NATIONAL SURFACE TRANSPORTATION SAFETY CENTER FOR EXCELLENCE

ANNUAL REPORT

January - December 2010

NSTSCE
National Surface Transportation Safety Center for Excellence

Message From the Director

Dr. Tom Dingus

As we end the fourth year of the National Surface Transportation Safety Center for Excellence (NSTSCE) at the Virginia Tech Transportation Institute (VTTI), it serves us well to reflect on the successes and challenges we have faced as a Center and as an Institute.

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). It also bears mentioning that the NSTSCE funding was included in the 2009 transportation bill extension which granted VTTI an additional year's funding of $687,000 to continue the program. Virginia Tech has made continued funding of the Centers for Excellence program a priority.

The NSTSCE stakeholders' model continues to prove important in extending the scope and reach of the NSTSCE research. Federal and state agencies as well as industry have provided multi-year funding commitments due to a shared vision of a safer national transportation system. Never before has such a wide range of representatives with such varied interests from heavy truck to infrastructure to insurance converged to solve transportation challenges. We would like to thank the FHWA, the Federal Motor Carrier Safety Administration (FMCSA), the Virginia Department of Transportation (VDOT), the Virginia Center for Transportation Innovation and Research (VCTIR), the General Motors Corporation (GM), Travelers, and Virginia Tech for their continued support. Our stakeholders make it possible for NSTSCE to make a significant difference in transportation safety well into the future and beyond the initial SAFETEA-LU designation. In fact, the investments made by the federal designation and stakeholder support have paid great dividends yielding nearly $20 million in additional research.

In just four years we have already made a positive impact on transportation safety in terms of research results. VTTI's seminal research about the safety implications of texting and driving was highly publicized, including a front page article in the New York Times. The findings of this study led to a national discussion about distracted driving and preceded the first U.S. Distracted Driving Summit in 2009. NSTSCE research results are beginning to lead to enhanced technology developments as engineers work to translate research findings into transportation safety applications.

The Center's support in exploring teen driving safety has led to new approaches in training novice drivers. Robust driver monitoring systems will be placed in the cars of 90 teens with the ultimate goal of improving driving performance. The monitoring systems are designed to provide real-time feedback to the teen and post hoc feedback to the parent. The feedback will be used to coach the drivers to learn and adopt safer driving behaviors.

The Center's research results are also providing insights into transportation safety policies and informing policy makers as they decide legislation. Funding has seeded programs to research special driving populations such as older drivers, teen drivers, and motorcycle riders. The data collected from these populations are allowing us to further examine from both countermeasure and policy standpoints the national transportation safety concern of distracted driving. In 2009 alone, VTTI researchers provided testimony of their findings before the U.S. House of Representatives Subcommittee on Commerce, Trade, and Consumer Protection and were featured presenters during the U.S. Presidential Distracted Driving Summit. Research conducted through NSTSCE allows us to provide data-driven support for policy makers in their efforts to improve transportation safety.

While research programs such as NSTSCE continue to make significant inroads to improving transportation safety, there are still many miles to go. We are continuing to answer the nation's call for safer highway and transportation systems. And we will need continued support.

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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.

NSTSCE's vision is to become recognized as The National Center for Surface Transportation Safety, make a significant impact in improving surface transportation safety, and leverage partnership and sponsor relationships to disseminate results.

NSTSCE has formed a Stakeholders' Committee comprising organizations that share our vision for improving road-user safety locally and across the nation. The Stakeholders' Committee members are Carl Andersen, Federal Highway Administration (FHWA); Tom Dingus, VTTI; John Capp, General Motors Corporation (GM); Gary Allen, 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. The role of stakeholders is to provide direct funding to NSTSCE, input to research direction, and oversight of research results. NSTSCE's approach is to build on VTTI's strengths and capabilities to make a measurable impact on road-user safety. NSTSCE uses a synergistic approach across the four research focus areas to maximize resources. These research focus areas include developing and testing transportation devices and techniques, examining advanced roadway delineation and lighting systems, addressing age-related driving issues, and addressing fatigued driver issues. VTTI, through NSTSCE, will analyze existing data sets to answer questions where possible. 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. Additionally, VTTI continues to further develop its strengths and capabilities in transportation safety research.

Goals of the Center

In order 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 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, provide input to research direction, and serve as overseers of research results. The Center's 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; Gary Allen, VDOT and the VCTIR; Martin Walker, FMCSA; and Chris Hayes, Travelers. 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 the 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 to the next stage of project planning.

Marketing Approach

NSTSCE subject matter experts and project managers accelerated NSTSCE marketing and outreach efforts in the fourth 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) workshops and meetings. VTTI/NSTSCE researchers serve as TRB committee members within primary research areas.

- NSTSCE researchers testified about the dangers of texting while driving before the state legislative subcommittee.

- NSTSCE researchers hosted a site visit of deputy administrators from the U.S. Department of Transportation.

- NSTSCE research was demonstrated to the Commonwealth of Virginia's Secretary of Transportation.

- NSTSCE researchers delivered the Second International Naturalistic Driving Symposium in Blacksburg, Virginia.

- NSTSCE researchers continue to develop tools and techniques to provide access to VTTI's naturalistic data by national and international transportation researchers.

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 the public as a whole. While NSTSCE and its research programs are products of the entire team and are meant to stand on their own 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

- Dr. Jon Antin made contact with the following organizations to recruit project involvement and possible NSTSCE stakeholder membership: Honda, IBM, and the National Highway Traffic Safety Administration (NHTSA). Dr. Jon Hankey presented NSTSCE research findings to the Second Strategic Highway Research Program (SHRP 2) funded by the National Academies of Science--Transportation Research Board (TRB).
- Dr. Ron Gibbons presented NSTSCE-based projects at the Illuminating Engineering Society of North America Annual Conference, the Illuminating Engineering Society of North America Annual Conference Roadway Lighting Committee, the Commission Internationale d'Eclariage Division 4 Meeting, and the TRB Visibility Committee Meeting.

Outreach Goals: Publication Analysis

Numerous publications were submitted to scientific agencies and journals during 2010, and several fresh observations are presently under research analysis to create additional publications. Resulting analyses and publications currently focus on naturalistic driving data while also addressing the foundational concerns of NSTSCE: age-related driving issues, fatigue, lighting and infrastructure, and driver performance. Utilizing 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 VTTI metadata collection of more than 40 terabytes (TB) includes data 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.

Safety Devices and Techniques that Enhance Driver Performance

100-Car Reanalysis and Mask Algorithm Validation

The 100-Car Study (released in 2006) collected longitudinal data for 108 primary drivers and associated secondary drivers during the course of an entire year in 2003 and 2004. This data set continues to provide a wealth of information for transportation research. However, in order to conduct subsequent analyses efficiently on a data set of this magnitude, a complete inventory of what it contains must be available.

The objective of the 100-Car Reanalysis project was to create such an inventory. Information obtained during the re-analysis for each trip file included driver identification; seat belt usage; ambient lighting (day or night); and which, if any, video views were unavailable. During this complete review of files, new secondary drivers were also identified and assigned identification codes. This supplemental information will strengthen many of the secondary analyses of these data and allow for more accurate estimates of exposure and risk.

This work was released in a final report during 2010 and is available for download as Report #10-UT-007 at http://scholar.lib.vt.edu/VTTI/. A very brief summary of the information contained in this report is provided below.

In addition to the 108 primary drivers, 299 secondary drivers are now included in the Driver Identification (ID) directory (including 166 newly identified secondary drivers). Driver IDs were associated with a total of 156,637 trip files covering 28,897 driving days and more than 1.2 million vehicle miles traveled.

Most driving took place during the daytime, with 73.9 percent of primary driver trip files and 71.8 percent of primary driver mileage occurring during daylight hours. Primary drivers were observed wearing their seatbelts an average of 81.5 percent of their trip files (ranging from 0 to 100 percent for individual drivers).

The National Highway Traffic Safety Administration (NHTSA) has contracted with VTTI to further mine the data that resulted from this re-analysis to examine seatbelt usage and the factors that affect a driver's decision to wear or not wear a seatbelt, especially among "occasional" seatbelt wearers. Three seatbelt user groups have been defined based on these data (Infrequent, Occasional, and Consistent seatbelt users). Analyses being conducted include a comparison of a variety of factors between the three groups and within the occasional user group. This work is expected to result in at least one journal article to be submitted this spring.

At the conclusion of the 100-Car Reanalysis work, remaining funds were re-allocated in order to conduct a validation of the Mask eye-glance algorithm. The Mask system was designed to automatically calculate driver glance direction in collected video based on an image-processing algorithm that considers various head and facial features. The driver glance direction is coded via head position and an association between these head positions and specific glance zones. The objective of this project is to provide validation work and offer feedback for improving algorithm performance, if necessary.

Previously reduced eye-glance data for naturalistic driving projects will be run through the Mask algorithm for comparison between manual eye-glance reduction and automatic Mask head position and rotation values. Accuracy summary statistics will be calculated based on various manual glance location setups. In addition, portions of epochs where Mask does not perform well will be reviewed by reductionists to identify potential reasons (e.g., lighting issues, face and/or clothing characteristics, head tilt, camera alignment).

Attention and Drowsy Driver Assist

This project will test different driver alerts in the context of drowsy driving. The goal is to understand what actions drivers may take when they receive a drowsiness alert and how those may vary as certain alert characteristics are modified. It is important to understand, for example, if there is potential for drivers to be unreasonably startled by drowsiness alerts.

Project planning has been accomplished. A plan for the different stages of the project was drafted and discussed internally and with General Motors (GM) personnel. The plan consists of the following tasks.

