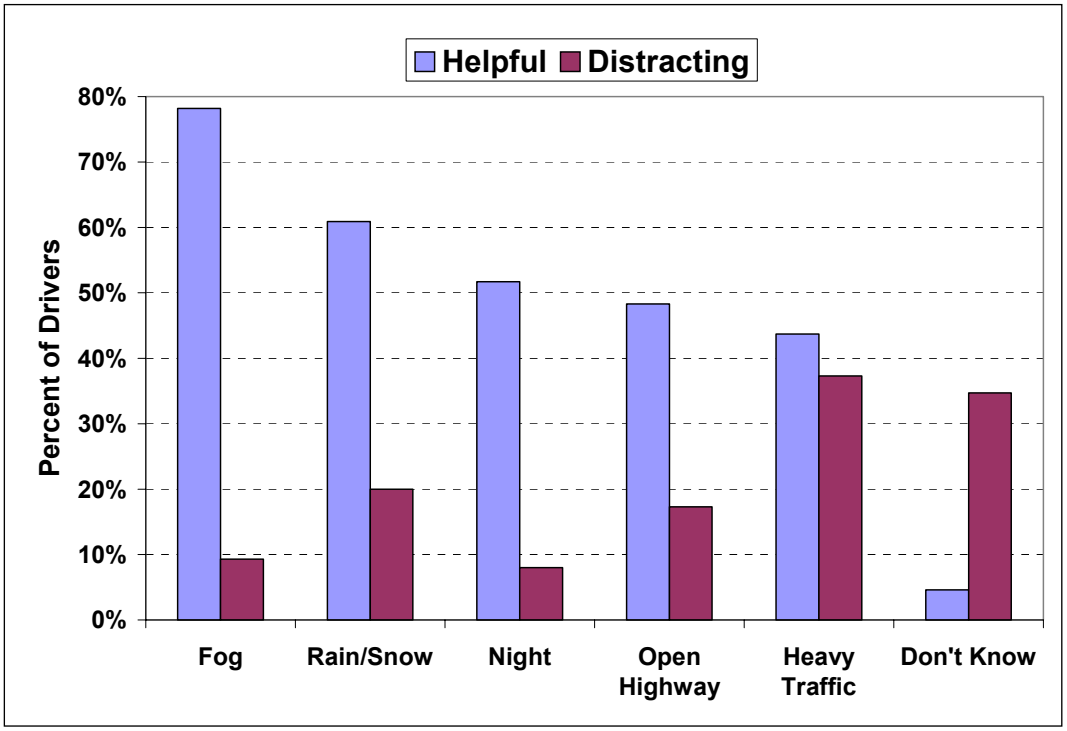

Figure 7. Traffic or weather conditions under which Vorad® forward radar is either particularly helpful or distracting.

- In general, over all the conditions investigated, Vorad® is viewed as more helpful than distracting.
- Most drivers view it as helpful in low visibility conditions, such as fog (78% of drivers), heavy rain/snow conditions (61%), or night driving (52%). Conversely, relatively few drivers say it is distracting under these conditions.
- As was seen in the driver comments about the distraction effects of Vorad®, more drivers find it distracting in heavy traffic (37%) than in any other situation (fog, night, heavy rain or snow, or open highway). These results mirror closely the relative rankings on helpfulness versus distraction in the Phase I survey.
- A large number of drivers (26 out of 87, or 34.7%) responded "don't know" when asked to select the traffic or weather conditions in which the Vorad® forward radar could draw their attention away from their driving tasks, i.e. be distracting. Many fewer drivers responded "don't know" when asked about the conditions in which the Vorad® forward radar could be more helpful. Drivers did not appear to be able to identify specific situations other than the heavy traffic conditions in which the Vorad® radar was more

distracting, potentially indicating that either these drivers did not think of the system as ever being distracting or these drivers thought the system was always distracting, regardless of the driving conditions.

False Alerts

False alerts can either be false positive or false negative alerts. A "false positive" alert occurs when Vorad® issues an alert when in reality there was no cause for the alert. A "false negative" occurs when Vorad® should have given a warning but failed to do so. In addition, in an effort to investigate drivers' perceptions of the Vorad® alerts, drivers were asked to indicate on the same scale how frequently they thought they received Vorad® alerts when there might have been a crash threat, but the alert was considered by them to have been unnecessary, for example, if they felt they had the situation in complete control and really did not need the Vorad® system's warning. These alerts are referred to as "unnecessary alerts".

False Positive Alerts

The drivers surveyed were asked to estimate the average number of false positive alerts out of every 10 Vorad® alerts they had received. Table 42 shows the distribution of responses on this question, and these results are illustrated below in figure 8. Also shown in figure 8 are driver responses regarding perceived false negative alerts, that reflect warnings drivers thought Vorad® should have given but it failed to give.

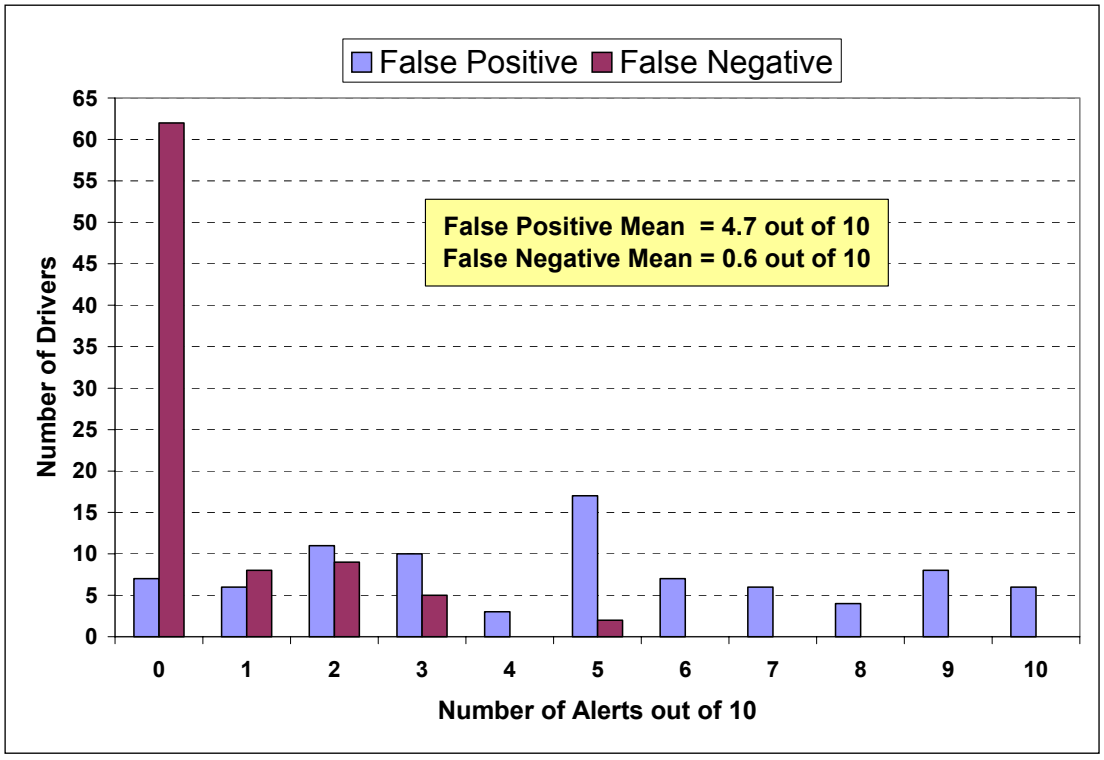

Figure 8. Average number of false positive alerts out of every 10 reported by drivers as received from the Vorad® forward radar, and number of alerts not given that should have been provided by Vorad® (false negatives).

- One-fifth of the drivers reported that they experienced false positive alerts about half the time (5 out of 10 times).
- Less than 10 percent of the drivers said they got no false positive alerts (8.2%), and almost the same percentage of drivers reported that every alert was a false positive (7.1%).
- The average number of false positive alerts reported by the drivers is 4.7 out of 10 (about 47% of the time), although this number varies a lot (figure 8).
- These results suggest that about half of all Vorad® alerts are issued when the driver believed that there was no crash threat.

Unnecessary Alerts in Crash or Near-Crash Situations

In an effort to investigate drivers' perceptions of the Vorad® alerts, drivers were asked to indicate on the same scale how frequently they thought they received Vorad® alerts when there might have been a crash threat, but the alert was considered by them to have been unnecessary. Drivers might respond in this way, for example, if they felt they had the situation in complete control and really did not need the Vorad® system's warning. The results are illustrated in figure 9.

- One-third of the drivers (32.6%) said they did not receive any Vorad® alerts they considered unnecessary in situations where there might have been a crash threat ("None" in figure 9). Among these respondents the overall average number of perceived unnecessary alerts was 3 out of 10 (30% of the time).
- Figure 9 shows there are significant numbers of drivers who say that most of the alerts they got were unnecessary, even when they thought a crash could have occurred: Fourteen out of the 87 drivers interviewed said this happens in 70 percent or more of these situations.

False Negative Alerts. In contrast to a false positive is a false negative. Table 43 and figure 8 show how drivers responded to this question, again on a "0" to "10" scale, where "0" indicates no times and "10" indicates every time.

- The number of reported false negative alerts is much lower than the number of reported false positives, as can be clearly seen by comparing responses to the two types of alerts in figure 8.
- The average number of reported false negative alerts is less than 1 out of 10 (mean = 0.6).
- Only 2 drivers reported experiencing an average of 50 percent of their alerts not occurring when they should have occurred, and none reported higher than that.
- Almost three-quarters of the drivers interviewed (72.1%) said they never received a false negative Vorad® alert.

Those drivers who reported false negative alerts were asked if these missed alerts reduced their overall confidence in the Vorad® forward radar (table 43).

- Most (80%) said "not at all," and only a few said "somewhat" or "a lot."

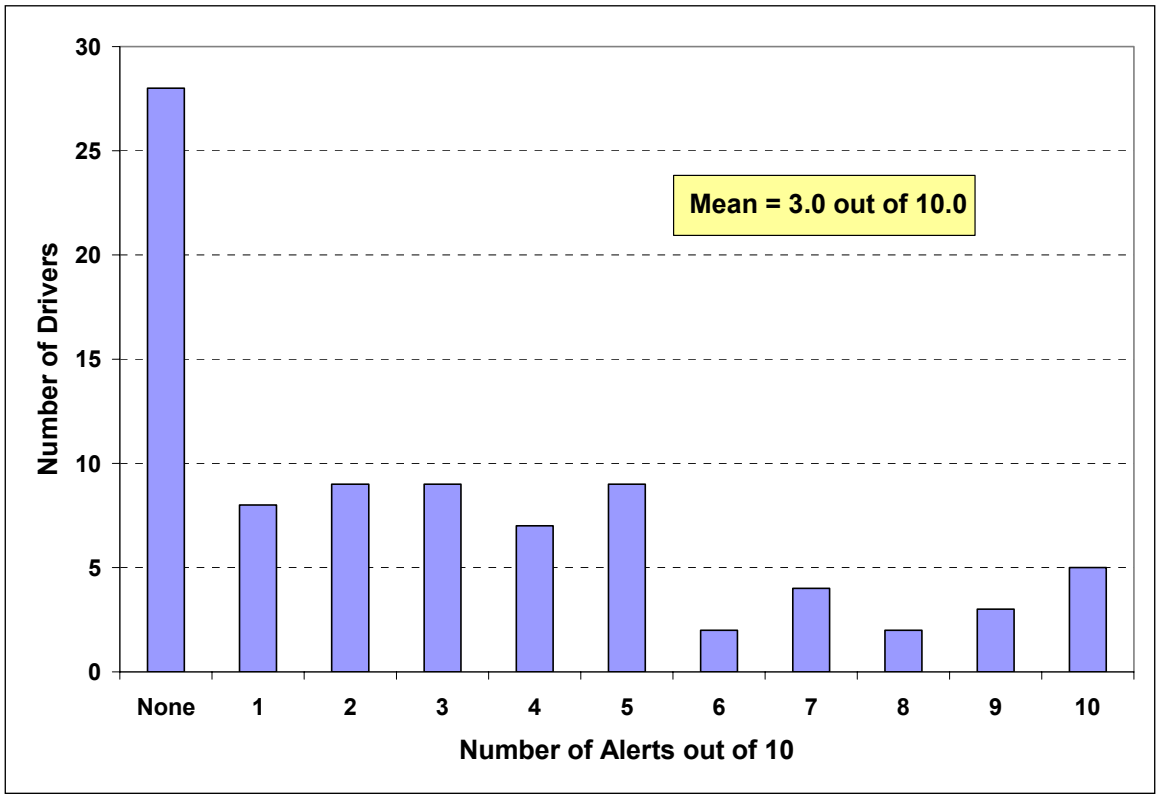

Figure 9. Average number of positive but unnecessary alerts out of every 10 reported by drivers as received from the Vorad® forward radar.

Drivers who reported getting some unnecessary alerts were asked whether or not these alerts presented a nuisance, even when they thought a crash might have been likely (i.e., more than 0 out of 10 to the prior question). Results are shown in table 44.

- The number of drivers who said this resulted in "somewhat" or "a substantial nuisance" exceeded those who said it was "not much of a nuisance" or "none at all" (59.4% versus 40.6%).
- Many truck drivers apparently feel that Vorad® gives a lot of false alerts, and even when it gives valid alerts, many of those are judged to be unnecessary and, furthermore, a nuisance to their driving.

5.3.2 Stress and Fatigue of Driving

As in the Phase I interviews, drivers in Phase II were asked whether driving with the Vorad® forward radar is more or less stressful and tiring than driving without it.

Phase I results showed that:

- About half of the test drivers interviewed agreed that IVSS had reduced the stress and fatigue of driving.
- About one-third of the test drivers disagreed that Vorad® reduced stress and fatigue.

- The IVSS drivers who did not have driving experience with the technologies were more likely to expect IVSS would not reduce stress and fatigue.

Table 23. Stress and workload: Driver stress and fatigue.

Question	Response Category	Phase I			Phase II		
		Vorad® N = 59	**Smart-Cruise** N = 59	**AdvBS** N = 59	**Vorad®** N = 87	**Smart-Cruise** N = 34	**AdvBS** N = 27
I find that ____ reduces the stress and fatigue of driving.	Strongly disagree/ Disagree	35.6%	22%	25.4%	-	-	-
	Neither agree nor disagree	15.2%	18.6%	25.4%	-	-	-
	Agree/ Strongly agree	**49.2%**	55.9%	**49.2%**	-	-	-
Which of the following statements reflects your experience driving with _____ compared to your experience driving without _____? Driving with _____ is *[response category]* stressful and tiring.	A lot more/ Somewhat more	-	-	-	17.4%	**23.6%**	7.4%
	No more or less	-	-	-	**33.7%**	**38.2%**	**37.0%**
	Somewhat less/ a lot less	-	-	-	**48.8%**	38.3%	**55.5%**

As shown in table 23 and figure 10, the Phase II results are consistent with the Phase I results for drivers with actual driving experience with each of the technologies.[10]

- About one-third or more of the drivers (33.7%, 38.2% and 37.0%) said that the Vorad®, SmartCruise and AdvBS respectively did not affect the stress and fatigue they experience while driving.
- Drivers experienced with Vorad® and AdvBS are more likely to say they have less stress and fatigue with each technology than without it (48.8% and 55.5%, respectively).
- Drivers were more likely to say that SmartCruise and Vorad® can increase stress and fatigue "somewhat" or "a lot" (23.6% and 17%, respectively), than AdvBS (7.4%).

Drivers were asked to explain in their own words how each technology affected the stress and fatigue of driving.

- **Vorad®:** Most drivers view Vorad® as decreasing stress and fatigue "a lot" or "somewhat." Because of the added sense of security, they view the technology as "another tool" that supports them as "another set of eyes":
  - *It picks up things I can't see.*
  - *If extremely heavy downpour, the only thing [a driver] can do is drive through the rain trusting Vorad® explicitly.*

[10] Although the question wording was different.

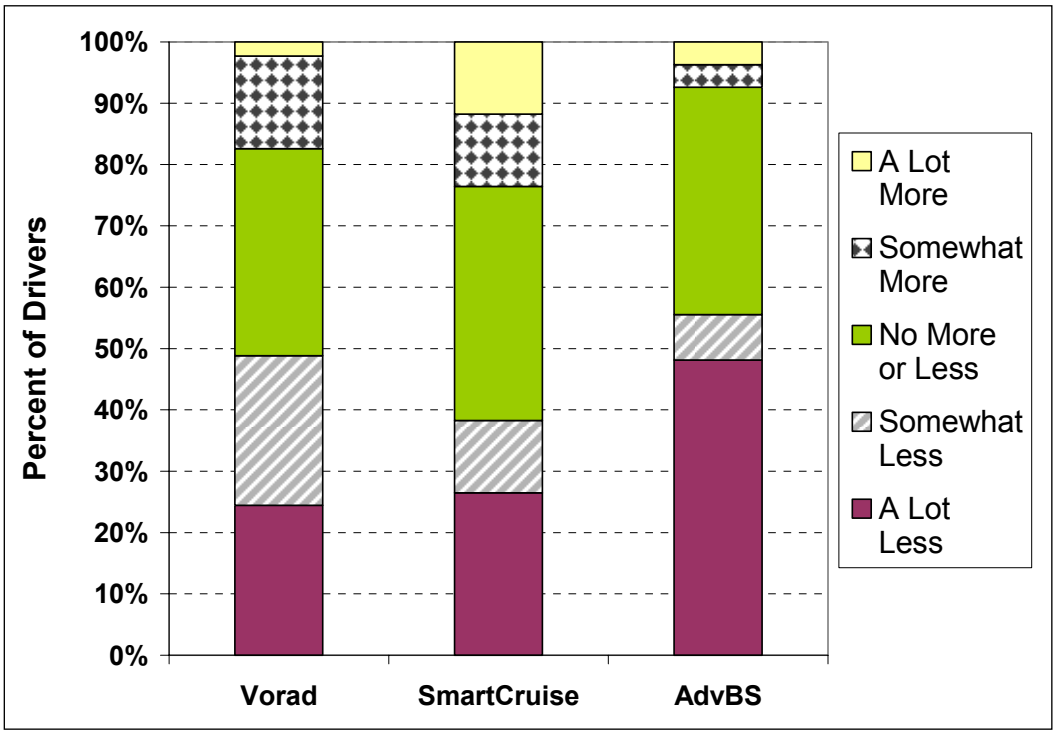

Figure 10. Stress and fatigue experienced by drivers with the IVSS technology versus without the technology.

