



**NATIONAL
SURFACE TRANSPORTATION SAFETY
CENTER FOR EXCELLENCE**

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NSTSCE

National Surface Transportation
Safety Center for Excellence

Message from the Director



Beginning in 2006, the National Surface Transportation Safety Center for Excellence (NSTSCE), located at the Virginia Tech Transportation Institute (VTTI), has engaged its world-class researchers and state-of-the-art facilities to enhance driver performance and to create a safer environment for the driving public.

NSTSCE was formally awarded to VTTI through the Federal Highway Administration (FHWA) in July 2006. We owe Senator John Warner, now retired, a debt of gratitude as he was instrumental in designating VTTI as a Center for Excellence in the 2005 transportation bill titled Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). NSTSCE funding was also included in the 2009 transportation bill extension, which granted VTTI an additional year of funding in the amount of \$687,000. Continued funding of the Centers for Excellence program is a priority for Virginia Tech.

NSTSCE stakeholders include organizations that derive direct benefit from the work being performed by the Center. We would like to thank our external stakeholders, including: FHWA, General Motors Corporation (GM), the Virginia Center for Transportation Innovation and Research (VCTIR), the Federal Motor Carrier Safety Administration (FMCSA), and Travelers Insurance. The role of stakeholders is to provide direct funding to NSTSCE, guidance towards research direction, and selection of research projects. Our stakeholders enable NSTSCE researchers to make a difference in current and future transportation safety beyond the initial SAFETEA-LU designation.

The NSTSCE approach is to build on the strengths and capabilities of VTTI to make a measurable impact on road-user safety. NSTSCE uses a synergistic approach across four research focus areas to maximize resources. Last year the stakeholders reevaluated the initial four focus areas of NSTSCE. Safety Devices and Techniques That Enhance Driver Performance remained as originally conceived. The other three areas were refocused to reflect the expected future research program of NSTSCE. For example, the driver fatigue area was refocused to include other impairments such as distraction and is now labeled Driver Impairment. Age-related driving is now categorized as Safe Mobility for Vulnerable Road Users. Evaluation of the Built Roadway Environment and Infrastructure-based Safety Systems now encompasses lighting and pavement delineation.

During the past six years we have made significant strides in advancing safety on national highways. NSTSCE research results are leading to enhanced technology developments as engineers work to translate research findings into transportation safety applications. These results also provide insights into transportation safety policies and inform decision makers as they craft legislation. For example, data collected and analyzed from studies about specialized driving populations (e.g., older drivers, teen drivers, and truck drivers) allow us to examine from both countermeasure and policy standpoints the national transportation safety concern of distracted driving. In 2011, VTTI researchers provided testimony and findings before the House Subcommittee on Transportation Security.

We have continued this important work with a teen driving program that involves real-time monitoring, immediate feedback to the teen driver, and post-trip feedback to the teen's parents. The program is currently being tested using funds provided by NSTSCE and other research partners. During this study, parents are provided with targeted coaching tips designed to improve the teen's driving performance. The ultimate goal of the project is to reduce teen driver fatalities (eight teens die every day from motor vehicle injuries; Centers for Disease Control).

The development of sophisticated, ruggedized equipment has led to a 100-motorcycle study. Funded by the Motorcycle Safety Foundation (MSF), this project is designed to explore motorcycle crash causation with the goal of developing crash countermeasures. The National Highway Traffic Safety Administration (NHTSA) is also funding a 160-motorcycle study that begins this year. From a safety perspective, motorcycles are over-represented in crashes. In 2008, one in seven motor vehicle fatalities were motorcyclists, though they represent only 2 percent of vehicles and only 0.3 percent of vehicle miles traveled (NHTSA).

NSTSCE and its stakeholders are committed to improving transportation safety. Although much has been accomplished, there are incredible opportunities available to accomplish even more in the future. We are excited about the safety and performance achievements made through this support and look forward to continuing to contribute to the NSTSCE mission of improving surface transportation safety.

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Mission of the Center

The mission of NSTSCE is defined as using state-of-the-art facilities, including the Virginia Smart Road, to develop and test transportation devices and techniques that enhance driver performance, examine advanced roadway delineation and lighting systems, and address age-related and fatigued driver issues. The vision of NSTSCE is to become recognized as The National Center for Surface Transportation Safety, to make a significant impact in improving surface transportation safety, and to leverage partnership and sponsor relationships to disseminate results.

NSTSCE has formed a Stakeholders' Committee comprising organizations that share a vision for improving road-user safety locally and nationally. The Stakeholders' Committee members are Carl Andersen, Federal Highway Administration (FHWA); Tom Dingus, VTTI; John Capp, General Motors Corporation (GM); Cathy McGhee, Virginia Department of Transportation (VDOT) and the Virginia Center for Transportation Innovation and Research (VCTIR); Martin Walker, Federal Motor Carrier Safety Administration (FMCSA); and Chris Hayes, Travelers Insurance. The role of stakeholders is to provide direct funding to NSTSCE, guidance towards research direction, and selection of research projects. The approach of NSTSCE is to build on VTTI strengths and capabilities to make a measurable impact on road-user safety. NSTSCE uses a synergistic approach across four research focus areas to maximize resources:

- **Safety Devices and Techniques That Enhance Driver Performance**, which includes public awareness and training on driver performance and behavior.
- **Evaluation of the Built Roadway Environment and Infrastructure-based Safety Systems**, which includes pavement markings, lighting, visibility, safety systems, and impacts on decision making.
- **Safe Mobility for Vulnerable Road Users**, which includes young and older drivers, pedestrians, cyclists, wheelchair users, transit users, and possibly motorcycle and scooter users.
- **Driver Impairment**, which includes fatigue, distraction, and other issues.

Building upon existing naturalistic driving databases (e.g., the 100-Car Naturalistic Driving Study), researchers will develop experiments and collect additional data to answer questions where needed. VTTI continues to develop its strengths and capabilities in transportation safety research.

Goals of the Center

To satisfy the mission of NSTSCE, the stakeholders and the research team have developed overarching strategic goals and specific focus area goals. These goals are designed with the purpose of improving road-user safety using an integrated and dynamic approach. Each goal is further described by a roadmap for achieving these goals. Partnerships with relevant agencies and industries are a critical component to achieving the maximum impact of NSTSCE, thus each specific focus area lists potential research partners. Note that it is assumed that the stakeholders are partners in each project. While the primary mission of NSTSCE is transportation safety research and development, all stakeholders and researchers will work to optimize outreach and technology transfer opportunities.

Goal 1: Identifying age-related deficiencies in driving performance and developing methods and countermeasures to mitigate the associated risks.

Goal 2: Understanding the role fatigue plays in crashes of both heavy and light vehicles and developing and evaluating countermeasures to reduce fatigue-related traffic incidents.

Goal 3: Improving the nighttime roadway visual environment through the assessment of behavior, establishment of visibility needs, and control of adverse lighting effects.

Goal 4: Developing a greater understanding of driver decision making and performance during normal driving through imminent crash situations in urban, rural, and freeway driving environments.

Goal 5: Developing and evaluating new devices and techniques for enhancing driver performance.



Role of Stakeholders

NSTSCE stakeholders comprise organizations that derive direct benefit from the work to be performed by NSTSCE. Stakeholders provide direct funding to NSTSCE, guidance towards research direction, and research project selection. The Agreement Officer's Technical Representative (AOTR), Carl Andersen, serves as the chair of the Stakeholders' Committee. Other Stakeholders' Committee members are Tom Dingus, VTTI; John Capp, GM; Cathy McGhee, VDOT and VCTIR; Martin Walker, FMCSA; and Chris Hayes, Travelers Insurance. Each of these members provides additional funding for NSTSCE research. The Stakeholders' Committee is joined by research partners from industry and federal and state governments that are willing to provide additional funding for specific research projects.

With input from the Stakeholders' Committee and other experts, VTTI continually reviews surface transportation safety research needs. VTTI incorporates strategic research needs in developing potential transportation safety projects. A prioritized list of potential projects and a multi-year strategic plan are presented to the Stakeholders' Committee. The plan strives to coordinate NSTSCE research efforts with those of FHWA, FMCSA, and other federal research programs. The Stakeholders' Committee will review and approve the strategic plan. Once the plan is approved, the potential research project list will serve as input into the next stage of project planning.

Marketing Approach

NSTSCE subject matter experts and project managers accelerated NSTSCE marketing and outreach efforts during the sixth full year of NSTSCE. Research entities with similar transportation safety goals were targeted. An overarching strategy continues to be to seek out representation from primary research areas in transportation safety and to draw membership from a proportionate mix of industry, state, and federal agencies.

NSTSCE representatives attended several conferences and workshops to garner interest in stakeholder participation and to disseminate NSTSCE research results:

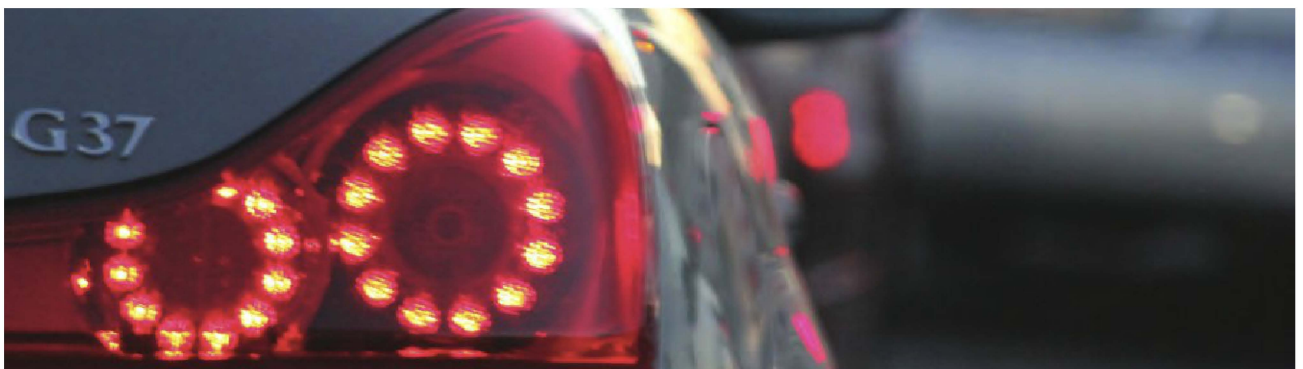
- Several NSTSCE researchers participated in relevant Transportation Research Board (TRB) meetings and workshops.
- VTTI/NSTSCE researchers served as TRB and SAE committee members within primary research areas.
- NSTSCE researchers presented at the 18th ITS World Congress.
- NSTSCE researchers were invited guest speakers at international conferences held in Australia, New Zealand, and Sweden.
- NSTSCE researchers hosted the U.S. Department of Transportation (US DOT) Secretary Ray LaHood and US DOT management and research staff.
- NSTSCE researchers hosted the Canadian Deputy Minister of Transport Highway and Safety.
- NSTSCE researchers continued to develop tools and techniques to provide national and international transportation researchers access to VTTI naturalistic data.

