Summary of Projects Funded by the Federal Highway Administration for the National Surface Transportation Safety Center for Excellence from July 2006 to June 2014

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FOREWORD

The *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users* authorization established the National Surface Transportation Safety Center for Excellence (NSTSCE) at the Virginia Tech Transportation Institute (VTTI). The core objectives of NSTSCE were to conduct research and develop safety devices and techniques that enhance driver performance; examine advanced roadway delineation and lighting systems; improve understanding of the impact of driver fatigue on crashes; develop and evaluate means to reduce the frequency of fatigue-related crashes; develop techniques to address age-related driver issues; and transmit project results to practitioners.

NSTSCE's efforts were structured around a diverse stakeholders group: the Federal Government (the Federal Highway Administration (FHWA) and the Federal Motor Carrier Safety Administration), State Government (the Virginia Department of Transportation), academia (VTTI), and the private sector (General Motors® and Travelers® Insurance). The stakeholders group collectively reviewed individual project proposals from VTTI, selected proposals to be addressed by VTTI's researchers, and allocated resources to the selected projects. NSTSCE represented a great opportunity for important safety research to be conducted in support of safety goals broader than those of any individual stakeholder. A total of 58 of the projects conducted by NSTSCE involved the direct funding participation by FHWA to develop advanced safety methods.

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Director, FHWA Office of Safety
Research and Development

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16. Abstract

This report summarizes the research projects undertaken at the National Surface Transportation Safety Center for Excellence (NSTSCE) under funding provided by the Federal Highway Administration (FHWA). FHWA was an important founding member of NSTSCE in 2006 and chaired the original stakeholders committee for several years. They maintained membership in NSTSCE until June 2014. With their guidance and financial contribution, 58 projects were conducted that support NSTSCE's mission of developing and disseminating advanced transportation safety techniques and innovations in both rural and urban communities. The report is organized according to NSTSCE's five research focus areas: enhancing driver performance, examining roadway lighting and delineation, addressing age-related issues, addressing issues of fatigue, and providing outreach. Each project contains a brief, general description about its methods and findings and identifies any deliverables.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ABBREVIATIONS

ALD	Adaptive Lighting Database
AVC	Animal-vehicle collisions
BMI	Body mass index
CI	Confidence interval
CIE	Commission Internationale d' Eclairage
CMV	Commercial motor vehicle
CNC	Crash and near-crash
CSRC	Collaborative Safety Research Center (Toyota®)
DAS	Data acquisition system
DDWS	Drowsy driver warning system
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FOT	Field operational test
GPS	Global Positioning System
H&W	Health and wellness
IFSTTAR	French Institute of Science and Technology for Transport, Spatial Planning, Development and Networks
IMU	Inertial measurement unit
HGF	High g-force
LED	Light-emitting diode
NC	Near-crash
ND	Naturalistic driving
NDS	Naturalistic driving study
NSTSCE	National Surface Transportation Safety Center of Excellence
NTDS	Naturalistic Truck Driving Study
OLAP	On-Line Analytical Processing
ORD	Observer rating of drowsiness
OSA	Obstructive sleep apnea
OTC	Over-the-counter
PI	Principal investigator
R&R	Repeatability and reproducibility
RID	Roadway Information Database
RLMMS	Roadway Lighting Mobile Measurement System
Rx	Prescription
SCE	Safety-critical event
SCI	Safety-critical incident
SHRP2	Strategic Highway Research Program 2
SME	Subject-matter expert
VDOT	Virginia Department of Transportation
VTTI	Virginia Tech Transportation Institute

CHAPTER 1. INTRODUCTION

BACKGROUND

Section 5309 of Public Law 109-59 (*Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users*) directed the Secretary of Transportation to "Establish the Center for Excellence in Surface Transportation Safety at the Virginia Tech Transportation Institute (VTTI)" and provide the sum of $750,000 per year for the establishment of the Center.[(1)] Furthermore, Public Law 109-59 offered the authority to award a cooperative agreement for this effort. VTTI worked with the Federal Highway Administration (FHWA) to develop this agreement and formed the National Surface Transportation Safety Center of Excellence (NSTSCE) in 2006. Its objective was to develop and disseminate advanced transportation safety techniques and innovations in both rural areas and urban communities. A multiyear strategic plan was developed, focusing on the following four surface transportation safety research areas:

- Safety devices and techniques that enhance driver performance.
- Advanced pavement delineation and lighting systems.
- Techniques to address age-related driver issues.
- Techniques to address fatigued driver issues.

RESEARCH FOCUS AREAS

Research areas were assigned a subject-matter expert (SME) who then developed projects that supported the strategic plan within each of the four focuses. To further facilitate this research, a stakeholder committee formed and was composed of organizations interested in improving surface transportation safety. FHWA chaired the original stakeholder committee, which included representatives from General Motors®, the Virginia Department of Transportation (VDOT), and VTTI. Each stakeholder provided $200,000 of funding annually for use on NSTSCE projects. In subsequent years, the Federal Motor Carrier Safety Administration (FMCSA) and Travelers® Insurance joined as stakeholders.

Each SME developed a list of possible projects, a scope of work to be accomplished within each project, and a budget. The individual projects were described in a document with the following headings and information:

- **Project title:** The formal title.
- **Lead researchers:** The project's principal investigator (PI) and often other key researchers.
- **Opportunity:** A brief description of the project's benefits.
- **Approach:** A brief description of how the project would be conducted.
- **Period of performance:** An estimate of the timeline, occasionally with specific dates when necessary (e.g., to leverage another project effort).

- **Probability of achieving results:** An estimate of the likelihood of project success. The stakeholders wanted a mixture of projects that were low risk that could be easily achieved and projects that were high risk but had the potential of high reward.

- **Deliverables:** Something produced from the project's efforts, such as a presentation highlighting the study and results, a new tool, a conference presentation, a final report, a Web site, etc.

- **Budget:** A rough cost estimate.

- **Strategic benefit:** A brief description of the importance to the NSTSCE program and transportation safety.

- **References:** A list of any relevant references that should be considered.

A compiled document of these two-page proposals was distributed to stakeholders prior to their annual fall meeting, where the SMEs or their designees presented each proposal and answered questions. The stakeholders concluded each meeting with a closed session, which included voting on the proposals and developing feedback for the SMEs, which resulted in that year's research portfolio implemented by the SMEs. The annual spring stakeholders meeting, designed to be interactive with questions and feedback, focused mostly on project status and progress. Occasionally, new projects were recommended to the stakeholders at the spring meeting, although these recommendation were fewer.

The reporting requirements mandated that FHWA funding be accounted for separately from the other funding sources. As a result, funding sources were tracked for FHWA projects. Initially, these projects were often created using a single source of funds. However, when changes were recommended for a project that required additional funding, other funds were used in some cases. Also, in some cases, the funds coming from multiple sources were allocated at the beginning of the project for logistical reasons. In all cases, the amount provided by FHWA to each project was tracked.

FHWA FUNDED PROJECTS

FHWA remained a member of the NSTSCE stakeholders committee until June 2014; during the span of its membership, FHWA funds contributed to 58 projects. The remaining four stakeholders continue to support NSTSCE.

An early requirement for the program was an outreach and marketing project for NSTSCE lasting from July 2006 to April 2010. The given budget of $245,405 was used specifically to provide outreach and marketing for NSTSCE that was approved by the stakeholders, including attempts to recruit other stakeholders who were supportive of the NSTSCE mission. From that point forward, specific outreach activities were proposed as projects along with those in the other four research areas. In 2012, NSTSCE added another SME who focused entirely on outreach.

This report details 58 projects, ranging from developing tools that could be used to support data collection to specific naturalistic data analysis activities designed to answer particular research

questions. Some of the projects were intermediate steps, while others were full projects with final reports. Final reports can be found at http://vtechworks.lib.vt.edu/handle/10919/5529 and will remain accessible to FHWA.

The projects presented in this report are grouped in chapters corresponding to their research area. The information for each project is organized as in table 1. Note that the funding shown is only the FHWA funding that was devoted to the project; in some cases, this was the only funding provided, and in other cases, funding from additional sources was required.

Table 1. Template for project information.

VTTI Project Number/Fund Code	Sub-fund charge number
Short Project Title	Project's common name
VTTI PI	Lead researcher
Begin	Sub-fund created
End	Sub-fund closed
FHWA Funding	Budget*
Long Project Title	Project's formal name
Project Description	General description
Deliverable	What was produced by the project

*VTTI received special permission from Virginia Tech to waive overhead on the FHWA NSTSCE funding to maximize its focus on research activities.

CHAPTER 2. DEVELOP SAFETY DEVICES AND TECHNIQUES THAT ENHANCE DRIVER PERFORMANCE

The first research area centered on investigating and developing safety devices and techniques that enhanced driver performance. Its broad span considered any aspect that could have a positive influence on driving performance not covered by the other three areas, such as evaluating specific in-vehicle devices or a Web site designed to help parents coach their teenagers on safe driving. Ultimately, the stakeholders expressed a great deal of interest in naturalistic driving; thus, improving its application became one of the research area's primary objectives. Key projects funded by FHWA in this area include the following:

- Developing data acquisition system (DAS) instrumentation bracketry for motorcycles.
- Creating a Web site for naturalistic driving data sharing.
- Creating a best practices document for international data sharing.
- Producing algorithms to better mine the naturalistic data for events of interest.
- Testing different statistical methods to apply to naturalistic data.

In 2010, the NSTSCE stakeholders reviewed each of the four research focus areas. Although the scope of other areas expanded because of the review, this area remained the same, with a continued focus on naturalistic driving. Table 2 through table 20 describe the 19 projects that are related to this research focus area.

Table 2. Method for Extracting Rural Driving Data from Naturalistic Driving Data.

VTTI Project Number/Fund Code	425767
Short Project Title	Method for Extracting Rural Driving
VTTI PI	Shane McLaughlin
Begin	December 2008
End	January 2008
FHWA Funding	$60,000.00
Long Project Title	Method for Extracting Rural Driving from Naturalistic Driving Data
Project Description	A methodology was developed for batch processing large quantities of naturalistic data to identify epochs of interest as they relate to geospatial information. Using this methodology, driving behavior and performance data can be related to specific locations or roadway networks to improve roadway safety and overall transportation system performance. The method permits more focused analyses in support of agency questions. For example, travel time and fuel efficiency can be studied and improved through investigation of driving behavior along specific corridors. Trip taking and routing selection behavior can be quantified and related to surrounding traffic to identify methods for reducing congestion.
Deliverable	*Method for Identifying Rural, Urban, and Interstate Driving in Naturalistic Driving Data*[(2)]

Table 3. Crash/Near Crash Algorithm for Use on Naturalistic Driving Data.

