National Surface Transportation Safety Center for Excellence

Annual Report January - December 2013

Virginia Tech
Transportation Institute

NSTSCE
National Surface Transportation
Safety Center for Excellence

photo by Jim Stroup

Message from the Director

photo byJessamine Kane-Wiseley

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

The NSTSCE approach is to build on the strengths and capabilities of VTTI to make a measurable impact on road-user safety. NSTSCE maximizes resources across four focus areas: safety devices and techniques that enhance driver performance, driver impairment, safe mobility for vulnerable road users, and the evaluation of the built roadway environment and infrastructure-based safety systems. NSTSCE comprises a stakeholders' committee that enables center researchers to make a difference in current and future transportation safety. Our stakeholders include organizations that derive direct benefit from the work being performed by the center: the Federal Highway Administration, General Motors Corporation, the Virginia Department of Transportation and the Virginia Center for Transportation Innovation and Research, the Federal Motor Carrier Safety Administration, and Travelers Insurance.

NSTSCE continues to make significant strides in advancing transportation safety, and research results are leading to enhanced technological developments as engineers work to translate research findings into transportation safety applications. NSTSCE results are also providing insights into transportation safety policies, informing decision makers as they craft legislation. For example, data collected and analyzed from studies about specialized driving populations (e.g., older drivers, motorcycle riders, teen drivers, and truck drivers) allow us to examine from both countermeasure and policy standpoints the national transportation safety concerns of distraction, fatigue, and impairment. NSTSCE researchers are frequently invited to provide testimony to congressional subcommittees, and our research endeavors are featured heavily at national and international conferences and symposia.

Our work includes projects specifically designed to mitigate crashes and near-crashes occurring within over-represented driving populations. For example, a continuing teen driving program that involves real-time monitoring and coaching of teen drivers is currently being tested using funds provided by NSTSCE and other research partners. During this study, an innovative data collection system developed at VTTI provides immediate feedback to teen drivers about risky driving behaviors; post-trip feedback is then provided to parents/guardians so they can coach their teen drivers of errors. The ultimate goal of the project is to reduce, and ultimately eliminate, teen driver fatalities and injuries.

The development of sophisticated, ruggedized equipment led to a 100-motorcycle study, which has finished data collection at four sites (California, Florida, Virginia, and Arizona). Funded by the Motorcycle Safety Foundation and covering more than 500,000 miles of data, this naturalistic driving study was the first of its kind to explore motorcycle crash causation with the goal of developing crash countermeasures. The National Highway Traffic Safety Administration (NHTSA) is also funding a complementary 160-motorcycle study that is underway in Southern California.

NSTSCE is enabling large-scale data collection and data sharing efforts on national and international levels. By facilitating the in-house creation of data acquisition system iterations (e.g., the MiniDAS) that can be installed across varying vehicle types, the center is ensuring that more data can be collected about myriad transportation users. Such increased data amounts will facilitate future analyses that seek to answer the greatest issues facing the traveling public.

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

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photo by VTTI staff

Mission of the Center

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

The approach of NSTSCE is to build on VTTI strengths and capabilities to make a measurable impact on road-user safety. NSTSCE uses a synergistic approach across four research focus areas to maximize resources:

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

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

Goals of the Center

NSTSCE 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 road map for achieving these goals. Partnerships with relevant agencies and industries are a critical component to achieving the maximum impact of NSTSCE, thus each specific focus area lists potential research partners. Note that it is assumed that the stakeholders are partners in each project. While the primary mission of NSTSCE is transportation safety research and development, stakeholders understand the value of outreach and technology transfer opportunities and have selected a fifth subject matter expert to focus on this endeavor.

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.

Stakeholders

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

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

Marketing Approach

NSTSCE subject matter experts and project managers accelerated NSTSCE marketing and outreach efforts during the seventh 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. During this reporting year, NSTSCE researchers:

- Participated in relevant Transportation Research Board (TRB) meetings and workshops.
- Initiated several new social media marketing campaigns, including an e-newsletter and a YouTube channel.
- Served as TRB and SAE committee members within primary research areas.
- Were scientific committee members at international conferences held in Belgium and Sweden.
- Were interviewed by myriad media outlets as transportation experts in the fields of distraction, fatigue, and impairment.
- Continued to develop tools and techniques to provide national and international transportation researchers access to VTTI naturalistic data.

photo by VTTI staff

Outreach Strategy

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

Outreach Accomplishments/Awards

- Tom Dingus was named a White House Champion of Change in Transportation and was an invited speaker on the distracted driver expert panel for the Association for the Advancement of Automotive Medicine in Chicago, Ill.
- Myra Blanco received the J. Cordell Breed Award for Women Leaders from the Society of Automotive Engineers.
- Greg Fitch was interviewed by local and national media affiliates about the dangers of distracted driving. He also made several distracted driving-related presentations at national symposia and workshops.
- Greg Fitch and Rich Hanowski served as co-authors of "Development of a Protocol to Classify Drivers' Emotional Conversation," which appeared in the Proceedings of the 3rd International Conference on Driver Distraction and Inattention in Gothenburg, Sweden.
- Naomi Dunn, Jeff Hickman, and Rich Hanowski authored "Crash trifecta: A complex driving scenario describing crash causation" that will appear in the Proceedings of the 5th International Conference on Applied Human Factors and Ergonomics. The proceedings are currently in press.
- Erin Mabry, Jeff Hickman, and Rich Hanowski have been accepted to present "Case Study on a Worksite Health and Wellness Program" during the annual Institute of Industrial Engineers Conference and Expo in Montreal, Canada.
- Justin Morgan, Myra Blanco, Alejandra Medina, and Rich Hanowski authored "Effective utilization of naturalistic data for driver distraction outreach campaigns" that appeared in the Proceedings of the 3rd International Conference on Driver Distraction and Inattention. The abstract is available at: http://www.distractionconference.com/program/program-papers.
- Erin Mabry, Jeff Hickman, and Rich Hanowski have been accepted to present "Case Study on a Worksite Health and Wellness Program for Commercial Motor Vehicle Drivers" at the annual American College of Sports Medicine Conference in Orlando, Fla.
- Erin Mabry, Jeff Hickman, and Rich Hanowski authored "Case study on a worksite sleep disorder program for commercial motor vehicle drivers" that will appear in the 3rd International Conference and Exhibition on Occupational Health & Safety.
- Laurel Marburg, Jeff Hickman, and Rich Hanowski will present their poster "Identification of Common Data Elements in the Large Truck Crash Causation Study Investigations and Commercially-Available Onboard Monitoring Systems" at the 2014 Lifesavers Conference on Highway Safety Priorities in Nashville, Tenn.
- Andy Schaudt, Stephanie Baker, and Tammy Trimble presented their poster "Evaluation of light-vehicle education programs on sharing the road with heavy vehicles" at the 2013 Lifesavers Conference in Denver, Colo.
- Erin Mabry, Stephanie Baker, Jeff Hickman, and Rich Hanowski led the panel presentation "Case Study on the Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers" at the annual meeting of the Transportation Research Board in Washington, D.C.
- Erin Mabry presented "Driving Healthy: Wellness Over the Road" at the Truck Safety and Education Symposium in Hartford, Conn.
- Erin Mabry, Stephanie Baker, Jeff Hickman, and Rich Hanowski presented "Case Study on the Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers" during the VTTI Open House.
- Jon Antin presented research about transportation issues specific to senior drivers at the 2013 Lifesavers Conference in Denver, Colo., and the 25th Annual Symposium of the Central Virginia Chapter of the Society for Neuroscience.

photo by VTTI staff

Outreach Goals

Heavy-vehicle Safety Outreach

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

Heavy-vehicle Safety Outreach Website

The Heavy-vehicle Safety Outreach website is an extension of the Heavy-vehicle Safety Manager workshop that was conducted August 9, 2013, in Hartford, Conn. This website will incorporate those materials in an easily accessible format for safety managers, risk managers, insurance entities, and other interested parties to view and use for training purposes. Video examples, where applicable, will also be included on the website. Discussions have been held about the domain name and overall layout, as well as content to be provided. The majority of the training materials will come from the presentations conducted at the Heavy-vehicle Safety Manager workshop. A resources and references page will also be included on the website.