Many drivers also reported that Vorad® reduced stress and fatigue by increasing their alertness and awareness of the environment:

- *It makes me more aware of surroundings.*
- *It makes me constantly think about it; awareness is up so it reduces stress.*
- *It keeps you alert.*
- *When it beeps, it keeps you awake.*

Drivers also view the technology as a "great safety back-up" because they "don't have to worry about a lot of things," specifically stressing the added value of Vorad® under low visibility and bad weather conditions:

- *It helps in fog and rain and stuff… bad weather.*
- *When it is foggy, the system lets me know there is someone in front of me before I even see it.*

One driver even reported using the technology as a fatigue indicator:

- *If I drive 10 hours, I get tired of the sound, and I know it is time to pull over.*

Among the 15 drivers who reported that driving with the Vorad® forward radar is "somewhat" or "a lot more" stressful and tiring, many of them reported annoyance with audible alarms as a source of increased stress and fatigue:

- *It can drive you crazy sometimes.*
- *It is an annoyance and a distraction.*
- *It is the beeping that bothers me.*

- *It wakes up partners, it gives you headaches, the sound is bothersome.*
- *If you're tired and it's constantly beeping, it is somewhat of a distraction.*
- *When beeps go off, it stresses me out.*

- **SmartCruise:** Some drivers found that SmartCruise decreases stress somewhat or a lot because of an increased feeling of "comfort and security" with an "added watchdog and safety feature." Some drivers reported that:
  - *When on cruise, I can relax a little bit.*
  - *You're not worried as much.*
  - *A part of your brain says you have an edge, and you don't have to concentrate on maintaining a fixed speed.*
  - *ACC helps maintain a constant legal distance, and eliminates the frequent use of Vorad®.*

  The drivers who reported that SmartCruise increases stress somewhat or a lot said so mainly because of:
  - A lack of satisfaction in the system's capabilities, not matching their needs:
    - *Should not kick off so soon.*
    - *It goes off too soon.*
  - A risk of dependency:
    - *You rely too much on that device.*
  - A lack of trust in the system:
    - *Not knowing what it was going to pick up.*
  - Some reluctance to give up control:
    - *You have no control, you wonder if SmartCruise is going to work right, and if you are going to have any control. Driver needs control over the truck.*
  - Added annoyance and stress caused by audible alerts:
    - *[It] can get on my nerves.*
    - *It aggravates you.*

- **AdvBS:** The drivers who expressed less stress and fatigue driving a truck with AdvBS referred to the comfort level of knowing that:
  - *When you hit the brakes, they were going to work, keep truck true, with an added feeling of security.*
  - *[You have] better stopping capability.*
  - *It was quicker to stop the truck.*
  - *You don't have to worry about stopping and beating your brakes up so much.*

  Only two drivers reported that driving with AdvBS increases stress and fatigue because of a lack of understanding of the system:
  - *If EBS fails, you have to be ready to take evasive or alternate action.*

  And because of the lack of maturity of the technologies:
  - *It was something new and the fault codes caused problem [sic].*[11]

[11] It is not known from the interview transcript what problem or problems were referenced by this respondent.

5.3.3 Driver Workload

Mental workload refers to the amount of mental effort it takes a driver to perform his or her driving tasks. Drivers were asked to think in terms of their level of concentration, amount of mental effort, or degree of mental focus, and to rate their assessment of the mental workload required under various driving conditions, using a scale that ranges from 1 to 10, where 1 means the lowest level of mental workload and 10 means the highest level. The results are shown in table 41 and figure 11. Figure 11 shows the average reported workload level under each of the 7 driving situations, along with the standard deviation around the mean, which reflects where about two-thirds (68%) of the driver responses clustered around the average value. The seven driving conditions are:

A = Personal automobile; normal conditions.
B = Truck; good conditions; light to moderate traffic; without IVSS.
C = Truck; heavy traffic; without IVSS.
D = Truck; low visibility; without IVSS.
E = Truck; good conditions; light to moderate traffic; with IVSS.
F = Truck; heavy traffic; with IVSS.
G = Truck; low visibility; with IVSS.

In most cases, driver responses ranged from 1 to 10 on each of the workload questions (A through G).

These data support the hypothesis that the IVSS will reduce the level of reported mental workload under a variety of driving conditions.

- As shown in figure 11, drivers report moderate mental workload (average 4.4) when driving their personal automobile under normal driving conditions. This common experience can serve as a benchmark for judging workload reported for truck driving with and without IVSS.
- Driving a truck under light to moderate traffic conditions without IVSS, a typical driving situation, takes greater concentration and effort (average 5.7) than driving a personal automobile (average 4.4). Driving a truck without IVSS under heavy traffic conditions (average 7.8) or low visibility conditions (average 8.7) takes substantial mental effort.

  Adding the IVSS capabilities results in a substantial reduction in all reported workload levels, especially in the two more difficult truck driving conditions; namely, heavy traffic (average 6.2) and low visibility situations (average 6.9). Even driving a truck in light to moderate traffic requires less mental effort with IVSS (average 4.8) compared to driving without IVSS (average 5.7). Each of these three paired differences is statistically significant at the 99 percent confidence level (2-tailed t-test). In the most difficult driving conditions, the reported level of mental workload is reduced by having IVSS operating on the truck. For example, drivers report a reduction in mental workload due to IVSS of 21 percent when driving in heavy traffic, and 20 percent when driving in low visibility driving conditions (fog, rain, snow, night).

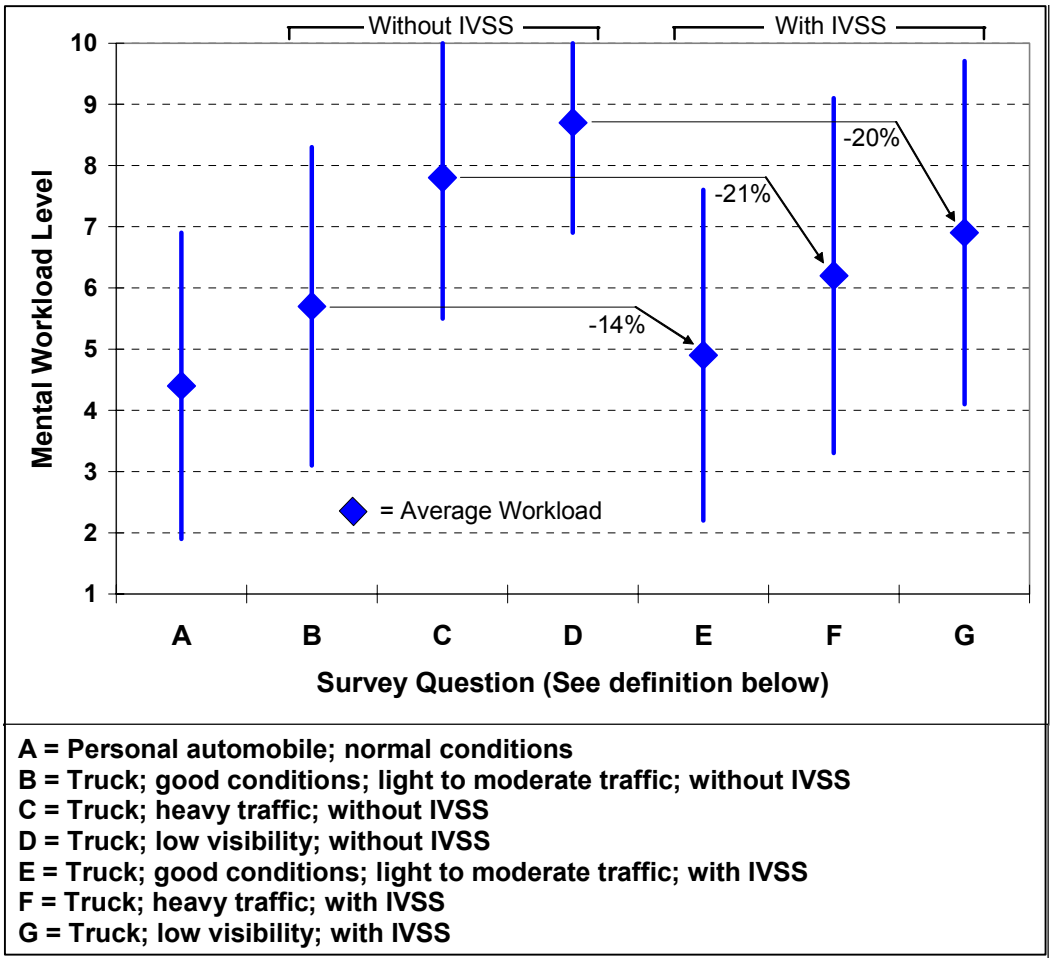

Figure 11. Reported level of average mental workload under various traffic conditions both with and without IVSS.

- Drivers stated that the IVSS affect the mental workload of driving a truck by giving them a sense of security, allowing them to relax and not work as hard:
  - *I know when it's there to give you a warning in case you miss something, you can relax a little bit.*
  - *It takes a little more tension off.*
  - *I don't have to work as hard.*
  - *[I] have to concentrate less hard when using Vorad®, [particularly in] heavy traffic and bad conditions.*
- Some drivers reported not being affected at all:
  - *I wouldn't notice any difference.*
  - *[It is] about the same as if not using it.*
  - *No change in mental workload in my opinion.*
  - *You should concentrate and check mirrors and [be] looking around you at all times regardless if presence of Vorad®.*

- A few drivers reported an increased workload:
  - *[You] have to concentrate harder because you are trying to determine a hazard based on Vorad® warnings.*
  - *Vorad® is annoying and makes things more stressful.*

5.3.4 Driver Acceptance

If truck drivers do not find new safety technologies acceptable and useful, then they will either not use them or they will use them reluctantly, thereby not gaining full benefit. Drivers were asked whether they preferred to drive a truck equipped with each of these technologies or one not equipped. The results are presented in table 45 and illustrated in figure 12. Drivers also were asked to explain why they did or did not want each of these technologies on their truck.

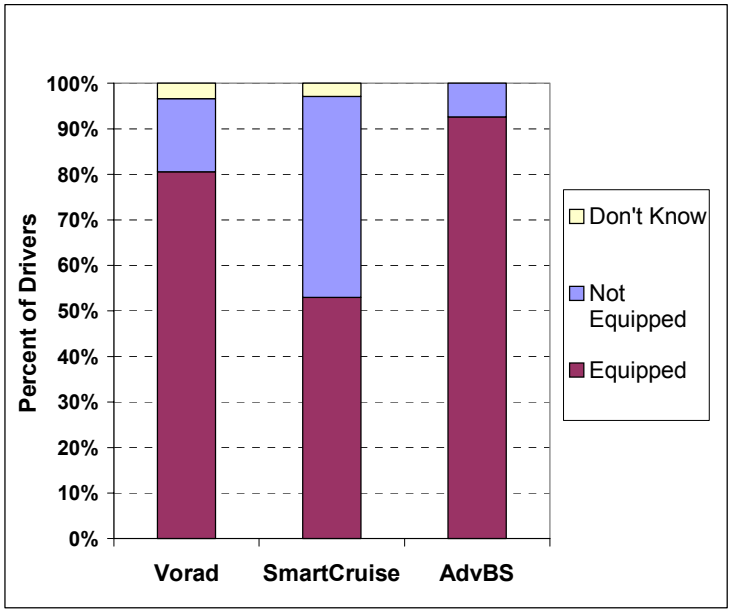

Figure 12. Preference for driving a truck equipped with each of the three safety technologies.

- **Vorad®:** About 81 percent of the drivers said they would rather drive a truck equipped with Vorad® than drive a truck without it because of the variety of benefits it offers:
  - Safety: Many drivers pointed out that they want to drive a truck equipped with Vorad® because they view the system as an "added safety measure," which "helps avoid accidents." One driver stated that Vorad® "helps safety record, and does a lot for the industry in the prevention of car and truck accidents." Some drivers reported "feeling safer," "more protected with it," or liking "being warned sooner." One driver even stated that he had "been glad he had it a couple of times."
  - Helpfulness: Drivers recognized the system as "helpful," because Vorad® can catch erratic drivers faster," it "helps with seeing other drivers" and "gives alerts on things [they] can not see." One driver referred to Vorad® as an "extra partner." A few drivers reported now that they are "used to it, it is more of a help than a hindrance."

- Awareness: Many drivers said that they would rather drive a truck equipped with Vorad® because Vorad® "keeps you aware of following distances," "it makes you pay attention," "it keeps you alert and out of trouble," or "it grabs your attention." Drivers also reported that the Vorad® system "increases [their] safety awareness," "teaches [them] distances," "improves [their] judgment of distance," or "has [an] alerting affect that has helped [them] slow down and correct [their] driving."
- Conditions: Drivers also mentioned the added benefits of Vorad® in "inclement weather," "at night time," "in foggy situations, it really comes in handy."

Fewer drivers answered that they would rather drive without it. Mostly, these drivers did not think that they needed the system to be safe:

- *[I] use my mirror and my own judgment to drive.*
- *For an old experienced driver like myself, I never had it before and don't feel like I need it now.*
- *The radar warns me of stuff I am already aware of.*
- *If you are a real good driver, you know not to follow someone too close, I don't need anything to tell me.*

In addition, these drivers found repeated audible alerts "noisy," "distractive," creating "noise": "I am tired of listening to beeps, I am a safe driver," especially when the system "picks up bridges and everything." Drivers also specifically referred to the lack of volume control.

- **SmartCruise:** SmartCruise has much less support among the drivers, with just over half (53%) preferring to drive a truck equipped with it and 44 percent saying they would rather drive a truck without it. The drivers who stated they would rather drive a truck with the SmartCruise referred to their "sense of security" ("I feel safer with it"), and a reduced stress level they experienced ("it is a little more relaxing," "[the system] rests your feet and makes you relax," "it takes a lot of stress out of the job").

  The other half of the drivers stated that they would rather drive a truck without it, because of some lack of capabilities ("does not let driver know you've slowed down," "picks up phantom objects," "250ft asks you to slow down," "SmartCruise interferes with the momentum needed when going up hill"), because of stress and aggravation due to "glitches in the system" or "worse gas mileage," because of the risk of becoming dependent on the system "with SmartCruise, you tend to rely too much," and because of a reluctance to give up control ("driver needs control").

- **AdvBS:** Almost all the drivers (93%) said they would rather drive a truck equipped with the Advanced Braking System. The main reasons for wanting to drive a truck equipped with the AdvBS was the fact that the drivers recognized its increased capabilities ("stops me faster," "not as worried about heating the brakes," "it's easier stopping all the way around," "brakes better"), its increased potential for safety ("safer braking," "safer"), it superior pedal response, and its faster response. The two drivers who expressed reluctance towards the system specifically quoted a reluctance to change "I am used to air brakes after 23 years."

All drivers were asked what they like most and least about each of the three technologies.

- **Vorad®:** Drivers mentioned a lot of aspects of the Vorad® that they ***liked the most***:
  - Supportive: "The idea that it is something besides yourself monitoring traffic and any kind of obstacles that are in your path."
  - Safety: "help you drive safe," "makes job safer," especially in bad weather, bad visibility or heavy traffic: "extremely helpful in foggy situations," "it is helpful when you can't see the road very far ahead." A couple of drivers said they liked the safety the system provides when they are sleeping at night: "at night being a solo driver this helps be more aware of surroundings, [I] get up to investigate."
  - Awareness: Drivers quoted the increased awareness and alertness the system provides: "it draws your attention quick," "it keeps me alert and focused."
  - Learning: A few drivers like the fact that the system helps them learn and teach how to keep following distances.
  - Reliability: Some drivers said they liked the reliability of the system ("it's always consistent and can be trusted," "having a reliable piece of equipment").
  - Alert Preferences: Drivers also specifically quoted liking the lights ("lighting that alerts drivers," "the visual warnings are good in certain conditions"), and warnings ("electronic lights and sounds," "gives advances warnings").
  - Features: Many drivers also reported they liked the blind spot detection feature of Vorad® "it covers the blind spot on the side of the truck."

  Drivers also indicated the things they ***liked the least*** about Vorad®:
  - False Alarms: They dislike the "false positive" alerts ("going off when no threat," "too many false alarms," "lies too much"), especially related to certain conditions such as when parked ("when parked, it will still beep when walkers pass by"), when passing bridges and overpass ("when beeps go off under structures"), in heavy traffic ("in congested traffic the tones go off quite often") or in construction zones ("going through construction").
  - Alarm Noise: Drivers also complained about the beep sounds ("hate the beeping"), the loud signal ("too loud"), the lack of volume control ("inability to control volume"), the noise created ("irritating beeping noise"), as well as the abundance of alerts ("beeps too much"), referring in particular to the low level warnings, or the sensitivity of the system.
  - Lack of Perceived Benefit: Finally, several drivers stated that they "just don't like it," because "it has no use."

- **SmartCruise:** Drivers mostly ***like*** the fact that the SmartCruise is a "safety device," creating a sense of security ("it gives me a sense of security if I do get tired I've got something that might be a life saver for me or someone else"), reducing worries ("didn't have to worry about anything"), helping them when they are tired ("helps you when you're getting tired"), providing more reaction time ("it takes the reflex time out of driving"), and making them better drivers ("it helps you become a better driver"). Drivers also mentioned items related to the principle of operation of the technology: maintaining constant distances ("perpetual safe distance"), and slows you down ("slow you down when you get to cruise"). Some drivers also liked the fact that the system is easy to use ("it's easy to set").

Drivers ***dislike*** the incorrect sensitivity of the system ("it screws up once in a while"), the lack of power of the system ("system is not powerful enough"), the fact that it causes the vehicles to loose power ("reduces my speed and I loose power"), the stress/confusion or surprises created ("it confuses me if the cruise control has kicked off, thinking that the truck has had a breakdown or something is wrong," "when it slows you down and you don't know why you are slowing down," "it was stressful driving with it") or the potential dependence in the system ("become lax," "it makes it hard to transition to my personal vehicle"). Some drivers specifically said they did not dislike anything with the system.

- **AdvBS:** The main characteristics of the AdvBS drivers said they ***like*** about the system were better stopping ("you can stop quicker"), the reduced risk of lock-up ("no skidding"), the better pedal feel ("less foot pedal pressure"), the reduced risk of fade ("it does not heat up as fast as regular shoes") or the sense of security it offers ("safe and efficient braking").

  Most drivers said that there was nothing they ***dislike*** about the AdvBS, except two drivers who reported disliking the lack of field data ("doesn't have a track record, I'd like to wait until they get the problems out of EBS"), or "component failure."

5.4 DRIVER RISK AND VIGILANCE (OBJECTIVE 3)

This chapter addresses driver perceptions about how the use of IVSS affects the risk of an accident, and whether or not use of IVSS has resulted in any change in their driving behaviors. The intent of IVSS is to enhance driving safety and reduce the risks of an accident; however, the opposite effect might occur if drivers begin to rely on IVSS and reduce their driving vigilance, or if they feel they can take greater driving risks because IVSS will warn them of potentially dangerous situations with time to respond.

The Evaluation Plan identified two hypotheses under Objective 3, as shown in table 24. These hypotheses were tested with the data from the driver surveys and the outcome of each test is shown in table 24 and discussed in more detail in this chapter.

Table 24. Driver risk and vigilance: Outcome of hypothesis tests.

Evaluation Hypotheses	Test Outcome	Sections
Drivers are aware that they modify their driving behavior (speed, following distance, braking, turn signal usage) for particular reasons (to be determined) in response to the IVSS.	Supported	5.4.1 Driving Behaviors
Drivers with the CWS and ACC systems are aware that they are more vigilant in their following distance behavior than those without the system, because of the feedback provided by the system.	Supported	5.4.2 Risk Taking

5.4.1 Driver Behaviors

In the Phase II survey, drivers were asked whether they thought their driving had changed as a result of having each of the IVSS technologies on their truck. The question was worded differently in the Phase I survey to ask whether they thought their driving had *not* changed as a result of having the IVSS on their truck.

