RITA Intelligent Transportation Systems
Joint Program Office

Cooperative Intersection Collision Avoidance System Limited to Stop Sign and Traffic Signal Violations (CICAS-V)

Task 13 Final Report

Preparation for Field Operational Test

(Appendix J)

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16. Abstract

This report presents the results of the work in Task 13 (Preparation for Field Operational Test) conducted during Phase I of the Cooperative Intersection Collision Avoidance System Limited to Stop Sign and Traffic Signal Violations (CICAS-V) project. The objective of Task 13 was to conduct the initial planning for the Phase II Extended Pilot FOT and full FOT. Three main areas of work are described in the report: the definition and evaluation of alternative FOT sizes, identification of a process for selecting the FOT location and intersection sites, and the description of the FOT design and protocols.

The CICAS-V project was a four-year project to develop a cooperative intersection collision avoidance system to assist drivers in avoiding crashes in the intersection by warning the driver of an impending violation of a traffic signal or a stop sign. The Vehicle Safety Communications 2 Consortium (VSC2) executed the project. Members of VSC2 are Ford Motor Company, General Motors Corporation, Honda R & D Americas, Inc., Mercedes-Benz Research and Development North America, Inc., and Toyota Motor Engineering & Manufacturing North America, Inc.

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List of Acronyms

CICAS-SLTA	Cooperative Intersection Collision Avoidance System for Signalized Left Turn Assistance
CICAS-SSA	Cooperative Intersection Collision Avoidance System for Stop Sign Assistance
CICAS-V	Cooperative Intersection Collision Avoidance System Limited to Stop Sign and Traffic Signal Violations
ConOps	Concept of operations
DAS	Data acquisition system
DSP	Digital signal processor
DSRC	Dedicated short range communications
DVI	Driver-vehicle interface
DVR	Digital video recorder
FHWA	Federal Highway Administration
FOT	Field operational test
GID	Geometric intersection description
GPS	Global positioning system
GPSC	Global positioning system correction
IEEE	Institute of Electrical and Electronics Engineers
IRB	Internal review board
ITE	Institute of Transportation Engineers
MCNU	Multiband Configurable Networking Unit
NHTSA	National Highway Traffic Safety Administration
OBE	On-board equipment
OEM	Original equipment manufacturer
PBA	Panic brake assist
PMRs	Project management reviews
POC	Proof of concept
RSE	Roadside equipment
SAE	Society of Automotive Engineers
SPaT	Signal phase and timing
U.S. DOT, DOT	United States Department of Transportation
VII	Vehicle Infrastructure Integration
VIIC	Vehicle Infrastructure Integration Consortium
VNTSC	Volpe National Transportation Systems Center
VSC2	Vehicle Safety Communications 2 Consortium

VTTI	Virginia Tech Transportation Institute
WAVE	Wireless access in vehicular environments
WSM	WAVE short messages

Table of Contents

Executive Summary v

1 Introduction 1

1.1 Project Description 1

1.2 Purpose for Implementing the System 1

1.3 CICAS-V Goals and Objectives 2

1.4 Objectives of the Field Operational Test 3

2 Definition of the FOT Size 5

2.1 Estimation of the Number of Alerts Experienced in the FOT 6

3 Process for Selecting the FOT Location and Intersections 12

3.1 Identification of Candidate FOT Locations 12

3.1.1 Supportive Local DOT 13

3.1.2 No Extended Summer or Winter Weather Extremes 13

3.1.3 Access to Local Infrastructure 14

3.1.4 Proximity to a Test Track 14

3.1.5 No Special Red-Light Enforcement Programs 14

3.2 Evaluation of Candidate Sites 15

3.2.1 Number of intersections available 15

3.2.2 Test area layout 15

3.2.3 Traffic volumes 15

3.2.4 Viable subject pool 15

3.2.5 Cooperative business in test area 16

3.2.6 Availability of office and garage space 16

3.3 Identification of Intersection Sites 16

3.3.1 Intersection Characteristics and Selection Criteria 16

4 FOT Design and Protocols 20

4.1 FOT Design Assumptions 20

4.2 FOT Location and Intersections 21

4.3 FOT Experimental Design 21

4.3.1 Vehicles 22

4.3.2 Drivers 22

4.3.3 Test Duration per Driver 22

4.3.4 Number and Type of Intersections 22
4.3.5 Overall Test Duration and Weeks of Data Collection 22
4.3.6 DVI Activation Status 23
4.3.7 Test Track Trial 23
4.3.8 Other Data Collected 23
4.3.9 Mapping the Data to the Evaluation Objectives 24
4.4 Data Collection Protocol 25
4.4.1 Step 1 25
4.4.2 Step 2 25
4.4.3 Step 3 26
4.5 Data Storage and Management 27
4.6 Data Analysis 30
4.7 Reporting 31
5 Protocol for Extended Pilot FOT 32
5.1 Vehicles 33
5.2 Drivers 33
5.3 Test Duration per Driver 33
5.4 Number and Type of Intersections 33
5.5 Overall Test Duration and Weeks of Data Collection 33
5.6 DVI Activation Status 33
5.7 Test-Track Trial 33
5.8 Other Data Collected 34
5.9 Optimize the FOT 34
6 References 35
APPENDICES 37
Appendix A: Driver Screening Questionnaire 37
Appendix B: Informed Consent 43
Appendix C: Form W-9 50
Appendix D: Health Screening 52
Appendix E: Pre-Drive Questionnaire 56
Appendix F: Telephone Interview Questions 58

Appendix G: Smart Road Test-track Informational Form 60

Appendix H:Post-Unexpected Event Questionnaire for Those Who Stopped 64

Appendix I: Post-Unexpected Event Questionnaire for Those Who Do Not Stop...69

Appendix J: Informed Consent...74

Appendix K: Post Driving Questionnaire: Experienced Alert during Naturalistic Driving 76

Appendix L: Post Driving Questionnaire: Experienced Alert ONLY during Smart Road Portion 86

Appendix M: Post Driving Questionnaire: Did NOT Experience Alert..........93

List of Figures

Figure 1: Basic concept of the CICAS-V system at a signalized intersection. 3
Figure 2: Data flow for safety benefits estimation.. 5
Figure 3: Modeling effort for different FOT sizes.. 6
Figure 4: Process for selecting FOT and intersection sites. 12
Figure 5: Proposed data storage and processing system for the CICAS-V FOT. 29

List of Tables

Table 1: Summary of violation rates observed in past driving research studies................. 7
Table 2: Estimation of number of alerts 8
Table 3: FOT size definition.. 9
Table 4: Intersection crossings and expected number of alerts 10
Table 5: Intersection Selection Criteria 18
Table 6: FOT Experimental Design Parameters 21
Table 7: Mapping of Collected Data to Evaluation Objectives 24
Table 8: Experimental Design for Extended Pilot FOT... 32

Executive Summary

This report presents the results of the work conducted during Task 13 of the Cooperative Intersection Collision Avoidance System Limited to Stop Sign and Traffic Signal Violations (CICAS-V) project. The focus of Task 13 was the preliminary planning of several activities leading up to and including a CICAS-V field operational test (FOT). The scope of Task 13 included the experimental design of an Extended Pilot FOT, the experimental design of the actual FOT, data storage and management plans, the logistics for subject recruitment, and developing a process for selecting the FOT site and the specific intersections.

The CICAS-V project was a four-year project to develop a cooperative intersection collision avoidance system to assist drivers in avoiding crashes in the intersection by warning the driver of an impending violation of a traffic signal or a stop sign. The Vehicle Safety Communications 2 Consortium (VSC2) executed the project under Federal Highway Administration (FHWA) Cooperative Agreement No. DTFH61-01-X-00014, Work Order W-05-001. Members of the VSC2 Consortium are Ford Motor Company, General Motors Corporation, Honda R & D Americas, Inc., Mercedes-Benz Research and Development North America, Inc. and Toyota Motor Engineering & Manufacturing North America, Inc. The goal of Phase I was to develop and test a prototype of a CICAS-V system that will be ready for testing with naive users. Phase II would have involved a field evaluation of the system and would have been scheduled to run for two additional years. However, in July 2008 the United States Department of Transportation (U.S. DOT) decided not conduct the FOT following the conclusion of Phase I .Nevertheless, an FOT might be reconsidered at a later time.

The objective of the FOT will be to collect data that can be used to evaluate safety benefits, driver acceptance, potential unintended consequences, and operational capabilities and limitations of the CICAS-V system. The goal of the FOT will be to prove that the CICAS-V developed in Phase I is ready for full deployment. In assessing safety benefits, the focus of the evaluation will be on intersection driving “events” (e.g., crashes, violations, near crashes, near violations and conflicts) that occur during intersection approaches to both traffic signals and stop signs. To answer the FOT questions regarding user acceptance and unintended consequences, a sufficient number of alerts need to be generated in the FOT so that most drivers will experience at least one alert during their driving with the CICAS-V equipped vehicle.

Task 13 was conducted by a joint team consisting of representatives from VSC2, the National Highway Traffic Safety Administration (NHTSA), Virginia Tech Transportation Institute (VTTI) and the Volpe National Transportation Systems Center (Volpe). The group initially investigated three alternative FOT sizes with different numbers of intersections, vehicles and drivers. (See Table ES-1.) The three designs were developed by Volpe after completing a statistical power analysis to identify the number of drivers needed to detect CICAS-V effects on driver performance. The three options for the FOT were deemed necessary to provide testing options with different levels of funding requirements.

Table ES-1: FOT designs investigated

FOT	No. of Subjects	Individual Subject Data Collection	No. of Signalized Intersections	No. of Cars	Overall Duration of Data Collection
Small	90	5 wks	20	10	52 wks
Medium	108	12 wks	20	27	52 wks
Large	204	12 wks	24	51	52 wks

One of the most important steps in Task 13 was to estimate how many alerts could be expected from the individual designs, and what additional efforts would be needed to arrive at meaningful conclusions about the three main questions. The team analyzed the three designs and concluded that only the large FOT would generate sufficient data to provide meaningful insight with respect to the extent of customer acceptance, identification of potential unintended consequences, and estimation of potential safety benefits with confidence equal to prior NHTSA FOTs involving other active safety technologies. Moreover, this FOT size would at least minimize, if not eliminate, the need for additional modeling to supplement the estimation of safety benefits. Table ES-2 shows the range of expected alerts in the large FOT under two options for data collection with the CICAS-V system active (i.e., six weeks and nine weeks).

Table ES-2: Expected number of alerts for the large FOT

FOT Size	Intersection Crossings during Treatment Signalized	Intersection Crossings during Treatment Stop Sign	No. of Subjects	Violations High Estimate	Violations Low Estimate	Total Alerts High Estimate	Total Alerts Low Estimate
Large 6 wks	293,760	17,136	204	984	191	801	143
Large 9 wks	440,640	25,704	204	1476	286	1,202	214

A process for selecting the FOT location and the individual intersection sites was also developed during Task 13. This process is depicted in Figure ES-1. The process begins with the identification of candidate FOT sites using five criteria, which all viable locations must have. The criteria are: supportive local DOT, no extended summer or winter weather extremes, access to local infrastructure, proximity to a test track and the absence of any red light enforcement program planned for the FOT area.

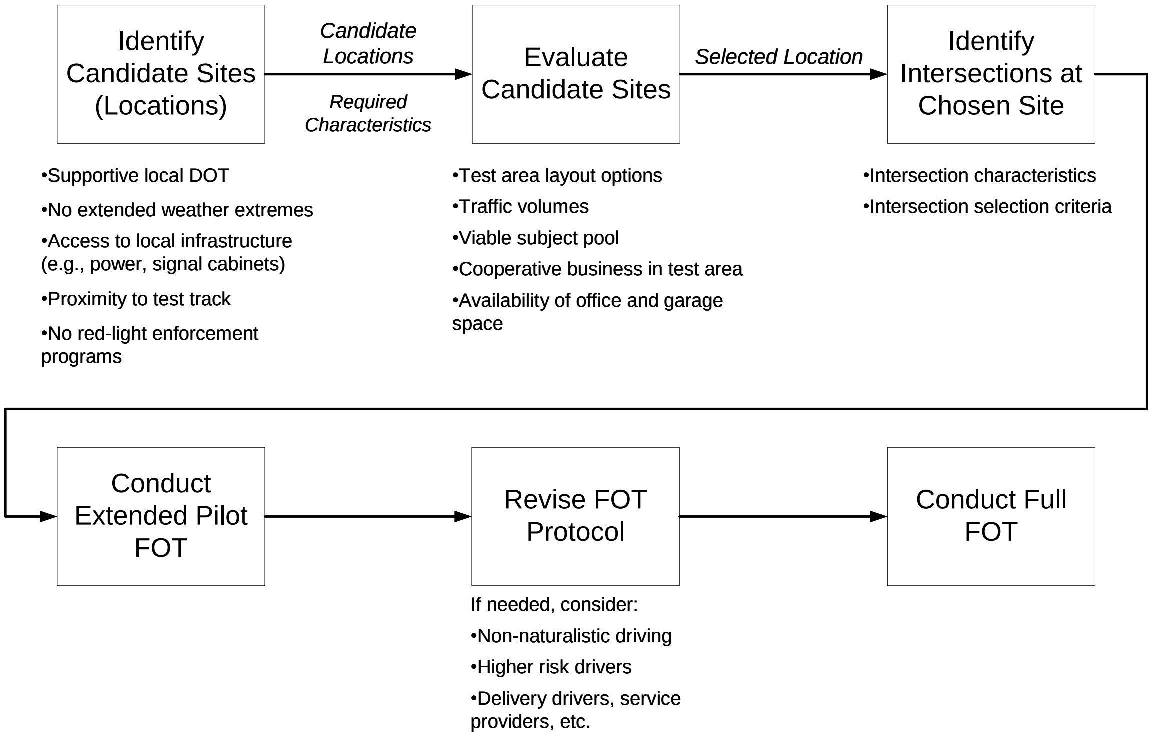

Figure ES-1: Process for selecting the FOT location and intersection sites

The next step in the process is to evaluate the candidate FOT sites in terms of the intersection layout options, traffic volumes, availability of a subject pool and cooperative businesses in the area, and the availability of office and garage space from which to stage the FOT. Sites offering flexibility in intersection selection and layout are desired so that the number of intersection crossings can be maximized during the FOT. The outcome from this step is the selection of the FOT location.

Once an FOT location is selected, individual intersections within the area will be selected. To facilitate this step, a set of over 30 intersection characteristics was identified to assist in screening potential intersection sites. The criteria include such categories as GPS availability, intersection control type, intersection geometry, and traffic characteristics. The criteria were pretested during Phase I in the work that was conducted to screen the test intersections built in Michigan, California and Virginia.

Based on a joint U.S. DOT/VSC2 decision to pursue a large FOT, the experimental design and data collection protocols for the Extended Pilot and full FOT were developed. Table ES-3 summarizes the designs for both of the studies. The data collection protocol for subjects was based on the protocol developed in the Pilot FOT conducted during Subtask 3.4, "Human Factors Pilot Test of the CICAS-V," (Neale et al., in print) and revised to incorporate the information obtained during the pilot study. Data collection forms, recruiting procedures and driver questionnaries were also prepared, based on the corresponding forms from the Pilot FOT. In addition, data storage and management procedures were defined to facilitate the coordination between the CICAS-V project and the U.S. DOT's Independent Evaluator (IE - Volpe).

Table ES-3: Experimental design parameters for Extended Pilot FOT and FOT

Test Parameter	Extended Pilot FOT (Number)	FOT (Number)
Vehicles (Comprised of one vehicle type)	6	51
Drivers	12	204
Test Duration per Driver (weeks)	6	12
Signalized Intersections Equipped and Mapped	24	24
Estimated Signalized Intersection Crossings 24 intersections x 2 crossings/day x 5 work days/wk x no. of weeks of data collection x no. of subjects	17,280	587,520
Stop-Controlled Intersections Mapped	50	50
Estimated Stop-Controlled Intersection Crossings 2 intersections x 7 days/wk x no. of weeks of data collection x no. of subjects	1,008	34,272
Overall Test Duration (weeks – including vehicle switching and maintenance)	13	52
Driver-Weeks of Data Collection Number of drivers x test duration per driver (weeks)	72	2,448

1 Introduction

This document presents the results of the work conducted during Task 13 (Preparation for Field Operational Test) of the Cooperative Intersection Collision Avoidance System Limited to Stop Sign and Traffic Signal Violations (CICAS-V) project. The focus of Task 13 was the preliminary planning of several activities leading up to and including conducting a CICAS-V field operational test (FOT), including the experimental design of an extended pilot FOT, the experimental design of the FOT, data storage and management plans, the logistics for subject recruitment, and the development of a process for selecting the FOT site and the specific intersections.

1.1 Project Description

The CICAS-V project was originally conceived as a four-year project to develop a cooperative intersection collision avoidance system to assist drivers in avoiding crashes in the intersection by warning the driver of an impending violation of a traffic signal or a stop sign. Cooperative means that the system involves both infrastructure and in-vehicle elements working together. The Vehicle Safety Communications 2 Consortium (VSC2) executed the project under Federal Highway Administration (FHWA) Cooperative Agreement No. DTFH61-01-X-00014, Work Order W-05-001. Members of the VSC2 Consortium are Ford Motor Company, General Motors Corporation, Honda R & D Americas, Inc., Mercedes-Benz Research and Development North America, Inc. and Toyota Motor Engineering & Manufacturing North America, Inc. Funding for this project was provided from the Joint Program Office of the United States Department of Transportation (U.S. DOT). The project was also supported by Virginia Tech University (Virginia Tech), who played a major role in the human factors research to define and evaluate the CICAS-V warning system. The work at Virginia Tech was conducted through its research group at the Virginia Tech Transportation Institute (VTTI).

The project was initiated in May 2006 and was divided into two phases. In Phase I the project team developed and tested a prototype of a CICAS-V system that will be ready for testing with naive users. Phase I ran through September 2008. At the end of Phase I, the U.S. DOT and VSC2 originally were jointly going to determine if the system will be tested in a Field Operational Test (FOT) in Phase II of the project. If a “go” decision were made by the two organizations, Phase II would have run for two additional years. In July 2008 the U.S. DOT decided to end the project after Phase I and not continue immediately with a Phase II, independent of the readiness of the system. However, since the FOT might be reconsidered at a later point, the current report provides valuable guidance on the conduct of a CICAS-V FOT.