NSTSCE Newsletter

The NSTSCE newsletter is an outgrowth of outreach efforts to more efficiently convey NSTSCE's mission to a wider audience. This newsletter will be published on a quarterly basis and will highlight several NSTSCE projects that have been completed, along with several currently ongoing projects. The focus of this newsletter is to reach a wide audience; thus, the articles are written not only for researchers and practitioners but also for the general public. This newsletter will be disseminated quarterly; the first edition is available at: http://issuu.com/vtti/docs/transportation_research_today_volum.

NSTSCE YouTube Channel

Similar to the NSTSCE newsletter, the NSTSCE YouTube channel is designed to disseminate NSTSCE's mission to a wide audience through short videos highlighting the accomplishments and results of NSTSCE research. These videos will include project overviews, high-level results, where to find the full publication, and contact information. The NSTSCE YouTube Channel has been created and includes a brief overview of NSTSCE, as well as links to the stakeholder websites and any stakeholder YouTube channels. The topics of the videos that will be produced have also been selected. The channel is available at: https://www.youtube.com/channel/UCbTwCWSVDctAPwnaRY3Es6A.

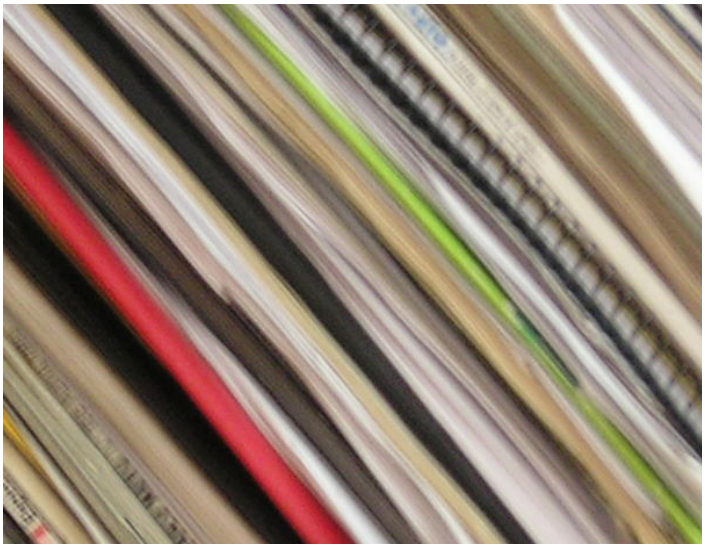
Symposium

VTTI will host the Fourth International Symposium on Naturalistic Driving Research (NDRS) at the Inn at Virginia Tech and Skelton Conference Center in August 2014. The two-day international symposium will be preceded and followed by optional workshops focused on the Second Strategic Highway Research Program (SHRP 2). The symposium will provide researchers with an overview of international naturalistic driving studies (NDSs) and insight into the next generation of NDSs. A special student podium session will focus on innovative ideas for using data from the SHRP 2 NDS.

Symposium Dates – August 26-27, 2014

Workshop topics and dates are:
Monday, August 25 – SHRP 2 Data InSight
Thursday, August 28 – SHRP 2 Data InDepth

More information about the symposium and workshops can be found at: http://www.vttindrs.org/.



Publication and Analysis Plan

Numerous publications were submitted to scientific agencies and journals during 2013, and several fresh observations are presently under research analysis to create additional publications. A separate NSTSCE subcommunity was created within VTechWorks (the institutional repository at Virginia Tech) that contains all published NSTSCE reports. This provides search capabilities and analytics, and feeds into The Summon® service (unified indexing) and Google. The NSTSCE subcommunity can be found at: http://vtechworks.lib.vt.edu/handle/10919/5529. A larger VTTI community was also in the process of being created within VTechWorks.

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

encompasses heavy- to light-vehicle naturalistic driving in rural and urban locales. These data are examined under all relevant perspectives for identified events and driving behavior to further interpret causal/associative factors.

Tips for Sharing the Road with Commercial Motor Vehicles: A Web-based Approach

NSTSCE has sponsored two recent projects focused on investigating light-vehicle driver education programs and the methods used to instruct young drivers on how to share the road with heavy vehicles. These projects were initiated in response to consistent research literature showing that larger proportions (approximately 78 percent) of light-vehicle drivers are at-fault in incidents involving light-vehicle/heavy-vehicle interactions. This larger proportion of light-vehicle at-fault incidents may be a result of inadequate training of heavy-vehicle dynamics in light-vehicle driver education programs. The NSTSCE research team is developing a best practices document to help instructors find and develop new techniques and updated materials. However, the NSTSCE team is in a unique position to do more. The objective of the current project is to develop a web-based tool using naturalistic videos to provide Tips for Sharing the Road with Commercial Motor Vehicles (CMVs).

This website will act as a supplemental driving tips training program that would be accessible to the public and based on naturalistic driving data. The purpose of this project is to develop a website dedicated to providing video examples of real-world scenarios involving light-vehicle/heavy-vehicle interactions and proper sharing-the-road driving behavior. If sharing-the-road scenarios exist that have not been previously captured by naturalistic studies (or if participant consent for using the videos cannot be obtained), the Virginia Smart Road and/or VTTI Commercial Training & Prototyping Simulator (CTAPS) will be used to recreate/simulate and video record these scenarios for upload to the website. This project will culminate in a letter report describing the project efforts and a live website featuring tips for sharing the road with CMVs. The research team has identified the particular road-sharing scenarios of interest on which the website will focus. The research team is also reviewing naturalistic driving videos to identify examples of poor and proper sharing-the-road behavior.

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

Application of Proximity Sensors to In-vehicle Data Acquisition Systems

A new suite of sensors that provides novel driving-related data is coming to market. These sensors measure the position and motion of specific parts of the human body and enable user interfaces based on gestures performed in the air. One example of such a technology is employed in the Microsoft Xbox game system under the name Kinect. Additional sensor technologies are coming to market with similar capabilities and low price points. These technologies can be applied to provide detection and tracking of a driver's hands or other body parts. Such information could provide measures of the hand position (e.g., steering wheel, center stack, etc.), thus augmenting and possibly replacing costly manual data reduction processes for classifying driver actions. This project is designed to review and evaluate these technologies to establish their viability of adoption from cost/performance perspectives.

During this reporting period, researchers evaluated pose estimation in a video sequence using a spatio-temporal framework; this is expected to extend the discrete frame-by-frame prediction to a smoother prediction in time. A tool required for annotating video sequences was also obtained and will be integrated into a protocol for annotating the videos. Additionally, after assessing the camera angles of available data sets, researchers obtained access to the SHRP 2 NDS data set to access higher-quality videos.

A post-processing tool used to estimate face pose was completed, and research into building a real-time algorithm was initiated. It was determined that the pose of the face can be estimated with an accuracy of 85 percent. Researchers evaluated different feature extraction methods and found that a “tiny image”-type feature extraction proved to be computationally beneficial for real-time performance.

Attention and Drowsy Driver Assist

Following a review of project plans and objectives, this study was redefined during the past year to focus on automated detection of driver drowsiness, impairment, and driver inattention. The literature review conducted as part of this project was used to support the development of a detection strategy and a preliminary algorithm design. The algorithm will integrate eye-gaze data with driver performance to characterize driver attention and drowsiness.

During this period, work began to include data collection of impaired driving in controlled conditions. Institutional Review Board (IRB) materials were developed and internal review started. Subsequent steps include identifying additional data, code development and testing, and algorithm finalization and documentation.

photo by Michael Kiernan

Crash—Near-Crash Trigger Algorithm

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

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

The following timeline has been drafted for the completion of this project:

- Curve estimation and fitting will begin during the first and second quarters of 2014.
- Functional classification methods will be applied during the second quarter of 2014.

Data Center

The VTTI data center recently experienced several expansions. Most noteworthy among these were a new computational cluster, the application of the Virginia Tech High Performance Computing (HPC) Storage System, and a significant upgrade to the storage system supporting the VTTI Scientific Data Warehouse environment. These systems compose the foundation for data-intensive scientific research programs conducted at VTTI, particularly the SHRP 2 NDS.