Outreach Strategy

While research and technology development are the primary goals of NSTSCE, the stakeholders and research team understand the importance of disseminating the results to the surface transportation research community and to the public. While NSTSCE and its research programs are products of the entire team and are meant to stand on their merits, creation of an independent identity for NSTSCE provides a focal point for the public, policy makers, and the research community and thereby improves access and dissemination of research results.

Outreach Accomplishments

- Rich Hanowski participated in a meeting with Human Factors Faculty from Virginia Tech and the University of Nottingham to discuss collaborative opportunities. On the topic of naturalistic driving research, NSTSCE was noted as a domain leader with the potential for future collaboration.
- Ron Gibbons was assigned as the Associate Director of the Lighting for Transport Division of the Commission Internationale d'Eclairage.
- Jon Antin presented NSTSCE-related material at the Toyota Collaborative Safety Research Center Safety Symposium in August and at the Senior Mobility Awareness Symposium in December.
- Charlie Klauer presented information about teen driver distraction at several conferences, including LifeSavers and the Toyota Safety Symposium.
- Erin Mabry attended and presented NSTSCE work about the Sleep Apnea Case Study at the Third International Symposium on Naturalistic Driving Research.
- Greg Fitch presented NSTSCE research at the 4th International Conference on Applied Human Factors and Ergonomics in San Francisco.
- Matt Camden presented a poster about the NSTSCE Prescription Drug project. The poster was titled, "Methods to examine the relationship between drug use and involvement in a safety-critical event" and was presented at the Third International Symposium on Naturalistic Driving Research.
- Andy Schaudt attended/presented at several events during which NSTSCE-related work was noted, including the 2012 Virginia Association for Driver Education and Traffic Safety (VADETS) Conference, the 2012 Transportation Research Board (TRB) Annual Meeting, the 2012 XL Insurance Safety Directors Roundtable, two Princeton High School Driver Education classes in West Virginia, and the 2012 International Symposium on Naturalistic Driving Research.
- Stephanie Baker and Laura Toole presented a poster about NSTSCE-related work titled, "Evaluation of Light-Vehicle Driver Education Programs on Sharing the Road with Heavy Vehicles" at the 2012 International Symposium on Naturalistic Driving Research.
- Tammy Trimble, Justin Morgan, Myra Blanco, and Rich Hanowski presented a poster about NSTSCE-related work titled, "Driving Healthy: Delivering Health and Wellness Information to Commercial Truck Drivers" at the 2012 International Symposium on Naturalistic Driving Research.
- Tammy Trimble and Darrell Bowman presented a poster about NSTSCE-related work titled, "Telematics Market Guide: Creating a Consumer's Guide to Currently Available Aftermarket Solutions" at the 2012 International Symposium on Naturalistic Driving Research.



Outreach Goals

Heavy-vehicle Safety Outreach

While many forums are available for researchers to disseminate and discuss heavy-vehicle safety research, there are few channels of communication available from research to the implementation stage. Thus, many safety managers at commercial fleets may not be aware of the latest heavy-vehicle research findings in areas that could help shape their fleet policies and practices (e.g., fatigue and distraction). The purpose of this outreach effort is to create an instructional package for fleet safety managers and officials that may be delivered in an informal manner. This package will provide information about the latest research findings related to heavy-vehicle safety. The culmination of this project will be a pilot session of the instructional package conducted with a group of safety managers.



Publication and Analysis Plan

Numerous publications were submitted to scientific agencies and journals during 2012, and several fresh observations are presently under research analysis to create additional publications. Greg Fitch and Rich Hanowski published a paper entitled, “Exploring drivers’ compensatory behavior when conversing on a mobile device” that appeared in the proceedings of the 4th International Conference on Applied Human Factors and Ergonomics. Ron Gibbons co-authored, “Visual Modeling: Exploring the Relationships between Nighttime Driving Behavior and Roadway Visibility Features,” which is currently in press for the Transportation Research Record. Jon Antin and Feng Guo co-authored, “Comparing the impairment profiles of older drivers and non-drivers: toward the development of a fitness-to-drive model” that appeared in Safety Science.

Resulting analyses and publications currently focus on naturalistic driving data while also addressing the NSTSCE mission: to develop countermeasures intended to facilitate independence and safe mobility by focusing on the safety-related transportation beliefs, behaviors, abilities, impairments, needs, concerns, and crash-related events for a range of vulnerable road users, including: young and older drivers, pedestrians, motor/pedal-cyclists, the wheelchair bound, and transit users. Using the largest repository of naturalistic driving data in existence, this project is focused on the development of an inclusive data mining, analysis, and publication plan. The VTI data collection of more than 400 terabytes (TB) includes incoming raw data and metadata sets from several large-scale studies and encompasses heavy- to light-vehicle naturalistic driving in rural and urban locales. These data are examined under all relevant perspectives for identified events and driving behavior to further interpret causal/associative factors.

Focus Area 1: Safety Devices and Techniques that Enhance Driver Performance

Attention and Drowsy Driver Assist

Following a review of project plans and objectives, this study was redefined during the past year to focus on automated detection of driver drowsiness and driver attention to, or away from, the forward roadway. The literature review conducted as part of this project was used to support the development of a detection strategy and a preliminary algorithm design. The algorithm will integrate eye-gaze data with driver performance to characterize driver attention and drowsiness. Subsequent steps include identifying useful data, accessing the data, video reduction, code development and testing, and algorithm finalization and documentation.

Institutional Review Board (IRB) materials were developed in which access to the 100-Car and Older Driver data sets was requested. Materials were submitted and approved. Appropriate epochs are currently being identified for use during code development and testing.

Crash—Near-Crash Trigger Algorithm

A common problem experienced while working with naturalistic driving data is extracting events of interest from a large data set without experiencing an excessive number of false alarms. This is typically accomplished through an iterative process of threshold triggering on kinematic data followed by video validation performed by trained reviewers.

In an attempt to improve the accuracy of the automated threshold triggering, statistical classification methods are being evaluated. These methods will be tested using valid and invalid events from the original 100-Car Study analysis as a gold standard to judge algorithm performance. Once the methods are developed using a 100-Car Study analysis, algorithm performance will be evaluated using other naturalistic data sets.

Data Center

The VTTI data center experienced several expansions this year. Most noteworthy among these were a new computational cluster, the application of the Virginia Tech HPC Storage System, and a significant upgrade to the storage system supporting the VTTI Scientific Data Warehouse environment. These systems compose the foundation for data-intensive scientific research programs conducted at VTTI, particularly the Second Strategic Highway Research Program (SHRP 2) Naturalistic Driving Study.

The 48-node compute cluster of the Institute moves data between the field and the data center, decrypts data, prepares data files for ingestion to the Scientific Data Warehouse, processes video files, and provides a platform for advanced analytical processing. A significant development of the HPC Storage System was a peta-scale archive file system, which will ultimately facilitate the long-term storage of numerous petabytes of data while maintaining data in an online state. Finally, the Scientific Data Warehouse expanded from approximately 100 terabytes (TB) to more than 500 TB as a result of the growth of the VTTI research data repository.

Building a data center at this scale requires various skills and teams. The VTTI data center team works closely with the central IT organization of Virginia Tech and the Virginia Bioinformatics Institute (VBI) to best leverage strategic investments of the University in research computing. This collaboration has been particularly noteworthy in the design and implementation of the HPC Storage System.

Data Sharing Across Borders

Traffic crashes continue to be a leading cause of death in countries around the world. If possible, naturalistic driving study data should be made available to researchers from other countries to help improve driving safety and reduce traffic crashes in these countries. This may prove to be especially useful for countries unable to mount such studies due to limited resources. VTTI has a goal of becoming an international naturalistic data warehouse. In some cases the international community has the ability to collect naturalistic data but not the tools for storage and use. There are many challenges to overcome before cross-border data sharing can be implemented. Project researchers are currently investigating the issues involved in cross-border data sharing and are developing a workbook of suggested practices for other researchers seeking access to naturalistic driving data collected in other countries.

VTTI is working with the international research community to assess and address issues associated with data sharing across borders. Issues to be addressed include the fact that not all countries have the equivalent of the IRB. Researchers from countries without such institutional protections should be trained in the issues and safeguards corresponding to the use of naturalistic data. Researchers should be made familiar with the terms of the original consent forms signed by research participants. Language and cultural barriers surrounding human subjects' protection issues may be a larger impediment to cross-border data sharing than the relatively minor differences in driving habits and behaviors.

The Office for Human Research Protections (OHRP; part of the U.S. Department of Health and Human Services) annually assembles and publishes *The Compilation of International Human Research Protections*. The publication contains a section about international policy (through the United Nations Educational, Scientific and Cultural Organization [UNESCO]) and a country-by-country guide. Links are provided in six categories: general; drugs and devices; privacy/data protection; human biological materials; genetics; and embryos, stem cells, and cloning. This NSTSCE project will focus on the general and privacy/data protection areas.

Several countries were selected for review (i.e., countries in which naturalistic driving studies have been conducted, are currently being conducted, or where such studies are being planned). Their international policies and guidelines are currently being evaluated in addition to those of the following countries: U.S., Canada, Australia, Sweden, China, Germany, Japan, Great Britain, France, New Zealand, and Israel.

Several VTTI researchers are currently involved in conducting naturalistic driving studies in other countries, with involvement ranging from guidance and consulting to active data collection. This project is designed to provide guidance about IRB and data-sharing concerns as part of researchers' participation. The principal investigator (PI) has developed a brief "best practices" document for use during these situations. This document is available upon request and will likely be similar to the conclusions section of the final report.

Developing Bayesian Models for a Naturalistic Driving Study

The Bayesian method has become an important branch in transportation safety studies. Compared to the classical statistical method, the Bayesian method has advantages of ease of interpretation, flexibility to accommodate a spatial/temporal correlation, the ability to incorporate prior information, and a natural hierarchical structure for modeling multicenter/group studies. This project focuses on developing robust Bayesian models for the two approach types used during a naturalistic driving study: the case-crossover and the case-control methods.



The first part of this study focuses on the case-crossover method. Based on a complete case-crossover study sponsored by the National Highway Traffic Safety Administration (NHTSA), the VTTI team used reduced data to develop a semi-parametric Bayesian model for matched case-crossover data. The proposed model is a significant improvement over the traditional, conditional logistic regression model. The latter only uses a small proportion of data where the status of a risk factor is different within a stratum. The team has theoretically proven that the proposed model provides less bias and more robust results than the conventional logistic regression model. A paper based on this result is under review for the journal *Statistics in Medicine*.