1.2 Purpose for Implementing the System

The purpose of implementing CICAS-V is to reduce crashes due to violation of traffic control devices (both traffic signals and stop signs).

When deployed, this system is intended to:

- Reduce fatalities at controlled intersections
- Reduce the number of injuries at controlled intersections

- Reduce the severity of injuries at controlled intersections
- Reduce property damage associated with collisions at controlled intersections
- Create an enabling environment that additional technologies can leverage to further extend safety benefits

Intersection crashes account for 27.3% of all police-reported crashes, or 1.72 million crashes annually in the U.S. About 44% occur at traffic signals and 56% at stop signs. In 2004, stop sign and traffic signal violations accounted for approximately 302,000 crashes, resulting in 163,000 functional years lost and $7.9 Billion of economic loss (Najm et al., 2007).

An initial analysis of relevant National Highway Traffic Safety Administration (NHTSA) crash databases shows that violation crashes have a variety of causal factors. The CICAS-V system is intended to address the causal factors that include driver distraction (a frequent factor [Campbell, Smith and Najm, 2004, p. 65]), obstructed/limited visibility due to weather or intersection geometry or other vehicles, the presence of a new control device not previously known to the driver, and driver judgment errors. Driver warnings, such as those planned for CICAS-V, may prevent many violation-related crashes by alerting the distracted driver, thus increasing the likelihood that the driver will stop the vehicle and avoid the crash.

1.3 CICAS-V Goals and Objectives

CICAS-V is intended to provide a cooperative vehicle and infrastructure system that assists drivers in avoiding crashes at intersections by warning the vehicle driver that a violation, at an intersection controlled by a stop sign or by traffic signal, is predicted to occur. The basic concept of CICAS-V is illustrated at a high level in Figure 1 for a signalized intersection. In the figure, a CICAS-V equipped vehicle approaching a CICAS-V equipped intersection receives messages about the intersection geometry, GPS differential corrections and status of the traffic signal. The driver is issued a warning if the equipment in the vehicle determines that, given current operating conditions, the driver is predicted to violate the signal in a manner which is likely to result in the vehicle entering the intersection. While the system may not prevent all crashes through such warnings, it is expected that, with an effective warning, the number of traffic control device violations will decrease and result in a decrease in the number and severity of crashes at controlled intersections.

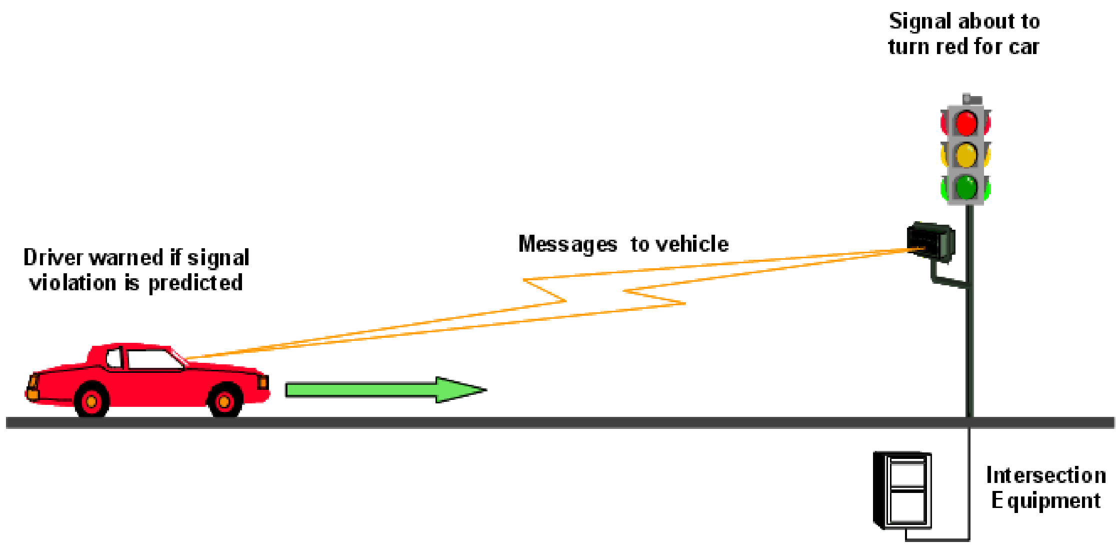

Figure 1: Basic concept of the CICAS-V system at a signalized intersection.

Specific goals of CICAS-V include the establishment of:

- A warning system that will be effective at reducing the number of fatal crashes, the severity of injuries and property damage at CICAS-V intersections
- A warning system that is acceptable to users
- A vehicle-infrastructure cooperative system that helps vehicle drivers avoid crashes due to violations of a traffic signal or stop sign
- A system that is deployable throughout the United States

1.4 Objectives of the Field Operational Test

The primary objective of the FOT will be to collect data that can be used to evaluate driver acceptance and system effectiveness, operational capabilities, limitations, and characteristics of the CICAS-V. The goal of the FOT will be to prove that the CICAS-V developed in Phase I is ready for full deployment. This will be accomplished by addressing the following independent evaluation objectives:

- Estimate Safety Benefits
- Assess Driver Acceptance
- Identify Unintended Consequences
- Characterize System Capability

In estimating safety benefits, a focus of the analysis will be on intersection driving "events" (i.e., drivers' performance, near violations, violations, and crashes) that occur during intersection approaches. The FOT will collect data on red-light and stop sign violations and near violations as well as rear-end conflicts surrounding intersection approaches.

2 Definition of the FOT Size

The ultimate measure of safety benefit is the number of violation-related crashes that can be prevented by the CICAS-V at equipped intersections. A limited testing will not capture a significant number of target crashes. Therefore, proposed test concepts (FOT sizes) would collect data on: (1) driver performance, (2) exposure to near violations, and (3) violations, which will be used to predict the crash experience.

The determining factor for the size of the FOT is the estimated number of violation alerts that the system generates over the duration of the FOT. Without drivers experiencing alerts, valid statements cannot be made about user acceptance and unintended consequences. Observation of a large enough sample of violations (without CICAS-V) and alerts (with CICAS-V) will allow for the determination of safety benefits without a substantial modeling effort.

Figure 2 shows the modeling steps necessary to get from indirect and more frequently occurring surrogate measures of driver performance and conflicts/near violations to the less frequently occurring traffic signal and stop sign violations. Direct violation observations or modeling to estimate violations must then go through a separate process using data collected outside of the FOT to determine the connection between violations and crashes given a violation severity or time after red. The estimated reduction in crashes is the parameter of prime interst in estimating safety benefits. As shown in Figure 2, and reinforced in Figure 3, a small FOT requires extensive modeling and, in this case, two steps to determine the connection between driver performance and crashes. Figure 3 also illustrates how direct measurement of violations in a large FOT requires no modeling. It is important, however, to note that a large FOT will still use driver performance and conflict/near violation surrogate measures to support direct violations measures, especially in the event of fewer violations than anticipated.

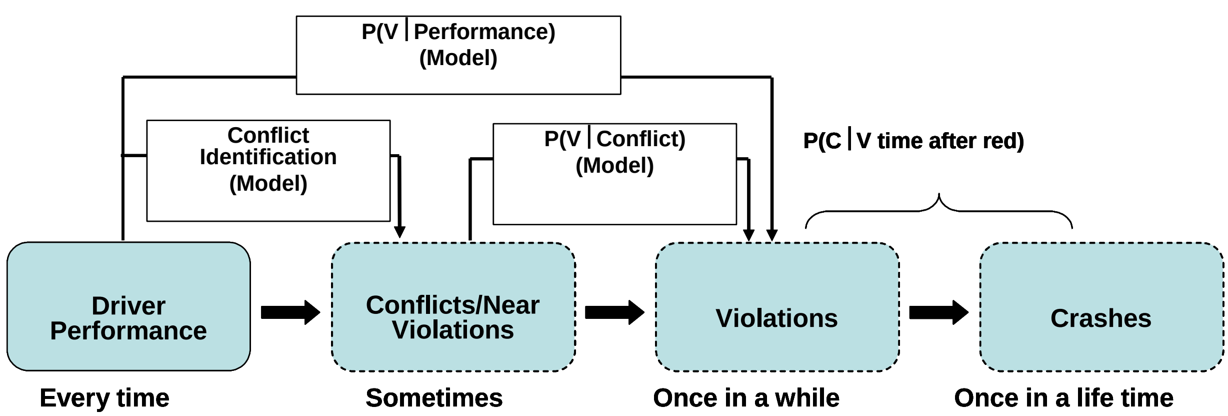

Figure 2: Data flow for safety benefits estimation

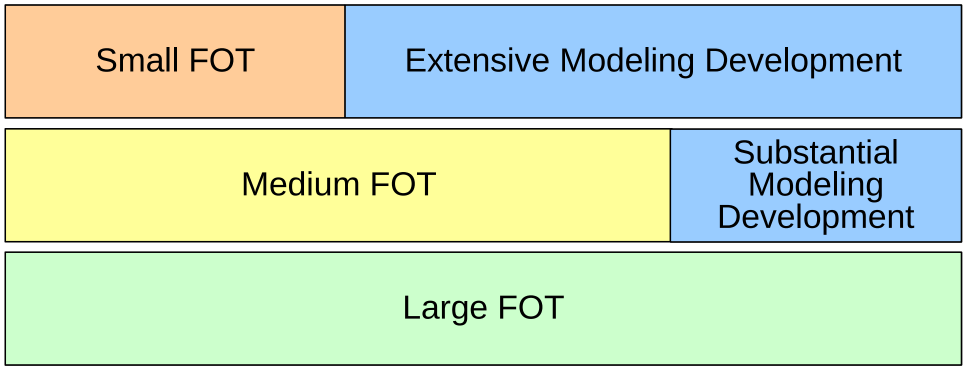

Figure 3: Modeling effort for different FOT sizes

2.1 Estimation of the Number of Alerts Experienced in the FOT

To answer the FOT questions, a sufficient number of alerts need to be generated in the FOT so that most drivers will experience at least one alert during the treatment period (i.e., CICAS-V system active). An alert is generated when, for example, a driver approaches an intersection that requires the vehicle to stop. Once the vehicle enters a calculated distance from the stop bar that is determined to be the latest distance for a safe stop, CICAS-V system will alert the driver via a DVI that he/she is approaching a stop or signal controlled intersection. The more alerts drivers experience, the better the statistical significance of the user acceptance and unintended consequences. The predicted number of alerts is based on the estimation of the violation rate (violations per 100,000 intersection crossing) and the number of intersection crossings that could be expected in a naturalistic environment.

The report *Analysis of Red Light Violation Data Collected from Intersections Equipped with Red Light Photo Enforcement Cameras* (Yang and Najm, 2006) arrives at violation rates between 6 and 29 violations per 100,000 intersection crossings. It also lists the rates determined in previous studies, which are shown in Table 1 and Table 2, along with violation rate estimates obtained during execution of the CICAS-V project. These data indicate that estimates of violation rates reported in the literature vary substantially.

Table 1: Summary of violation rates observed in past driving research studies

Reference	Rate Before Project Implementation	Rate After Project Implementation
[Lum and Wong, 2003]	Average weekday red light violations ranging from 16.0 to 111.8 per day at two "T" intersections before implementation of red light cameras.	Weekday red light violations reduced to 13.4 to 58.6 per day at two "T" intersections after installation of red light cameras.
[Ruby and Hobeika, 2003]	10 intersections with various red light violation rates ranging from 2.00 violations to 11.0 violations per 10,000 vehicles.	3 months after installation of red light running cameras, violation rates at these intersections were reduced to between 1.7 violation and 70 violations per 100,000 vehicles.
[Brewer et al., 2002]	An overall average of 401 red light runners per 100,000 vehicles.	N/A
[Fakhry and Salaita, 2002]	An average of 130 red light violations per 100,000 vehicles (manual observation).	N/A
[Kamyab, et al., 2002; Kamyab, et al., December 2000]	13 intersections with various violation rates ranging from 45 violations per 100,000 entering vehicles to 3850 violations per 100,000 vehicles.	N/A
[Retting et al., 1999a]	129 violations per 100,000 vehicles at red light camera sites and 160 violations per 100,000 vehicles at non-camera sites.	77 violations per 100,000 vehicles at red light camera sites and 80 violations per 100,000 vehicles at non-camera sites 4 months after the implementation of red light cameras.
[Retting et al., 1999b]	363 violations per 100,000 vehicles at red light camera sites and 378 violations per 100,000 vehicles at non-camera sites.	204 violations per 100,000 vehicles at red light camera sites and 25.0 violations per 10,000 vehicles at non-camera sites 1 year after the installation of red light cameras.

Table 2: Estimation of number of alerts

Data Source	Number of Violation-Based Alerts per 100K Intersection Crossings
VTTI's Analysis of Subtask 3.2 Signalized Data	47 – 423
VTTI's Analysis of Subtask 3.2 Stop Sign Data	607
Volpe Center's Sacramento Study	6 – 29
Subtask 3.1 Data	42
Other Literature	17 – 401

Given the wide range of violation rates, it was decided to analyze the number of expected violations in the form of a minimum / maximum description of the expected alerts.

After reviewing the above results, the minimum number of violations for signalized intersections was chosen to be 30 per 100,000 crossings and the maximum number was chosen to be 300 per 100,000 crossings. The rate for a stop sign controlled intersection was chosen as 600 per 100,000 crossings, based on the data from Subtask 3.2, "Naturalistic Infrastructure-Based Driving Data Collection and Intersection Collision Avoidance Algorithm Development," of the CICAS-V project (Doerzaph et al., in print).

The critical number for the FOT design is the number of alerts that can be expected in the course of the study. This number is determined by the violation rate (VR) which is the number of expected violations per 100K crossings (NV) times the effectiveness (E) of the warning algorithm to warn the potential violators.

$$VR = NV * E$$

The total number of alerts is the Violation Rate times the number of intersection crossings (NC).

$$\text{Number of Alerts} = VR * NC$$

For the warning algorithms for signalized and stop controlled intersections that were used in the Pilot FOT, the parameter E was (Doerzaph et al., in print):

Signalized: E = 83% (predicted for Algorithm 641-11)

Stop Sign: E = 68% (predicted for Algorithm 741-9)

To determine the total number of alerts, three FOT sizes were considered: small, medium and large, as shown in Table 3. The work to define the alternative FOT designs was conducted by the Volpe Center. Three alternative designs were defined that spanned the size spectrum in terms of the number of intersections, number of drivers and vehicles, and length of data collection involved. Designs of varying sizes were deemed necessary to provide testing options with regard to funding requirements. For each FOT alternative, the experimental design process estimated the number of drivers needed to study the effect of the CICAS-V system on a key driver performance measure (e.g., number of violations for the large FOT) based on initial assumptions about system effectiveness and driver exposure to events during the FOT. For example, the large FOT design was based on the ability to detect a 50 percent change in the proporation of violators between baseline (without CICAS-V assistance) and treatment (with CICAS-V assistance) with a 95 percent confidence level and 80 percent statistical power. Similar assessments were made for the small FOT (based on detecting CICAS-V effects on vehicle deceleration) and for the medium FOT (detecting changes in the number of near violations). The resulting sample sizes (i.e., required number of subject drivers) were then used to estimate the number of test vehicles and test duration per subject, using the stated number of signalized intersections and an overall test duration of 52 weeks.

Table 3: FOT size definition

FOT	No. of Subjects	Individual Subject Data Collection	No. of Signalized Intersections	No. of Cars	Overall Duration of Data Collection
Small	90	5 wks	20	10	52 wks
Medium	108	12 wks	20	27	52 wks
Large	204	12 wks	24	51	52 wks

The total number of expected intersection crossings for the medium and large FOT are:

<u>Medium:</u>

- NC Signalized = 20 intersections * 2 crossings/day * 5 days/wk * 12 wks * 108 drivers = 259,200 crossings
- NC Stop Sign = 2 stop signs/day * 7 days/wk * 12 wks * 108 drivers = 18,144 crossings

<u>Large</u>

- NC Signalized = 24 intersections x 2 crossings/day x 5 days/wk x 12 wks x 204 drivers = 587,520 crossings
- NC Stop Sign = 2 stop signs/day x 7 days/wk x 12 wks x 204 drivers = 34,272 crossings

The above computations were based on the assumption that the drivers will cross each signalized intersection in the FOT test area twice per day during the five-day work week and cross two stop sign intersections each day during the seven-day week.

The duration of the data collection is split into two intervals: the baseline period and the treatment period. During the baseline period the CICAS-V system would be switched off but all vehicle and driver data would be collected. During the treatment period, the CICAS-V system would be active. The initial planning work for the FOT examined two options for this split: 6 weeks baseline / 6 weeks treatment and 3 weeks baseline / 9 weeks treatment. Table 4 shows the number of alerts that would be generated by the various designs.

Table 4: Intersection crossings and expected number of alerts for the treatment period

FOT Size (Baseline/Treatment Duration)	Intersection Crossings during Treatment Signalized	Intersection Crossings during Treatment Stop Sign	No. of Subjects	Violations High Estimate	Violations Low Estimate	Total Alerts High Estimate	Total Alerts Low Estimate
Medium 6wks/6wks	129,600	9,072	108	443	93	360	69
Medium 3wks/9wks	194,400	13,608	108	664	140	540	104
Large 6wks/6wks	293,760	17,136	204	984	191	801	143
Large 3wks/9wks	440,640	25,704	204	1,476	286	1,202	214

The number of expected alerts for the small FOT was considered too small to determine an answer to the FOT questions.

The number of total alerts has to be high to increase the likelihood for each driver to experience an alert. The modeling effort for the high-end estimate for the large FOT case would be relatively minor or not necessary. If the number of alerts is at the low end, the medium FOT would not generate enough data since only half of the drivers would experience an alert in the case of the six week treatment period and each driver would experience one alert in the case of the nine week treatment period, if the number was evenly distributed. This would require extensive modeling to determine the safety benefit, and there would not be enough data to answer the questions about user acceptance. For those reasons, it was determined that the large FOT was the best choice for giving the answers to the FOT questions with the smallest risk of not generating sufficient data to support an analysis. The overall evaluation was:

- The small FOT is not viable for estimating user acceptance, safety benefits, and unintended consequences (insufficient data).
- The medium-sized FOT, using the high estimate for violation rate (alert rate), requires additional modeling to determine the safety benefit.
- The large FOT using the high violation rate estimate does not require additional modeling.
- Additional test track studies should be conducted where drivers experience the system under identical conditions and user feedback could be solicited. This would be beneficial for the overall evaluation of safety benefit and user acceptance.