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

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

Substantial expansion of storage for the VTTI data warehouse environment has occurred, as well as the migration of data into an expanded storage system. The operational stability of the Virginia Tech HPC storage service had a significant impact on the VTTI computational and data ingestion throughput. The stability of this system has been substantially improved, with resulting performance enhancements to data ingestion, particularly for SHRP 2 data.

Data Sharing Across Borders

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

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

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

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

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

During this reporting period, the PI completed reviewing the links provided by the OHRP with a focus on the general and privacy/data protection categories. In addition to international policy and guidelines, countries that have been reviewed include the United States, Canada, Australia, Sweden, China, Germany, Japan, Great Britain, France, New Zealand, and Israel.

The PI continued to work with several other VTTI researchers who are conducting (or who are close to conducting) collaborative NDSs in other countries. The PI previously developed a brief "best practices" document for use during these situations. This document is available upon request and will likely be similar to the conclusions section of the final report. Updates are provided below for Canada, Australia, China, Germany, and Sweden.

Canada: VTTI is the contractor for an NDS currently being conducted in Saskatoon, Saskatchewan. Data are being collected in Canada with data held at VTTI and shared with researchers from Canada (and possibly other countries). The naturalistic study is now collecting data with about one-third of the projected vehicles currently enrolled. The data for this study will be housed in the United States and will be accessible by Canadian researchers.

Australia: VTTI researchers are conducting a small, collaborative NDS in Australia, with data stored at VTTI and in Australia (and possibly shared with other countries). Australian ethics rules appear to most closely align with those of Canada in terms of format and organization. During this reporting period, additional coordination activities were pursued with the Australian investigators. Additional human subjects support was provided at the end of the pilot project, in preparation for the larger research project currently under negotiation. A related study to be conducted with novice drivers in New Zealand is in the very early stages of planning (this project has overlap with the researchers in the Australian study).

China: Data collection continued in Shanghai, China, in collaboration with General Motors (GM) China and Tongji University for the Shanghai NDS. The Tongji University IRB approved the study, including the consent form, and relevant documents were translated prior to submission to the Virginia Tech IRB. The Virginia Tech IRB approved the protocol as well, and Virginia Tech has begun receiving, processing, and storing its first international naturalistic driving data. Key findings in the IRB and data-sharing arenas include: 1) It is difficult to find English translations of Chinese IRB requirements; 2) It can be difficult to find an IRB qualified to evaluate NDS efforts (in this case, the Tongji University Medical School IRB agreed to review the study); and 3) The Chinese IRBs may be less stringent in their review (as compared to those in the United States).

VTTI is currently planning for a large-scale study in China using 100 vehicles. One goal of the next year is to determine if this approach is transferable and scalable.

Germany: Although the research is not part of an NDS, Virginia Tech has worked with the Wuerzburg Institute for Traffic Sciences to analyze video of parking maneuvers collected from German participants. The protocol has been submitted and approved by a local German ethics board and has been submitted to the Virginia Tech IRB. The PI worked with VTTI investigators to ensure that the consent form lists VTTI as receiving, holding, and analyzing identifiable data. It appears that working with Germany in this capacity will not be a problem.

Sweden: As part of the SHRP 2 NDS, VTTI has worked with the SAFER group in Sweden for a SHRP 2 data analysis project that required shipping data to researchers in Sweden. This required a data-sharing agreement with the research team; this, in turn, involved obtaining documentation of Swedish ethics board approval (in translated form). No major hurdles were encountered in completing this process.

During the past few months of this project, the Edward Snowden and National Security Agency (NSA) revelations have added new twists to the topic of data sharing. The first twist is the revelation that the NSA is able to decrypt encrypted files, reducing trust in U.S. researchers promising that the data collected from a country's citizens will remain secure and will be treated with confidentiality. When the Canada NDS was beginning, VTTI researchers were informed that in some similar cases consent forms had to include a statement that data may be subject to review under the Patriot Act. In the end, this statement was not included, but if the study had begun after the NSA revelations, this might have been different. A second twist is that the European Union will soon meet to discuss new restrictions on data transfers to the U.S.; this may end up including restrictions on research data. These issues will be explored further in the final report.

Final considerations have become clearer over the past year. First, every new research project is different in its risks and protocol details, and every new country has different human subjects requirements. This results in an ongoing case-by-case process, which requires significant legwork and research each time (albeit with some efficiencies of knowing where to begin the research). Second, the human subjects protections offered by each country change over time such that prior knowledge cannot be depended upon. This is the reason the OHRP updates its international resources each year. Thus, any guidance provided by this project must be updated early in the process of beginning a new international NDS.

photo by VTTI staff

Developing Bayesian Models for a Naturalistic Driving Study

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

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

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

The paper about the semi-parametric Bayesian model is under review for the *Journal of Applied Probability*. Major computation has been completed for the random exposure Bayesian model.

Distraction Index Framework

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

To determine the feasibility of this effort, researchers selected crash and near-crash surrogates and overlaid these with naturalistic data. A literature review and a reanalysis of existing data were required (no additional data collection was needed).

The analyses were completed using a previously collected naturalistic data set focusing on, but not limited to, infotainment system use. In most cases, findings from analyses were not powerful enough to be conclusive but showed interesting and meaningful trends. A noteworthy finding was that the use of infotainment systems in naturalistic environments changed the normal patterns of visual attention but had limited or no effect on the lateral control of the vehicle (at least compared to the normal “noise” experienced in this measure during naturalistic driving).

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

The final report (13-UT-020) was distributed to NSTSCE stakeholders and is available at: http://vtechworks.lib.vt.edu/handle/10919/23318.

Driving Scenario Classification

Driving scenarios (e.g., driving relatively straight, negotiating a cloverleaf, turning at an intersection, or decelerating for a light) affect the driving-related measures collected for vehicles. The goal of this project is to be able to identify a driving scenario in the naturalistic data using automated methods. Once a scenario is

identified, driver behavior can be quantified with respect to the specific scenario, which greatly increases the sensitivity of data mining.

During this year, a global positioning system (GPS)-based approach to scenario classification was also developed. The method rapidly matches vehicle location to digital maps of road segments, which provides a reference to all associated road data included in departments of transportation and private map sources. The digital maps contain sufficient attributes describing the road segments to differentiate many driving scenarios, thus addressing the bulk of the objectives of this scenario classification effort.

The method for associating GPS points with roadway segments was documented and submitted to Virginia Tech Intellectual Properties for review. It was then submitted to the U.S. Patent Office; the patent review process is underway (U.S. Patent Application No: 61/829,024).

Effective Use of Commercially Available Onboard Safety Monitoring Technologies: Guidance for CMV Carriers

Many drivers choose to behave in ways that put themselves and others at risk for a vehicle crash and/or serious injuries. At-risk driving behaviors have been found to be the primary contributing factor in crashes; thus, reduction of at-risk driving behavior will lead to a reduction in crashes and their associated fatalities and injuries. Behavioral approaches to safety have provided robust positive results when applied in organizations seeking to reduce employee injuries due to at-risk behaviors. However, almost all prior behavioral safety research has been applied in work settings where employees can systematically observe the safe versus at-risk behavior of their coworkers. By contrast, truck and bus drivers typically work alone in relative isolation, which thus requires alternative strategies. Until recently, the primary problem with implementing behavior-based approaches has been obtaining quality behavioral data about driving behaviors. New technologies are currently available that provide objective measures of driver behavior. These in-vehicle technologies, or onboard safety monitoring (OSM) technologies, are able to provide continuous or event-based measures for a variety of driving behaviors previously unavailable to fleet safety managers. Thus, OSM technologies have the potential to be used in conjunction with behavioral safety techniques to greatly reduce a variety of at-risk behaviors.

photo by VTTI staff

However, various OSM technologies exist, each with their own strengths and weaknesses. Moreover, less is known about the safety efficacy of these onboard safety technologies and how the technologies work. These factors can make it difficult for a fleet safety manager to be well informed about the OSM technology that best fits his/her organization. The implementation of OSM technologies involves more than simply installing the technology in trucks; it requires detailed planning and involvement from all levels within the organization. What is needed is a manual or guide for commercial motor carriers that provides a detailed overview of each OSM technology and describes how to most effectively use and implement them.