- In Phase I, 41 percent, 49 percent, and 64 percent of the test drivers said they agreed their driving had not changed as a result of having Vorad®, SmartCruise, and AdvBS, respectively.
- In Phase II, 38 percent, 59 percent, and 56 percent of the drivers said their driving did not change, respectively (table 47 and figure 13).
- Vorad® is the system most likely to lead to a change in driving behavior: over 60 percent of the drivers said that their driving has changed "somewhat" or "a lot" as a result of having Vorad® on their truck, with nearly one quarter (24%) saying their driving has changed "a lot."

Drivers were asked to briefly explain how their driving has changed as a result of having the IVSS technology on their truck.

- **Vorad®:** The majority of the drivers who said that their driving has changed "somewhat" or "a lot" as a result of having Vorad® on their truck specifically said:
  - *[I have] increased my following distances.*
  - *[I am] more aware of the following distances.*
  - *I do not follow as closely as I may have on the past.*
  - *[I drive] more defensively, increasing following distance.*
  - *I become more aware of tailgating.*
  - *I have become a lot safer driver than I used to be. I look further ahead and come to know I need to look a lot more than I was taught.*
  - *I pay more attention when I am driving.*
  - *[I am] taking less risk, [I am] more aware of surroundings.*
  - *[I drive] more carefully in fog and snow conditions.*
  - *The system gives [me] more confidence in driving in bad conditions.*
  - *[Vorad® helps me] recognize blind spot situations.*

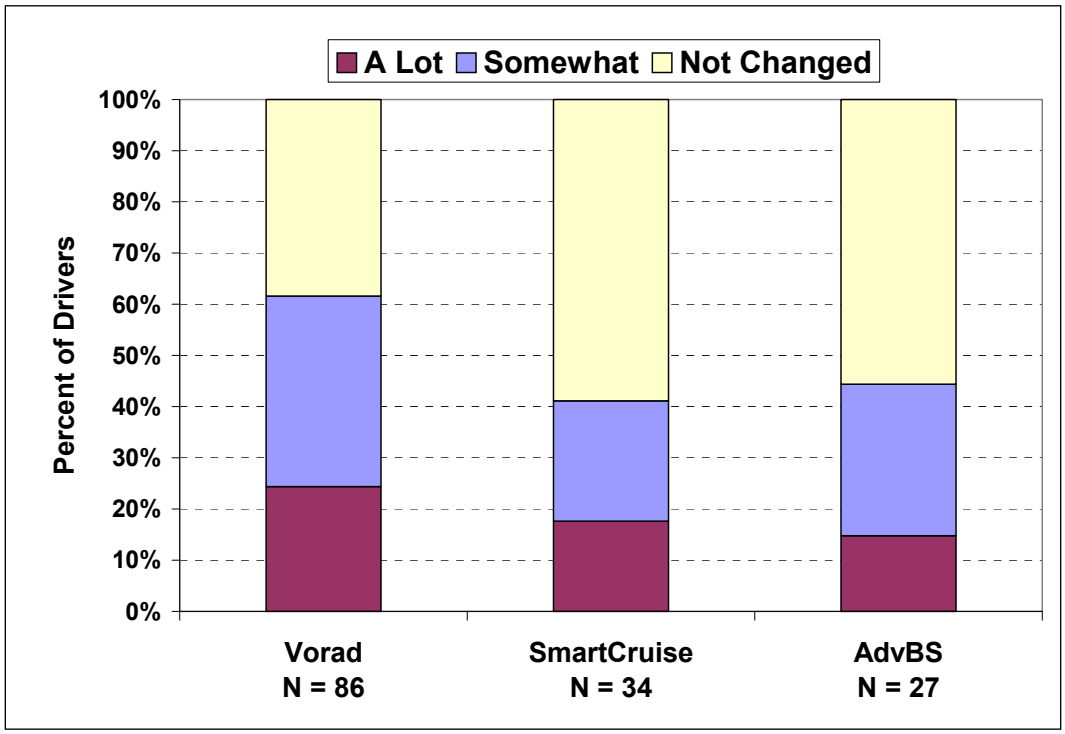

Figure 13. How has your driving changed as a result of having IVSS on your truck?

- **SmartCruise:** The few drivers who responded stated being more relaxed in their driving. One driver said he was "more lax."
- **AdvBS:** Drivers said that they could brake with less pedal pressure, had to re-learn braking technique, felt more secure, and maybe less careful:
  - *You don't apply as much pressure.*
  - *[I don't] need to press brakes as hard to come to a stop.*
  - *You have to learn how to use brakes all over again; you can't pump the brakes like you do on a regular system.*
  - *[I feel] more secure in driving the truck with the EBS.*
  - *[I don't] have to get on the brakes as soon as [I] need to stop for a light or anything.*

5.4.2 Risk Taking

Drivers were asked whether they thought the likelihood of an accident or a near-accident situation had been affected (reduced, increased, or no change) by the use of any of the three safety technologies. The Phase I survey included a similar question focused on accident reduction. Results shown in table 46 and figure 14 are very similar to the Phase I survey results for test drivers. The drivers were asked to briefly explain in their own words how each of the IVSS affects the likelihood of accidents or near-accident situations.

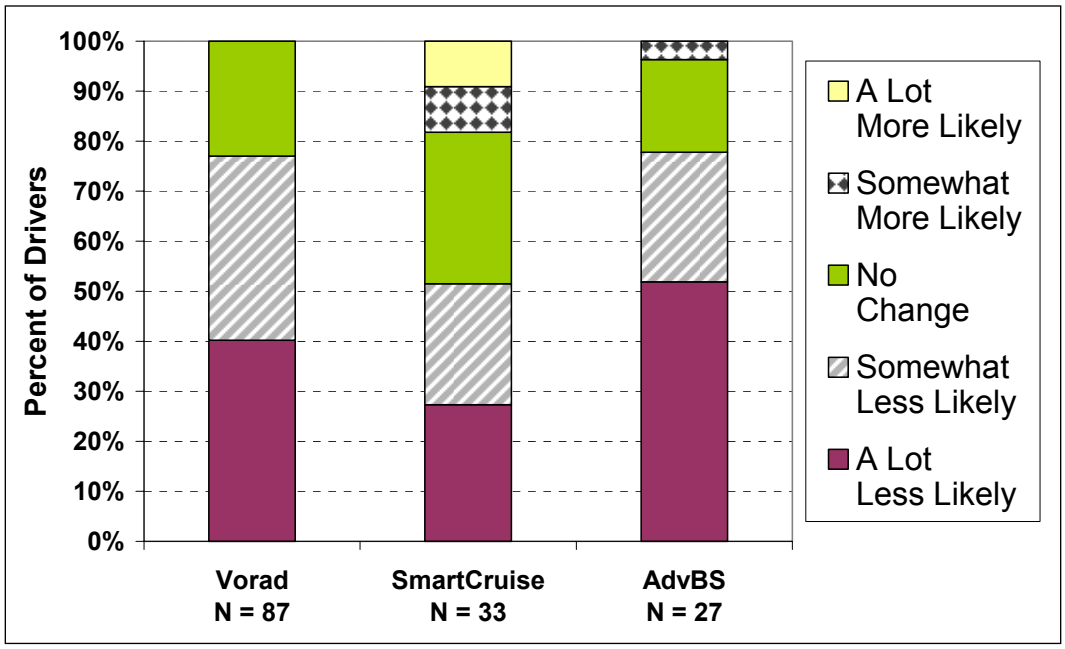

Figure 14. Has the likelihood of an accident been affected by the use of IVSS?

- **Vorad®:** Over three quarters of the drivers (77%) said they thought Vorad® reduces the risk of an accident. No driver thought that Vorad® increases the risk of an accident. The drivers who said that Vorad® reduces the likelihood of an accident stated so because they say the system:
  - Helps keep a safe following distance.
    - *I do not tend to follow as close as I did in the past.*
    - *Knowledge of distances.*
    - *Makes you maintain better space between vehicles and helps you maintain that distance.*
  - Increases the reaction time.
    - *It may draw your attention a little sooner.*
    - *It has saved me a couple of times because it gives me more reaction time.*
  - Assists them in bad visibility conditions.
    - *It is best used in inclement weather as heavy fog or snow, alerts [me] before [I] can see the object.*
    - *Helps the most in low visibility.*
    - *When [I] ran into a dust storm, the Vorad® went off & immediately warned [me] that someone had stopped dead in [my] lane so [I] avoided an accident because of Vorad®.*
  - Increases their awareness if they are distracted.
    - *Keeps awareness on the road, and reminds if you're getting close to something. Keeps you focused.*
    - *If talking on phone and not paying attention, Vorad® may go off and does get my attention most of the time.*
    - *It would likely help me to avoid an accident because it gives me a heads*

up warning.
    - Assists them in heavy traffic when used in combination with their mirror.
        - *In heavy traffic when having to use mirrors more, Vorad® is looking out for you.*

- **SmartCruise:** Only about half of the drivers (52%) thought SmartCruise reduces accident risk, and 18 percent said they thought it actually increases the risk. Similarly to the drivers who said that Vorad® can reduce accidents, the drivers who said that SmartCruise reduces the likelihood of an accident stated so specifically because the system helps:
    - Keep a safe following distance.
        - *Reduce accidents by helping keep a safe following distance.*
        - *It safely maintains distance.*
        - *When driving SmartCruise gives 6 second distance interval -- a lot of time to stop and avoid an accident possibly.*
    - Increase the reaction time.
        - *It notifies you in two different ways and it takes the reflex time out of the equation.*
    - Increase their awareness if they are distracted.
        - *If you are reaching for something and are a little distracted it helps to have the system.*

  Some drivers expressed concern about:
    - The likelihood of increased accidents with SmartCruise because of a potential dependence of the driver on the system.
        - *You come to rely on it and your attention span is not normal.*
        - *The system takes control away from the driver.*
    - Or because they felt the system did not perform well.
        - *System did not perform properly and will kill you.*

- **AdvBS:** Over three quarters of the drivers (78%) said they thought AdvBS reduces the risk of an accident. Some but very few drivers (<4%) thought AdvBS would increase the risk of an accident. The drivers who said that the likelihood of an accident is reduced with AdvBS said so either because:
    - AdvBS reduces braking distance.
        - *I could stop faster.*
        - *Stops you in a way shorter distance than other brakes if a situation comes up all of a sudden.*
        - *Lag time or response time improved.*
    - Or provides better stopping stability.
        - *No fish tailing, no jack knife.*
        - *You have better control with electronic disc brakes-whether slippery or any other adverse condition. You are a lot less likely to have an accident.*
    - One driver reported that AdvBS could increase the likelihood of an accident.
        - *If the driver is not adapted to having it, he may not know how to react, if alternate actions are needed.*

5.5 PRODUCT QUALITY AND MATURITY (OBJECTIVE 4)

This chapter assesses drivers' perspectives on the quality and maturity of the IVSS technologies, based on driving experiences using these safety systems. The evaluation addressed driver perceptions of system performance and functionality, and solicited driver recommendations for any changes that could improve the systems or make them easier to use and learn how to use.

The Evaluation Plan identified 3 hypotheses under Objective 4, as shown in table 25. The first two of these hypotheses were tested with the data from the driver surveys. The outcome of each test is shown in table 25 and discussed in more detail in this chapter. The third hypothesis was not tested because data were not collected from the fleet managers. The two tested hypotheses bear on whether or not drivers made recommendations for improvement, and not on the substance of their recommendations. Their more detailed comments and recommendations for changes, though limited in number, are covered in this chapter.

Table 25. Quality and maturity: Outcome of hypothesis tests.

Evaluation Hypotheses	Test Outcome	Sections
Drivers have recommendations for changes that might make it easier to use or learn how to use the IVSS.	Supported	5.5.1 Changes to Improve Ease of Use or Learning
Drivers have recommendations for changes that might improve the performance or functionality of the IVSS.	Partially Supported	5.5.2 Recommended Performance Changes

5.5.1 Recommended Changes to Improve Ease of Use or Learning

Although most drivers did not think the systems needed improvements, some had suggestions for both improvements of the use and the learning.

- **Vorad®:** Most of the drivers (54) did not have any suggestions to make Vorad® easier to use or to learn how to use, as they reported Vorad® as being "self-explainable," "very simple," or "not really complicated." Some drivers (5) would like to see more detailed information, such as a display or indication of the "distance between the truck and the target in feet or time to collision in seconds," or information on the height sensitivity of the system. Some drivers (4) also would like to have control of the output volume of the audible alarms or different alarms (verbal commands). A number of drivers (12) suggested that better training should be provided "to make drivers more aware of its full capabilities," with "tutorial video," a "company seminar," and "hands on" experimentation. A few drivers (5) suggested that a manual, or a manual with simpler instructions, would be helpful.
- **SmartCruise:** Very few drivers had suggestions on ways to improve the use or the learning process of SmartCruise. Most of them (18) had no suggestions, and some expressed their general dislike of the system (3). Similarly to Vorad®, drivers suggested better orientation training (7), especially for "new drivers," and use of a manual (3).
- **AdvBS:** The drivers were not questioned about ways to improve the use or the learning process of AdvBS as this was not expected to present a critical issue to drivers.

5.5.2 Recommended Performance Changes

Drivers were asked how well each of these systems (Vorad®, SmartCruise, and AdvBS) worked, whether they failed to work properly at any time, and if they did fail to work, how often that happened. The results are shown in table 48 and figure 15.

- The majority of the drivers reported no problems with their safety systems, and, except for AdvBS, those who did experience downtime reported this happened a few times. For AdvBS, more than half of the drivers who had a problem said it occurred "a lot."
- According to the drivers, Vorad® was more likely than the other two safety systems to work improperly, with about one-third of the drivers (33.7%) reporting at least some downtime with Vorad®. The downtime percentages reported for SmartCruise and AdvBS were less: 17.6 percent and 18.5 percent, respectively.

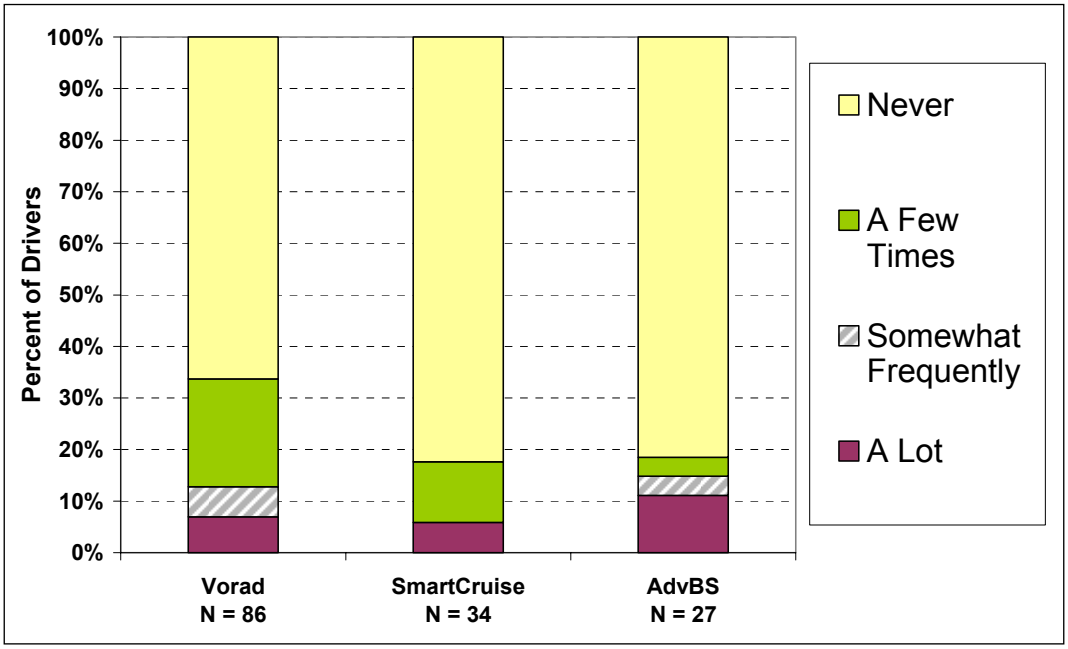

Figure 15. How often would you say that the IVSS did not work properly?

Those who reported any problems were asked to describe what did not work properly. Most of the comments provided pertained to the Vorad® system performance. There were very few comments on the other two systems, and none that were different than some of those provided for Vorad®.

- **Vorad®:** Several drivers said the system gives alerts "constantly," or for no apparent reason, or when there is no other traffic around. Drivers noted false alerts caused by overpasses or other inappropriate objects along the roadside. Some said they had bad sensors, bad wiring, blown fuse, or other issues that were fixed when they took their truck into the shop. A couple of drivers said that interaction between Vorad® and SmartCruise was apparently causing Vorad® to malfunction. And finally a few commented that Vorad® performance is adversely affected by mud or ice blocking the sensor, and they found they need to be careful to keep the sensors clean and clear.

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6. SUMMARY OF FINDINGS

This chapter summarizes the findings from driver responses to the Phase II survey, as well as taking account of the results from the Phase I survey. Phase I largely focused on driver expectations for the performance of the IVSS technologies, while Phase II focused on driver perceptions, behaviors, and recommendations for changes based on extensive experience using the technologies. The summary presents an overview of what was learned from the drivers who responded to each of these surveys. While an almost 53 percent response rate for Phase II is considered to be good, given that these drivers are no longer driving Volvo® trucks equipped with the IVSS under the evaluation program, the opinions of the non-respondent drivers who were notified in Phase II remain unknown. For this reason, readers are cautioned in their use of the findings as representative of all U.S. Xpress drivers, or all truck drivers in general, based on results from this limited sample.

6.1 DRIVER EXPECTATIONS FROM PHASE I

Findings on drivers' expectations for the IVSS from Phase I are summarized below:

- Most of the drivers in the baseline, control, and test groups expressed positive attitudes toward each of the IVSS technologies (Vorad®, SmartCruise, and AdvBS). Those drivers who had not yet tried these technologies were positive about their likely benefits, and those who already had driving experience with any of them reported that the benefits outweighed any drawbacks.
- Many drivers reported that they had limited or no training in the use of Vorad®. Those drivers who did have training and who thought the training was useful tended to be more positive about the value of the technology. Therefore, emphasis on training could lead to greater benefits to be derived from these technologies, coupled with greater support from the drivers.
- Drivers in the initial Phase I survey said they believed that these technologies would help avoid front-end collisions, that they would be better off with these systems in their trucks than without them, and that the benefits are likely to vary depending on driving conditions.
- The research expectation at the end of Phase I was that driver attitudes toward each of these technologies would improve with experience using them, based on comparing responses between *baseline* drivers (with no experience with any of the three systems), *control* drivers (experienced only with Vorad®) and *test* drivers (experienced with all the systems). Drivers in the first survey believed that these technologies would help avoid front-end collisions, that drivers are better off with these systems on their trucks, and that the benefits are likely to be greater in some driving condition (such as poor visibility) than in others (such as heavy traffic).

6.2 DRIVER EXPERIENCES FROM PHASE II

Findings on drivers' experiences with the IVSS from Phase II are summarized below:

- **Driving Experience.** The drivers interviewed in Phase II reported a substantial amount of experience both with truck driving and driving with each of the IVSS technologies. This level of experience, shown in table 26, is more than sufficient for providing informed judgments about each of the 3 safety technologies.

Table 26. Average driving experience driving trucks and driving with IVSS (years).

Average Driving Experience (Years)	Truck Driving Overall	Driving with Vorad®	Driving with SmartCruise	Driving with AdvBS
Mean*	11.9	3.1	1.1	1.5
Median**	8.5	3.0	1.0	1.0

*The arithmetic average.
**The mid-point such that half the drivers have more years and half have less years.