The research team is currently working on Bayesian hierarchical models that have been proposed to evaluate distraction risks for different age and gender groups. The random effect meta-analysis method has been used to set up the model structure. It was found that the model results are sensitive to prior specification. The research team is working on conducting an in-depth evaluation of this and finding a solution.

Distraction Index Framework

A number of surrogate measures of distraction exist, but their contributions to the overall construct have not been quantified. The goal of this research is to establish a framework for the creation and, to the extent possible, validation of a distraction index that combines the effects of the most important surrogate indicators of distraction. The concept will be similar to the widely used (in the musculoskeletal arena) National Institute for Occupational Safety and Health (NIOSH) Lifting Index and will result in a published research guideline that can be used as a common measure across studies.

To determine the feasibility of this effort, researchers will start with select crash and near-crash surrogates and will overlay these with naturalistic data. A literature review and a reanalysis of existing data are required (no additional data collection will be needed).

Project progress primarily included completion of the analyses and a final report draft. During most cases, findings from analyses were not powerful enough to be conclusive but showed interesting and meaningful trends. In general, data showed that the use of infotainment systems in naturalistic environments changed the normal patterns of visual attention but had limited or no effect on the lateral control of the vehicle (at least compared to the normal "noise" experienced in this measure during naturalistic driving).

Results indicated that: i) Infotainment system use was present for approximately 10 percent of near-crashes compared to the 2 percent of the driving time during which infotainment systems were used; ii) Use of infotainment systems had measurable demands on drivers' visual resources; iii) Infotainment system use showed trends towards a reduced propensity to respond to unexpected events on the forward roadway, especially when those events were peripheral; and iv) Estimates of crash risk derived from some of these measures place infotainment system use risk at a level higher than "normal" driving but lower than other visual-manual control tasks that are often performed while driving. These estimates support the presence of radio tasks in the crash record but at low levels.

A final report was drafted and submitted for internal review. Reviewer comments were received; the final report is currently undergoing revisions to address these comments.

Driving Scenario Classification

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 will be developed to review naturalistic driving data and to classify data epochs according to driving scenarios. Variances in data created by common driving scenarios can be parsed out earlier during the data-mining process.

Having developed operational definitions of the different scenarios, a reductionist was trained, and video reduction was conducted on 195 trips to identify when drivers were involved in scenarios. During the review, approximately 1,350 cases of 60 drivers involved in 24 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 only found in one trip.

A global positioning system (GPS)-based approach to scenario classification was also developed. The method rapidly matches vehicle location to digital maps of road segments, which provides a reference to all associated road data included in departments of transportation and private map sources. This approach addresses the bulk of the objectives of this scenario classification effort.

The GPS-based matching method will be finalized and written up for publication during the next reporting period.

Generic Motorcycle Bracketry and Housings

VTTI is conducting two safety-related naturalistic motorcycle studies. The first study has placed 93 of 100 motorcycles on the road (Motorcycle Safety Foundation Naturalistic Study). The second study is in the planning phases and will include 160 motorcycles (NHTSA Instrumented On-road Study of Motorcycle Riders). The original bracketry and accessory housings (e.g., radar, GPS, cameras) were designed for a small number of motorcycles with no accessories or modifications. This project will support the design of bracketry and housings that can be used on a range of motorcycle models.

Under this project, off-the-shelf bracketry solutions have been identified for many of the most common models of motorcycles. Generic components have also been engineered that complement 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.



Identifying Cognitive Load from Naturalistic Data

The goal of this project is to develop a methodology that will use naturalistic data to identify epochs of cognitive activity performed during driving. The input measures for the algorithm comprise eye-behavior indicators that are already typically present in the data stream derived from naturalistic studies. The project leverages previous findings that relate cognitive load while driving with drops in blink rates, concentration of long glances on the forward roadway, and narrowed breadth of scanning. The results show promise for a “Cognito” protocol that can be used to distinguish cognitive load from other types of visual, manual, or mental activity present in naturalistic driving data. The algorithm focuses on long glances to the forward roadway and reduced peripheral scanning.

During the next reporting period, work will begin on a final report for this project.

Impacts of Safety-critical Events on Driver Behaviors

The objective of this study is to evaluate the impacts of crashes on driving behavior. Specifically, the driving behavior is measured by two primary metrics: 1) The near-crash and safety-critical event (SCE) rates and 2) The driver distraction. The VTTI team defined a certain time window before and after a crash; the near-crash and SCE rates during these windows were compared. According to data, the smallest interval between two crashes occurred for the same driver in 0.0308 hours (approximately two minutes). This is because a second accident occurred immediately after the first. Most crash intervals are generally longer than 20 hours; only 10 percent of intervals are less than 20 hours. Thus, 10 hours was chosen as the initial window of time before and after a crash.

An initial analysis performed using the 100-Car Study data indicated that there are differences in critical incident rates. However, the differences were not statistically significant. The team is developing a time-to-event-based approach to conduct the assessment. The time-to-event-based approach is not constrained by a subjectively defined window and can provide more power in detecting the differences. Preliminary results indicated that the change in risk of critical incidents before and after a crash is affected by gender and the order of crashes.

IMU Utility Tool

The next generation of the VTTI data acquisition system (DAS) measures acceleration along six axes: three orthogonal linear and three orthogonal rotational orientations. This package of measures composed the first complete inertial measurement unit (IMU) used during large-scale vehicle deployments. Presently, VTTI does not have the capabilities to use IMU data to full potential.

This project comprised the following objectives:

- Develop signal-processing methods to filter and/or clean IMU data,
- Develop a method to “reorient” the IMU to provide measures aligned with the vehicle,
- Develop a dead reckoning system that essentially derives linear positions,
- Develop a method for deriving linear speeds from linear accelerations, and
- Develop a method for deriving angular positions from rotational accelerations.

The project team completed the product development cycle and focused on rolling the code out for production. This included creating documentation for the algorithms, fully commenting the code, and implementing the code into a version control system. The research team deployed the code for general VTTI consumption and used it across a variety of projects. The final report is in the publication process.

International Driver Behavior Comparison using a Shanghai Naturalistic Driving Study

The Shanghai naturalistic driving study was conducted in partnership with the General Motors Company (GM) and Tongji University (Tongji). The objectives of the study are: 1) To evaluate driver behavior, traffic conditions, and the effects of active safety warning systems in Shanghai, one of the largest cities in China with a population of more than 20 million; and 2) To evaluate the feasibility of instrumenting, coordinating, and supporting an international naturalistic driving study using the VTTI naturalistic driving study data center model developed for SHRP 2. The study involves five vehicles instrumented with the latest NextGen DAS developed by VTTI. The study will collect data for three years from approximately 90 participants. Each participant will drive a testing vehicle for three years. The testing vehicles are equipped with a MobileEye active safety warning system, which includes forward collision warning, lane-departure warning, and pedestrian warning. Each participant will drive the testing vehicle with MobileEye disabled for one month followed by activation of MobileEye for another month.

The international naturalistic driving study involved addressing complicated logistics and computing, hardware, and software challenges. The research team solved a series of issues and achieved the following key milestones:

- A test vehicle was instrumented in September 2012 by a VTTI technical expert.
- The first five subjects were on the road in December 2012 for official data collection.
- VTTI received the first month of data and successfully ingested the data into its naturalistic driving study data center. The first 552 trips are in the system and are ready for research.

The team has gained extensive experience in conducting an international naturalistic driving study. Specifically, the team successfully addressed the following challenges:

- Set up standalone Transserver and database server for an international naturalistic driving study.
- Ensure NextGen DAS works properly outside of the United States.
- Address export control issues.
- Obtain Virginia Tech IRB approval and help Tongji receive approval from its Ethics Reviewing Committee.
- Transfer large amounts of data across international borders.
- Provide long-distance technical support for the NextGen DAS.

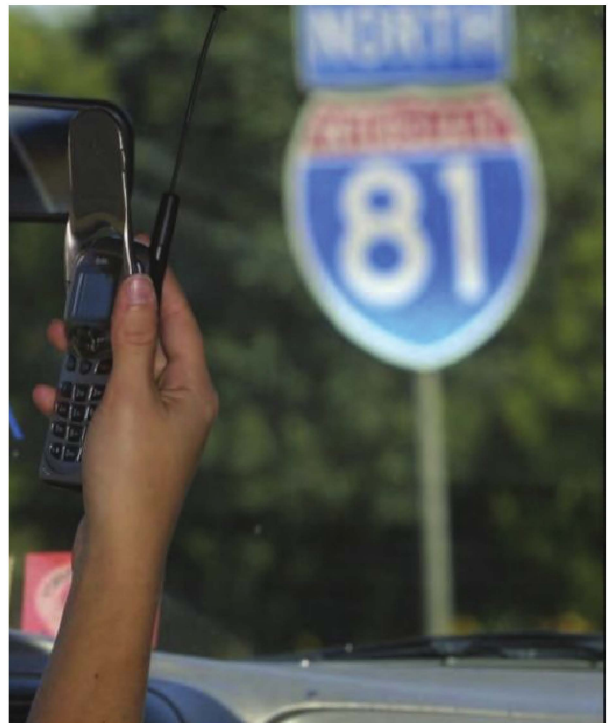
Investigating Drivers' Compensatory Behavior when using a Mobile Device

This study comprises a re-analysis of existing naturalistic driving study data sets. There are two goals. The first is to investigate whether conversing on a mobile device is found to be associated with a decreased risk of an SCE. It is hypothesized that drivers alter the way they drive when conversing on a mobile device, thus increasing their safety margins by slowing their vehicles and increasing their headways to lead vehicles. This change in driving performance may be evidence of a compensatory mechanism being invoked.

The second goal is to investigate the relationship between drowsiness and the SCE risk from mobile device use. Here it is hypothesized that the SCE risk associated with conversing on a mobile device will decrease when drivers have obtained little sleep the previous day. By contrast, the SCE risk associated with complex cell phone subtasks (e.g., dialing, texting) is hypothesized to increase when drivers have obtained little sleep the previous day.

Goal 1 Status – An analysis was performed of the speed of commercial motor vehicles (CMVs) when drivers used and did not use a mobile device. Commercial drivers were not found to decrease their speeds. Rather, they were found to increase their speeds by 4 km/h and 2 km/h during low and moderate driving task demands, respectively. No speed differences were found during high driving task demands. Although drivers did not decrease their speeds when using a mobile device, they were observed to talk/listen less during high driving task demands.