This study will pursue the possibility of working with several OSM providers (e.g., DriveCam, SmartDrive, Qualcomm, and GreenRoads) that currently have corporate outreach on their respective websites. The research team will contact the aforementioned companies to request assistance in developing materials for a guide for motor carrier fleets regarding the effective use of OSM. The research team is well positioned to conduct this research as it has already established relationships with several of the OSM vendors noted above. Some potential topics to be addressed include: training, safety culture, development of a steering committee, and employee involvement and commitment.

The research team reviewed commercially available OSM companies for inclusion in the guide. To be included in the guide, the company must have a commercially available technology that can be used to monitor driver behavior and/or performance in some way. The research team reviewed technical journals, the Internet, and a recently published NSTSCE telematics guide, *Market Guide to Fleet Telematics Services; Creating a Consumer's Guide to Currently Available Aftermarket Telematics*, to identify potential candidate companies.

Generic Motorcycle Bracketry and Housings

VTTI recently completed data collection for one motorcycle study in which 100 motorcycles were instrumented to support the Motorcycle Safety Foundation. The bracketry and accessory housings (e.g., radar, GPS, cameras) for that study were designed for a small number of motorcycles with no accessories or modifications.

Under this project, generic components have been engineered that permit installation of equipment on a wide range of motorcycles. These generic components permit rapid placement of cameras and radars on different makes and models of bikes in a number of locations. The components also permit the installer to adjust angles of the equipment according to the geometry of the bike. In addition to the generic components, off-the-shelf hardware has been identified that further expands VTTI's ability to mount equipment on different bikes.

Generic solutions have been produced for mounting radars and cameras on motorcycles. These parts are now in use in the NHTSA 160-motorcycle study.

photo by VTTI staff

Identifying Cognitive Load from Naturalistic Data

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

The final report will be delivered during the third quarter of 2014.

Impacts of SCEs on Driver Behaviors

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

The recurrent-events-based statistical model has been completed. Evaluations were completed of driver behavior before and after crashes, and the results showed that the intensity of an SCE tends to decrease after a crash. Also, no significant difference was detected in the distraction frequency occurring before and after a crash.

IMU Utility Tool

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

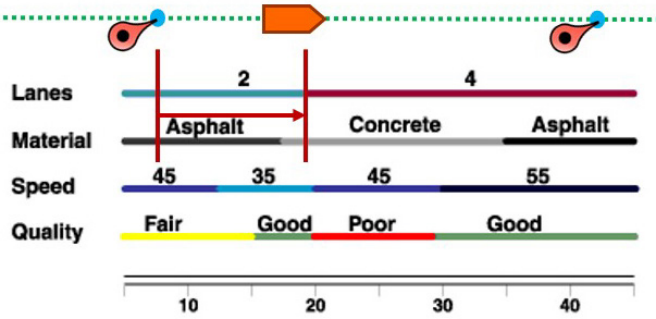
This project comprised the following objectives:

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

The draft final report has been submitted for review and is expected to be published during the second quarter of 2014.

Integrating Roadway Data with VTTI's Naturalistic Data Set

A systems approach to understanding surface transportation safety integrates consideration of the driver, the vehicle, and the roadway. The naturalistic data housed by VTTI offers a rich data set for understanding the interactions of these three subsystems. Interest from the driver and vehicle domains has been strong for many years. Interest is growing rapidly from individuals in the roadway and infrastructure domains (e.g., civil engineers). There is an opportunity to increase the accessibility of naturalistic data for individuals approaching it from a roadway infrastructure perspective.



This project will provide avenues to the driving data sets to facilitate work being conducted by individuals more familiar with roadway and infrastructure attributes than driver- or vehicle-related measures. These avenues will provide addresses to data organized relative to roadway-related attributes. Data mining will be applied to multiple data sets (e.g., 100-Car, Older Driver, Truck) to associate the location of the vehicle with a segment of roadway. The data mining will use a new VTTI algorithm and a nationwide roadway map (Nokia/Navteq). Roadway attributes such as road class, speed limit (where available), levels of Annual Average Daily Traffic (AADT), number of lanes, grade, etc., will be included. Additional high-level descriptors of both the driver and the roadway will be cataloged, such as state (e.g., Virginia, Connecticut, North Carolina), urban/rural, participant age group, vehicle type (car, pick-up, tractor trailer), trip date, etc. Documentation of the work will be developed in coordination with civil engineers, traffic modelers, etc.

This project will make the naturalistic data set more accessible to agencies, companies, and individual researchers whose emphasis is roadway infrastructure.

During this period, preliminary work was conducted to understand roadway-infrastructure-related use cases. Roadway infrastructure research areas were also considered in preparation for contacting researchers.

International Driver Behavior Comparison using a Shanghai NDS

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

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

- Test vehicles were instrumented in September 2012 by a VTTI technical expert.
- The first five subjects were on the road in December 2012 for official data collection.
- VTTI received the first month of data and successfully ingested the data into its NDS data center. The first 552 trips are in the system and are ready for research.

Data have been collected from 30 participants to date.

Investigating Drivers' Compensatory Behavior when using a Mobile Device

The purpose of this study was to investigate CMV driver performance and risk when using a cell phone through the use of previously collected naturalistic driving data. There were two primary objectives. Each objective and the resultant findings are summarized below.

The first goal was to investigate whether CMV drivers alter the way they drive when conversing on a cell phone. It was hypothesized that drivers may increase their safety margins when conversing on a cell phone by slowing down and increasing their headway to a lead vehicle, thus compensating for the increased workload.

An analysis addressing the first goal provided no indication that drivers increased their longitudinal safety margins when conversing on a cell phone. Their headways to a lead vehicle did not differ despite CMV drivers significantly increasing their speed by 4 km/h when conversing on a cell phone. However, CMV drivers changed lanes significantly less when conversing on a hand-held cell phone. These changes suggest that drivers slightly reduced the driving demands when conversing on a cell phone. Overall, the changes in driving performance observed were not substantial. Because drivers look forward more often when conversing on a cell phone, it is foreseeable that the increased visual attention to the forward roadway may be the ultimate reason why conversing on a cell phone has not been found to increase SCE risk.

The second goal was to investigate the relationship between drowsiness and the SCE risk associated with cell phone use. Research has shown that drivers become more alert when conversing on a cell phone (Jellentrup et al., 2011). It was thus hypothesized that CMV drivers were at a decreased risk of an SCE when conversing on a hands-free cell phone because the conversation served to stave off drowsiness.

The CMV naturalistic driving data set used in Olson et al. (2009) was analyzed to address the second goal. Drivers' driving time and time on duty were used to assess their fatigue levels, while the time of day and drivers' amounts of sleep obtained during the previous 24 hours (measured via actigraphy) were used to indirectly assess their drowsiness levels. Odds ratios computed the SCE risk for cell phone use subtasks across binned levels of fatigue and drowsiness. Generalized linear mixed models and Chi-square tests were used to assess changes in cell phone use frequency across bins. It was found that there was an increase in

photo by VTTI staff

SCE risk for visual-manual subtasks for all bins in which analyses were possible. Drivers had a higher proportion of cell phone use from 2:00 a.m. – 3:59 a.m. (circadian low period) than all other times of day that were analyzed.

The findings about CMV driver compensation when conversing on a cell phone were reported in a manuscript accepted for publication in the *Transportation Research Record Journal*. The findings about the relationship between drowsiness and the SCE risk associated with cell phone use were accepted for publication in the proceedings of the 3rd International Conference on Driver Distraction and Inattention. A report documenting the work performed for both objectives is being finalized.

Mask Algorithm Validation

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

A concurrent Mask project funded through SHRP 2 will validate the Mask algorithm against other independent, automatic head-tracking systems. The team is leveraging the efforts of these two projects for consistency among conditions tested and to maximize the utility of the results of both projects.

Initial validation work on the Mask algorithm indicated that this version of Mask does not work well enough for most researchers to be able to use the results. As a result of this outcome, the research team has reallocated the remaining funds to instead perform a comparison of three alternative manual eye-glance coding protocols, with a specific focus on the method used to code transitions between glance fixations.