Task 1: Literature Review

This task will consist of a focused review of literature associated with drowsiness elicitation, drowsiness detection, and drowsiness prevention. The findings from the literature review will be used to inform the protocols for the two experiments in Task 2.

Task 2: Experiment 1 – Alert Optimization

This experiment will be used to test the effectiveness of different drowsiness alert modalities, locations, and characteristics. The experiment is expected to take place at nighttime to increase the probability of drowsiness being present (this and other details of the experimental protocol will be subject to change based on the findings of the literature review).

Task 2: Experiment 2 – On-road and Smart Road

The second experiment will be a combination of on-road and Smart Road driving. On-road driving will serve the purpose of priming the participant for drowsiness and will be followed by driving on the Smart Road. As will be the case for Experiment 1, the second experiment will take place during nighttime hours. A surprise event may be introduced into the test track portion of the study. The surprise event would occur a short period of time after a drowsiness alert. The goal of the surprise event would be to examine the alertness of participants after they receive the alert.

Crash—Near-Crash Trigger Algorithm

One common problem in naturalistic driving research data is extracting all the crashes and near-crashes from a large data set without having an excessive number of false alarms. This is typically accomplished through an iterative process of threshold triggering on kinematic data followed by video validation with trained reviewers. Video reviewers would determine if a given threshold trigger was valid or invalid according to a set of operational definitions. For the valid events additional video review was conducted to evaluate such elements as event severity, driver behaviors, and impairment.

The threshold trigger of interest in this project is a yaw rate trigger, which was developed to identify situations in which a driver performed a sudden steering maneuver since such maneuvers are possibly indicative of safety-relevant driving events. The final 100-Car yaw rate trigger criteria were as follows:

1. Yaw rate oscillation in excess of 4 degrees/second (s) within a three-second window (vehicle returned to direction of travel prior to steering maneuver).
2. A minimum speed of 6.7 m/s (15 mph) at the onset of the trigger.

When this algorithm was run across the entire 100-Car data set, approximately 85,000 yaw rate triggers were identified with approximately two percent being declared as valid and subject to further video analysis. There were several driving scenarios in which a yaw rate threshold trigger was activated. As it seems likely that the causal mechanisms for evasive maneuvers under various scenarios differ, it is possible that scenario identification prior to classification would be beneficial.

The refinement of scenario identification showed some improvement in previous efforts. The yaw rate triggers were divided into initial movement direction groups (left or right) and partitioned based on trigger duration. Three levels of trigger duration were created: 1 s, 2 s, and 3 s. In order to ensure that enough yaw rate triggers were included in each of the duration categories any triggers with duration up to 0.3 s less than the stated category were included. For example, the one-second category includes triggers with durations of 0.7 s, 0.8 s, 0.9 s, and 1.0 s.

Classifiers were applied to distinguish between valid and invalid triggers for each trigger duration category within each initial movement group. Currently two types of discriminant analysis are being applied to the task of distinguishing between driving safety-relevant events and innocuous driving situations using yaw rate kinematic triggers. The first method is linear discriminant analysis (LDA) and the second is penalized discriminant analysis (PDA). PDA is an extension to linear discriminant analysis and is designed to handle situations with many highly correlated predictors that arise from the discretization of analog signals.

Data Center

The purpose of this project is to integrate Virginia Tech's petabyte-scale, high performance data storage system into VTTI's data infrastructure. Once completed, data from multiple naturalistic driving studies will be migrated to this infrastructure. These data will be analyzed using high performance computational systems in order to perform more complex computational algorithms and data mining.

Data Mining of the Independence by Franklin Intersection to Identify Factors Leading to Traffic Signal Violations

The purpose of this study was to investigate the factors related to red-light intersection violations at three signalized intersections in the New River Valley. This was accomplished by mining an existing database that was collected as part of the Cooperative Intersection Collision Avoidance System for Violations (CICAS-V) project.

The database included two months of continuous intersection approach data measured by roadside data acquisition equipment. The equipment recorded kinematic information for each vehicle along with corresponding signal phase information at a 20 Hz rate. As part of the CICAS-V project, vehicles that violated the traffic signal were identified. These violating vehicles then underwent a manual validation and reduction process to extract additional data from the video stream.

This study performed the next step by extracting a comparative set of baseline intersection approaches. These baseline intersection approaches were carefully selected such that the team obtained a set data in which drivers were in very similar situations with respect to the signal phase and timing; however, unlike the previous data set, they did not violate the traffic control device. Overall, this resulted in a data sample containing 6,000 violating drivers and 6,000 compliant drivers. Detailed analyses of these data were performed to identify differences between the two groups.

Although a number of descriptive statistics were performed, the analysis focused on the application of a logistic regression model. The model identified several key differences between the violating and compliant driver groups. For example, the analysis demonstrated that drivers of heavy vehicles (e.g., buses, tractor-trailers) were 300 percent more likely to violate than light vehicles such as cars and vans. Furthermore, drivers were approximately 80 percent more likely to violate at the Franklin intersection than at either of the other two locations.

A final report is available at http://scholar.lib.vt.edu/VTTI/reports/ViolationPropensityFactors_02042011.pdf.

Data Sharing Across Borders

Traffic crashes continue to be a leading cause of death in countries around the world. If possible, data from naturalistic driving studies 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 that are not able to mount such studies on their own due to limited resources. In addition, 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 to store and use it. There are many challenges to overcome before such cross-border data sharing can be implemented. This research project proposes to investigate the issues involved in cross-border data sharing and to develop a workbook of suggested practices for researchers seeking access to naturalistic driving data collected in other countries.

VTTI will work with the international research community to assess and address issues associated with data sharing across borders. This will include addressing issues such as the one posed by the fact that not all countries have the equivalent of the Institutional Review Board (IRB). Researchers from countries without such institutional safeguards should be trained in the issues and safeguards corresponding to the use of these data. They should be made familiar with the terms of the original consent forms that research participants signed. Language and cultural barriers surrounding these human subjects' protections issues may be a bigger impediment to cross-border data sharing than the relatively minor differences in driving habits and behaviors.

Plans were made for the approach to the issues related to sharing data across borders. There will be a three-phase approach for this study: an extensive Internet research effort followed by convening an international panel of experts (via email and other Internet communications), and ending with an Internet survey. The final report will provide the methods and results used in each phase. It is expected that the principal investigator (PI) will attend the Annual Meeting of the Transportation Research Board (TRB) and make personal contact with international attendees who will help form the core of the panel of experts. Initial contact will then be made with the panel. The Internet research effort will be completed during the second quarter of 2011.

Design and Implementation of OLAP Cube for Older Driver Data Set

VTTI maintains naturalistic databases relevant to many driving safety research efforts. The ability to allow researchers timely access to kinematic and parametric data needs to be developed. Online analytical processing (OLAP) cubes are data structures that allow fast analysis of data and represent one possible method for providing timely access to large quantities of data. These data structures can be thought of as an extension to the array layout of spreadsheet applications in which numeric facts, called measures, are categorized by dimensions. For example, dimensions of interest to driving safety researchers might include driver age groups, road type and weather conditions. Measures of interest that would be categorized by these dimensions might include deceleration, headway and speed.

There are two primary objectives for this project: 1) Design and develop an OLAP cube with naturalistic driving data (Older Driver data set) and 2) Determine the feasibility of OLAP cubes for general use with naturalistic driving data.

Work was begun on transforming conceptual OLAP models into a functional OLAP cube based on the Older Driver data set. Cube development is being conducted using the Microsoft Business Intelligence Development Studio (BIDS), Microsoft SQL Server 2008 and SAS. The following updated timeline has been drafted for the completion of this project:

- Cube implementation completed Q1 2011
- Remote viewing implemented Q2 2011
- Evaluation and use Q3 2011
- Draft final report 2011

Developing Bayesian Models for a Naturalistic Driver Study

VTTI developed a non-parametric Bayesian model for analyzing the data extracted using a case-crossover design approach. The developed model advanced the state-of-practice conditional logistic models by allowing within-stratum variation and, more importantly, accommodating observations with identical covariates. The results have been submitted to the Biostatistics journal. The research team is currently working on developing hierarchical models that allow simultaneous risk assessment for a subgroup of drivers; for example, young, middle-aged and older drivers.

Device Survey

The purpose of this project was to gather self-reported data regarding portable consumer electronics devices that are used during driving, including what devices are owned, what devices are used while driving, patterns of usage while driving, how individuals acquire their devices (i.e., as gifts or by making a purchase), and how they shop for and buy devices. The survey was administered to two samples associated with Virginia Tech: 1) Faculty, staff, graduate and undergraduate students; and 2) Blacksburg Transit drivers holding a commercial driver's license (CDL). Data were separately analyzed from the two samples. The purposes of this effort were to compare CDL drivers to non-CDL drivers in terms of a variety of factors relating to the following:

1. To identify and characterize types of device users and types of buying behaviors;
2. To better understand how to develop consumer information about devices and their use during driving;
3. To better understand how to reach consumers of different types in the delivery of information about driving distraction; and
4. To supplement/confirm patterns of behavior observed in naturalistic studies with small samples of drivers.

The survey was administered to more than 1,455 individuals in 2009, including approximately 25 CDL drivers. In 2010, the survey was administered to a larger group of CDL drivers and analyzed. A draft final report has been submitted for internal independent review, and the review has been completed.

Distraction Index Framework

Progress in the Distraction Index project primarily consisted of the completion and analysis of the first wave of events identified. Steps in the process included:

- Initial identification of triggers for reduction (e.g., large longitudinal deceleration, large lateral accelerations);
- Analysis of these triggers to verify their validity and mark them as valid events;
- Observation of the presence of infotainment system use during the valid events;
- Judgment of whether infotainment system use was a factor in the extreme kinematics that were used to identify the events;
- Coding of the video of these events to indicate eye-glance patterns;
- Assessment of the driving-related events that occurred on the forward roadway during the event; and
- Calculation of the frequency counts for the measures of interest (statistics could not be calculated due to the low number of valid events).