As a result of the above assessment of FOT options, the subsequent work in Task 13 focused on planning needed for a large FOT.

3 Process for Selecting the FOT Location and Intersections

One of the primary objectives of Task 13 was to develop the process for selecting the location for the FOT and the individual intesection sites that will be used. The actual selection of these locations, however, will be deferred until Phase II of the project is conducted. Figure 4 illustrates the selection process at a high level. The steps outlined in the figure include: the initial screening of potential sites to identify a set of suitable candidates, further evaluation of candidates leading to a selected location, and the identification of individual intersections at the selected FOT site. Following these three steps, the Extended Pilot FOT and the full FOT will be conducted. The Extended Pilot FOT planned for Phase II will be different from the Pilot FOT conducted in Phase I in that it will involve fully naturalistic driving by the participants. Each of the three steps leading to the Extended Pilot FOT will be discussed in this chapter in the material below. A description of the protocols for the Extended Pilot FOT and the full FOT are presented in the next two chapters of the report.

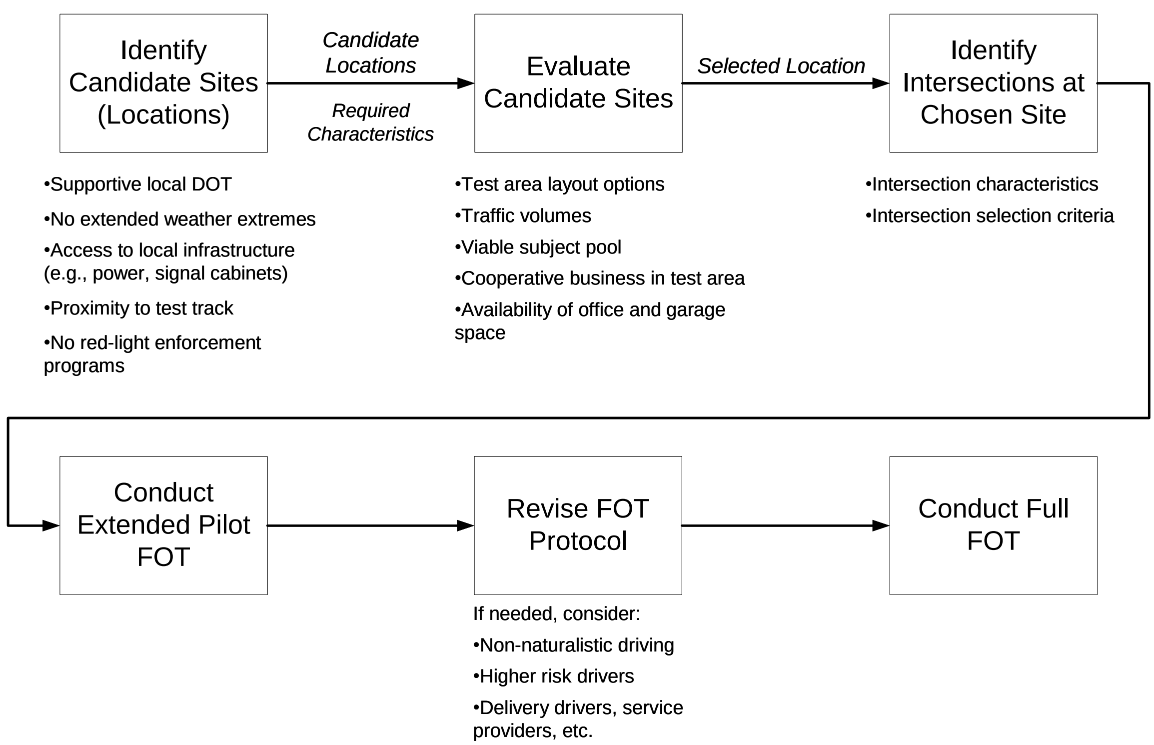

Figure 4: Process for selecting FOT and intersection sites.

3.1 Identification of Candidate FOT Locations

As shown in Figure 4, the first step in the process is to identify candidate FOT sites (i.e., locations) that will be considered further in the selection process. Five criteria were established to aid in screening potential locations. The criteria are shown below. All candidate sites must meet each of the folloing criteria:

- A supportive local DOT
- No extended summer or winter weather extremes
- Access to local infrastructure
- Proximity to a test track
- Absence of special red light enforcement programs during the FOT phase of the project.

3.1.1 Supportive Local DOT

For the purposes of screening candidate sites, a supportive local DOT means one that is familiar with the CICAS-V project (i.e., project goals, CICAS-V system operation and FOT plans) and the type of equipment that must be installed at the intersections in order for the system to function. There must be a commitment on the part of the local DOT to provide timely installation and maintenance support through the duration of the FOT. There also must be a willingness to potentially change traffic signal controllers at signalized intersections during the FOT. The latter point is significant as the CICAS-V FOT prototype developed in Task 10, “Integration of Subsystems, Building of Prototype Vehicles and Outfitting of Intersections,” (Maile et al., in print) is only designed to work with a limited number of traffic signal controller types. If the compatible signal controller types are not used in the FOT location selected, they would either need to be made compatible or replaced with compatible signal controllers during the equipment installation phase of the FOT.

3.1.2 No Extended Summer or Winter Weather Extremes

The primary objective of the FOT is to collect as much data as possible on driver behavior both with and without the CICAS-V to permit the three research questions of the FOT to be addressed. Although the hardware comprising CICAS-V utilizes prototype components suitable for the application, there are concerns that any weather-related system outages affecting the vehicle or intersection equipment would reduce the amount of data available for subsequent analysis. To address this concern, the second criterion used to screen candidate FOT sites is the general weather conditions in the FOT area.

Given that the events of interest in the FOT (i.e., stop sign and traffice signal violations and CICAS-V driver warnings) are relatively rare events, it is important that operation of CICAS-V and the vehicle and infrastructure DASs be maintained at as high a level as possible during the FOT. Conducting the FOT at a location that has harsh extremes in either summer or winter weather is not desired in order to limit the amount of down time due to weather-related disruptions in operation. In addition, some extreme weather conditions (e.g., snow and ice on roadways) will affect driver performance (e.g., altered braking profiles and slower than normal travel speeds) in ways that could reduce the number of valid alerts during the FOT, making it difficult to identify system benefits during these periods.

To be considered as a viable FOT location, candidate sites must not have extended periods of daytime summer temperatures that exceed 100° F. In addition, the candidate sites should be located in an area where the average annual snowfall does not exceed 30 inches per year.

3.1.3 Access to Local Infrastructure

Installation of the infrastructure portion of the CICAS-V system will require electrical power at signalized intersections. Installation of equipment components will also require sufficent space in existing signal cabinets to house the CICAS-V equipment or the ability to install additional cabinets at the intersections to contain the CICAS-V equipement. Detailed information regarding the CICAS-V hardware is presented in the Task 10, "Integration of Subsystems, Building of Prototype Vehicles and Outfitting of Intersections," Final Report (Maile et al., in print). A viable FOT location must afford the project team access to these infrastrure elements.

3.1.4 Proximity to a Test Track

It is anticipated that not all drivers participating in the FOT will receive a warning from the CICAS-V and, consequently, would not have sufficent basis on which to provide feedback to the project on the characteristics of the driver-vehicle interface (DVI) or the warning algorithm. Driver evaluation of the DVI and the warning algorithm are key parts of the FOT assessments that will be performed during Phase II. To address this issue, drivers participating in the FOT will be also participate in a surprise trial test-track study after they conclude their involvement in the FOT. This trial, described in Section 2.4 of the Subtask 3.3 Final Report, "Test of Alternative Driver-Vehicle Interfaces on the Smart Road," (Perez et al., in print), will be conducted to ensure that every driver that participated in the FOT will experience at least one valid CICAS-V warning before they provide their subjective feedback on system operation and design. In addition, this will help ensure that all drivers experience the CICAS-V alert approach under identical conditions, which is advantageous from the perspective of evaluation safety and driver performance implications. The candidate FOT locations must be located within proximity to a test track that can support the surprise trial method. In general, this means that the test track must have a functioning signalized intersection that can support CICAS-V (or allow one to be built), have sufficient length and a configuration that will enable multiple intersection approaches at 35 mph to be made efficiently, and permit the staging of simulated traffic (including cross-traffic). Exclusive use of the track by the project team during testing is also a requirement.

3.1.5 No Special Red-Light Enforcement Programs

One of the goals for the FOT is to estimate the safety benefits of CICAS-V. To accomplish this, the FOT must be conducted in an area in which there are no other safety programs underway that could affect the occurrence of violations and near violations of stop sign and traffic signals. Red-light enforcement programs, such as photo enforcement programs, can have a major effect on driver behavior and could create a confounding factor at intersections where reductions in violations or near violations were observed. This would make it difficult to ascertain whether the source of the benefit was CICAS-V or the enforcement effort. As a result, the FOT location should not be targeted for any special intersection enforcement efforts during the period of the FOT.

3.2 Evaluation of Candidate Sites

As shown in Figure 4, the next step in the FOT site selection process is the evaluation of the candidate sites to select the optimum site from the list that is the outcome of the candidate site identification. The main criteria to gauge their suitability are:

- Number of Suitable Intersections Available
- Test area layout options
- Traffic volumes
- Viable subject pool
- Cooperative business in test area
- Availability of office and garage space

3.2.1 Number of intersections available

The FOT site must contain enough intersections to support the initial FOT experimental design that identifies the need for 24 signalized intersections and 50 stop sign intersections.

3.2.2 Test area layout

In order to maximize the number of intersection crossings given the constraints in test subjects and vehicles, the layout of the test site is of importance. The layout should support test subjects crossing a majority of signalized intersection at least twice a day but should also provide a variety of driving situations and approach speeds. For maximization of intersection crossings, a corridor along an arterial which most people use to commute between their residence and work is ideal. Since this kind of commuting corridor frequently has only one intersection approach speed, those intersections need to be complemented by intersections in the residential areas on either side of the corridor and, if possible, intersections with higher approach speeds than on the corridor.

3.2.3 Traffic volumes

To evaluate the system, various levels of traffic need to be present to make sure there will be conflicts for both safety benefits and unintended consequences. In addition to traffic volume, it would also be beneficial to the FOT if high crash intersections were included since volume and intersection characteristics contribute to the occurrence of conflicts and crashes. This is a criterion that might decide the candidate site if all other factors are equal.

3.2.4 Viable subject pool

The subject pool at the candidate site should be large enough to support the number of test subjects and the distribution of subjects across all the different categories (male/female, age, etc.).

3.2.5 Cooperative business in test area

The intent in the FOT is to use naive drivers recruited from the general population at large. However, if results from the Extended Pilot FOT planned for Phase II indicate that number of actual intersection crossings observed is lower than predicted, additional steps might be need to be used to increase the frequency of intersection crossings. One possibility of getting a large number of intersection crossings is using delivery type businesses (food delivery, etc.) as test subjects as they could potentially travel the test route multiple times during the work day. This requires businesses in the test area to be interested in participating in the study. An FOT location with such a pool of business would offer greater flexibility in planning the FOT than other locations without a potential pool of businesses .It should be noted that a careful consideration of the implications of this approach for estimating safety benefits to the broader population of drivers (i.e., those not involved in delivery type businesses) would be required.

3.2.6 Availability of office and garage space

The FOT will require office and garage space to brief and debrief test subjects, clean and maintain the test vehicles, store components, computers, etc. Test sites where such spaces can be found with minimal cost to the program will be preferred.

3.3 Identification of Intersection Sites

After the candidate site evaluation and the selection of the best candidate site, the intersections at the chosen site will be identified. This identification will take into account the intersection characteristics and intersection selection criteria.

3.3.1 Intersection Characteristics and Selection Criteria

The intersections at the FOT site will be investigated and analyzed according to the intersection selection criteria as shown in Table 5. The intersection selection criteria gauge whether an intersection is suitable for installation of the CICAS-V system and that there is sufficient variance in the intersections with regard to complexity, approach speeds, traffic volume, etc. The criteria shown were developed during Phase I of the project and were used to assess the intersections in Michigan, California and Virginia before installing the CICAS-V equipment at test intersections. The basic criteria are presented below.

3.3.1.1 GPS Availability

The GPS availability at the intersection has to support road level/lane level positioning capabilities for at least 95% of the time over the course of the day and there should be no overpasses within 300 m of the intersection to ensure that the vehicle has a position fix throughout the approach.

3.3.1.2 Intersection Control Type

The intersection can be fixed cycle or adaptive cycle but the signal phase and timing has to come directly from the controller without using a signal sniffer. (A signal sniffer is a device that senses the signal phase without direct connection to the signal control circuitry.) The amber clearance interval has to be of fixed length and there has to be sufficient cabinet space for the necessary equipment.

3.3.1.3 Intersection Geometry

Intersection geometry refers to the criteria to address the complexity of the intersections: what is the required level of positioning accuracy, are there dedicated turn lanes, how many approaches, angle between the approaches, etc. About 10% of the signalized intersections should require road-level positioning accuracy, whereas, the other 90% should require lane-level positioning accuracy. The term road-level accuracy means that the CICAS-V vehicle can identify its location to the intersection approach leg, while lane-level accuracy refers to identifying vehicle location to the specific travel lane on the intersection approach .Finally, the road grade should be less than 6% on the last 50 m of the approach to avoid complications with the warning algorithm.

3.3.1.4 Traffic Characteristics

The traffic characteristics address issues such as traffic volume, pedestrian presence, approach speeds, railroad tracks, and “right turn on red.” There should be low and high volume intersections. In addition, approach speeds should lie between 25 mph and 45 mph, and there should be no railroad tracks within 100 m of the intersection.

Table 5: Intersection Selection Criteria

Selection Criterion	Units	Stop Sign	Simple Signalized Intersection	Complex Signalized Intersection
GPS Availability				
Minimum number of satellites in view	Number	5	5	5
Number of Satellites visible at least 95% of time	Number	5	5	6
Overpasses and other blockages on approach legs	Distance from intersection	None within 300 m of intersection	None within 300 m of intersection	None within 300 m of intersection
Intersection Control Type				
Fixed cycle/adaptive	F = fixed cycle A = adaptive	N/A	Either	Either
Signals on fixed mast arm or signals on wires	MA = mast arm W = wires	N/A	Either	Either
Controller type	Controller model	N/A	Controller outputs signal phase and timing information via a standard interface (no sniffers)	Controller outputs signal phase and timing information via a standard interface (no sniffers)
Bus preemption	Yes/No	N/A	Any	Any
Emergency vehicle preemption	Yes/No	N/A	Any	Any
Variable amber phase	Yes/No	N/A	No; fixed amber phase only	No; fixed amber phase only
Sufficient cabinet space or space on pole for RSE	Yes/No	N/A	Yes	Yes
Advance warning signs	Yes/No	No	No	No
Proximity to another CICAS-V equipped intersection	Distance in km	Approximately 20% of intersections in FOT should be within range of another equipped intersection.		
Intersection Geometry				
Mix of intersection types		Only road-level accuracy needed	Approx. 10% of signalized intersections in FOT should require road-level accuracy	Approx. 90% of signalized intersections in FOT should require lane-level accuracy
Total number of approach lanes per leg	Number	1	1-3	>2

Selection Criterion	Units	Stop Sign	Simple Signalized Intersection	Complex Signalized Intersection
Number of dedicated left turn lane(s)	Yes/No	0	0	Up to 2
Number of dedicated right turn lane(s)	Yes/No	0	0	Up to 2
Length of left turn/right turn lane	Length in m	N/A	N/A	>150m
Reversible lanes	Yes/No	No	No	No
Two way left turn lanes	Yes/No	No	No	No
Bicycle lanes	Yes/No	No	No	No
Roadway grade	Percent	<6% within 50 m of intersection	<6% within 50 m of intersection	<6% within 50 m of intersection
Communication distance needed for CICAS-V operations	Meters	>100 m	300 m	300 m
Divided (median strip or barrier)	Yes/No	Any	Any	Any
One way streets	Yes/No	Any	Any	Any
Angle between approach legs	Degrees	90 ± 20	90 ± 20	90 ± 20
On-street parking on main approach leg	Yes/No	Any	Any	Any
Traffic Characteristics				
Traffic volume	Vehicles/Day	Any	A mix of high and low volumes	A mix of high and low volumes
Pedestrian crossings	Yes/No, and on which approach legs	Any	Any	Any
Posted approach speed	mph	≤ 45 w/ a distribution of several speeds	≤ 45 w/ a distribution of several speeds	≤ 45 w/ a distribution of several speeds
Railroad tracks	Yes/No	Not within 50 m of intersection	Not within 100 m of intersection	Not within 100 m of intersection
Right turn on red allowed	Yes/No, and on which approach legs	N/A	Yes, majority of intersections should involve right turn on red	Yes, majority of intersections should involve right turn on red

4 FOT Design and Protocols

This chapter presents the design and protocols proposed for the Phase II FOT along with a discussion of the procedures for retrieving and handling data after it is collected in the field. The design of the FOT and the protocols presented in the report were initially developed during Task 3, “Human Factors Research,” and tested during the Pilot FOT conducted by VTTI in Phase I, Subtask 3.4, “Human Factors Pilot Test of the CICAS-V,” (Neale, et al., in print). The protocols were subsequently refined for use in Phase II.

As a result, the protocols discussed in this section regarding the FOT, and the next section of the report (Extended Pilot FOT), contain elements that conform to Virginia Tech policies and procedures (e.g., with respect to Institutional Review Board protocol).

