Fiscal Year 2013

Virginia Tech
Transportation Institute

Message from the Director

Twenty-five years ago, the Virginia Tech Transportation Institute (VTTI) began as the Center for Transportation Research with 15 employees poised to become a resource for intelligent vehicle/infrastructure research. Today, VTTI has grown to become the second largest U.S. university-level transportation institute with more than 350 employees.

We have built six buildings and have accumulated more than one-quarter of a billion dollars in sponsored program research expenditures. Since 1996, we have funded more than 1,000 students who work here gaining hands-on experience to become the next generation of researchers.

VTTI has pioneered groundbreaking naturalistic driving studies made possible by internally developed data acquisition systems that allow drivers to be observed as they go about their lives. The results of such studies have made a significant impact on transportation policy at the local, state, and national levels. VTTI researchers have provided congressional testimony about the dangers of distracted driving. We were invited to the White House summit on distracted driving, the result of which was a national call to end distracted driving that has thus far influenced 41 states and the District of Columbia to ban text messaging for all drivers. We are currently conducting the largest naturalistic studies to date for light vehicles, trucks, motorcoaches, and motorcycles. Our revolutionary studies are also being conducted on a global scale, with research efforts under way in China, Canada, and Australia.

While our research continues aided by the evolution of "big data" – the capacity to process thousands of hours of data streams – VTTI is once again ramping up its research endeavors. Using such resources as the Smart Road and an instrumented test bed opened in Northern Virginia, our researchers are leading studies that examine the potential benefits of the next wave of transportation innovation: connected and automated vehicles.

The impact of VTTI has been unprecedented on many levels, from effecting change in state and national laws to enhancing public awareness of important driving issues. Not only have we grown as a research community, we are growing our surrounding area. We have created more jobs in this county than any other private or public entity. The opening of the National Tire Research Center in Alton, Va., will answer the call for not only an advanced tire testing facility but the need to create jobs in the Southern Virginia region. Essentially, we have the capacity to not only increase safety on national roadways but to serve as an economic developer.

To become what we are today, VTTI has had to grow in size and complexity. However, we are still a family at our core; we are a community committed to conducting cutting-edge research to save lives, save time, save money, and protect the environment.

Tom Dingus
Director of VTTI

Dr. Thomas A. Dingus speaks at the opening of the Virginia Connected Test Bed • photo by Logan Wallace

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Mission and Impact

The Virginia Tech Transportation Institute (VTTI) conducts research to save lives, save time, save money, and protect the environment. Researchers and students from multiple fields are continuously developing the techniques and technologies to solve transportation challenges from vehicular, driver, infrastructure, and environmental perspectives.

As one of seven premier research institutes created by Virginia Tech to answer national challenges, VTTI has effected significant change in public policies for driver, passenger, and pedestrian safety and is advancing the design of vehicles and infrastructure to increase safety and reduce environmental impacts. The VTTI impact has been significant:

- VTTI studies have shown that looking away from the roadway just prior to the occurrence of an unexpected event is responsible for up to 90% of crash and near-crash events.
- The VTTI Driver Distraction in Commercial Vehicle Operations study found that texting while driving raises a heavy truck driver's crash and near-crash risk by 23 times. This statistic has been touted nationally, from the New York Times to the Ad Council to AT&T.
- The "23 times" message helped lead U.S. Transportation Secretary Ray LaHood and the U.S. Department of Transportation (US DOT) to issue a call to end distracted driving. Currently, 39 states and the District of Columbia have banned text messaging for all drivers.
- VTTI teen driving studies have shown that teens are four times more likely to get into a crash or near-crash while distracted than their adult counterparts. Teen fatalities are three times greater than adult fatalities, so this is an important discovery of the prominence of a major causal factor.
- VTTI light-vehicle naturalistic driving studies have shown that driver drowsiness is a significantly greater factor in crashes and near-crashes than was previously thought. Like heavy-truck drivers, light-vehicle drivers get into crashes and near-crashes between 15% and 20% of the time while at least moderately drowsy. Previous estimates were between 4% and 8%.
- The VTTI-developed data acquisition system provided the Federal Motor Carrier Safety Administration (FMCSA) the information required to evaluate its hours-of-service regulations (e.g., off-duty time, on-duty time, breaks, re-start provisions).
- The VTTI Teen Risk and Injury Prevention (TRIP) group is currently developing a teen driving program that provides monitoring and feedback via the VTTI data acquisition system.

These studies represent only a small fragment of the work performed at VTTI. An Onboard Monitoring System Field Operational Test is currently being conducted that will result in the largest truck and motorcoach naturalistic data set to date. VTTI researchers are completing the first large-scale, naturalistic motorcycle study funded by the Motorcycle Safety Foundation and were tapped by the National Highway Traffic Safety Administration (NHTSA) to conduct a complementary study with 160 motorcycles. In fact, the national success of VTTI has generated research efforts on a global scale. Currently, VTTI is leading naturalistic driving studies in China, Canada, and Australia.

Sponsors, Clients, Partners

During the past 25 years, VTTI has grown its research portfolio to encompass hundreds of sponsors, partners, and clients from both the public and private sectors. The continued success of the Institute is due in large part to its diverse collaborations with local, state, and national transportation agencies; fellow industry researchers; major automotive companies; and automotive suppliers. Since 1988, key VTTI partners have included:

- 3M
- AAA Foundation for Traffic Safety
- AAA Mid-Atlantic
- ACF
- American Association of Motor Vehicle Administrators
- American Association of State Highway and Transportation Officials
- American Transportation Research Institute
- Amoco
- Arlington County, VA
- Atlantic Construction Fabric
- Attention Technologies, Inc.
- Automotive Events
- Battelle
- Beam Brothers
- Bedford County, VA
- Bekaert
- Bishop Consulting
- BMW
- Booz Allen Hamilton
- Bosch
- California Department of Transportation (DOT)
- Calspan
- Cambridge Systematics
- Canadian Council of Motor Transport Administrators
- Carnegie Mellon Robotics Institute
- CARPI USA
- CEI Group
- Center for Innovative Technology
- Cisco Systems
- Clean Air Tech International
- Clear Roads
- Cohda Wireless
- Continental Automotive Systems, Inc.
- Corning Cable Systems
- Crack Sealant Consortium
- Crash Avoidance Metrics Partnership
- Delaware Department of Motor Vehicles
- Delaware Technical and Community College
- DENSO
- DLA Piper
- Donovan Hatem
- Dunlap and Associates, Inc.
- Dynamic Research, Inc.
- Enercon Services, Inc.
- Ergonomic Analysis, Inc.
- Fairfax County Transit
- Fairfax County, VA
- Federal Highway Administration
- Federal Motor Carrier Safety Administration
- Fluor, VA
- Ford Motor Company
- Foundation for Outdoor Advertising Research and Education
- General Motors
- General Motors OnStar Division
- George Mason University
- Georgia DOT
- Google
- Guard Rail of Roanoke, Inc.
- Howard/Stein-Hudson Associates, Inc.
- Hubbell Lighting, Inc.
- Human Factors North
- Hyundai Motor Company
- Institute for Critical Technology and Applied Science (ICTAS)
- IDEA Programs
- Institute for Transportation Research and Education at North Carolina State University
- Interactive Design and Development, Inc.
- Jacobs, Edwards, and Kelcey, Inc.
- Johns Hopkins University
- Kapsch TrafficCom
- Kimley-Horn and Associates
- Last Resource
- Lisboa, Inc.
- Litton Network Access Systems
- Lord Corporation
- Maccaferri
- MaineWay Services
- MCI Federal
- Mercedes-Benz
- Michelin
- Minnesota DOT
- Mississippi DOT
- ModComp
- Montana State University – Western Transportation Institute
- Monterey Technologies, Inc.
- Motor Coach Industries
- Motorcycle Safety Foundation
- National Academy of Sciences
- National Cooperative Highway Research Program
- National Highway Traffic Safety Administration
- National Institutes of Health
- National Parks
- National Private Truck Council
- National Science Foundation
- National Transit Institute
- National Transportation Research Center, Inc.
- NAVTEQ
- New River Valley Planning District Commission
- Nissan
- Norfolk Southern Railroad
- North American Fatigue Management Program
- North Carolina State University
- Oilcom
- Omni Weight Corporation
- Osram/Sylvania
- Outdoor Advertising Association of America
- PACCAR, Inc.
- Pacific-Sierra Research
- Parsons Brinckerhoff
- PB Farradyne, Inc.
- PB World
- Penn State University
- Pennsylvania DOT
- Performance Fuels System
- Philips Lighting
- Pitt Ohio
- Professional Truck Driving Institute
- PSMJ Resources, Inc.
- Qualcomm
- Realtime Technologies, Inc.
- REI Safety Services, Inc.
- Research and Special Programs Administration
- RGS Associates, Inc.
- ROHO, Inc.
- Rowan University
- Rutgers University
- SAE International
- Savari
- Schneider National, Inc.
- Science Museum of Western Virginia
- Scientex
- Shenandoah Telephone
- Shentel Service Company
- Siecor/Corning
- Siemens
- Snow Economics
- Software Technology, Inc.
- South Carolina DOT
- Southwest Research Institute
- Systems Technology, Inc.
- Texas DOT
- Texas A&M Transportation Institute
- TNO Defense, Security and Safety
- Tom Tom
- TORC Robotics
- Toyota
- Transanalytics
- Transecurity
- Transportation Research Board
- Travelers Insurance
- United Defense, L.P.
- University of Calgary
- University of Central Florida
- University of Iowa
- University of Maryland
- University of Massachusetts/Amherst
- University of Michigan Transportation Research Institute
- University of Minnesota
- University of North Carolina-Chapel Hill
- University of New South Wales
- University of Pennsylvania
- University of South Dakota
- U.S. Air Force
- U.S. Department of Agriculture ChooseMyPlate.gov Program
- Vehicle Safety Communications 3
- Veridian
- Virginia Center for Transportation Innovation and Research/Virginia DOT Operations and Security Division
- Virginia Department of Conservation and Recreation
- Virginia Department of Environmental Quality
- Virginia Department of Motor Vehicles
- Virginia Department of Rail and Public Transportation
- Virginia DOT
- Virginia Rail Policy Institute
- Virginia Tech Parking Auxiliary
- Virginia Tourism Commission
- Visteon Corporation
- Volvo
- Volvo Trucks North America
- Weigh-In-Motion
- Westat
- Western Research Institute
- Windwalker Corporation
- Wisconsin DOT

Facilities and Equipment

Overview

The traditional laboratories at VTTI are housed in two buildings totaling more than 52,000 square feet. Building I is 30,000 square feet and houses office, laboratory, and garage facilities. Low-service laboratories include facilities dedicated to driver interface development, eye-glance data reduction, lighting research, accident analysis, accident database analysis, pavement research, and traffic simulation. The National Surface Transportation Safety Center for Excellence (NSTSCE) building comprises 22,000 square feet of office and laboratory space and was occupied in July 2006. VTTI expanded its on-site capacity by 7,000 square feet of warehouse space and housing for a shock tube lab, a paint booth facility, and a lighting lab. An additional 24,400 square-foot annex was opened during August 2013. This addition eliminated most of the flex space rented in Research Building 7 and the Moss Building at the Virginia Tech Corporate Research Center.

To supplement and support the focused transportation research of the Institute, facilities feature a fully staffed garage and machine shop to instrument experimental vehicles. Technicians and engineers use full-scale machine and welding shops, electronics laboratories, and garage facilities to customize transportation hardware and software designed to collect large amounts of data. These facilities are also used to support the maintenance and expansion of the Virginia Smart Road systems and capabilities. Additionally, VTTI occupies an adjacent four-bay, 7,200-square-foot garage. This facility is used to store the VTTI instrumented vehicle fleet and the equipment necessary for research and Smart Road operations.

Vehicle Fleet

The VTTI vehicle fleet is uniquely instrumented for specific experiments. The Fleet Inventory outlines the year, make and model, date of acquisition, and color of each vehicle or trailer. Researchers use the vehicle fleet for Smart Road tests; experimental test vehicles are used to develop new instrumentation packages. Several of the vehicles are long-term loaners from vehicle manufacturers, the Virginia Department of Transportation (VDOT), and other partnering organizations.

All vehicles are maintained in-house when possible with fully functional garages and a machine shop. Loaned vehicles are maintained in cooperation with the organization that provided the vehicle.