Transitions between driver glance fixations typically range in duration from approximately 0.1 seconds to 0.5 seconds or longer, depending on the distance between fixations and the characteristics of the driver. International Organization for Standardization (ISO) standards for the measurement of driver visual behavior (i.e., eye-glance) state that transitions between fixations are to be coded either separately or joined with the destination fixation. (With this method, the transition between forward and right window would be coded as either "transition" or "right window.") To date, VTTI has performed manual eye-glance reduction such that these transitions are joined with the origin fixation; for example, the transition between forward and right window would be coded as "forward" until fixation on the right window is observed.

It has been argued that (1) the effect on subsequent analysis of these different methods is negligible, (2) the alternate ways to code transitions would result in a zero-net-difference effect, and (3) the cost and time savings that result from the use of the origin-fixation method make this the preferred method in most circumstances. Recently, however, data that have been collected are being made available to a larger audience of researchers and, in particular, researchers from outside VTTI who prefer the ISO method and, in fact, may require the ISO method to obtain results that are directly comparable to other data sets. This has already been a topic of discussion between VTTI and some external users of SHRP 2 data, and concern is likely to increase as more users and additional data sets are shared.

The current effort will test three different methods of manual eye-glance reduction in terms of time/cost to perform and inter-rater reliability. The three methods to be tested are "origin coding" (transitions combined with the origin fixation), "transition coding" (transitions coded as separate entities), and "destination coding" (transitions coded with the destination fixation). A set of video epochs from SHRP 2 data will be selected and randomly assigned to one of the three coding methods (e.g., 30 one-minute epochs for each method). The same group of six reductionists trained in eye-glance coding will complete each set of epochs, using the method assigned to that set. The analysis will then look at the total time to complete the epochs in each set, that time translated into cost, and the inter-rater reliability that resulted from each set of epochs.

The results of this analysis will be a report comparing the three methods and recommending which method(s) to use in the future.

MiniDAS

The MiniDAS facilitates epoch and continuous recording and contains many of the same features as the NextGen DAS, including:

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

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

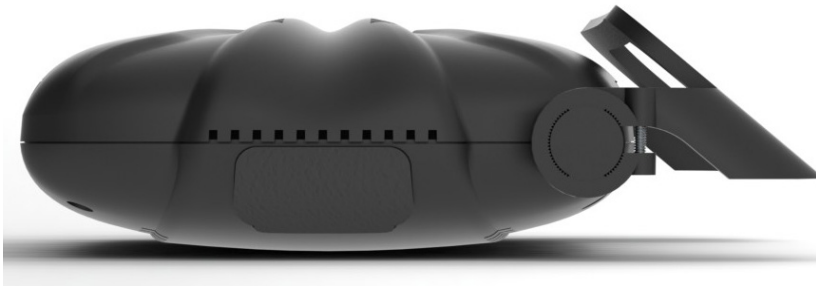


photo by VTTI staff

Due to the service center VTTI has implemented for use of these systems, this project was rerouted to be used in support of any NSTSCE projects funded in whole or in part which require the use of the MiniDAS. The service center fee of $40 per month includes the MiniDAS hardware, software, cables, maintenance/updates, and refurbishments/repairs. If a cellular data plan is required, this is a separate charge through the service center that varies, depending on the data plan needed, up to $48 per month. The SD cards, installation/deinstallation costs, shipping to project sites, and data storage or analysis are not included in the service center and are directly charged to the projects.

Naturalistic Observation of Motorcycle Riders

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

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

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

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

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

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

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

The final report (13-UT-019) was distributed to stakeholders and is available at: http://vtechworks.lib.vt.edu/handle/10919/23317.

photo by VTTI staff

Public Access to VTTI-Maintained Data Sets

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

The knowledge gained during this project was used to create a forum and a data distribution website for the SHRP 2 NDS (available at forums.shrp2nds.us). As of March 2014, 5,761 files have been downloaded from this site. During 2013, five refereed publications made use of and referenced data from the site.

This project is in an ongoing maintenance and support phase. Maintenance tasks include culling invalid user accounts, responding to user questions, and rectifying errors as they are discovered on the site or in data sets.

Quiet Vehicle Assessment

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

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

The final report underwent final revisions.

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

Active and Adaptive Roadway Delineation Systems

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

The research team has been waiting for the equipment to be shipped by the manufacturer. (The high-cost system is a loan from the manufacturer.) There were some unexpected problems during the testing process, but in a meeting with the manufacturer in January, the manufacturer assured the research team that the system will be delivered soon. The VTTI team has conducted meetings with the Virginia Department of Transportation (VDOT) to see how to enrich the experiment in a way that can directly serve some of the transportation issues in Virginia.

Color Camera

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

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

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

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

Final dynamic evaluations of the Color Camera system were conducted during this reporting period. Final comparisons were made among the Color Camera, ProMetric photometer recordings of color, and a CS-100 chroma meter on public roads. These comparisons will be discussed fully in the final report, which is currently being reviewed.

photo by VTTI staff

Roadway Lighting Design and Safety

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

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

Exploration of the Integration of the SHRP 2 Naturalistic Driving Data with the VTTI Lighting Database

This is part of the FHWA project Strategic Initiative for Evaluation of Reduced Lighting on Roadways. To evaluate all issues associated with the application of adaptive lighting to the roadway environment and to develop recommended practices for adaptive lighting systems, VTTI is conducting an intensive data collection and processing effort in eight states, including the City of Seattle, for six primary types of data that include: crash data, traffic data, lighting design/maintenance, and *in situ* data lighting data collection and roadway. As part of the SHRP 2 naturalistic database, VTTI is also collecting naturalistic driving data from the City of Seattle. The purpose of this project is to explore the possibility of incorporating the NDS data as an additional data set in the City of Seattle lighting database. One important consideration is that the lighting data collection will be performed at the same time that naturalistic data are collected. This project will involve: a) Exploring mechanisms to link the NDS as an additional data set to the database structure for the City of Seattle, b) Identifying what type of information from the NDS will be relevant for future safety studies, and c) Linking the naturalistic data with the VTTI lighting database.

This project will allow the creation of a data set not yet available so that the research community can answer future research questions.

Due to the extensive amount of data collected during the Adaptive Lighting Database Study, the research team has been redefining some of the collected parameters on the VTTI Lighting Database to directly link to the naturalistic database. The most promising corridors have been identified.

Glare Metric

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

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

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

The modeling effort has progressed well. There is significant interest in this effort as glare has been shown to be spectrally based. It is currently being investigated if spectrum can be part of the overall glare model.

Identifying the Impact of Roadway Improvements on Crashes through Naturalistic Data

The evaluation of the reduction of crashes as a result of roadway improvements can be problematic as before-and-after evaluations require either long periods of data collection or cohort sites for comparison, which can be statistically weak. The use of naturalistic driving data may provide a unique opportunity to evaluate roadway improvements. Investigating the overlap of NDS trips in areas where roadway improvements have been made can provide data for a safety analysis. The number of events or changes to driver behavior can be used as an indication of the impact of the improvements. This is a proof-of-concept project through which the VTTI team will: a) Identify potential overlap between improvements/situations and the naturalistic driving database, b) Evaluate the potential for a safety analysis based on the availability of events in the naturalistic database, and c) Conduct a sample safety analysis from a selection of the available data.

This project could provide a potential tool for the ongoing evaluation of the benefit of roadway improvements.

This project is just in its inception. The SHRP 2 data that will feed this project continue to be reduced by VTTI. The research team has begun contacting state DOT representatives to try to identify locations where a change of behavior can be identified. Specifically, the research team is looking at improvements, such as curve delineation in general, that have been made during the SHRP 2 data collection process.

Initial Investigation of Intersection Lighting

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

photo by Anne Wernikoff

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

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

A literature review of current lighting design methods for intersections is underway and nearing completion. Alternate lighting designs are being assessed for testing. This project will be linked with the results of the Rural Intersection Lighting Safety Analysis project. Please see the section below related to that project for specific updates.

Rural Intersection Lighting Safety Analysis

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

The report has been finished and is under internal review.

Light Sources in Fog

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

Members of the research team met to discuss the experimental design of this project, which also incorporates the project Performance of New Roadway Lighting in Rain and Wet Conditions (below). It was decided to use a full-factorial design in which each participant will see every combination of factors.