VTTI Project Number/Fund Code	425768
Short Project Title	Crash/Near Crash Algorithm
VTTI PI	Jeremy Sudweeks
Begin	July 2006
End	June 2014
FHWA Funding	$90,046.47
Long Project Title	Crash/Near Crash Algorithm for Use on Naturalistic Driving Data
Project Description	Identifying SCEs of interest from large naturalistic datasets in a cost-effective manner continues to be a problem. Kinematic thresholds are often used to identify potential SCEs. Trained video analysts then manually verify whether any of the kinematic triggers have successfully identified SCEs of interest. This project developed a crash/near crash algorithm using a functional yaw rate classifier that significantly reduced the number of false positives while maintaining the majority of SCEs.
Deliverable	*Using Functional Classification to Enhance Naturalistic Driving Data Crash/Near Crash Algorithms*[3]

SCE = safety-critical event.

Table 4. Driver Behavior in Crash Hot Spots and Rural Areas.

VTTI Project Number/Fund Code	425813
Short Project Title	Rural Driving Assessment
VTTI PI	Brad Cannon
Begin	October 2007
End	October 2009
FHWA Funding	$99,999.73
Long Project Title	Driver Behavior in Crash Hot Spots and Rural Areas
Project Description	The project used the method for extracting rural driving developed in an earlier NSTSCE project to address crash hot spots. Specifically, naturalistic driving data through intersections and rural road hotspots were compared to naturalistic driving data through similar intersections and rural road locations with low crash counts. Unfortunately, though the method had promise, the results showed few significant differences.
Deliverable	*Geospatial Analysis of High-Crash Intersections and Rural Roads Using Naturalistic Driving Data*[4]

Table 5. Distraction Index Framework.

VTTI Project Number/Fund Code	425814
Short Project Title	Distraction Index
VTTI PI	Miguel Perez
Begin	June 2008
End	June 2014
FHWA Funding	$50,008.74
Long Project Title	Distraction Index Framework
Project Description	The use of a radio while driving has long been considered socially acceptable. However, there is recent concern about radio usage, in its ever-changing context, remaining a relatively low-risk activity to perform while driving. This investigation examined how often drivers with access to an advanced and novel infotainment system for about 4 weeks were involved in CNC situations. Results suggest that the use of infotainment systems in NC events was slightly overrepresented. Furthermore, the use of infotainment systems had measurable demands on the driver's visual resources and tended to result in a reduced propensity of response to unexpected events on the forward roadway. However, the use had limited or no measurable effect on the control of the vehicle.
Deliverable	*Distraction Index Framework*[5]

CNC = Crash and near-crash.
NC = Near-crash.

Table 6. Modeling 100-Car Safety Events: A Case-Based Approach for Analyzing Naturalistic Driving Data.

VTTI Project Number/Fund Code	425815
Short Project Title	Modeling Crash Data—100-Car
VTTI PI	Feng Guo
Begin	November 2007
End	May 2008
FHWA Funding	$30,000.00
Long Project Title	Modeling 100-Car Safety Events: A Case-Based Approach for Analyzing Naturalistic Driving Data
Project Description	This project focused on methodological issues for evaluating risks using the safety outcomes of a naturalistic study. Specifically, it looked at different modeling approaches for CNCs in NDSs. The 100-car naturalistic study was used as the test dataset. A new baseline was selected based on driving time, simple contingency table analysis, the generalized estimating equation model, and the mixed-effect logistic regression model. This resulted in an integrated framework for modeling the safety outcomes of NDSs that addresses several critical methodological issues. The results indicate a certain level of discrepancy between the model-based approaches and the crude odds ratios.
Deliverable	*Modeling 100-Car Safety Events: A Case-Based Approach for Analyzing Naturalistic Driving Data*[6]

NDS = Naturalistic driving study.

Table 7. Data Mining of the Independence by Franklin Intersection.

VTTI Project Number/Fund Code	425820
Short Project Title	Franklin Intersection
VTTI PI	Zac Doerzaph
Begin	September 2008
End	October 2009
FHWA Funding	$74,993.15
Long Project Title	Data Mining of the Independence by Franklin Intersection
Project Description	This study analyzed previously collected data to investigate factors related to the prevalence of red-light violations at three signalized intersections with Franklin Street in Christiansburg, VA. Three four-way signalized intersections ranging in speed from 25 to 45 mi/h were used. Fixed instrumentation at the intersection was used to collect the data. The instrumentation included a GPS, weather station, traffic signal phase detector, a video camera off the traffic signal arm, and high-performance radar designed specifically for use at intersections. A sample of 3,000 violators out of the 16,998 potential violations was compared to a matched set of compliant vehicle approaches using a logistic regression model. The focus was on identifying and exploring causal factors with the aim of assisting efforts to discover potential strategies for mitigation.
Deliverable	*Identification of Factors Related to Violation Propensity: Mining the Data of the Franklin Intersections*[7]

GPS = Global Positioning System.

Table 8. Post-Processing to Determine Orientation of DAS Units.

VTTI Project Number/Fund Code	425821/451053
Short Project Title	IMU Calibration II/IMU Utility Tool
VTTI PI	Shane McLaughlin
Begin	February 2009/October 2010
End	June 2014/July 2011
FHWA Funding	$45,019.38/$35,000.00
Long Project Title	Post-Processing to Determine Orientation of DAS Units
Project Description	In NDSs, various mounting locations of the DAS instrumentation are often required. These different locations can prove challenging for a researcher attempting to use the kinematic data, particularly so in the case of naturalistic motorcycle driving research. Physical abuse, intentional manipulation, or simple vehicle vibration can cause instrumentation to become misaligned. Therefore, a method for monitoring changes to the mounting orientation would ensure its validity throughout the course of the study. Motorcycles are the most challenging vehicle for which to accurately interpret the IMU values. This is exacerbated by continued changes in alignment. Therefore, this study developed a method to determine the orientation of the DAS on a motorcycle as well as a method to monitor potential future misalignments of the DAS. A static alignment method was incorporated into the software that assisted motorcycle installerware so the initial mounting orientation could be determined. A kinematic alignment method was also developed for use with motorcycles. It is compatible with the Nextgen, MiniDAS, and Remote IMU systems. The kinematic alignment algorithm is currently being adapted to work with IMUs mounted on car and truck platforms.
Deliverable	*Post Processing to Determine Orientation of Inertial Measurement Units*[8]

IMU = Inertial measurement unit.

Table 9. Public Access to VTTI Data.

VTTI Project Number/Fund Code	425877
Short Project Title	Public Access
VTTI PI	Jeremy Sudweeks
Begin	September 2008
End	June 2012
FHWA Funding	$105,447.89
Long Project Title	Public Access to VTTI Data
Project Description	The purpose of this project was to develop and support a Web site to initially house the 100-car naturalistic crash, NC, and baseline datasets. This allowed multiple researchers to publish papers using this dataset. The Web site was later expanded to house some truck naturalistic datasets.
Deliverable	*VTTI Data Warehouse*[9]

Table 10. Bayesian Method for Naturalistic Driving Study.

VTTI Project Number/Fund Code	425895/425958
Short Project Title	Bayesian Model Project
VTTI PI	Feng Guo
Begin	October 2008/January 2010
End	August 2009/June 2014
FHWA Funding	$44,753.77/$14,793.40
Long Project Title	Bayesian Method for Naturalistic Driving Study
Project Description	This project developed Bayesian models for evaluating distraction risk using NDS data and looked at alternative models, including a hierarchical model, a random exposure model, and semiparametric Bayesian model. Methodology development for all three parts has been completed. The random exposure and semiparametric Bayesian models were applied to the 100-car data. For the hierarchical model, the evaluated models showed that the results are highly constrained by the number of strata and that the 100-car sample size is perhaps too small for its application.
Deliverable	*A Bayesian Random Exposure Poisson Regression Model to Evaluate the Risk of Visual-Manual Cellphone Tasks*[10]

Table 11. Data Center.

VTTI Project Number/Fund Code	425916
Short Project Title	Data Center
VTTI PI	Clark Gaylord
Begin	March 2009
End	June 2014
FHWA Funding	$115,072.09
Long Project Title	Data Center
Project Description	Facilitated by this project, VTTI completed needed upgrades to its computational and data management resources as well as improvements to data center operations and data analysis support software used in NDSs. The following upgrades were made: • Established a server virtualization test environment. • Improved operational monitoring of service uptime. • Upgraded to general purpose database servers supporting NDS instrumentation. • Researched project management Web servers. • Upgraded compute cluster dispatch node. • Acquired software licenses to support data analysis.
Deliverable	This project was intended to develop capability for other projects. No report was prepared.

Table 12. Texting.

VTTI Project Number/Fund Code	425956
Short Project Title	Texting
VTTI PI	Justin Owens
Begin	November 2009
End	March 2010
FHWA Funding	$15,000.00
Long Project Title	Texting
Project Description	This study presented an evaluation of driver performance while sending a text message via handheld mobile phones and an in-vehicle texting system. Participants sent and received text messages using their personal mobile phones and the vehicle's system while driving with an experimenter on a closed-road course. The test vehicle was an instrumented 2010 Mercury® Mariner equipped with an original equipment manufacturer in-vehicle system that supports text messaging and voice control of mobile devices via Bluetooth®, which was modified to allow text messaging during driving. A total of 20 participants were tested, 11 from the ages of 19 to 34 and 9 from the ages of 39 to 51. All participants were regular users of the in-vehicle system, although none had experience with the texting functions. Results indicated that handheld text message sending and receiving resulted in higher mental demand, more frequent and longer glances away from the roadway, and degraded steering measures compared to the baseline. Using the in-vehicle system to send messages showed less performance degradation but still had more task-related interior glance time and higher mental demand than the baseline. Using the system's text-to-speech functionality for incoming messages showed no differences from the baseline. These findings suggest that using handheld phones to send and receive text messages may interfere with drivers' visual and steering behaviors; the in-vehicle system showed improvement, but performance was not at baseline levels during message sending.
Deliverable	"Driver Performance While Text Messaging Using Handheld and In-Vehicle Systems"[11]

Table 13. Attention and Drowsy Driver Assist.