4.1 FOT Design Assumptions

In order to develop and design the Extended Pilot FOT and FOT, assumptions were made to constrain the process. These assumptions include the following:

1. The timeframe for the entire FOT will not exceed 36 months. This includes the time needed for site and intersection selection, preparations (e.g., vehicle and intersection build-up), FOT data collection, data analysis and report writing. The FOT data collection period will be one year.
2. The FOT will use a naturalistic data collection method in which data is collected while participants drive normally using the test vehicle as their personal vehicle, using routes of their choice.
3. The FOT will include a test track trial, which necessitates proximity to a controlled test facility. The trial will be conducted after each subject completes their participation in the FOT.
4. The intersection equipment will use the roadside equipment (RSE) developed under Phase I of the CICAS-V project and will not include the Vehicle Infrastructure Integration (VII) Program RSE. A backend network will not be used. In lieu of a backend network, daily diagnostics will be run at each intersection to verify continuing intersection operation.
5. The CICAS-V project will include intersection equipment costs in the FOT budget. These costs were not included in the original VSC2 proposal to U.S. DOT since it was assumed that the VII Program would provide these items to CICAS-V as part of their FOT. Since the VII FOT will not take place, the CICAS-V intersection equipment, Geometric Intersection Descriptions (GID), GID validation, equipment installation and equipment testing must be provided through the CICAS-V project.
6. All FOT data collection will be conducted with the vehicle DAS. Hence, no intersection data acquisition systems (DASs) will be used. This assumption will be re-examined following the Extended Pilot FOT after the initial field data from the actual FOT location becomes available.
7. The signalized intersections used in the FOT will include intersections along a continuous corridor.

8. The location of the FOT will involve support from a "local" DOT agency deemed cooperative. In this context, "cooperative" means that the DOT must be familiar with the CICAS-V project, including a DOT that shall commit to supporting the FOT Project Plan (including the Project Timing assumption expressed in #1 above). There must be a clear willingness on the part of the local DOT to install new equipment and potentially replace the traffic signal controllers at a relative large number of CICAS-V intersections to facilitate the FOT.
9. One vehicle make/model/year will be used. This assumption will reduce the cost of the FOT compared with using multiple vehicle types and avoid stratification of the data across multiple vehicle types.
10. A new vehicle model (different from those used for Phase I) may be chosen for the FOT. This would require time at the beginning of Phase II to determine the best instrumentation method for the particular vehicle and possibly work to develop the haptic brake pulse.

4.2 FOT Location and Intersections

The selection of the FOT location and the intersections used for testing will be deferred until Phase II of the project. The process for selecting the FOT location and specific intersections was presented in the previous section of the report.

4.3 FOT Experimental Design

Table 6 presents the recommended experimental design parameters for the full FOT. Each is discussed in the material that follows the table.

Table 6: FOT Experimental Design Parameters

Test Parameter	Number
Vehicles (Comprised of 1 vehicle type)	51
Drivers	204
Test Duration per Driver (weeks)	12
Signalized Intersections Equipped and Mapped	24
Estimated Signalized Intersection Crossings 24 intersections x 2/day x 5 workdays/wk x 12 wks x 204 subjects	587,520
Stop-Controlled Intersections Mapped	50
Estimated Stop-Controlled Intersection Crossings* 2 intersections x 7 days/wk x 12 wks x 204 subjects	34,272
Overall Test Duration (weeks – including vehicle switching and maintenance)	52
Driver Weeks of Data Collection 51 vehicles x 4 cycles x 12 weeks	2448

*The study is designed with the assumption that each driver will encounter at least two equipped stop-controlled intersections per day.

4.3.1 Vehicles

Fifty-one vehicles will be instrumented for the FOT plus the two Phase I vehicles used by VTTI during Task 3 will be retained as “backup” (spare) vehicles. Additional “spare” vehicles may be considered if more than one vehicle type is ultimately used in the FOT. To make instrumentation as efficient as possible, and to reduce performance variability due to vehicle make, only one vehicle make and model will be chosen.

4.3.2 Drivers

Each of the 51 vehicles will be cycled four times for a total of 204 drivers. An equal number of younger (20-30 years), middle-aged (40-50 years), and older (60-70 years) drivers will be recruited and these age groups will be split by gender. All drivers will be required to meet minimum driving mileage criterion within the test area. Since drivers will be given a vehicle to use as their own personal vehicle throughout the data collection period of 12 weeks, attrition will likely be very minimal. Furthermore, if a vehicle is crashed during the course of the study, back-up vehicles will be available.

4.3.3 Test Duration per Driver

The test duration per subject was computed (as part of FOT parameters) based on estimated exposure and practical considerations. The logistics associated with the naturalistic data collection makes a 12-week cycle most conducive to vehicle maintenance since oil changes and other routine maintenance can be conducted on a three-month cycle. The maintenance can be done when the vehicle is being turned around for the next subject driver.

4.3.4 Number and Type of Intersections

4.3.4.1 Signalized

Twenty-four (24) signalized intersections will be CICAS-V equipped and mapped. The intersections will be chosen based upon several factors, including accessibility (along a well-traveled corridor), geometry (simple, complex), sky (clear view of GPS satellites or obstructed view), and so forth. The goal would be to choose intersections that would be on a commuting corridor such that drivers will need to go through the 24 signalized intersections at least twice in each of five working days.

4.3.4.2 Stop-Controlled

Fifty (50) stop-controlled intersections will be surveyed and geometric intersection descriptions (GIDs) will be prepared. The goal is to choose intersection locations such that each driver will cross two stop-controlled intersections per day. Note that the estimation of the number of stop-controlled intersection crossings considers that the driver will cross these intersections 7 days per week as opposed to only five days per week as with the signalized intersections. This difference reflects the fact that stop-controlled intersection locations will be chosen based on drivers’ home location in order to increase exposure.

4.3.5 Overall Test Duration and Weeks of Data Collection

The study design provides for 48 weeks of naturalistic data collection and four weeks for set-up and logistics in the chosen location, switching vehicles between drivers, scheduling for pre- and post- interview meetings with the participants for a total of 52 weeks. The total weeks of data collection is 51 vehicles x 4 vehicle cycles x 12 weeks per driver for a total of 2,448 vehicle weeks of data.

4.3.6 DVI Activation Status

Of the 12-week period, the first three weeks will be a control period whereby the CICAS-V system will be operating in the background but will not issue an alert. The DAS will also be active. After the three-week control period, the nine-week treatment period will begin. An experimenter will go to the vehicle and switch the CICAS V system into an "active" mode whereby all modes of the DVI will provide information to the driver.

Due to the fact that violations are relatively rare events, the VSC2 team suggests that data collection occurs "in the background" during the three-week baseline (no DVI) condition so that any violation or near-violation events are recorded for analysis, and baseline versus treatment driver behavior can be asessed.

It should be noted that the allocation of the 12-week data collection cycle into a three-week baseline period (i.e., no DVI) and a nine-week treatment period (i.e., DVI active) differs from the initial FOT planning that was conducted by the U.S. DOT. From the analysis conducted during the initial planning, a six-week baseline period and a six-week treatment period was identified in order to generate data to be able to identify a 50% change in the proportion of violators. A change to a three-week / nine-week baseline-treatment allocation may not provide the data needed to support identification of the hypothesized change in driver behavior. Thus, while this change may facilitate the collection of more alerts (which would enhance the investigation of user acceptance and unintended consequences), it may not be conducive to the evaluation of the safety effectiveness of the CICAS-V system.

4.3.7 Test Track Trial

At the completion of 12 weeks of data collection, each driver will participate in a test-track trial similar to that conducted in Phase I, Subtask 3.3, "Test of Alternative Driver-Vehicle Interfaces on the Smart Road," (Perez et al., in print). There are two reasons for conducting this additional task. First, if a driver does not receive a warning during the participation in the study, a Subtask 3.3-type study will provide researchers with some data on how a driver might respond if they had received a "valid" warning during the participation in the naturalistic portion of the study. Second, unlike the case with the naturalistic data, this technique allows examination of each participant's behavior under the same controlled, intersection approach conditions. The test track trial will be limited to signalized intersection tests.

4.3.8 Other Data Collected

The vehicle data represents the objective data that will be collected in the FOT. The list of vehicle data parameters and the data acquisition system for the FOT were developed under Phase I, Task 12, "Infrastructure and Vehicle Data Acquisition System Functional Designs." The interested reader should refer to the Task 12 Final Report (Stone, et al., in print), where extensive details about these subjects are presented. In addition to a driver demographics questionnaire, three post-test questionnaires will also be used. These include one for those who experienced an alert during the naturalistic portion of the study, one for those that experienced a test track alert, and another one for those that experienced no alerts. The questionnaires were derived from similar questionnaires developed for the Pilot FOT during Subtask 3.4. VTTI will administer the following driver acceptance data collection materials:

- Driver Demographics – drivers will be administered a screening questionnaire to identify age and gender characteristics.
- Pre-test Questionnaire - drivers will be administered a pre-test questionnaire to assess their driving history and familiarity with various equipment in their personal vehicle.
- Test-track Questionnaire – drivers will be administered a test-track questionnaire to assess their opinions directly after experiencing the system on the test-track
- Post-test Questionnaire- drivers will be administered a post-test questionnaire to assess their opinions of the system and their experience in the naturalistic portion of the study.

4.3.9 Mapping the Data to the Evaluation Objectives

When discussing what data will be collected, it is important to not lose sight of the purpose of the data collection which is to facilitate the conduct of the system evaluation. The evaluation objectives are:

1. Examine potential system safety benefits.
2. Determine driver acceptance of the system.
3. Characterize system capability.
4. Determine any potential unintended negative consequences.

With an understanding of the Evaluation Objectives for the FOT, and an understanding of the data that are planned to be collected, Table 7 provides a mapping of the data to the Evaluation Objectives.

Table 7: Mapping of Collected Data to Evaluation Objectives

	Evaluation Objectives			
	Safety Benefits	Driver Acceptance	System Capability	Unintended Consequences
In-Vehicle Video	X	X	X	X
Quantitative Data (Vehicle DAS)	X		X	X
Driver Demographics	X	X		
Pretest Questionnaire		X		
Post-test Questionnaire		X		X
Test-Track Trial	X	X		X

4.4 Data Collection Protocol

The study is composed of three steps. The first step involves determining eligibility and obtaining informed consent from the participant. The second step involves the naturalistic driving portion of the study. The last step involves the test-track portion of the study.

4.4.1 Step 1

The initial screening process will involve all recruited participants. The screening process will take place over the telephone (Appendix A). When participants are deemed eligible, an informed consent form will be mailed (or emailed) to them and they will then schedule an appointment to come to VTTI. Upon arrival, participants will be escorted to the participant preparation room by an experimenter. They will then be asked to read and sign the informed consent form if they agree to take part in the study (Appendix B). Next, their license to drive a motor vehicle will be verified and photocopied and they will be asked to fill out a Virginia Tech W-9 tax form (Appendix C). The Virginia Tech Controller's office has requested that these forms be submitted to them in the event that a participant receives a payment of $75.00 or greater. An eye exam will be administered at this time (must be or be corrected to better than 20/40 to operate a motor vehicle per Virginia law), followed by a color blindness test and contrast sensitivity test. The participants will be asked to complete a medical questionnaire to verify they are not under the influence of any drugs or alcohol and do not have medical conditions that may impair their ability to drive (Appendix D; presence of any factors that may impair the participant's ability to safely operate the experimental vehicle will exclude them from participation). Lastly, participants will be asked to fill out a pre-driving questionnaire (Appendix E). If participants are deemed ineligible to participate in the study at any point during this initial part of the study (e.g., if they fail their vision test), they will be paid for their time, thanked for their participation, and dismissed.

4.4.2 Step 2

After completing the initial paperwork, participants will be escorted to the instrumented vehicle and given verbal instructions concerning the operation of the vehicle in addition to a hard copy of the contact information for the CICAS-V experimenter(s) at VTTI. The instructions will be intended to mimic owner's manual-like information provided with a new vehicle. The safety mechanisms will be identified (e.g., fire extinguisher and first aid kit) and the adjustments for the mirrors, steering wheel, and driver's seat will be demonstrated. Participants will be given verbal instructions as to the nature of the CICAS-V system during this time. Participant questions concerning the operation of the vehicle will also be addressed.

The CICAS-V system will involve a warning (a combination of a visual, auditory, and brake pulse warning) that is issued when the driver may be in danger of violating one of the instrumented signalized or stop-controlled intersections. The auditory warning consists of a speech alert, the visual warning consists of a flashing icon, and the brake pulse consists of a single short duration, low intensity, braking pulse. In addition to receiving a hard copy of VTTI contact information, the participant will be asked to identify specific times to be available for a 15-minute telephone interview (Appendix F). Participants will be asked to drive a consistent route as part of their commute each day. The route will include 24 signalized and 50 stop-controlled intersections. During the study, an experimenter will check the integrity of the incoming raw data stream and processed data. This involves the experimenter accessing the interior and the trunk of the vehicle, and hence, does not necessarily require the involvement of the participant. This is necessary to enable close monitoring of the DAS and collision avoidance system performance, ensuring these systems are operated "as intended." Upon completion of the 12-week study, participants will be asked to return the vehicle to VTTI.

4.4.3 Step 3

Prior to completing the 12-week study, participants will be mailed a copy of the test-track informational form. Upon completing the 12-week study, participants will be asked to re-read the informational form (Attachment G) and sign if they agree to take part in the test-track portion of the study. This test-track portion follows the protocol of a study previously approved by IRB (VT IRB #06-566). One of the experimental tasks requires an element of surprise, therefore, this task will not be detailed on the initial informed consent form. The participants will be asked to show their driver's license and review the medical questionnaire once again to verify that there have not been any changes in this information. Participants will be escorted to the instrumented vehicle, asked to adjust their seat and mirrors for their comfort, and asked to drive to the test track. The test track will provide a controlled-access facility ensuring that only the experimental vehicles will be on the roadway during testing. There will not be any interaction with atypical-roadway obstacles or non-experimental vehicles. Tests will only be conducted during the daytime and with dry road conditions. Participants will drive loops on the test track crossing a four-way signalized intersection where the data are collected. An in-vehicle experimenter will be present at all times during this test-track study. The experimenter will provide instructions, supervise the operation of the computer system, answer questions as necessary, and administer required questionnaires. Except for supervising the operation of the computer system, these tasks will not be performed concurrently, but, rather, independently at different stages of the experiment. The protocol has been successfully proven through two prior expertiments (Perez et al., in print and Neale et al., in print).

Once the drivers access the test track, they will be asked to stop and receive a general orientation on the road (e.g., location of turnarounds) and their task (i.e., drive as they normally would). At this time, participants will be told that the experiment concerns the use of in-car and personal electronic devices. During this brief orientation, participants will be allowed to experience the devices they will be using in a static setting before beginning their drive. Participants will be informed that they will need to perform a certain task whenever they receive a pre-recorded message.

Participants will be told that they are to follow all normal traffic rules. During the study, they will not experience any warning prior to the surprise trial. Finally, participants will be told that maintenance vehicles will occasionally be entering and leaving the road via a standard signalized intersection. These maintenance vehicles will actually be confederate vehicles, driven by trained experimenters who are involved in the study. The in-vehicle experimenter and confederate drivers will be in contact at all times.

Participants will drive loops around the test track at 35 mph. For each loop, different tasks will be assigned, to be performed whenever instructed by a pre-recorded message that will be initiated based upon GPS location. As they approach the intersection, they will occasionally be presented with a changing light. The signal change will occur such that the decision to stop is obvious (signal turns red while car is still far from the intersection). The confederate vehicle will then cross the intersection from an adjacent approach and either leave or enter the roadway while the light is red and the subject vehicle is stopped.

For the surprise condition, the participants will be presented with a task instruction message immediately prior to the signal changing to amber, which is intended to get the driver to look away from the forward scene. When they look back from the task (after their attention is regained via the warning or because the light is visible in their peripheral vision), they will see an amber light (that would be expected to turn red), and might be expected to believe that the maintenance vehicle (really the trained confederate driver) is entering the road. However, the confederate vehicle will not be near the intersection at this time. This scenario is felt to be desirable in order to obtain driver response behavior representative of one might experience under real–world driving conditions with approaching cross traffic. The participants will be presented with a combination of a visual, auditory, and haptic violation warning. The auditory warning consists of a speech alert, the visual warning will consist of a flashing icon presented at a vehicle centerline "top of dashboard" location, and the haptic warning will consist of a single short duration, low intensity, single brake pulse (or vehicle jerk).

As the participant begins the approach towards the intersection for the surprise presentation, a confederate vehicle will begin following the subject vehicle. The following vehicle will stay 2 +/- 0.5 seconds behind the subject vehicle. The following vehicle is felt to be a desirable addition to the scenario for purposes of increasing the complexity of the intersection crossing decision and scenario realism.

Once participants have completed the surprise trial, they will be asked to complete a short questionnaire (Appendix H or I, depending on whether or not they stop at the intersection). They will then be debriefed on the true purpose of the experiment and asked to read and sign a new informed consent form (Appendix J) detailing the true purpose of the experiment. Participants will then return to the office to complete a questionnaire (Appendix K, L, or M, depending on whether or not they receive a warning during the 12-week period and/or test-track portion). At this point the experiment will conclude and participants will be paid and thanked for their time.

4.5 Data Storage and Management

For this project, it is expected that up to 5 terabytes of data will be collected. The CICAS-V Team has substantial experience with the download and storage of large amounts of data. Projects conducted at VTTI alone have required the management of projects that have collected 7 terabytes of data (100-Car Naturalistic Driving Study) and 20 terabytes of data (the Drowsy Driver Warning System [DDWS] FOT) that include both numerical and video data. The CICAS-V Team's strategy would be to would be to leverage the lessons learned from a previous data exchange with Volpe under the DDWS FOT project to create a clear protocol and data sharing methods. This will address storage format, data rates, data exchange format, fixing erroneous data, etc.

VTTI will be responsible for overall data collection, storage, archival, in-house data evaluations, and delivery to the Volpe Center of large datasets for independent evaluations. Data files and supporting documentation will be provided to the Independent Evaluator (IE, Volpe) on a per-participant basis. VTTI and the IE will jointly agree to an overall format and organization for the dataset. VTTI will run diagnostics on each subject's complete dataset, which should take approximately four to six weeks. VTTI will ship the initial copy of the dataset to the IE once VTTI is certain any changes will be minor and can be done through a script VTTI will provide. Changes to the dataset will be made incrementally and will not require VTTI to resubmit the entire database to the IE.

VTTI has designed a Storage Area Network (SAN) system to provide both large storage capacity and enable fast data transfer and analyses on lab workstations. The system performs the following three primary tasks:

1. Maintain all FOT data on the storage system for immediate availability and back-up/archival of all data and result files to an offsite location.
2. Analyze driver performance during events of interest by determining trigger configurations, scanning for epochs that meet trigger criteria, and extracting the resulting data.
3. Collect, configure, and deliver large sets of current FOT data, including video, and documentation to IE.