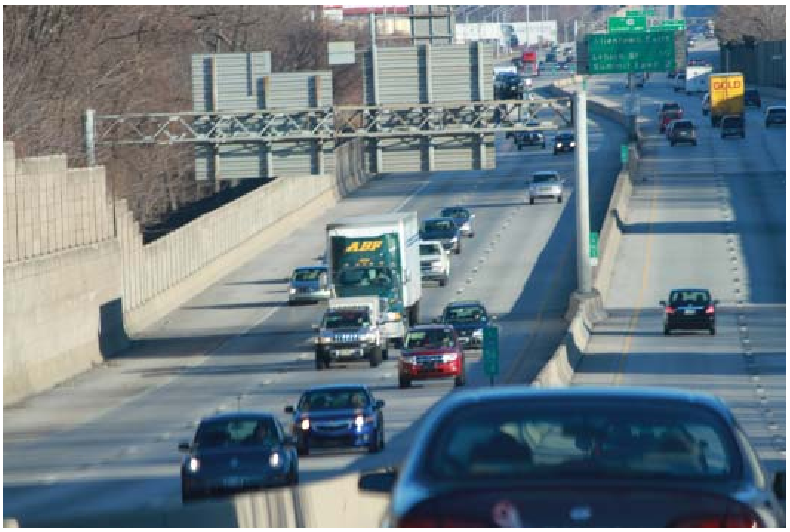
As the last item suggests, while there was a sizable number of triggers identified, relatively few were determined to be valid events, and fewer still were observed to be accompanied by infotainment system use.

The triggers resulted in 46 individual events (more than one trigger may have been present per event). Of these, most were lead-vehicle conflicts where the lead vehicle was decelerating, stopped, or incurring into the lane. Infotainment system use as a causal factor for the event was observed in three out of the 46 cases (six percent), and cell phone use as a causal factor was observed in two out of the 46 cases (four percent). Participants were glancing to the forward roadway during ~69 percent of cases but failed to see all the relevant events during ~15 percent of these. Braking was the most common reaction to these events (~84 percent), either by itself or in combination with steering.

As a result of the limited information provided by these initial events (given their small number), detection and analysis of additional events where particular instances of system use are identified (followed by analysis of driving performance within those events) will be completed during the next year. These analyses will yield the final results for the project and ideas for further research.

Driver Behavior in Crash Hot Spots and Rural Areas

This project built on the *Methods for Extracting Rural Driving* project, which created automated methods for associating participant trip data with urban, rural, and high crash rate road segments. In the present project, these methods were used to locate participants traveling through high crash rate rural and urban road segments, or hot spots. Video reduction was then performed to explore potential crash-related factors or driver behaviors occurring within these segments. An older driver data set collected in southwestern Virginia was added to increase the availability of rural driving segments for use in the investigation. Video reduction of drivers passing through these segments as well as baseline comparison segments was performed, and statistical comparisons were made. Factors which were compared include the number of secondary tasks being conducted while traversing the segments, duration of secondary tasks, and different types of distraction present such as interaction with electronics or vehicle systems. Differences in these measures were not consistent across the high and low crash rate segments. Several explanations for the mixed results exist. It may be that drivers are not aware of the different risks associated with the road segments, so they do not adjust their involvement in secondary tasks according to the segments. Another is that the high and low crash risk segments used for the analysis were not different enough to generate differences or the measures of differences were not sensitive enough to provide reliable indication of differences. The report is in the final stages of editing and will be completed during the second quarter of 2011. The report includes recommendations of alternate methods and other safety-related approaches based on researcher observations while conducting this video reduction and analysis.



Driver Performance While Text Messaging Using Handheld and In-Vehicle Systems

In this study, driver performance while texting using a handheld mobile telephone was compared to performance while texting using an integrated vehicle system. The study was conducted in parallel with privately funded work investigating manual versus voice control of other typically manual-controlled technologies. The texting portion of the study investigated driver performance while sending and receiving text messages on the Smart Road test track using personal handheld phones and the vehicle system. Measures included task duration, mental demand, eyes-off-road time, steering variability and maximum steering rate. Data collection for this project began in late 2009 and was completed in early 2010 with 20 participants in two age groups (11 between the ages of 19 and 34 and nine between 39 and 51 years of age). Results indicated that handheld text message sending and receiving showed performance degradations compared to baseline driving; using the in-vehicle system to send messages also resulted in performance decrements relative to baseline although less so than handheld messaging. Receiving text messages using the in-vehicle system's text-to-speech function resulted in no significant differences from baseline driving. These findings were published as a journal article in Accident Analysis and Prevention (Owens, McLaughlin, & Sudweeks, 2011).

Reference:

Owens, J.M., McLaughlin, S.B., & Sudweeks, J. (2011). Driver performance while text messaging using handheld and in-vehicle systems. Accident Analysis and Prevention, 43, 939-947, doi:10.1016/j.aap.2010.11.019.

Driving Scenario Classification

Driving scenarios (such as driving relatively straight, negotiating a cloverleaf, turning at an intersection, or decelerating for a light) will affect the driving-related measures collected for vehicles. During this project, automated methods will be developed to review naturalistic driving data and to classify the epochs of the data according to driving scenarios such as these. In this way, the variance in the data created by common driving scenarios can be parsed out earlier in the data-mining process.

The methods that will be used for the project have been developed, a literature review of roadway geometric design was initiated, candidate data sets were identified, and materials to obtain approval from the Institutional Review Board (IRB) were drafted.

IMU Utility Tool

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

This project has the following objectives:

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

Dr. Zachary Doerzaph attended a Society of Automotive Engineers (SAE) course covering vehicle dynamics to gain new insights into the mechanics that dictate the underlying kinematic measures. This course provided a solid foundation of principles through classroom lectures and reinforced the concepts through in-vehicle experiences. In addition, two graduate students were hired as Graduate Research Assistants (GRAs) for this project. One GRA has a strong background in vehicle dynamics and is currently pursuing a master's degree in mechanical engineering. The second GRA has a significant volume of experience with signal processing and is pursuing his doctoral degree in electrical and computer engineering. The two GRAs will work together to examine the many facets of this problem from filtering and signal processing in order to solve the vehicle dynamics equations. They are being granted one semester for this task.

The GRAs will draft a work plan, including a schedule of deliverables. This work plan will become the basis for the development cycles. There will be a series of two-week "sprints" in which software development will take place. At the beginning of each sprint there will be a meeting between the developer and customer that determines the objectives of the next development cycle.

At the beginning of each sprint, a test will be created based on the objective of the development cycle. This test will be applied at the end of the sprint and must be passed in order to move forward in development. Otherwise, the cycle will be adjusted and re-executed until successful. In this way, the objective for each sprint is clear, and the software is designed to pass the validation tests. This agile test-driven development method keeps the project on track, retains flexibility in changing objectives, and helps to mitigate "cowboy coding."

Mask Post-Processing

VTTI's proprietary Mask software offers an ideal opportunity to use machine-vision technology to automatically scan a naturalistic driving video database to quantify the extent of a driver's head turn from its nominal forward position and perhaps much more. Such metrics may be particularly relevant and provide insight during maneuvers such as left turns across traffic. This research capability is intended to be applied to a related NSTSCE project, Age-Related Driver Difficulties at Intersections, which is designed to investigate the visual scanning of drivers, particularly during maneuvers such as left turns. In the future, this technology can be applied to other video libraries, including those of the forthcoming large-scale Second Strategic Highway Research Program (SHRP 2) and the 250-Truck Naturalistic Driving Study (NDS).

The current project was successful at developing the necessary middleware to allow the Mask to scan a video database (or any specified subset thereof) as a batch process in real-time, post-hoc analyses. Formerly, the mask had to be applied in a fairly labor-intensive single video basis.

This project facilitated the first research application of the Mask technology in the *Age-Related Driver Difficulties at Intersections* project.

Naturalistic Observation of Motorcycle Riders

Motorcycle fatalities and injuries have been increasing 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 is to develop naturalistic data collection capabilities for motorcycles in support of research efforts to develop countermeasures to reverse this trend. 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 on motorcycles. These modifications are primarily due to:

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

Once a DAS and sensor suite is developed for motorcycle use, it will be tested on a small number of motorcycles, and the data will be analyzed to estimate the value of conducting a large-scale motorcycle naturalistic data collection.

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, 229 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 that were developed by a combination of this NSTSCE project and the leveraged National Highway Traffic Safety Administration (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 (DOT).

During this year, VTTI equipped its Versys motorcycle with an early prototype based on the 100-Car DAS platform. This early prototype allowed engineers to select appropriate sensors such as camera locations and 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. During that time the participant rode approximately 2,500 miles during which a variety of riding conditions were encountered.

While data were being collected by the first participant, development of the DAS continued, and a migration to the NextGen was performed. The second participant had his Honda VFR sport bike equipped with the NextGen mounted in an inconspicuous location where a saddle bag might normally reside. This rider had the system installed for 12 weeks and rode more than 1,258 miles. The third participant had a BMW R1200R bike equipped with the NextGen and rode for four weeks and more than 1,229 miles. Overall, the three participants provided an opportunity to refine the DAS and protocols and to provide an initial data set on which data analysis methods were developed.

A number of analyses were performed and demonstrated 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.). Although the data sample is insufficient for determining statistically significant conclusions, analysis did demonstrate the feasibility of collecting and analyzing naturalistic data about motorcycles. Interested readers should refer to the final report presented to the NHTSA, which contains a detailed discussion of the 2009 project accomplishments.