VTTI Project Number/Fund Code	425957
Short Project Title	J24
VTTI PI	Shane McLaughlin
Begin	February 2011
End	June 2014
FHWA Funding	$83,466.82
Long Project Title	Attention and Drowsy Driver Assist
Project Description	Several preliminary efforts were shared with the stakeholders on this project. With the stakeholders' guidance, this project's objective was shifted toward developing a probabilistic model of eye gaze as a function of driver performance variables collected from a vehicle. In this way, vehicle-based measures might be used to determine when the eyes are likely away from the road and adjust driver support systems accordingly, such as generating alerts to draw the driver's eyes back to the road. Eye-glance data from the 100-car study were used. In previous efforts, these data were coded as to the locations in front of, beside, and inside the vehicle. The present work collapsed these codes into four zones during analysis. Driving data from curves were investigated with the expectation that eyes not looking forward when entering and negotiating turns would create more salient effects in the vehicle data and, thus, provide a good starting point for analysis. Lateral accelerations and yaw-related measures were developed and tested. A relationship between eyes-off-road and lateral accelerations was observed. The false positive rates observed would make it difficult to use the approach in real-time applications, but the approach may provide value in postprocessing applications such as data mining.
Deliverable	*Identifying Distraction: Kinematic Detection of Off-Road Eye Glances*[12]

Table 14. Design and Implementation of OLAP Cube for Older Driver Dataset.

VTTI Project Number/Fund Code	425960
Short Project Title	Cube
VTTI PI	Jeremy Sudweeks
Begin	May 2010
End	May 2013
FHWA Funding	$39,998.98
Long Project Title	Design and Implementation of OLAP Cube for Older Driver Dataset
Project Description	The purpose of this project was to develop an OLAP cube, which allows fast data analysis by categorizing numeric facts by dimensions for the older driver naturalistic dataset. It was hoped that this process would provide a way for researchers to answer research questions with aggregated non-personally identifying information. During the project, SHRP2 began discussing development of an OLAP cube for the SHRP2 data. With this knowledge, the stakeholders decided to reallocate the project's remaining funds to the Public Access to VTTI Data project described in table 9.
Deliverable	This project had no deliverable; the funds were reallocated during a stakeholder review to further maintain the Web site for the Public Access to VTTI Data project (see table 9).

OLAP = On-Line Analytical Processing.
SHRP2 = Strategic Highway Research Program 2.

Table 15. Data Sharing Across Borders/Naturalistic Driving Studies – International Cooperation.

VTTI Project Number/Fund Code	451048/451102
Short Project Title	Data Sharing Across Borders/NDS International
VTTI PI	Suzie Lee
Begin	November 2010/December 2013
End	July 2011/August 2013
FHWA Funding	$20,004.84/$5,014.37
Long Project Title	Data Sharing Across Borders/Naturalistic Driving Studies – International Cooperation
Project Description	The purpose of this project was to investigate data sharing as it pertains to naturalistic driving across different countries. VTTI worked with other countries to collect and share naturalistic driving data. As part of this project, the data sharing international policies and guidelines of the following countries were reviewed: the United States, Canada, Australia, Sweden, China, Germany, Japan, the United Kingdom, France, New Zealand, and Israel.
Deliverable	*Data Sharing Across Borders Current Status*[13]

Table 16. Driving Scenario Classification.

VTTI Project Number/Fund Code	451049
Short Project Title	Driving Scenario Classification
VTTI PI	Shane McLaughlin
Begin	November 2010
End	September 2012
FHWA Funding	$34,999.86
Long Project Title	Driving Scenario Classification
Project Description	Driving scenarios (e.g., driving relatively straight, negotiating a cloverleaf, turning at an intersection, or decelerating for a light) affect the driving-related measures collected for vehicles. During this project, automated methods were explored to review naturalistic driving data and to classify the epochs of the data according to different driving scenarios. In this way, the variance in the data created by common driving scenarios could be parsed out earlier during the data-mining process. To explore the potential for scenario classification of this type, researchers developed operational definitions for the different scenarios, trained a data reductionist, and conducted video reduction on 60 drivers, which determined when drivers were involved in the scenarios. In the review, approximately 1,465 epochs of drivers involved in 26 different scenarios were identified. Scenarios such as left and right turns were frequently found (more than 300 cases), whereas scenarios such as interchange merges to the left or right were found in only a single trip. These cases were divided into subsets where possible and used to guide code development testing. While the code was intended to explore a proof-of-concept for scenario classification using kinematic and other variables, an unrelated effort was found to have considerable power to classify roadway scenarios. That effort matched GPS records to digital map data. Attributes in the digital maps clearly defined the roadway scenario. The GPS road-matching approach has distinct advantages in that it provides access to numerous roadway attributes available in digital maps (e.g., functional class, number of lanes, speed limit), and it leaves the kinematic variables largely not confounded for subsequent analysis. The kinematic scenario classification method that was being pursued was surpassed by this breakthrough in associating driving with the roadway segment. Based on this, the NSTSCE stakeholders decided to conclude activities on this project.
Deliverable	This project was closed to pursue research into GPS road matching.

Table 17. The Impacts of Safety-Critical Events on Driver Behaviors.

VTTI Project Number/Fund Code	451143
Short Project Title	Impacts
VTTI PI	Feng Guo
Begin	December 2011
End	June 2014
FHWA Funding	$24,835.39
Long Project Title	The Impacts of Safety-Critical Events on Driver Behaviors
Project Description	This study evaluated the impacts of crashes on driver behavior and driving risk using the 100-car data. Two metrics were used to measure driver behavior and risk: the proportion of baselines where the drivers were engaged in complex and moderate secondary tasks, and the intensity of NCs and SCIs. Results indicated that the percentage of baselines where drivers engaged in complex secondary tasks dropped after crashes. Researchers developed four alternative recurrent event models to evaluate the impact of crashes on NC and SCI risk. Results show reduction in SCI intensity after the first and second crash for male drivers. Females were observed with decreased SCI intensity after the second crash. This study indicated that crashes do have positive effects on driver's behavior in both distraction and aggressive driving behavior.
Deliverable	*Evaluating the Influence of Crashes on Driving Behavior using Naturalistic Driving Study Data*[14]

SCI = Safety-critical incident.

Table 18. Secure Feedback for Onboard Monitoring System Training.

VTTI Project Number/Fund Code	451161
Short Project Title	Secure OBMS
VTTI PI	Charlie Klauer
Begin	July 2012
End	October 2013
FHWA Funding	$75,005.13
Long Project Title	Secure Feedback for Onboard Monitoring System Training
Project Description	This project developed the necessary infrastructure for an associated project, the driver coach study. Driver coach was an experimental study testing whether teenage drivers benefit from receiving both real-time and post hoc feedback on their driving performance. Specifically, the post hoc feedback required potential safety-related events to be automatically uploaded to VTTI servers so a reductionist could review, record, and annotate critical information. Parents and teens then received Web links to the video and aggregate data for both the individual teenager as well as the performance of the teenager in relation to all the drivers in the study. This project established the necessary computing infrastructure, software, and hardware for providing this feedback.
Deliverable	The deliverable for this project was the necessary infrastructure and Web portal for the driver coach study.

Table 19. Generic Motorcycle Bracketry and Housings.

VTTI Project Number/Fund Code	451162
Short Project Title	Cycle Bracket
VTTI PI	Shane McLaughlin
Begin	May 2012
End	October 2013
FHWA Funding	$35,000.04
Long Project Title	Generic Motorcycle Bracketry and Housings
Project Description	This project built on the lessons learned regarding instrumentation during the first naturalistic motorcycle study. The first study, conducted for the Motorcycle Safety Foundation, involved the instrumentation of 100 motorcycles. In the planning phase of that study, seven motorcycle models were selected for inclusion, and instrumentation was developed to fit those specific motorcycles. While the instrumentation performed well, locating willing riders of those specific models severely limited the project's approach and recruitment. To remedy this, the cycle bracket intended to support the design of bracketry and housings that would be feasible to use on a range of motorcycle models. The most common motorcycle models were identified using records of models from State transportation department registration lists. These models were ordered from most to least common; then, bracketry solutions were developed that could accommodate the largest number of motorcycles possible. Off-the-shelf bracketry solutions were identified for many of the most common models of motorcycles; thus, generic components were engineered that complemented the off-the-shelf products. These generic components permit rapid placement of cameras and radars on different makes and models of bikes in a number of locations. The components also permit the installer to adjust angles of the equipment according to the geometry of the bike. The solutions were developed in prototype form, tested for fit and installation feasibility, and produced in quantity. The brackets were used in the National Highway Traffic Safety Administration 160-Motorcycle study.
Deliverable	The study yielded the design of bracketry that can be used in motorcycle research.

Table 20. Integrating Roadway Data with Our Naturalistic Dataset.

VTTI Project Number/Fund Code	451258
Short Project Title	Roadway Linking
VTTI PI	Shane McLaughlin
Begin	September 2013
End	June 2014
FHWA Funding	$64,606.45
Long Project Title	Integrating Roadway Data with Our Naturalistic Dataset
Project Description	The goal of this project was to organize databases and materials that would facilitate use of the naturalistic data housed at VTTI by individuals more familiar with the roadway and infrastructure domains (e.g., civil engineers) than the driver and vehicle domains. Within this project, a range of datasets were pursued that would be of particular interest to individuals working on infrastructure design-related research. Methods were developed to associate roadway attributes with naturalistic data from the 100-car study. A proof of concept was also done with 6,000 SHRP2 files. The database contained tables with data from five State transportation departments, digital mapping software, the SHRP2 Roadway Information Database, and the FHWA Office of Highway Performance Monitoring. The tables contained information describing roadway segments, such as the number of lanes, average annual daily traffic counts for heavy trucks and light vehicles, International Roughness Index Scores, vehicle miles traveled, and functional class. Tables also identified features such as transition zones, frontage roads, bridges, tunnels, etc. These attributes were coded and organized to identify epochs of time within the naturalistic datasets in which the different roadway related descriptors apply. For example, the roughness index table identified files and timestamps within files in which participants were driving on pavement identified with a particular roughness index.
Deliverable	*Roadway Epochs Documentation and User Manual*[15]

CHAPTER 3. EXAMINE ADVANCED ROADWAY DELINEATION AND LIGHTING SYSTEMS

The second research area focused on advanced roadway delineation and lighting systems. Projects within this subject-matter area originally considered the effectiveness of lighting and delineation systems for enhancing the safety of drivers; roadway lighting has been found to be an effective crash deterrent in specific cases, while roadway delineation is the primary method for defining the roadway environment. Delineation typically consists of pavement markings and signs that outline the path of the roadway. The initial project submissions focused primarily on the roadway lighting application, which included the development of a roadway lighting measurement system and new roadway design metrics as well as the consideration of glare in the roadway. New technologies that aid in the analysis of lighted environments in much greater detail were developed and incorporated into the research efforts, such as charge-coupled device photometry, eye tracking, and video capture. These innovations gained insight into the parameters that lead to driver safety.