Figure 5 illustrates the proposed data management process, including data retrieval from the data acquisition systems, storage at VTTI, offsite backup from VTTI, and delivery of all data to the IE. There are several data protection features and productivity optimization decisions embodied within the storage system design, which are:

- Workstations access data files via the host server across a high-speed gigabyte (GB) network.
- Highly redundant server design ensures excellent system reliability and minimizes downtime. Dual CPUs, power supplies, fans, disk controllers, mirrored Redundant Array of Independent Disks (RAID-5) hard drives (+3rd hot-spare drive), etc. enable continued operation in the event of single component failures.
- Extremely fast fiber-optic communications between the server and SAN controller (using latest technology PCI-express host bus adapters).
- Fast front-end fiber channel drives for current data storage and configuring data sets across the SAN by task
- Back-end storage of large ATA drive arrays for data reduction and analysis, long-term storage, and mid-term dataset back-ups.
- Hot-swap hard drives are designated for front- and back-end drive arrays and function as an immediate "stand-in" for a failed drive.
- RAID5 data protection is utilized on the SAN to enable fast drive re-builds onto one of the designated hot-swap drives if an arrayed-hard-disk fails.
- Back-up/archive data sets are maintained in offsite storage at the Virginia Tech Media Vault where the tape cartridges and DVD disks are indexed into a locked

metal cabinet within a limited-access, temperature, and humidity-controlled vault. (This service is offered free of charge by Virginia Tech).

- Large datasets are copied to high capacity external hard disks for shipment to the IE.

This established system and data management plan will be used to benefit the CICAS-V program. It is acknowledged that for the CICAS-V program the IE may not want a complete data set, but may prefer a reduced or filtered data set. VTTI can work with the IE to accommodate their data requirements. In the end, VTTI will have a “live” dataset on the VTTI server that can be readily duplicated. In addition, backup copies of the data on DVD and/or tape will also be made to ensure data protection.

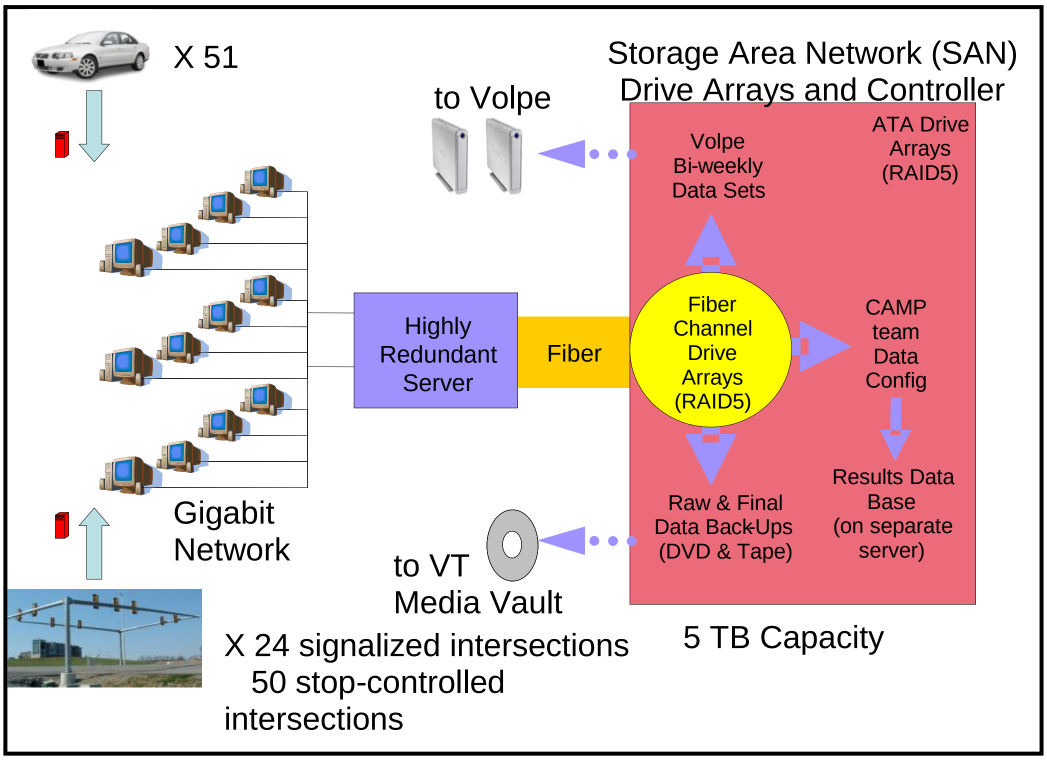

Figure 5: Proposed data storage and processing system for the CICAS-V FOT.

For the CICAS-V program, VTTI will provide to the IE a copy of all data from the infrastructure DAS, the Vehicle DAS that is within 700ft (213m) of the equipped intersections, and all questionnaire data. More specifically, VTTI will:

- Provide the IE with numerical and video FOT data in a format to be specified by IE.
- Provide IE documentation of how data was collected and organized.
- Ensure data quality by sending the IE a regularly updated list of valid trips that contain “good” valid data, and identify the segments of “bad” invalid data within a valid trip. Through in-house software this process will be automated to the greatest extent possible, though some manual validation may be required to check

certain issues (e.g., non-FOT driver operating vehicle). The quality assurance methods will be agreed upon in mutual cooperation between the DOT, CAMP, VTTI and the IE. Data validity will be further checked by the IE who will perform independent quality assurance. VTTI will also provide documentation of the quality assurance process used.

- Notify the IE of software or hardware problems encountered during the FOT with system operation or DAS and report on design changes and improvements in a timely manner.
- Provide the U.S. DOT with logistical support in conducting independent data collection activities with an FOT vehicle and help in the retrieval and formatting of on-board data.
- Share information to build similar basic database structure for data quality control.
- Develop (SQL) scripts or procedures to fix data discrepancies that might be uncovered after sending the data to the IE. Sharing such scripts would be a simple fix to correct the data given both parties have similar database structure.
- Parse data and provide the IE with data in SQL Bulk Copy (BCP) format since this maintains time synchronization among different data media and results in fewer errors.
- Provide time or indicator offsets to synchronize numerical and video data, including the list of trips with synchronization problems along with the numeric data time stamps, video time stamps, and offsets.
- Send FOT data along with trip summary tables with a list of variables to be provided by IE that help the IE to check incoming data and perform quality control.
- The data provided to the IE will include time stamps expressed in “deci-seconds” in addition to the sync number which is indexed at 10Hz.

4.6 Data Analysis

In addition to the analyses to be conducted by the IE, VTTI and VSC2 will conduct an on-going series of concurrent and supportive analyses that are of special interest to the OEM system developers. For these analyses, the VTTI /VSC2 team will use not only the vehicle data that was collected inside the 700ft (213m) radius to CICAS-V equipped intersections but also data outside the 700ft (213m) radius and data from the baseline “non-equipped” intersections.

In other words, VTTI will reduce and analyze data from all non-FOT intersections. As an example, this additional data could be used to answer the following questions:

- For drivers who had a high number of crash and near-crash red light events, did those drivers also have a high number of conflicts at non-equipped intersections and during general driving?

- When was distraction, versus willful violations, the cause of red-light and stop-sign violations at non-equipped intersections?
- What is the perceived reliability of the system when the driver is not receiving a warning when violating at an unequipped intersection during the course of the study?
- What were the operational circumstances during violations?

Given the possibility that the number of alerts issued during the FOT may be relatively low, special analyses, such as those listed above, may provide useful information to developers to improve system performance.

4.7 Reporting

VTTI will work with VSC2 to develop a Final FOT report detailing the conclusions gained from all field-testing activities.

5 Protocol for Extended Pilot FOT

An Extended Pilot Study will be conducted to obtain an initial assessment of the CICAS-V and the vehicle DASs, the data management approach, and all FOT protocols. This pilot study will use a small number of participants and collect data for a time period that is sufficient to provide a “dress rehearsal” for the test method used in the FOT. The test will provide pre-operational evidence of FOT readiness. Although a Pilot FOT was conducted during Phase I (Neale et al., in print), this study did not employ the final Phase I system software and featured drivers who drove a prescribed route through the CICAS-V equipped intersections following a pseudo-naturalistic protocol. In contrast, the Phase II Extended Pilot FOT will involve a fully naturalistic driving protocol using the final system software. In addition, the Pilot FOT was a short-term study in which each driver only participated in approximately two hours of vehicle operations. Consequently, additional pilot testing is needed to evaluate the final FOT software under longer term, naturalistic driving conditions similar to those planned for the FOT. It is expected that any prominent FOT problems from the CICAS-V, the DAS, and the experimental method will be identified in the Extended Pilot FOT study.

Table 8 presents the experimental design for the Extended Pilot FOT. Twelve drivers will participate in the pilot FOT. Each driver will drive an instrumented vehicle for six weeks that will result in 72 total driver-weeks of pilot data. The overall data collection period for the Extended Pilot FOT will be 13 weeks (i.e., two vehicle cycles of six weeks each plus one week for vehicle turnaround between the cycles). More weeks will be added should significant problems with any part of the system or method be identified. All drivers would be administered the Informed Consent as well as the pre- and post-test questionnaires.

Table 8: Experimental Design for Extended Pilot FOT

Test Parameter	Extended Pilot FOT (Number)
Vehicles (Comprised of one vehicle type)	6
Drivers	12
Test Duration per Driver (weeks)	6
Signalized Intersections Equipped and Mapped	24
Estimated Signalized Intersection Crossings 24 intersections x 2 crossings/day x 5 work days/wk x 6 weeks of data collection x 12 subjects	17,280
Stop-Controlled Intersections Mapped	50
Estimated Stop-Controlled Intersection Crossings 2 intersections x 7 days/wk x 6 weeks of data collection x 12 subjects	1,008
Overall Test Duration (weeks – including vehicle switching and maintenance)	13
Driver-Weeks of Data Collection Number of drivers x test duration per driver (weeks)	72

Naive drivers will be recruited and the pilot test will strictly follow the FOT protocol (with the exception being the number of weeks each participant drives the CICAS-V vehicle). At least once every other day researchers will check the data to monitor the data stream and ensure that the sensors and systems are working "as intended." Drivers will only be contacted if it is necessary to maintain a sensor or address a study issue. Information learned from the pilot will be used, as appropriate, to modify the overall FOT plan to help ensure that the FOT is effectively carried out.

5.1 Vehicles

Six (6) vehicles will be instrumented for the extended pilot test. These vehicles will be part of the fleet equipped vehicles used in the full FOT.

5.2 Drivers

Each of the six vehicles will be cycled two times for a total of 12 drivers. To the greatest degree possible, drivers will be recruited that are representative of the driving population in the FOT location for variables including age (younger, middle-aged, and older), gender, and mileage.

5.3 Test Duration per Driver

Each driver will have the vehicle for a total of six weeks.

5.4 Number and Type of Intersections

All 24 signalized and 50 stop-controlled intersections selected for the full FOT will be equipped and mapped for the extended pilot test.

5.5 Overall Test Duration and Weeks of Data Collection

The study design provides for 6 weeks of naturalistic data collection. The total weeks of data collection is 6 vehicles x 2 vehicle cycles x 6 weeks per driver for a total of 72 vehicle-weeks of data. A one-week vehicle turnaround period between cycles will also be required. Thus, the total overall data collection time for the Extended Pilot FOT will be 13 weeks.

5.6 DVI Activation Status

Of the six-week period, the first week will be a baseline (control) period whereby the CICAS-V system will be operating in the background but will not issue an alert. The DAS will also be active. After the one-week baseline period the treatment period will begin. An experimenter will go to the vehicle and switch the CICAS-V system into an "active" mode whereby all modes of the DVI will provide information to the driver. The system will be active for the remaining five weeks of data collection.

Due to the fact that violations are relatively rare events, the VSC2 team suggests that data collection occurs "in the background" during the one-week baseline (no DVI) condition.

5.7 Test-Track Trial

Each driver will be asked to participate in a test-track trial just as in the full FOT. The test track trial will be conducted after the participant completes the full FOT.

5.8 Other Data Collected

All questionnaire data will be collected for the Extended Pilot FOT.

5.9 Optimize the FOT

One of the important aspects of assessing FOT readiness following the Extended Pilot FOT will be the examination of the assumptions that were made during the effort to define the size of the FOT. This step was illustrated in the lower portion of Figure 4 presented earlier in the report. These assumptions include estimates of the expected number of intersection crossings, the expected number of system alerts, etc. The risk of insufficient data to address the FOT research questions (i.e., system benefits, user acceptance and potential unintended consequences) was a major concern during FOT planning and, in part, lead to the selection of the large FOT as the desired design for evaluating CICAS-V.

Consequently, following the conclusion of the Extended Pilot FOT, the data collected will be analyzed to determine the number of intersection crossings that actually occurred during the Phase II pilot study along with any alerts, violations and near-violations that also occurred. (It should be noted that these latter three items occur relatively infrequently during actual driving and may not be observed from the sample of drivers participating in the Extended Pilot FOT.) The intersection crossing rates and rates at which the alert, violation and near-violation events occurred (if observed) will be compared with the assumptions made during the earlier planning phase to ascertain whether adjustments to the FOT experimental design are warranted to increase the probability that sufficient data will be available for analysis following the FOT.

Joint discussions involving the U.S. DOT, VSC2 and the IE will be needed to evaluate the potential design changes and identify those that are most likely to enhance the FOT outcome and/or reduce project risk. Because the design options have different effects on FOT cost and schedule, any future decisions affecting the FOT design must consider the resource and timing constraints applicable to Phase II. However, if FOT design refinements are needed, the options available for increasing exposure to system operation include increasing the number of subjects, increasing the number of CICAS-V equipped intersections or vehicles, lengthening the duration of data collection period, or a combination of these. In addition, the adjustments to the data collection protocol and subject characteristics are also possible to increase system exposure. For example, instead of using a completely naturalistic driving protocol as is currently planned, drivers could be asked to drive a prescribed route at regular intervals during the study period (possibly daily), thus insuring that the equipped intersections are frequently traversed. Similarly, by including delivery or route drivers based at businesses near the FOT area as part of the subject sample, it may be possible to increase intersection crossings during the FOT as compared with using drivers recruited from the general population.

6 References

Brewer, M. A., Bonneson, J., Zimmerman, K. (2002). Engineering Countermeasures to Red-Light-Running. Proceeding of the ITE 2002 Spring Conference and Exhibit (CD-ROM). Washington, DC: Institute of Transportation Engineers.

Dingus, T.A., Klauer, S.G., Neale, V.L., Peterson, A., Lee, S.E., Sudweeks, J., Prez, M.A., Hankey, J., Ramsey, D., Gupta, S., Bucher, C., Doerzaph, Z.R., Jermeland, J., & Knipling, R.R. (2006). The 100-Car Naturalistic Driving Study, Phase II – Results of the 100-Car Field Experiment. (Contract No. DTNH22-00-C-07007). Washington, DC: National Highway Traffic Safety Administration.

Doerzaph, Z. R., Neale, V. L., Bowman, J. R., Viita, D. C., and Maile, M. (In Print). *Cooperative Intersection Collision Avoidance System Limited to Stop Sign and Traffic Signal Violations (CICAS-V) Subtask 3.2 Interim Report: Naturalistic Infrastructure-Based Driving Data Collection and Intersection Collision Avoidance Algorithm Development*. Washington, DC: National Highway Traffic Safety Administration.

Fakhry, S. M. and Salaita, K. (2002). Aggressive Driving: A Preliminary Analysis of a Serious Threat to Motorists in a Large Metropolitan Area. Journal of Trauma, 52(2), 217-224.

Kamyab, A., McDonald, T., and Stribiak, J. J. (2002). The Scope and Impact of Red Light Running in Iowa. Preprint CD-ROM of the 81st Annual Meeting of the Transportation Research Board, Washington, DC.

Kamyab, A., McDonald, T., Stribiak, J. J., and Storm, B. (December 2000). Red Light Running in Iowa: The Scope, Impact, and Possible Implications. Ames IA: Center for Transportation Research and Education, Iowa State University.

Lum, K. M. and Wong, Y. D. (2003). Impacts of Red Light Camera on Violation Characteristics. Journal of Transportation Engineering, November/December, 648-656.

Maile, M., Ahmed-Zaid, F., Basnyake, C., Caminiti, L., Kass, S., Losh, M., Lundberg, J., Masselink, D., McGlohon, E., Mudalige, P., Pall C., Peredo, M., Popovic, Z., Stinnett, J., and VanSickle, S. (In Print). *Cooperative Intersection Collision Avoidance System Limited to Stop Sign and Traffic Signal Violations (CICAS-V) Task 10 Final Report: Integration of Subsystems, Building of Prototype Vehicles and Outfitting of Intersections*. Washington, DC: National Highway Traffic Safety Administration.

Perez, M. A., Neale, V. L., Kiefer, R. J., Viita, D., Wiegand, K., and Maile, M. (In Print). *Cooperative Intersection Collision Avoidance Systems Limited to Stop Sign and Traffic Signal Violations (CICAS-V) Subtask 3.3 Interim Report: Test of Alternative Driver-Vehicle Interfaces on the Smart Road.* Washington, DC: National Highway Traffic Safety Administration.

Porter, B. E. and England, K. J. (2000). Predicting Red-Light Running Behavior: A Traffic Safety Study in Three Urban Settings. Journal of Safety Research, 31(1), 1-8.

Retting, R. A. and Williams, A. F. (1996). Characteristics of Red Light Violators: Results of a Field Investigation. Journal of Safety Research, 27(1), 9-15.

Retting, R. A., Williams, A. F., Farmer, C. M., and Feldman, A. F. (1999a). Evaluation of Red Light Camera Enforcement in Oxnard, California. Accident Analysis and Prevention, 31, 169-174.

Retting, R. A., Williams, A. F., Farmer, C. M., and Feldman, A. F. (1999b). Evaluation of Red Light Camera Enforcement in Fairfax, Virginia. ITE Journal, Vol. 69, No. 8, 30-34.