Participants will observe both pedestrians and targets in each weather and lighting condition. Pedestrians will be wearing red, blue, and gray clothing. The targets will also be colored red, blue, and gray. Red and blue were chosen due to the different spectral interactions of the light-emitting diode (LED) and high-pressure sodium (HPS) lights with these colors (blue tends to be more visible with LEDs, and red tends to be more visible with HPS). Gray was chosen as a neutral color. Catch trials (i.e., trials with no bicyclist present) and lighting and object order balancing will be used to reduce the learning effect in participants.

Performance of New Roadway Lighting in Rain and Wet Conditions

This project is being conducted jointly with the Light Sources in Fog project. Similar lighting and objects will be used as those of Light Sources in Fog, though in rainy conditions. These two projects will be run simultaneously by splitting the Smart Road's weather system into fog and rain sections, allowing participants to observe both.

Visual Behavior in Roundabouts

The focus of this project is to examine driver eye-glance behavior in roundabouts and how it pertains to pedestrian safety. Participants will drive a route through Blacksburg, Va., which will include 12 different maneuvers through two roundabouts. During the drive, participants will wear an eye-tracker device so

their glance behaviors may be recorded for analysis. Pedestrians will sometimes be stationed at points of interest at each roundabout so that typical glance patterns can be determined with and without a pedestrian present. The proposed research has the potential to provide information about driver eye-glance behavior in roundabouts, which can help determine where conflicts with pedestrians might occur and how those conflicts may be mitigated. This study also encompasses a phase of the Nighttime Bicycle Visibility study (below) that places cyclists on public roads to evaluate their visibility using various lighting and reflective methods.

Data collection will continue in January 2014, and no new roundabouts will be added to the protocol.

Nighttime Bicycle Visibility

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

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

A follow-up project was conducted and completed. This project included evaluations of varying visual aids placed on cyclists, joggers, or bicycles using different viewing angles. One viewing angle involved a parked participant vehicle facing a crossing lane through which a cyclist or jogger traveled. The other angle included

photo by Jim Stroup

a stationary cyclist or jogger on the right shoulder of the road as the test vehicle approached. Test vehicles featured differing headlamp styles. Data are currently being analyzed.

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

The experimental protocol has been finalized, and data collection is underway.

Roadside Evaluation of a Buried Cable Animal Detection System

Animal-vehicle collisions (AVCs) are a common occurrence and a significant safety and environmental problem on America's 3.9 million miles of roads. As of 2008, more than 300,000 AVCs occurred yearly in the U.S., resulting in many potentially preventable injuries, nearly 300 human fatalities, and property damage estimated at more than $2,000 per occurrence. AVCs now account for more than 5 percent of all reported motor vehicle collisions. As the rate of overall motor vehicle crashes has leveled off by comparison, the occurrence of AVCs has increased. Approximately 4 to 10 percent of AVCs involving large animals result in human injury. Costs for related property damage, medical care, crash management, and animal carcass management exceed $8 billion per year. This number does not include secondary costs related to traffic delays, emergency management, litigation, infrastructure damage, etc. These issues are further exacerbated in western states where fences are uncommon and open-range policies place liability for livestock-vehicle collisions on drivers.

Evaluation of an innovative roadside animal detection system in naturalistic and controlled conditions is proposed. The subject animal detection system, a buried cable system, detects the crossing of large animals and provides data about their locations along the length of the cable. The system will be installed and tested at a highly suitable site on the Smart Road where large wild animals are often observed. Researchers will use continuous, all-weather, and nighttime-capable video surveillance systems to monitor animal movement and gauge system detections and, potentially, non-detections. Recorded data will be analyzed to determine overall detection system performance and its suitability for implementation in problem areas on Virginia public roads. If indicated by the results, a second phase of evaluation of the system on a public road will be proposed.

A sole-source request was prepared and executed to purchase the specialized buried cable detection system from Senstar, Inc. The acquired system was installed, and initial testing was performed at the southern terminus of the Smart Road where large wild animals, such as deer and bear, are often observed. The system was integrated with the existing Smart Road power and data networks. The detection system comprises two 150-meter cable sets and a central control unit (processor) for data collection. Various infrared (IR) lighting units (illuminators) covering a wide range of distances (20 m to 110 m) and an IR surveillance camera were purchased and are being tested to assess their capabilities in different weather and natural light conditions, including nighttime monitoring. Daytime and nighttime video were recorded and reviewed as part of preliminary data acquisition methodology.

Visual Information Modeling

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

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

Focus Area 3: Safe Mobility for Vulnerable Road Users

Age-related Driver Difficulties at Intersections III

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

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

photo by VTTI staff

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

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

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

This project comprises the following activities:

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

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

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

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

During this reporting period, participant recruitment and data collection have continued for all three groups (two training and control); recruitment is complete for all three groups: Car Training, Computer Training, and the Control groups. The research team is also continuing to conduct regular data checks of all incoming DAS data to ensure integrity.

A total of 71 participants have been recruited, which is higher than the original supplemental total number planned (69) due to larger-than-expected attrition in the Car Training group.

Of the 21 targeted for each group, accounting for attrition, the research team currently has:

- 21 in the Control group (recruitment complete);
- 21 in the Car Training group (recruitment complete);
- 23 in the Computer Training group (recruitment ongoing).

A project extension has been obtained from Toyota's Collaborative Safety Research Center (CSRC) until the end of 2014, along with additional funding to support this.

Driver Coach: Bedford/Montgomery, Virginia Evaluation Project

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

This reporting period continued to focus on participant recruitment and installation of MiniDAS units. The goal was to have 45 instrumented vehicles on the road by mid-December of 2013. That number has been met and exceeded: 51 vehicles were instrumented by mid-December.

The research team is also continuing to work on revising the real-time feedback triggers that will be used during the last eight months of data collection for each participant. These triggers will be finalized during the next reporting period.

Additionally, the research team presented teen driving safety information during Parent/Teen Safe Driving meetings held at five high schools in Roanoke County and three high schools in Montgomery County. The attendance at each of the meetings was as follows:

photo by VTTI staff

Roanoke County Public Schools

- Glenvar: 24 attendees (10 students/14 parents)
- Hidden Valley: 61 attendees (27 students/34 parents)
- Cave Spring: 122 attendees (64 students/58 parents)
- Northside: 143 attendees (80 students/63 parents)
- William Byrd: 69 attendees (32 students/37 parents)

Montgomery County Public Schools

- Christiansburg High School: 120 attendees
- Blacksburg High School: 44 attendees
- Auburn High School: 110 attendees

As was previously reported, system testing was performed during the summer of 2012 using a NextGen DAS to determine driving performance trigger thresholds prior to data collection. A touchscreen was used in a test vehicle to present the trigger type and an auditory alert each time a driving performance threshold was exceeded. Work also began on the development of a feedback webpage during the summer of 2012. Pilot testing of both the auditory alerts and the feedback webpage were conducted during November 2012. Data collection for this study began during June 2013.

The Effects of Adverse Conditions on Senior Drivers' Vehicle Control

The unique set of challenges facing senior drivers may be exacerbated when driving at night or in adverse weather conditions. There exist little data to address the real-world risk encountered by seniors who choose to drive in these conditions. Previous closed-road work has suggested that drivers tend to slow down when driving at night but that this slowing is not sufficient to maintain recognition of low-contrast roadside obstacles, particularly for senior drivers, who were significantly less likely to recognize dark-clad pedestrians in dark conditions (Owens et al., 2007). In addition to the findings that drivers fail to slow sufficiently at night, several studies suggest that drivers may underestimate speed in foggy conditions and fail to slow sufficiently (e.g., Snowden et al., 1998). These findings, as part of a larger literature review about night and inclement weather driving, suggest that drivers may not adequately adapt their driving behavior for adverse conditions. However, most of the research studying this problem has been conducted on closed roads or in driving simulators, and little work has been done studying the interactions among the aging driving population and road conditions in a naturalistic setting. The purpose of this study is to use SHRP 2 data to identify epochs of driving under both baseline and adverse weather and lighting conditions on similar road types and to compare driver behavior among these. It is expected that this study will identify differences in vehicle control behavior across age groups and weather conditions; the identification of such differences may eventually lead to improved safety countermeasures.

Initial work was completed on IRB and data-sharing agreement paperwork. However, data reduction was delayed until more data are available.