During the 2010 stakeholders committee review, this area expanded to cover the built roadway environment and infrastructure-based safety systems, thereby moving away from roadway lighting towards more infrastructure-based themes such as eye-glance behavior in roundabouts. Table 21 through table 35 describe the 15 projects that are under this research focus area.

Table 21. Development of the Luminance Camera System.

VTTI Project Number/Fund Code	425770
Short Project Title	Luminance Camera Development
VTTI PI	Ron Gibbons
Begin	July 2006
End	June 2008
FHWA Funding	$125,000.00
Long Project Title	Development of the Luminance Camera System
Project Description	An effort was undertaken to develop a system of image capture to analyze luminance data gathered in naturalistic driving research. Currently, still photometers exist to capture luminance data in an image as well as handheld luminance meters to capture luminance data in the environment. However, still photometers are unable to capture rapidly changing luminance data, while handheld luminance meters are time consuming to operate for multiple areas of interest within a scene and lack the ability to capture the scene's image. The primary method used in this research was the calibration of smaller, more mobile luminance cameras through the use of an imaging photometer. Prediction results were compared to actual luminance recorded values, and an additional evaluation of data collection R&R was conducted. R&R evaluation results indicate the luminance camera is highly repeatable and capable of reproducing consistent data through multiple trials. The calibration of a luminance camera for recording luminance data was found to be successful with a relatively high level of accuracy based on comparisons to known luminance values.
Deliverable	*Development and Validation of a Luminance Camera*[16]

R&R = Repeatability and reproducibility.

Table 22. Luminance Metrics for Roadway Lighting.

VTTI Project Number/Fund Code	425771
Short Project Title	Metric For Roadway Lighting Designers
VTTI PI	Ron Gibbons
Begin	July 2006
End	July 2008
FHWA Funding	$50,000.00
Long Project Title	Luminance Metrics for Roadway Lighting
Project Description	In nighttime driving, the visibility of a pedestrian or any object depends on its physical characteristics such as the luminance of the object and the contrast. The luminance, or light being reflected back to the observer, is a metric with little room for interpretation as to how it is derived. However, the concept of the contrast of an object has not been quite as clearly understood. The concept of contrast has been the focus of much investigation in past and current research. This study compared multiple contrast metrics and implemented those determined to be most applicable as realistic measures. Specifically, researchers focused on the root sum of squares and power spectrum signature methods of determining contrast. These metrics were also used in conjunction with well-established metrics such as the Doyle and Michelson contrast metrics in order to make comparisons and inferences. These contrast metrics were also used in making comparisons to previously collected data of detection distances.
Deliverable	*Luminance Metrics for Roadway Lighting*[17]

Table 23. Color Measurement System.

VTTI Project Number/Fund Code	451000
Short Project Title	Color Camera
VTTI PI	Ron Gibbons
Begin	March 2010
End	June 2014
FHWA Funding	$40,003.05
Long Project Title	Color Measurement System
Project Description	This project was an effort to develop a color camera system that could collect naturalistic video data with accurate color rendering. Photometric devices can accurately measure color but cannot record the video data necessary for understanding visibility in dynamic environments such as nighttime driving. Video recorders can take video data yet are inaccurate in measuring color. To measure color and its effects on visibility in naturalistic settings, a color camera system was developed that could record video data with color rendering similar to what humans perceive. This system included a calibrated color camera and image analysis software. The camera system was selected and calibrated in different lighting scenarios using a standard color chart. Calibration files were compared for color-rendering accuracy, and the best file, based on calibration in daylight, was selected for further analysis. A new image-analysis method was developed. Along with its accompanying custom MATLAB programs, researchers were able to select portions of an image and analyze their three-dimensional color space coordinates. That capability would be useful in future work comparing photometric equipment and in analyzing naturalistic video data.
Deliverable	*Color Camera: Development of a Video Imaging System that Can Accurately Record Chromaticity and Luminance*[18]

Table 24. Performance of New Roadway Lighting in Foggy Conditions/Performance of New Roadway Lighting in Rain Conditions.

VTTI Project Number/Fund Code	451171
Short Project Title	Foggy Lights/Rainy Nights
VTTI PI	Ron Gibbons
Begin	July 2013
End	June 2014
FHWA Funding	$18,907.16
Long Project Title	Performance of New Roadway Lighting in Foggy Conditions/Performance of New Roadway Lighting in Rain Conditions
Project Description	This project examined the effectiveness of different types of roadway lighting in foggy and rainy conditions. Specifically, the visibility distance of pedestrians and small targets is being measured in fog and rain under four lighting conditions: 3,500-K LED, 6,000-K LED, traditional high-pressure sodium, and no lighting.
Deliverable	*The Impact of Spectrum on the Performance of Roadway Lighting Systems in Rain and Fog Conditions*[19]

LED = Light-emitting diode.

Table 25. Assessment of Active Delineation Systems.

VTTI Project Number/Fund Code	451158
Short Project Title	Delineation
VTTI PI	Ron Gibbons
Begin	April 2012
End	June 2014
FHWA Funding	$59,281.96
Long Project Title	Assessment of Active Delineation Systems
Project Description	This project examined the impact of active delineation systems on drivers' speed and lane-keeping behavior in foggy conditions. Both objective and subjective measures were gathered to assess drivers' perceptions of the systems. Using two custom-made LaneLight™ delineation systems, the project considered three patterns, two brightness levels, and two unit spacings in fog using the Smart Road's all-weather system. (The Smart Road is a limited-access road in Virginia used to test new transportation technologies.) Results provided information for safely guiding drivers through fog using active delineation systems.
Deliverable	*The Performance of Active Delineation Systems in Rain and Fog Conditions*[20]

Table 26. Roadside Evaluation of a Buried Cable Animal Detection System.

VTTI Project Number/Fund Code	451159
Short Project Title	Roadside AVC
VTTI PI	Andy Alden
Begin	November 2013
End	June 2014
FHWA Funding	$23,035.22
Long Project Title	Roadside Evaluation of a Buried Cable Animal Detection System
Project Description	AVCs account for more than 5 percent of all reported motor vehicle collisions, and the problem continues to grow as both vehicle-miles traveled and wildlife numbers increase. Approximately 4 to 10 percent of AVCs involving large animals result in human injury. Costs for related property damage, medical care, crash management, and animal carcass management exceed $8 billion per year. To mitigate this problem, an innovative roadside buried cable animal detection system was developed for testing at a particular site on the Smart Road where large wild animals are often observed. Researchers used surveillance systems to monitor animal movement and gauge system detections. Collected data were analyzed to determine the overall performance of the system and its suitability for implementation in problem areas on Virginia's public roads. This project was a partnership with VDOT.
Deliverable	This phase of the project included the development of the system specifications and the system installation. The second phase of the project funded by VDOT will produce a final report describing the system installation, data collection, analysis methods, results, and implementation prospects.[21]

Table 27. Exploration of the Integration of the SHRP2 Naturalistic Driving Data with the VTTI Lighting Database.

VTTI Project Number/Fund Code	451269
Short Project Title	Lighting Database
VTTI PI	Ron Gibbons
Begin	December 2013
End	June 2014
FHWA Funding	$15,176.34
Long Project Title	Exploration of the Integration of the SHRP2 Naturalistic Driving Data with the VTTI Lighting Database
Project Description	The primary objective of this project was to investigate the feasibility of integrating the ALD with the SHRP2 NDS data. During this project, the research team developed two spatial data integration approaches, with each one targeting different needs and requirements. The first approach involved data integration directly between the ALD and NDS time series data, illustrating a process to link NDS data directly onto custom roadway data (e.g., the ALD roadway network and lighting data). This link provides users with a flexible means to cater to unique data integration needs, especially when they require roadway-related data elements not included in the SHRP2 RID data. The second approach involved data integration based on the NDS RID that utilized the roadway matching results completed by SHRP2, therefore decreasing the necessary computing resources and processing time. These data integration approaches generated an integrated dataset with rich driving, roadway, and in situ lighting performance information, enabling a large variety of analyses that may yield results of great significance to safety researchers, transportation agencies, and the traveling public.
Deliverable	*Integrating the Adaptive Lighting Database with SHRP2 Naturalistic Driving Study Data*[22]

ALD = Adaptive Lighting Database.
RID = Roadway Information Database.

Table 28. Measurement of Visibility Conditions with Traffic Cameras.

VTTI Project Number/Fund Code	451268
Short Project Title	Weather Camera
VTTI PI	Matthew Palmer
Begin	December 2013
End	June 2014
FHWA Funding	$20,067.22
Long Project Title	Measurement of Visibility Conditions with Traffic Cameras
Project Description	Roadway images can detect and quantify adverse weather. Traffic cameras prevalent on highways and some secondary roads offer an opportunity to develop a system that detects adverse weather conditions automatically from the camera feeds and warn drivers using existing systems. During the first phase of this project, the specifications for VDOT's latest digital cameras were identified; camera cost was determined with a consideration towards alternative, lower-cost cameras. Researchers also used an existing camera on the back of a VTTI building, similar to the current VDOT traffic cameras, capturing some photographs of the Smart Road at maximum zoom. These photographs were used to become familiar with the IFSTTAR modules and to create a Lambertian map of the scene. The IFSTTAR modules required specific image format and folder structures, so the team developed a method to convert the photographs and folders captured by the existing camera into data usable with the modules. During the next phase, a brand-name camera identical to VDOT's current model will be installed on the Smart Road to collect data and develop prototype software using the IFSTTAR modules to measure fog visibility and rainfall rate. Also, a method of normalizing the data will be developed to eliminate the need for additional sensors for in situ calibration.
Deliverable	*Using Traffic Cameras to Assess Visibility Conditions*[23]

IFSTTAR = French Institute of Science and Technology for Transport, Spatial Planning, Development and Networks.

Table 29. Discomfort-Disability Glare.