Fleet Inventory

VTTI-owned Vehicles (by Year/Make and Model/Date of Acquisition/Color)

1990/Hyster Forklift/July 2004
1991/Ford F800 Truck/June 2012/Beige
1993/Fruehauf Trailer/White
1995/Peterbilt Tractor-trailer/Sept. 1998/White/Blue
1995/GMC Sierra/March 2011/Orange
1997/Volvo Tractor-trailer/Nov. 1996/Blue
1997/Ford Taurus/Dec. 1996/White
1997/Wabash Trailer/June 2007/Orange
1998/GMC Sierra/March 2011/Orange
1999/Chevrolet Van (15-Passenger)/Dec. 1998/White
1999/Ford Explorer XLT/March 1999/White
1999/Ford Crown Victoria/April 1999/White
1999/Ford Contour/April 1999/White
1999/Dodge Ram Pickup/Nov. 2006/Green
2000/Ford Explorer XLS/Jan. 2000/White
2000/Chevrolet K 2500/June 2000/White
2000/Mitsubushi Mighty Mitz/Dec. 2006/Silver
2001/Saab 504-ASR/Nov. 2003/Midnight Blue
2002/Ford News Van/Feb. 2002/White
2002/Chevrolet Silverado 2500/May 2002/White
2002/Cadillac Escalade/Aug. 2002/Pewter/Gold
2002/Cadillac Seville/Aug. 2003/Red
2003/Chevrolet Malibu/Jan. 2008/White
2003/Chevrolet Malibu/Sept. 2008/White
2006/Cadillac STS/Oct. 2006/White
2006/Cadillac STS/Oct. 2006/White
2006/Mercedes-Benz R350/Dec. 2010/Silver
2006/Cascadia Semi-truck/June 2011/White
2006/Chevrolet Malibu/July 2012/Red
2006/Chevrolet Malibu/July 2012/Green
2007/Utility Trailer/June 2007/White
2008/Ram Lin Trailer-Wind Machine/Oct. 2007/ Maroon/Orange
2008/Chevrolet Tahoe/May 2008/Gray
2008/Chevrolet Tahoe/May 2008/Granite
2008/Chevrolet Tahoe/May 2008/Gold
2008/Chevrolet Tahoe/May 2008/Red
2008/Chevrolet Tahoe/May 2008/Blue
2008/Chevrolet Tahoe/May 2008/White
2008/Kawasaki Versys LE650-A/Jan. 2009/Red
2009/Yamaha V Star XVS950A/April 2011/Black
2010/Buick LaCrosse/Feb. 2010/Maroon
2012/Toyota Camry/Nov. 2011/Gray
2012/Honda Goldwing/June 2013/White
2013/Trailer Arising Industries/April 2013/White
2013/Cadillac SRX - Sport Utility/May 2013/Raven
2013/Yamaha 1670 CC Motorcycle/April 2013/Royal Blue

Motor Pool Vehicles (by Year/Make and Model/Date of Acquisition/Color)

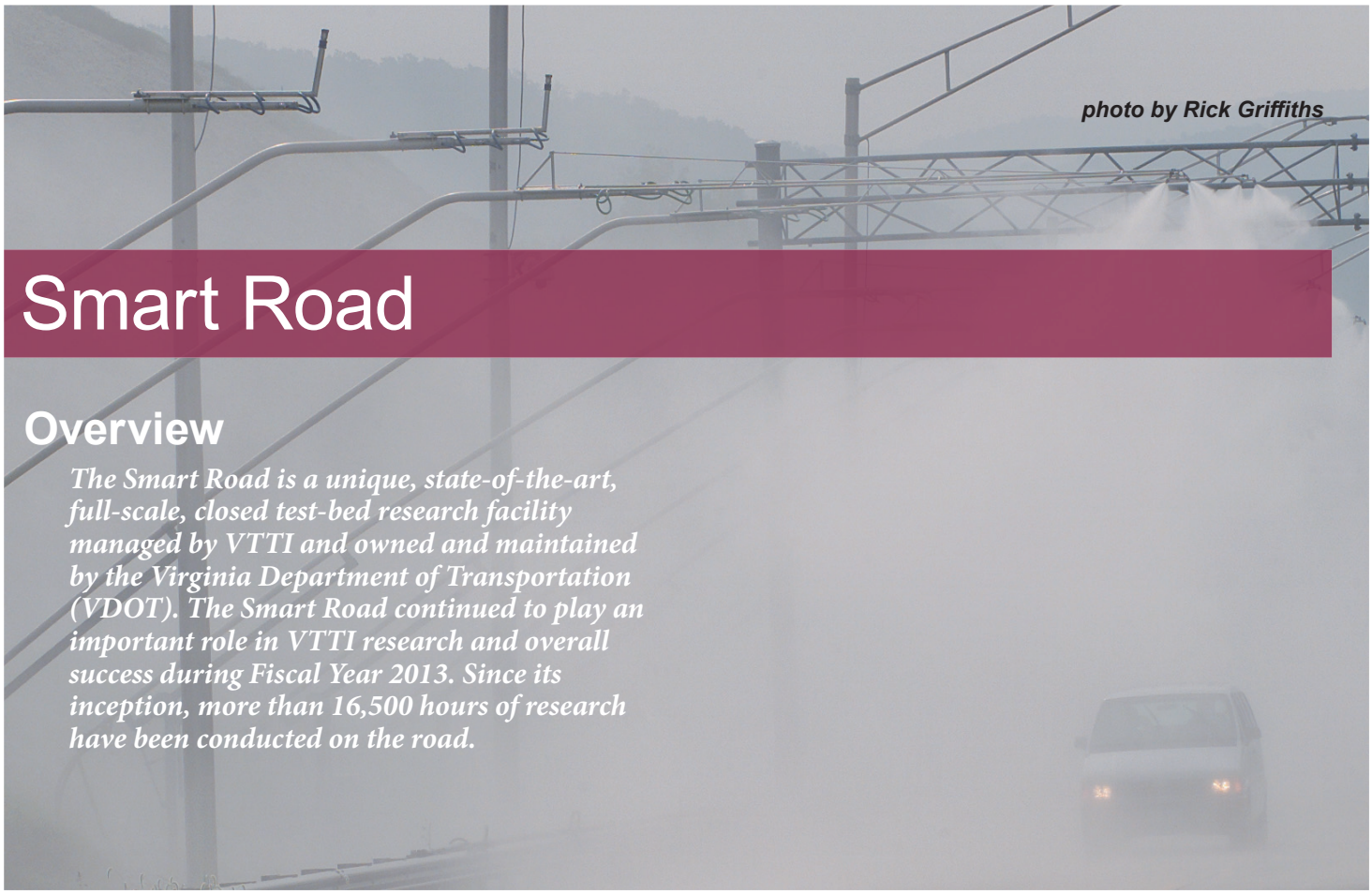
2009/Ford Fusion/May 2010/Silver
2013/Dodge Mini-van/Aug. 2013/White

Loaned Vehicles (by Year/Make and Model/Date of Acquisition/Color)

2009/Ford F450/March 2010/White
2009/Yamaha V Star 650/Black

Leased Vehicles (by Year/Make and Model/Date of Acquisition/Color)

2003/MCI Bus/Oct. 2010/White
2005/Infiniti FX35/Sept. 2010/Gold
2006/Infiniti M35/Dec. 2005/Silver
2006/Infiniti M35 (in Florida)/Dec. 2005/Silver
2009/Honda Rebel CMX250C/Dec. 2010/Blue
2009/Harley-Davidson Sportster XL 1200C/May 2011/Silver
2011/Volvo VN 6x4 Tractor with Sleeper/April 2013/Yellow
2012/Kawasaki ZX600-R/Nov. 2012/Green
2012/Infiniti M56/Feb. 2013/Black
2013/Caddy XTS



Smart Road

Overview

The Smart Road is a unique, state-of-the-art, full-scale, closed test-bed research facility managed by VTTI and owned and maintained by the Virginia Department of Transportation (VDOT). The Smart Road continued to play an important role in VTTI research and overall success during Fiscal Year 2013. Since its inception, more than 16,500 hours of research have been conducted on the road.

Features and Operations

- A 2.2-mile, controlled-access test track built to interstate standards;
- Two paved lanes:
- Three bridges, including the Smart Road Bridge (the tallest bridge in Virginia);
- Full-time staff that coordinate all road activities;
- 24/7 access control and oversight;
- Centralized communications;
- Lighting and weather system controls;
- Safety assurance and surveillance;
- Fourteen pavement sections, including an open-grade friction course;
- In-pavement sensors (e.g., moisture, temperature, strain, vibration, weigh-in-motion);
- Zero-crown pavement section designed for flooded pavement testing;
- An American Association of State Highway and Transportation Officials (AASHTO)-designated surface friction testing facility;
- Seventy-five weather-making towers accessible on crowned and zero-crown pavement sections;
- Artificial snow production of up to four inches per hour (based on suitable weather conditions);
- Production of differing intensities of rain with varying droplet sizes;
- Fog production;
- Two weather stations with official National Oceanic and Atmospheric Administration (NOAA) weather available within one mile;
- Variable pole spacing designed to replicate 95 percent of national highway systems;
- Multiple luminaire heads, including light-emitting diode (LED) modules;
- A wireless mesh network variable control (i.e., luminaire dimming);
- A high-bandwidth fiber network;
- A differential global positioning system (GPS) base station;
- Complete signal phase and timing (SPaT) using remote controls; and
- Wide shoulders for safe maneuvering during experimental testing.

Control Room/Laboratories

VTTI houses the Smart Road Control Room through which on-road research is scheduled and

overseen. The Control Room also acts as the 511 Virginia Data Quality Assurance/Quality Control (QA/QC) Center. Dispatchers located in the Control Room have the ability to manipulate lighting and all-weather testing systems on the road and can control access to the facility itself.

VTTI has several laboratories to aid in research objectives. These labs include driver-interface development, eye-glance data reduction, lighting research, accident analysis, accident database analysis, pavement research, and traffic simulation.

Enhancements/Additions

Connected-vehicle equipment was installed at seven locations along the Smart Road. Roadside dedicated short-range communication transceivers, or roadside equipment (RSE), were installed on existing or newly installed light poles at an approximate spacing of 2,000 feet. Accompanying communication equipment and power supplies were installed in stainless steel equipment cabinets affixed to the respective light poles. Two additional mobile RSE sites were added in the form of solar-powered equipment trailers with elevated masts.

The existing optical fiber communication system was expanded and upgraded. Optical fiber was extended through the Wilson Creek Bridge to provide connectivity at the southern turn-around. Additional fiber patch panels were installed to facilitate a connection between RSEs and the intersection controller. Ethernet fiber transceivers and Ethernet switches were installed to allow communication between RSEs and networking equipment in the Smart Road Control Room.

A new equipment rack and processing, power, and networking equipment were installed in the Smart Road Control Room. Three rack-mount computers were installed to provide for RSE and switch management, connected-vehicle program processing, and Ethernet packet capture. Networking equipment installed includes a high-speed Ethernet optical-copper switch and a high-speed Ethernet switch (copper only). Uninterruptible power supplies (UPSs) were installed to support the processing and networking hardware.

A high-resolution dome camera was installed for observation of the static test area portion of the Smart Road. This camera features weather-tight construction and zoom/pan capabilities and communicates via Internet Protocol (IP). This camera is currently under evaluation as a potential replacement for current cameras installed at the facility.

The existing ultra-high frequency (UHF) radio system repeater was relocated to the sign bridge area to provide improved two-way radio communication coverage.

The intersection controller and cabinet were replaced with a model compatible with anticipated connected-vehicle operations.

Smart Road Control Room desktop computers used for scheduling and billing operations were replaced with laptop computers. This and other provisions allow for quick relocation of staff and continued services in the event of a power outage or other outage. The control room was also equipped with a WiFi cellular access point to allow continued operations during network outages.

A wireless control system was installed on the main Smart Road entry gate. This system replaces a wired one that was susceptible to damage from lightning strikes and water.

The sign bridge was modified to allow quick changeover of signs for experimental testing purposes.

The replacement of weather-making system hydrants continued along with installation of a wireless mesh network for hydrant control.

VDOT 511 Virginia

VTTI serves as the primary QA/QC agency for the VDOT 511 Virginia project. The 511 system is designed for travelers and delivers information about events that may affect traffic (e.g., crashes, congestion, road work, inclement weather).

QA/QC services provided by VTTI include, but are not limited to:

- Reviewing entries within the VDOT VaTraffic incident management system.
- Monitoring the various 511 public services to ensure that VaTraffic information is delivered to the public in an accurate and timely manner. These 511 public services include:
  - The 511 public website that provides coverage for most roads in Virginia (www.511virginia.org);
  - The 511 interactive voice response phone system (dial 511), which includes information for approximately 400 Virginia roads (all interstate roads and most primary roads);
  - The VA511 Alert emails, available free to the public via subscription; and
  - Dynamic message boards at nine welcome centers across Virginia.

The VTTI 511 QA/QC team functions within the Smart Road Operations Group and includes three full-time staff members and as many as 15 part-time employees. The 511 and VaTraffic systems are monitored 24/7, 365 days per year from the Smart Road Control Room.