Goal 2 Status – Goal 2 was completed as part of a master's thesis of a graduate research student at VTTI. All analyses regarding the relationship between drowsiness and the SCE risk of mobile device use were completed. A main finding was that commercial drivers had more mobile device use between 2 a.m. and 4 a.m. than any other time interval examined. However, it was also found that drivers' mobile device use did not differ based on how much sleep they obtained during the previous 24 hours. The SCE risk of mobile device use was also not found to change based on the amount of sleep obtained during the previous 24 hours. The results of this study generate insight into commercial drivers' use of cell phones when they are drowsy. A final report documenting the results is being prepared.



Market Guide to Fleet Telematics Services

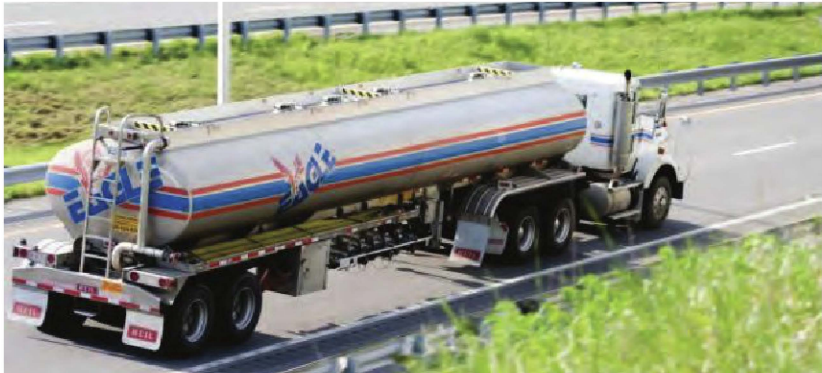
The objective of this project was to provide a detailed market guide about current telematics solutions offered by both heavy- and light-vehicle telematics providers. To that end, a market guide about fleet telematics services was developed and distributed. This guide provides an overview of the currently available third-party, aftermarket telematics solutions. The focus of this review was complete telematics solutions aimed at benefiting overall fleet operations (i.e., solutions that are designed to improve a range of driving, safety, and operational tasks).

The guide includes a review of identified solution providers in the U.S., Canada, United Kingdom, Ireland, and the European Union. For each provider, available telematics features were identified and grouped into the following categories:

1. **Integration Features:** These features relate to the operation of vehicles and include those solutions associated with vehicle location, safety, diagnostics, communication, and interactivity.

2. **Usability Features:** These features relate to the usability of the solution and refer to solution types offered (e.g., small fleets/individual users, overall fleet management, specialized fleets or services), features describing how data are filtered and presented to the user (e.g., web-based reporting/data access program, customizable dashboard, multiple report types), and how data are integrated into company operations (e.g., staff management, risk reduction).

3. **Service Region:** Solution providers vary greatly not only in comprehensiveness of solutions but in their service regions.



A final report is available at:

http://scholar.lib.vt.edu/VTTI/reports/FleetTelematics_12212012.pdf

Mask Algorithm Validation

Manually reduced eye-glance data from naturalistic driving projects will be processed through the Mask algorithm for comparison to the calculated head position and rotation values. Accuracy statistics will be calculated based on different levels of glance zone specificity. For example, a simple “forward” versus “not forward” zone definition will be compared to a definition that breaks “not forward” into additional categories. Data epochs where Mask does not perform ideally will be assessed to identify the problem-causing factors that should be addressed during future versions of the algorithm (e.g., lighting issues, face and/or clothing characteristics, head tilt, camera alignment).

A concurrent Mask project funded through SHRP 2 will validate the Mask algorithm against other independent, automatic head-tracking systems. The team is leveraging the efforts of these two projects for consistency among conditions tested and to maximize the utility of the results of both projects. Due to technical logistics, data were not able to be collected for SHRP 2 during the reporting period. Data collection will commence during early 2013.

MiniDAS

Development is underway of the newest VTTI DAS, the MiniDAS; procurement plans are in place to purchase 100 systems. This DAS facilitates epoch and continuous recording and contains many of the same features as the NextGen DAS, including:

- A three-axis accelerometer,
- GPS technology,
- Forward and driver video,
- Network variables, and
- Machine-vision applications (e.g., lane tracker and head tracker).

The MiniDAS is designed to be mounted quickly on the windshield or the dashboard. It can also support onboard monitoring and driver feedback for both traditional and non-traditional vehicles.

It is currently estimated that the systems will be received during the first quarter of 2013.

Naturalistic Observation of Motorcycle Riders

Motorcycle fatalities and injuries have increased during the last 10 years, a period during which those same measures of transportation safety have been decreasing for other vehicle types. The objective of this project was to develop naturalistic data collection capabilities for motorcycles in support of research efforts to create crash countermeasures. While much of the equipment used for light- and heavy-vehicle research can be used on motorcycles, a number of modifications are necessary for successful implementation. These modifications are primarily due to:

- Smaller available package space for sensors and the DAS;
- Exposure of sensors, cameras, and the DAS to weather (rain, cold, heat, wind, etc.);
- More significant vehicle roll than cars and trucks, which creates more complex dynamics and may affect sensors such as radar and lane tracker;
- Harsher vibrations; and
- Greater electromagnetic sensor interference both from the DAS itself and from the bike ignition system.

To gather additional inputs for the study and hardware design process, a DAS Design Questionnaire was distributed to riders by placing questionnaire packets on motorcycles and by mailing the questionnaire or links to the questionnaire to motorcycle riders identified in the VTTI participant database. Overall, 424 individuals responded to the questionnaire (90 percent male, 10 percent female). Although a significant amount of information was obtained, one of the key feasibility conclusions was the outstanding response rate and the willingness of riders to participate in the study. The questionnaire responses (such as where riders parked bikes, when they rode, how often they rode, etc.) were used to set specifications that led to the prototype systems developed by a combination of this NSTSCE project and the leveraged NHTSA motorcycle feasibility project. The NSTSCE project funds were focused on developing radar and brake-sensing capabilities. Furthermore, the responses were used to develop the protocols and questionnaires for a large motorcycle feasibility study that is currently being planned cooperatively by VTTI and the U.S. Department of Transportation (US DOT).

VTTI DAS modifications for motorcycle use were completed. The modified DAS was first used in prototype form on the VTTI Kawasaki Versys. This early prototype allowed engineers to select appropriate sensors such as camera locations and to verify that sensors such as radar would function on a motorcycle. The first of three participants was given this bike for four weeks to use as his motorcycle. After collecting approximately 2,500 miles in this form, migration of the motorcycle DAS to the VTTI NextGen platform occurred. NextGen motorcycle DASs were installed on two additional motorcycles and were used to collect data.

A number of analyses were performed with data collected from these initial units. The analyses were successful in demonstrating the feasibility of collecting and analyzing data about motorcycles. The analyses included measuring the effects of exposure (day of week, time of day, type of road, number of intersection crossings, etc.), time series (when brakes were pressed, typical deceleration, following distance, etc.), and event capture (crashes, near-crashes, etc.). This work is reported in the NHTSA report, Pilot Study of Instrumentation to Collect Behavioral Data to Identify On-Road Rider Behavior - DOT HS 811 442 (McLaughlin et al., 2011).

Further refinements of the instrumentation occurred. In particular, strategies were identified to measure brake application force independently on the front and rear brakes. A method for measuring engine load was also developed through a monitoring vacuum. An RPM sensor was also developed. In addition to this work on independent sensors, the hardware development team designed a single-board approach that integrates the circuitry for these sensors, an IMU, and turn signal circuitry into a single unit for use on motorcycles. These measures will help characterize the rider's style and ability to appropriately control the bike.

NSTSCE funds allocated for these hardware development and rider survey tasks provided the foundation for attracting the first and second projects at VTTI investigating motorcycle rider safety. VTTI completed a feasibility study for NHTSA to evaluate the potential of collecting naturalistic riding data and is now conducting the first large-scale naturalistic motorcycle rider study. This study will put 100 instrumented motorcycles on the road in three states and is funded by the Motorcycle Safety Foundation, which is the largest rider safety training organization in the world. NHTSA also awarded VTTI a contract to conduct a naturalistic motorcycle study using 160 riders.

The final report for this project has been reviewed internally and will be finalized, distributed, and published during the next reporting period.

Public Access to VTTI-Maintained Data Sets

VTTI maintains naturalistic databases relevant to many driving safety research efforts. The ability to make portions of these data sets publicly available has been developed. There are two primary objectives of this project: 1) Develop the tools and procedures necessary to provide timely access to data sets and 2) Allow VTTI personnel to gain experience in providing appropriate levels of service to external researchers.

The knowledge gained during this project was used to create a forum and a data distribution website for the SHRP 2 naturalistic driving study (available at forums.shrp2nds.us). This website will be used to support many aspects of this study, including S08 analysis proposals, user workshops, and access to analysis tools (e.g., the open-source Community Viewer).

This project is in an ongoing maintenance and support phase. Maintenance tasks include culling invalid user accounts, responding to user questions, and rectifying errors as they are discovered on the site or in data sets. Continued efforts will focus on providing maintenance and support for current users of the forum website. Tasks will likely include continuing to cull invalid user accounts and fielding questions regarding additional data availability.

Quiet Vehicle Assessment

The increasing presence of quiet vehicles (e.g., those powered by a hybrid or electric drive system) on our roadways poses a greater risk of injury to visually impaired persons, sighted pedestrians, bicyclists, or others who depend upon sound as a primary indicator of potential conflicts. Some have proposed that under certain conditions silent vehicles could emit audible indicators to address this issue. However, there are obvious issues with the introduction of additional audible pollution to already noisy urban environments, especially when one considers that the audible indication is only infrequently required.

This project provided a comprehensive and concise overview of the apparent safety issues for pedestrians and cyclists caused by the operation of quiet vehicles on roadways. Background information was provided to establish how this issue became the focus of safety research in the U.S. and elsewhere. Literature review findings from notable research endeavors were presented as an evaluation of related pending and established regulations. Implemented and proposed countermeasures were described as opportunities for future potential research to address knowledge gaps and improve the overall understanding of quiet vehicle issues.

The final report is expected to be completed during the next reporting period.



Secure Feedback for Onboard Monitoring System Training

The Driver Coach project is an experimental study designed to test whether teenaged drivers can benefit from receiving both real-time and post hoc monitoring and feedback about their driving performances. Specifically, post hoc feedback will require that triggered events be automatically uploaded to VTTI servers so that reductionists can review, record, and annotate critical information. Parents and teens will then be provided web links to both the video and to aggregate data about the individual teenager and the performance of the teenager in relation to all teenaged study participants. To support the data collection and analysis efforts of the Driver Coach project, computer server hardware and software development efforts are required. These systems will support the receipt of safety-related events from Driver Coach participants, the reduction and annotation of these events, and dissemination of the events to participants and their parents via a web portal.