VTTI Project Number/Fund Code	425816
Short Project Title	Glare Metrics
VTTI PI	Ron Gibbons
Begin	May 2008
End	June 2009
FHWA Funding	$100,000.00
Long Project Title	Discomfort-Disability Glare
Project Description	This project considered disability and discomfort glare in roadway lighting installations. Researchers conducted an experimental phase where the metrics for discomfort were measured in a live road arrangement with differing luminaires on the Smart Road. A target detection task was also used to determine the impact of the luminaire on target detection. The experiments resulted in a modeling phase of the project that allowed for the assessment of glare in a calculated environment. These results have been provided to the CIE for the development of the CIE document on roadway glare through CIE committee TC 4-33.
Deliverable	*A New Approach to Glare Modeling: Discomfort and Disability*[24]

CIE = Commission Internationale d'Eclairage.

Table 30. Metric for Roadway Lighting Design.

VTTI Project Number/Fund Code	425823
Short Project Title	Roadway Lighting Safety
VTTI PI	Ron Gibbons
Begin	June 2008
End	Feb 2011
FHWA Funding	$149,886.00
Long Project Title	Metric for Roadway Lighting Design
Project Description	This project developed an approach for determining the impact of roadway lighting on crash safety. Researchers measured lighting, calculated the crash impact, and developed the statistics linking these two aspects of roadway design. Other factors such as geometrical design and Bayesian analyses were also considered. The methodology developed in this project was extensively used in the FHWA supported project Strategic Initiative for Reduced Lighting on Roadways.
Deliverable	This method has been documented in the project Strategic Initiative for Reduced Lighting on Roadways.[25,26]

Table 31. Visual Information and Driver Performance.

VTTI Project Number/Fund Code	425870
Short Project Title	Visual Information
VTTI PI	Ron Gibbons
Begin	September 2008
End	January 2012
FHWA Funding	$149,311.39
Long Project Title	Visual Information and Driver Performance
Project Description	This project followed the FHWA supported Exploratory Advanced Research Project on Visibility Modeling. The eye-glance and performance characteristics of a driver were measured in both controlled closed-track and live-traffic situations. The results linked the luminance of the objects, the eye-glance locations, and the performance metrics together. The final aspect of the project was the development of statistical odds ratios for detection in addition to a model for cumulative detection probability. These results are being implemented in a new approach to measure the effectiveness of roadway lighting.
Deliverable	The results of this effort were included in the FHWA project on visibility modeling and have been published in several locations such as the Transportation Research Board and the Illuminating Engineering Society proceedings.[27–29]

Table 32. Roadway Lighting Mobile Measurement System (RLMMS).

VTTI Project Number/Fund Code	425896
Short Project Title	RLMMS
VTTI PI	Ron Gibbons
Begin	October 2008
End	September 2009
FHWA Funding	$49,988.26
Long Project Title	Roadway Lighting Mobile Measurement System
Project Description	This project created a system to measure roadway lighting characteristics from a moving vehicle. Referred to as RLMMS, this system consists of a grid of illuminance meters located on the top of a vehicle to measure illuminance, sensors inside the vehicle to measure glare, luminance and color cameras, spectroradiometers, user inputs, links to the vehicle network, and links to an eye-tracking system. These inputs are then linked to a GPS receiver that stores the resulting measurements. This portable system, already used extensively in other projects, can be shipped and installed on any vehicle. Since the completion of this project, three additional systems have been constructed. At present, it is estimated that over 5,000 mi of roadway lighting have been measured using the RLMMS.
Deliverable	*Development of a Mobile Measurement System for Roadway Lighting*[30]

Table 33. Rural Intersection Lighting Safety Analysis.

VTTI Project Number/Fund Code	425902
Short Project Title	Rural Intersection Lighting
VTTI PI	Ron Gibbons
Begin	December 2008
End	January 2011
FHWA Funding	$74,993.02
Long Project Title	Rural Intersection Lighting Safety Analysis
Project Description	Most of the existing research on intersection lighting indicates the number of night crashes and the ratio of night-to-day crashes are lower at lighted intersections when compared with unlighted intersections. This research also suggests a safety benefit in the presence of lighting at rural intersections. Yet in all of these analyses, the presence of lighting is used as a binary variable: lighting is either present or absent. Consequently, the studies did not account for the lighting level, including the amount of light incident on the roadway surface (illuminance) or reflected from the roadway surface (luminance) from the roadway lighting system, or light from surrounding business establishments (e.g., parking lots, gas stations, malls, etc.). In addition, stray light from structures and establishments greatly affects the lighting level at both unlighted and lighted intersections. To better understand the importance of lighting at rural intersections, the relationship between lighting levels and night crashes at these locations needed to be studied. Researchers conducted a comparative statistical analysis on lighting and crash data in order to understand the effect of lighting level and quality on the number of night crashes at rural intersections. This study analyzed rural intersections in the state of Virginia for the lighting level and crash information using the RLMMS. Adding this data to the crash data enhanced the quality and understanding of rural intersection lighting.
Deliverable	*Rural Intersection Lighting Safety Analysis*[31]

Table 34. Exploratory Color Contrast Experiment.

VTTI Project Number/Fund Code	425999
Short Project Title	Object Color
VTTI PI	Ron Gibbons
Begin	March 2010
End	April 2011
FHWA Funding	$60,000.00
Long Project Title	Exploratory Color Contrast Experiment
Project Description	This project was an experiment to determine the impact of color in the roadway environment. Traditional roadway lighting does not consider color in any manner; typical roadway light sources are either monochromatic or a dark amber color. With the development of white LEDs, the Smart Road was used to conduct target detection tasks performed under 3,000-K LED, 6,000-K LED, and 4,200-K fluorescent. The results indicated color was a significant aspect of vision and color benefits. However, the benefits were unpredictable as the energy in the light source by wavelength and the colors of the objects seen in the roadway interacted. As a result, although color had an effect, a complete metric was not developed.
Deliverable	*Assessment of the Impact of Color Contrast in the Detection and Recognition of Objects in a Road Environment*[32]

Table 35. Visual Behavior in Roundabouts.

VTTI Project Number/Fund Code	451157
Short Project Title	Roundabouts
VTTI PI	Ron Gibbons
Begin	April 2012
End	June 2014
FHWA Funding	$40,014.81
Long Project Title	Visual Behavior in Roundabouts
Project Description	This project considered eye-glance and lighting issues in roundabouts because many State transportation departments are considering the implementation of roundabouts into their roadways. Pedestrian visibility at crosswalks, particularly on the roundabout exit, remains an issue. Investigating driver behavior and eye glances in the roundabout could provide insight into the optimization of lighting and crosswalk placement. The study examined the performance of a driver in an active roundabout environment with double and single lanes. Participants were asked to drive through the roundabout with an eye-tracking device and a variety of signaling types. Eye-glance behavior was measured and linked to the lighting and signaling characteristics. The results showed a variation in driver behavior at several aspects of the roundabout and are currently being used in the FHWA sponsored project Accelerating the Implementation of Roundabouts.
Deliverable	*Pedestrian Visibility in Roundabouts: Naturalistic Study of Driver Eye Glance Behavior*[33]

CHAPTER 4. DEVELOP TECHNIQUES TO ADDRESS AGE-RELATED DRIVER ISSUES

The third research area included investigations into and development of techniques to address age-related driver issues. This research area was quite timely, with many in the transportation research community seeking ways to reduce crashes among newly licensed teenagers and aging drivers. Car crashes are a leading cause of loss of life for teenagers; this age group is also involved in a disproportionately high number of crashes and has high instances of fault in multivehicle crashes. Drivers at this age must develop good defensive driving skills and apply good judgment while driving. Graduated licenses and behavioral modification techniques have already been applied to address this need.

On the other end of the spectrum are aging drivers. The lengthening lifespan of baby boomers has increased the proportion of older drivers on the roadways, a trend expected to continue for several decades. Some of those drivers within this group may suffer from age-related decrements along a range of functional impairments, which individually or together may affect driving skills and risk. There are some indications that older drivers are aware of these decrements and self-regulate by avoiding riskier situations and times of the day. However, they are still involved in a disproportionate number of crashes and fatalities, although the latter is mostly due to the fragility of older drivers.

With guidance from the NSTSCE stakeholders in 2010, this area was expanded to include a wider array of individuals who are also more vulnerable to crashes or injuries simply because of who they are or their mode of travel. In addition to the young and aging drivers previously studied, researchers began to consider bicycle riders, pedestrians (especially the young and old), and wheelchair users. Table 36 through table 45 describe the 10 projects that are under this research focus area.

Table 36. Older Driver Biomechanics.

VTTI Project Number/Fund Code	425817
Short Project Title	Older Driver Biomechanics
VTTI PI	Jon Antin
Begin	March 2008
End	November 2008
FHWA Funding	$50,000.00
Long Project Title	Older Driver Biomechanics
Project Description	Fragility is estimated to be responsible for a major portion (60 to 95 percent) of the fatalities of older drivers and passengers.[34] Prior to this study, VTTI's DAS collected acceleration and gyro data at a temporal resolution of 10 Hz. While this was sufficient for the development of CNC detection algorithms and other related applications, it was not enough to model the biomechanical stress and injuries experienced during a vehicular crash. Therefore, VTTI's Older Driver NDS would enhance the capabilities of the DAS to collect acceleration and gyro data with sufficient range, temporal resolution, and accuracy to facilitate subsequent biomechanics-injury analysis and modeling. That initial study produced no serious crashes to evaluate from a biomechanics perspective. However, the approach pioneered in that study has been applied to all of VTTI's subsequent NDSs, including SHRP2, the largest NDS of its kind ever conducted. Additionally, non-injurious exposure can be modeled to provide a set of data on tolerable events. This approach may benefit older drivers and likely many others as well, perhaps leading to countermeasures related to safety belt design, air bag design and deployment factors, seat factors, and cabin structures design.
Deliverable	The deliverable was enhanced data acquisition capability.

Table 37. Teen Driving Initiative.