Special Initiatives

International Center for Naturalistic Driving Data Analysis at Virginia Tech (formerly Smart Data Center)

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

The 48-node compute cluster of the Institute moves data between the field and the data center, decrypts data, prepares data files for ingestion to the Scientific Data Warehouse, processes video files, and provides a platform for advanced analytical processing. The Scientific Data Warehouse expanded from approximately 100 terabytes (TB) to more than 500 TB as a result of the growth of the VTTI research data repository. 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.

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.

Training and Education for VTTI Employees

The human resources staff at VTTI, in cooperation with administrative staff and research associates from several centers at the Institute, provided a variety of training and educational opportunities for faculty and staff throughout the fiscal year, including the following: All employees at VTTI (students, staff, faulty, and wage employees) participated in a Harassment Prevention and Complaint Handling Course.

U.S. Secretary of Transportation Ray LaHood visits VTTI • photo by Logan Wallace

Tours and Open Houses

VTTI staff, in partnership with other employees from the Virginia Department of Transportation (VDOT), annually host one public open house, one school day event, and multiple tours.

Open House

The open house was held during April 2013, and approximately 350 people attended. Attendees saw a presentation about naturalistic driving studies, toured the Smart Road Control Room, viewed instrumented vehicles, and took a ride on the Smart Road through a simulated rain shower created by specialized weather towers on the road.

School Day Event

The VTTI School Day event was held during April 2013. Students in attendance included first graders to college students and public, private, and home-schooled groups from various regions of the Commonwealth. Attendance numbered approximately 400. All students were given a presentation about the construction and capabilities of the Smart Road, toured the Smart Road Control Room, viewed instrumented vehicles, and took a ride on the Smart Road through a simulated rain shower created by specialized weather towers on the road.

Community Tours

Currently, weekly tours for the public have been closed due to increased use of the Smart Road for research. However, to continue enhancing general public education and awareness about the Smart Road and the types of research conducted at VTTI, community tours are given to large groups. Research hours on the Smart Road take precedence, but every effort is made to have as many groups as possible tour the Smart Road and the facilities at VTTI.

Media Coverage

103.5 FM WTOP
*ABC
*Arkansas State University Herald
*CBC (Canadian)
*CBS
*Daily Herald
*Digital Journal
*Fairfax Times
*Herald Online
*Inside Science (American Institute of Physics)
*Insurance Journal
*LATimes
*LED Magazine
*Market Wire
*Medical Express
*NBC 29
*Phys.org
*Pilot online
*Roanoke Times
*Science Daily
*The Huffington Post
*The Ledger.com
*The Legal Examiner
*The Wall Street Journal
*The Washington Post
*VT NEWS
*WDBJ7
*WSET
*WSLS 10
Akron.com
Albuquerque Express
Alton Telegraph
AOL Autos
Area Development
Arkansas.gov
AT&T; anti-texting campaign
Auto Insurers of Virginia
Automotive Fleet
Automotive World
Autonet.ca
BBC Autos
Boston.com
Business Wire
Capitol Confidential & Democrat and Chronicle (article appeared on both sites)
CarInsurance.org
Cars.com
CCJ (Commercial Carrier Journal) & Etrucker
Cell Control
Center for Automotive Research
Chicago Tribune
Chron.com
Citizensvoice.com
City of NAPA
CNN
CNN Tech
CNN Travel
Collegiate Times
Columbus Ledger-Enquirer
Connected Vehicle/Infrastructure University Transportation Center
Consumer Reports
Contra Costa Times
Courant.com
Courant.com
Ctpost.com & newstimes.com (article appeared on both sites)
Daily Herald & FindLaw (article appears on both sites)
Daily Press
Deseret News
DesignNews
Detriot Free Press
Digtriad.com
Discovery News
E News/World News Report
Edgar Snyder & Associates
Electric Light and Power
electronista
Energy Sciences Network
Environmental Leader
Equities.com
Fairview Republican
FindLaw
FleetOwner.com
Foley Carrier Services
Fox 23
Fox Business
Frederick News
Fredericksburg.com
Gainesville.com
Gering Citizen
Green Bang
Guidelnews.com
HispanicBusiness.com
Iafrica.com
Inside Bay Area
Insurance News Report
Insurance Quotes
IslandPacket.com
ITS International
Joliet Path
Journal of American Medical Association
KATC.com
Kentucky.com
KLEWTV.com
Know it
Knoxville News
KTVX -Good Morning Utah
Kurzweil Accelerating Intelligence
Kypost
LandLinemag.com
Las Vegas Review-Journal
Ledinside.com
Leesburg Today
Live Insurance News
Lynchburg News & Advance
Makeup.com
Market Watch
Market Wire
Men's Health
Midlands.com
Motorcycle USA
Motorcycledaily.com & Motor Sports Newswire
Motorsports Newswire
MPR news
MSN News
NASDAQ
Natural News
Networking Exchange Blog
New Jersey 101.5
New York Times
News Talk 650
Newsday Tuesday
Newsmedical
Newswise
Niagara Gazette
Nightline
One News Page
Online Media Daily
OpenPR
Oregonlive.com
Ozarksfirst.com
Parade
PC Mag
Petaluma360.com
PHYS.org
PHYS.org & The Roanoke Times
Politic 365
Positive Parenting Solutions
PostGazette.com
PR Web
PubMed.gov
Purple Press
Red Orbit
Redwood Times
Rubber News
SAE International
salineriverchronicle.com
SB wire
Science Codex
SDPB (South Dakota Public Broadcasting)
Sonoran News
Space Mart
StarTribune
StuttgartDailyLeader.com
Surf Coast Times
Tampa Bay online
TCPalm
Technology PR News
Technology Tell
Telegram.com
The Age National
The Apex Herald
The Berkely Daily Planet
The Burgs
The Daily Star
The Des Moines Register
The Free Lance Star
The Gazette
The Gazette Virginian
The Hawk Eye
The Journal
The Modesto Bee
The Nation's Health
The Record Herald
The Roanoke Star
The Roanoke Times
The Salt Lake Tribune
The University of Auckland Library
The Wall Street Journal
The Washington Post
The Weather Channel
TheTrucker.com
Tire Review
Transportation Nation
Tribune Democrat
Truck Parts & Service
Truckinginfo.com
Tyre Express
UPI.com
USA Today
USA Today
Vimeo
Virginia Tech News
VT News
Warwock beacon
West Chester Buzz
Wisconsin State Journal
WQAD8
WUSA 9
WVTF
WWL
Yes Virginia Blog
Your GV.com
YouTube

**Multiple mentions*

VTTI centers and initiatives have evolved through the years to address the transportation demands of today and the research needs of tomorrow. Such evolution and change is necessary to ensure that VTTI remains a leader in providing cutting-edge transportation technology and creating solutions to the greatest challenges that face the motoring public.

To that end, VTTI created several new centers and initiatives during 2013, while retiring others. The individual missions and projects of each center and initiative are described herein. The new VTTI organizational structure may be found in the Personnel section of this report.

Center for Advanced Automotive Research

The Center for Advanced Automotive Research (CAAR) focuses on the research, development, and evaluation of next-generation automotive systems. CAAR is staffed by a multidisciplinary team of dedicated individuals who are passionate about improving the safety and efficiency of our nation's transportation system. This team strives to solve a broad set of challenges associated with integrating cutting-edge technologies into the vehicles of tomorrow. The primary research areas of CAAR include crash warning/avoidance/mitigation, connected vehicles, driver-vehicle interfaces, crash causation, and vehicle automation. The center comprises two research groups: the Advanced Product Test and Evaluation (APTE) group and the Connected Vehicle Systems (CVS) group. These groups work cooperatively with their industry and governmental partners to solve complex transportation problems through technology advancement.

New Project

Technical Support and Tasks for the Saxton Transportation Operations Laboratory

As part of the connected-vehicle systems research effort, the Federal Highway Administration (FHWA) Turner-Fairbank Highway Research Center (TFHRC) has built the state-of-the-art Saxton Transportation Operations Laboratory (STOL) to perform research of vehicle-to-vehicle and vehicle-to-infrastructure technologies. FHWA has contracted with a team of research organizations, led by Science Applications International Corporation (SAIC), to perform research related to both conventional transportation operations issues and intelligent transportation systems. The team will also provide support for laboratory and field experiments conducted by FHWA and its program offices and will design, develop, and integrate systems in which vehicles, users, and the infrastructure interact with each other seamlessly to support enhanced mobility, safety, environmental sustainability, productivity and economic competitiveness, and overall customer satisfaction and livability.

STOL currently incorporates an intelligent intersection with dedicated short-range communication (DSRC) transceivers that allow communication with vehicles, representative roadway sensors to record vehicle passages, high-speed cameras to record results, and vehicles with core connected-vehicle communication technologies to enable cooperative vehicle-vehicle and vehicle-highway testing. STOL uses two test vehicles that were developed during previous efforts. This project will provide for expansion of the test fleet to include three additional vehicles with the basic core connected-vehicle equipment. These will contain the specialized equipment needed to allow partial vehicle control functions to be tested.

During this project, VTTI will lead the efforts to apply world-leading vehicle instrumentation systems and techniques to the vehicles delivered under this contract, which will be used to enable advanced mobility and safety services to be explored at STOL. These services will allow drivers to share control with a semi-automated system that includes pervasive vehicle-to-vehicle and vehicle-to-infrastructure communications. The concept presumes that the vehicle is guided through a specialized section of roadway, such as a "managed lane" section of an urban freeway, using data provided from the infrastructure (e.g., suggested speed, following distance, and acceleration rates). The vehicles for this effort will be designed from the ground up to support ongoing research efforts with evolving and unique requirements.

Ongoing Projects

Drowsy Driver Detection and Alerting System Development Support

In 2010 Transecurity, LLC, completed the first phase of a Small Business Innovative Research (SBIR) contract with the Federal Motor Carrier Safety Administration (FMCSA) for the development of a prototype drowsy driver detection and alerting system. During Phase II of this project, VTTI will provide ongoing research and support to Transecurity in the advancement and commercialization of this technology.

This project will include the development, installation, evaluation, and expansion of i) on-road testing of Mask head- and eye-tracking software and ii) a drowsiness detection algorithm on the Transecurity DriveVision Pro hardware platform. Mask is a machine-vision application for sensing attributes of a driver's face relative to the vehicle.

VTTI will support the continuous development of Mask software; the continuous development of a drowsiness detection algorithm; develop-

ment of data reduction protocols for drowsiness events observed during field operational tests (FOTs); evaluation and optimization of drowsiness detection performance, including hit, miss, and false alarm rates; and integration of all functionality into the DriveVision Pro and DriveMetrix Pro systems to support commercial operations.

Light-Vehicle Builds and Model Deployment Support for the Safety Pilot Program

Vehicle connectivity may have the ability to enable a safer and more efficient surface transportation system. The United States Department of Transportation (USDOT) Connected Vehicle Safety Pilot Program was created to demonstrate the safety capabilities of connected vehicles in a real-world environment and provide technical data in support of the National Highway Traffic Safety Administration's (NHTSA) 2013 decision on Connected Vehicle technology on light vehicles for vehicle safety.

The two critical test efforts which make up the program are the Safety Pilot Driver Clinics and the Safety Pilot Model Deployment. The Driver Clinics project, in which VTTI contributed, evaluated driver acceptance within controlled test environments and operational scenarios, and completed testing in early 2012. From August 2012 to August 2013, the Model Deployment will include approximately 3,000 cars, trucks, and transit vehicles operating on an open roadway to assess fully integrated V2V (Vehicle-to-Vehicle) systems, aftermarket devices, and roadside infrastructure (V2I or Vehicle-to-Infrastructure).

The Crash Avoidance Metrics Partnership (CAMP) Vehicle Safety Communications 3 (VSC3) Consortium of eight vehicle manufac-

turers, is leading the efforts to build and evaluate 72 light vehicles equipped with fully integrated V2V systems. VTTI has been selected to provide support to the CAMP VSC3 in Pre-Model Deployment Testing, Model Deployment data collection, processing, storage and analysis, and Post-Model Deployment Evaluation.

During the first stage of this project, VTTI will design, develop, and instrument 72 vehicles with customized Data Acquisition Systems including camera and sensor packages, as well as concealing fixtures, necessary for data collection; 64 of these vehicles will be evaluated in the Safety Pilot Model Deployment. VTTI will then assist in the development and performance of objective and application-level testing of the instrumented vehicles, as well as readiness validation testing prior to releasing the vehicles to the Model Deployment Test Conductor for integration into the Model Deployment fleet. VTTI will develop driver training materials and train integrated vehicle drivers, in addition to assisting with interoperability testing, performance testing, and the development and validation of a method that estimates positioning accuracy.

VTTI will monitor and maintain the condition of every integrated light vehicle during the second stage of this project, the Model Deployment, using a cellular link and automated health check systems, collect, store, process, and transfer vehicle data from the fleet, and coordinate with the CAMP VSC3 Consortium to analyze and report Model Deployment data as well as support to the Volpe National Transportation Systems Center, the Independent Evaluator for the Model Deployment.