Retting, R. A., Williams, A. F., and Greene, M. A. (1998). Red-Light Running and Sensible Countermeasures: Summary of Research Findings. Transportation Research Record 1640, 23-26. Transportation Research Board, Washington, DC.

Ruby, D. E. and Hobeika, A. G. (2003). Assessment of Red Light Running Cameras in Fairfax County, Virginia. Transportation Quarterly, Vol. 57, No. 3, 33-48.

Schattler, K. L., Hill, C., and Datta, T. K. (2002). Clearance Interval Design and Red Light Violations. Proceeding of the ITE 2002 Spring Conference and Exhibit (CD-ROM). Washington, DC: Institute of Transportation Engineers.

Stone, S., Neale, V. L., Wiegand, K., Doerzaph, Z. R. and Maile, M. (In Print). *Cooperative Intersection Collision Avoidance Systems Limited to Stop Sign and Traffic Signal Violations (CICAS-V) Task 12 Final Report: Infrastructure and Vehicle DAS Functional Designs.* Washington, DC: National Highway Traffic Safety Administration.

Yang, C.Y.D. and Najm, W.G. (2006). Analysis of Red Light Violation Data Collected from Intersections Equipped with Red Light Photo Enforcement Cameras, (DOT-VNTSC-NHTSA-05-01, DOT HS 810 580). Washington, DC: U.S. Department of Transportation.

APPENDICES

Appendix A: Driver Screening Questionnaire

Note to Researcher:
Initial contact between participants and researchers may take place over the phone .If this is the case, read the following Introductory Statement, followed by the questionnaire .Regardless of how contact is made, this questionnaire must be administered verbally before a decision is made regarding suitability for this study .**Do not place any participant information on this questionnaire**, it should only be used to record participant answers .Once eligibility has been determined (i.e., the participant answers comply with all the screening criteria) and you've recorded the participant information on the last page, discard the rest of this questionnaire.

Introductory Statement:
After prospective participant calls or you call them, use the following script as a guideline in the screening interview.

Hello .My name is _____ and I'm a researcher with the Virginia Tech Transportation Institute in Blacksburg, VA .We are currently recruiting people to participate in a research study .This study involves participating in two driving sessions .The first session will last one week and VTTI will supply participants with an instrumented vehicle to drive during their daily commute. You should drive the car as you normally would, but we ask that you use 460 Business as part of your daily commute. The second session will last approximately one hour. This session will take place on the Smart Road. Does this sound interesting to you?

If No, thank them for their time and finish the call.

If Yes:
First, I would like to collect some information from you to determine if you're eligible.

1. Do you have a valid driver's license?
- **Yes**
- **No**

(STOP and tell them they're not eligible for the study if they answer No)

2. How old are you? _______________

(STOP and tell them they're not eligible for the study if they are under 18 years of age)

3. Are you authorized to work in the United States? Please note that we are NOT offering employment to you.
- **Yes**
- **No**

Please explain:____

(STOP and tell them they're not eligible for the study if they answer No because they carry a non-working VISA [e.g., F2 Visa])

4. **Please note that for tax recording purposes, the fiscal and accounting services office at Virginia Tech (also known as the Controller's Office) requires that all participants provide their social security number to receive payment for participation in our studies. You do NOT need to provide it now, but are you willing to provide us with your social security number?**
    - **Yes**
    - **No**

(Stop and tell them they are not eligible for the study if they are not willing to provide their social security number)

5. **Are you able to drive an automatic transmission without assistive devices or special equipment?**
    - **Yes**
    - **No**

(STOP and tell them they're not eligible for the study if they answer No)

6. **Do you already or are you willing to travel 460 Business as part of your daily commute?**
    - **Yes**
    - **No**

    If "yes", at which intersections to you begin and end driving on 460 Business as part of your daily commute?

    ____

    If "yes", would you agree to use 460 Business as your driving route during your daily commute?
    - **Yes**
    - **No**

(STOP and tell them they are not eligible for the study if they

a) are not willing to drive 460 Business as part of their daily commute, and
b) do not travel - or are not willing to travel - between East/West Main Street intersection and the new mall intersection – *need to travel through both Depot and Pepper's Ferry on 460*)

7. **Have you participated in any experiments at the Virginia Tech Transportation Institute? If "yes," please briefly describe the study.**
    - **Yes ____**
    - **No**

(STOP and tell them they're not eligible for the study if they have participated in previous studies involving intersection collision avoidance systems or surprise events)

8. Have you been convicted of a DUI?

- **Yes**
- **No**

(STOP and tell them they're not eligible for the study if they have been convicted of a DUI)

9. Have you been involved in any accidents within the past 3 years? If so, please explain.

- **Yes ____**
- **No**

(STOP and tell them they're not eligible if they've caused an accident resulting in injury in the past 3 years)

10. Do you smoke?

- **Yes**
- **No**

If "yes," would you agree to NOT smoke in the vehicle?

- **Yes**
- **No**

(STOP and tell them they're not eligible if they smoke in the vehicle)

11. Do you have a history of any of the following? If yes, please explain.

Heart Condition	**No____**	**Yes____________________________**
Stroke	**No____**	**Yes____________________________**
Brain tumor	**No____**	**Yes____________________________**
Head injury	**No____**	**Yes____________________________**
Neck or back pain or injury	**No____**	**Yes____________________________**
Epileptic seizures	**No____**	**Yes____________________________**
Respiratory disorders	**No____**	**Yes____________________________**
Motion sickness	**No____**	**Yes____________________________**
Inner ear problems	**No____**	**Yes____________________________**
Dizziness, vertigo, or other balance problems	**No____**	**Yes____________________________**
Diabetes	**No____**	**Yes____________________________**
Migraine, tension headaches	**No____**	**Yes____________________________**

(See criterion 11 on next page to determine eligibility if they answer Yes to any of the conditions)

12. (Females only, of course) Are you currently pregnant? ***If yes, explain that they cannot participate because the Virginia Tech IRB does not allow pregnant women to participate in this type of driving study.***

- **Yes**
- **No**

13. Are you currently taking any medications that may interfere with your driving ability (e.g., medications that may cause drowsiness, medication that may make you dizzy)? If yes, please list them.

- **Yes ____**
- **No**

(STOP and tell them they're not eligible if they're taking any substances that may interfere with their driving)

14. Do you have normal or corrected to normal hearing and vision? If no, please explain.

- **Yes**
- **No ____**

(STOP and tell them they're not eligible if they report CORRECTED vision lower than 20/40 or uncorrected hearing)

<u>Criteria for Participation:</u>

1. ***Must hold a valid driver's license.***
2. ***Must be 18 years or older.***
3. ***Must be eligible for employment in the U.S.***
4. ***Must be willing to provide a valid social security number.***
5. ***Must be able to drive an automatic transmission without special equipment.***
6. ***Must be willing to drive 460 Business as part of their daily commute, and be willing to travel between East/West Main Street intersection and the new mall intersection.***
7. ***Must not have been a participant in previous VTTI studies involving intersection collision avoidance systems or surprise events.***
8. ***Must not have been convicted of a DUI.***
9. ***Must not have caused an injurious accident in the past three years.***
10. ***Must agree to NOT smoke in the vehicle.***
11. ***Must not have lingering effects of back or neck injury or pain. Cannot have lingering effects of heart condition, brain damage from stroke, tumor, head injury, recent concussion, or infection. Cannot have had epileptic seizures within 12 months, respiratory disorders, motion sickness, inner ear problems, dizziness, vertigo, balance problems, diabetes for which insulin is required, chronic migraine or tension headaches.***
12. ***Must not be pregnant.***
13. ***Cannot currently be taking any substances that may interfere with driving ability (cause drowsiness or impair motor abilities).***
14. ***Must have normal (or corrected to normal) hearing and vision.***

If the Participant is Not Eligible:

Unfortunately, you are not eligible to perform the study because _______________. Thanks for your time.

If the Participant is Eligible:
You're eligible to participate in this study. If you verify the following contact information, one of our researchers will contact you to determine a mutually agreeable time for you to complete the study.

Information for Screened and Eligible Participant:

Screener: Please record this information if the participant is eligible. Discard the screening questionnaire after this information has been recorded.

Name ____

Age __________

Phone Number ____________________

Best Time/Day to Call ___________________________________

Date and Time Scheduled ___________________________________

An Informed Consent Form will be mailed to you, so you have an opportunity to review the procedures ahead of time.

Mailing Address ____

____

Email (optional) ____

Appendix B: Informed Consent

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants
in Research Projects Involving Human Subjects

Title of Project: CICAS: Pilot Field Operational Test
Investigator(s): Vicki Neale, Zac Doerzaph, Derek Viita, Kendra Wiegand, and Jodi Bowman

I. Purpose of this Research Project

The purpose of this research project is to investigate new safety devices. We want to find out whether the devices are effective and whether you find them useful. Two-hundred adults will be recruited to participate for this study. There will be an equal number of males and females.

II. Procedures

You are being asked to participate in a naturalistic driving study. The study involves a twelve-week data collection effort in which you will be asked to drive along 460 Business for your daily commute. You will be driving a vehicle equipped with next generation assistive safety devices. In addition, the vehicle will be equipped with a data collection system using an array of sensors and cameras for use in recording a variety of driving measures.

During today's session, you will be asked to read and sign this informed consent form, show the experimenter your valid driver's license, fill out questionnaires, and participate in a hearing and vision test. You will also be shown the instrumentation system and safety systems in the vehicle. We ask that you drive this vehicle instead of your own vehicle for one week.

You will be asked to drive the vehicle as you normally would for one week, using 460 Business as your daily commute. You will be instructed to contact Virginia Tech Transportation Institute (VTTI) if you encounter any difficulties with the vehicle that could be related to the instrumentation system or if you notice any maintenance issues with the system (for example, a camera that comes loose and dangles).

A VTTI experimenter will call you for a telephone interview to talk about your experiences. The phone interview will take approximately 15 minutes. While you are in possession of the vehicle, VTTI staff will periodically find the vehicle and download the data, which will involve accessing the interior and the trunk of the vehicle. They will be wearing a VTTI badge when performing this activity.

During the week, we ask that you do the following:

1. Wear your seatbelt at all times.
2. Drive the instrumented vehicle as you normally would your own vehicle to your normal destinations and use 460 Business as your route for your daily commute.
3. Do not allow anyone else to drive the vehicle.
4. Do not wear sunglasses unless absolutely necessary. Sunglasses are recommended if at any time you are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and surrounding environment.
5. Participate in two scheduled telephone interviews.
6. Permit VTTI researchers to access the experimental vehicle (at your home or work location) to download data. Data downloads will require an experimenter to access the trunk and interior of the vehicle. You do not need to be present during the data downloads. Subject to your approval, data downloads will be completed between 7am and 11pm.
7. In the event of equipment malfunctioning or vehicle damage, notify VTTI as soon as possible.
8. If you are involved in a crash, please follow the instructions listed on the orange envelope located in the glove compartment.
9. At the end of your participation period, please return the vehicle to VTTI.

As a participant in this study, you are requested to perform the following duties:

1. Carefully read the consent form and sign it if you agree to participate.
2. Agree to drive a VTTI vehicle that is equipped with a data acquisition system and experimental assistive safety systems.
3. Agree to drive along 460 Business as part of your daily commute.
4. Agree that, if you are involved in a crash, you will follow the instructions on the orange envelope in the glove compartment and contact VTTI so that we can come inspect the data collection system.
5. Agree to notify us if vehicle maintenance is needed. VTTI personnel will pick up the vehicle for maintenance. In addition, please do not receive a "jump start" or give a "jump start" to another vehicle.
6. Agree to be the sole driver of the vehicle and not allow others to drive the vehicle.

Your role during this study will be to drive a vehicle on both public roads. It is important that you understand that we are not evaluating you in any way. We are collecting information about assistive safety systems and are interested in your opinion about their usefulness.

III. Risks

Caution should be exercised when operating a vehicle with which you are not familiar. Be aware that accidents can happen at any time while driving.

As a participant, you may be exposed to the following risks or discomforts by volunteering for this research:

1. The risk of an accident normally present while driving.
2. Any risk present when driving a new and unfamiliar vehicle.
3. While you are driving the vehicle, cameras will videotape you. Due to this fact, we will ask you not to wear sunglasses unless absolutely necessary; however, if at any time you are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and surrounding environment, sunglasses are recommended.

The following precautions will be taken to ensure minimal risk to you:

1. You may decide not to participate at any time.
2. The vehicle is equipped with a driver's side and passenger's side airbag supplemental restraint system, fire extinguisher and first-aid kit.
3. All data collection equipment is mounted such that, to the greatest extent possible, it does not pose a hazard to you in any foreseeable case.
4. You will be required to wear the lap and shoulder belt restraint system while in the car.

Please notify VTTI immediately if at any point during the study you experience any preexisting or new medical conditions in which you feel you cannot safely operate a vehicle or if you find out you are pregnant. To ensure your safety, we will remove you from the study and you will be promptly paid for your time participating in the study.

In the event of an accident or injury in an automobile owned or leased by Virginia Tech, the automobile liability coverage for property damage and personal injury is provided. The total policy amount per occurrence is $2,000,000. This coverage (unless the other party was at fault, which would mean all expense would go to the insurer of the other party's vehicle) would apply in case of an accident for all volunteers and would cover medical expenses up to the policy limit. For example, if you were injured in an automobile owned or leased by Virginia Tech, the cost of transportation to the hospital emergency room would be covered by this policy. Any coverage of the participant is limited to the terms and condition s of the insurance policy.

Participants in a study are considered volunteers, regardless of whether they receive payment for their participation; under Commonwealth of Virginia law, worker's compensation does not apply to volunteers; therefore, if not in the automobile, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

For example, if you were injured outside of the automobile owned or leased by Virginia Tech, the cost of transportation to the hospital emergency room would be covered by your insurance.

IV. Benefits

While there are no direct benefits to you from this research, you may find the experiment interesting. No promise or guarantee of benefits is made to encourage you to participate. Participation in this study will contribute to the improvement of future studies concerning advanced vehicle systems.

V. Extent of Anonymity and Confidentiality

The data gathered in this experiment, including the Health Screening Questionnaire, will be treated with confidentiality. Shortly after participation, your name will be separated from your data. A coding scheme will be employed to identify the data by participant number only (e.g., Participant No. 1). If you choose to do so, you will be allowed to see your data and withdraw the data from the study if you so desire. If you want to base withdrawal of your data on observation of the data, you must ask for an appointment to see the data immediately after you finish your participation. If upon seeing your data you decide to withdraw it from the experiment, the data will be promptly removed and discarded. At no time will the researchers release data identifiable to an individual to anyone other than individuals working on the project without your written consent. VTTI will not turn over the video of your image to its client without your permission. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

If you are involved in a crash while participating in this study, the data collection equipment in your vehicle will likely capture the events leading up to the event. The data collection equipment SHOULD NOT be given to police officers or any other party. You are under NO LEGAL OBLIGATION to mention participation in this study.

We will do everything we can to keep others from learning about your participation in the research. To further help us protect your privacy, the investigators have requested a Confidentiality Certificate from the Department of Health and Human Services. If the certificate is approved, we may disclose information about you as required by law, in conjunction with a government inquiry, or in litigation or dispute resolution. Disclosure will be necessary, however, upon request of DHHS for audit or program evaluation purposes. The Certificate of Confidentiality is not an endorsement of the project by the DHHS.
The Certificate cannot be used to resist a demand for information from personnel of the United States Government that is used for auditing or evaluation of federally

funded projects or for information that must be disclosed in order to meet the requirements of the federal Food and Drug Administration (FDA).

You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information.

The Certificate of Confidentiality also does not prevent the researchers from disclosing matters such as child abuse, or subject's threatened violence to self or others. In terms of a vehicle, this could also include items such as driving under the influence of drugs or alcohol or allowing an unlicensed minor to drive the vehicle. If this type of behavior is observed, we reserve the right to remove you from the study and inform the appropriate authorities of what we have observed. In all cases, we will notify you first of the behaviors we have observed prior to removing you from the study or informing others of our observations. If you are removed from the study, you will be compensated for any time already spent in the study, but will receive no further payments.

VI. Compensation

For this portion of the study, you will be paid $50.00 per week for your participation. You will also be paid $20 per hour for the time you spend completing paperwork and filling out questionnaires. You will be paid at the end of this portion in cash.

You will be provided a vehicle for a twelve-week time period. The vehicle will be provided to you with a full tank of gas, though you are not required to return the vehicle with the tank full. You will, however, be responsible for fueling the vehicle while you are using it and for paying all parking tickets and/or traffic violations issued to the research vehicle during the time the vehicle is in your possession.

VII. Freedom to Withdraw

As a participant in this research, you are free to withdraw at any time without penalty. If you choose to withdraw, please notify VTTI staff immediately, and arrangements will be made for VTTI staff to pick up the test vehicle. Circumstances could arise in which VTTI opts to end the study early. These could include, but are not limited to, safety concerns and/or equipment malfunctions. If this occurs, VTTI staff will contact you to make arrangements to pick up the test vehicle. You will be compensated for the portion of time of the study for which you participated. Furthermore, you are free not to answer any question or respond to experimental situations without penalty.

VIII. Subject's Responsibilities

If you voluntarily agree to participate in this study, you will have the following responsibilities:

1. To follow the experimental procedures as well as you can.
   a) Drive the instrumented vehicle as you normally would your own vehicle to your normal destinations and use 460 Business as your route for your daily commute.
   b) Participate in scheduled, 15-minute telephone interviews.
2. To inform the experimenter at VTTI if you have difficulties of any type.
3. To wear your seat and lap belt.
4. To abide by the posted speed limits and traffic laws.
5. To abstain from any substances that will impair your ability to drive.
6. To drive the test vehicle in a safe and responsible manner.
7. Do not allow anyone else to drive the vehicle.
8. You are responsible for fuel purchases and for paying all parking tickets, traffic violations, and tolls issued to the research vehicle during the time the vehicle is in your possession.
9. Do not wear sunglasses unless absolutely necessary. Sunglasses are recommended if at any time you are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and surrounding environment.
10. Do not take the vehicle into any facilities that do not permit video recording devices.
11. Permit VTTI researchers to access the experimental vehicle (at your home or work location) to download data. Data downloads will require an experimenter to access the trunk and interior of the vehicle. You do not need to be present during the data downloads. Subject to your approval, data downloads will be completed between 7am and 11pm.
12. In the event of equipment malfunctioning or damage, notify VTTI as soon as possible.
13. If you are involved in a crash, please follow the instructions listed on the orange envelope located in the glove compartment.