- **Training and Learning.** About half of the drivers reported receiving Vorad® training (54%), and only 24 percent and 19 percent received training in SmartCruise and AdvBS, respectively. Almost all the drivers said the training they received was "very" or "somewhat" helpful. The majority (between two-thirds and three-quarters) of the drivers said they learned these systems by trial and error. However, drivers did recommend more training as one possible improvement.
- **Understanding Alerts.** To better assess drivers' understanding of the meaning of the visual and auditory alerts provided by Vorad®, drivers were asked to describe in their own words what various combinations of lights and beeps meant. Generally, drivers recognized the need to exercise special caution. They understood the visual warnings better than the auditory warnings, but many lacked a specific understanding of the meaning of each different warning. Most indicated they know what appropriate actions to take in response to the various warnings, but the responses were similar to all the various warnings: *become more alert; slow down.* Most drivers recognized a sense of urgency or indication of danger when warnings were provided.
- **Distinguishing Alerts.** Drivers were asked how easily they could distinguish the different warnings in their truck (forward, side, visual, auditory, and other non-IVSS warning systems). Most of the drivers (64%) said they could "always" distinguish IVSS alerts from one another, but sometimes they could be confused (for example, when the driver is tired, or is focusing on a particular driving situation). Drivers rarely reported problems distinguishing IVSS warnings from those provided by other systems in the truck.
- **Stress and Fatigue.** More drivers said the IVSS reduced stress and fatigue (Vorad® 49%, SmartCruise 38%, AdvBS 56%) than those who said it increased stress and fatigue (Vorad® 17%, SmartCruise 24%, AdvBS 7%). About one-third of the drivers said that the IVSS technologies had no particular effect on their driving stress and fatigue. IVSS is viewed as a useful driving *tool* that adds *another set of eyes,* thereby providing a sense of security, increasing awareness and alertness, reducing worry in poor visibility conditions. Drivers who reported an increase in stress and fatigue cited annoyance with the alerts, reluctance to give up driving control, or concern they might become dependent on IVSS.
- **Driver Distraction.** Most drivers said the visual (78%) and auditory (84%) alerts provided by Vorad® *rarely* or *never* drew their attention away from their driving tasks. Where there was a concern about distraction effects, it had to do with the need to look away from the road to attend to the alert, perceived false alerts, or just the startling effect of a sudden alert. About 61 percent of drivers said Vorad® causes them to be more alert

and focused when they are bored or tired driving; only 20 percent of drivers reported that SmartCruise has this effect.

- **Interference with Driving.** Drivers report that SmartCruise is more likely to interfere with their driving tasks (between "a little" and "a lot" – 44%) than Vorad® (23%). Though most drivers say these IVSS do not interfere, those who do report that Vorad® alerts occur too frequently in heavy traffic or construction zones to the point of becoming annoying. Drivers reported that SmartCruise can lead to a loss of power and momentum on hills or for passing, or that the system kicks off too soon and forces the driver to compensate.
- **Driving Conditions.** In general, over all driving conditions, Vorad® is viewed as more helpful than distracting. It is most useful in poor visibility conditions (fog, rain/snow, night), and more distracting in heavy traffic.
- **Driver Workload.** Mental workload refers to the amount of mental effort, concentration or focus experienced in driving tasks. The results show that the IVSS reduced drivers' perceptions of the mental workload, compared with driving without IVSS, and under a variety of driving conditions. Drivers reported that the IVSS affects mental workload by giving them a sense of security, allowing them to relax more. Figure 16 shows the percentage reduction in the average workload scores from the driver survey. The use of the IVSS technologies results in a perceived decline in workload levels of between 14 percent and 21 percent, compared with driving without IVSS operating in these drivers' trucks under each of the indicated driving conditions (see also figure 11). The largest reductions in mental workload levels are associated with driving in heavy traffic and low visibility driving conditions.
- **False Alerts.** Driving safety technologies have the potential to produce alerts when in reality there was no cause for the alert (false positive) or fail to issue an alert when it should have done so (false negative). About one-fifth of the drivers in the survey reported that they experienced false positive alerts from Vorad® about half the time. Overall, the average number of false positives was about 4.7 out of every 10 times. Less than 10 percent of the drivers reported receiving no false positive alerts. Thus, the results suggest that about half of all Vorad® alerts were issued when the driver believed that there was no crash threat. Even when drivers thought a crash could have occurred, 3 out of 10 Vorad® alerts were still judged to be unnecessary. The number of false negative alerts is much lower, with less than 1 out of every 10 alerts reported (average 0.6 out of 10). For most of these drivers, the false negative alert situations did not reduce their confidence in Vorad®.

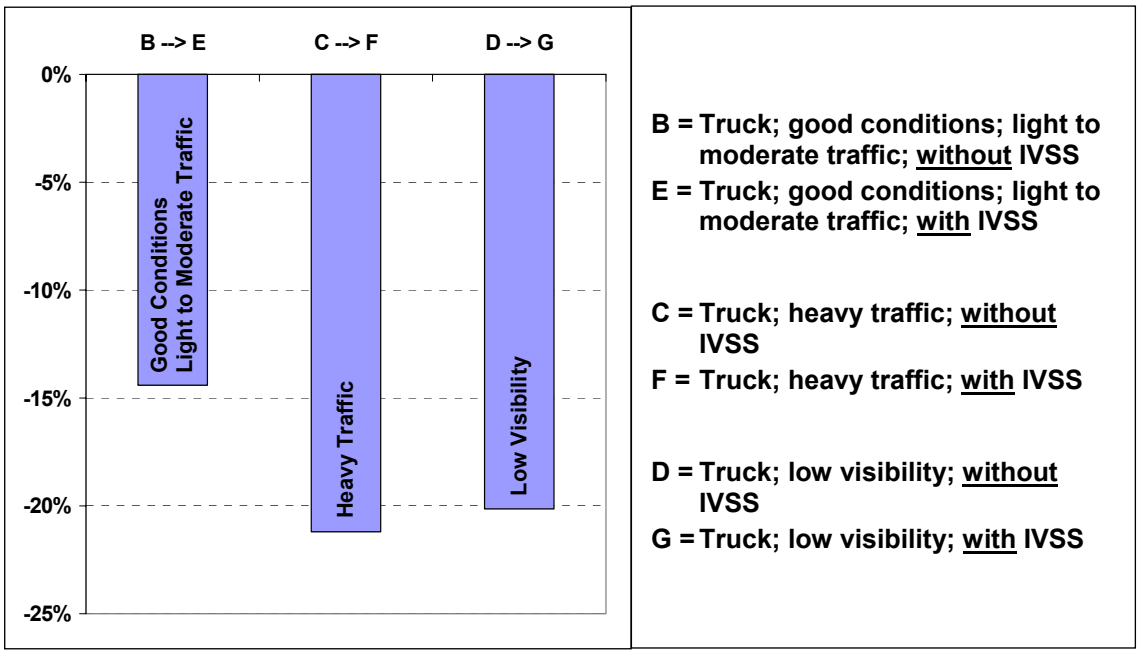

Figure 16. IVSS effect on change in mental workload levels under different conditions.

- **Driver Acceptance.** Most of the drivers (81%) said they would rather drive a truck → equipped with Vorad® than drive a truck without it. Benefits cited included increased safety, helpfulness in anticipating dangerous situations, and general situational awareness. About half (53%) of these drivers preferred to have SmartCruise on their truck (44% said they would rather not have it), and 93 percent said they prefer to drive with AdvBS on their truck.
- **Like Most about IVSS.** With regard to Vorad®, drivers most liked the fact that it is supportive of their driving, helps them drive more safely, increases their awareness and alertness, helps them drive better, is a reliable system, and has features they like. Drivers liked the sense of security provided by SmartCruise, and the fact that it makes them a better driver. Drivers liked the better stopping capabilities provided by AdvBS and the added sense of security that provides.
- **Like Least about IVSS.** Regarding Vorad®, drivers disliked the occurrence of false alarms and the noisiness of the alarms. Drivers dislike it when their truck loses power on hills or passing when SmartCruise kicks in. Very few drivers expressed any negative aspects of AdvBS.
- **Driving Risks.** The evaluation sought to understand how the IVSS affects drivers' perceptions of the risk of driving. Over three-quarters (77%) of the drivers said they thought Vorad® reduces the risk of an accident. About half (52%) said this with regard to SmartCruise (18% thought SmartCruise *increases* driving risk due to driver dependence or system performance problems), and 78 percent thought AdvBS reduces risk. Vorad® is seen as reducing accident risks by:
    - Helping keep a safe following distance.

- Increasing reaction time.
- Assisting in bad visibility.
- Increasing awareness if they are distracted.
- Assisting in heavy traffic.

SmartCruise helps by:

- Keeping a safe following distance.
- Increasing reaction time.
- Increasing awareness.

AdvBS helps by:

- Reducing braking distance.
- Providing better stopping ability.

- **Driving Behavior Change.** Vorad® is the system most likely to lead to a change in driving behavior, with about 62 percent of the drivers indicating that their driving changed "somewhat" or "a lot" as a result of driving with Vorad®. Fewer said their driving had changed as a result of SmartCruise (41%) or AdvBS (44%). Asked to explain these changes, drivers said Vorad® caused them to increase following distances and drive more defensively and safely, with greater situational awareness. Drivers said SmartCruise made them more relaxed driving. Drivers said AdvBS caused them to re-learn proper braking techniques, stopping with less pedal pressure.

Based on these experiences with the IVSS technologies, drivers were asked to comment on overall system performance and to recommend any changes to improve performance and ease of learning. Most of the drivers had no performance problems to report, and those who had problems said they were infrequent, except for those who had problems with the AdvBS. Vorad® was more likely than the other two systems to work improperly, with about 34 percent reporting at least some downtime for Vorad®, 18 percent for SmartCruise, and 19 percent for AdvBS. Vorad® problems cited mostly had to do with excessive or false alerts.

Most drivers did not have recommended changes to any of these IVSS technologies. Some thought information display and detail could be improved with Vorad® and others recommended better training for drivers, both for Vorad® and for SmartCruise.

6.3 CONCLUSIONS

In conclusion, the two surveys of drivers regarding their expectations and experiences associated with three truck safety technologies—Vorad®, SmartCruise and AdvBS—suggest that drivers understand and appreciate the benefits that these technologies can provide. These are highly experienced drivers who take great pride in their driving skills, and they can be expected to want to be convinced of the merits of technology before accepting the need for it in their trucks. The surveys reflected a range of positive and negative reactions to various aspects of these technologies, but the drivers believe these technologies help avoid or reduce accidents, and they prefer to have them installed on their trucks. The evaluation hypotheses that could be tested with the survey data were generally supported. The perceived benefits of each technology outweigh the drawbacks and depend mainly on driving conditions (particularly visibility and traffic density) and system performance (false alerts and distraction or annoyance factors). The results from these surveys lend support to the further refinement and deployment of these technologies throughout truck fleets to enhance driver safety, performance and satisfaction.

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APPENDIX A. DESCRIPTION OF THE INTELLIGENT VEHICLE SAFETY SYSTEMS

The Volvo FOT Safety Systems partnership proposed to test a safety package comprised of three systems (figure 17):

- A Collision Warning System.
- An Adaptive Cruise Control.
- An Advanced Braking System.

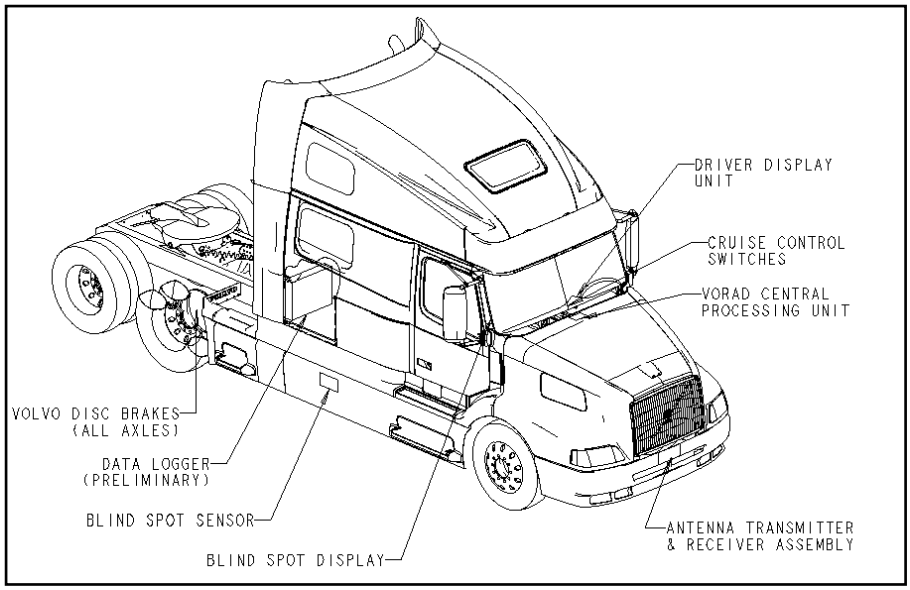

Figure 17. Technologies available on the vehicle (Schematic courtesy of Volvo).

A.1 COLLISION WARNING SYSTEM

The CWS evaluated is the EVT-300, commercially available from Eaton® VORAD® Technologies. Specifications are listed in table 27. The CWS uses front-end mounted radar and optional side mounted radar to monitor vehicles ahead and in the right side blind spot, respectively (figure 18). Through the transmission and reception of radar signals, the distance and relative speed between the host vehicle and the target vehicle ahead can be determined. The CWS uses audible and visual alerts to warn the driver when other vehicles are within given pre-defined distances or time headways and present a potential dangerous situation if no evasive action is taken. The side sensor uses transmission and reception of radar signals as well to detect objects or vehicles that are within 2 to 10 feet from the side of the host vehicle. The side blind spot CWS also uses audible alerts to warn the driver only when the turn signal is activated.

Table 27. Eaton VORAD® CWS specifications.

Description	Value	
Temperature range	-40 to +185°F	-40 to +85°C
Vehicle closing rate (1%, ±0.2mph)	0.25 – 100 mph	0.4 – 160 km/h
Host vehicle speed	0.5 – 120 mph	0.8 – 190 km/h
Operating range (±5%, ±3ft)	3 – 350 feet	0.9 – 110 meters
Azimuth radar field	-6° to +6°	
Elevation radar field (±0.2%)	-2.5° to +2.5°	
Frequency	24.725 GHz	

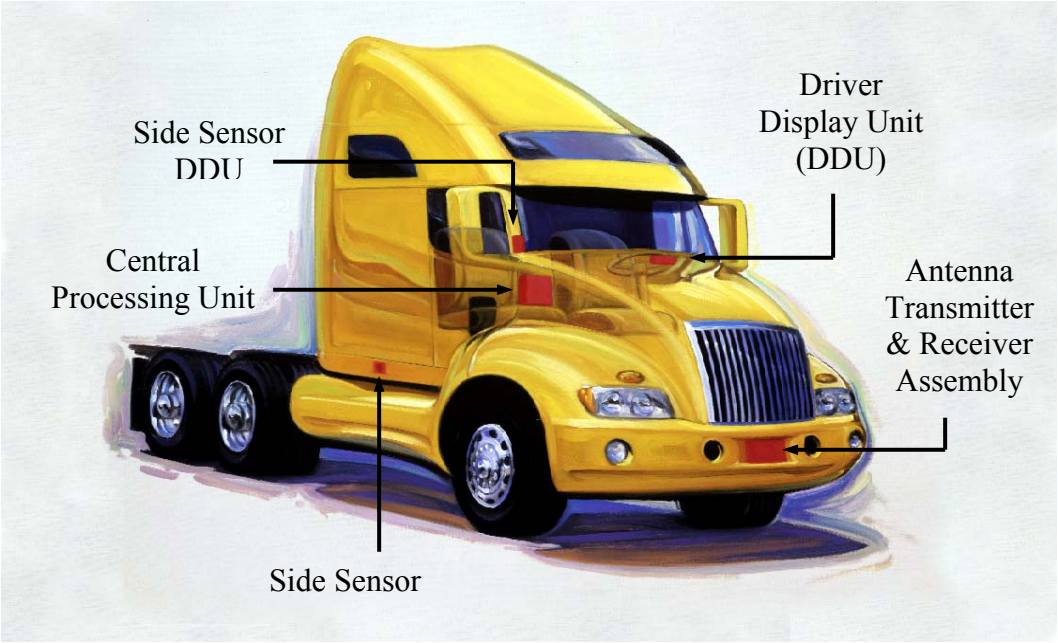

Figure 18. Location of the VORAD® elements on the tractor (Photo courtesy of Eaton® VORAD®).

The CWS includes four main components as shown in figure 19: an antenna assembly, a Central Processing Unit (CPU), a driver display unit, and an interconnecting harness. In addition, a side sensor and a side sensor display are also installed on the U.S. Xpress trucks.

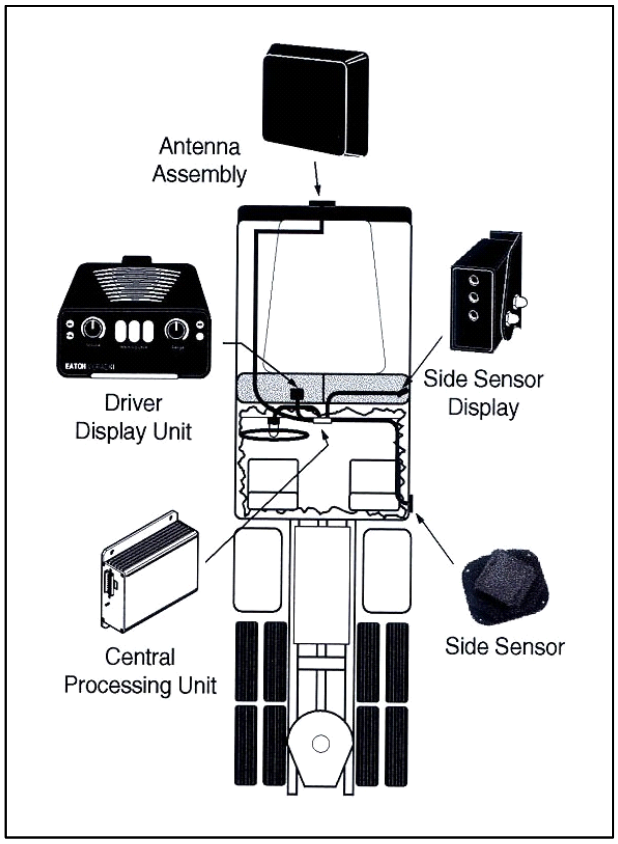

Figure 19. Components of the VORAD® CWS (courtesy of Eaton® VORAD®).

Antenna Assembly

Mounted near the center of front bumper of the vehicle, the antenna assembly transmits and receives high-frequency, low-power monopulse radar signals. The transmitted signals reflect off objects and are received back at the antenna assembly. The radar beam only reflects off objects with sufficiently large surface area, which are within the beam field (±6° azimuth and ±2.5° elevation). The antenna assembly compares transmitted and received signals and forwards the information in digital format to the CPU. The antenna assembly can monitor up to 20 objects, moving or stationary, within a 350-foot range.