The Safety Pilot Model Deployment is a full-scale test of safety related connected vehicle systems and will provide valuable information to understand their potential for improving the transportation system.

Human Factors for Connected Vehicles Integration Research and Design Guidelines Development

The Human Factors for Connected Vehicles (HFCV) program is a USDOT research effort focused on the unique human factors associated with connected vehicles. The program seeks to provide behavioral- and technology-based research for ensuring that connected vehicle (CV) applications improve safety rather than increase driver workload and distraction.

VTTI has been selected by NHTSA to lead efforts to (1) develop an architecture for integrating multiple safety and non-safety CV applications, and associated driver-vehicle interfaces (DVIs), into a cooperative system, (2) test protocols for such integrated systems, and (3) develop the voluntary Human Factors Design Guidelines product for the HFCV Program.

VTTI is working with a number of leading experts within the transportation research field to assess previous connected vehicle and related research literature in order to design, develop, and execute coordinated experiments which will address the primary goals of this research project. Key focus areas of the proposed research include the filtering, prioritization, scheduling, and presentation of information to the driver, and will encompass light passenger vehicles, as well as heavy vehicles and commercial drivers.

The assembled team will coordinate multiple studies across a variety of locations, encompassing simulated and closed test-track studies, on-road observations, and focus groups. Each study performed in this project will look at how to best integrate the multitude of information and applications competing for the driver's attention, as well measure the success of that integration.

The results of the proposed studies are expected to be condensed into a summary that characterizes the key findings and their implications

within the Human Factors Design Guidelines. This document will be a voluntary guidelines document by which automotive manufacturers and CV technology developers may choose to develop and assess their CV technologies.

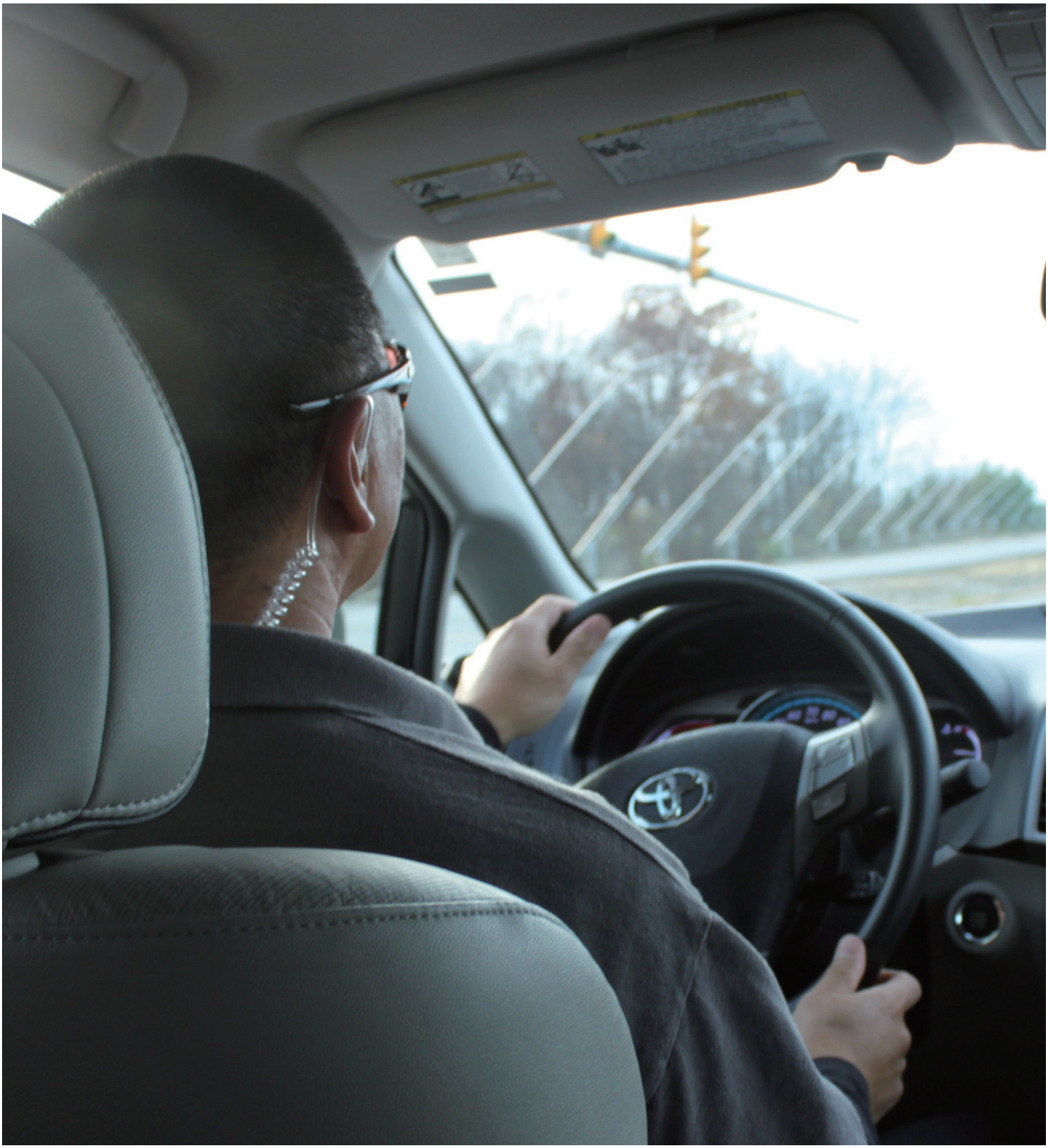
Completed Project

Connected-Vehicle Communications Safety Pilot Driver Clinics Supervisor

The USDOT and its contractors have demonstrated that vehicle connectivity can have transformational impact on safety, mobility, and the environment. The Connected Vehicle Communications (CVC) Safety Pilot program was created to support the NHTSA 2013 regulatory decision. This regulatory decision will determine whether connected vehicle equipment will become a mandated or optional vehicle system. A key component of this plan is gathering field data to prove feasibility of CVCs in the real world and driver acceptance. Under the Safety Pilot Roadmap, The CAMP VSC3 Consortium will lead Light Vehicle Driver Clinics to gather such data. VTTI was selected to serve as the Driver Clinics Supervisor (DCS) for the Driver Acceptance Clinics (DACs).

There were six DACs held from July 2011 to May 2012 at various locations in the United States, with the objective of obtaining data on driver acceptance of communication-based safety systems. As the DCS, VTTI directed and supervised the planning, protocol development, human subjects protections, and execution activities conducted by the Driver Clinics Conductor (DCC) with the assistance of the VSC3 original equipment manufacturer (OEM) personnel and the US DOT. In these DACs, volunteers drove vehicles equipped with V2V safety applications on a closed test track under controlled conditions to experience the V2V safety applications. VTTI developed subjective evaluation surveys/questionnaires, managed the Institutional Review Board (IRB) process, conducted data analysis of the subjective data gathered from participant surveys and focus groups, and participated in dry-run driver clinics prior to execution of the DACs.

After each DAC was completed, system performance testing was also performed at each location to assess hardware and software performance and reliability in diverse geographic regions of the country (i.e. unique terrain, urban vs. rural locations) under real-world conditions. VTTI developed the data acquisition system necessary to record performance evaluation data, installed the device on the vehicles, supported VSC3 in establishing performance tests metrics, executed performance testing, and analyzed the data acquired.



Center for Data Reduction and Analysis Support

The Center for Data Reduction and Analysis Support (CDRAS) specializes in adding value to existing driving data at VTTI. The center continually strives to achieve this mission in a timely, efficient, and cost-effective way by leveraging and engaging multiple centers within VTTI and by serving not only the internal needs of the Institute but those of its strategic partners. CDRAS supports standardized access to and analysis of numerous naturalistic driving study data sets held at VTTI. CDRAS services include coding video and audio data, data quality assurance, data standardization, data mining, event selection, and data analysis. The center also actively supports data analysis collaborations with external institutions.

photo by John McCormick

The Center for Data Reduction and Analysis Support (CDRAS) comprises two groups:

The Data Reduction Group serves many different research groups, both internal and external to VTTI, whose research requires video and/or audio analyses in the areas of driver performance and behavior metrics, situational analyses, and environmental characteristics. The goal of this group is to provide efficient, accurate, and comprehensive coding of videos to meet the specific needs of each unique research project. The group begins by conducting necessary groundwork to prepare a video data set for analysis and working alongside the researcher to develop a data reduction protocol. The group then trains and manages the required data reduction staff, conducts extensive quality control throughout the reduction phase, and prepares final sets of coded data. In addition to the group leader, the group currently includes three coordinators, a large staff of data reductionists, and three data reduction labs with nearly 50 combined workstations. The labs currently operate six days a week, 60 hours per week to meet these demands.

The Data Analysis Support Group performs activities and projects that improve the state of and access to the naturalistic driving data sets available at VTTI. The group comprises experts in data preparation, standardization, mining, and analysis. The goal of the group is to remove any roadblocks to efficient data use and analysis. Group clients not only include VTTI personnel but external research organizations interested in using large-scale naturalistic driving data sets.

New Projects

Data Analysis Support for the Second Strategic Highway Research Program (SHRP 2) Naturalistic Driving Study, Phase 2:

- MRIGlobal
- Center for Transportation Research and Education (CTRE)
- Safety and Fitness Electronic Records (SAFER) System

Support for International Naturalistic Driving Collaborations in China and Australia

Data Reduction Efforts:

- Safety Pilot Model Deployment
- Small Business Innovation Research (SBIR)
- Collision Avoidance Systems
- Motorcycle Safety Foundation (MSF)

Ongoing Projects

Data Reduction and Standardization for the SHRP 2 Naturalistic Driving Study

Support Projects for the SHRP 2 Naturalistic Driving Study:

- Data access website maintenance
- Creation of event and epoch files for collisions
- Data standardization
- Conducting data user workshops
- Providing data access support to non-SHRP 2 users

Support for the Investigating the Impact of Hand-Held and Hands-Free Cell Phone Use on Driving Performance and Safety-Critical Event Risk Study

Support for Connected Vehicle/Infrastructure University Transportation Center Projects

Data Reduction Efforts:

- Crash reduction and data processing for the SHRP 2 Naturalistic Driving Study
- Supervised Practice Driving Study
- Human Factors of Connected Vehicles
- Various projects funded through the National Surface Transportation Safety Center for Excellence (NSTSCE)

Completed Projects

Data Analysis Support for the SHRP 2 Naturalistic Driving Study, Phase 1:

- MRIGlobal
- CTRE
- University of Minnesota
- SAFER

Initial Research on Portable Devices and Voice Interfaces

Support for the National Highway Traffic Safety Administration (NHTSA) Visual Manual Guideline

Data Reduction Efforts:

- 100-Car Study
- Naturalistic Teen Driving Study
- Cooperative Intersection Collision Avoidance Systems for Violations (CICAS-V)
- Older Driver Study
- Field Demonstration of an Advanced Heavy Vehicle Indirect Visibility System (IVS)
- 8-Truck and 34-Truck Studies

Center for Infrastructure-Based Safety Systems

Researchers with the Center for Infrastructure-Based Safety Systems (CIBSS) focus their endeavors on roadway-based safety systems such as lighting, visibility treatments, pavement markings, signage, signals, barriers, the interaction of visibility with roadway design, and weather considerations. The goal of CIBSS is to conduct research and development efforts that advance knowledge and provide solutions to real-world issues.

Judging lighting at VTTI • photo by Anne Wernikoff

New Projects

Visibility Support

This Federal Highway Administration (FHWA)-sponsored project was awarded on September 1, 2012. The objective of this project is to support the FHWA Visibility Program by providing responses to and interpretation of technical issues, measurement and characterization of lighting and signaling systems, development of measurement standards, and development of consensus standards.

During the course of this project, the overall responsibility of the team will be to provide support to the FHWA Visibility Program for the evaluation, standardization, and testing of lighting and signaling systems. This includes the evaluation and analysis of technical and program issues and the provision of advice, recommendations, and support.

Safety IDIQ Management

This FHWA-sponsored project was awarded on February 1, 2013. The primary purpose was to provide the FHWA Office of Safety with an outlet for performing various task orders in an indefinite delivery/indefinite quantity (IDIQ) format. This IDIQ contract was competitive. CIBSS researchers successfully provided an appropriate response to Task Order Proposal Requests (TOPRs) #30, #34, and #45.

During the course of the fiscal year, CIBSS researchers worked to enhance their responses to the requested TOPRs through a continual improvement process from the standpoint of both team capabilities and an understanding of FHWA requirements. The center also continued to seek communication with FHWA partners to provide a better resource to the agency as the contract moved forward.