During 2010, 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 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 inertial measurement unit (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 project at VTTI investigating motorcycle rider safety. VTTI completed a feasibility study for the NHTSA to evaluate the potential of collecting naturalistic riding data and is now conducting the first large-scale naturalistic motorcycle rider study ever conducted. This study will put 100 instrumented motorcycles on the road in three states and is funded by the Motorcycle Safety Foundation (MSF). The MSF is the largest rider safety training organization in the world.

Privacy's Impact on Emerging Safety Technology

Public safety versus personal privacy in transportation policy has become a timely issue. A major driving force behind this issue is the potential a host of new and emerging technologies in transportation could have on personal privacy. The usage of imaging technology, for example, is an evolving application that poses questions regarding appropriate use, legality, system management, and public and political acceptance. This project objective was designed to help define the scope and nature of the issue, address reasons for acceptance or objection, and look for common ground to ensure legal and desirable safety-related deployments. VTTI's analysis spanned the full range of technical, social, legal and political issues. While this project had the goal of examining privacy, it also had multiple objectives. Generally, it involved inventorying and defining the characteristics that comprise the concept of "privacy" in transportation applications. Once the first phases were completed, the team focused on potential transportation safety applications of emerging technologies and their impact on privacy.

A survey of the Intelligent Transportation Society of America (ITSA) membership was administered to the membership on February 6, 2009, inquiring what technologies they were involved with and how it related to personal privacy. The final report will be submitted in the first quarter of 2011.

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 is currently under development. There are two primary objectives for this project: develop the tools and procedures necessary to provide timely access to data sets and allow VTTI personnel to gain experience in providing appropriate levels of service to external researchers.

The capabilities of the data distribution website (forums.vtti.vt.edu) were expanded to include a forum with threaded discussions and a content management system to allow the hosting of user-contributed files. Supporting documentation for the data sets included data dictionaries, vehicle sensor information, and guidelines for secondary analysis.

The data portal created through this project was also used to host sample Second Strategic Highway Research Program (SHRP 2) data in support of SO8 analysis proposals. In addition, this data portal will be used to provide support to those entities that are awarded SO8 analysis contracts.

Advanced Roadway Delineation and Lighting Systems

Color Camera

This project focuses on the development of a camera system that accurately defines color in a driver's environment and allows for color analysis during projects. The camera allows for the capture of a succession of images at a rate of approximately 4 frames per second and will be used in conjunction with the already developed luminance camera system. A calibration technique is being developed that will allow the color camera to be incorporated into other ongoing projects and the Roadway Lighting Mobile Measurement System (RLMMS).

The calibration of the Point Grey Flea2 color camera in an outdoor environment was improved upon. A more automated calibration procedure was accomplished that allows a faster calibration. Calibrations were completed under a number of light samples ranging from typical high-pressure sodium roadway lighting to metal halide overhead lighting. This will enable greater accuracy in color rendering depending on the type of lighting to be encountered during a testing scenario.

Although preliminary findings indicated minimal differences when calibrating to enlarged color copies of the standard Gretag-Macbeth color checker chart, calibrations have continued using the 8½" x 11" standard color checker chart. Reverting back to this initial smaller standard of color samples was decided upon due to the conversions taking place when creating the enlarged copies. While the copies appear suitable based on initial visual inspection, a calibration to these copies has indicated inaccurate rendering of colors in the environment. Calibrations using the smaller (8½" x 11") chart, however, have continued to be more reliable.

The next steps are to perform more in-depth calibrations in the outdoor environment. This will include making comparisons to the color rendering of an already calibrated digital photometer. This will be conducted during both day- and nighttime hours under multiple roadway lighting scenarios.

Color Contrast

This project was designed to use the Smart Road lighting system to analyze the effect of broad spectrum light sources on the detection distance through the impact of color contrast. Targets and pedestrians were placed along the roadway for participants to identify. Participants were also asked to correctly identify the colors of these objects. Three different light sources were tested, and participants completed testing of each light source during three separate nights. Forty participants completed the study.

Participants verbally identified as soon as they could see an object while simultaneously an in-vehicle experimenter would flag this instance in the data to determine detection distance. Color recognition distance was measured much the same way with the participant verbally identifying the object's color as soon as he or she could discern it. The video recorded inside the vehicle was later reduced to confirm the exact moments of identification. The moment of identification combined with speed and the moment of passing the object were used to determine the detection and recognition distances of the objects.

Detection distances and color recognition distances have been compiled and analyzed. An analysis of variance (ANOVA) has been completed detailing the results and their significances.

Color and luminance cameras inside the vehicle captured color and luminance contrast data that were later reduced using MATLAB©. The results gathered from this data are currently being paired with the detection distance data to determine if correlations exist between the contrast of the object (luminance or color) and the detection distance at which it is perceived or its color is recognized.

A draft final report has been developed and will be sent for review. The additional analyses regarding contrast are currently being processed to be added to the final report.

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' ability 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.

In addition, 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 rates a glare scenario a certain way. To help better understand disability glare, the Glare Metric experimental vehicle utilized 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.

A final report is in review and final editing; the report is expected to be released shortly.

Luminance Metrics for Roadway Lighting

The goal of this effort was to analyze images from both dynamic and still image collection methods using metrics other than the simple contrast formula ([luminance of target – luminance of background]/ luminance of background). This simple metric is limited in instances when contrast is not evenly distributed across an image. Therefore, this research effort was designed to identify metrics that can better describe the natural nighttime driving environment.

In order to analyze the information-rich data from the luminance camera, the research team reviewed and enhanced luminance metrics for roadway luminance data. Multiple metrics of contrast have been applied to existing images, such as the Weber, Michelson, and Simple contrast measurements. The team further improved these metrics through the use of Root Sum of Squares (RSS) and Power Spectrum Signature (PSS) methods in an effort to identify contrast information through the use of the variation of luminance within an object of interest (e.g., target).

The strengths and weaknesses of the mentioned metrics have been explored. The results of these methodologies have provided interesting contrast information in addition to different automation techniques for identifying this information.

An initial analysis of a set of in-house images was conducted, and the calculations for the luminance metrics were automated so that users can select a target of interest and have multiple luminance metrics determined.

The luminance metric calculations have been applied to a number of studies that include Glare Metric, Visual Information Modeling, and Color Contrast. A final report of the Luminance Metric project is in the final review and editing stage.

Roadway Lighting Design and Safety

This project is an assessment of existing roadway lighting analyses in an effort to establish an initial model describing the relationship between driver safety and roadway lighting design level. This project has and continues to collect an extensive literature review that aids in the establishment of a Bayesian statistical model.

In order to establish a model to assess the relationship between roadway lighting and driver safety, a number of factors must be considered. An initial review of the literature identified a ratio calculation that can be potentially integrated into a model that evaluates illuminance as a potential safety metric. Other alternatives from the previous literature are also being considered as part of the model components. These alternatives will need to be investigated in greater depth before integration can be accomplished. These components will also likely include other safety metrics that have not been identified.

The model creation is continuing. The purpose of the modeling is to connect the selected safety metric with a set of covariates. The example above uses illumination as a safety metric when comparing daytime and nighttime crashes, and this condition variable(s) can be integrated into the model as a covariate. The statistical significance and absolute value of the coefficient(s) for illumination will help with understanding the impact of illumination on safety.

Additional variables of interest that can be added to the model and likely influence driver safety include traffic volume (i.e., annual average daily traffic [AADT]), driving lane count, defined locations (e.g., urban versus rural), weather, surface condition, traffic control influences, etc. The most convenient way is to also include them as independent variables in the regression.

Depending on the final metric, a number of statistical techniques can be used. For example, a Poisson or negative binomial regression can integrate the previously described variables of interest, and the number of crashes can be modeled. The final form of the model will be based on available data and engineering metrics of each alternative.

Roadway Lighting Mobile Measurement System (RLMMS)

The RLMMS allows the research team to collect lighting data dynamically and also incorporate a number of previous NSTSCE project features into the data collection process. The RLMMS captures illuminance, luminance, and global positioning system (GPS) information in an effort to monitor lighting levels. The system has the potential to provide valuable data that incorporate illuminance, luminance, and a number of vehicle controller area network (CAN) variables such as speed, acceleration, and steering behavior. The integration of illuminance and luminance information adds another valuable data source for understanding the quality of lighting and potential safety impacts within the nighttime driving environment.

The hardware components are all interconnected to a main data collection system. For example, illuminance data are collected by four waterproof Minolta detector heads placed within a "Spider" apparatus and mounted directly on the roof of any vehicle. The heads are positioned horizontally on the vehicle roof such that two illuminance heads are positioned over the right and left wheel paths; the other two meters are placed along the center line of the vehicle. A fifth Minolta illuminance meter is positioned on the vehicle windshield and collects glare data from there. Each of the Minolta heads is connected to a single Minolta T10 body. Data from these units are then sent via Ethernet to the data collection laptop personal computer (PC). A NovaTel GPS device is positioned at the center of the four roof-mounted illuminance meters and attached to the "Spider" apparatus. The GPS device is connected to the data collection box, and the vehicle latitude and longitude position data are incorporated into the overall data file.

Two separate video cameras are mounted onto the vehicle windshield; one collects color images of the forward driving scene, and the second camera collects calibrated luminance images of the forward driving scene. Each camera connects to a stand-alone PC computer, which connects to the data collection laptop. The data collection PC is responsible for collecting illuminance and GPS data and also timestamps the camera PC images. Additional equipment includes buttons for participant responses, CAN connectivity, Spectrometer connectivity, and eye-tracker connectivity.