VTTI Project Number/Fund Code	425883
Short Project Title	Driver Coach
VTTI PI	Charlie Klauer
Begin	September 2008
End	June 2014
FHWA Funding	$149,999.78
Long Project Title	Teen Driving Initiative
Project Description	Teenage drivers are four times more likely to be involved in a crash than any other age group. The reasons for these crash rates are largely unknown, but it is believed that if risky driving behaviors are reduced through providing feedback to the driver, crash rates will also fall. The driver coach project evaluated the effectiveness of providing driving-related feedback to teens with the goal of reducing unsafe behaviors that lead to injury and fatal crashes. FHWA partially contributed funds, while VDOT, the National Institutes of Health, and the Toyota® Collaborative Safety Research Center contributed the additional funding. A total of 90 vehicles were instrumented with devices to record the driving performance and audio data of individuals who had received their learner's permit within the past 2 weeks. Driving performance feedback began a few weeks prior to licensure and continued for a period of 6 mo post licensure. During the seventh month, feedback was halted while researchers monitored the novice's driving performance to see if it remained constant or the driver reverted to unsafe behavior.
Deliverable	*Driver Coach Study: Using Real-time and Post Hoc Feedback to Improve Teen Driving Performance*[35].

CSRC = Collaborative Safety Research Center.

Table 38. Creating Capability for Automated Mask Post-Processing of Face Video in Naturalistic Databases.

VTTI Project Number/Fund Code	425959
Short Project Title	Maskpost
VTTI PI	Jon Antin
Begin	November 2009
End	June 2014
FHWA Funding	$39,999.01
Long Project Title	Creating Capability for Automated Mask Post-processing of Face Video in Naturalistic Databases
Project Description	VTTI technicians developed a machine vision-based tool called the Mask that uses facial landmarks observed in naturalistic driving face video to determine the position of the driver's face and head as well as degree of rotation in space. While this tool cannot yet determine exact gaze location, some valuable information can be gleaned from its output in terms of breadth of head movement at intersections, gross metrics, or implications of eyes-off-road time. This project developed the capability for use of the Mask in postprocessing of a naturalistic dataset. The Mask was effectively applied to the Older Driver and 40-Teen NDS databases and generated the expected head position and rotation data. Antin, Wotring, and Foley used this new approach to successfully evaluate data about breadth of head rotations at intersections from VTTI's Older Driver NDS.[36]
Deliverable	The deliverable for this project is a tool that can be applied post hoc to datasets.

Table 39. Comparing the Driving Safety Benefits of Brain Fitness Training Programs for Older Drivers.

VTTI Project Number/Fund Code	451165
Short Project Title	Caboose
VTTI PI	Jon Antin
Begin	May 2012
End	January 2014
FHWA Funding	$74,995.50
Long Project Title	Comparing the Driving Safety Benefits of Brain Fitness Training Programs for Older Drivers
Project Description	The goal of this project was to evaluate two different training-based approaches to enhance senior driver safety. A total of 74 male and female licensed drivers aged 70–85 were recruited from the New River Valley area of Virginia to participate in an evaluation of a prototype in-vehicle implicit learning system designed by Toyota® engineers and a commercially available computer-based application from Posit Science®. A no-contact control group received no training. Both training approaches emphasize expanding senior drivers' useful field of vision and otherwise strengthening other visual-cognitive functional abilities, such as speed of information processing and ability to visually track moving objects. Dependent measures include laboratory metrics (useful field of view, trail-making of parts A and B, and visualization of missing information), roadside object recognition distance, peripheral detection tasks, and public road driving performance. Data collection and analyses have been completed.
Deliverable	*Comparing the Driving Safety Benefits of Brain Fitness Training Programs for Elderly Drivers*[37]

Table 40. Older Driver Head Rotations at Intersections: An International Meta-Analysis of U.S. and Australian ND Databases.

VTTI Project Number/Fund Code	451188
Short Project Title	Oz Sequel
VTTI PI	Jon Antin
Begin	October 2012
End	June 2014
FHWA Funding	$12,270.02
Long Project Title	Older Driver Head Rotations at Intersections: An International Meta-Analysis of U.S. and Australian ND Databases
Project Description	In a joint effort, VTTI researchers and their colleagues at the Monash University Accident Research Center in Melbourne, Australia, collected naturalistic driving data on older drivers. This project compared key aspects of the seniors' driving behavior across the two continents, specifically secondary task engagement. This type of engagement is associated with complexity of situation (i.e., less likely when vehicle is moving). Both the U.S. and Australian researchers noted differences in frequency of engagement with specific types of secondary activities such as cell phone use and adjustment of control panels, which could be attributed to differences in law enforcement priority. Yet general patterns were consistent across the continents and the findings supported previous research efforts. Unfortunately, the study had several limitations, including a relatively small sample size and differences in vehicle familiarity; Australian drivers used an unfamiliar vehicle, whereas those in the United States used their personal vehicles. Although difficulties arose when aligning the two analyses post hoc, the results suggested a propensity for older drivers to self-regulate by reducing potentially distracting tasks at intersections when cognitive demand is high.
Deliverable	The results of this project have been included in the final report for *An Exploration of Driver Behavior During Turns at Intersections*.[38]

ND = Naturalistic driving.

Table 41. Fitness to Drive II.

VTTI Project Number/Fund Code	451195
Short Project Title	Fitness to Drive II
VTTI PI	Jon Antin
Begin	October 2012
End	May 2014
FHWA Funding	$15,478.80
Long Project Title	Fitness to Drive II
Project Description	In this study, researchers evaluated the relationship between an older driver's fitness assessment profiles and their driving risk, represented primarily by CNC rate and secondarily by HGF event rate, all recorded during a naturalistic study of senior drivers. Due to the relatively small sample size of only 20 primary drivers in this pilot investigation, principal component analysis was used for dimension reduction and classification of the 60 total fitness profile metrics. Negative binomial regression models were employed to model the CNC and HGF events. The results indicated that contrast sensitivity measures were significantly associated with CNC rate: the greater the sensitivity, the lower the CNC rate. In the HGF event analysis, the CNC rate was positively related to the HGF rate. The fitness metric contrast sensitivity was also related to the HGF event rate. In addition, two metrics related to metacognition (a measurement of one's perception of one's own cognitive status) were associated with HGF event rate. Higher HGF rates were associated with greater self-rating of cognitive status as well as greater disparities between that same self-rating and an objective metric of cognitive status. The results of this study provided crucial information on the metrics and protocols, which could be applied by motor vehicle departments, physicians, occupational therapists, certified driving rehabilitation specialists, and others for whom determining seniors' fitness to drive is an important component of their work. Furthermore, these results can be further investigated and validated using the much larger database of senior driver data collected in the SHRP2 NDS.
Deliverable	*Evaluation of Older Driver Fitness-to-Drive Metrics and Driving Risk Using Naturalistic Driving Study Data*[39]

HGF = High g-force.

Table 42. Senior Mobility Symposium.

VTTI Project Number/Fund Code	451200
Short Project Title	Senior Mobility II
VTTI PI	Jon Antin
Begin	October 2012
End	June 2014
FHWA Funding	$19,053.39
Long Project Title	Senior Mobility Symposium
Project Description	These funds enabled VTTI to host a symposium designed to increase awareness of mobility issues faced by seniors and offer state-of-the-art solutions to the challenges faced by aging drivers on a daily basis (e.g., driving at night in complex or high-traffic situations or at highway speeds, walking and handling packages once the destination is reached, etc.). Additionally, as drivers begin to self-regulate to avoid such situations or cease driving altogether, a new challenge arises of finding accessible and affordable living and personal mobility options that permit them to perform all the necessary and leisure activities important to maintaining healthy and satisfying lives.
Deliverable	*Senior Mobility Awareness Symposium Brief*[40]

Table 43. Validation of the Driver Coach Trigger Algorithms Using the 40-Teen Naturalistic Driving Study Dataset.

VTTI Project Number/Fund Code	451265
Short Project Title	Teen Trigger Dent
VTTI PI	Charlie Klauer
Begin	November 2013
End	June 2014
FHWA Funding	$30,027.76
Long Project Title	Validation of the Driver Coach Trigger Algorithms Using the 40-Teen Naturalistic Driving Study Dataset
Project Description	The purpose of this project was to identify and develop the best procedures to evaluate driver coach trigger algorithms on the first 2 to 3 mo of driving in the 40-Teen Naturalistic Dataset. The 40-Teen study data provided the most accurate estimates because these drivers were within 2 weeks of receiving their provisional licenses and drove in the general geographic area as the driver coach participants. No other dataset, including the SHRP2 dataset, provided as precise estimates as the 40-Teen dataset. Primary benefits of this venture included analysis and validation of driver coach triggers over an existing, complete dataset; increased ability to accurately estimate current and future project expenses (i.e., telemetry and labor); and establishment of a development framework to aid future algorithm recoding efforts. Researchers gained information regarding the number of expected triggers, especially for the high-risk, moderate-risk, and low-risk teenage drivers. Results suggested that the mere presence of the MiniDAS coupled with emails to parents had a positive effect on novice driving performance because the number of triggered events was less than what was obtained during the NTDS.
Deliverable	*Driver Coach Trigger Validation Using the Naturalistic Teenage Driving Study Data*[41]

NTDS = Naturalistic Truck Driving Study.

Table 44. Inclusion of a Driver Distraction Trigger for Driver Coach Project.

VTTI Project Number/Fund Code	451284
Short Project Title	Distraction Warning II
VTTI PI	Charlie Klauer
Begin	September 2013
End	June 2014
FHWA Funding	$10,044.34
Long Project Title	Inclusion of a Driver Distraction Trigger for Driver Coach Project
Project Description	Two methods of determining driver head pose positioning, both developed at VTTI prior to this contract, were compared to evaluate the feasibility of a real-time driver distraction trigger. The first method, colloquially referred to as "Driver Watchdog," used a support vector machine approach. The second approach drew from prior work completed on the Mask 2.0 gesture-sensing algorithm. The initial provision for both approaches required 80 percent or greater accuracy in detecting scenarios where the driver's face is outside of a ±15-degree cone of vision from the forward roadway. Both approaches were tested on a captured video feed to ensure they would be capable of running effectively within the constraints of the MiniDAS digital signal processor's power. The Driver Watchdog algorithm requires a separate model for each individual driver to be created and stored on the MiniDAS platform. Therefore, the creation of these driver-specific models would require significant costs, in both human data reduction (labor) and database storage, and DAS package assignment capabilities. However, the Driver Watchdog algorithm shows promise as a means for identifying consented drivers in real-time, with identification and driver trip assignments taking place on the DAS. Therefore, future development will be directed toward this goal instead of driver distraction. Upon review of the both approaches, it was determined that the MASK 2.0 algorithm was a more appropriate choice due to lower implementation costs. Further testing and refinement of the MASK 2.0 algorithm did not provide acceptable results for field deployment in the field for real-time monitoring and feedback. The algorithm did not achieve the necessary 80-percent accuracy mark for a ±15 degree cone of vision from the forward roadway.
Deliverable	The deliverable was testing a potential tool for detecting driver distraction in real time.