Trinidad Nights

This Colorado Department of Transportation-sponsored project is designed to provide an evaluation of the guardrail-mounted lighting installation in Trinidad, Colorado. In an effort to control light pollution from a viaduct over the city of Trinidad, Colorado, a light-emitting diode (LED) experimental guardrail-mounted lighting system was implemented. This lighting system uses vertically mounted LED strips that project light in the travel direction of the driver. These LED strips provide a high level of vertical illuminance on objects that may be in the lane of travel of the vehicle.

This implementation of LEDs is unique, and the effectiveness of the system as compared to traditional lighting systems is unknown. A performance test will be valuable in comparing the ability of this system to provide object visibility in the roadway to that of traditional lighting. This test will involve an experiment conducted with participants from the general public in Trinidad. These experiments will be compared to similar experiments performed under traditional lighting systems.

CIBSS researchers provided the Roadway Lighting Mobile Measurement System (RLMMS) for the lighting evaluation in the test sections. The Center also conducted the evaluation with the general public. The results of the evaluation and the visibility distance will be documented and provided to the project sponsor.

Ongoing Projects

Shiny Sign

This project, sponsored by the National Cooperative Highway Research Program (NCHRP) through the Texas A&M Transportation Institute, compares different sign lighting types with different combinations of sign materials. The purpose of the study is to determine the most visible combination of sign materials and sign lighting by having participants identify a series of words printed

on the signs while driving. New sign material technology may provide an opportunity for dimming sign lighting, which can reduce energy costs and sky glow or light pollution.

The testing for this project was conducted this year on the Smart Road using a changeable sign that can be raised and lowered to alter the sign message. The Smart Road lighting control system was also used to modify the lighting conditions. The legibility of the sign in varying conditions was measured from the human factors testing perspective.

Airport Garage Lighting

This Airport Cooperative Research Program (ACRP)-sponsored project is designed to investigate the functionality and possible energy savings that may result from changes made to airport parking garage lighting. Current lighting technologies will be considered during cost-benefit analyses of transitions to alternative airport parking garage lighting. Activities to be undertaken by VTTI include site selection of multiple airports and field testing with a modified version of the VTTI-developed RLMMS. Lighting design activities will be conducted with assistance from the engineering firm of Parsons Brinckerhoff. Cost-benefit analyses of transitions to different parking garage lighting will be performed with the assistance of the program management firm, MCR Federal.

The first phase of the project is complete, and scheduling of the site visits and photometric measurements is underway and is expected to be completed in September.

LED Night

The Virginia Center for Transportation Innovation and Research (VCTIR) is sponsoring this assessment of LED-based exterior luminaires. LED luminaires have been tested at VTTI for electrical and lighting performance. Following this laboratory testing, luminaire systems will be evaluated in the field at a Virginia Department of Transportation (VDOT) Park and Ride facility using the VTTI-developed RLMMS. Both evaluations and ongoing measurements of luminaire performance during a 24-month period will be reported to the sponsor to determine which luminaires meet VDOT specifications.

The lighting systems were installed during September 2012 and have been measured three times for performance. During the spring, the project team held an educational seminar with the project sponsor.

Foggy Signs

This VCTIR-sponsored project is designed to investigate the performance of internally illuminated roadway signs using different color schemes and intensities to determine which configurations perform best during foggy conditions. A Smart Road study will be conducted during which participants will be asked to read aloud an alphanumeric combination displayed using each sign configuration. The distance at which a participant can correctly read the sign (i.e., the legibility distance) will be used as the measure of performance. Results of this study will provide information that can help increase active sign legibility during foggy conditions.

The measurements of the fog-making system performance were made using a VTTI-developed visibility meter. Human factors testing is ongoing.

Wet Visibility V

This VCTIR-sponsored project is another in the Wet Visibility family. Wet Visibility V is an extension of the efforts made during the previous project to assess the durability of pavement markings. The retroreflectivity of test markings installed on Route 460 in Blacksburg, VA, will be monitored for an additional two

years to assess their long-term durability. The results of this study will provide information about the performance of various pavement markings during a four-year period. Results will be used by VDOT to inform its pavement-marking policies.

The final set of measurements has been completed, and the final report is being prepared.

Spectral Interactions

Spectral Interactions is the second phase of the Spectral Effects project and is sponsored by FHWA. The focus of this project is to investigate the impact of headlamps on overhead roadway lighting. This investigation will use varying levels of overhead roadway lighting paired with standard vehicle headlamps. The project will use the Small Target Visibility (STV) model and pedestrian detection. The detection distances of objects under the prescribed conditions will show the impact of headlamps at different dim levels. The findings may result in an opportunity for energy savings as the threshold for dimming roadway lights and adequate nighttime visibility are examined.

Spectral Effects

FHWA and the National Highway Traffic Safety Administration (NHTSA) are sponsoring this evaluation of the impact of the spectral power distribution of light on driver performance. With a new focus on energy savings, alternative light source technologies (both traditional and

Ron Gibbons studies bicycle visibility • photo by Jim Stroup

new) are being applied to roadway lighting.

This has caused the spectral power distribution of the light source to play a more important role in the consideration of a roadway lighting application. Broad-spectrum sources (i.e., a light source with significant spectral output across the entire visible spectrum) potentially provide the driver additional benefits such as improved visual performance, better object color recognition, and greater visual comfort. This project investigates these effects and considers the potential benefits of a broad-spectrum source. The project considers the impacts of both the fixed overhead lighting system and vehicle headlamps. Data collection has been completed; data analysis and final reporting of the project are under way.

An additional aspect of the project is the development of a potential system that uses vehicle headlights to highlight pedestrians on the side of the roadway. This is coupled with the initial study of broad-spectrum sources and the potential benefits that such light sources may provide in allowing drivers to detect pedestrians and animals along the side of the roadway. The design and manufacture of this peripheral illumination system is complete, and data collection is expected to begin during late 2013.

Adaptive Lighting

This FHWA-sponsored project considers the possibilities of adapting lighting systems to the needs of the driving environment. The first step is to create a causal link between the lighting system and the vehicular crash rate. Current projects connect the existence of lighting to a reduction in crashes, but insufficient data exist to link roadway brightness to the crash rate. To accomplish this goal, this project considers the crash rate for six states and the performance measurements of the lighting systems. A Bayesian analysis is then planned to associate the lighting performance to the crash rate. Draft procedures will be developed to aid in the design of adaptive lighting systems. These procedures will also provide guidelines for when to dim a lighting system and how to perform the adaptation. The final step in this project is the performance of a legal review of the proposed guidelines to ensure the viability of such a system.

The lighting measurements have been completed, and the final analysis is under way. A draft of the design specifications is also currently under review.

Accelerating Roundabout Implementation

This project is primarily performed by partners North Carolina State University and Kittelson and Associates, Inc. The purpose of the project is to identify factors that limit the implementation of roundabouts in the highway system. These factors include the yielding of drivers to pedestrians in roundabouts. The other limitation is the potential for backups at peak traffic times. The research team has performed reviews of the various roundabouts throughout the U.S. to link roundabout design characteristics to driver behavior. The study also includes crash and environmental analyses. The resulting report will provide a guideline for agencies to minimize the impact of such factors on roundabout implementation.

Completed Projects

Pacific Nights

This project was sponsored by Clanton and Associates and comprised an LED assessment study that occurred in Seattle, Washington, during March 2012. The purpose of the study was to compare different LED luminaires to conventional high-pressure sodium (HPS)

luminaires at varying dim levels. These comparisons were made to examine the potential to dim roadway luminaires with the goal of conserving energy costs while maintaining the current standard of visibility. Results will inform the City of Seattle and Seattle City Light of potential ways to enhance or maintain visibility while transitioning to LED technology. The final report has been completed and issued.

FHWA Safety Indefinite Delivery/ Indefinite Quantity

This FHWA-sponsored project was awarded on July 1, 2010. The primary purpose was to provide the FHWA Office of Safety with an outlet for performing various task orders in an IDIQ format. This IDIQ contract was competitive. CIBSS researchers successfully provided an appropriate response to TOPRs #30 and #34. This project has been continued as Safety IDIQ Management.

photo by Jim Stroup

Center for Injury Biomechanics

The Center for Injury Biomechanics (CIB) strives to mitigate the human suffering and societal costs associated with unintentional injuries. This is accomplished by conducting research to determine the mechanisms of injury and human tolerance to injury. The impact and injury responses and physical properties of post-mortem human surrogates and in vivo biomedical models are measured on multiple scales via cellular, tissue, organ structure, body region, and whole-body-level testing. Human volunteer testing is conducted at low energy levels to investigate the effects of posture and muscle activation. The tolerance to various loading regimes using different injury mechanisms is determined to develop or improve injury metrics and predictive functions for a given injury type.

Warren Hardy (left), director of CIB, and Stefan Duma (right), department head of the Virginia Tech - Wake Forest University School of Biomedical Engineering and Sciences • photo by Logan Wallace

New Projects

Intravenously Administered Nanoparticles to Halt Blast Trauma

The purpose of this research is to investigate whether intravenously administered nanoparticles functionalized with a peptide that binds with activated platelets could reduce bleeding and improve survival in a model of blast trauma. Blood loss is the primary cause of death at acute time points post-injury in both civilian and battlefield traumas. Immediate intervention is critical to minimize mortality associated with severe trauma. Poly(lactic-co-glycolic acid)-based nanoparticles with poly(ethylene glycol) arms and the RGD peptide to target activated platelets were fabricated. These functionalized nanoparticles or controls are delivered in a whole-body blast injury model in rats. Blasted animals are immediately injected intravenously with nanoparticles. Physiological monitoring is conducted, and survival time is recorded for one hour. Subsequently, tissues are collected for biodistrubution of nanoparticles and lung tissue injury. The particles reduce injury severity, and the functionalized nanoparticles or synthetic platelets reduce bleeding in a model of blast trauma. This treatment has the potential to greatly impact survival outcomes related to internal hemorrhage.

Investigation of Thoracic and Abdominal Loading Due to Different Safety Restraint Conditions Using ATDs and PMHSs

The overall purpose of this project is to quantify the degree of thoracic and abdominal loading due to different restraint conditions in full-scale frontal sled tests. There are three primary objectives for this project. The first objective is to quantify the response of post-mortem human surrogates (PMHSs), the Hybrid III anthropometric test device (ATD), and the Test device for Human Occupant Restraint (THOR) ATD during high-speed sled tests with a combination of standard safety restraint systems, particularly focused on the response of the thorax and abdomen. The second objective is to compare the responses for a given combination of standard safety restraint systems between surrogate types. The third objective is to compare the responses of each surrogate type between combinations of standard safety restraint systems.

Ongoing Projects

Roadside Features for the Highway Safety Manual (HSM)

The objective of this research is to develop quantitative measures that can be incorporated into the Highway Safety Manual (HSM) to evaluate the effects of roadside designs and features on the frequency and severity of lane-departure crashes. The project is designed to: 1) Use completed and ongoing research projects to identify crash modification factors (CMFs) and available data sources related to lane-departure crashes; 2) Determine the strengths, weaknesses, and differences between the HSM prediction models and the Roadside Safety Analysis Program (RSAP) and identify opportunities to provide consistency by updating data sources, base models, or modification factors; and 3) Develop new roadside crash modification factors for this type of collision event.

CIREN: Crash Injury Research and Engineering Network

This primary purpose of this project is to provide support for the Wake Forest University (WFU) Crash Injury Research and Engineering Network (CIREN) center by participating in a subset of the reviews conducted by the WFU CIREN center of the automobile accident case data collected by WFU, either on-site at WFU or remotely via webcast. CIB will also participate in a retrospective analysis of previously collected automobile crash head-injury cases in an attempt to better understand head injury mechanisms, travel to participate in CIREN network general meetings and/or to present material at technical conferences, and contribute to the drafting of journal publications.

Abdominal Injury Patterns

The objective of this project is to investigate abdominal injuries incurred during motor vehicle collisions. Epidemiological and etiological studies using National Automotive Sampling System (NASS)/Crashworthiness Data System (CDS) and CIREN cases are being performed to supplement current, limited data about the subject. A laboratory PMHS capable of reproducing the requisite abdominal damage and injury mechanisms will be developed. This whole-body testing will involve examination of loading and damage parameters, determination of the damage tolerance/threshold, and development of an associated predictive metric. The mechanism of abdominal injury will be investigated using high-speed, biplane x-rays to record the internal kinematics.