Since April, programmers have established the Driver Coach database. The test vehicle was instrumented, and data were collected for system programmers to develop the data reduction website and the website portal through which parents and teenagers will access data. Initial drafts of the data reduction and the parent/teen website were created during the fall of 2012 and will continue to be modified throughout the first half of 2013. A pilot study of the website will be conducted in early 2013. Data collection is scheduled to begin during April 2013.

Focus Area 2: Evaluation of the Built Roadway Environment and Infrastructure-based Safety Systems

Active and Adaptive Roadway Delineation Systems

This assessment will benefit both Virginia and the Federal Highway Administration (FHWA) through further analysis of safety needs and guidance for the development of active delineation system standards.

A significant effort has been made on the literature review. In general, curve delineation and straight roadway systems have been identified, and their functionalities have been and continue to be assessed during this effort. Initial contacts have been made with vendors to gauge interest in participation in this research effort. A draft experimental plan is being developed.

Color Camera

This project focuses on the development of a camera system that accurately defines color in a driver's environment and facilitates color analyses during projects. The camera captures a succession of images at a rate of approximately four frames per second; the camera will be used in conjunction with the already developed luminance camera system. A calibration technique was developed. Following ongoing evaluations conducted on public roads, the Color Camera will be incorporated into other ongoing projects and into the Roadway Lighting Mobile Measurement System (RLMMS).

Comparisons were made between measurements taken with a spectrometer and images taken by a daylight-calibrated Color Camera. Squares from the standard color chart were measured with a calibrated spectrometer. Square colors were split into the X, Y, and Z color components. An image of these same squares was taken and analyzed using the daylight-calibrated Color Camera.

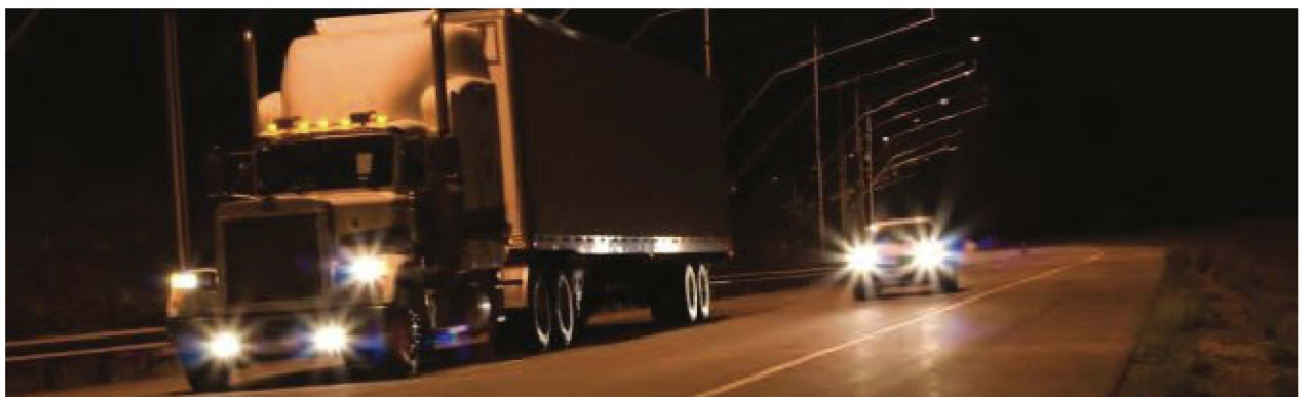
To provide an idea of how the Color Camera performs in the environment it will be used, a vehicle was instrumented with a Color Camera calibrated using the color chart and the vehicle's tungsten-halogen headlamps as the light source. A test route was driven following instrumentation, and images were recorded with the camera.

A final calibration of the color camera was conducted under multiple lighting intensities. Based on previous attempts, it became clear that calibrations would need to be completed at lower luminance levels (closer to what is experienced by a driver at night). Calibrations were completed across a range of luminance levels with tungsten-halogen headlamps being the main source of light during the calibration. A strength resulting from the use of the lowest light levels ($< 2 \text{ cd/m}^2$) is that this is similar to much of the driving that occurs without overhead lighting. However, camera settings such as shutter time reach a maximum level at this point to let the most amount of light into the camera, which results in a blurring of images in a dynamic setting. An alternative to this is selecting calibration values obtained at slightly higher luminance levels (approximately 4 cd/m^2). While sacrificing a direct match between the level in the lab and that of the environment, colors continue to be rendered accurately while minimizing image blur.

Final reporting for this project will continue during the next reporting phase.

Glare Metric

The Glare Metric project allowed the research team to create a universal metric for measuring glare and how it affects driver safety and comfort. Two types of glare must be considered: disability glare and discomfort glare. Disability glare is glare that reduces a person's ability to see other objects in the presence of the glare source. Discomfort glare is glare that a person finds uncomfortable to a greater or lesser extent.



During data collection, several different glare scenarios were presented to participants as they drove around the Smart Road. These scenarios included different combinations of glare sources, glare intensities, and overhead lighting. Disability glare was measured by determining how each glare scenario affected the participants' abilities to see objects on the roadway such as pedestrians and small targets. Discomfort glare was measured by having each participant rate his or her level of discomfort on a nine-point, Likert-type scale.

Several other factors were recorded to better understand these two types of glare. An illuminance meter was placed by drivers' heads at approximately eye level. This allowed the research team to see how much light was reaching the participants' eyes. This provided insight into why a participant rated a glare scenario a certain way. To better understand disability glare, the Glare Metric experimental vehicle used the luminance camera system. The camera system recorded images during the entire study. This allowed the research team to analyze the images that corresponded to the point at which a participant could first detect an object in the road when in the presence of glare.

The modeling of glare with respect to illuminance has been delayed as there are limited positional data available for the illuminance source. This was reviewed in the data. The next meeting of this committee will be held during April 2013, and a draft of the document should be delivered by then.

Initial Investigation of Intersection Lighting

Based on the results of rural intersection analyses and a potential urban intersection review, new design criteria for intersection lighting can be developed. The current design standard is based on illuminance only and represents inefficient design methodologies for summing the lighting in roadways and over-lighting intersections. New strategies can be investigated that include the impact of broad-spectrum light sources and peripheral pedestrian detection strategies.

A literature review of current intersection lighting design methods is nearing completion.

Alternate lighting designs are being assessed for testing. This project will be linked with the results of the Rural Intersection Lighting Safety Analysis project.

Light Sources in Fog

This project considers the performance of light sources in foggy conditions. New lighting technologies allow a variety of spectral distributions to be used for roadway lighting. The performance of these light source options in fog conditions remains a point of interest. This project is designed to evaluate these lighting options in the roadway environment. The approach taken for the project is to use the Smart Road fog simulator and develop conditions during which a visibility task will be used to determine the impact of the lighting system during the fog condition.

One limitation of the project has been ensuring that the simulated fog is comparable to the natural fog. A method of measuring particles using a plane of laser light has been devised. During this method, a laser is fitted with an optic that produces a plane of laser light at a 90-degree angle. The laser light illuminates particles in the air, creating a type of cross section. A special camera tuned to the wavelength of the laser then photographs the plane. A computer analysis of a predetermined area of the image (e.g., one square foot) should provide a measure of fog density.

Construction of the fog-measuring system has been completed. The system can be mounted to any vehicle with a standard trailer hitch. This will allow the system to be easily transported to locations of interest (e.g., Afton Mountain and Fancy Gap) and measure fog directly on or near the roadway. This effort is gaining priority as VTTI has been requested to measure the visibility of changeable speed limit signs in fog conditions.

The IRB documentation process began during this reporting period. With the fog-measuring system complete, measurements of natural fog will be taken and analyzed during the next reporting phase to calibrate the Smart Road weather-making system to match natural conditions. The IRB documentation will be completed and submitted for approval.

Nighttime Bicycle Visibility

This project is designed to analyze the conspicuity of certain types of visibility aids displayed by cyclists and their bicycles. These aids are necessary to improving the visibility of cyclists at night so they can be seen by motorists.

An initial bicycle visibility test incorporated into the Headlamp Sag study was completed. That project included evaluations of lighting alternatives as a bicycle crossed the path of a vehicle. Test vehicles featured differing headlamp types, and the results will be used to narrow the experimental design in terms of the inclusion of headlamp types. Data have been analyzed, and a report of analyses has been initiated.

A follow-up project was conducted and completed. This project included evaluations of varying visual aids placed on cyclists, joggers, or bicycles using different viewing angles. One viewing angle involved a parked participant vehicle facing a crossing lane through which a cyclist or jogger traveled. The other angle included a stationary cyclist or jogger on the right shoulder of the road as the test vehicle approached. Test vehicles featured differing headlamp styles. Data are currently being analyzed.

A third part of the nighttime bicycle investigation has been incorporated into the NSTSCE Roundabout study. This aspect involves placing cyclists on public roads and assessing their visibility using various lighting and reflective methods placed on both the cyclist and on the bicycle. As drivers navigate the course, they verbally identify the presence of cyclists who are either in the drivers' lanes, in an opposing lane, or stopped at an intersection. This study should help apply much of what has been determined during previous studies in a naturalistic setting (e.g., a public road). This data collection is ongoing in concert with the efforts of the roundabout research. A series of bicycle approaches have been identified and are being used during the research effort. The daytime data collection is being performed on the weekends so that it is not impacted by pedestrians on campus and class change times. A comprehensive literature review of bicycle visibility is ongoing.

Data collection is expected to be completed by mid-February of 2013, barring any adverse weather that may cause delays. An analysis of existing data is expected to begin by the end of January.



Roadway Lighting Design and Safety

This was a continuation of the luminance camera system project. The goal of this research effort was to validate the luminance camera through field testing and to analyze a variety of real-world sites and short-term Smart Road testing. The outcome was analyzed in terms of potential crash causes and possible mitigation techniques.

The measurement method developed for this project is implemented as part of the FHWA-sponsored Adaptive Lighting project. The final plan will be incorporated into the final report of this project. The adaptive project is ongoing. Guidelines based on the experimental plan are currently being written.

Rural Intersection Lighting Safety Analysis

This project was designed to address recent research that indicated lighting may impact driver safety at rural intersections. Research results showed that the ratio of night-to-day and total night crashes was lower at lighted intersections compared to unlighted intersections. However, this research only used lighting as a strictly binary measure during analysis (i.e., lighting was either present or absent according to the database). These results suggest that lighting enhances driver safety. However, the data do not account for the quality or levels of light at intersections.