Each component of the RLMMS is controlled by a specialized software program created in LabVIEW™. The entire hardware suite is synchronized through the software program, and data collection rates are currently set at 20Hz. The image capture rate for each camera is set at 7.5 frames per second (fps) of which an average of 3.75 fps is currently achieved. The final output file contains a synchronization index stamp, GPS latitude and longitude data, button/keyboard presses, individual images from each of the cameras inside the vehicle, and the illuminance meter data from each of the Minolta T10s.

The RLMMS has undergone hardware consolidation during the past year, and the amount of hardware components has decreased, which in turn has increased the portability and deployment of the system. The RLMMS has been heavily utilized and has contributed to projects in Anchorage, San Diego, and Honolulu and has been heavily used to characterize the lighting on the Smart Road. An evaluation of the repeatability and reproducibility of the RLMMS is being undertaken in order to determine the reliability of the system across multiple users and among multiple trials.

Rural Intersection Lighting Safety Analysis

This research effort was based on research results from the University of Iowa, which showed that the ratio of night-to-day and total-night crashes were lower at lighted rural intersections compared to unlighted rural intersections that had a similar configuration. This research showed the potential safety benefits of lighting at rural intersection locations; however, the data were binary in nature. This meant that crash comparisons were only performed based on whether or not lighting was present (and on). The research did not account for the lighting level or the quality of lighting at the intersection locations. In an effort to identify and enhance the crash information a similar analysis is being finalized using rural intersection locations within the state of Virginia. However, to add to the quality of data, the research team will also physically assess the level and quality of lighting at intersection locations of interest. Adding this information to the overall analysis will enhance the quality and understanding of the rural intersection lighting. A number of steps are required to identify and analyze this information.

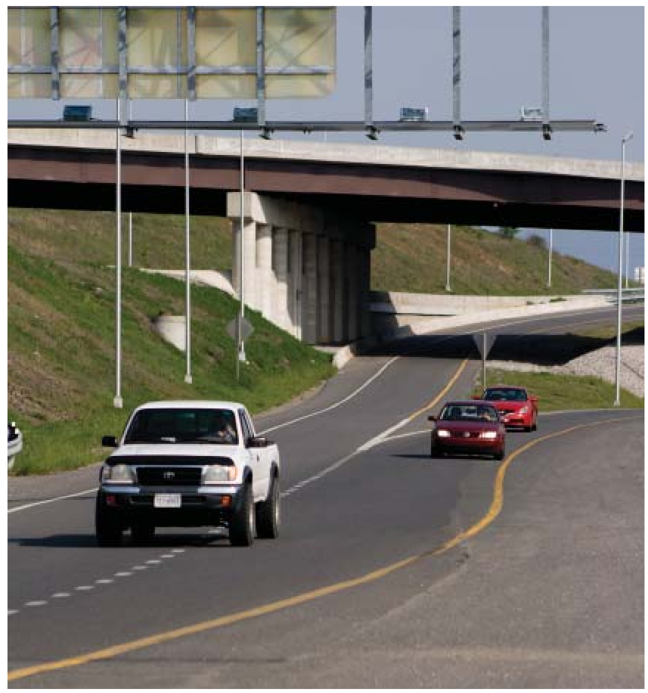
The initial data identification was similar to what was conducted during previous research, which involved identifying and locating intersections of interest. The research team obtained and used the crash data from the Virginia Department of Transportation (VDOT) crash database focusing on crashes for rural intersections (lighted and non-lighted) from 2003 to 2007. After a review of the data, the research team had to then clean and verify the data such that intersection locations of interest were checked for appropriate lighting, approach configurations, collision counts, collision types, etc. Some intersections of interest were found to contain conflicting information regarding the presence or absence of lighting in or near the intersection. A final list of intersections for data collection was created and includes high and low crash intersections (lighted and non-lighted) that are matched with the intersection type (e.g., T-intersection).

The data were collected during clear evening conditions and involved a total of 131 intersections from an initial list of 148. Intersection locations were dropped from the data collection effort either before or during the data collection effort most often due to a misclassification of intersection type (e.g., freeway proximity). Data were collected at rural lit and unlit locations, and lighting (or non-lighting) was verified during the data collection process. The collection effort gathered data using the RLMMS that employs a number of data collection techniques. GPS, illuminance, and luminance data were collected at each of the rural intersection locations.

The data are currently being processed into a database. The illuminance data for the intersections have been analyzed and will be inserted into the modeling effort. The luminance data are being analyzed. Each intersection has data collected from every approach in order to establish the quality of lighting (or the absence) at that location. This data will then be incorporated into a model that can potentially establish the effect of lighting quality in relation to crash rates at rural intersections in addition to other factors.

Visual Information Modeling

Analysis of a driver's nighttime visual environment requires consideration of multiple interrelated variables, including human factors as well as roadway features and lighting. A driver's field of view contains such features as the roadway, the hood of the vehicle, the instrument panel, off-roadway facilities and roadway fixtures (i.e., 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.



This research project attempts to develop a link between driver safety and the visual environment. The project will integrate new technology that linked luminance images to eye movement data. A dynamic driver visual model (DDVM) framework was also identified during the initial phase of the project. A DDVM is conceptually a system of rules, statistics, and expectations that can be used to define how a driver collects visual information from the nighttime driving environment. To accomplish this research effort, the research team explored a number of components during a literature review process. The literature review included driver vision and visibility, driver eye-tracking, nighttime driver eye-tracking, photometric literature, and other visibility models. Once these elements were identified, an initial DDVM framework was created based on a logistic regression methodology. The factors were entered into the logistic regression, and a series of odds ratios were calculated. The drawback to this method is that specific odds ratios will be calculated based on specific distances from the object of interest. Defining specific distance points will be derived from the average detection distances collected during experimentation. Standard detection distance increments such as 1,000 feet, 750 feet, 500 feet, 250 feet, and 100 feet will be used.

In order to collect data for the DDVM, the research team had to integrate a number of hardware components that included the luminance camera, an eye tracker, and the VTTI data acquisition system (DAS). This required the creation of a common timestamp among the different data collection components in order to synchronize the data stream. This hardware suite was part of the larger experimental design to capture driver, lighting, and vehicular data.

The research team designed an experiment with data collection components occurring at the Smart Road and the Texas Transportation Institute (TTI) facility. The Smart Road portion was designed to include a number of potential target objects appearing in lighted and non-lighted sections of the roadway. The TTI portion included the impact of signage on driver nighttime visual behavior. Both research data collection efforts have been completed, and the data analysis has been concluded.

The final stages of the analysis have been completed, and a final report is anticipated early in the first quarter of 2011.

Development of Techniques to Address Age-Related Driver Issues

Age-Related Driver Difficulties at Intersections

This project examines the behavior of drivers making left turns at intersections with an emphasis on older drivers compared to middle-aged and teenage drivers. Aging drivers have historically been over-represented in multi-vehicle angled impact crashes (resulting from turns at intersections) and have a higher rate of fatality than younger drivers. For example, Staplin et al. (2001) reported that 48 to 55 percent of all fatal crashes involving drivers aged 80 years or older occurred at intersections, which was more than twice the rate for drivers under the age of 50 (23%). Of particular interest is whether older drivers show narrowed visual scanning as they prepare for and initiate their turns (both in terms of the spatial extent of their eye movements and in terms of head-rotation to look). Such reduced scanning has been reported in prior simulator work and in prior experimental work but has not yet been confirmed using naturalistic driving data. The first phase of this work will examine already collected naturalistic data to determine whether previously reported findings are also seen in the natural driving of older drivers at intersections (relative to a sample of middle-aged and teenage drivers who also produced naturalistic driving data in the same area as the older drivers). Automated algorithms and tools will be used and verified as they are developed and become available.

Further work will be conducted in future phases to ascertain the causes of changes in visual scanning (to confirm "what goes wrong") in order to facilitate the identification of countermeasure approaches for assisting older drivers with this area of driving difficulty.

This project utilizes data from the previously collected naturalistic data sets, Older Driver and 40-Teen, and was enabled by an Institutional Review Board (IRB) proposal that was submitted to and approved by the Virginia Tech IRB during prior reporting periods.

During 2010, the following accomplishments were made:

- An algorithm for identifying left turns in naturalistic databases was specified, requested, developed, and completed.
- An algorithm for identifying left turns across traffic in these databases was completed, and instances of left turns across traffic were found, marked, extracted, and counted in the Older Driver and 40-Teen databases.
- A turn categorization schema was developed, including definition of zones for turn: initiation, conflict, and completion.
- A sample of four teens, four parents, and four older unrelated drivers was identified with participants each making one or more left turns at a set of un-signalized (and unprotected) intersections. In addition, another signalized and left-green-arrow-protected intersection was included for comparison purposes. Finding this subset across databases proved to involve a number of complexities of natural data and was a non-trivial task. This sample formed the basis for subsequent analyses of visual scanning.
- The glance scoring protocol was applied to the selected sample of left-turn epochs based on this sample.
- Analyses of the data about glance from left turns (together with data for each subject about eye health) were undertaken.
- A set of left turns at matched intersections across ages (and databases) was successfully extracted for analysis. This set included two types of un-signalized intersections (one that had a stop sign and through traffic and one that had no stop sign and no through traffic) as well as one signalized comparison intersection (i.e., left-green-arrow-protected).
- The glance scoring protocol was applied to the selected sample of left-turn epochs.
- Analyses of the left-turn glance data were initiated.
- Several key findings were identified:
  - » Different ages do scan differently, and scan patterns are uniquely affected by turn-specific variables (even when turn types are matched).
  - » Scan patterns are affected by the changing information needs and demands as a driver progresses through the zones of a turn.
  - » Visual scanning differences by age do not appear to be as simple as studying one intersection and turn type and then generalizing findings across age (as many experimental studies do).
- The Mask software was applied to the Older Driver and 40-Teen data sets, and data were extracted from the identified left-turn epochs for which eye-glance data had been scored. The development of the software to extract the Mask data proved to be more difficult than expected but was accomplished.
- Methods were created for calibrating the data from each driver to a common coordinate system (representing areas of interest in the forward roadway toward which the head/eyes might be turned for viewing). These methods allowed the Mask data to be re-coded for analysis. It should be noted that calibration and recoding of the Mask data were a

challenge. Developing techniques with which to validate the calibrations and mappings to the environment continues to be a technical challenge, but we are very much encouraged by initial findings and will persist in efforts to verify our use of the Mask data so that a more general capability becomes available to others.