IX. Participant's Permissions and acknowledgments
Check one of the following:

☐ VTTI **has my permission** to provide digital video including my image to the sponsor of this research. I understand that the sponsor will only see the video for research purposes.

□ VTTI **does not have my permission** to provide digital video including my image to the sponsor of this research. I understand that VTTI will maintain possession of the digital video, and that it will only be used for research purposes.

X. Subject's Permission

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

____ Date__________

Subject signature

____ Date __________

Witness

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject, I may contact:

Investigators	
Derek Viita	xxx-xxxx
Zac Doerzaph	xxx-xxxx

David M. Moore
Chair, Virginia Tech Institutional Review
Board for the Protection of Human Subjects
Office of Research Compliance
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, VA 24060

[NOTE: Subjects must be given a complete copy (or duplicate original) of the signed Informed Consent.]

Appendix C: Form W-9

Form W-9

Certification of Taxpayer Identification Number for Individuals

Please check one:

_______ I am a U S citizen, **or**

_______ I have been granted permanent residency (green card holder), **or**

_______ I am a Resident Alien for tax purposes and have contacted Janet Kunz at 540-231-3754 or jakunz@vt.edu to discuss the additional documentation that is required by federal law.

1. Name

First: ________________________ Middle: _____________________ Last: _________________________

2. U.S. taxpayer identification number (required)

____

_______3. Address (number, street, and apt. or suite no.)

____

_______4. City, State and ZIP code

____

Certification:
Under the penalties of perjury, I declare that to the best of my knowledge and belief, the above statements are true, correct, and complete and that:

1. The number shown on this form is my correct taxpayer identification number, **and**
2. I am not subject to backup withholding because: (a) I am exempt from backup withholding, or (b) I have not been notified by the Internal Revenue Service (IRS) that I am subject to backup withholding as a result of a failure to report all interest or dividends, or (c) the IRS has notified me that I am no longer subject to backup withholding, **and**
3. I am a U.S. person (including a U. S. resident alien).

Certification Instructions. You must cross out item 2 above if you have been notified by the IRS that you are currently subject to backup withholding because you have failed to report all interest and dividends on your tax return.

Signed:______________________________________ Date: ______________

Revised 8/01

Appendix D: Health Screening

Health Screening Questionnaire

1. Are you in good general health? Yes No

   If "No", list any health-related conditions you are experiencing or have experienced in the recent past.

   ____
   ____
   ____
   ____

2. Have you, in the last 24 hours, experienced any of the following conditions?

	Session 1	
Inadequate sleep	Yes	No
Hangover	Yes	No
Headache	Yes	No
Cold symptoms	Yes	No
Depression	Yes	No
Allergies	Yes	No
Emotional upset	Yes	No

3. Do you have a history of any of the following?

   Visual Impairment Yes No

   (If yes, please describe.)

   ____
   ____
   ____

   Seizures or other lapses of consciousness Yes No

   (If yes, please describe.)

   ____

Any disorders similar to the above or that would impair your driving ability   Yes   No

(If yes, please describe.)

____

____

____

4. List any prescription or non-prescription drugs you are currently taking or have taken in the last 24 hours that may interfere with your ability to drive (e.g., medications that may cause drowsiness, medications that may make you dizzy).

____

____

5. List the approximate amount of alcohol (beer, wine, fortified wine, or liquor) you have consumed in the last 24 hours.
Session 1: ____

6. Emergency Contact Information (Optional)

Name:____

Telephone Number: ____________________________

______________________________   _________________
Signature   Date

For experimenter use:

Vision Test (Snellen)   ____________________

Color vision: ______________

____

____

____

____

____

Appendix E: Pre-Drive Questionnaire

1. How long have you had your driver's license? ____________years

2. Approximately what is your annual mileage? __________miles
    1.

3. Are you…(circle one)
    a. Employed
    b. Student
    c. Retired
    d. Unemployed
4. If you are employed, do you drive as part of your work requirement? (circle one)
    a. Yes
    b. No
5. What is the make/model/year of your current vehicle?
    Make_______________
    Model______________
    Year________________
6. Which type of transmission does your primary vehicle have? (circle one)
    a. automatic
    b. manual (stick, straight, standard)
    c. select shift (automatic with a manual option)

7. Does your vehicle have any of the following (please check all that apply)?
    - ☐ Head Up Display
    - ☐ Navigation system
    - ☐ Voice recognition
    - ☐ Adaptive Cruise Control
    - ☐ Forward Collision Warning
    - ☐ Park aid
    - ☐ Rear Vision System (monitor)
    - ☐ Blind Spot Alert
    - ☐ None of the above

8. Do you have experience using any of the following (please check all that apply)?
   - ☐ Head Up Display
   - ☐ Navigation system
   - ☐ Voice recognition
   - ☐ Adaptive Cruise Control
   - ☐ Forward Collision Warning
   - ☐ Park aid
   - ☐ Rear Vision System (monitor)
   - ☐ Blind Spot Alert
   - ☐ None of the above

9. What percentage of driving trips do you use your cell phone? (circle one)
   a. 0-25%
   b. 26-50%
   c. 51-75%
   d. 76-100%

10. How many times do you use your cell phone in a typical trip? _________ times

Appendix F: Telephone Interview Questions

1. Have you experienced any of the assistive safety systems in the vehicle? YES
      NO
   2. If "No", skip to question 10

3.

2. Please describe the events that triggered the assistive safety system?
   4. ____
   5. ____
   6.
3. Please describe the assistive safety system you experienced?
   7. ____
   8. ____
   9. If it was not the CICAS system, skip to question 8
   10. If they mention the visual warning, continue to question 4
   11. If they mention the auditory warning, continue to question 5
   12. If they mention the Haptic warning, continue to question 6
   13.
4. VISUAL ICON:
   a. What color was the icon you saw? ______________
   b. Did it change colors? _________________
      i. If so, did you notice when it changed colors? ______________________
   c. What did it mean to you? ____________________________
      14.
5. AUDITORY WARNING:
   a. Please describe the sound you heard:____________________________________
   b. Was it a word or a tone?   WORD   TONE
      i. If "Word", what was the word? _________________________
      ii. If "Tone", what did it sound like? _________________________
   c. What did it mean to you? __________________________
      15.
6. HAPTIC WARNING:
   a. Please describe what you felt the car doing? ________________________________
   b. What did you think was happening? ___________________________
      16.
7. Did you stop? YES   NO
   17.
8. What are your thoughts about the warning?
   18. ____

19. ____

20.

9. How comfortable do you feel, knowing that this system is in the vehicle?

21.

10. Do you have any questions or concerns?

Appendix G: Smart Road Test-track Informational Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informational Form for Participants
in Research Projects Involving Human Subjects

Title of Project: CICAS: Pilot Field Operational Test
Investigator(s): Vicki Neale, Zac Doerzaph, Derek Viita, Kendra Wiegand, and Jodi Bowman

I. Purpose of this Research Project
The purpose of this research project is to evaluate in-vehicle devices and identify your comfort level with these devices. Two-hundred (200) adults will be recruited to participate for this study. There will be an equal number of males and females.

II. Procedures

You have just completed the naturalistic driving portion of this study. This next portion involves driving the same instrumented vehicle on the Smart Road.

For this session, you will be asked to read and sign this informational form. You will then be asked to drive the vehicle on the Smart Road with a trained experimenter and complete some questionnaires about your experience. Shortly after that time, you will receive final payment for participation.

Your role during this study will be to drive a vehicle on the Smart Road. It is important that you understand that we are not evaluating <u>you</u> in any way. We are collecting information about the in-vehicle devices.

III. Risks

Caution should be exercised when operating a vehicle with which you are not familiar. Be aware that accidents can happen at any time while driving.

As a participant, you may be exposed to the following risks or discomforts by volunteering for this research:

1. The risk of an accident normally present while driving.
2. Any risk present when driving a new and unfamiliar vehicle.
3. While you are driving the vehicle, cameras will videotape you. Due to this fact, we will ask you not to wear sunglasses unless absolutely necessary; however, if at

any time you are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and surrounding environment, sunglasses are recommended.

The following precautions will be taken to ensure minimal risk to you:

1. You may take breaks or decide not to participate at any time.
2. The vehicle is equipped with a driver's side and passenger's side airbag, supplemental restraint system, fire extinguisher, and first-aid kit.
3. All data collection equipment is mounted such that, to the greatest extent possible, it does not pose a hazard to you in any foreseeable case.
4. The experiment will not be run during hazardous road conditions, including wet or icy conditions.
5. You will be required to wear the lap and shoulder belt restraint system while in the car.
6. In the event of a medical emergency, or at your request, VTTI staff will arrange medical transportation to a nearby hospital emergency room. Note that in addition to the in-vehicle experimenter being present, the road and its communications channels are monitored by dispatchers at all times, who can quickly notify the necessary emergency services if required.

In the event of a medical emergency, or at your request, VTTI staff will arrange medical transportation to a nearby hospital emergency room. The cost of this transportation would be covered by whichever insurance policy covers the incident causing the medical emergency (see examples in the next section).

In the event of an accident or injury in an automobile owned or leased by Virginia Tech, the automobile liability coverage for property damage and personal injury is provided. The total policy amount per occurrence is $2,000,000. This coverage (unless the other party was at fault, which would mean all expense would go to the insurer of the other party's vehicle) would apply in case of an accident for all volunteers and would cover medical expenses up to the policy limit. For example, if you were injured in an automobile owned or leased by Virginia Tech, the cost of transportation to the hospital emergency room would be covered by this policy. Any coverage of the participant is limited to the terms and conditions of the insurance policy.

Participants in a study are considered volunteers, regardless of whether they receive payment for their participation; under Commonwealth of Virginia law, worker's compensation does not apply to volunteers; therefore, if not in the automobile, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses. For example, if you were injured outside of the automobile owned or leased by Virginia Tech, the cost of transportation to the hospital emergency room would be covered by your insurance.

IV. Benefits

While there are no direct benefits to you from this research, you may find the experiment interesting. No promise or guarantee of benefits is made to encourage you to participate. Participation in this study will contribute to the improvement of future studies concerning advanced vehicle systems.

V. Extent of Anonymity and Confidentiality

The data gathered in this experiment will be treated with confidentiality. Shortly after participation, your name will be separated from your data. A coding scheme will be employed to identify the data by participant number only (e.g., Participant No. 1). If you choose to do so, you will be allowed to see your data and withdraw the data from the study if you so desire. If you want to base withdrawal of your data on observation of the data, you must ask for an appointment to see the data immediately after you finish your participation. If upon seeing your data you decide to withdraw it from the experiment, the data will be promptly removed and discarded. At no time will the researchers release data identifiable to an individual to anyone other than individuals working on the project without your written consent. VTTI will not turn over the video of your image to its client without your permission. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

VI. Compensation

You will be paid $25.00 per hour for participating in this session, including the time you spend completing paperwork and filling out questionnaires. You will be paid at the end of today's session. Your payment will be in cash, unless you receive more than $75.00, in which case it will be by check.

VII. Freedom to Withdraw

As a participant in this research, you are free to withdraw at any time without penalty. If you choose to withdraw, you will be compensated for the portion of time of the study for which you participated. Furthermore, you are free not to answer any question or respond to experimental situations without penalty.

VIII. Subject's Responsibilities

If you voluntarily agree to participate in this study, you will have the following responsibilities:

1. To follow the experimental procedures as well as you can.
2. To inform the experimenter if you have difficulties of any type.

3. To wear your seat and lap belt.
4. To abide by the posted speed limits and traffic laws.
5. To abstain from any substances that will impair your ability to drive.
6. To drive the test vehicle in a safe and responsible manner.

Participant's Permissions and acknowledgments

Check one of the following:

□ VTTI **has my permission** to provide digital video including my image to the sponsor of this research. I understand that the sponsor will only see the video for research purposes.

□ VTTI **does not have my permission** to provide digital video including my image to the sponsor of this research. I understand that VTTI will maintain possession of the digital video, and that it will only be used for research purposes.

X. Subject's Permission
I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:
____ Date__________
Subject signature
____ Date __________
Witness (Optional except for certain classes of subjects)

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject, I may contact:

Investigators
Derek Viita xxx-xxxx
Zac Doerzaph xxx-xxxx

David M. Moore
Chair, Virginia Tech Institutional Review
Board for the Protection of Human Subjects
Office of Research Compliance
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, VA 24060

[NOTE: Subjects must be given a complete copy (or duplicate original) of the signed Informed Consent.]

Participant Number: ____

Appendix H:Post-Unexpected Event Questionnaire for Those Who Stopped

The true purpose of this research is to evaluate warnings which are intended to warn you that you may be about to go through either a red light or stop sign, and you may have to stop quickly. One aspect of the research project deals with how people might respond to such a warning. To do this, we needed to create a situation where you were presented with the warning while not looking at the forward roadway. If you had been looking directly at the road, you might have seen the light turn red and the data would not have been as useful. There was no "correct" or "incorrect" information in the data that you provided. We are simply evaluating how drivers respond to this situation. All known precautions were taken to ensure your complete safety throughout this session and during the presentation of the scenario. Please let the experimenter know at this time if you would like further explanation before completing this questionnaire.

Questionnaire

Please keep in mind, there is no "correct," "incorrect," or expected way for you to respond. We are interested in your honest opinion.

Please **circle one number** that most closely corresponds to your experience during this stop.

---

1. I expected this event at the time it occurred.

Do Not at All Agree	1	2	3	4	5	6	7	Strongly Agree

---

2. What do you think about the timing of the warning?

Too Early	1	2	3	4 Just Right	5	6	7	Too Late

---

3. How comfortable was the stop you just made?

Very Uncomfortable	1	2	3	4	5	6	7	Very Comfortable

---

4. Please rate your level of vehicle control during the stop you just made.

Very Much In Control	1	2	3	4	5	6	7	Very Much Out of Control

5. Please rate your feeling of safety during the stop.

Not At All Safe	1	2	3	4	5	6	7	Very Safe

6. Did you notice anything come on or happen inside the car before you began braking?

Yes No

If yes, please describe what came on (please be as specific as possible).

7. Did you notice anything else come on or happen inside the car before you began braking?

Yes No

If yes, please describe what came on (please be as specific as possible).

If driver mentioned a warning:

8. Please describe the warning you just received.

If driver mentioned a visual alert:

9. What color was the indicator?

10. Where was this indicator located?

11. Please describe the picture.

12. What does this picture mean to you?
13. Please rate the intensity and duration of the visual alert using the following scales:

a. How would you rate the intensity of the visual alert that occurred during this warning?

1	2	3	4	5	6	7
Extremely Dim	Moderately Dim	Slightly Dim	Just Right	Slightly Bright	Moderately Bright	Extremely Bright

b. How would you rate the duration or length of this warning?

1	2	3	4	5	6	7
Extremely Short	Moderately Short	Slightly Short	Just Right	Slightly Long	Moderately Long	Extremely Long

If driver mentioned an auditory alert:
14. What was the type of sound you noticed?

15. Was the sound a tone, a word, or both?

If you heard a tone, please describe the sound.

If you heard a word, please say the word.

16. Please rate the intensity and duration of the speech alert using the following scales:

a. How would you rate the sound of the speech alert that occurred during this warning?

1	2	3	4	5	6	7
Extremely	Moderatel	Slightly	Just Right	Slightly	Moderatel	Extremely

Quiet	y Quiet	Quiet		Loud	y Loud	Loud

b. How would you rate the duration or length of this warning?

1	2	3	4	5	6	7
Extremely Short	Moderately Short	Slightly Short	Just Right	Slightly Long	Moderately Long	Extremely Long

If driver mentioned a brake pulse alert:

17. Please describe the sensation or what you felt.

18. Why do you think this occurred? *After they answer, clarify that it was meant to be a warning, if it is not clearly understood*.

19. Please rate the strength and duration of the brake pulse using the following scales:

a. How would you rate the strength of the vehicle jerk that occurred during this warning?

1	2	3	4	5	6	7
Extremely Weak	Moderately Weak	Slightly Weak	Just Right	Slightly Strong	Moderately Strong	Extremely Strong

b. How would you rate the duration or length of this warning?

1	2	3	4	5	6	7
Extremely Short	Moderately Short	Slightly Short	Just Right	Slightly Long	Moderately Long	Extremely Long

20. How many times did you feel the car _______? (*use the term the participant used to refer to the system*)

21. How many times did you feel ______ happening?

Participant Number: ____

Appendix I: Post-Unexpected Event Questionnaire for Those Who Do Not Stop

The true purpose of this research is to evaluate warnings which are intended to warn you that you may be about to go through either a red light or stop sign, and you may have to stop quickly. One aspect of the research project deals with how people might respond to such a warning. To do this, we needed to create a situation where you were presented with the warning while not looking at the forward roadway. If you had been looking directly at the road, you might have seen the light turn red and the data would not have been as useful. There was no "correct" or "incorrect" information in the data that you provided. We are simply evaluating how drivers respond to this situation. All known precautions were taken to ensure your complete safety throughout this session and during the presentation of the scenario. Please let the experimenter know at this time if you would like further explanation before completing this questionnaire.

Questionnaire

Please keep in mind, there is no "correct," "incorrect," or expected way for you to respond.

Please **circle one number** that most closely corresponds to your experience during this stop.

1. I expected this event at the time it occurred.

Do Not at All Agree	1	2	3	4	5	6	7	Strongly Agree

2. What do you think about the timing of the warning?

Very Early	1	2	3	4 Just Right	5	6	7	Very Late

3. Why did you decide not to stop?

4. If I had decided to stop the car it would have been:

Not At All Difficult	1	2	3	4	5	6	7	Very Difficult

5. If I had decided to stop, I would have been:

Very Much In Control of the Vehicle	1	2	3	4	5	6	7	Very Much Out of Control of the Vehicle

6. Please rate your feeling of safety as you crossed the intersection

Not At All Safe	1	2	3	4	5	6	7	Very Safe

7. Did you notice anything come on or happen inside the car before you crossed the intersection?

Yes No

If yes, please describe what came on (please be as specific as possible).

8. Did you notice anything else come on or happen inside the car before you crossed the intersection?

Yes No

If yes, please describe what came on (please be as specific as possible).