Development and Validation of the THOR-k Finite Element Model

The advanced, anthropomorphic THOR was developed by the National Transportation Biomechanics Research Center of the National Highway Traffic Safety Administration (NHTSA) at the U.S. Department of Transportation (USDOT). THOR is designed to facilitate both the development and evaluation of advanced vehicle occupant safety systems. The device features improved biofidelity and expanded capabilities to assess injury in all bodily regions. Though designed specifically for use during frontal and oblique crash environments, THOR offers multi-directional faculties in several of its components. The latest THOR dummy features numerous functional benefits with its enhanced design and measurement capabilities compared to previously existing crash test dummy technology. The goal of this project is to develop and validate a new finite element model (FEM) of the recent version of the THOR dummy (k model). The mesh and assembly of the new model will be developed by researchers from George Washington University (GWU). The material properties based on material characterization tests will be identified by Virginia Tech researchers led by Dr. Costin Untaroiu. Virginia Tech researchers will also validate the model against data available from calibration, biofidelity, and sled tests. Virginia Tech researchers will compare the predictions of the final THOR model in a frontal crash-sled simulation with corresponding data of the Total Human Model for Safety (THUMS). The model sensitivity against material properties and test conditions will be investigated.

Evaluation and Calibration of a FEM of the THOR-NT Dummy for Assessing Vertical Impact Loading

ATDs are frequently used during crash testing to evaluate injury risk for vehicle occupants. The THOR dummy has been developed and continuously improved by NHTSA. The device has shown better biofidelity during impact tests relative to the Hybrid III, which is the dummy used for present regulations. Current efforts of improving the THOR-NT advanced frontal crash test dummy have been based exclusively on comparative frontal crash tests using PMHSs and Hybrid III ATDs. Therefore, the adequacy of using THOR during evaluations of injuries caused by vertical loading is not ideally understood. To address this gap, the objective of this Virginia Tech project, conducted with NASA Langley Research Center (LaRC), is to evaluate and calibrate the FEM of the THOR-NT dummy under vertical loading conditions corresponding to Federal Aviation Administration (FAA) and Department of Defense regulations for crash safety and NASA Orion Crew Module Landing requirements.

Evaluation of Pre-tensioning and Force-limiting Used in Novel Seat Belt Restraint Systems

Current seat belt systems have proven to be

effective by preventing 45 percent of fatal injuries and 67 percent of serious injuries. However, it is understood that an early coupling of the occupant to the vehicle seat using pre-tensioners during a frontal crash can additionally reduce the injury risk of the occupant. Until recently, low-power pre-tensioners have been used only to take up the slack in a seat belt to avoid submarining (i.e., occupants sliding down under the lap section of the seat belt). The current trend of increased vehicle stiffness has resulted in a requirement for a better coupling of the occupant to the seat by applying greater forces in the belts using high-power pre-tensioners, especially in the lap belt. It is known that applying greater forces may increase injury risk in the occupant's bodily regions that are compressed by the belts (e.g., thorax, pelvis, and abdomen). The objective of this project is to evaluate the performance of pre-tensioning and force-limiting used in novel seat belt restraint systems for better protection of the occupant involved in a frontal crash. The methodology is a multi-faceted approach involving: 1) Experimental static deployment tests with both ATDs and PMHSs; 2) Data analysis of dynamic penetration of the surrogate abdomen/thorax and belts during tests using the Vicon system; 3) Statistical correlation between levels of thorax/abdomen deformations, injuries/non-injuries, and anthropometric characteristics of PMHSs; and 4) Tissue tests conducted on abdominal solid organs to investigate the influence of variability in the material properties on the PMHS response to pre-tensioning.

Task 4.1 - Generic Hull 2

The purpose of this study is to gain a better understanding of the loading conditions present in a representative vehicle experiencing an underbody blast. The loads and timing associated with various types of damage predicted by ATDs will provide insight into potential injury mechanisms and the ability of the ATDs to respond to and predict those injuries under such conditions. The results of this research will help direct future studies.

Task 4.2 - Blast Buck Comparison Testing

These series of tests are designed to investigate the kinematics of surrogate occupants undergoing high-level and high-rate vertical accelerations. Two surrogates are positioned on top of a blast buck having a rigid frame and seat structure with a deformable floor. Paired comparisons are conducted to examine the effects of different postures, personal protective equipment, and mitigation strategies.

Factors Related to Serious Injury and Fatal Motorcycle Crashes with Traffic Barriers

The goal of the proposed research program is to use in-depth accident investigations to determine the characteristics of serious injury and fatal motorcycle crashes into traffic barriers. The long-term goal is to recommend injury-mitigating strategies for motorcyclists that continue to protect passenger-vehicle occupants. The scope of the research program will include collisions with all forms of traffic barriers such as guardrail barriers, concrete barriers, bridge rails, crash cushions, and end terminals.

Head and Thoracic Injury

In the automotive safety field, FEMs are commonly used to predict and ultimately mitigate injuries to human occupants. However, there currently are limited data that can be used to validate the kinematics and inertial responses of internal organs due to applied loading. Therefore, the injury patterns of restrained occupants will be reconstructed on PMHSs under controlled loading conditions using impact tests that simulate injury mechanisms observed during field accidents. The project comprises two goals: 1) To simulate field accident internal organ injury mechanisms through local impact testing; and 2) To quantify

the three-dimensional (3D) motion of internal organs due to isolated thoracic impacts. To accomplish these goals, radiopaque markers will be implanted in various thoracic structures. A high-speed, biplane x-ray system will be used to visualize the motion of the markers.

Roadside Data

Each year, more than 10,000 motorists in the U.S. are fatally injured during road departure crashes. The reasons why road departure crashes often lead to fatality or injury despite the installation of thousands of miles of advanced countermeasures are complex and not completely understood. This study will conduct in-depth investigations of 1,000 road-departure crashes at 24 sites across the United States. The study promises to provide fundamental insights into the crash conditions associated with road departures (e.g., impact speed, impact angles, vehicle road-departure orientations, encroachment frequencies, and roadside topography) to reduce the severity and frequency of roadside crashes. The study will couple these crash causation factors with complete injury information for each of the crash victims to identify the influence of infrastructure design on injury outcomes.

Military Biomechanics II

A new fluid-filled eye will be designed and developed to replace the current solid eye in the Facial and Ocular Countermeasure Safety (FOCUS) headform, a state-of-the-art physical model capable of measuring impact loads to the face and eyes. The new eye will be instrumented with a high-rate pressure sensor that will be calibrated to predict eye injury risk. The FOCUS form will be slightly modified to allow for a new eye and sensor cable. To investigate the internal loading mechanisms of the eye subjected to blast loading, a full-eye computational model that is able to incorporate non-symmetric loading patterns and omnidirectional impacts will be developed.

The biomechanics of cervical spine arthroplasty (i.e., the surgical repair of a joint) in the military will be investigated by first further analyzing existing tests of the effects of cervical spine implants then developing a suitable cadaver testing apparatus. This is important for head-supported mass issues. Related to head-supported mass, FEMs of various face shields will be created to evaluate the effects of spinal loading on candidate designs.

This project is also designed to characterize the physical responses of a previously developed pulmonary surrogate under a series of representative impact loading conditions. The surrogate's responses will be correlated to the strain distribution within a FEM of the human lung. Finally, this project will evaluate the effect of non-censored rib fracture timing on thoracic injury criteria.

WinSmash Update

The objective of this project is to update and enhance the WinSmash crash reconstruction code. Specifically, the project corrects known programming bugs, implements an improved strategy for the search of stiffness values, rewrites the code in the more modern language C#, and develops an expanded library of stiffness values that better reflect the current vehicle fleet. This project has resulted in the development of WinSmash 2010, a completely rewritten and restructured version of the WinSmash crash reconstruction code. Earlier phases of this project developed WinSmash 2007 and WinSmash 2008. WinSmash 2007 was used to generate delta-V estimates in NASS/CDS 2007. WinSmash 2008 was used for the same function in NASS/CDS 2008 and NASS/CDS 2009. WinSmash 2010 will be used to generate delta-V estimates for NASS/CDS 2010 and later versions.

Completed Projects

Quantitative Evaluation of Deflection Equivalence (DEQ)—Part I

Certain vehicle safety regulatory agencies are considering adapting into the standard frontal vehicle safety compliance tests a new thoracic injury criterion called the deflection equivalence (DEQ). However, concerns have been raised regarding the ability of DEQ to accurately predict under certain loading conditions thoracic injury risk using the 50th percentile male Hybrid III ATD. Specifically, DEQ that is calculated based on the Hybrid III sternum-chest potentiometer (single-point) does not appear to be sensitive to cases during which a knee-bolster airbag (i.e., a knee airbag designed to reduce loading on lower limbs) is deployed or in cases where the steering wheel rim directly loads the chest due to the airbag "bottoming out" (i.e., the airbag does not provide sufficient cushion to the vehicle occupant). The proposed research program comprised three primary goals designed to investigate these concerns: 1) Assess the effectiveness of knee-bolster airbags with respect to thoracic injuries experienced during real-world automotive collisions using the NASS/CDS and CIREN databases; 2) Determine if direct steering wheel contact due to the lack of an airbag deployment or the airbag "bottoming out" is still a major source of thoracic injury during real-world automotive collisions using the NASS/CDS and CIREN databases; and 3) Evaluate the pros and cons

Warren Hardy, director of CIB • photo by Logan Wallace

of DEQ, sternum deflection, and peak chest deflection as thoracic injury predictors during frontal impacts using an ATD, human body FEM simulations, and various combinations of safety restraint systems.

IMPACT Response to WIAMan

The Virginia Tech – WFU CIB formed a consortium of universities to address the primary injury concerns of today's military. Better vehicle structures, seating and restraint systems, and personal protective equipment are needed to improve the safety of the mounted soldier, particularly during vehicle vertical loading. Currently, no valid development and evaluation tool exists to aid in the design of these systems or to assess the risk of injury during an underbody blast. This project contributed to the determination of biofidelity corridors and risk curves associated with the implementation of a new form of test dummy, the Warrior Injury Assessment Manikin (WIAMan).

Crash Injury Research and Engineering Network (CIREN)

CIB participated in a subset of reviews, which were conducted by the WFU CIREN center, of automobile accident case data collected by WFU. CIB supported the CIREN case study and/or statistical findings by conducting pilot biomechanical testing.

Light-vehicle Event Data Recorder Technologies

The objective of this program was to evaluate the current potential of event data recorders (EDRs), manufacturer-planned upgrades to EDRs, and potential updates of EDR capabilities based on data about safety needs. The evaluation included an assessment of the requirements and capabilities for EDR survivability (i.e., the ability of the EDR to withstand impacts). The research program focused on both light vehicles (e.g., cars and light trucks) and heavy vehicles that included truck-tractors, straight trucks, and buses (e.g., transit and motorcoaches). The research program supported the NHTSA decision about regulating future generations of EDRs.

Advanced Automated Collision Notification

This project sought new methods to improve triage decisions (i.e., the process of determining the priority of patient treatment based on condition severity) made during vehicle crashes by taking advantage of electronic data collected during a crash. This project was designed to develop and validate Advanced Automated Collision Notification algorithms using the advanced capabilities of EDRs to specifically improve triage decisions. EDRs in current-production passenger vehicles provide a unique source of data about a crash, storing data elements that describe the vehicle and occupant

VTTI/CIB Crash Sled Lab • photo by Logan Wallace

restraint responses to an impact. These EDR data elements can be used to dramatically improve the prediction of impact injury incidence and severity for field triage decisions.

New Jersey Graduated Driver's License

Teen crash fatalities occur for a number of reasons, including driver inexperience, lack of proper training, and a propensity for excessive risk-taking among some teens. These tragic events continue to occur at the rate of approximately 100 deaths per year in New Jersey despite state implementation in 2001 of the graduated driver's license (GDL). The goal of this research program was to develop a comprehensive teen driver monitoring method and program for New Jersey that uses current and future data sources. This system will be used to determine the effectiveness of the New Jersey GDL law in reducing motor vehicle crashes, injuries, fatalities, and property damage for novice drivers who are typically 16 to 25 years of age. The resulting system will be designed to facilitate evaluation of the current New Jersey GDL law and proposed enhancements to the law.

Specifically, this research program: 1) Developed a comprehensive teen driver monitoring method and program for New Jersey that uses current and future data sources; 2) Evaluated crash data to determine if teen driver crashes and fatalities in New Jersey have significantly declined since enactment of a GDL law in 2001; 3) Conducted a study that compared the driving experiences of teens who had 50 hours of practice driving coupled with formal driver training versus those who had 100 hours of practice driving without formal driver training in terms of future crash involvement, traffic violations, and other factors; 4) Conducted a study that compared the driving experiences of teens who held their driving permits for six months versus those who held their permits for 12 months in terms of future crash involvement, traffic violations, and other factors; 5) Evaluated the effectiveness of the September 2008 directive that banned plea bargains for drivers with a GDL; and 6) Developed a detailed plan for a pilot study of an in-vehicle observation of teen driving behavior.