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

A recent project sponsored by NSTSCE surveyed light-vehicle driver education program administrators/teachers in each state in the U.S. to assess the presence of curricula relevant to heavy-vehicle characteristics and procedures for sharing the road. Survey results showed that, while a large proportion (91 percent) of light-vehicle driver education programs include a component about how to safely share the road with heavy vehicles, there may be room for improvement regarding the content of these programs (82 percent perceived effectiveness). The purpose of this project was twofold. First, researchers wanted to investigate current light-vehicle driver education programs that contain components about sharing the road with heavy vehicles and develop a supplemental practices document that includes key sharing-the-road information teachers could cover with students and how the information may be taught. A public program (e.g., high school driver education program) and private programs that teach key sharing-the-road information were identified and were used to develop the supplemental practices document.

In addition, a case study was performed with a light-vehicle driver education program in a single state that only included a basic textbook-based component about sharing the road with heavy vehicles. Two components were introduced into different driver education classrooms and were evaluated through a comparison with the basic textbook-based component. The first component introduced was updated material (i.e., a DVD). The second component introduced was a hands-on truck experience program developed by NSTSCE researchers based on an investigation of how other organizations conduct hands-on truck demonstrations at high schools. Each classroom of students that received one of the components was invited to take part in a survey two months later, and knowledge retention of key learning points (e.g., heavy-vehicle "No Zones") was measured. Focus groups were also conducted with students to explore learning preferences related to driver education, understanding of key sharing-the-road information, and ratings of the various components.

During this reporting period, the research team conducted surveys, focus groups, and interviews; analyzed data; and worked on the final report and supplemental practices document.

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

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

The research team recruited the last participant during this reporting period, so data are now being collected about the final seven participants. Also during this reporting period, the first three participants completed data collection, and their vehicles were deinstalled. Data reduction will be performed in conjunction with data reduction for the SPDS, which will begin during the next reporting period.

Improving the Licensing Ceremony Curriculum

Virginia has a unique aspect to its driver's licensing process. To receive the actual driver's license, both a parent and the teenaged driver must appear before a family district court judge and participate in the Virginia Driver's Licensing Ceremony. This is a poignant moment during which safety information is disseminated to both parents and their novice drivers. These ceremonies are written and created primarily by district

court judges. While some judges have taken a great deal of time and compiled excellent information, others are unsure about the information that should be relayed. This project will use a systematic approach to developing a research-based curriculum that ensures teens and their parents receive relevant information during this critical time in teen safety.

During this reporting period, the research team continued to review the literature. This literature review will be finalized during the next reporting period, and work will commence on the creation of slides to best present research findings to parents and teenagers.

Older Driver Fitness to Drive Study

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

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

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

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

photo by VTTI staff

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

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

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

The final report is in the technical editing process and should be completed by the end of January 2014.

Senior Mobility Day

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

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

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

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

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

The final report (13-UM-023) is available at:
http://vtechworks.lib.vt.edu/handle/10919/24205.

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

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

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

Focus Area 4: Driver Impairment

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

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

Data from NDSs involving CMV drivers and light-vehicle drivers were re-analyzed. The NDS data sets were partitioned into low, moderate, and high task demand subsets using criteria from the workload literature. Odds ratios for cell phone use and its subtasks were then computed. During low task demands, only dialing was associated with an increased SCE risk for light-vehicle drivers. During moderate task demands, cell phone use (collapsed across subtasks) was associated with an increased SCE risk for CMV drivers. During this condition, texting and dialing were associated with an increased SCE risk, while talking/listening was not. Furthermore, talking/listening on a hands-free phone or CB radio was associated with a decreased SCE risk. During high task demands, cell phone use (collapsed across subtasks) was associated with a decreased SCE risk for both CMV and light-vehicle drivers. However, cell phone use during this condition primarily comprised talking/listening, which on its own was associated with a decreased SCE risk. Overall, the SCE risk related to talking/listening on a cell phone was not found to increase during the three driving task demand conditions examined. Furthermore, unlike light-vehicle drivers, CMV drivers' cell phone use was lowest during high task demands.

photo by VTTI staff

This suggests that CMV drivers may regulate their cell phone use differently than light-vehicle drivers as the driving task demands vary.

A journal manuscript that reports these findings is currently under review. A technical report has also undergone an internal review and is currently being finalized.

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

Given distributed operations in long-haul trucking, limited access to healthy food options, and sedentary lifestyles, it is not surprising that the prevalence of obesity among commercial drivers far outpaces that of the U.S. adult population. Approximately two-thirds of U.S. adults are overweight or obese, and nearly one-third of U.S. adults may be considered obese. Studies in the U.S. reported overweight and obesity rates in commercial drivers to be as high as 87 percent and 57 percent, respectively (Whitfield, 2007). Thus, there is a need for fleets to implement health and wellness (H&W) programs for their driver populations. This study examined and detailed the Schneider National, Inc. (SNI) H&W program for commercial drivers by conducting phone interviews with key executives from Atlas Ergonomics (Atlas, which manages the SNI H&W program), United Healthcare (UHC), and SNI. Questionnaires were administered to participating SNI drivers and staff at Atlas, UHC, and SNI to determine their opinions, perceptions, and satisfaction with the H&W program.

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

The final report (13-UI-021) has been distributed to stakeholders and is available at: http://vtechworks.lib.vt.edu/handle/10919/24207.

photo by VTTI staff

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

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

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

A final report (12-UI-017) that includes descriptions of the two carriers' OSA programs, findings from the focus group and interview research, and carrier recommendations is available at: http://vtechworks.lib.vt.edu/handle/10919/23320.

VTTI continues to work with the University of Minnesota (UM) and SNI to analyze the de-identified carrier health, safety, and cost data. VTTI maintains regular communication with UM and SNI about the data set, analyses approaches, and preliminary findings to ensure that these processes progress. The team is currently drafting the first manuscript for publication. Per earlier reports, completion of Task 4 has been delayed due to circumstances beyond our control (notably, the receipt, organization, and preliminary analyses of the de-identified carrier data from UM).

Common Data Elements between the Large Truck Crash Causation Study (LTCCS) Investigations and Commercially Available Onboard Monitoring Systems (OMS)

At the heart of traffic safety is the identification of factors that lead to crashes. Thus, interventions can be developed to mitigate or prevent these factors from occurring in future crashes. The epidemiological approach, which was employed in the LTCCS, uses post hoc reconstructions based on physical reconstruction and interviews with drivers and witnesses. Another approach, naturalistic driving, is a proactive approach which involves data collection while drivers carry out their "day-to-day" operations in vehicles instrumented with sensors and video cameras. Both approaches provide in-depth information, but have contrasting strengths and weaknesses; thus, a great opportunity exists for learning about crash causation by analyzing and comparing data from both approaches.

Currently, several commercially available onboard monitoring systems are in use in thousands of commercial motor vehicles. Thus, many more crashes will likely be available for analysis and comparison in these naturalistic data sets. The inherent, contrasting strengths and weaknesses of these two fundamental approaches provide an opportunity for synergistic comparisons to complement each other, which will lead to a more complete understanding of crash genesis and potential countermeasures. It would also address one of the primary limitations in the Bocanegra et al. (2010) study by comparing crashes in the LTCCS to crashes found in the data sets provided by vendors that distribute onboard monitoring systems (e.g., DriveCam, SmartDrive, etc.). However, before such comparisons can take place, a data directory of common variables, mutually exclusive variables, and new variables must be developed. This data directory will guide what research questions are possible. For example, the LTCCS has hundreds of variables regarding the driver, environment, and vehicle, but vendors of onboard safety monitoring technologies typically code only a few variables. However, as video and kinematic data from the crash is available, it's possible to go back and code variables using the same operational definitions found in the LTCCS.

This study is designed to create a data directory of common data elements in the LTCCS and crash data collected from commercially available onboard monitoring systems. It's likely a few of the LTCCS and naturalistic driving variables are defined similarly or identically. However, many occasions will arise when the naturalistic driving data requires additional data reduction in order to make this data set consistent with the LTCCS. The research team will work with the leading onboard monitoring system vendors to assess their current data reduction process (the research team has already established relationships with the top two vendors, DriveCam and SmartDrive). Comparison of these variables will be made with the LTCCS codebook. The video and kinematic data will be used to assess which LTCCS variables could potentially be coded using the naturalistic crash data, but currently is not part of the existing data reduction approach used by the vendors.