Table 45. A Survey of U.S. Light-Vehicle Driver Education Programs.

VTTI Project Number/Fund Code	451050
Short Project Title	Light Vehicle Ed Survey
VTTI PI	Andy Schaudt
Begin	October 2010
End	October 2011
FHWA Funding	$19,999.58
Long Project Title	A Survey of U.S. Light-Vehicle Driver Education Programs
Project Description	Light-vehicle driver education programs containing content about heavy-vehicle operation may be helpful in reducing light-vehicle and heavy-vehicle interactions. However, the extent of current state curricula requirements, content, and perceived effectiveness of both public and private programs regarding heavy-vehicle operation and associated recommended procedures for light-vehicle driving is unclear. This project resulted in an online survey targeting instructors and administrators of State driver education programs to identify current curricula addressing heavy vehicles (or lack thereof) and perceived effectiveness. At least two surveys were completed from each State and the District of Columbia. Survey results showed that while a large proportion of light-vehicle driver education programs include a component on how to safely share the road with heavy vehicles (91 percent), there is room for improvement in the content of these programs (82 percent perceived effectiveness). Qualitative analysis performed using the open-ended survey questions revealed areas of improvement.
Deliverable	*A Survey of Light-Vehicle Driver Education Programs to Determine the Prevalence of Curriculum on Sharing the Road with Heavy Vehicles*[42]

CHAPTER 5. DEVELOP TECHNIQUES TO ADDRESS DRIVER FATIGUE ISSUES

The driver fatigue focus area within the NSTSCE program centered on the role fatigue plays in both light- and heavy-vehicle crashes and developing and evaluating countermeasures to reduce fatigue-related crashes (a noteworthy mission because driver fatigue is a major issue in transportation safety). Naturalistic driving research conducted by VTTI in both light- and heavy-vehicle domains identified driver fatigue as a contributing factor in approximately 20 percent of all SCEs.

While assessing the impact of driver fatigue on safety is an important topic area, the subject-matter area broadened the definition in 2010 to include driver impairment. Acknowledging that driver fatigue is a type of impairment, the focus area now includes research directed at other types of impairment, such as driver distraction and alcohol/drugged driving. Furthermore, research topics that are either directly or tangentially related to these key types of impairment are also considered. For example, health and wellness (H&W) issues that can affect driver fatigue levels (e.g., obstructive sleep apnea (OSA)), environmental and regulatory factors that can affect driver safety (e.g., hours-of-service regulations), and the impact of technology on impairment (e.g., technology as a distracting agent or as a countermeasure to address impairment) are growing areas of interest in the driver impairment field. Table 46 through table 56 describe the 11 projects that are under this research focus area.

Table 46. Commercial Motor Vehicle Driver Health and Fatigue Study.

VTTI Project Number/Fund Code	425818
Short Project Title	Truck Driver Health-Fatigue
VTTI PI	Doug Wiegand
Begin	December 2007
End	November 2008
FHWA Funding	$39,999.77
Long Project Title	Commercial Motor Vehicle Driver Health and Fatigue Study
Project Description	This project looked at driver BMI and its relation to fatigued driving. A literature review provided support for the notion that obesity is linked to sleep problems (e.g., OSA) and fatigue-relevant outcomes (e.g., excessive daytime sleepiness); in addition, analyses of naturalistic driving data supported the notion that obesity is a risk factor for driving while fatigued. A focus group of commercial drivers investigated perceived barriers to living a healthy lifestyle while on the road. Finally, several existing H&W programs were described. The findings of this report indicated that obesity is a major problem in CMV operations. Of the 103 analyzed drivers, a majority (81.6 percent) were classified as either overweight or obese based on their BMI scores. Naturalistic driving data analysis found that being overweight or obese is a risk factor for driving while fatigued; obese drivers were between 1.89 [CI = 1.33, 2.70] and 8.31 [CI = 5.38, 12.84] times at greater risk than normal weight individuals for driving while fatigued, depending on the fatigue measure used. The data analysis also showed that individuals with a higher BMI are at greater risk for experiencing an SCE when compared to those with a lower BMI.
Deliverable	*Commercial Motor Vehicle Health and Fatigue Study*[43]

BMI = Body mass index.
CI = Confidence interval.
CMV = Commercial motor vehicle.

Table 47. Assessment of Fatigue from the Drowsy Driver Warning System Field Operation Test (DDWS FOT).

VTTI Project Number/Fund Code	425769
Short Project Title	Fatigue FOT
VTTI PI	Doug Wiegand
Begin	June 2006
End	September 2007
FHWA Funding	$100,000.00
Long Project Title	Assessment of Fatigue from the Drowsy Driver Warning System Field Operation Test (DDWS FOT)
Project Description	The objective of this study was to use naturalistic driving data to investigate issues in the trucking industry such as driver sleep/rest cycles and crash countermeasures. Continuous driving performance data were collected for 100 CMV drivers during 4 mo of their normal driving routine, collecting approximately 14,600 h of driving data. During this period, over 2,800 SCEs were identified: 13 crashes, 58 NCs, 1,595 crash-relevant conflicts, and 1,213 unintentional lane deviations. In addition to video and performance data, each participant wore an actigraph watch (a sleep monitor) and filled out a daily activity log. The data provided information about the drivers' daily sleep patterns and amount of sleep, as well as a reference for measuring the amount of time since the last sleep period in reference to a critical incident. One or more crash countermeasures were also identified for each critical incident. The results of this study provided information about the driver's daily work/sleep schedule and development of countermeasures for SCEs.
Deliverable	*Fatigue Analyses: From 16 Months of Naturalistic Commercial Motor Vehicle Driving Data*[44]

Table 48. Sneak Preview: A Proof of Concept of an Early SCE Detection Algorithm.

VTTI Project Number/Fund Code	451164
Short Project Title	Sneak Peek
VTTI PI	Myra Blanco
Begin	May 2012
End	May 2014
FHWA Funding	$30,075.42
Long Project Title	Sneak Preview: A Proof of Concept of an Early SCE Detection Algorithm
Project Description	The Sneak Peek project developed a data evaluation and analysis tool (Sneak Peek) for projects with specific limitations inconsistent with typical naturalistic data collections. Use cases identified for such a tool included projects lacking the budget for full data storage, insufficient funding for complete data reduction, and pilot-testing large-scale naturalistic data studies. The results of this effort demonstrated that the data evaluation and analysis tool is feasible; however, its limited features preclude it from more complex analysis needs. The Sneak Peek tool was also found to decrease the amount of storage capacity required by reducing the amount of data needed within the data warehouse.
Deliverable	The deliverable of this project is an assessment of a proof of concept tool. The stakeholders did not fund the next phase of this project.

Table 49. Development and Evaluation of a Naturalistic Observer Rating of Drowsiness Protocol.

VTTI Project Number/Fund Code	425819
Short Project Title	ORD
VTTI PI	Doug Wiegand
Begin	December 2007
End	October 2008
FHWA Funding	$44,999.57
Long Project Title	Development and Evaluation of a Naturalistic Observer Rating of Drowsiness Protocol
Project Description	Video examples from both the DDWS FOT and 100-car studies were identified for each relative indicator of drowsiness. A behavior and mannerism checklist was also developed for the protocol as a tool for individuals to use while performing ORD ratings. In addition to the relative indicators of drowsiness, individual driver data were reviewed to select six drivers who exhibited a range of drowsiness during the DDWS FOT and 100-car studies. Video examples were selected from those drivers and identified as driving while alert, slightly drowsy, moderately drowsy, very drowsy, and extremely drowsy. Each clip was reviewed, evaluated, and edited in the same manner as the relative indicators of drowsiness videos, and the research team developed a written description of how each one was classified. The final training protocol included the following: • Defining ORD and its purpose. • Describing the five levels of drowsiness. • Describing driver appearance. • Giving instructions for determining and recording ORD ratings. Once developed, a peer-review meeting solicited feedback from senior research faculty at VTTI regarding the protocol, video examples, and study design for evaluating the training protocol. All feedback was incorporated into the finalized protocol document. Evaluation of the training protocol to assess intrarater reliability and interrater reliability was also conducted.
Deliverable	*Development and Evaluation of a Naturalistic Observer Rating of Drowsiness Protocol*[45]

ORD = Observer rating of drowsiness.

Table 50. Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers: A Case Study.

VTTI Project Number/Fund Code	425998
Short Project Title	OSA Case Study
VTTI PI	Erin Mabry
Begin	March 2009
End	December 2013
FHWA Funding	$43,270.05
Long Project Title	Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers: A Case Study
Project Description	Two leading U.S. transportation companies partnered with two commercial sleep apnea treatment providers and a sleep management provider to implement OSA programs that screen, diagnose, treat, and manage their OSA-positive CMV drivers. This NSTSCE project included focus groups and phone interviews with drivers and staff involved in each OSA program to assess drivers' and staff perceptions and opinions of their respective programs. The majority of drivers expressed satisfaction with participating in their company's OSA program. Drivers reported the following benefits: improved sleep quality, increased energy and feeling well rested, improved health, and decreased concerns about falling asleep while driving. Overall, OSA program personnel believed their programs were successful and were eager to continue refining and improving the material. Staff also reported challenges they faced while implementing and maintaining the OSA programs, such as gaining driver acceptance of the program and significant time delays between screening and testing drivers for OSA due to the high volume of drivers at risk for OSA.
Deliverable	*Case Study on the Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers*[46]

Table 51. Identifying High-Risk Commercial Truck Drivers Using a Naturalistic Approach.

VTTI Project Number/Fund Code	451051
Short Project Title	High Risk CMV Drivers
VTTI PI	Jeff Hickman
Begin	October 2010
End	March 2011
FHWA Funding	$24,999.86
Long Project Title	Identifying High-Risk Commercial Truck Drivers Using a Naturalistic Approach
Project Description	Several research reports suggest that individual differences in personality and performance may predispose some people to a greater risk of being involved in a crash. This project assessed the concept of high-risk CMV drivers and their characteristics. The study used naturalistic data collected during the FMCSA-funded DDWS FOT and NTDS projects. Three distinct clusters of CMV drivers (safe, average, and risky) emerged in the cluster analysis. A small percentage of CMV drivers was responsible for a disproportionately large amount of SCEs, whereas the vast majority of CMV drivers consistently operated their vehicles safely. It appears that interventions targeting the risky group of drivers would yield the largest impact on crash reduction.
Deliverable	*Identifying High-Risk Commercial Truck Drivers Using a Naturalistic Approach*[47]

Table 52. Case Study on a Worksite Health and Wellness Program.