If driver mentioned a warning:
9. Please describe the warning you just received.

If driver mentioned a visual alert:
10. What color was the indicator?

11. Where was this indicator located?

12. Please describe the picture.

13. What does this picture mean to you?

14. Please rate the intensity and duration of the visual alert using the following scales:

a. How would you rate the intensity of the visual alert that occurred during this warning?

1	2	3	4	5	6	7
Extremely Dim	Moderatel y Dim	Slightly Dim	Just Right	Slightly Bright	Moderatel y Bright	Extremely Bright

b. How would you rate the duration or length of this warning?

1	2	3	4	5	6	7
Extremely Short	Moderatel y Short	Slightly Short	Just Right	Slightly Long	Moderatel y Long	Extremely Long

If driver mentioned an auditory alert:

15. What was the type of sound you noticed?

16. Was the sound a tone, a word, or both?

If you heard a tone, please describe the sound.

If you heard a word, please say the word.

17. Please rate the intensity and duration of the speech alert using the following scales:

a. How would you rate the sound of the speech alert that occurred during this warning?

1	2	3	4	5	6	7
Extremely Quiet	Moderatel y Quiet	Slightly Quiet	Just Right	Slightly Loud	Moderatel y Loud	Extremely Loud

b. How would you rate the duration or length of this warning?

1	2	3	4	5	6	7
Extremely Short	Moderatel y Short	Slightly Short	Just Right	Slightly Long	Moderatel y Long	Extremely Long

If driver mentioned a brake pulse alert:
18. Please describe the sensation or what you felt.

19. Why do you think this occurred? *After they answer, clarify that it was meant to be a warning, if it is not clearly understood*.

20. Please rate the strength and duration of the brake pulse using the following scales:

a. How would you rate the strength of the vehicle jerk that occurred during this warning?

1	2	3	4	5	6	7
Extremely Weak	Moderatel y Weak	Slightly Weak	Just Right	Slightly Strong	Moderatel y Strong	Extremely Strong

b. How would you rate the duration or length of this warning?

1	2	3	4	5	6	7
Extremely Short	Moderatel y Short	Slightly Short	Just Right	Slightly Long	Moderatel y Long	Extremely Long

21. How many times did you feel the car _______? (*use the term the participant used to refer to the system*)

22. How many times did you feel ______ happening?

Appendix J: Informed Consent

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants of Investigative Projects
Debriefing and Informed Consent for Participants of Investigative Projects

Title of Project: Pilot Field Operational Test
Investigator(s): Vicki Neale, Zac Doerzaph, Derek Viita, Kendra Wiegand, and Jodi Bowman

I. The Purpose of this Research Project
The true purpose of this research is to evaluate a system which would warn drivers if they are about to run a red light or stop sign. One aspect of the research project deals with how people might respond to such a warning. To do this, we needed to create a situation in which you were presented with the warning while looking away from the forward roadway. If you had been looking directly at the road, you might have seen the light turn red and the data would not have been as useful. There was no "correct" or "incorrect" information in the data that you provided. We are simply evaluating how drivers respond to this situation. All known precautions were taken to ensure your complete safety throughout this session and during the presentation of the scenario. We would like to thank you for your participation in this study, as the results may contribute to future improvements of collision avoidance systems. We would also like to ask that you do not talk about the details of this study to others for at least 8 months after your participation as this may invalidate future data that may be collected.

We again assure you that all data will be treated with complete anonymity. Shortly after participating, your name will be separated from the data. A coding scheme will be employed to identify the data by subject number only (for example, Subject No. 3).

All other aspects of the earlier informed consents you signed, including risks, benefits, safety precautions, and your responsibilities, continue to apply to the remainder of this experiment.

☐ Please check if you give your voluntary consent for your data to be used in this project.

I hereby acknowledge the above.

____

Participant's Signature	Date

Should I have any questions about this research or its conduct, I may contact:

Investigators	Telephone/email
Derek Viita	xxx-xxxx
Zac Doerzaph	xxx-xxxx

David M. Moore xxx-xxxx
Chair, Virginia Tech Institutional Review
Board for the Protection of Human Subjects
Office of Research Compliance

Appendix K: Post Driving Questionnaire: Experienced Alert during Naturalistic Driving

Thank you for taking the time to complete this questionnaire. Your feedback is important to us because it will help us understand how to improve the Intersection Warning System. We are interested in learning your honest opinions about the System and about your experiences driving the research vehicle. The questionnaire should only take about 10-15 minutes of your time. Please note that your answers will be completely confidential.

As you read through the questionnaire you will notice that it has several sections. Each section will ask your opinion about the Intersection Warning System and its three parts: the "Running Red Light" alert, the "Running Stop Sign" alert, and the "Intersection Ahead" display.

Questionnaire Sections

A. Your Overall Impressions of the "Running Red Light" Alert
B. Your Overall Impressions of the "Running Stop Sign" Alert
C. Your Experiences Driving the Research Vehicle at Red Lights and Stop Signs
D. "Running Red Light" Alerts at Traffic Lights
E. "Running Stop Sign" Alerts at Stop Signs
F. The "Intersection Ahead" Display
G. The "Running Red Light/Stop Sign" Display
H. The Speech Alert
I. The Brake Pulse Alert
J. Purchasing the System
K. Open-ended Question (where we ask you for your suggestions on improving the system)

After reading each statement, please rate how strongly you agree or disagree with it by circling the corresponding number. If you would like to clarify an answer, feel free to write your comments alongside the question.

Example:

A.) Strawberry ice cream is better than chocolate.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

You would circle the "1" if you really liked chocolate ice cream, or you might really like strawberry ice cream. In which case, you would circle the "7."

Section A. Your Overall Impressions of the "Running Red Light" Alert

This section applies to the Intersection Warning System for Traffic Lights only (not stop signs).

1. The "running red light" alert that let me know that I may be about to run a red light was useful in my everyday driving.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

2. The "running red light" alert was effective at communicating that I may be about to run a red light.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

3. The "running red light" alert was effective at getting my attention quickly.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

4. What do you think about the timing of the "running red light"?

1	2	3	4	5	6	7
Too Early			Just Right			Too Late

5. When I received the "running red light" alert, I braked without checking for traffic behind me.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

6. The "running red light" alert was annoying when the alert was unnecessary.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

7. I feel the “running red light” alert will increase my driving safety.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

8. If I was told that I was allowed to turn the “running red light” alert system off, I would have turned it off for the rest of my driving experience.

   - ☐ Yes
   - ☐ No

9. Did you ever intentionally activate the “running red light” alert?

   - ☐ Yes
   - ☐ No

10. Overall, how satisfied were you with the “running red light” alert?

1	2	3	4	5	6	7
Not at all Satisfied						Very Satisfied

<u>Section B. Your Overall Impressions of the “Running Stop Sign” Alert</u>

This section applies to the Intersection Warning System for Stop Signs only (not traffic lights).

11. The “running stop sign” alert that let me know that I may be about to run a stop sign was useful in my everyday driving.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

12. The “running stop sign” alert was effective at communicating that I may be about to run a stop sign.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

13. The “running stop sign” alert was effective at getting my attention quickly.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

14. What do you think of the timing of the "running stop sign" alert?

1	2	3	4	5	6	7
Too Early			Just Right			Too Late

15. When I received the "running stop sign" alert, I braked without checking for traffic behind me.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

16. The "running stop sign" alert was annoying when the alert was unnecessary.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

17. I feel the "running stop sign" alert will increase my driving safety.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

18. If I was told that I was allowed to turn the "running stop sign" alert system off, I would have turned it off for the rest of my driving experience.

☐ Yes
☐ No

19. Did you ever intentionally activate the "running stop sign" alert?

☐ Yes
☐ No

20. Overall, how satisfied were you with the "running stop sign" alert?

1	2	3	4	5	6	7
Not at all Satisfied						Very Satisfied

<u>Section C. Your Experiences Driving the Research Vehicle at Red Lights and Stop Signs</u>

21. How many times, if ever, did you run a red light or come close to running a red light while driving the test vehicle?

    __________ times (please state a number)

22. How many times, if ever, did you run a stop sign or come close to running a stop sign while driving the test vehicle?

    __________ times (please state a number)

<u>Section D. “Running Red Light” Alerts at Traffic Lights</u>

23. How many times, if ever, did you get a “running red light” alert while approaching a traffic light that you felt was appropriate?

    __________ times (please state a number)

24. How many times, if ever, did you get a “running red light” alert that you felt was not necessary?

    __________ times (please state a number)

25. How many times, if ever, did you <u>NOT</u> get a “running red light” alert when you felt one was appropriate?

    __________ times (please state a number)

26. How many times, if ever, did you get a “running red light” alert where you could not identify the source of the alert?

    __________ times (please state a number)

<u>Section E. “Running Stop Sign” Alerts at Stop Signs</u>

27. How many times, if ever, did you get a “running stop sign” alert that you felt was appropriate?

    __________ times (please state a number)

28. How many times, if ever, did you get a “running stop sign” alert that you felt was not necessary?

    __________ times (please state a number)

29. How many times, if ever, did you NOT get a “running stop sign” alert when you felt one was appropriate?

    __________ times (please state a number)

30. How many times, if ever, did you get a “running stop sign” alert where you could not identify the source of the alert?

    __________ times (please state a number)

The next sections address the issue of the location, color, and conspicuity of the warning system itself. The items in these sections will ask your opinions about how easy it was for you to notice and interpret the displays.

Section F. The “Intersection Ahead” Display

31. The blue “intersection ahead” display was effective in letting me know that the intersection warning system had detected an intersection ahead.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

32. The blue “intersection ahead” display was easy to detect.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

33. I like the location of the blue “intersection ahead” display.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

34. The size of the blue “intersection ahead” display was appropriate.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

35. The blue “intersection ahead” display was annoying.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

36. The blue “intersection ahead” display was distracting.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

<u>Section G. The “Running Red Light/Stop Sign” Display</u>

37. The red flashing alert was effective in letting me know that I may be about to run a red light or stop sign.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

38. The red flashing alert was easy to detect.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

39. I like the location of the red flashing alert.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

40. The red flashing alert was effective at getting my attention quickly.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

41. The red flashing alert was startling.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

42. The red flashing alert was annoying.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

43. The red flashing alert was distracting.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

<u>Section H: The Speech Alert</u>

44. The speech ("stop sign,", "stop light") alert was effective in letting me know that I may be about to run a red light or stop sign.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

45. The speech alert was easy to detect.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

46. The speech alert was effective at getting my attention quickly.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

47. The speech alert was startling.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

48. The speech alert was annoying.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

49. The speech alert was distracting.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

Section I: The Brake Pulse Alert

50. The brake pulse (vehicle jerk) alert was effective in letting me know that I may be about to run a red light or stop sign.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

51. The brake pulse alert was easy to detect.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

52. The brake pulse alert was effective at getting my attention quickly.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

53. The brake pulse alert was startling.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

54. The brake pulse alert was annoying.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

55. The brake pulse alert was distracting.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

Section J: Purchasing the System

56. Cost aside, if you were purchasing a new vehicle, how likely would you be to consider purchasing the Intersection Warning System?

1	2	3	4	5	6	7
Not at All Likely						Very Likely

57. At what price level might you begin to feel this feature is too expensive to consider purchasing?

    ____________ dollars

Open-ended Question

58. Do you have any suggestions for improving the intersection warning system that might improve it?

Thank you for your feedback. Your responses in this questionnaire will help us determine how to improve the Intersection Warning System.

Appendix L: Post Driving Questionnaire: Experienced Alert ONLY during Smart Road Portion

Thank you for taking the time to complete this questionnaire. Your feedback is important to us because it will help us understand how to improve the Intersection Warning System. We are interested in learning your honest opinions about the System and about your experiences driving the research vehicle. The questionnaire should only take about 10-15 minutes of your time. Please note that your answers will be completely confidential.

As you read through the questionnaire you will notice that it has several sections. Each section will ask your opinion about the Intersection Warning System and its two parts: the "Running Red Light" alert and the "Intersection Ahead" display.

<u>Questionnaire Sections</u>

A. Your Overall Impressions of the "Running Red Light" Alert
B. Your Experiences Driving the Research Vehicle at Red Lights and Stop Signs
C. The "Intersection Ahead" Display
D. The "Running Red Light/Stop Sign" Display
E. The Speech Alert
F. The Brake Pulse Alert
G. Purchasing the System
H. Open-ended Question (where we ask you for your suggestions on improving the system)

After reading each statement, please rate how strongly you agree or disagree with it by circling the corresponding number. If you would like to clarify an answer, feel free to write your comments alongside the question.

Example:

A.) Strawberry ice cream is better than chocolate.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

You would circle the "1" if you really liked chocolate ice cream, or you might really like strawberry ice cream. In which case, you would circle the "7."

Section A: Your Overall Impressions of the "Running Red Light" Alert

1. The "running red light" alert that let me know that I may be about to run a red light would be useful in my everyday driving.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

2. The "running red light" alert was effective at communicating that I may be about to run a red light.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

3. The "running red light" alert was effective at getting my attention quickly.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

4. What did you think about the timing of the "running red light" alert?

1	2	3	4	5	6	7
Too Early			Just Right			Too Late

5. I feel the "running red light" alert will increase my driving safety.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

6. Overall, how satisfied were you with the "running red light" alert?

1	2	3	4	5	6	7
Not at all Satisfied						Very Satisfied

Section B: Your Experiences Driving the Research Vehicle at Red Lights and Stop Signs

7. How many times, if ever, did you run a red light or come close to running a red light while driving with the test vehicle?

   ____________ times (please state a number)

8. How many times, if ever, did you run a stop sign or come close to running a stop sign while driving with the test vehicle?

   22.__________ times (please state a number)

The next sections address the issue of the location, color, and conspicuity of the warning system itself. The items in these sections will ask your opinions about how easy it was for you to notice and interpret the displays.

Section C: The "Intersection Ahead" Display

9. The blue "intersection ahead" display was effective in letting me know that the intersection warning system had detected an intersection ahead.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

10. The blue "intersection ahead" display was easy to detect.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

11. I like the location of the blue "intersection ahead" display.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

12. The size of the blue "intersection ahead" display was appropriate.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

13. The blue “intersection ahead” display was annoying.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

14. The blue “intersection ahead” display was distracting.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

<u>Section D: The “Running Red Light/Stop Sign” Display</u>

15. The red flashing alert was effective in letting me know that I may be about to run a red light or stop sign?

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

16. The red flashing alert was easy to detect.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

17. I like the location of the red flashing alert.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

18. The red flashing alert was effective at getting my attention quickly.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

19. The red flashing alert was startling.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

20. The red flashing alert was annoying.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

21. The red flashing alert was distracting.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

Section E: The Speech Alert

22. The speech ("stop light") alert was effective in letting me know that I may be about to run a red light.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

23. The speech alert was easy to detect.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

24. The speech alert was effective at getting my attention quickly.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

25. The speech alert was startling.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

26. The speech alert was annoying.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

27. The speech alert was distracting.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Section F: The Brake Pulse Alert

28. The brake pulse (vehicle jerk) alert was effective in letting me know that I may be about to run a red light.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

29. The brake pulse alert was easy to detect.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

30. The brake pulse alert was effective at getting my attention quickly.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

31. The brake pulse alert was startling.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

32. The brake pulse alert was annoying.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

33. The brake pulse alert was distracting.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Section G: Purchasing the System

34. Cost aside, if you were purchasing a new vehicle, how likely would you be to consider purchasing the intersection warning system?

1	2	3	4	5	6	7
Not at All Likely						Very Likely

35. At what price level might you begin to feel this feature is too expensive to consider purchasing?

____________dollars

Section H: Open-ended question

36. Do you have any suggestions for improving the intersection warning system?

____

____

____

____

____

____

Thank you for your feedback. Your responses in this questionnaire will help us determine how to improve the Intersection Warning System.

Appendix M: Post Driving Questionnaire: Did NOT Experience Alert

Thank you for taking the time to complete this questionnaire. Your feedback is important to us because it will help us understand how to improve the Intersection Warning System. We are interested in learning your honest opinions about the System and about your experiences driving the research vehicle. The questionnaire should only take about 5-10 minutes of your time. Please note that your answers will be completely confidential.

As you read through the questionnaire you will notice that it has several sections and will ask your opinion about the Intersection Warning System and its display: the Intersection Ahead display.

<u>Questionnaire Sections</u>

A. Your Experiences Driving the Research Vehicle at Red Lights and Stop Signs
B. The "Intersection Ahead" Display
C. Purchasing the System
D. Open-ended Question (where we ask you for your suggestions on improving the system)

After reading each statement, please rate how strongly you agree or disagree with it by circling the corresponding number. If you would like to clarify an answer, feel free to write your comments alongside the question.

Example:
A.) Strawberry ice cream is better than chocolate.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

You would circle the "1" if you really liked chocolate ice cream, or you might really like strawberry ice cream. In which case, you would circle the "7."

Section A: Your Experiences Driving the Research Vehicle at Red Lights and Stop Signs

1. How many times, if ever, did you run a red light or come close to running a red light while driving with the test vehicle?

   ____________ times (please state a number)

2. How many times, if ever, did you run a stop sign or come close to running a stop sign while driving with the test vehicle?

   23.__________ times (please state a number)

Section B. The "Intersection Ahead" Display

The next section addresses the issue of the location, color, and conspicuity of the warning system itself. The items in this section will ask your opinions about how easy it was for you to notice and interpret the displays.

1. The blue "intersection ahead" display was effective in letting me know that the intersection warning system had detected an intersection ahead?

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

2. The blue "intersection ahead" display was easy to detect.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

3. I like the location of the blue "intersection ahead" display.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

4. The size of the blue "intersection ahead" display was appropriate.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

5. The blue “intersection ahead” display was annoying.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

6. The blue “intersection ahead” display was distracting.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

Section C: Purchasing the System

1. Cost aside, if you were purchasing a new vehicle, how likely would you be to consider purchasing the intersection warning system?

1	2	3	4	5	6	7
Not at All Likely						Very Likely

2. At what price level might you begin to feel this feature is too expensive to consider purchasing?

   ____________dollars

Section D: Open-ended question

3. Do you have any suggestions for improving the intersection warning system?

   ____

   ____

   ____

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Thank you for your feedback. Your responses in this questionnaire will help us determine how to improve the Intersection Warning System.

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