- It was possible to analyze the re-coded Mask data in terms of ranges; namely, the spatial range across which head-turning occurred during each segment of the left turn (for each age group). Preliminary findings were striking. The extent of head-turning for older drivers may indeed be narrower than for the other age groups and appears to be oriented differently than for middle-aged (parent) drivers. In addition, while teen drivers show a similar spatial breadth of head-turning to that used by middle-aged (parent) drivers teens also appear to orient their heads/looks differently (from either of the other two age groups).

Additional funding was made available in July to allow work to proceed to the following steps:

- Additional analyses of eye-glance behavior will be performed. In particular, an analysis similar to the one applied to the head rotations from the Mask (depicting the extent of spatial scanning by the eyes) will be performed to allow direct comparison of eye-scanning and head-turns.
- Data about eye health for older drivers will be examined and analyzed.
- The head-turn results from the Mask will be combined with that from the glance and eye-health data into an overall analysis.
- Analyses will be initiated for driving performance measures, including:
    - Approach speeds to intersections;
    - Turn initiation speeds;
    - Times through intersection; and
    - Key traffic, the roadway or other factors that may affect visual scanning.

Between July 2010 and March 2011, the following additional work was accomplished:

- Glance data were processed to obtain a different metric (namely, durations of glances to each location). Formal statistical analyses of this metric were also completed. During the prior period, analyses of left-turn glance data had focused on frequency and proportion of glances across locations.
- Formal statistical analyses of the durations of glances that drivers made while turning left converged on those from analyses of the proportion of glances, indicating that the longest glances are those focused on the forward path through the intersection for all three age groups. Though there appeared to be slight differences in the glance lengths of teen and older drivers, the interaction of age and area of interest did not reach statistical significance. Findings also indicated that this pattern (of lengthened glance durations to the forward path) was most pronounced when an intersection had oncoming traffic moving through the intersection toward the left-turning driver's vehicle and there were no traffic lights to protect the turn (only a stop sign for the driver).
- In addition, new methods were explored for depicting the duration and range of locations across which gazes were distributed during each segment of the left turn (for each age group). This has not been completed but is expected to generate such illustrations as those depicting the proportion of time glances were distributed in each spatial area during a left turn.

Beyond analyses of visual behavior:

- Data about eye health and neck health for older drivers were examined and descriptive statistics computed and interpreted. The average degrees of neck rotation for older drivers (136 degrees) were indeed less than the norms reported in the literature for active young adults (ranging from 155 for men to 162 for women) and conformed to the loss of 4 degrees of flexibility per decade of age reported in a meta-analysis (Chen et al. [1999]). Less head rotation is consistent with the narrower ranges of head rotation extracted from the Mask data.
- A more complete examination of the scientific literature was undertaken for use in the final report, including a consideration of theoretical constructs that could help understand/predict how and why scanning at intersections may differ with age.
- Data mining was also undertaken to identify additional turns in the databases that could be examined in terms of other factors that may be subject to age-related differences in turning behavior. These included both left turns and right turns that would be suitable for examining the effects of age on gap acceptance and traffic density on turn behavior.
- A new technique was defined for use in quantifying the presence of traffic at an intersection and for rigorously analyzing its effects on driver glance behavior, gap acceptance, and kinematic behavior as they drive through the intersection. The new technique was applied to more than 100 trips through intersections. Coding will continue until there are sufficient data to allow an analysis of this and variables related to gap acceptance.

During the next quarterly reporting period:

- Analyses of glance duration data will be completed, along with analyses of the final glance metrics.
- The head-turn results from the Mask will be combined with those from the glance data into an overall analysis.
- Analyses will be initiated for driving performance measures, including:
  - » Approach speeds to intersections;
  - » Turn initiation speeds;
  - » Times through intersection; and
  - » Key traffic, roadway, or other factors that may affect visual scanning.
- Analysis work will be expanded to turns at other types of intersections and to the issues of gap acceptance and traffic density effects on turn behavior.

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 lead to injury and fatal crashes. Teen drivers are three times more likely to get into 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 to mitigate 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 three parts include: 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 using advanced in-vehicle technology. This project will support all three parts, with special emphasis on the driver monitoring and coaching program. The driver monitoring and coaching will be accomplished by means of an unobtrusive data collection system that will provide both real-time monitoring (with instantaneous feedback for the teenage driver) and delayed summary feedback (for the parent).

In the fall of 2010, VTTI researchers continued to present Teen Driver Night Programs at three high schools in Montgomery County. The purpose of the Teen Driver Night Programs was to educate 10th graders (who usually obtain their learner's permit and/or driver's license) and their parents about the challenges that are unique to new drivers, the licensing process, how the driver's education program works, legal issues associated with teen drivers, insurance issues regarding teen drivers, how parents can be effective driving coaches for their teens, and to present current research opportunities at VTTI. Altogether, there was outreach to 360 people in Montgomery County, as seen below. Unfortunately, the Bedford County Public School Board opted to not host these meetings in either the spring or the fall semesters.

- Blacksburg High School - 100 families (200 people)
- Auburn High School - 40 families (100 people)
- Christiansburg High School - 25 families (60 people)

The Driver Coach research team also attended the Transportation Research Board (TRB) Young Driver Subcommittee annual meeting held in Washington, D.C., in January 2010 and the mid-year meeting of the same group in July 2010 in Woods Hole, MA. For the mid-year meeting, Dr. Charlie Klauer organized this meeting, which was a workshop on the topic of the importance of driving exposure for young drivers. The research team also continued to consult with National Institutes of Health (NIH) sponsors about the research design for Driver Coach. It is anticipated that participants will be enrolled into the monitoring and feedback portion of the Driver Coach study beginning in January 2012. This research directly supports traffic safety research of the Federal Highway Administration (FHWA) and the Department of Transportation (DOT) with a particular emphasis on developing new technologies for saving lives.

Development of Techniques to Address Fatigued Driver Issues

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

Research findings are mixed with regard to whether talking on a device (such as a hands-free mobile phone, a handheld mobile phone, or a CB radio) while driving elevates the risk of encountering a safety-critical event (SCE). This study is using naturalistic driving data to investigate whether driving task demands moderate the risk associated with talking on a device while driving. The same SCEs and baseline epochs used in the Commercial Vehicle Operator (CVO) distraction study (Olson et al., In Press) will be queried to identify cases where the driving task demands were high and cases where the driving task demands were low. The odds that talking on a device elevates crash risk will be computed using both the high and low task demand data sets. It is hypothesized that talking on a device will elevate crash risk when task demands are high and decrease crash risk when task demands are low. This study will complement the previous driver distraction research and help address the ongoing discussion amongst transportation researchers, policy makers, safety advocates, and the general driving population about whether there are safety implications from talking on a device while driving.

Approval to perform a re-analysis of the naturalistic driving data collected during two previous heavy-vehicle studies was obtained from the Virginia Tech Institutional Review Board (IRB). A review of the literature about driver distraction, workload, vigilance, and what constitutes high and low driving task demands was initiated.

The preparation of the high and low driving task demand databases is expected to commence. Criteria identified from the literature review will be used to select SCEs and baseline epochs that fall into the high and low workload categories. The code used to compute the odds ratios during the previous naturalistic driving studies will be examined so that it can be utilized in the current re-analysis.

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

Given the 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 the U.S. adult population is overweight or obese and nearly one-third of U.S. adults may be considered obese. Studies in the U.S. have 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 population. This study will examine and detail the Schneider National, Inc. (SNI) H&W program for commercial drivers by conducting phone interviews with key Atlas Ergonomics (Atlas) and SNI executives. Questionnaires will be administered to participating SNI drivers and Atlas staff to inquire about their opinions, perceptions, and satisfaction with the SNI H&W program.

The research team proposes to:

- Conduct phone interviews with company executives and detail the SNI commercial driver H&W program with Atlas.
- Examine drivers' and program staff's opinions, perceptions, and satisfaction with the H&W program via questionnaires.
- Develop a set of recommendations for applying and maintaining a successful carrier-implemented H&W program for commercial drivers. The findings will aid in the development of recommendations for a carrier-implemented H&W program. These recommendations will be useful for trucking fleets wishing to implement a driver-focused H&W program to improve the health of their drivers.

In Task 1, several institutions were identified by VTTI as potential collaborators in the current study (the goal being to leverage the NSTSCE initiative with these partners). These organizations recognized the need to better understand the impact of driver health and obesity on commercial driving. The research team devised a plan to approach these potential stakeholders and initiated contact and discussions with each organization. VTTI contacted the following organizations: the National Institute for Occupational Safety and Health (NIOSH)/National Occupational Research Agenda (NORA), the Owner Operator Independent Drivers Association (OOIDA), and the American Transportation Research Institute (ATRI). Task 1 was completed on October 30, 2010.

In Task 2, the research team developed a work plan that documents the roadmap for conducting the project. The work plan detailed the procedures for conducting the phone interviews with key Atlas and SNI personnel, as well as designing and distributing the participant questionnaires. The work plan also detailed the recruitment procedures for drivers and personnel involved in the H&W program. Task 2 was completed on December 22, 2010.