Central Processing Unit

The CPU is the electronic control unit for the EVT-300 CWS. The CPU compiles information received from the antenna assembly, the engine control unit, the speedometer, the optional side sensor, and the brake and turn signal circuits to generate visual and audible alerts at the driver display unit. The CPU can be located in various places on the truck, e.g., vehicle firewall, underneath the dashboard, or behind the driver's seat. On U.S. Xpress trucks, the CPU is installed in the dashboard, at the centerline of the vehicle under the cupholder.

Driver Display Unit (DDU)

The driver display unit for the forward sensor, shown in figure 20, contains controls and indicators related to system operation: system power-up, speaker volume, ranges for vehicle warnings, and headway thresholds for ACC. Lights come on as an indication of system power, system failure, ACC enabled, and multiple stages of warning levels. A light sensor controls the brightness of the indicators. A speaker located in the display unit provides informational tones such as volume level, system failure, and alerts to the driver. The forward CWS driver display is mounted in, as shown in figure 21, or on the dashboard. For the Volvo FOT, the DDU will be mounted on the dashboard. The combination of lights and audible tones defines the danger level of the imminent hazard detected as shown in table 28.

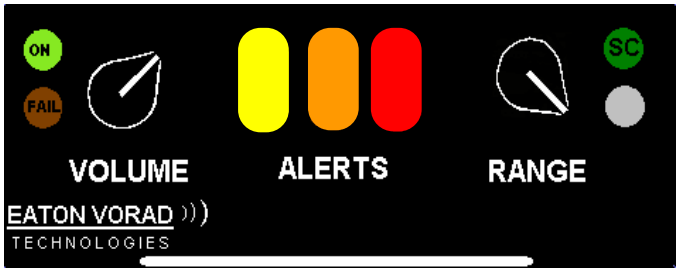

Figure 20. Eaton® VORAD® driver display unit for the forward sensor.

Figure 21. Eaton® VORAD® forward sensor driver display unit mounted in the dashboard. (Note: This picture was not taken on a U.S. Xpress unit. The DDU is on the dashboard in the U.S. Xpress trucks.)

Table 28. Levels of VORAD® alerts (forward radar and side sensor). The following interval is defined as range/host velocity speed.

			Following Interval [Note 1]	Visual Alarms	Audible Alarms	Condition
Forward Alarms						
Detect	1	Object detected		●		Notes 2-3
Follow	3	Opening/Closing	2-3 seconds	● ●		Notes 2-4
	4	Opening	1-2 seconds	● ●		Notes 2-4, 7
	5		<1 second	● ● ●		Notes 2-4, 8
	6	Closing	1-2 seconds	● ●	🔔	Notes 2-5, 10
	7		<1 second	● ● ●	🔔🔔🔔	Notes 2-5, 11
½ second	10	Opening/Closing	< ½ second	● ● ●	🔔 🔔 🔔 🔔 …	Notes 2-4, 5
Stationary	8	Stationary Target	3 seconds	● ● ●	🔔🔔🔔	Notes 4, 6, 9
Slow moving	9	Slow moving Target				Notes 6, 12
Creep	2	Closing		●	🔔	Notes 13-15
Side Alarms						
Object detected				●		
Object detected AND Turn signal activated				●	🔔🔔🔔	

Note 1: Following interval as defined as range/host velocity speed.
Note 2: Target is in same lane as host vehicle.
Note 3: R < Rmax.
Note 4: Host speed VF > 10 mph.
Note 5: Audible alarm is disabled if brakes are applied or in a hard turn (≥5 degrees/s).
Note 6: R is < 220 ft or Rmax, whichever is smaller.
Note 7: VL > 101% * VF. Note 8: VL > 105% * VF. Note 9: VF > 35mph.
Note 10: VL < 101% * VF. Note 11: VL < 105% * VF. Note 12: VF >1.2 * VL.
Note 13: R < 15 feet. Note 14: VF < 2 mph. Note 15: VL -VF < -0.5mph.

R = Range, distance (target to host)
Rmax = Maximum Vorad range,
= 350 feet, or
= [2 x Turn radius x sin(6°)
VL = Target or lead vehicle speed
VF = Host or following vehicle speed

Right Side Sensor

The right side sensor can detect stationary or moving objects, which are within 2 to 10 feet of the vehicle, in a blind spot area. Similar to the forward-looking sensor, the information on transmitted and received radar signals is sent to the CPU for processing.

Right Side Sensor Display

As shown in figure 22, the right side sensor display includes red and yellow indicators. Table 28 summarizes the alarm levels for the right side sensor. A light sensor in the display adjusts the indicators' brightness with changes in ambient light.

The right-side driver display, shown in figure 22, is mounted inside the vehicle on the right side A pillar, in the driver's field of vision for the right-side mirror. The combination of lights and audible sounds warns the driver of the presence of an object in the right-side blind spot area. The audible alarms are activated only if the right turning signal is on.

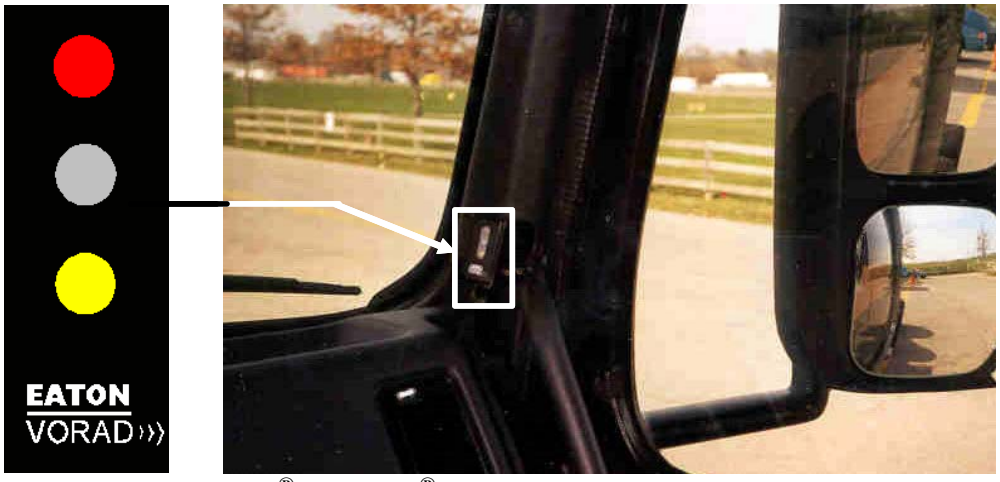

Figure 22. Eaton® VORAD® driver display unit for the side sensor.

A.2 ADAPTIVE CRUISE CONTROL

Eaton® VORAD® Adaptive Cruise Control, or SmartCruise®, combines the forward radar with conventional cruise control. If the radar identifies a vehicle ahead in the same lane of the host vehicle and within the radar's operational range, then a minimum following interval will be maintained between the target vehicle and the host vehicle. When no target is identified by the radar system, then the vehicle maintains a set speed, like conventional cruise control. This principle of operation is illustrated in figure 23.

The "RANGE" control knob adjusts following intervals between 2.25 and 3.25 seconds[12]. Correspondences between the following interval in seconds and following distance in feet at various speeds are listed in table 29.

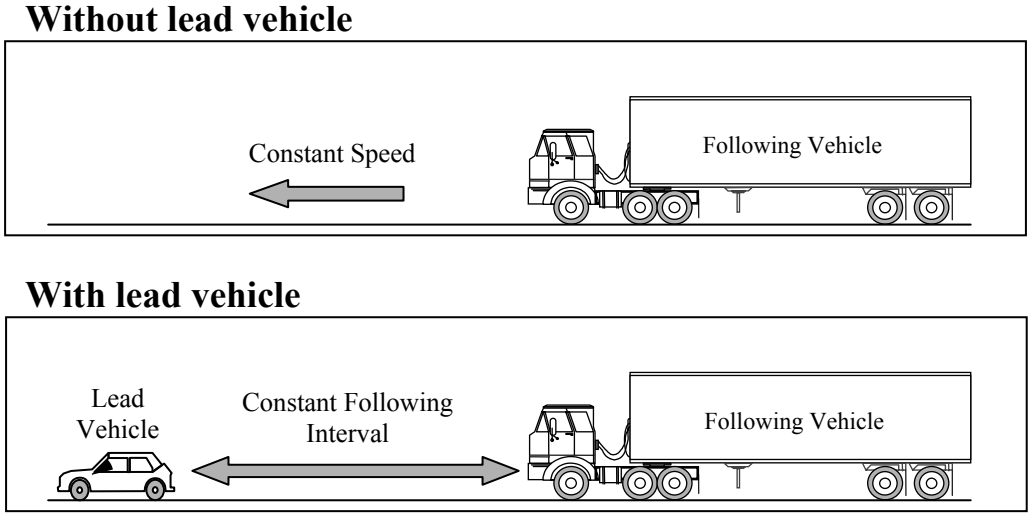

Figure 23. Principle of operation of adaptive cruise control.

[12] The OEM can disable this option as in the Volvo FOT, where the range is preset by U.S. Xpress at 3.25 seconds.

Table 29. Following distances in feet (meters) as a function of following time interval and speed.

Time (seconds)	Following Distance in Feet (Meters)	
	@ 50 mph (80 km/hr)	@ 60 mph (97 km/hr)
2.25	165 (50.3)	198 (60.3)
3.00	220 (67.0)	264 (80.5)
3.25	238 (72.5)	286 (87.2)

To close a gap if the target vehicle speeds up (not a safety issue), acceleration is limited by the vehicle capabilities while the maximum speed is kept below a preset limit. When the gap between the target and the host vehicles is decreasing, the ACC informs the engine control module, via the J1939 bus, to reduce the vehicle's speed. The engine control module then issues a command to de-throttle the engine (e.g., reduce fuel), apply the engine brake, and, when available, downshift the automated transmission. The deceleration rates achieved range from 0.1g to 0.2g,[13] depending on the vehicle load, the road grade, and the vehicle's performance characteristics. At this time, ACC does not actively control the vehicle's service brakes, thus does not have the capability to bring the vehicle to a stop. As a consequence, for abrupt changes in driving state from a following to a critical (i.e., rapidly) closing rate, the ACC system is dependent on its tie-in with the CWS and driver intervention. The ACC does not react to stationary objects. Some features can be specified by the fleet operator.

A.3 ADVANCED BRAKING SYSTEMS (ADVBS)

The advanced braking system comprises Eaton® Bosch EBS and Volvo disc brakes. AdvBS is expected to lead to shorter overall stopping distances as well as enhanced stability while braking, thereby giving the vehicle enhanced braking capabilities.

Air Disc Brakes and Conventional S-Cam Drum Brakes

On an air-braked commercial vehicle, when the driver pushes the brake pedal, a proportional air control signal is generated and air pressure is delivered to each wheel's brake chambers, which, in turn, activate the foundation brakes. All foundation brakes today are mechanical devices which utilize friction. In both drum and disc brakes, the friction force is developed between the rotating member fastened to the wheel hub (drum or rotor, respectively) and the stationary members fastened to the axle/spindle flange (shoes or pads, respectively). In the case of drum brakes, the air chamber under pressure applies a force proportional to the pedal position to the slack adjuster, causing the camshaft to rotate. The camshaft rotation forces the shoes and lining assembly to move into the rotating drum. In the case of air disc brakes, similar to drum brakes, air pressure is transformed to mechanical output causing brake pads to tighten on each side of a rotating rotor or disk, like a c-clamp.

S-cam drum brakes can be found today on more than 95 percent of North American commercial motor vehicles, as they are effective, inexpensive, simple, and easy to maintain. However, they are known to be relatively heavy and subject to fade at high temperatures as the drum expands

[13] g is the acceleration due to gravity (32.2 $ft.s^{-2}$ or 9.8 $m.s^{-2}$).

away from the shoes. In contrast, disc brakes are known to generate a linear brake torque output, to be consistent, stable and fade-resistant. Indeed, in disc brakes, not only does thermal expansion bring the disc in closer contact with the pads, but also the exposed friction surfaces provide better thermal dissipation than is available with drum brakes. Brake dust is also automatically cleaned during operation. Disc brakes, however, require more force to generate the torque output than do drum brakes (lack of self-energization) and the exposed friction surfaces are more sensitive to contamination and moisture than drum brake surfaces.

The disc brakes installed on the Volvo tractors can be seen in figure 24. The brake chambers are installed axially.

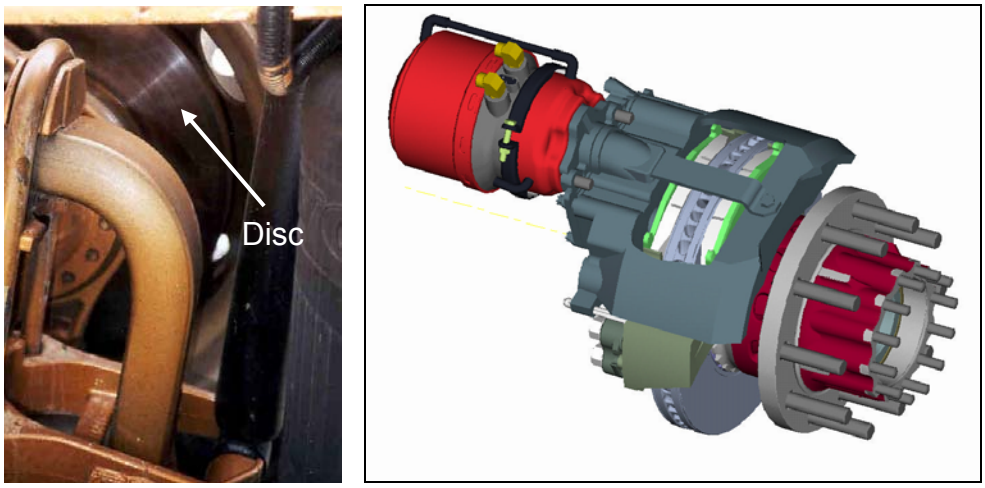

Figure 24. Air disc brakes.

EBS and Anti-lock Braking Systems (ABS)

The principal function of ABS is to prevent wheel lock during severe braking by monitoring wheel speed and modulating air pressure in the brake chambers (using electronic signals). Wheel speed is continuously monitored and the information is sent to an electronic control unit (ECU). The ECU will process the information and send appropriate signals to modulator valves to provide brake pressure. Possible control modes include: no intervention, decreasing, holding or increasing the braking pressure (to the level set by the driver). When brakes are applied on a heterogeneous road surface (one wheel on ice while others on dry surface), ABS provides enhanced directional stability, the vehicle can still be steered, and optimum deceleration rates are achieved.

In theory, EBS integrates ABS, traction control and electronics to control the braking system of the vehicle, during both normal and severe braking. In EBS, control signals to the brake chambers are sent electronically. Air is still required to provide the power to apply foundation brakes, but electronics control the power. Currently, EBS is overlaid onto a dual air brake system: two pneumatic control circuits and one electronic control circuit.

The potential benefits of EBS include: improved dynamic brake force distribution, improved timing resulting in shorter stopping distances, reduced pad wear, reduced system hysteresis, improved combination vehicle brake balance (if both the tractor and trailer are equipped), brake fade warning, and self-diagnostics capabilities. In this FOT, only the tractors are equipped with EBS.

APPENDIX B. PHASE II DRIVER NOTIFICATION AND DATA COLLECTION METHODS

DATA COLLECTION PERIOD

Qualcomm messages were sent to selected drivers every day between March 29 and April 6, 2004. The messages instructed the drivers to phone in to an 800 number for an interview. Specific scripts of the messages are included in attachment B-1. Each driver received a notification message every day.

Number of Trucks and Drivers

Number of Trucks

The number of trucks is not applicable to this analysis because trucks were no longer in service during the interview week.

Number of Drivers

Because the Phase II interviews were conducted after trucks were pulled out of service, drivers were selected based on whether or not they drove one of the three types of units in the past three years, not because they were assigned to the units at the time of the interviews (as in Phase I). In support of US Xpress's operations, many drivers were assigned to the 100 vehicles during the 3-year evaluation period, with driving experience on these trucks ranging from 1 day up to 852 days. Details on assignments for the vehicles were obtained from US Xpress, including start, finish and duration of assignment. From the list of 1,176 drivers, 344 drivers were selected based on the length of their assignments to the vehicles, which reflects their exposure to the technologies, as well as based on the last date of the assignments. The US Xpress driver turn-over rate is high, and out of the 344 selected candidates, only 165 were still working at US Xpress at the time of the Phase II interviews.

To assess results of the Phase II interviews, respondents can be categorized in one of two groups:

1. Drivers exposed to Vorad® only (control drivers).
2. Drivers exposed to Vorad®, SmartCruise and AdvBS (test drivers).

All drivers are therefore exposed to Vorad®.

Table 30. Number of drivers notified, number of respondents and response rates.

	Phase II		
	Control	**Test**	**Total**
# of drivers notified	62	103	165
# of respondents	40	47	87
Response rate	*64.5%*	*45.6%*	*52.7%*

Figures 25 and 26 illustrate the number of days respondents were assigned and driving FOT vehicles in the past three years.

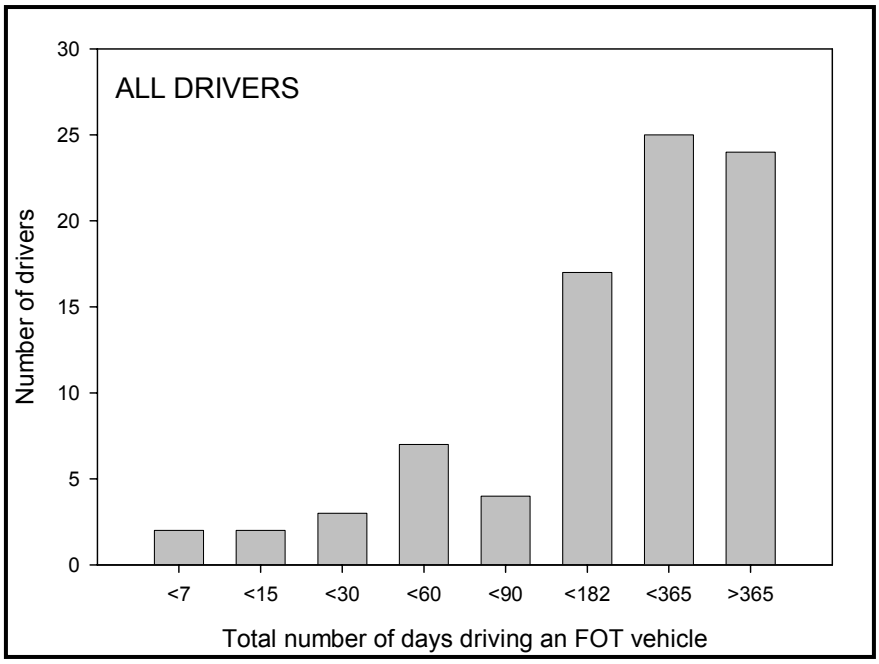

Figure 25. Number of days respondents were assigned and driving any of the FOT vehicles.