Human Abdomen Model Center of Expertise

This research was conducted for the Global Human Body Models Consortium (GHBMC). This was a multi-year, multimillion dollar project coordinated by the GHBMC, which is a consortium of the world's largest automobile manufacturers and suppliers. The effort was designed to develop and validate the most advanced FEMs of the human body. Regional models were separated for development into five centers of expertise, with the full-body center performing integration of the regions. The models were highly anatomically detailed and possessed the most accurate tissue representations possible, particularly in terms of mechanical responses and failure characteristics. The models were designed to predict relevant crash-induced injuries. Individuals were modeled to cover the maximum range of normal sizes in the world population. Fifth and 50th percentile females and 50th and 95th percentile male models were developed. Scalable models were developed to represent other shapes and sizes. Subsequent models represented children and the elderly.

CIB participated in the GHBMC effort as the Abdomen Model Center of Expertise. CIB collaborated with Dr. Philippe Beillas of the French National Institute for Transport and Safety Research (INRETS) in Lyon-Bron and Dr. Philippe Vezin, head of the Laboratory of Biomechanics and Impact Mechanics. The research approach involved empirical and numerical components on multiple scales. For the development of an improved FE tool for the evaluation of local abdominal injury, material properties, tolerance of tissues and systems, and the local structural responses during impact were needed and were obtained during the course of this project. CIB conducted the majority of the empirical work, and INRETS conducted the majority of the numerical work for the abdomen center of expertise.

Center for Sustainable Mobility

photo by Jim Stroup

The mission of the Center for Sustainable Mobility (CSM) is to conduct research relevant to society's transportation needs, to translate the results of that research into a realistic and workable application, to create and provide the tools needed to apply developed knowledge and processes, and to educate qualified engineers to meet today's transportation demands and tomorrow's transportation challenges.

CSM comprises four groups:

- Transportation Systems and Operations
- Traffic Signal Operations
- Energy and Environmental
- Data Visualization

New Projects

MAUTC Incident and Weather: Effects of Major Transportation Incidents and Disruptive Events

During the last five years, the Northern Virginia transportation system has experienced several major incidents and disruptive events, including a Metrorail train collision, an earthquake, and a collapsed crane. The magnitudes and sources of these incidents are different from the more common vehicle collisions. This study will compare the impacts of the three major events with common vehicle collisions in terms of demand changes, network performance, and the applicability of congestion mitigation strategies. The overall goal of this project is to better understand the similarities and differences between extraordinary disruptive events and more common incidents and the traffic mitigation strategies that are effective during these situations. The associated objectives include: 1) Identifying similarities and differences among major incidents and more common incidents; 2) Determining the network performance under major incident and disruptive event conditions; 3) Determining the network performance under more common incident conditions; and 4) Identifying and evaluating traffic mitigation strategies for applicability to the different event conditions. The outcomes of the study will help the Virginia Department of Transportation (VDOT) and other departments of transportation plan for unusual events of different types and will evaluate the benefits of implementing traffic mitigation strategies in different scenarios.

MAUTC Incident and Weather: Winter Weather Demand Considerations

In 2011, the "perfect [snow] storm" hit the Washington, D.C., commuting area during the evening peak period, causing some drivers to spend 13 hours on the road. While it is acknowledged that severe weather reduces speeds and capacities, the impact of such weather cannot be determined without knowing how many drivers will be affected. Predicting the winter weather demand involves understanding the complexities associated with the decision to travel at a particular time. School closures, workplace policies, storm characteristics, and road conditions influence drivers' trip decisions during winter events. This study explores these influences and complexities. The goal is to examine winter weather effects on demand and estimate demand models. Towards this goal, this study involves collecting original data about citizens' travel decisions during snowstorms and the dependence of these decisions on the aforementioned influential factors; identifying school and employer policies with respect to early closures during snow events; and developing snowstorm-related demand models.

Conference on Agent-Based Modeling in Transportation Planning and Operations

The inaugural Conference on Agent-Based Modeling in Transportation Planning and Operations, which is funded by the Mid-Atlantic Universities Transportation Center (MAUTC), will be held September 30 to October 1, 2013, at the Inn at Virginia Tech in Blacksburg, Virginia. The conference has the following objectives:

- Present the current state of the art/science in agent-based transportation modeling.
- Provide the lessons learned from the current research efforts in this field.
- Define where the future lies in this type of modeling effort and what steps and research agenda need to be taken to ensure its success.

A website for the conference has been established at http://www.cpe.vt.edu/abmconf/index.html. An organizing committee has been formulated. Also, a paper review committee has been formed to review the papers and the presentations. Qualified papers will be published in a special issue of Transportation Research-Part C, which is dedicated to this conference.

Using Mobile Probes to Inform and Measure the Effectiveness of Macroscopic Traffic Control Strategies on Urban Networks

Urban traffic congestion is a problem that plagues many cities in the United States. Devising and testing strategies to alleviate this congestion is especially challenging due to the difficulty of modeling these complex urban traffic networks. However, recent work has shown that these complicated systems can be modeled in relatively simple ways by leveraging consistent relationships that exist between network-wide averages of pertinent traffic properties, such as average network flow, network density, and the rate at which trips are completed. Using these "macroscopic" traffic models, various control strategies can be developed to mitigate congestion and improve network performance. However, the effectiveness of many of these strategies depends on the ability to estimate traffic conditions on the network in real-time. This jointly proposed research between Penn State and Virginia Tech seeks to investigate how real-time mobile vehicle probes can be combined with macroscopic urban traffic models to implement more efficient network-wide traffic control strategies. Additionally, this work will examine how the effectiveness of these strategies can be directly measured in the field using only mobile vehicle probe data. These two efforts can lead to more efficient control of downtown traffic networks and a reduction in vehicular delay during rush-hour periods. This project is a collaborative effort between Penn State and Virginia Tech funded under MAUTC.

Modeling the Dynamics of Driver's Dilemma Zone Perception using Machine Learning Methods for Safer Intersection Control

Rural, high-speed signalized intersections are associated with vehicle crashes due to dilemma zone problems. Dilemma zones are defined in either time or space as zones in which some drivers may decide to proceed and some may decide to stop at the onset of a yellow light. This disagreement among drivers can lead to

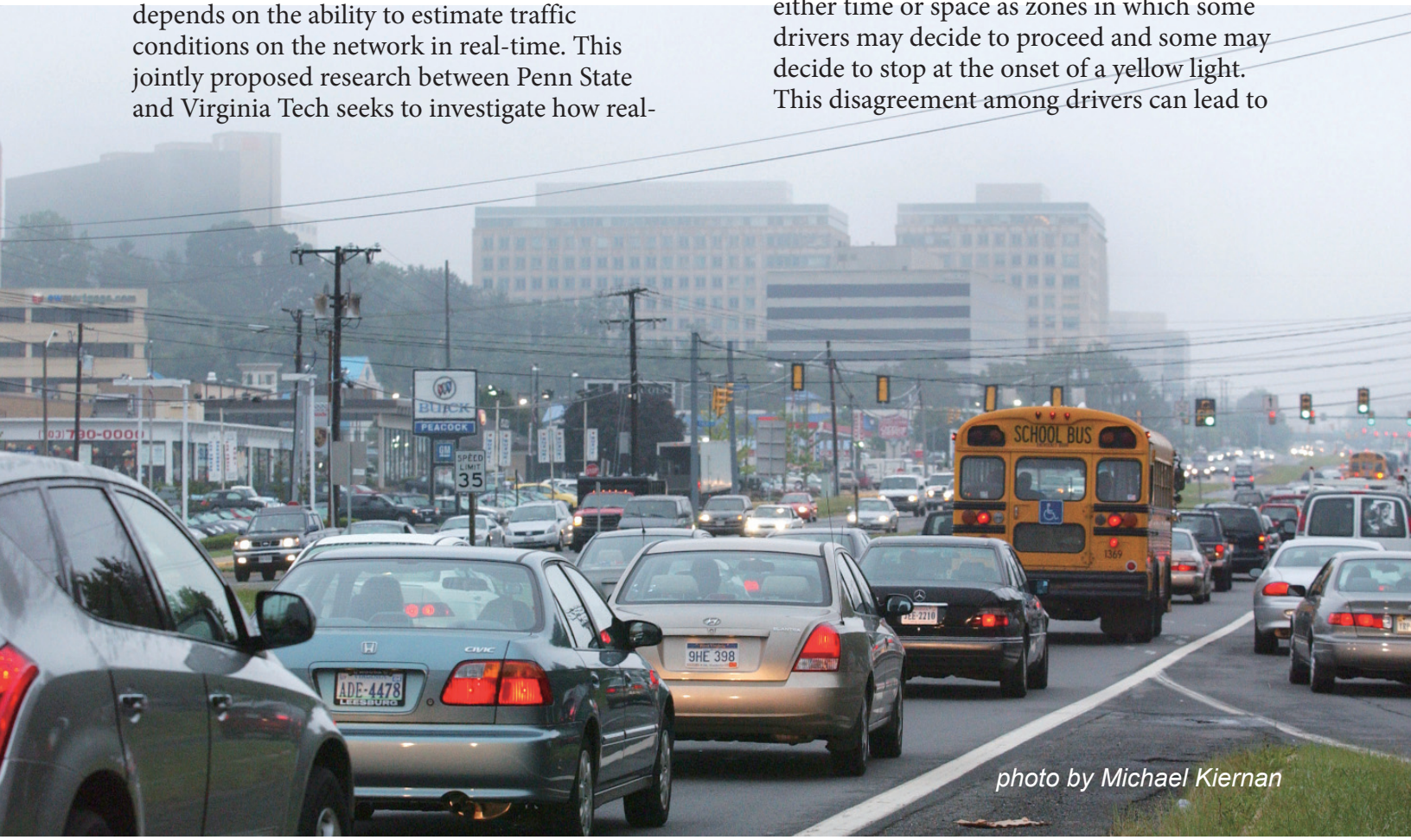


photo by Michael Kiernan

rear-end crashes (when a driver decides to stop while the following driver decides to proceed) and/or right-angle crashes (when drivers end up violating the red light and crash with side street traffic). This joint proposed research between Virginia Tech, Morgan State University, and Penn State will investigate the dynamic nature of drivers' perceptions of dilemma zones and whether that perception changes as a function of their experience driving through safe or unsafe intersections. A matching project funded by the Virginia Center for Transportation Innovation and Research (VCTIR) is investigating different control methods to minimize dilemma zone-related crashes. These methods range from traditional advanced detector and actuated control optimal configuration to the use of advanced technologies such as Wavetronix and detection-control systems. These two efforts can lead to better modeling of driver perception, better control algorithms, and safer intersections.

Development of a Ground-Coupled Bridge Deck Deicing System Using Energy Foundations

The long-term goal of this research is to develop a ground-coupled bridge deck deicing system that uses geothermal energy harvested through bridge foundations or geothermal trenches/boreholes. The proposed system is different from ground-source heat pump systems used for building heating and cooling as it uses a circulation pump. The warm fluid extracted from the ground is circulated through a tubing system embedded within the bridge deck. The envisioned technology will help reduce the use of salts and deicing chemicals, thus decreasing bridge deck deterioration and offsetting the detrimental effects and environmental hazards caused by these chemicals. The knowledge base developed from the proposed phase of the research will be critical for successful product development during the next phase. During the proposed phase, the research team will investigate the operational principles, identify key design parameters, and develop a proof-of-concept testing approach that will eventually transform the concept to a ready-to-use technology. Laboratory and field tests will be performed on instrumented bridge decks and heat-exchanger piles (energy piles) to investigate heat transfer within different components of the ground-coupled bridge deck system. The knowledge and experience gained from this research will allow the team to develop a well-planned strategy for achieving its long-term goal. This research is a collaborative MAUTC project between Penn State and Virginia Tech.

MAUTC Training on Pavement Surface Characteristics

The purpose of this project is to develop an effective education training program for roadway agency engineers and managers at the federal, state, and local levels. The program will introduce participants to the state of the art in pavement surface characteristics measurement and management and their impacts on the performance of national road transportation infrastructure systems. It is anticipated that this research will prepare state and local department of transportation (DOT) workforces to better address pavement contribution to the performance of their networks as it relates to the requirements of the Moving Ahead for Progress in the 21st Century Act (MAP-21). The hypothesis of the research team is that agencies can better achieve their performance goals if they understand the contribution of the pavement to the various road-vehicle interactions (e.g., ride comfort, safety, gas consumption, traveling speed and reliability, environmental pollution, etc.). This will help decision makers align their investment decisions with performance goals.

STOL Task 1

CSM is part of the SAIC team that is providing support operations for the Saxton Transportation Operations Laboratory (STOL). The research that the team is conducting under the program relates to cooperative vehicle systems research, including cooperative adaptive cruise control (CACC) system development, speed harmonization system development, and the modeling of these cooperative systems.