In Task 3, the research team will prepare all necessary paper materials needed to conduct the study, including Virginia Tech Institutional Review Board (IRB) approval, informed consent forms (ICF) to conduct phone interviews with staff, ICFs for drivers and staff to complete the questionnaires, and the driver and staff questionnaires. Task 3 will be completed by February 15, 2011.

In Task 4 the research team will review documents and materials provided by Atlas that detail the SNI H&W program. These may include, but are not limited to, program protocols, program results, presentations and driver feedback. These materials will be summarized and included in the detailed write-up of the SNI H&W program. Task 4 will be completed by March 15, 2011.

In Task 5, key Atlas and SNI executives involved in the SNI H&W program will be asked to participate in phone interviews to discuss the details of the H&W program. The purpose of these interviews will be to collect supplemental information not included in the materials and documents collected during Task 4. Topics of interest will include how drivers are recruited to participate in the SNI H&W program, a description of the battery of tests the drivers complete, the types of health coaching the drivers receive, how health achievements are assessed, and what strategies Atlas employs to keep drivers motivated to make lifestyle changes.

There will be no exclusion criteria based on sex, health, status, or ethnicity for SNI and Atlas personnel participating in the phone interviews; however, all participants must be eligible for employment in the U.S. and be involved in the SNI H&W program (managed by Atlas). VTTI plans to conduct at least one focus group with one or more representatives from Atlas and SNI. Each phone interview will include one to four participants. Task 5 will be completed by March 31, 2011.

In Task 6, SNI drivers and Atlas and SNI staff in the H&W program will be recruited to participate in the questionnaire research. As indicated above, the purpose of the questionnaires will be to examine SNI drivers' and Atlas program staff's opinions, perceptions, and satisfaction with the H&W program. The research team will work with Atlas to distribute these questionnaires to a sample of SNI drivers and Atlas program staff. Task 6 will be completed by June 30, 2011.

In Task 7, the research team will analyze the questionnaire data collected during Task 6. Drivers and staff will complete different questionnaires. The driver questionnaire will include demographic questions, questions about driving experience, experience and satisfaction with the H&W program, if and how the program has improved the driver's health, what the driver likes about the program, and suggestions for improvement. The staff questionnaire will include demographic questions, questions about work experience; the driver's role, experience, and satisfaction with the H&W program; if and how the program has improved the health of the drivers; what the drivers like about the program; and suggestions for improvement. Task 7 will be completed by July 29, 2011.

In Task 8, The H&W Case Study Draft Final Report will be completed. The report will provide information about the methods, results, and conclusions of the H&W Case Study. Specifically, the H&W Case Study Final Report will present a description of the SNI H&W program and the findings from the questionnaire data. Task 8 will be completed by August 31, 2011.

In Task 9, revisions and edits from the Draft Final Report will be incorporated into the revised H&W Case Study Final Report. This report will provide information about the methods, results, and conclusions of the H&W case study. Also included in the Final Report will be a set of recommendations for implementing and maintaining a successful H&W program for commercial drivers. Task 9 will be completed by September 30, 2011.

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

This project will: 1) Assess the overall effectiveness of the Schneider National, Inc. (SNI) sleep apnea program; 2) Document two different sleep apnea programs implemented by truck carriers (SNI and J.B. Hunt [JBH]); and 3) Develop a sleep apnea implementation manual to include a set of best practices for a successful obstructive sleep apnea (OSA) treatment program that 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 will be to distribute the OSA treatment manual to other trucking fleets. To this end, VTTI has enlisted the assistance of several other agencies, including the National Institute for Occupational Safety and Health (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 the manual produced during this study will be beneficial to other transportation modalities and industries. Specifically, the goals of the current study are:

1. Evaluate the efficacy of OSA treatment, including automatic positive air pressure (APAP), while commercial motor vehicle (CMV) drivers are on the job;

2. Assess the safety and health benefits in treating OSA (e.g., reduced crashes and improved health profile);
3. Evaluate the overall return-on-investment (in terms of reduced heath care premiums, lower crash rates, and increased driver retention compared to the costs of treatment);
4. Develop models to predict beneficial health and safety outcomes (e.g., compliance rates, age, gender, etc.); and
5. Develop a set of best practices for implementing and maintaining a successful OSA program for the trucking industry.

Focus group research was conducted with drivers and staff involved with SNI and JBH. The purpose of these focus groups was to assess participants' perceptions and opinions of their respective OSA programs and gain insight from those who participated in these programs. Findings from this study will provide recommendations as to how carriers should implement an OSA program in an effective and cost efficient manner.

The contract for the Case Study on the Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers (OSA Case Study) was awarded to VTTI on September 1, 2009. In Task 1, several institutions were identified by VTTI and the NSTSCE Stakeholders' Committee as potential collaborators in the OSA Case Study (the goal being to leverage the NSTSCE initiative with these partners). The research team devised a plan for approaching these potential stakeholders and initiated contact and discussions with each organization. The research team contacted each organization by sending an electronic letter to a point of contact at each organization and making a follow-up telephone call. Many organizations expressed interest in the OSA Case Study. Several organizations, including the FTA, ASAA, NIOSH, NSF, and ATRI expressed interest in NSTSCE and requested additional stakeholder information. Going forward, the research team will maintain contact with these organizations with project updates and allow them to disseminate the final sleep apnea manual developed during this study. Task 1 was completed on September 30, 2009.

In Task 2, the research team developed a work plan that provides the roadmap for conducting the current project. The work plan details the procedures for collecting, organizing, and analyzing the existing data from the SNI OSA program. Moreover, the work plan details the methods for recruiting and conducting the focus groups comprising drivers and personnel involved in the OSA programs at SNI and JBH. Task 2 was completed on October 30, 2009.

During Task 3, interim Virginia Tech Institutional Review Board (IRB) approval was granted on September 3, 2009. VTTI prepared all the necessary paper materials needed to conduct the study. This included Virginia Tech IRB approval to conduct this study, informed consent forms for drivers and staff, questionnaires, and focus group procedures. Task 3 was completed on October 30, 2009.

In Task 4, the research team will collect data previously gathered by SNI and Precision Pulmonary Diagnostics (PPD) regarding their OSA program. The research team obtained permission to collect the necessary data from SNI and PPD; however, these data are not stored in one location and involve an extensive formatting process. Discussions with SNI and the University of Minnesota (UM) are moving forward as data use agreements are being finalized; SNI is in the process of pulling the required data. The research team maintains regular communication with the UM and SNI to ensure the data collection and formatting processes move forward. The research team was granted a no-cost time extension (NCTE) to complete this task. Due to the nature of the existing health and medical data, a Certificate of Confidentiality (COC) was needed prior to SNI and PPD sending any data to the research team. The COC was obtained by the UM on December 8, 2010.

In Task 6, 15 drivers and 17 staff involved in the SNI and JBH OSA programs participated in the focus groups to assess their opinions and perceptions about their respective OSA program. The research team met with SNI drivers and staff in Charlotte, NC, and met with JBH drivers and staff in Atlanta, GA. Phone interviews were also scheduled to speak with staff members who were unable to attend the focus group meetings. All focus group meetings and phone interviews were audio recorded for transcription and content analyses (which was completed on October 30, 2010).

In Task 7 of the project, a description of the SNI and JBH OSA programs was completed. The description of these OSA programs will serve as a guide to other trucking fleets who are interested in implementing an OSA program. Moreover, this information will be used in conjunction with the results from the focus groups to inform the best practices in implementing and maintaining a successful OSA program for commercial vehicle operations. Task 7 will be completed once the analysis of existing data is complete. Completion of the Task 7 final report will be delayed due to circumstances beyond the control of the research team (most notably receipt of the de-identified carrier data from the UM).

Commercial Driver Health and Well-Being, Phase II

The purpose of this project is to provide an outreach website for commercial motor vehicle (CMV) drivers that offers information about maintaining a healthy lifestyle as a driver. Studies indicate that a substantial portion of CMV drivers have an unhealthy body weight. The NSTSCE Commercial Motor Vehicle Health and Fatigue study (Wiegand, Hanowski, and McDonald, 2009) examined the body mass index (BMI) and driving performance of 103 CMV drivers. Results of this study found that 28 percent of CMV drivers were overweight; 53 percent were obese. These drivers were found to have a significantly greater risk of driving while fatigued, not wearing a seatbelt, and being involved in a safety-critical event. However, many CMV drivers' jobs present barriers to maintaining a healthy body weight and overall good health. The NSTSCE Driver Health Tips Website will serve as a single-source information portal for CMV drivers, allowing them to gain information and the support needed for maintaining a healthy lifestyle as a CMV driver. In doing so, the site will serve as a critical outreach vehicle for the NSTSCE, partners, and potential stakeholders.

The NSTSCE Driver Health Tips Website project began in October 2009, and work has progressed in several main areas. The VTTI research team launched the website (www.drivinghealthy.org) and is promoting the site among the CMV driving community. The research team also launched the associated social networking sites. The Facebook page (www.facebook.com/drivinghealthy) and Twitter feed (@drivinghealthy) are active and regularly updated. Notably the Twitter feed is followed by several influential Twitter accounts, including the National Institute for Occupational Safety and Health (NIOSH) and Department of Transportation Secretary Ray LaHood. Additionally, many CMV-specific companies and resources follow the account. Early feedback from the Facebook and Twitter account interactions indicate that these resources have the potential to be effective tools for sparking dialogue and information sharing among those interested in CMV driver health and wellness issues.