A luminance data reduction was completed for Virginia rural intersections but at a slower rate than anticipated. The effort required reductionists to review more than 200 images per intersection in a semi-automated process. While the reduction process was semi-automated, it was still time-consuming, requiring reductionists to review and modify information as needed every 10 images. All data have been uploaded to a database. Initial analyses revealed a strong correlation between night crashes and the average illuminance at intersections. Intersections with lower average illuminance levels had greater numbers of crashes and crash rates (day-to-night crash ratio). An additional analysis is underway to determine the relationship between crashes, illuminance, and luminance. A report outlining the methodology for the research effort has been initiated. Models are currently being developed to analyze the impact of lighting on intersection safety. It has been determined that Bayesian analyses will be used to interpret data. Upon review, data were found to be over-dispersed, and it was decided that negative binomial regression modeling would be used for these data. Negative binomial regression modeling on the overall data also showed a significant effect of lighting.

The negative binomial regression analyses will be re-run on the data. The remaining analyses and interpretation of data will be completed for the next reporting period.

Visual Behavior in Roundabouts

The focus of this project is to examine driver eye-glance behavior in roundabouts and how it pertains to pedestrian safety. Participants will drive a route through Blacksburg, VA, which will include 12 different maneuvers through two roundabouts. During the drive, participants will wear an eye-tracker device so their glance behaviors may be recorded for analysis. Pedestrians will sometimes be stationed at points of interest at each roundabout so that typical glance patterns can be determined with and without a pedestrian present. The proposed research has the potential to provide information about driver eye-glance behavior in roundabouts, which can help determine where conflicts with pedestrians might occur and how those conflicts may be mitigated.

The roundabout testing protocol has been established and is ready to be executed. The driving trip takes approximately one hour and includes traversing a single-lane roundabout four times and a two-lane roundabout six times. Between the roundabouts, the bicycle presentations from the Bicycle Visibility investigations will be exhibited. The premise of the activity is bicycle visibility, and the eye tracker will be used to track drivers' visibility patterns. The drivers will not be told they are participating in a roundabout study. A total of 24 participants are planned for both daytime and nighttime evaluations. Data collection is expected to be completed by mid-February of 2013, barring any adverse weather that may cause delays. An analysis of existing data is expected to begin by the end of January.

Visual Information Modeling

An analysis of a driver's nighttime visual environment requires consideration of multiple interrelated variables (e.g., human factors, roadway features, and lighting). A driver's field of view includes such features as the roadway, the hood of the vehicle, the instrument panel, off-roadway facilities and roadway fixtures (e.g., signs, traffic signals, and pavement markings), and the activities of other road users. From this environment, a driver must continuously draw information about the presence of potential hazards in the roadway, navigate using roadway signage and delineation, and maintain control of the vehicle. Drivers must attend to and select which objects present important information and determine those that are superfluous. Reviewing and identifying, where possible, what attracts a driver's gaze towards an object while driving at night can provide insight into visual behavior.

Project results have been extensively presented at Transportation Research Board (TRB) annual meetings via posters and lectures. The final project task is to incorporate comments into the final report. This effort has been delayed due to other priorities but will be completed during the next reporting phase.

Focus Area 3: Safe Mobility for Vulnerable Road Users

Age-related Driver Difficulties at Intersections III

This project represents a meta-analysis of data collected during two VTTI naturalistic driving efforts: one focused on drivers aged 65 and older and another focused on newly licensed teen drivers and their middle-aged parents.

Results of this work indicate that visual scanning differs between age groups at unprotected T-shaped intersections. In particular, there is a significant difference in visual entropy for drivers of all age groups when negotiating a left turn in the presence of traffic at an intersection. The analysis showed that younger drivers scan more narrowly than other driver groups when no traffic is present at an intersection but scan broadly (and more randomly) when in the presence of traffic at an intersection. A link analysis revealed that younger drivers look at more locations during their turns and are more random in their glance patterns. Analyses of glance distribution and glance duration revealed that older drivers spend a slightly greater proportion of time than other driver age groups looking at the direction (or directions) from which traffic could strike them during a turn if they were to emerge towards the intersection. Individual glances made by older drivers to these areas are longer, perhaps suggesting that it took these drivers longer to extract the information they needed.

Research completed under this project has yielded a clearer picture of age-related differences in making turns at intersections. These differences are distinct for younger drivers and older drivers, and a pattern of behavior has emerged for each age group. The findings have suggested entirely different sources and vulnerabilities to risk during turns. These results can be useful for supporting traffic safety goals through the development of countermeasures for both aging drivers and teen drivers. Furthermore, methods and techniques developed during the project will facilitate future analyses of naturalistic data as they become available from projects such as SHRP 2.

Comparing the Driving Safety Benefits of Brain Fitness Training Program for Older Drivers

Recent research has indicated that older individuals can enjoy fairly long-term driving safety benefits from a variety of fairly modest cognitive training protocols. If this approach could be successfully applied and verified via driving behaviors, performance metrics, and long-term safety outcomes, it may represent a breakthrough in terms of helping maintain safe mobility and independence for the older members of society.

This project comprises the following activities:

Training Program Selection

The following training approaches will be evaluated: DriveSharp™, a Posit Science desktop computer program designed to enhance older driver safety; and an in-vehicle system designed and developed by Toyota Motor Company that is based on the concept of useful field of view.

Participant Recruitment and Selection

Sixty-three male and female drivers aged 70 and older are being recruited from the areas around VTTI to participate in the study. Selection criteria include perceptual and cognitive functional abilities and metrics related to driving frequency and safety. For instance, individuals with substantially impaired peripheral vision may not be able to benefit from useful field-of-view training, which is a crucial element of both of the selected training programs. Each participant will be briefly assessed on key functional abilities at the outset so that post hoc analyses can be conducted to determine what type of individual may benefit most from such training.

Training Program Administration and Evaluations

Participants are being randomly assigned to one of three treatment groups: 1) desktop, 2) in-vehicle, or 3) control (i.e., a group that receives no training). A series of driving tests using a specially instrumented 2012 Toyota Camry are being conducted on the Smart Road. These tests have been devised in such a way that the efficacy of the selected training programs can be evaluated. Such tests include potential hazard detection and identification distances, driver-centric peripheral detection, and vehicle tasks (accuracy and latency). In addition, a naturalistic component has been implemented wherein participants will drive an on-road route in the surrounding area to facilitate evaluation of driving performance on public roads in a variety of conditions.

Data Analysis and Reporting

Results will be evaluated during the various formative and summative phases of the research effort to determine the effectiveness of the two training programs relative to the performance observed with the control group. Post hoc analyses will attempt to determine how personal characteristics inform the effectiveness of the various programs evaluated.

Participant recruitment and data collection continued for the control and in-vehicle groups and began for the desktop group. The research team is also continuing to conduct periodic data checks of incoming DAS information to ensure integrity.



Driver Coach: Bedford/Montgomery, Virginia Evaluation Project

The purpose of this project is to forward the concept of teen driver coaching and monitoring to eliminate behaviors that can result in injurious and fatal crashes. Teen drivers are three times more likely to be involved in fatal crashes than their adult counterparts. The causes of teen crashes include: excessive speed, alcohol use, distraction, and failure to recognize hazards, among others. VTTI has been independently approached by two Virginia counties (Bedford and Montgomery) to help design a program that mitigates what they believe is a tragic and growing problem in their communities. VTTI has recommended a “three-pronged” approach to help reduce teen deaths and injuries. The approach comprises: 1) Parent-teen contracts with elements of an enhanced graduated driver’s licensing (GDL) program, 2) Training of specific skills at a specially designed training facility, and 3) A teen driver monitoring and coaching program that uses advanced in-vehicle technology. This project will support all three approach elements with emphasis placed on the driver monitoring and coaching program. The driver monitoring and coaching will be accomplished via an unobtrusive data collection system designed to provide both real-time monitoring (i.e., instantaneous feedback for the teen driver) and delayed summary feedback (for the parent).

As part of the outreach portion of the Teen Task Force, VTTI researchers participated in seven Parent/Teen Safe Driving Meetings held at seven local high schools. Meeting attendance during 2012 was as follows:

- Northside, 73 parents and teenagers
- Cave Spring, 38 parents and teenagers
- William Byrd, 38 parents and teenagers
- Glenvar, 35 parents and teenagers
- Blacksburg, 44 parents and teenagers
- Auburn, 56 parents and teenagers
- Staunton River, 80 parents and teenagers

For the driver monitoring and feedback study, the kickoff meeting for the Virginia Center for Transportation Innovation and Research (VCTIR) Driver Coach project was held in January. The research plan was submitted in May 2012.

System testing using a NextGen DAS was performed during the summer of 2012 to determine driving performance trigger thresholds. A touchscreen was used in a test vehicle to present the trigger type and an auditory alert each time a driving performance threshold was exceeded. This system was used during a demonstration held September 2012 for the Toyota Collaborative Safety Research Center.

Work also began on the development of a feedback webpage during the summer of 2012. Pilot testing of both the auditory alerts and the feedback webpage were conducted during November 2012. The study will begin during April 2013.

Evaluation of Light-vehicle Driver Education Programs Targeting Sharing the Road with Heavy Vehicles: Case Study Analysis

A recent project sponsored by NSTSCE surveyed light-vehicle driver education program administrators/teachers in each state in the U.S. to assess the presence of curricula relevant to heavy-vehicle characteristics and procedures for sharing the road. Survey results showed that while a large proportion (91 percent) of light-vehicle driver education programs include a component about how to safely share the road with heavy vehicles, there may be room for improvement regarding the content of these programs (82 percent perceived effectiveness). The purpose of this project is to investigate current light-vehicle driver education programs that contain components about sharing the road with heavy vehicles and to develop a best practices document detailing these components. A case study will also be performed with a light-vehicle driver education program in a single state that does not yet include the components identified in the best practices document. A student group that participates in the driver education program prior to implementation of the new components and a group that participates after implementation will each be interviewed two months later. Knowledge retention will be measured. This project will culminate in a letter report that will provide best practices for driver education programs that include a component about sharing the road with heavy vehicles and a description of the case study performed.

The research team transcribed audio recordings from the first set of focus groups and created a data set of survey results. The research team also developed protocols for the hands-on experience portion of the case study using several sources for guidance, including the Walmart Road Team demonstration held at a regional high school about how to share the road with trucks, discussions with the Wisconsin Road Team, and a review of the American Trucking Association “Share the Road” website. The team then implemented the hands-on experience with driver education students. The research team also began recruitment of students for the focus groups and surveys that will occur during 2013.



Improving Driving Safety for Teenagers with Attention Deficit Hyperactivity Disorder (ADHD)

Past research conducted by the Centers for Disease Control showed teenaged drivers with attention deficit hyperactivity disorder (ADHD) have five times the number of traffic tickets and are seven times more likely to be involved in more than one accident compared to non-ADHD teen drivers. To better assess driver error and crash/near-crash rates of ADHD teen drivers, the vehicles (10 total) of teen drivers clinically diagnosed as ADHD will be instrumented during this study. Data will be collected through the learner's permit phase and during the first six months of independent driving. Driving performances of these ADHD teen drivers will be compared to non-ADHD teen drivers and borderline ADHD teen drivers (as identified during the Supervised Practice Driving Study [SPDS]). The types of errors and crashes/near-crashes will be assessed to provide support for a large-scale ADHD teen driving study.