VTTI Project Number/Fund Code	451052
Short Project Title	Worksite Health and Wellness
VTTI PI	Erin Mabry
Begin	October 2010
End	December 2013
FHWA Funding	$25,001.52
Long Project Title	Case Study on a Worksite Health and Wellness Program
Project Description	The typical lifestyle of a CMV driver involves irregular work and sleep hours, physical inactivity, poor eating habits and nutrition, and mental and physical stress. Up to 90 percent of CMV drivers are overweight or obese. To combat the rise in obesity and its associated risks, a leading transportation company initiated an H&W program. This study detailed the company's H&W program and evaluated the opinions, perceptions, and program satisfaction of participating drivers and program staff. Phone interviews were conducted with key program personnel to detail the H&W program. The interview discussed recruitment methods, tests and assessments administered to drivers, H&W education, health coaching, health achievements, motivational strategies, and long-term follow-up. Questionnaires administered to the company's drivers and program staff collected demographic information and inquired about their opinions, perceptions, and satisfaction with the H&W program. Recommendations were developed to aid carriers wishing to implement an H&W program for their fleets.
Deliverable	*Case Study on Worksite Health and Wellness Program for Commercial Motor Vehicle Drivers*[48]

Table 53. Prescription and Over-the-Counter Drug Use and Their Relationship to Involvement in a Safety-Critical Event.

VTTI Project Number/Fund Code	451141
Short Project Title	Prescription Drug
VTTI PI	Jeff Hickman
Begin	December 2013
End	June 2014
FHWA Funding	$50,091.79
Long Project Title	Prescription and Over-the-Counter Drug Use and Their Relationship to Involvement in a Safety-Critical Event
Project Description	This project served as a pilot study that illustrated the feasibility of using naturalistic driving data to assess the risk of an SCE associated with Rx and OTC drug use while driving. The research found that nearly 97 percent of CMV drivers used an OTC drug at least once (mostly caffeine pills), and 25 percent used at least one Rx drug. Results also showed that Rx and OTC (non-caffeine) drug use was not associated with an increased or decreased risk of involvement in an SCE. In addition, drugs that had potential adverse effects related to driving were not found to increase the risk of involvement in an SCE. The use of caffeine was found to be associated with a decreased risk of SCE involvement in all seven half-lives (odds ratios ranging from 0.44 to 0.66). Recording OTC and Rx use via an activity register (or something similar) should be considered in all future naturalistic studies because collecting this data likely involves minimal cost and effort.
Deliverable	*Prescription and Over-the-Counter Drug Use and Its Relationship to Involvement in Safety-Critical Events*[49]

OTC = Over-the-counter.
Rx = Prescription.

Table 54. Evaluation of Light-Vehicle Driver Education Programs Targeting Sharing the Road with Heavy Vehicles: Case Study Analysis.

VTTI Project Number/Fund Code	451144
Short Project Title	Drivers Ed Case Study
VTTI PI	Andy Schaudt
Begin	July 2012
End	December 2013
FHWA Funding	$49,988.48
Long Project Title	Evaluation of Light-Vehicle Driver Education Programs Targeting Sharing the Road with Heavy Vehicles: Case Study Analysis
Project Description	This case study had a twofold purpose: first, researchers investigated current light-vehicle driver education programs that contained components on sharing the road with heavy vehicles and developed a supplemental practices document on key sharing-the-road information that teachers could cover with students. Second, a case study was performed with a light-vehicle driver education program in a single state that only included a basic textbook-based component on sharing the road with heavy vehicles. Researchers evaluated two components introduced in different driver education classrooms and compared them with the basic textbook-based component. The first component was updated digital video disc material by the Commercial Vehicle Safety Alliance titled *Teens and Trucks*. The second component was a hands-on truck experience program developed by researchers. Each classroom of students that received one of the components was invited to take part in a survey 2 mo later and knowledge retention of key learning points (e.g., heavy-vehicle no-zones (blind spots)) was measured. Focus groups were also conducted in which participants discussed how to share the road with heavy vehicles.
Deliverable	*Evaluation of Light-Vehicle Driver Education Programs Targeting Sharing the Road with Heavy Vehicles*[50]

Table 55. Tips for Sharing the Road with Commercial Motor Vehicles: A Web-Based Approach.

VTTI Project Number/Fund Code	451219
Short Project Title	Road Share
VTTI PI	Naomi Dunn
Begin	January 2013
End	May 2013
FHWA Funding	$3,617.58
Long Project Title	Tips for Sharing the Road with Commercial Motor Vehicles: A Web-Based Approach
Project Description	This project sought to create a Web-based tool utilizing naturalistic videos to provide tips for sharing the road with CMVs, offering a supplemental driving tips training program that would be accessible to the public and based on naturalistic driving data. The Web site would be dedicated to providing video examples of real-world scenarios involving light- and heavy-vehicle interactions, as well as proper sharing-the-road driving behavior. If sharing-the-road scenarios exist that have not been previously captured by naturalistic studies (or participant consent for using the videos cannot be obtained), the Smart Road or VTTI's Commercial Training and Prototyping Simulator will be used to re-create or simulate and record these scenarios as examples for the Web site.
Deliverable	Report: *Tips for Sharing the Road with Commercial Motor Vehicles: A Web-based Approach*[51] Web site: *Tips for Sharing the Road with Commercial Motor Vehicles*[52]

Table 56. Distraction and Fatigue in Occupational Light-Vehicle Drivers.

VTTI Project Number/Fund Code	451266
Short Project Title	Occupational Distraction
VTTI PI	Jeff Hickman
Begin	December 2013
End	June 2014
FHWA Funding	$26,375.79
Long Project Title	Distraction and Fatigue in Occupational Light-Vehicle Drivers
Project Description	This research included an analysis of naturalistic data collected by a contractor across a 3-mo period. Supervisors in utilities and service organizations were the targeted vehicle operators in these analyses because those employees frequently drove to sites or locations in their territories on a daily basis. These data provided descriptive information about the adverse consequences of fatigue and tertiary tasks while driving. In addition, the contractor completed a secondary review of all cell phone SCEs and spurious baselines within the last 90 days to determine the frequency of the following cell phone variables: dial cell phone, reach for cell phone, reach for Bluetooth®/headset/earpiece, talk/listen on hands-free cell phone, talk/listen on handheld cell phone, and text/email/surf Web on cell phone. The results of these analyses provided information about the scope of cell phone use (as well as other distractions) and fatigue during safety-related events and spurious baselines. The data reduction and reliability protocols were finalized and approved by Lytx™. With the data sharing agreement in place, the research team hopes to begin data reduction and reliability analysis soon.
Deliverable	*Distraction and Fatigue in Occupational Light Vehicle Drivers*[53]

CHAPTER 6. OUTREACH

Until 2012, NSTSCE did not have a dedicated resource for outreach, so the stakeholders decided to add another SME to handle this area in particular. It was hoped that the addition of the SME would increase the transmission of results of NSTSCE projects to the individuals who would benefit most from them. This SME also took responsibility for NSTSCE branding and marketing to potential stakeholders and sponsors, ultimately coordinating the biannual International Naturalistic Driving Symposium. Table 57 through table 59 describe the three projects that are under this research focus area.

Table 57. Driver Health Tips Web Site.

VTTI Project Number/Fund Code	425961
Short Project Title	Driver Health Tips Web Site
VTTI PI	Justin Morgan
Begin	October 2009
End	May 2011
FHWA Funding	$100,000.00
Long Project Title	Driver Health Tips Web Site
Project Description	Many CMV drivers struggle to maintain a healthy lifestyle given the demands of their job, yet previous CMV health programs have failed to adequately address the needs of CMV drivers, adapt programs suited to their unique lifestyle challenges, and widely implement those programs. In addition, reaching this highly fragmented and mobile population proved difficult. This project called for the creation of an integrated social networking-based health outreach effort directed at CMV drivers called Driving Healthy. This resource provides health information and best practices for CMV drivers and empowers them to make healthier lifestyle choices while on the road. It was anticipated that this effort would result in greater H&W information acceptance among target audiences and more effective use of H&W information, as well as foster mutual support within the target audience.
Deliverable	The deliverables included a Web site, Facebook® page, Twitter® page, and report. (See references 54 through 57.)

Table 58. YouTube® Video Library.

VTTI Project Number/Fund Code	451280
Short Project Title	YouTube® Outreach
VTTI PI	Myra Blanco
Begin	August 2013
End	June 2014
FHWA Funding	$14,193.25
Long Project Title	YouTube® Video Library
Project Description	In order to help NSTSCE increase the exposure of surface transportation safety research to the general public, a YouTube® channel was created that highlights completed NSTSCE projects. SMEs helped select the featured projects. Most videos are approximately 5 min long and provide highlights of the key findings as well as links to the full report. The first set of videos included an NSTSCE overview along with two projects. The second set of videos, which is currently in production, includes an additional five projects. In addition to the videos, the YouTube® channel also features links to the stakeholder YouTube® channels as well as other NSTSCE outreach Web sites (e.g., Driver Health Tips and HV Driving Safety).
Deliverable	YouTube® channel[58]

Table 59. Heavy Vehicle Safety Outreach.

VTTI Project Number/Fund Code	451163
Short Project Title	HV Safety Outreach
VTTI PI	Rebecca Hammond
Begin	May 2012
End	April 2014
FHWA Funding	$85,005.07
Long Project Title	Heavy Vehicle Safety Outreach
Project Description	The objective of the Heavy-Vehicle Safety Outreach project was to develop and implement a pragmatic curriculum to support the needs of safety managers. Safety managers for motor carrier fleets are primarily responsible for heavy-vehicle safety. These individuals have a unique understanding of the safety challenges within their fleets. However, many of them operate without access to the latest research in heavy-vehicle safety. Providing a workshop that immersed fleet safety managers in the latest safety information could positively affect their approach to fleet safety. To be as effective as possible, this workshop included both science- and practice-based presentations. This project used the analysis, design, development, implementation, and evaluation method, which has become one of the most frequently used training models in recent years. Specifically, it encourages the trainer to use an iterative process by obtaining feedback at each step and using it to improve the next step.
Deliverable	*Heavy-Vehicle Safety Outreach*[59]

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