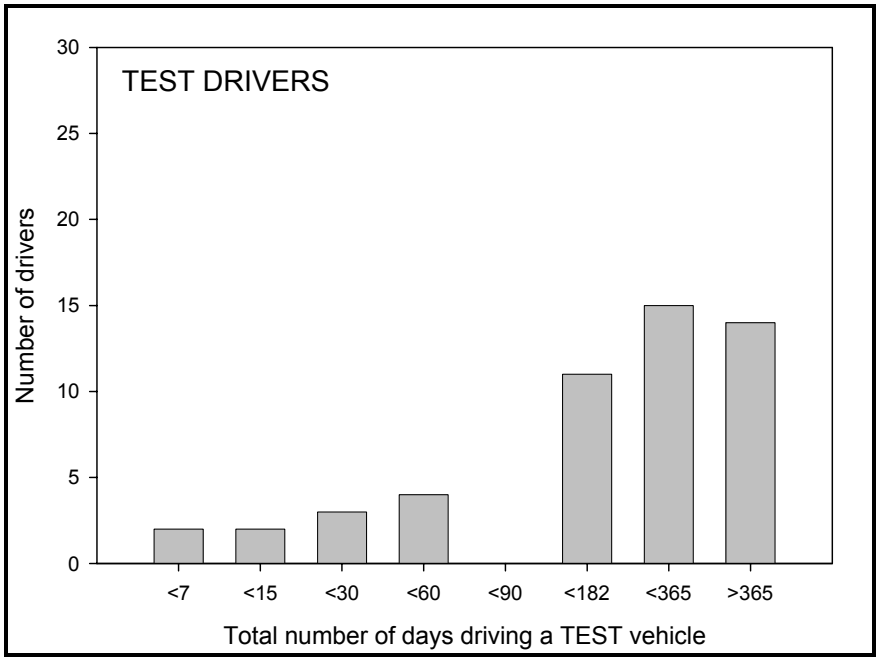

Figure 26. Number of days respondents were assigned and driving a TEST vehicle.

Results

Completed interviews

The number of completed interviews per day and per truck group is illustrated in figure 27, and listed in table 30. The average response rate across all drivers is 52.7 percent.

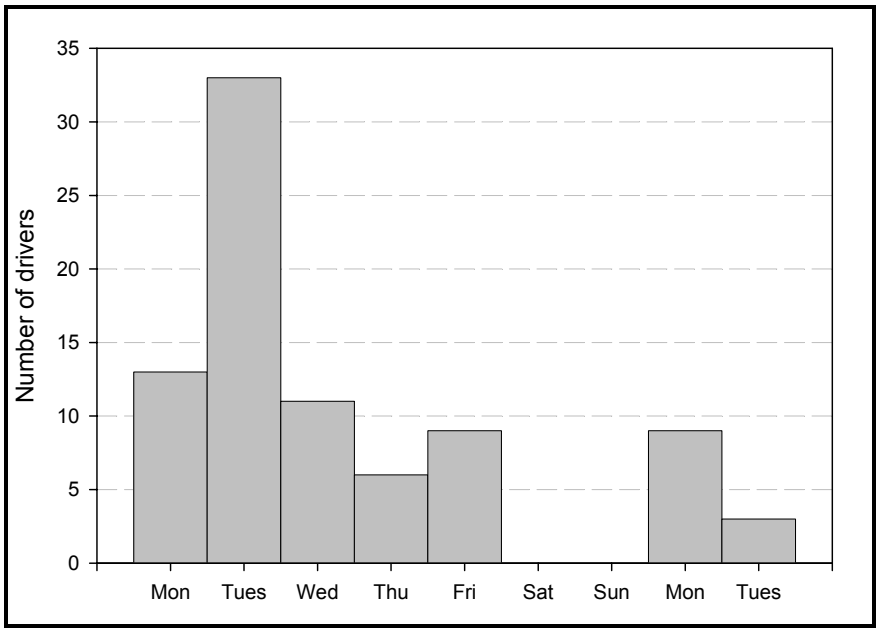

Figure 27. Number of completed interviews per day.

Finally, figure 28 illustrates the number of drivers who participated in both Phase I and Phase II interviews.

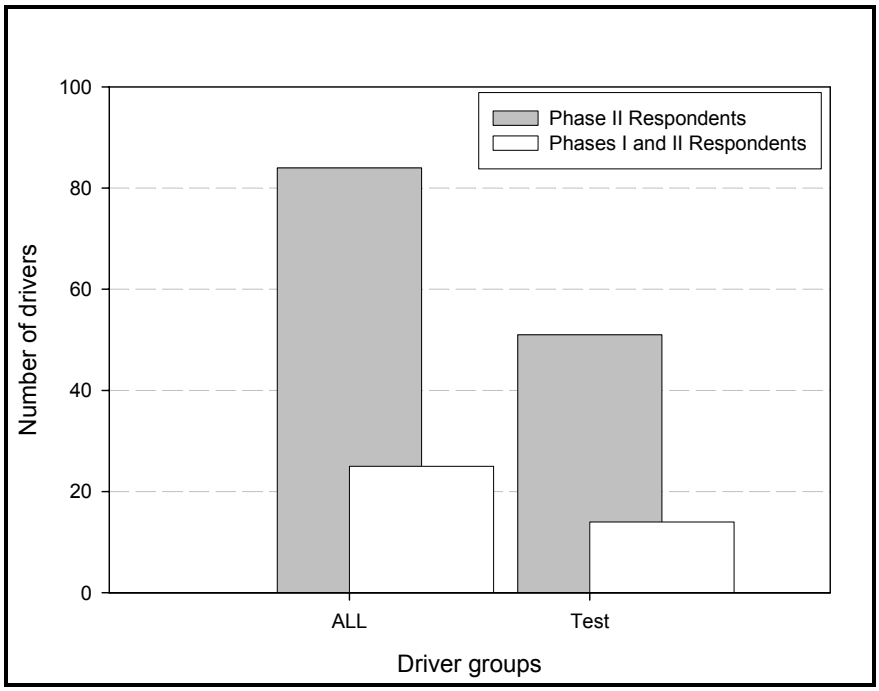

Figure 28. Number of drivers who participated in both Phase I and II interviews.

Attachment B-1
Notification messages

Notification Date		Message Content	
Day	Time (EST)	Group 1	Group 2
Monday, March 29	AM/PM	Message 1	Message 1
Tuesday, March 30	AM/PM	Message 2	Message 2
Wednesday, March 31	AM/PM	Message 3	Message 3
Thursday, April 1	AM/PM	Message 4	Message 4
Friday, April 2	AM/PM	Message 5	Message 5
Saturday, April 3	/	/	/
Sunday April 4	/	/	/
Monday, April 5	AM/PM	Message 4	Message 4
Tuesday, April 6	AM/PM	Message 4	Message 4

Message 1: (Day 1)
CALL 866-559-0924 BTWN 9AM-8:30PM CST FOR MANDATORY SURVEY. IF TEAM, BOTH DRVS MUST CALL. LEAVE MSG IF VOICEMAIL

Message 2: (Day 2)

CALL 866-559-0924 BTWN 9AM-8:30PM CST FOR MANDATORY SURVEY. IF HVNT CALLED ALRDY

Message 3: (Day 3)
IF HVNT ALRDY COMPLTD MANDATORY SURVEY. CALL 866-559-0924 9AM-8:30PM CST 2DAY. IF TEAM, BOTH DRVS MUST CALL.

Message 4: (Day 4)
URGENT: IF U HAVNT COMPLTD MANDATORY SURVEY, PLZ CALL 866-559-0924 BE4 8:30PM CST. IF TEAM, BOTH DRVS MUST CALL

Message 5: (Day 5)
2DAY IS FNL DAY FOR MANDATORY SURVEY.IF NOT ALRDY DONE, CALL 866-559-0924 BE4 6:00PM CST. LEAVE MSG IF VOICEMAIL

APPENDIX C. PHASE II SURVEY QUESTIONNAIRE

Volvo IVI FOT

Phase II Driver Telephone Interviews

Notes to readers:

- To allow easy comparison of the questions between groups and to facilitate tracking the total number of questions, the questions were numbered as follows:
  1- First digit identifies the category or the technology in question where:
     0: background questions.
     1: Vorad®-related questions.
     2: SmartCruise related questions.
     3: AdvBS related questions.
     4: Mental workload questions.
  2- Second and Third digit identify the question number for each category.
  3- Example:
     001 is the first question for background purposes.
     101 is the first question for Vorad®.
     210 is the 10^{th} question for SmartCruise.
     302 is the second question for AdvBS.
- Comments are embedded in the list of questions below to help with the review of this document.
- Note that Vorad® questions are specifically worded in terms of "forward radar" since the Vorad® side sensor is not under evaluation in this FOT.

INTRO: Hello, my name is [INTERVIEWER'S FULL NAME]. Thank you for calling in. We are conducting this study on behalf of the U.S. Department of Transportation. We are interviewing all drivers who are participating [have participated] in US Xpress's truck safety program. The evaluation of this program is designed to get your thoughts and opinions about truck safety and the value of new safety technologies.

Your participation in this study is completely voluntary. You have the right to refuse to be interviewed or to refuse to answer any question, and you may skip any question you do not want to answer. All of the information you provide in this interview will be kept strictly confidential and will not be disclosed to anyone but the researchers conducting the study. Your employer will not be given your answers to these questions.

This is the second time we are seeking the opinions of US Xpress drivers. Drivers' opinions were collected two years ago in a first series of similar interviews. The interview should take about 20 minutes to complete. We really appreciate your taking the time to answer our questions and helping us in this important research.

Before we begin the survey, we need to have both your truck and driver ID numbers.

What is your truck ID number? _____ 5 digits

What is your driver ID number? _____ 6 digits

Background

Q001: How long have you been a truck driver? Include both US Xpress and any other driving experience. **(ANSWER CAN BE IN YEARS AND MONTHS)**

_____**YEARS** Range 0-60
_____**MONTHS** Range 0-11

Q002: For how long have you been driving a truck with the Vorad® forward radar installed and active? Include both US Xpress and any other driving experience. **(ANSWER CAN BE IN YEARS AND MONTHS)**

_____**YEARS** Range 0-20
_____**MONTHS** Range 0-11

Vorad®

Q101a1: Did you receive training in the use of the Vorad® forward radar?
1= YES **(CONTINUE TO Q101A2)**
2= NO **(GO TO Q101B1)**
8= REFUSE **(GO TO Q101B1)**
9= DON'T KNOW **(GO TO Q101B1)**

Q101a2: How helpful was Vorad® forward radar training for you? Would you say it was…
1= NOT AT ALL HELPFUL
2= SOMEWHAT HELPFUL
3= VERY HELPFUL
8= REFUSE
9= DON'T KNOW

Q101b1: How much would you say explanations in the driver's manual help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
4= DON'T HAVE A MANUAL
8= REFUSE
9= DON'T KNOW

Q101c1: How much would you say informal discussions with other drivers help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
4= DON'T TALK TO OTHERS ABOUT THE SYSTEM
8= REFUSE
9= DON'T KNOW

Q101d1: How much would you say that just using it and trial and error help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
8= REFUSE
9= DON'T KNOW

Q102a: When all three lights (yellow, green and red) are illuminated on the Vorad® forward radar Display, what does it indicate?

(TEXT ANSWER) _____

Q102b: When a single Vorad® beep sounds, what does it indicate?

(TEXT ANSWER) _____

[Offer probes to the interviewers: What condition(s) trigger the single beep?]

Q102c: When a double Vorad® beep sounds, what does it indicate?
(TEXT ANSWER) _____
Offer probes to the interviewers: What condition(s) trigger the double beep?]

Q103: Does the Vorad® forward radar interfere with your driving tasks**?**
[Offer probes to the interviewers for driving tasks: maintaining safe following distance, changing lanes, staying in lane, braking, maintaining speed]
1= THE VORAD® FORWARD RADAR INTERFERES A LOT WITH MY DRIVING TASKS **(GO TO Q103B)**
2= THE VORAD® FORWARD RADAR INTERFERES SOMEWHAT WITH MY DRIVING TASKS **(GO TO Q103B)**
3= THE VORAD® FORWARD RADAR INTERFERES A LITTLE WITH MY DRIVING TASKS **(GO TO Q103B)**
4= THE VORAD® FORWARD RADAR DOES NOT INTERFERE WITH MY DRIVING TASKS **(GO TO Q104)**
8= REFUSE **(GO TO Q104)**
9= DON'T KNOW **(GO TO Q104)**

Q103b: Briefly describe the driving tasks with which the Vorad® forward radar interferes, how it interferes with them, and how frequently.
(TEXT ANSWER) _____

Q104: As a result of having the Vorad® forward radar on your truck, has your driving…
1= CHANGED A LOT? **(GO TO Q104B)**
2= CHANGED SOMEWHAT? **(GO TO Q104B)**
3= NOT CHANGED? **(GO TO Q105)**
8= REFUSE **(GO TO Q105)**
9= DON'T KNOW **(GO TO Q105)**

Q104b: Briefly explain how your driving has changed as a result of having the Vorad® forward radar on your truck.
(TEXT ANSWER) _____
[Offer probes to the interviewers: Are they driving more or less attentive, are they driving more carefully? Are they taking more risks? Driving faster? In certain conditions? Did they drive any faster in fog or rain because they thought the system would protect them? Did they tend to ignore the lights after building up some experience with the system? Did they tend to ignore the auditory alarms or respond less urgently after building up experience driving with the system? If so, how many days/weeks did it take?]

Q105: Which of the following statements reflects your experience driving with the Vorad® forward radar compared to your experience driving without the Vorad® forward radar?
1= DRIVING WITH THE VORAD® FORWARD RADAR IS A LOT MORE STRESSFUL AND TIRING **(GO TO Q105B)**
2= DRIVING WITH THE VORAD® FORWARD RADAR IS SOMEWHAT MORE STRESSFUL AND TIRING **(GO TO Q105B)**
3= DRIVING WITH THE VORAD® FORWARD RADAR IS NO MORE OR LESS STRESSFUL AND TIRING **(GO TO Q106**)

4= DRIVING WITH THE VORAD® FORWARD RADAR IS SOMEWHAT LESS STRESSFUL AND TIRING **(GO TO Q105B)**
5= DRIVING WITH THE VORAD® FORWARD RADAR IS A LOT LESS STRESSFUL AND TIRING **(GO TO Q105B)**
8= REFUSE **(GO TO Q106)**
9= DON'T KNOW **(GO TO Q106)**

Q105b: Briefly explain how the Vorad® forward radar affects the stress and fatigue of driving.

(TEXT ANSWER) _____

Q106: Has the likelihood of an accident or a near-accident situation been affected by the use of the Vorad® forward radar on your truck?
1= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS A LOT MORE LIKELY. **(GO TO Q106B)**
2= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS SOMEWHAT MORE LIKELY. **(GO TO Q106B)**
3= DOES NOT CHANGE THE LIKELIHOOD OF AN ACCIDENT OR A NEAR-ACCIDENT SITUATION. **(GO TO Q107)**
4= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS SOMEWHAT LESS LIKELY. **(GO TO Q106B)**
5= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS A LOT LESS LIKELY. **(GO TO Q106B)**
8= REFUSE **(GO TO Q107)**
9= DON'T KNOW **(GO TO Q107)**

Q106b: Briefly explain how the Vorad® forward radar affects the likelihood of accidents or near-accident situations.
(TEXT ANSWER) _____

Q107: Based on your experience with the Vorad® forward radar, would you rather:
1= DRIVE A TRUCK EQUIPPED WITH THE VORAD® FORWARD RADAR?
2= DRIVE A TRUCK NOT EQUIPPED WITH THE VORAD® FORWARD RADAR?
8= REFUSE
9= DON'T KNOW

Q107b: Please explain why.
(TEXT ANSWER) _____

Q108: The warning lights from Vorad® forward radar are easy to see.
1= ALWAYS **(GO TO Q109)**
2= MOST OF THE TIME **(GO TO Q108B)**
3= SOME OF THE TIME **(GO TO Q108B)**
4= RARELY **(GO TO Q108B)**
5= NEVER **(GO TO Q108B)**
8= REFUSE **(GO TO Q109)**
9= DON'T KNOW **(GO TO Q109)**

Q108b: Indicate why Vorad® forward radar warning lights are not always easy to see.
(TEXT ANSWER) _____

[Offer probes to the interviewers: sunlight, location on dash…]

Q109: The alerts from Vorad® forward radar are easy to hear.
1= ALWAYS **(GO TO Q110A)**
2= MOST OF THE TIME **(GO TO Q109B)**
3= SOME OF THE TIME **(GO TO Q109B)**
4= RARELY **(GO TO Q109B)**
5= NEVER **(GO TO Q109B)**
8= REFUSE **(GO TO Q110A)**
9= DON'T KNOW **(GO TO Q110A)**

Q109b: Indicate why Vorad® forward radar alerts are not always easy to hear.
(TEXT ANSWER) _____
[Offer probes to the interviewers: radio on…]

Q110a: When all three lights (yellow, green and red) are illuminated on the Vorad® forward radar Display, what do you do?
(TEXT ANSWER) _____

Q110b: When a single forward Vorad® beep sounds, what do you do?
(TEXT ANSWER) _____

Q110c: When a double forward Vorad® beep sounds, what do you do?
(TEXT ANSWER) _____

Q111: The various Vorad® warnings given by the forward sensor, including single beeps, double beeps and visual alerts, are easily distinguished from one another.
1= ALWAYS **(GO TO Q111C)**
2= MOST OF THE TIME **(GO TO Q111C)**
3= SOME OF THE TIME **(GO TO Q111B)**
4= RARELY **(GO TO Q111B)**
5= NEVER **(GO TO Q111B)**
8= REFUSE **(GO TO Q111C)**
9= DON'T KNOW **(GO TO Q111C)**

Q111b: Indicate why the various Vorad® forward radar warnings are NOT easily distinguished from one another.
(TEXT ANSWER) _____

Q111c: The various warnings given by the **forward** Vorad® (including single beeps, double beeps and visual alerts) are easily distinguished from the warnings given by the **side** Vorad®.
1=ALWAYS **(GO TO Q112)**
2=MOST OF THE TIME **(GO TO Q112**)
3=SOME OF THE TIME **(GO TO Q111D)**
4=RARELY **(GO TO Q111D)**
5=NEVER **(GO TO Q111D)**
8= REFUSE **(GO TO Q112)**
9= DON'T KNOW **(GO TO Q112)**

Q111d: Indicate why the various forward Vorad® radar warnings are NOT easily distinguished from the side Vorad® warnings.
(TEXT ANSWER) _____

Q112: Is your truck equipped with warning or beeping systems other than the Vorad® forward or side radar?
1= YES **(GO TO Q113)**
2= NO **(GO TO Q114A)**
8= REFUSE **(GO TO Q114A)**
9= DON'T KNOW **(GO TO Q114A)**

Q113: The various Vorad® warnings (forward or side) are easily distinguished from other systems' warnings.
1= ALWAYS **(GO TO Q114A**)
2= MOST OF THE TIME **(GO TO Q113B)**
3= SOME OF THE TIME **(GO TO Q113B)**
4= RARELY **(GO TO Q113B)**
5= NEVER **(GO TO Q113B)**
8= REFUSE **(GO TO Q114A)**
9= DON'T KNOW **(GO TO Q114A)**

Q113b: Indicate why Vorad® forward radar alerts are not easily distinguished from other systems' warnings.
(TEXT ANSWER) _____

Q114a: On average, out of every 10 Vorad® forward radar alerts you have received, how many of the alerts were given when you thought there was no crash threat? Indicate a number between 0 and 10, where 0 indicates none and 10 indicates all. _____
_____ Range 0-10
[Probe: If alerts were given when you thought there was no crash threat ~30% of the time, your answer would be 3 or if ~50% of the time, your answer would be 5.]