Two graduate research assistants (GRAs) in the field of psychology were funded (each at 50 percent) to perform the ADHD assessments. Virginia Tech IRB approval was granted in early 2012, and subject recruitment began. The first participant was recruited, completed an assessment, and his/her vehicle was scheduled for installation in early July. Additional participants were identified and scheduled to complete assessments during July. The team recruited all 10 participants by December 2012. However, two installations will occur during the first quarter of 2013.

Older Driver Fitness to Drive Study

This project is a follow-up to Antin et al. (2012), which compared the fitness profiles of older drivers and non-drivers in an initial effort to develop fitness-to-drive assessment models. The same fitness profile data are used during the current project. The objectives of this study are twofold: 1) Investigate the relationships between fitness profiles of older drivers and crash/near-crash risk and 2) Construct statistical models to quantify such relationships.

The fitness profile data set used 53 assessment metrics to evaluate the characteristics of 49 older participants (i.e., 26 drivers and 23 non-drivers). Antin et al. (2012) classified the 53 metrics into four categories: physical ability (13 metrics), visual ability (24 metrics), general and health-related information (10 metrics), and cognitive ability (6 metrics). During this study, a driver's risk is measured by crash/near-crash events. The data analysis and statistical modeling comprise two stages. During each stage, a principal component analysis is performed to reduce the dimensionality of a large number of metrics. This is followed by Poisson regression and negative binomial regression analyses designed to model the relationship between crash/near-crash risk and driver fitness characteristics.

During the initial stage of the analysis, the principal component analysis was performed for each category of metrics among the 53 metrics. Sixteen significant principal components (Physical 1-3, Visual 1-7, General 1-3, and Cognitive 1-3) were identified. Poisson and negative binomial regression analyses of crash/near-crash events based on each component showed that four components (Visual 2, Visual 5, Visual 6, and General 3) had significant impacts on crash/near-crash risk. Moreover, within these four components, 13 metrics made significant contributions to crash/near-crash risk.

During the second stage of analysis, a principal component analysis of these 13 metrics was performed. As expected, four significant components were identified. An exhaustive model selection technique performed during the Poisson analysis showed that the model of crash/near-crash events based on Components 1 and 3 was ideal. Component 1 included five metrics regarding right-eye contrast sensitivity; Component 3 included a discomfort glare rating, total number of color-vision plates correct, and right-eye contrast sensitivity.

In summary, initial analyses indicated that some visual characteristics may have a significant impact on older drivers' crash/near-crash risk. The next step is to continue screening through the 53 metrics and potentially recover some metrics that may be significant but were omitted when principal components were not significant or were omitted during the first stage of the Poisson regression analysis.



Because of the relatively small number of crash/near-crash events (as compared with SCEs [e.g., high g-force events]), the team began to evaluate the relationship between older drivers' fitness assessment data and their driving risk using high g-force events. The crash/near-crash events are well defined and can be easily tracked, while the high g-force events are recorded by an accelerometer. The definition of a "high" g-force event relies on appropriate threshold values for lateral, longitudinal acceleration rates and/or yaw rates.

The major challenges of this study are processing large amounts of data (more than 100 million frames and 3,000 hours of accelerometer data), reducing noise, and finding the appropriate threshold values. The drivers in this project are elderly, and the team cannot use thresholds developed for drivers of general or younger ages.

The research team has successfully accessed and processed the large data sets. Several tasks have been accomplished such as identifying the accelerometer dynamic curve and using a centered-moving average smoothing technique to reduce noise and fluctuation.

Senior Mobility Day

The Senior Mobility Awareness Symposium was a community outreach activity held December 6, 2012. Its purpose was to channel research findings and policy perspectives to the hands-on professionals who daily support seniors and their transportation needs. The event lineup included speakers from: NHTSA, the University of Michigan Transportation Research Institute (UMTRI), the Independent Transportation Network, AARP, the Virginia Department of Motor Vehicles (DMV), the Massachusetts Institute of Technology (MIT) AgeLab, VTTI, and the Virginia Tech Center for Gerontology. The event was held at the Inn at Virginia Tech and Skelton Conference Center, and each attendee received continuing education credit. The long-term goals of the project were to: 1) Foster a community of researchers, transportation leaders, physicians/therapists, gerontologists, and other senior service providers in the New River Valley who regularly meet and work together to creatively solve senior mobility issues; and 2) Develop a program suitable for implementation within other communities across the United States.

In addition to formal presentations, there were several tables set up in the foyer featuring information about the following organizations: the VTTI Senior Mobility Research Program, the Virginia GrandDriver Program, and the New River Valley Agency on Aging. Attendees also had an opportunity to experience first-hand physical demonstrations of CarFit and a fully instrumented VTTI research vehicle. The final session featured an open forum discussion amongst all attendees, with the aforementioned speakers serving as the session panel discussants. Finally, all attendees had a chance to interact at a reception that followed the formal activities of the day.

Attendance and Feedback – There were 56 attendees, of which 41 traveled to Virginia Tech from four different states: Virginia, North Carolina, Michigan, and California.

Twenty-six post-symposium surveys were collected. The VTTI team asked attendees to rate the usefulness and presentation quality of each session on a scale from 1 (lowest) to 5 (highest). The sessions included: opening keynote, technical session 1, lunch keynote, technical session 2, and the panel discussion. The mean values for both usefulness and quality of each session were substantially above 4.00; in addition, mean ratings of the symposium as a whole and the likeliness of attendees to recommend future symposia were substantially above 4.00.

Drs. Jon Antin and Myra Blanco are currently planning a panel discussion about Senior Mobility at the next annual meeting of the Human Factors and Ergonomics Society in San Diego. This will partially fulfill the project goal of disseminating information and the program to a broader audience.

Using Naturalistic Driving Data to Compare the Behaviors of American and Australian Older Drivers Turning at Intersections

VTTI and researchers at the Monash University Accident Research Center (MUARC) in Melbourne, Australia, have collected naturalistic driving data about older drivers. The team is now comparing key aspects of driving behaviors across two continents. Metrics include those related to secondary task engagement and distraction at unprotected turns-across-path intersections. Finding commonalities and/or differences between the driving environments of the two continents will assist in making a statement about the universality of seniors' driving behaviors.

Data analysis plans were coordinated, refined, and finalized with Australian colleagues. Reduction and analyses of the reduced data set are complete. Analyses revealed that the two driver populations were similar but that the U.S. sample may have been more impaired than the Australian sample. Intersection types (e.g., uncontrolled, partly controlled, or fully controlled) were distributed roughly equally across the two driver samples. Preliminary results indicated that the U.S. driver sample was more willing to engage in cell phone use while moving through an intersection. Analyses across both samples indicated a sensible tendency to moderate overall engagement in secondary activities with respect to intersection complexity (i.e., reduced engagement at partially controlled and uncontrolled intersections compared with engagement at fully controlled intersections).

Plans for the next reporting period are to:

- Complete the remaining data analysis of odds/rate ratios.
- Adjudicate any remaining discrepancies in methods.
- Coordinate final interpretation of results and determine next steps (i.e., if there are findings suitable for submission to a refereed journal).
- Create the final report.

Focus Area 4: Driver Impairment

Assessing the Risk of Talking during High and Low Driving Task Demands

Previous research has shown that using a cell phone while driving is associated with an increased risk of involvement in an SCE. However, examination of cell phone use by its constituent subtasks revealed that complex subtasks (e.g., texting and dialing) were associated with an increased SCE risk while talking/listening on a device was not. The current study investigated the risk of SCE involvement associated with using a mobile device as a function of driving task demands.



Data from naturalistic driving studies involving CMV drivers and light-vehicle drivers were re-analyzed. The naturalistic driving study data sets were partitioned into low, moderate, and high task demand subsets using criteria from the workload literature. Odds ratios for mobile device use and its subtasks were then computed. During low task demands, only dialing was associated with an increased SCE risk for light-vehicle drivers. During moderate task demands, cell phone use (collapsed across subtasks) was associated with an increased SCE risk for CMV drivers. During this condition, texting and dialing were associated with an increased SCE risk while talking/listening was not. Furthermore, talking/listening on a hands-free phone or CB radio was associated

with a decreased SCE risk. During high task demands, cell phone use (collapsed across subtasks) was associated with a decreased SCE risk for both CMV and light-vehicle drivers. However, cell phone use during this condition primarily comprised talking/listening, which on its own was associated with a decreased SCE risk. Overall, the SCE risk related to talking/listening on a mobile device was not found to increase during the three driving task demand conditions examined. Furthermore, unlike light-vehicle drivers, CMV drivers' mobile device use was lowest during high task demands. This suggests that CMV drivers may regulate their mobile device use differently than light-vehicle drivers as the driving task demands vary. A journal manuscript that reports these findings is currently under review. A technical report has also undergone an internal review and is currently being finalized.

Case Study on a Worksite Health and Wellness Program for Commercial Drivers

Given distributed operations in long-haul trucking, limited access to healthy food options, and sedentary lifestyles, it is not surprising that the prevalence of obesity among commercial drivers far outpaces that of the U.S. adult population. Approximately two-thirds of U.S. adults are overweight or obese, and nearly one-third of U.S. adults may be considered obese. Studies in the U.S. reported overweight and obesity rates in commercial drivers to be as high as 87 percent and 57 percent, respectively (Whitfield, 2007). Thus, there is a need for fleets to implement health and wellness (H&W) programs for their driver populations. This study will examine and detail the Schneider National, Inc. (SNI) H&W program for

commercial drivers by conducting phone interviews with key executives from Atlas Ergonomics (Atlas, which manages the SNI H&W program), United Healthcare (UHC), and SNI. Questionnaires will be administered to participating SNI drivers and staff at Atlas, UHC, and SNI to determine their opinions, perceptions, and satisfaction with the H&W program.

The goals of the current study are to: 1) Conduct phone interviews with company executives and detail the SNI commercial driver H&W program with Atlas and UHC; 2) Examine driver and program staff opinions, perceptions, and satisfaction with the H&W program via questionnaires; and 3) Develop a set of recommendations for applying and maintaining a successful carrier-implemented H&W program for commercial drivers. These recommendations will be useful for trucking fleets wishing to implement a driver-focused H&W program designed to improve driver health.