The research team completed drafts for the Introduction and Methods sections in the final report and began work on the Results section.

Crash Trifecta: A Complex Driving Scenario that Describes Crash Causation

The crash trifecta concept does not consider crash genesis as a simple unitary element but as a convergence of elements. Specifically, the crash trifecta is defined as three separate yet converging events:

1. Unsafe pre-incident behavior or maneuver (e.g., speeding, tailgating, unsafe turn).

2. Transient driver inattention (which may be related to driving [e.g., mirror use] or unrelated [e.g., reaching for an object]).

3. An unexpected traffic event such as unexpected stopping of the lead vehicle. Naturalistic driving studies and crash databases (compiled from police accident reports) emphasize the critical reason (CR) as a primary proximal cause in the crash/event. However, other factors have been identified as associated factors, and neither data collection approach has identified contributing factors in a systematic way. That is, no factor

photo by VTTI staff

other than the CR has been specified as directly contributing to crash/event genesis. In some ways, this appears to be a matter of convenience as it is easy to report and understand that speeding was the primary proximal cause during a truck crash. Yet, the CR variable comprises choices that could be ongoing pre-event behaviors (e.g., tailgating) and others that are more likely to be transient, precipitating errors (e.g., inattention). Not every element of the crash trifecta occurs during every crash/event, but two or more elements are often present. Naturalistic driving data allow researchers to directly observe crashes/events and to observe convergences of multiple elements such as the common pattern outlined above in the crash trifecta.

A pilot test of the crash trifecta concept was performed by Bocanegra et al. (2010) on 272 SCEs in two naturalistic truck databases. The crash trifecta concept seems intuitive, yet until recently it has been difficult to measure an unexpected traffic event. The video data collected from naturalistic driving studies allow data analysts an opportunity to make a subjective interpretation about whether the SCE involved an unexpected traffic event. Information about the other two crash trifecta elements (i.e., transient inattention and at-risk driving behavior) is readily available through video review. Though limited in sample size, the pilot study showed what appeared to be a trend in the percent of all crash trifecta elements being present as the severity level of the SCE increased (0.0 percent in unintentional lane deviations, 9.4 percent in crash-relevant conflicts, 20.0 percent in near-crashes, and 25.0 percent in crashes). Thus, the crash trifecta concept appears to imply that the probability of a crash given the three crash trifecta elements is greater than the probability of a crash given only one of the crash trifecta elements.

This study will apply the crash trifecta concept to the SCEs found in a number of existing naturalistic driving data sets from studies conducted by VTTI. Crashes, near-crashes, and crash-relevant conflicts will be identified in existing naturalistic driving data sets (e.g., 100-Car study, 8-Truck study, 34-Truck study, SHRP 2 NDS). Unsafe driving behaviors (e.g., following too closely, failed to signal) were recorded during previous data reductions. From this data, an indicator variable will be created to allow for easy detection of such behaviors. Previous data reductions have also already calculated the total time the driver's eyes were off the forward roadway. The pilot study by Bocanegra et al. (2010) used a threshold of more than one second for the determination of transient driver inattention (this was consistent with the threshold for a significant increase in the odds of involvement in an SCE documented during the three naturalistic driving studies). Thus, two of the three crash trifecta concepts have already been reduced during prior data reduction efforts. However, new data reduction will be required to determine if an unexpected traffic event was present during the crash/event. Using the same operational definition developed in Bocanega et al. (2010), data analysts will examine the 10 seconds prior to the trigger to obtain all the information needed to determine if an unexpected traffic event occurred. This could indicate movement by another vehicle/object/animal that was unexpected and/or an unexpected event due to a lack of attention.

The value of the crash trifecta concept and convergence concepts in crash causation is that it provides a structure for understanding the complexities of crash genesis. The results of the pilot study, though limited in sample size, suggest high-severity SCEs based on the convergence of multiple elements and low-severity SCEs based on a unitary element (such as CR). Thus, the crash trifecta concept may help explain the differences between the genesis of a crash and low-severity SCE. The research team completed all the analyses and is currently drafting the final report.

Bocanegra, J., Hickman, J.S., & Hanowski, R.J. (2010). Comparative Analysis of the Large Truck Causation Study and Naturalistic Driving Data (Contract #DTMC75-07-D-0006). Federal Motor Carrier Safety Administration.

Evaluating the Sleeper-berth Provision: Investigating Usage Characteristics and SCE Involvement

The purpose of this study is to further assess (on both shift and driver levels) if SCE occurrence varies as a function of sleeper berth provision (SBP) use. In the current hours-of-service (HOS) regulations, CMV drivers may restart a duty shift by splitting the required 10 consecutive off-duty hours into a period of at least eight (but less than 10) consecutive hours in the sleeper berth plus a period of at least two (but less than 10) consecutive hours in the sleeper berth, off duty, or a combination of both. Because the SBP comprises two

shorter breaks, the former may provide CMV drivers greater flexibility in obtaining rest when they need it. However, the rest periods may result in less adequate rest than that provided by a 10+ hour restart break.

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

The final report is being prepared for publication. The report summarizes past research and includes the data collection and development methods, statistical analyses, results, and discussion. Findings in the study include no significant difference in SCE rate for shifts following an SBP break compared with shifts following a 10+ hour or 34+ hour shift-restart break.

Prescription and Over-the-counter Drug Use and its Relationship to Involvement in SCEs

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

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

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

During this performance period, the research team continued to perform data analyses to assess if prescription and OTC drug use is related to drivers' involvement in SCEs. These analyses identify the base rate of prescription and OTC drug use in baselines. To assess the relationship between drug use and SCE involvement, odds ratios will be calculated to compare a "no drug" group (essentially a quasi-control) with a "drug group" to assess if certain drug classes and OTC medications affect involvement in an SCE. Moreover, a logistic regression may be performed to determine the correlations, primarily driver factors, that predict SCE involvement when using prescription and OTC drugs. The research team completed all the analyses and is currently drafting the final report.

Supporting CMV Driver Distraction Outreach Efforts

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

This project involved reviewing the distracted driving information available on the existing site and enhancing it with information from research published after the creation of the site. The end result is that the site will be updated with driver-distraction risk information that has come to the forefront since the site was first launched.

The research team finalized site text revisions, added a distraction tip sheet, and included additional video selections. Since another focus of this project was to simplify the text to reach a wider audience, the site text has a maximum Flesch-Kincaid grade-level score of 12, indicating that all site text is written at a level of complexity that does not require more than a high school education. The one-page tip sheet about avoiding distraction is written at a 7th grade Flesch-Kincaid grade-level score. In addition, the revised site text and tip sheet were translated into Spanish. The translated text will be in the Spanish reading-level equivalent of the English text.

The final report for this project is nearing completion.

Supporting CMV Driver Health Outreach Efforts

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

photo by VTTI staff

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

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

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

The final letter report was distributed. The letter report, which documents the Phase II effort, supplements the Phase I report and describes the ongoing efforts associated with the development of an integrated social-networking-based health effort. Specifically, Phase II focused on a website redesign, the development of additional driver-focused health information, and the creation of new outreach tools and materials. The project's final report (13-UI-022) was updated and finalized. The report is available at:
http://vtechworks.lib.vt.edu/handle/10919/24206.

Validation and Improvement of an Emotional Conversation Reduction Protocol

This study aims to validate reduction protocols for identifying emotional conversation. Current protocols based on the Facial Action Coding System have been applied to NDSs but need to be validated and improved for use during future studies. This study comprises a re-analysis of existing NDS data sets. Short clips of drivers displaying emotions during hand-held and hands-free cell phone conversations will be produced. Reductionists will apply the current protocols to the clips to evaluate the types of emotions displayed and the intensity of the emotions. Ratings will be compared across reductionists to evaluate the level of agreement between them. Disagreements during the reduction will be used to assess how the protocols can be improved.

Approval from the Virginia Tech IRB was obtained. A procedure for validating emotional reduction protocol was developed. It will use expert and novice reductionists at VTTI to evaluate the same set of data for emotional behavior. The results will be compared to determine if and where novice reductionists were less accurate than expert reductionists. This knowledge will be used to refine the emotion reduction protocol.

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