Q114b: On average, out of every 10 Vorad® forward radar alerts you have received, how many of the alerts were given when there might have been a crash threat but you thought the alert was unnecessary? Indicate a number between 0 and 10, where 0 indicates none and 10 indicates all.
_____ Range 0-10
[Probe: If alerts were given when you thought it was unnecessary ~30% of the time, your answer would be 3 or if ~50% of the time, your answer would be 5.]

[Offer probes to the interviewers: because you were alert, aware of the situation or had already taken action…]
IF YOU INDICATED "0" (NONE), GO TO Q115.

Q114c: Do you consider such inappropriate or unnecessary warnings presented by Vorad® forward radar to be a nuisance?
1= A SUBSTANTIAL NUISANCE
2= SOMEWHAT OF A NUISANCE
3= NOT MUCH OF A NUISANCE
4= NO NUISANCE AT ALL

8= REFUSE
9= DON'T KNOW

Q115: On average, how often has the Vorad® forward radar not given you an alert when you thought it should have? On average, out of every 10 times you thought an alert would be appropriate, how many times did the system not provide an alert? Indicate a number between 0 and 10, where 0 indicates none and 10 indicates all**.**

____ Range 0-10

IF YOU INDICATED "0" (NONE), GO TO Q116.

[Probe: If alerts were not given when you thought they should have been ~30% of the time, your answer would be 3 or if ~50% of the time, your answer would be 5.]

Q115b: Have these missed alerts reduced your overall confidence in the Vorad® forward radar?
1= A LOT
2= SOMEWHAT
3= A LITTLE
4= NOT AT ALL
8= REFUSE
9= DON'T KNOW

Q116: The visual Vorad® forward radar warnings draw my attention away from my driving tasks.

[Offer probes to the interviewers: take focus away from driving tasks]
1= ALWAYS **(GO TO Q116B)**
2= MOST OF THE TIME **(GO TO Q116B**)
3= SOME OF THE TIME **(GO TO Q116B)**
4= RARELY **(GO TO Q116B)**
5= NEVER **(GO TO Q117)**
8= REFUSE **(GO TO Q117)**
9= DON'T KNOW **(GO TO Q117)**

Q116b: Explain how the visual Vorad® forward radar warnings draw your attention away from your driving tasks.
(TEXT ANSWER) _____

Q117: The auditory Vorad® forward radar warnings draw my attention away from my driving tasks.
1= ALWAYS **(GO TO Q117B)**
2= MOST OF THE TIME **(GO TO Q117B)**
3= SOME OF THE TIME **(GO TO Q117B)**
4= RARELY **(GO TO Q117B)**
5= NEVER **(GO TO Q117C)**
8= REFUSE **(GO TO Q117C)**
9= DON'T KNOW **(GO TO Q117C)**

Q117b: Explain how the auditory Vorad® forward radar warnings (beeps) draw your attention away from your driving tasks. **(TEXT ANSWER)** _____

Q117c: The auditory Vorad® forward radar warnings (beeps) get my attention if I get a little tired or bored driving.
1= ALWAYS **(GO TO Q117D)**
2= MOST OF THE TIME **(GO TO Q117D)**
3= SOME OF THE TIME **(GO TO Q117D)**
4= RARELY **(GO TO Q117D)**
5= NEVER **(GO TO Q118)**
8= REFUSE **(GO TO Q118)**
9= DON'T KNOW **(GO TO Q118)**

Q117d: Explain when the auditory Vorad® forward radar warnings (beeps) can be attention grabbing.
(TEXT ANSWER) _____

Q118: In which of the following traffic or weather conditions is the Vorad® forward radar particularly helpful (check all that applies)?
1= OPEN HIGHWAY WITH LIGHT TO MODERATE TRAFFIC
2= IN HEAVY TRAFFIC
3= IN FOG
4= AT NIGHT
5= IN HEAVY RAIN OR SNOW CONDITIONS
8= REFUSE
9= DON'T KNOW

Q119: In which of the following traffic or weather conditions is the Vorad® forward radar likely to draw your attention away from your driving tasks? (Check all that applies.)
1= OPEN HIGHWAY WITH LIGHT TO MODERATE TRAFFIC
2= IN HEAVY TRAFFIC
3= IN FOG
4= AT NIGHT
5= IN HEAVY RAIN OR SNOW CONDITIONS
8= REFUSE
9= DON'T KNOW

Q120: Do you have recommendations for changes that might improve the performance or functionality of the Vorad® forward radar?
(TEXT ANSWER) _____

Q121: How well did the Vorad® forward radar work? Was there any time where it did not work properly (downtime)?
1= YES **(GO TO Q121B)**
2= NO **(GO TO Q122)**
8= REFUSE **(GO TO Q122)**
9= DON'T KNOW **(GO TO Q122)**

Q121b: Please describe what did not work properly with the Vorad® forward radar?
(TEXT ANSWER) _____

Q121c: How often would you say it happened to you?
1= A LOT
2= SOMEWHAT FREQUENTLY
3= A FEW TIMES
4= NEVER
8= REFUSE
9= DON'T KNOW

Q122: Do you have recommendations for changes that might make it easier to use or learn how to use the Vorad® forward radar?
(TEXT ANSWER) _____

Q123: What do you like most about Vorad®?
(TEXT ANSWER) _____

Q124: What do you like least about Vorad®?
(TEXT ANSWER) _____

SmartCruise

[SMARTCRUISE® is similar to regular cruise control, except that, when there is a vehicle in front of you, it also maintains a fixed distance between your truck and that vehicle, even when it changes speed. For example, when the vehicle in front of you slows down, SMARTCRUISE® will automatically slow your truck down to maintain the same distance.]

Q200: Have you driven a truck equipped with SMARTCRUISE®?
1= YES **(GO TO Q200A)**
2= NO **(GO TO Q300)**
8= REFUSE **(GO TO Q300)**
9= DON'T KNOW **(GO TO Q300)**

Q200a: How long have you driven a truck equipped with SMARTCRUISE®? Include both US Xpress and any other driving experience. **(ANSWER CAN BE IN YEARS AND MONTHS)**
_____**YEARS** Range 0-30
_____**MONTHS** Range 0-11

Q201a1: Did you receive training in the use of SMARTCRUISE®?
1= YES **(CONTINUE TO Q201A2)**
2= NO **(GO TO Q201B1)**
8= REFUSE **(GO TO Q201B1)**
9= DON'T KNOW **(GO TO Q201B1)**

Q201a2: How helpful was SMARTCRUISE® training for you? Would you say it was…
1= NOT AT ALL HELPFUL
2= SOMEWHAT HELPFUL
3= VERY HELPFUL
8= REFUSE
9= DON'T KNOW

Q201b1: How much would you say explanations in the driver's manual help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
4= DON'T HAVE A MANUAL
8= REFUSE
9= DON'T KNOW

Q201c1: How much would you say informal discussions with other drivers help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
4= DON'T TALK TO OTHERS ABOUT THE SYSTEM
8= REFUSE
9= DON'T KNOW

Q201d1: How much would you say that just using it and trial and error help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
8= REFUSE
9= DON'T KNOW

Q203: Does SMARTCRUISE® interfere with your driving tasks**? [Offer probes to the interviewers for driving tasks: maintaining safe following distance, changing lanes, staying in lane, braking, maintaining speed]**
1= SMARTCRUISE® INTERFERES A LOT WITH MY DRIVING TASKS **(GO TO Q203B)**
2= SMARTCRUISE® INTERFERES SOMEWHAT WITH MY DRIVING TASKS **(GO TO Q203B)**
3= SMARTCRUISE® INTERFERES A LITTLE WITH MY DRIVING TASKS **(GO TO Q203B)**
4= SMARTCRUISE® DOES NOT INTERFERE WITH MY DRIVING TASKS **(GO TO Q204)**
8= REFUSE **(GO TO Q204)**
9= DON'T KNOW **(GO TO Q204)**

Q203b: Briefly describe the driving tasks with which SMARTCRUISE® interferes, how it interferes with them, and how frequently.
(TEXT ANSWER) _____

Q204: As a result of having SMARTCRUISE® on your truck, has your driving…
1= CHANGED A LOT? **(GO TO Q204B)**
2= CHANGED SOMEWHAT? **(GO TO Q204B)**
3= NOT CHANGED? **(GO TO Q205)**
8= REFUSE **(GO TO Q205)**
9= DON'T KNOW **(GO TO Q205)**

Q204b: Briefly explain how your driving has changed as a result of having SMARTCRUISE® on your truck.
(TEXT ANSWER) _____
[Offer probes to the interviewers: Are they driving more or less attentive, are they driving more carefully? Are they taking more risks? Driving faster? In certain conditions? Did they drive any faster in fog or rain because they thought the system would protect them?]

Q205: Which of the following statements reflects your experience driving with SMARTCRUISE® compared to your experience driving without SMARTCRUISE®?
1= DRIVING WITH SMARTCRUISE® IS A LOT MORE STRESSFUL AND TIRING **(GO TO Q205B)**
2= DRIVING WITH SMARTCRUISE® IS SOMEWHAT MORE STRESSFUL AND TIRING **(GO TO Q205B)**
3= DRIVING WITH SMARTCRUISE® IS NO MORE OR LESS STRESSFUL AND TIRING **(GO TO Q206)**

4= DRIVING WITH SMARTCRUISE® IS SOMEWHAT LESS STRESSFUL AND TIRING **(GO TO Q205B)**
5= DRIVING WITH SMARTCRUISE® IS A LOT LESS STRESSFUL AND TIRING **(GO TO Q205B)**
8= REFUSE **(GO TO Q206)**
9= DON'T KNOW **(GO TO Q206)**

Q205b: Briefly explain how SMARTCRUISE® affects the stress and fatigue of driving.
(TEXT ANSWER) _____

Q206: Has the likelihood of an accident or a near-accident situation been affected by the use of SMARTCRUISE® on your truck?
1= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS A LOT MORE LIKELY. **(GO TO Q206B)**
2= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS SOMEWHAT MORE LIKELY. **(GO TO Q206B)**
3= DOES NOT CHANGE THE LIKELIHOOD OF AN ACCIDENT OR A NEAR-ACCIDENT SITUATION. **(GO TO Q207)**
4= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS SOMEWHAT LESS LIKELY. **(GO TO Q206B)**
5= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS A LOT LESS LIKELY. **(GO TO Q206B)**
8= REFUSE **(GO TO Q207)**
9= DON'T KNOW **(GO TO Q207)**

Q206b: Briefly explain how SMARTCRUISE® affects the likelihood of accidents or near-accident situations.
(TEXT ANSWER) _____

Q207: Based on your experience with SMARTCRUISE®, would you rather:
1= DRIVE A TRUCK EQUIPPED WITH SMARTCRUISE®?
2= DRIVE A TRUCK NOT EQUIPPED WITH SMARTCRUISE®?
8= REFUSE
9= DON'T KNOW

Q207b: Please explain why.
(TEXT ANSWER) _____

Q217: SMARTCRUISE® gets my attention if I get a little tired or bored driving.
1= ALWAYS **(GO TO Q217B)**
2= MOST OF THE TIME **(GO TO Q217B)**
3= SOME OF THE TIME **(GO TO Q217B)**
4= RARELY **(GO TO Q217B)**
5= NEVER **(GO TO Q220)**
8= REFUSE **(GO TO Q220)**
9= DON'T KNOW **(GO TO Q220)**

Q217b: Explain when SMARTCRUISE® can be attention grabbing.
(TEXT ANSWER) _____

Q220: Do you have recommendations for changes that might improve the performance or functionality of SMARTCRUISE®? **(TEXT ANSWER)** _____

Q221: How well did SMARTCRUISE® work? Was there any time where it did not work properly (downtime)?
1= YES **(GO TO Q221B)**
2= NO **(GO TO Q222)**
8= REFUSE **(GO TO Q222)**
9= DON'T KNOW **(GO TO Q222)**

Q221b: Please describe what did not work properly with SMARTCRUISE®?
(TEXT ANSWER) _____

Q221c: How often would you say it happened to you?
1= A LOT
2= SOMEWHAT FREQUENTLY
3= A FEW TIMES
4= NEVER
8= REFUSE
9= DON'T KNOW

Q222: Do you have recommendation for changes that might make it easier to use or learn how to use SMARTCRUISE®?
(TEXT ANSWER) _____

Q223: What do you like most about Smartcruise?
(TEXT ANSWER) _____

Q224: What do you like least about SmartCruise?
(TEXT ANSWER) _____

AdvBS

[AdvBS means Advanced Braking System, also called ABS. Electronic disc brakes include an Electronic Braking System, called EBS, combined with disc brakes. EBS works like ABS, except that electronics are used to enhance stopping capabilities. EBS combined with disc brakes give you shorter stopping distances, greater automatic braking control in slippery or dangerous situations, and more stability while braking.]

Q300: Have you driven a truck equipped with electronic disc brakes?
1= YES **(GO TO Q300A)**
2= NO **(GO TO Q401)**
8= REFUSE **(GO TO Q401)**
9= DON'T KNOW **(GO TO Q401)**

Q300a: How long have you driven a truck equipped with electronic disc brakes? Include both US Xpress and any other driving experience. **(ANSWER CAN BE IN YEARS AND MONTHS)**

_____**YEARS** Range 0-30
_____**MONTHS** Range 0-11

Q301a1: Did you receive training in the use of electronic disc brakes?
1= YES **(CONTINUE TO Q301A2)**
2= NO **(GO TO Q301B1)**
8= REFUSE **(GO TO Q301B1)**
9= DON'T KNOW **(GO TO Q301B1)**

Q301a2: How helpful were electronic disc brakes training for you? Would you say it was…
1= NOT AT ALL HELPFUL
2=SOMEWHAT HELPFUL
3=VERY HELPFUL
8= REFUSE
9= DON'T KNOW

Q301b1: How much would you say explanations in the driver's manual help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
4= DON'T HAVE A MANUAL
8= REFUSE
9= DON'T KNOW

Q301c1: How much would you say informal discussions with other drivers help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
4= DON'T TALK TO OTHERS ABOUT THE SYSTEM
8= REFUSE
9= DON'T KNOW

Q301d1: How much would you say that just using it and trial and error help you learn this system?
1= A LOT
2= SOMEWHAT
3= NOT AT ALL
8= REFUSE
9= DON'T KNOW

Q304: As a result of having electronic disc brakes on your truck, has your driving…
1= CHANGED A LOT? **(GO TO Q304B)**
2= CHANGED SOMEWHAT? **(GO TO Q304B)**
3= NOT CHANGED? **(GO TO Q305)**
8= REFUSE **(GO TO Q305)**
9= DON'T KNOW **(GO TO Q305)**

Q304b: Briefly explain how your driving has changed as a result of having electronic disc brakes on your truck.
(TEXT ANSWER) _____
[Offer probes to the interviewers: Are they driving more carefully? Are they taking more risks? Driving faster? In certain conditions? Did they drive any faster in fog or rain because they thought the system would protect them?]

Q305: Which of the following statements reflects your experience driving with electronic disc brakes compared to your experience driving without electronic disc brakes?
1= DRIVING WITH ELECTRONIC DISC BRAKES IS A LOT MORE STRESSFUL AND TIRING **(GO TO Q305B)**
2= DRIVING WITH ELECTRONIC DISC BRAKES IS SOMEWHAT MORE STRESSFUL AND TIRING **(GO TO Q305B)**
3= DRIVING WITH ELECTRONIC DISC BRAKES IS NO MORE OR LESS STRESSFUL AND TIRING **(GO TO Q306)**
4= DRIVING WITH ELECTRONIC DISC BRAKES IS SOMEWHAT LESS STRESSFUL AND TIRING **(GO TO Q305B)**
5= DRIVING WITH ELECTRONIC DISC BRAKES IS A LOT LESS STRESSFUL AND TIRING **(GO TO Q305B)**
8= REFUSE **(GO TO Q306)**
9= DON'T KNOW **(GO TO Q306)**

Q305b: Briefly explain how electronic disc brakes affect the stress and fatigue of driving.
(TEXT ANSWER) _____

Q306: Has the likelihood of an accident or a near-accident situation been affected by having electronic disc brakes on your truck?
1= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS A LOT MORE LIKELY. **(GO TO Q306B)**
2= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS SOMEWHAT MORE LIKELY. **(GO TO Q306B)**
3= DOES NOT CHANGE THE LIKELIHOOD OF AN ACCIDENT OR A NEAR-ACCIDENT SITUATION. **(GO TO Q307)**

4= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS SOMEWHAT LESS LIKELY. **(GO TO Q306B)**
5= AN ACCIDENT OR A NEAR-ACCIDENT SITUATION IS A LOT LESS LIKELY. **(GO TO Q306B)**
8= REFUSE **(GO TO Q307)**
9= DON'T KNOW **(GO TO Q307)**

Q306b: Briefly explain how electronic disc brakes affect the likelihood of accidents or near-accident situations.
(TEXT ANSWER) _____

Q307: Based on your experience with electronic disc brakes, would you rather:
1=DRIVE A TRUCK EQUIPPED WITH ELECTRONIC DISC BRAKES?
2=DRIVE A TRUCK NOT EQUIPPED WITH ELECTRONIC DISC BRAKES?
8= REFUSE
9= DON'T KNOW

Q307b: Can you explain why?
(TEXT ANSWER) _____

Q320: Do you have recommendations for changes that might improve the performance or functionality of electronic disc brakes?
(TEXT ANSWER) _____

Q321: How well did electronic disc brakes work? Was there any time where they did not work properly (downtime)?
1= YES **(GO TO Q321B)**
2= NO **(GO TO Q323)**
8= REFUSE **(GO TO Q323)**
9= DON'T KNOW **(GO TO Q323)**

Q321b: Please describe what did not work properly with electronic disc brakes?
(TEXT ANSWER) _____

Q321c: How often would you say it happened to you?
1=A LOT
2=SOMEWHAT FREQUENTLY
3=A FEW TIMES
4=NEVER
8= REFUSE
9= DON'T KNOW

Q323: What do you like most about electronic disc brakes?
(TEXT ANSWER) _____

Q324: What do you like least about electronic disc brakes?
(TEXT ANSWER) _____

Mental Workload

Q401: "Mental workload" is the mental effort it takes for you to perform tasks. Think in terms of your level of concentration, amount of mental effort, or degree of mental focus. On a mental workload scale of 1 to 10, 1 means very low mental workload, and 10 means the highest mental workload. Please check a number between 1 and 10 that reflects your estimate of the level of mental workload under each of the following conditions:

Q401a: Normal driving conditions when you drive your own personal automobile?
_____ Range 1-10

Q401b: When driving your US Xpress truck in good driving conditions with good visibility and light to moderate traffic without safety technologies such as the Vorad® forward radar, SmartCruise® or AdvBS.
_____ Range 1-10

Q401c: When driving your US Xpress truck in heavy traffic conditions without safety technologies such as the Vorad® forward radar, SmartCruise® or AdvBS.
_____ Range 1-10

Q401d: When driving your US Xpress truck in low visibility conditions (fog, rain, snow, night) without safety technologies such as the Vorad® forward radar, SmartCruise® or AdvBS.
_____ Range 1-10

Q401e: When driving your US Xpress truck in good driving conditions with good visibility and light to moderate traffic with the Vorad® forward radar, SmartCruise® and AdvBS functioning properly.
_____ Range 1-10

Q401f: When driving your US Xpress truck in heavy traffic conditions with the Vorad® forward radar, SmartCruise® and AdvBS functioning properly.
_____ Range 1-10

Q401g: When driving your US Xpress truck in low visibility conditions (fog, rain, snow, night) with safety the Vorad® forward radar, SmartCruise® and AdvBS functioning properly.
_____ Range 1-10

Q402: Tell me in your own words how you think the Vorad® forward radar, SmartCruise® and AdvBS affect the mental workload of driving a truck
(TEXT ANSWER) _____
[Probe: Do you find, for example, that you have to concentrate harder or less hard when you are using Vorad® than when you are not using Vorad®?]