Case Study on the Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers

This project: 1) Documented two different sleep apnea programs implemented by truck carriers (SNI and J.B. Hunt [JBH]), 2) Will assess the overall effectiveness of the SNI sleep apnea program, and 3) Will result in the development of an implementation manual that includes a set of best practices for a successful obstructive sleep apnea (OSA) treatment program. The manual may serve as a guide for trucking fleets wishing to implement an OSA treatment program to improve the health of their drivers, reduce fatigue-related crashes and traffic incidents, and reduce health- and safety-related costs. The goal is to distribute the OSA treatment manual to other trucking fleets. To this end, VTTI has enlisted the assistance of several other agencies, including NIOSH, the Federal Transit Administration (FTA), the National Sleep Foundation (NSF), the American Transportation Research Institute (ATRI), and the American Sleep Apnea Association (ASAA). The research team anticipates that the manual produced during this study will benefit other transportation modalities and industries.

The goals of the current study are to:

- Document two different OSA programs implemented by leading truck carriers (SNI and JBH);
- Assess safety and health benefits of treating OSA (e.g., reduced crashes, improved health);
- Evaluate the overall return-on-investment in terms of reduced health care premiums, lower crash rates, and increased driver retention compared to the costs of treatment;
- Develop models to predict beneficial health and safety outcomes (e.g., compliance rates, age, gender, etc.); and
- Develop best practices for implementing and maintaining a successful OSA treatment program within the trucking industry.

Focus groups and phone interviews were conducted with drivers and staff at SNI and JBH. The purpose of these focus groups and phone interviews was to assess participants' perceptions and opinions of their respective OSA treatment programs and to gain insight from those who participated in these programs. Findings from this study will result in recommendations to carriers for implementing an OSA treatment program in an effective and cost-efficient manner.

A final report that includes descriptions of the two carriers' OSA programs, findings from the focus group and interview research, and carrier recommendations is available at:

http://scholar.lib.vt.edu/VTTI/reports/CaseStudySleepApnea_Final%20Report%2009282012.pdf.

This report will be updated once the remaining project tasks have been completed, including the assessment of the safety, health, and cost benefits of treating OSA in CMV operations.

Evaluating the Sleeper-berth Provision: Investigating Usage Characteristics and Safety-critical Event Involvement

The purpose of this study is to further assess (on both shift and driver levels) if SCE occurrence varies as a function of sleeper berth provision (SBP) use. In the current hours-of-service (HOS) regulations, CMV drivers may restart a duty shift by splitting the required 10 consecutive off-duty hours into a period of at least eight (but less than 10) consecutive hours in the sleeper berth plus a period of at least two (but less than 10) consecutive hours in the sleeper berth, off duty, or a combination of both. Because the SBP comprises two shorter breaks, the former may provide CMV drivers greater flexibility in obtaining rest when they need it. However, the rest periods may result in less adequate rest than that provided by a 10+ hour restart break.

This proposed study will use existing data from the VTTI Naturalistic Truck Driving Study (NTDS) and will build off of the recently completed Blanco et al. (2011) study about current HOS regulations. Using the existing algorithm developed in Blanco et al. (2011), shifts and drivers that used the SBP were identified. These data were used to assess the relationships between SBP use and SCE occurrence, driver demographics, and drive hour/work hour schedules.

Data were prepared for analysis, and IRB approval was granted. The hybrid log book was updated to reflect baseline driving videos using the same algorithms and logic about SCEs from the Blanco et al. (2011) study. The break type preceding each shift has been identified. Analyses are complete, and a brief summary of the findings follow. Years of CMV driving experience had an inverse relationship with SBP use (i.e., drivers with less experience used the SBP more often). Drivers who reported taking medications on a regular basis reported a higher proportion of SBP breaks on average (15 percent) than drivers who reported not taking medications on a regular basis (5 percent; $t=3.77$, $p=.0003$). SBP use was greater among long-haul drivers than line-haul drivers (14 percent of shifts and 1 percent of shifts, respectively). The SBP was associated with a significantly lower risk than the 10+ hour restart and 34+ hour restart methods during the first shift following the break. The odds ratio and 95 percent confidence interval for 10+ hour restart compared to SBP was $OR=1.37$ ($LCL=1.16$, $UCL=1.62$). The odds ratio and 95 percent confidence interval for 34+ hour restart compared to SBP was $OR=4.36$ ($LCL=3.52$, $UCL=5.40$). The 10+ hour restart and 34+ hour restart did not have significantly different risk values.



Prescription and Over-the-counter Drug Use and its Relationship to Involvement in Safety-critical Events

The purpose of this study is to conduct a comprehensive analysis of CMV drivers' prescription and over-the-counter (OTC) drug use and its relationship to SCE involvement. Impairment by drugs, especially related to legal drug use, has received considerable attention during the last few years. In fact, NHTSA co-sponsored a workshop discussing the effects of drugs in transportation (Transportation Research Board, 2006). Studies have shown an increase in crash risk while driving under the influence of alcohol, cannabis, and benzodiazepines (Beirness et al., 2006; Stewart, 2006). Although the adverse effects of alcohol and illicit drug use while driving have been widely documented, less is known about the adverse consequences of driving while under the influence of prescription and OTC medications.

The Large Truck Crash Causation Study (LTCCS) found that almost 30 percent of truck drivers involved in a one-truck/one-passenger-vehicle crash had an associated factor of prescription drug use (Federal Motor Carrier Safety Administration [FMCSA], 2006). At first glance these statistics appear noteworthy. However, there are several methodological considerations to be made before researchers can conclude that prescription and OTC drug use while driving results in a significant crash risk. More data are needed to support this contention, including: a) Base rates of prescription and OTC drug use among truck drivers not involved in crashes; b) When the drug was taken in relation to the crash; c) If the drug affects the truck driver's performance, attention, or decision-making ability; d) If the illness itself or the drug contributed to these decrements; e) If the critical reason or primary contributing factor of a crash is related to the drug's adverse effect on the driver's performance, attention, or decision-making capability; and f) Other mitigating factors (e.g., sleep before crash, alcohol or illicit drug use, etc.).

A case-control study could address most, if not all, of these issues. However, case-control studies are expensive and time-consuming. The VTTI NTDS database provides an excellent opportunity to assess the relationship between prescription and OTC drug use and SCE involvement. Included in the NTDS are daily driver logs in which drivers self-reported what medications they took, the time the medication was taken, and the medication dosage. Thus, this research will use the NTDS to address some of the methodological issues described above and potentially provide more data to suggest a link between prescription and OTC drug use and SCE involvement.

Sneak Peek: A Proof of Concept of an Early Safety-critical Event Detection Algorithm

The magnitude of the data collection projects that are currently unfolding will involve data reduction efforts that entail terabytes of data storage. For example, the FMCSA-funded Onboard Monitoring System Field Operational Test (OBMS FOT) comprises 270 over-the-road trucks with continuous data collected during a period of 18 months. It will likely be the largest naturalistic data study in regards to storage. The OBMS FOT objective is to examine whether safe driving habits can be enhanced and risky behavior reduced among commercial drivers using real-time feedback and coaching from safety supervisors (Study 1). A byproduct of this study is a continuous data set (Study 2).

The storage and processing of these data to obtain epochs of interest for research purposes are not trivial tasks. They involve kinematic trigger selection, implementation, and (for the resultant epochs) a visual inspection to appropriately characterize an event of interest. Data need to move through several gates (e.g., ingestion, demuxing, staging, classification, database development) before they are available to identify epochs of interest. The proof of concept provides an opportunity for developing an algorithm that will expedite this process by allowing immediate access to filtered epoch data during the data ingestion process.

The proposed research effort will be piloted with a portion of the incoming data from the OBMS FOT. The focus of this proof of concept is to quickly identify epochs of interest to allow researchers an early start in the data reduction and analysis process. This effort does not endeavor to replace the successful data-triggering approach VTTI has pioneered (i.e., detail triggers across the full data set). Instead, the goal is to serve as an enhancement by facilitating a “sneak preview” of incoming data.

OBMS FOT data are ideal for the Sneak Preview algorithm. Data will already be marked with epochs of interest for Study 1 (based on Transecurity trigger criteria). Though not identical to the VTTI criteria, both are focused on obtaining SCEs. Therefore, it is expected that if an epoch could be a potential SCE, both criteria should be able to identify it. Study 1 data are flagged and ingested together with the continuous data. The flags will not be used to identify epochs by Sneak Preview but as a validation tool. Once Sneak Preview identifies the epochs of interest, these epoch data will be overlaid with the Study 1 flags. Data reduction will be performed for all identified epochs (i.e., Sneak Preview and Study 1) to identify Hits, Correct Rejection, etc. The Sneak Preview development process will entail the creation of a development subset and several validation subsets. These subsets will be created from the data obtained for the first few OBMS FOT participants, thus avoiding any data overlap.

Supporting Commercial Motor Vehicle Driver Distraction Outreach

The FMCSA-hosted, VTTI-developed, “CMV Web-Based Driving Tips” site provides CMV drivers practical guidance about the safe operation of a heavy vehicle. This site has proven to be popular, gathering more than 100,000 views since its creation. Due to increased attention about distracted driving, the site pages dealing specifically with this topic have received more traffic. This presents a unique opportunity to expand and enhance the driver distraction section of the site.

This project involves reviewing the distracted driving information available on the existing site in comparison to research published after the creation of the site. The site will be updated with information about distraction risks as needed.



The research team finalized site text revisions, a distraction tip sheet, and video selections. The site text has a maximum Flesch-Kincaid grade-level score of 12, indicating that all site text is written at a level of complexity that does not require more than a high school education. Likewise, the one-page tip sheet about avoiding distraction is written at a similar (7th) Flesch-Kincaid grade-level score. Work began on translating the revised site text and tip sheet into Spanish. The translated text will be in the Spanish reading-level equivalent of the English text. The final report for this project is under review.

Supporting Commercial Motor Vehicle Driver Health Outreach Efforts

This project focused on redesigning the Driving Healthy website, developing additional driver-focused health information, and creating new outreach tools and materials. A final letter report was prepared that supplements the Phase I report and describes the ongoing activities associated with the development of an integrated social networking-based health effort.

During the course of the current project, the Driving Healthy website was redesigned and enhanced with new features and information that will increase the utility of the site. Furthermore, in an effort to simplify the overall readability of the site, the language throughout the site was reviewed and simplified. The redesigned site was developed using a WordPress template, which allows researchers to update the site directly and on a regular basis and facilitates search engine optimization.

The development of additional driver-focused health information includes a revised and dynamic home page, featured wellness topics, customized website sidebar content, expanded health and wellness information, and an updated and expanded resource center. New outreach materials include the development of a Driving Healthy marketing handout. The one-page handout provides an overview of the Driver Healthy resources. Because eating right while on the road is challenging, a simple food and activity tracker was also created to help drivers make healthier choices. In addition, regular updates have been made to the Facebook and Twitter accounts.

The Driving Healthy website is available at: www.drivinghealthy.org.



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