The research team is actively promoting NSTSCE research in national- and international-scope venues. The research team presented information about the project at the International Conference on Commercial Driver Health and Wellness (November 8-10, 2010) and is scheduled to present information about the project at the National Institutes of Health (NIH) Annual Conference on the Science of Dissemination and Implementation (March 21-22, 2011). The website has also been promoted on the Secretary of Transportation's official Twitter feed and on the Transportation Communications Newsletter.

Ongoing work on this project will include the continued updating of the sites, promotion of the resources, and continued outreach to potential partners and stakeholders.

Identifying High-risk Commercial Truck Drivers Using a Naturalistic Approach

Various studies have indicated that crash, incident, and violation risk is disproportionately distributed among commercial motor vehicle (CMV) drivers, with a relatively small percentage (e.g., 10 to 15 percent) of drivers being associated with disproportionate risk (e.g., 30 to 50 percent). We currently have kernels of knowledge that suggest certain factors are associated with high-risk driving; however, we do not have a comprehensive model on how these factors interact with each other. Further, all these factors have not been included in one study, nor have they been studied under naturalistic driving conditions. The current study will use data from the Drowsy Driver Warning System Field Operational Test (DDWS FOT) and the Naturalistic Truck Driving Study (NTDS) to identify groupings of drivers (worst, middle, and best) based on statistical techniques (such as cluster modeling). Data will be presented about individual risk factors (or predictors) such as marital status, age, body mass index (BMI), ethnicity, sleep, etc. that can be used to identify differences between these groups. If 15 percent of the CMV drivers represent 50 percent of the crash risk, then efforts directed at those 15 percent of drivers could yield significant safety benefits. Improved safety selection procedures could ensure that many of the worst drivers are never hired. Improved safety management procedures and onboard safety monitoring devices (and other safety technologies) could ensure that drivers performing high-risk driving behaviors are identified early so that effective safety management interventions can be implemented to reduce these safety-related driving behaviors.

Project tasks include:

Task 1: Develop Work Plan
In Task 1, VTTI developed a work plan that provides the guidelines for conducting the project. The work plan reviews procedures for collecting, organizing, and analyzing the existing data from VTTI's NTDS and DDWS FOT. The work plan will be delivered to NSTSCE stakeholders and partners. After review of the work plan by NSTSCE stakeholders and partners, any necessary modifications will be made by VTTI research personnel. Task 1 was completed on December 3, 2010.

Task 2: Complete Study Preparatory Work
In Task 2, a list of data elements common to both NTDS and DDWS FOT questionnaires was prepared. Because the NTDS and DDWS FOT used different questionnaires, it was important to identify which data elements were collected in both studies. Data elements must have identical response options in the NTDS and DDWS FOT to be considered for inclusion in the proposed analyses. Also in Task 2, the Virginia Tech Institutional Review Board (IRB) application was prepared and approved on November 3, 2010.

Task 3: Retrieve and Organize Existing Data

In Task 3, data will be gathered and organized for analysis. For each driver who participated in the NTDS and DDWS FOT, the at-fault, non-fault, and high drowsiness rate of safety-critical events (SCE)/mile will be calculated. Non-fault SCEs will be included as high-risk drivers may not perform defensive driving skills, thereby placing themselves at-risk for an SCE (although it may be judged to not be their fault). Anthropometric, demographic, and personal data previously collected in the NTDS and DDWS FOT were coded and placed in distinct files based on the questionnaire from which the data were obtained. In each of these files the driver will be assigned a new unique driver identification. These questionnaires will include, but will not be limited to, information about each driver's age, gender, BMI, alcohol/caffeine/smoking use, medication use, health conditions, highest level of education, experience driving a CMV, symptoms associated with sleep apnea, English as preferred reading/speaking language, common health problems (such as trouble sleeping, etc), and sleep quantity (measured via an Actigraph watch, a small, wrist-worn device that measures restful sleep and length of sleep). For each of the questionnaires, keys for the NTDS and DDWS FOT will be compared to ensure common coding methods were used. Once the keys have been checked and each driver's data has a unique driver identification number assigned, the questionnaire responses can be merged to form a single database. Task 3 will be completed by January 1, 2011.

Task 4: Analyze Existing Carrier Data

In Task 4, VTTI will conduct analyses on the merged data set created in Task 3. The first step will be to conduct a cluster analysis of the data to identify distinct groupings among the data. A hierarchical k-means cluster analysis performed on the at-fault SCE rate, non-fault SCE rate, and drowsiness event rate will provide three clusters of drivers. Next, a one-way analysis of variance (ANOVA) will test whether there exist significant differences between the clusters for the at-fault SCE rate, non-fault SCE rate, and drowsiness event rate. If a significant difference is found in the one-way ANOVA, a follow-up analysis using Tukey's test will be conducted. After determining which clusters are indeed distinct, the anthropometric, demographic, and personal characteristics that are common within each cluster will be examined. For characteristics with discrete or categorical values, contingency tables will be made to compare the characteristic across the different clusters. A chi-squared test will test for significance. For characteristics with continuous values, a one-way ANOVA can test for significant differences in mean values across the three clusters. After conducting the statistical analyses described above, the team will determine whether significantly distinct clusters of drivers do exist and which characteristics are associated with each cluster. Task 4 will be completed by February 1, 2011.

Task 5: Prepare Draft Final Report

A draft final report that includes a description of the data previously gathered in the NTDS and DDWS FOT, methods and procedures, and results will be written and delivered to NSTSCE personnel. The draft final report will also include recommendations about how to identify high-risk CMV drivers and research ideas to be conducted in the future regarding high-risk CMV drivers and the characteristics of these drivers. The draft final report will be delivered in electronic and hard-copy forms to NSTSCE stakeholders and partners. After review of the technical draft report by NSTSCE stakeholders and partners, any necessary modifications will be made and incorporated into Task 6: Final Report. Task 5 will be completed by March 1, 2011.

Task 6: Prepare Final Report

Based on the feedback obtained from NSTSCE personnel for the draft final report, the final report will be written and will incorporate these revisions (including additional analyses). The final report will be delivered to NSTSCE by April 1, 2011.

Supporting Commercial Motor Vehicle Driver Distraction Outreach

The Federal Motor Carrier Safety Administration (FMCSA)-hosted, VTTI-developed, "CMV Web-Based Driving Tips" site provides CMV drivers with practical guidance on 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 distracted driving have received increased traffic. This presents a unique opportunity to expand and enhance the driver distraction section of the site. This project involves reviewing the existing site's distracted driving information in comparison to research published after the site's creation and, as needed, updating the site with information about distraction risks.

The research team completed its review of the existing site materials and began gathering new potential sources of information to add to the site. The team is continuing to review material in order to identify any needed updates to the distraction section of the CMV Driving Tips website.

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

The purpose of this project is to survey curricula of light-vehicle driver education/improvement programs and assess any information that is relevant to heavy-vehicle characteristics and procedures for sharing the road. Recent research investigated light-vehicle/heavy-vehicle near-crashes and crashes (critical incidents) and found that 78 percent were initiated by the light-vehicle driver (Hanowski et al., 2007). The most common incident type involved the light vehicle changing lanes without sufficient gap to the heavy vehicle. This larger proportion of light-vehicle at-fault incidents may result from inadequate training in heavy-vehicle dynamics during light-vehicle driver education/improvement programs. Light-vehicle driver education/improvement programs that contain content about heavy-vehicle operation may be helpful in reducing light-vehicle/heavy-vehicle interactions. However, it is unclear as to the extent of current state curriculum requirements and content (for both public and private programs) regarding heavy-vehicle operation and associated light-vehicle driving recommended procedures.

This project will involve the development of an online survey targeted at individual state driver education/improvement program administrators that will identify current commercial vehicle characteristics curricula (or lack thereof) and perceived effectiveness. It is expected that this project will identify information and training gaps that can be built upon during future efforts.

In 2010, the research team began assembling a list of potential members for involvement in a peer review committee consisting of individuals knowledgeable about driver curricula and light-vehicle/heavy-vehicle interaction research. In addition, the research team began contacting some of these individuals to participate. In parallel, the development of a work plan was initiated detailing the project tasks and deliverables. In 2011, the research team will complete the creation of the peer review committee, the work plan document, and the development and delivery of the survey.

U.S.-EU Common Distraction Driving Taxonomy

The purpose of this project, which involves a collaboration between INRETS (France) and VTTI/NSTSCE, is to develop a taxonomy of distraction sources that can be used as the basis for the collection, analysis and reporting of data from future naturalistic driving studies in the United States and Europe. Briefly, the project involves the development of a suitable, properly scientifically justified definition and taxonomy of driver distraction by utilizing videos from the VTTI naturalistic studies.

Project tasks include:

- Revising a taxonomy developed by INRETS based solely on theory.
- Using VTTI's naturalistic driving video data to assess the taxonomic categories and find exemplars, where possible, to support the description of the categories.
- Validating and refining the taxonomy based on the real-world example video data.
- Documenting the project in a brief NSTSCE report.
- Outlining the study process involving the use of pragmatic data to evaluate and ground a theoretically based taxonomy and submit it to the 2nd International Conference on Driver Distraction and Inattention.
- Documenting the study results and finalizing taxonomy in a journal article (to be determined).

The research team had an in-person meeting in Lyon, France. INRETS staff outlined the initial taxonomy while VTTI staff presented videos of distraction events that can be used to validate the taxonomy. At the end of the meeting, INRETS staff continued in the taxonomy validation process by using event narratives derived from VTTI naturalistic study reports. The research team will continue to integrate real-world event examples into the taxonomy. In addition, the study idea, objectives, and process will be documented in a paper proposal submitted to the 2nd International Conference on Driver Distraction and Inattention. When a revised taxonomy has been developed that integrates real-world events collected via naturalistic studies, a journal article will be written and submitted.

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