EXIT SCRIPT-READ TO ALL RESPONDENTS

Those are all the questions I have for you right now. I can provide you with the name and telephone number of someone at USDOT you can speak with if you have any questions about this program or the evaluation process. I also have an Internet URL that has more information about this program. Would you like this information now?

IF YES**, SKIP TO INFO PARAGRAPH.**
IF NO, SKIP TO END.

INFO PARAGRAPH: You can call 1-202-366-5678 and speak with Jim Britell at USDOT if you have any questions about this program or the evaluation process. Alternatively, you

can go to the following URL on the Internet for more information about this program: http://www.its.gov/ivi/volvo.htm

END: Do you have any other comments or questions at this time?
Thank you for your participation.

APPENDIX D. SURVEY DATA FREQUENCY DISTRIBUTIONS

Table 31. Background: Experience with truck driving.

Question	Response Category	Vorad® N = 87
How long have you been a truck driver? (Years and Months)	Less than 6 months	1 (1.1%)
	6 months to less than 1 year	5 (5.7%)
	1 year to less than 3 years	9 (10.3%)
	3 years to less than 6 years	17 (19.5%)
	6 years to less than 9 years	12 (13.8%)
	9 years to less than 12 years	9 (10.3%)
	12 years to less than 15 years	5 (5.7%)
	15 years to less than 18 years	7 (8.0%)
	18 years to less than 21 years	7 (8.0%)
	21 years or more	15 (17.2%)

Table 32. Background: Ever driven a truck with IVSS.[1]

Question	Response Category	SmartCruise N = 87	AdvBS N = 87
Have you driven a truck equipped with _____?	Yes	34 (39.1%)	27 (31.0%)
	No	52 (59.8%)	54 (62.1%)
	Don't know	1 (1.1%)	6 (6.9%)

[1]All drivers in survey have experience driving a truck equipped with Vorad®.

Table 33. Background: Experience driving with IVSS.[1]

Question	Response Category	SmartCruise N = 87	AdvBS N = 87
How long have you driven a truck equipped with _____? Include both US Xpress and any other driving experience. (Years and Months)	None	52 (59.8%)	54 (62.1%)
	Less than 6 months	7 (58.0%)	1 (1.1%)
	6 months to less than 1 year	10 (11.5%)	6 (6.9%)
	1 year to less than 2 years	10 (11.5%)	11 (12.6%)
	2 years or more	7 (8.0%)	9 (10.3%)
	Don't know	1 (1.1%)	6 (6.9%)

[1]Vorad® driving experience shown in table D-1.

Table 34. Usability: Training and learning style.

Question	Response Category	Control	Test			Phase II Survey		
		Vorad®	Vorad®	SmartCruise	AdvBS	Vorad®	SmartCruise	AdvBS
Did you receive training in the use of _____?	Yes	17 (54.8%)	31 (52.5%)	19 (32.8%)	15 (25.9%)	47 (54.0%)	8 (23.5%)	5 (19.2%)
	No	14 (45.2%)	28 (47.5%)	39 (67.2%)	43 (74.1%)	40 (46.0%)	26 (76.5%)	21 (80.8%)
How helpful was _____ training for you? Would you say it was…	Very helpful	5 (16.1%)	15 (48.4%)	12 (63.2%)	8 (53.5%)	20 (42.6%)	5 (62.5%)	5 (100.0%)
	Somewhat helpful	9 (29.0%)	14 (45.2%)	6 (31.6%)	6 (40.0%)	25 (53.2%)	3 (37.5%)	0 (0.0%)
	Not at all helpful	3 (9.7%)	2 (6.5%)	1 (5.3%)	1 (6.7%)	2 (4.3%)	0 (0.0%)	0 (0.0%)
How much would you say explanations in the driver's manual help you learn _____?	A lot	—	—	—	—	28 (32.6%)	5 (15.2%)	2 (7.4%)
	Somewhat	—	—	—	—	20 (23.3%)	4 (12.1%)	7 (25.9%)
	Not at all	—	—	—	—	23 (26.7%)	10 (30.3%)	5 (18.5%)
	Don't have a manual	—	—	—	—	15 (17.4%)	14 (42.4%)	13 (48.1%)
How much would you say informal discussions with other drivers help you learn _____?	A lot	—	—	—	—	13 (14.9%)	7 (20.6%)	5 (18.5%)
	Somewhat	—	—	—	—	24 (27.6%)	5 (14.7%)	2 (7.4%)
	Not at all	—	—	—	—	24 (27.6%)	10 (29.4%)	7 (25.9%)
	Don't talk about this	—	—	—	—	26 (29.9%)	12 (35.3%)	13 (48.1%)
How much would you say that just using it and trial and error help you learn _____?	A lot	—	—	—	—	57 (66.3%)	24 (70.6%)	21 (77.8%)
	Somewhat	—	—	—	—	22 (25.6%)	6 (17.6%)	2 (7.4%)
	Not at all	—	—	—	—	7 (8.1%)	4 (11.8%)	4 (14.8%)

Table 35. Usability: Ease of seeing and hearing Vorad® warnings.

Question	Response Category	Vorad® N = 87
The warning lights from Vorad® forward radar are easy to see.	Always	76 (87.4%)
	Most of the time	7 (8.0%)
	Some of the time	1 (1.1%)
	Rarely	1 (1.1%)
	Never	1 (1.1%)
	Refuse	0 (0.0%)
	Don't know	1 (1.1%)
The alerts from Vorad® forward radar are easy to hear.	Always	81 (93.1%)
	Most of the time	6 (6.9%)
	Some of the time	0 (0.0%)
	Rarely	0 (0.0%)
	Never	0 (0.0%)
	Refuse	0 (0.0%)
	Don't know	0 (0.0%)

Table 36. Usability: Ease of distinguishing Vorad® warnings.

Question	Response Category	Vorad® N = 87
The various Vorad® warnings given by the forward sensor, including single beeps, double beeps and visual alerts, are easily distinguished from one another.	Always	56 (64.4%)
	Most of the time	19 (21.8%)
	Some of the time	7 (8.0%)
	Rarely	1 (1.1%)
	Never	2 (2.3%)
	Refuse	0 (0.0%)
	Don't know	2 (2.3%)
The various warnings given by the **forward** Vorad® (including single beeps, double beeps and visual alerts) are easily distinguished from the warnings given by the **side** Vorad®.	Always	54 (62.1%)
	Most of the time	12 (13.8%)
	Some of the time	8 (9.2%)
	Rarely	4 (4.6%)
	Never	6 (6.9%)
	Refuse	0 (0.0%)
	Don't know	3 (3.4%)
Is your truck equipped with warning or beeping systems other than the Vorad® forward or side radar?	Yes	33 (37.9%)
	No	54 (62.1%)
	Refuse	0 (0.0%)
	Don't know	0 (0.0%)
The various Vorad® warnings (forward and side) are easily distinguished from other systems' warnings.	Always	26 (78.8%)
	Most of the time	6 (18.2%)
	Some of the time	0 (0.0%)
	Rarely	1 (3.0%)
	Never	0 (0.0%)
	Refuse	0 (0.0%)
	Don't know	0 (0.0%)
	Skipped	54 —

Table 37. Stress and workload: Driver stress and fatigue.

Question	Response Category	Vorad® N = 87	SmartCruise N = 87	AdvBS N = 87
Which of the following statements reflects your experience driving with _____ compared to your experience driving without _____? Driving with _____ is *[response category]* stressful and tiring.	A lot more	2 (2.3%)	4 (11.8%)	1 (3.7%)
	Somewhat more	13 (15.1%)	4 (11.8%)	1 (3.7%)
	No more or less	29 (33.7%)	13 (38.2%)	10 (37.0%)
	Somewhat less	21 (24.4%)	4 (11.8%)	2 (7.4%)
	A lot less	21 (24.4%)	9 (26.5%)	13 (48.1%)
	Refused	1 —	0 (0.0%)	0 (0.0%)
	Skipped	—	53 —	60 —

Table 38. Stress and workload: IVSS distraction effects.

Question	Response Category	Vorad® N = 87	SmartCruise N = 87
The visual Vorad® forward radar warnings draw my attention away from my driving tasks.	Always	1 (1.1%)	—
	Most of the time	3 (3.4%)	—
	Some of the time	15 (17.2%)	—
	Rarely	15 (17.2%)	—
	Never	53 (60.9%)	—
	Don't know	0 (0.0%)	—
	Refused	0 (0.0%)	—
The auditory Vorad® forward radar warnings draw my attention away from my driving tasks.	Always	1 (1.1%)	—
	Most of the time	1 (1.1%)	—
	Some of the time	12 (13.8%)	—
	Rarely	17 (19.5%)	—
	Never	56 (64.4%)	—
	Don't know	0 (0.0%)	—
	Refused	0 (0.0%)	—
The auditory _____ warnings (beeps) get my attention if I get a little tired or bored driving.	Always	37 (42.5%)	4 (11.8%)
	Most of the time	16 (18.4%)	3 (8.8%)
	Some of the time	9 (10.3%)	9 (26.5%)
	Rarely	11 (12.6%)	2 (5.9%)
	Never	14 (16.1%)	16 (47.1%)
	Don't know	0 (0.0%)	0 (0.0%)
	Refused	0 (0.0%)	0 (0.0%)
	Skipped	—	53 —

Table 39. Stress and workload: IVSS interference with driving tasks.

Question	Response Category	Vorad® N = 87	SmartCruise N = 87
Does the _____ interfere with your driving tasks? The _____ interferes *[response category]*.	A lot	2 (2.3%)	7 (20.6%)
	Somewhat	7 (8.0%)	6 (17.6%)
	A little	11 (12.6%)	12 (5.9%)
	Does not interfere	67 (77.0%)	19 (55.9%)
	Don't know	0 (0.0%)	0 (0.0%)
	Refused	0 —	0 —
	Skipped	—	60 —

Table 40. Stress and workload: Conditions in which Vorad® is particularly helpful or distracting.

Question	Response Category	Vorad® N = 87
In which of the following traffic or weather conditions is the Vorad® forward radar particularly helpful? (check all that apply).	Open highway with light to moderate traffic	42 (48.3%)
	In heavy traffic	38 (43.7%)
	In fog	68 (78.2%)
	At night	45 (51.7%)
	In heavy rain or snow	53 (60.9%)
	Don't know	4 (4.6%)
	Refused	0 (0.0%)
In which of the following traffic or weather conditions is the Vorad® forward radar likely to draw your attention away from your driving tasks? (check all that apply).	Open highway with light to moderate traffic	13 (17.3%)
	In heavy traffic	28 (37.3%)
	In fog	7 (9.3%)
	At night	6 (8.0%)
	In heavy rain or snow	15 (20.0%)
	Don't know	26 (34.7%)
	Refused	12 —

NOTE: Percentages do not add up to 100% because drivers could indicate "yes" to more than one response category. N=75 (12 refusals) for second question.

Table 41. Stress and workload: Perceived mental workload under various driving conditions.

Estimated level of mental workload under the following conditions:	Lowest				Mental Workload Scale (N=87)					Highest	Missing
	1	2	3	4	5	6	7	8	9	10	
Normal driving conditions when you drive your own personal automobile.	14 16.3%	10 11.6%	8 9.3%	12 14.0%	17 19.8%	7 8.1%	9 10.5%	4 4.7%	1 1.2%	4 4.7%	1
Driving your US Xpress truck in good driving conditions with good visibility and light to moderate traffic without IVSS.	8 9.3%	3 3.5%	6 7.0%	6 7.0%	21 24.4%	9 10.5%	12 14.0%	6 7.0%	8 9.3%	7 8.1%	1
Driving your US Xpress truck in heavy traffic conditions without IVSS.	1 1.2%	1 1.2%	3 3.5%	5 5.8%	4 4.7%	8 9.3%	9 10.5%	14 16.3%	12 13.8%	29 33.7%	1
Driving your US Xpress truck in low visibility conditions (fog, rain, snow, night) without IVSS.	0 0.0%	0 0.0%	1 1.1%	1 1.1%	5 5.7%	8 9.2%	3 3.4%	11 12.6%	13 14.9%	45 51.7%	0
Driving your US Xpress truck in good driving conditions with good visibility and light to moderate traffic with IVSS functioning properly.	12 14.0%	10 11.6%	8 9.3%	6 7.0%	17 19.8%	8 9.2%	7 8.1%	9 10.5%	5 5.8%	4 4.7%	1
Driving your US Xpress truck in heavy traffic conditions with IVSS functioning properly.	7 8.2%	4 4.7%	9 10.6%	5 5.9%	10 11.8%	9 10.6%	7 8.2%	12 14.1%	7 8.2%	15 17.6%	2
Driving your US Xpress truck in low visibility conditions (fog, rain, snow, night) with IVSS functioning properly.	6 7.0%	1 1.2%	6 7.0%	2 2.3%	11 12.8%	7 8.1%	11 12.8%	12 14.0%	7 8.1%	23 26.7%	1

Table 42. Stress and workload: Perceived false positive and positive but unnecessary Vorad® alerts.

Question	Response Category	Vorad® N = 87
On average, out of every 10 Vorad® forward radar alerts you have received, how many of the alerts were given when you thought there was no crash threat? Indicate a number between 0 and 10, where 0 indicates none and 10 indicates all. **[False Positive]**	0	7 (8.2%)
	1	6 (7.1%)
	2	11 (12.9%)
	3	10 (11.8%)
	4	3 (3.5%)
	5	17 (20.0%)
	6	7 (8.2%)
	7	6 (7.1%)
	8	4 (4.7%)
	9	8 (9.4%)
	10	6 (7.1%)
	Missing	2 —
On average, out of every 10 Vorad® forward radar alerts you have received, how many of the alerts were given when there might have been a crash threat but you thought the alert was unnecessary? Indicate a number between 0 and 10, where 0 indicates none and 10 indicates all. **[Positive but Unnecessary]**	0	28 (32.6%)
	1	8 (9.3%)
	2	9 (10.5%)
	3	9 (10.5%)
	4	7 (8.1%)
	5	9 (10.5%)
	6	2 (2.3%)
	7	4 (4.7%)
	8	2 (2.3%)
	9	3 (3.5%)
	10	5 (5.8%)
	Missing	1 —

Table 43. Stress and workload: Perceived false negative Vorad® alerts and effect on driver confidence in Vorad®.

Question	Response Category	Vorad® N = 87
On average, how often has the Vorad® forward radar not given you an alert when you thought it should have? On average, out of every 10 times you thought an alert would be appropriate, how many times did the system not provide an alert?? Indicate a number between 0 and 10, where 0 indicates none and 10 indicates all. **[False Negative]**	0	62 (72.1%)
	1	8 (9.3%)
	2	9 (10.5%)
	3	5 (5.8%)
	4	0 (0.0%)
	5	2 (2.3%)
	6	0 (0.0%)
	7	0 (0.0%)
	8	0 (0.0%)
	9	0 (0.0%)
	10	0 (0.0%)
	Missing	1 —
Have these missed alerts reduced your overall confidence in the Vorad® forward radar?	A lot	1 (4.0%)
	Somewhat	3 (12.0%)
	A little	0 (0.0%)
	Not at all	20 (80.0%)
	Refuse	0 (0.0%)
	Don't know	1 (4.0%)
	Skipped	62 —

Table 44. Stress and workload: Perceived nuisance associated with unnecessary Vorad® alerts.

Question	Response Category	Vorad® N = 87
Do you consider such inappropriate or unnecessary warnings presented by Vorad® forward radar to be a nuisance?	A substantial nuisance	9 (15.3%)
	Somewhat of a nuisance	26 (44.1%)
	Not much of a nuisance	11 (18.6%)
	No nuisance at all	13 (22.0%)
	Refuse	0 (0.0%)
	Don't know	0 (0.0%)
	Skipped	28 —

Table 45. Stress and workload: Driver acceptance of the safety technologies.

Question	Response Category	Vorad® N = 87	SmartCruise N = 87	AdvBS N = 87
Based on your experience with ____, would you rather drive a truck equipped with ____ or one not equipped with ____?	Equipped	70 (80.5%)	18 (52.9%)	25 (92.6%)
	Not equipped	14 (16.1%)	15 (44.1%)	2 (7.4%)
	Refuse	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Don't know	3 (3.4%)	1 (2.9%)	0 (0.0%)
	Skipped	—	53 —	60 —

Table 46. Risk and vigilance: Likelihood of an accident.

Question	Response Category	Vorad® N = 87	SmartCruise N = 87	AdvBS N = 87
Has the likelihood of an accident or a near-accident situation been affected by the use of the _____?	A lot more likely	0 (0.0%)	3 (8.8%)	0 (0.0%)
	Somewhat more likely	0 (0.0%)	3 (8.8%)	1 (3.7%)
	No change in likelihood	20 (23.0%)	10 (29.4%)	5 (18.5%)
	Somewhat less likely	32 (36.8%)	8 (23.5%)	7 (25.9%)
	A lot less likely	35 (40.2%)	9 (26.5%)	14 (51.9%)
	Don't know	0 (0.0%)	1 (2.9%)	0 (0.0%)
	Refused	0 —	0 —	0 —
	Skipped	—	53 —	60 —

Table 47. Risk and vigilance: Has your driving changed?

Question	Response Category	Vorad® N = 87	SmartCruise N = 87	AdvBS N = 87
As a result of having the _____ on your truck, has your driving…	Changed a lot?	21 (24.1%)	6 (17.6%)	4 (14.8%)
	Changed somewhat?	32 (36.8%)	8 (23.5%)	8 (29.6%)
	Not changed?	33 (37.9%)	20 (58.8%)	15 (55.6%)
	Don't know	1 (1.1%)	0 (0.0%)	0 (0.0%)
	Refused	0 —	0 —	0 —
	Skipped	—	53 —	60 —

Table 48. Product quality and maturity: Occurrence and frequency of Vorad®, SmartCruise, and AdvBS downtime.

Question	Response Category	Vorad® N = 87	SmartCruise N = 87	AdvBS N = 87
How well did _____ work? Was there any time where it did not work properly (downtime)?	Yes	34 (39.1%)	7 (20.6%)	5 (18.5%)
	No	53 (60.9%)	27 (79.4%)	22 (81.5%)
	Don't Know	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Refuse	0 —	0 —	0 —
	Skipped	—	53 —	60 —
How often would you say it happened to you?	A lot	6 (18.2%)	2 (28.6%)	3 (60.0%)
	Somewhat frequently	5 (15.2%)	0 (0.0%)	1 (20.0%)
	A few times	18 (54.5%)	4 (57.1%)	1 (20.0%)
	Never	4 (12.1%)	1 (14.3%)	0 (0.0%)
	Don't know	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Refuse	1 —	0 —	0 —
	Skipped	53 —	80 —	82 —

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