STOL Task 2

As part of STOL, this task entails developing and demonstrating the use of optimized variable speed targets to reduce congestion. In coordination with technology deployed in operating vehicles, the variable speed recommendations are designed to provide travelers the benefit of improved highway performance. The speed recommendations originate in a traffic management center (TMC; or, for purposes of this study, a surrogate for a TMC communicating to roadside equipment is acceptable). The TMC will calculate the ideal speed to create a safe traffic flow while maximizing vehicle throughput, thereby providing an overall benefit to the traveling public. The TMC will transmit the speed information to connected vehicles that contain communications and timing technologies combined with CACC to implement the system. Drivers of the connected vehicles can opt-in to the speed harmonization system provided, and the TMC will update the information sent to the vehicles to maintain the improved performance. Initial engineering development and testing will be performed at the Turner-Fairbank Highway Research Center STOL, followed by field tests.

Traffic Bottlenecks Identification and Diagnosis, Countermeasure Prioritization, and Innovative Solutions to Local/Systemic Problems

The primary goal of this Federal Highway Administration (FHWA)-sponsored project is to provide guidance about the characteristics of localized congestion/bottlenecks that occur on a facility level and relevant existing and innovative solutions to localized congestion/bottlenecks that are primarily on the infrastructure side and low-cost in nature. It is understood that the solutions space for systemic congestion will positively impact localized congestion/bottlenecks primarily by lowering traffic demand or significantly increasing supplies with multimillion/multibillion dollar infrastructure improvements. However, the scope of this project will limit itself to identifying existing literature and research materials about the solutions space for systemic congestion and will not try to research innovative solutions or improve existing solutions for systemic congestion.

This project involves six tasks to support the vision of this initiative. During the first part of the project, Tasks 1 through 4 will provide for progressive development of traffic bottleneck identification and diagnosis and countermeasure prioritization guidance that is helpful to state and local agencies. These tasks will involve the completion of a series of interim deliverables. During the second part of the project, Tasks 5 and 6 will provide the platform for researching new solutions to bottlenecks and developing additional guidance for selected low-cost innovative treatments. These tasks will also include the completion of a series of interim deliverables.

Use of Probe Data for Arterial Roadway Travel Time Estimation and Freeway Medium-term Travel Time Prediction

Urban traffic congestion is a problem that plagues many cities in the United States. One approach to alleviating such congestion is to provide drivers with better travel time information so that they can make better departure time and routing decisions. This research project focuses on two efforts: 1) Validating the use of probe data to estimate arterial travel times; and 2) Validating and developing techniques to predict freeway travel times during a two- to four-hour window. With regard to arterial travel time estimation, the objective is twofold. The first goal is to provide a comprehensive validation of INRIX arterial probe data. During validation, the variability and reliability of arterial data in different corridors equipped with permanent and portable Bluetooth detectors will be studied under different traffic conditions. The second objective is to develop a methodology for augmenting INRIX data with other data sources to improve the data quality. With regard to freeway travel time prediction, the objective is also twofold. The first objective is to validate existing medium-term travel time prediction algorithms along one or two corridors in the state of Virginia. The second objective is to enhance the medium-term prediction accuracy using various artificial intelligence and traffic modeling techniques.

Guidance for Alternative Intersections

State and local DOTs are searching for guidance about how to move forward with the analysis of "Alternative Intersections/ Interchanges." Recently, significant interest has developed in the double crossover diamond interchange (DCD; also known as divergent diamond interchange [DDI], the displaced left turn [DLT], the median U-turn [MUT], and the restricted conflict U-turn [RCUT]) that is proliferating for converting existing intersections and for facilitating new construction. Currently, most analyses are conducted using microsimulation software that is time consuming and costly at early analysis. The Highway Capacity Manual (HCM) does not have analysis procedures for alternative intersections, with the exception of roundabouts.

The objective of this research effort is to develop HCM analysis procedures for evaluating the capacity and quality of service of the DCD, DLT, MUT, and RCUT. These procedures or guides should include extensions of HCM methods to address gaps in the HCM relevant to the operations of these advanced intersection types. The analysis procedure and guide should be suitable for inclusion in Volume 4 of the 2010 HCM and will be issued as an FHWA Traffic Analysis Document. CSM is part of a multi-university team working on this effort.

CoSMob: Cooperative Systems for Smart Mobility Services and Solutions

The goal of CoSMob is to explore the potential of using real-time information collected from cooperative transportation systems via vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication and to produce useful mobility information that could be disseminated through multiple communication technologies to drivers, traffic controllers, service providers, and transport authorities. Specifically, the project will build an integrated end-to-end system (framework) for capturing, processing, analyzing, and delivering (near) real-time V2V or V2I data/information to produce multimodal mobility management services that can enhance the performance of the overall transportation network. The CoSMob engine will be plugged into the MasarakTM of QUWIC. In addition to this integration, CoSMob will make use of the CopITS, a three-year National Priorities Research Program (NPRP) project that began in December 2010. Onboard units (OBUs) and roadside units (RSUs) are aftermarket products under development at QUWIC. This

project is funded by the NPRP of the Qatar National Research Foundation (QNRF). This is a collaborative effort between the Qatar Mobility Innovations Center and VTTI.

Ongoing Projects

MAUTC Penn State

MAUTC has been the federally designated university transportation center (UTC) for Region 3 since the inception of the UTC Program in 1988. CSM leads the Virginia Tech team within a consortium that also includes Penn State (lead university), University of Maryland, University of Virginia, and West Virginia University. For much of its history, MAUTC has functioned as a research funding clearinghouse for its constituent members. The changing transportation profession dictates that MAUTC also function as a clearinghouse for knowledge creation, knowledge management, and knowledge implementation. MAUTC is a single entity serving multiple, non-university stakeholders who are part of the transportation enterprise of the mid-Atlantic region.

TranLIVE UTC

TranLIVE is a Tier 1 UTC. The theme of TranLIVE is, "Transportation for Livability by Integrating Vehicles and the Environment," with an emphasis on developing technologies to reduce the environmental impact of transportation. The TranLIVE UTC is a consortium of five universities: the University of Idaho (lead), Virginia Tech, Texas Southern University, Syracuse University, and Old Dominion University. The mission of TranLIVE is to help the nation achieve the goals of a cleaner environment and greater energy independence through 1) eco-traffic signal-system technologies, 2) eco-routing tools, and 3) alternative fuels and vehicles. More accurate and reliable vehicle emission and fuel consumption models will be developed by integrating vehicle and environmental data systems. These efforts will lead to improved technology for the industry and better decision-making tools for transportation and land-use officials.

This mission supports the U.S. DOT strategic goals of livable communities and environmental

photo by Kim Peterson

sustainability by developing integrated engineering solutions to better manage planning and land use (livability) and by reducing energy and environmental impacts (sustainability) of the transportation system.

Eco-signal Evaluation

As part of an FHWA-funded effort, CSM researchers developed an algorithm to compute the fuel-optimal speed profile of a vehicle approaching a signalized intersection that displays a red indication for different values of time-to-green (TTG). The optimized vehicle trajectory is part of an Eco-Speed Control Model. To predict the most fuel-optimal speed trajectory and advise a driver of the optimal actions to take, the model incorporates information received about future signal changes from an upcoming traffic signal controller using V2I communication. As a vehicle equipped with V2I communication capability enters the dedicated short-range communication (DSRC) scope of a particular intersection, the vehicle receives information about lead vehicles and upcoming signal changes. If the vehicle can maintain its current speed and safely pass through the intersection while the light is green, then it is directed to do so. If the traffic signal indication is yellow, the algorithm calculates if the vehicle can accelerate to some value below a set limit (usually the speed limit) and pass through the intersection safely before the red indication is introduced. If this is possible, then the vehicle is controlled to proceed as directed. If the vehicle arrives while the traffic signal is red, then the algorithm computes the fuel-optimal speed profile so that the vehicle arrives at the intersection stop line when the traffic signal turns green and all queues have been cleared. The proposed research effort will use the eTEXAS model to test the proposed algorithm. The test will consider various intersection geometries, various arrival rates, different expected times of arrival, different DSRC scopes, and different initial queues to quantify the potential benefits of such a system. The work plan includes the following tasks: a) Develop an optimization approach to compute the optimum vehicle trajectory; b) Develop an algorithm to estimate queue lengths and queue clearance times using DSRC and loop-detector data; c) Provide support to implement the proposed logic within the eTEXAS model; d) Provide support to implement the Virginia Tech Comprehensive Power-based Fuel Model (VT-CPFM) within the eTEXAS framework; and e) Construct sample networks and conduct a sensitivity analysis.

Completed Projects

MAUTC Data Quality Needs Assessment

The objective of this MAUTC/VDOT-sponsored effort was to prepare and disseminate accurate medium-term travel-time predictions (i.e., up to 120 minutes in advance) for a major corridor between Richmond and Virginia Beach using probe-based INRIX data. The study section that was considered included Interstate 64 (I-64) from Interstate 295 (I-295; east of Richmond) to Interstate 264 (I-264). Project tasks included: 1) Assembling INRIX data and constructing a database of historical data categorized by the day of the week and weekends for the entire freeway section from Richmond to Virginia Beach; 2) Developing data imputation techniques and k-Nearest Neighbor (kNN) algorithms to identify similar spatiotemporal conditions for use in travel-time prediction and considering the use of pattern recognition and other statistical techniques to identify comparable conditions; 3) Testing the algorithm by displaying the travel times on VDOT variable message signs (VMSs); and 4) Writing a final report documenting the findings of the study.

Blue Castle Nuclear Plant Evacuation Study

This project entailed approximating the evacuation time estimate (ETE) in the vicinity

of the Blue Castle Nuclear plant in Green River, Utah. Dr. Hesham Rakha led a team from VTTI that conducted the modeling study of the evacuation plan. In accordance with the draft guidance, a minimum of 10 evacuation scenarios were modeled to reflect seasonal, day-of-the-week, weather, special events, and roadway impacts on ETEs. These scenarios were developed to identify combinations of variables and events, provide ETEs under varying conditions, and support protective action decisions. The scenarios included a range of potential evacuation situations dependent on site-specific considerations. The team also considered the introduction of staged evacuations as alternatives to a keyhole evacuation. Staged evacuations necessitate the evacuation of one area while adjacent areas are ordered to shelter in place until directed to evacuate. For each evacuation scenario, an estimate of the time to complete a staged evacuation was provided to support protective action decision making. The ETE report included a discussion of the approaches used during the development of staged evacuations.

Region 3 University Transportation Center

The theme of the Region 3 UTC was "Technology for Integrated Transportation Systems Operation and Performance." The theme recognized that now and in the future transportation needs to be envisioned as a set of mobility options that are fully integrated to ensure optimal system performance. For too long, transportation has been considered a series of modes with discrete missions, goals, customers, and problems. The nature of the obstacles that have to be faced and the complexity of transportation system elements dictate use of advanced technologies to formulate solutions. With innovative solutions in hand, the national strategic objectives of safety, mobility, global connectivity, environmental stewardship, and security can be addressed effectively.

Developing Eco-driving Strategies

Numerous variables influence vehicle energy and emission rates. These variables can be classified into six broad categories: travel-, weather-, vehicle-, roadway-, traffic-, and driver-related factors. To reduce fuel consumption and emissions, significant efforts are required to decrease the total trip distance and improve vehicle technologies and road infrastructure. Several research efforts have studied the impact of aggressive driving on fuel consumption and emission rates (Nam et al., 2003; Nesamani and Subramanian, 2006; Tzirakis et al., 2006). One study from Sierra Research found that aggressive driving is responsible for 15 and 14 times greater carbon monoxide (CO) and hydrocarbon (HC) emissions for the same trip (NRC, 1995), respectively. This project was sponsored by MAUTC.

MAUTC Rollover Propensity Estimation

This MAUTC-funded regional project involved fundamental collaborative research between Penn State and Virginia Tech. The project included two tasks. Task 1 entailed developing calibration tools to estimate the vehicle mass and center of gravity for use in a vehicle safety system. This task will make it possible for vehicles to inexpensively estimate their inertial parameters on the road. This will enable vehicle safety algorithms to adapt to changes in loading, thereby significantly improving the safety of on-road vehicles. Task 2 entailed battery health prognostic and diagnostic algorithms that can predict, detect, and isolate catastrophic plug-in hybrid electric vehicle (PHEV) battery failures before they cause significant vehicle damage and/or accidents on the road. This task will enable vehicles to accurately estimate the states of health of battery packs on the road. This action will allow relevant vehicles to use battery packs safely and efficiently, thereby improving overall vehicle fuel economy and minimizing the likelihood of catastrophic battery failures on the road (e.g., thermal runaway).

photo by Michael Kiernan

Center for Sustainable Transportation Infrastructure

The Center for Sustainable Transportation Infrastructure (CSTI) focuses on asset management, road surface characterization, general pavement design, and life-cycle cost assessment. The mission of CSTI is to: 1) Advance the state of knowledge and provide quality education and research in transportation/infrastructure areas; 2) Conduct outreach activities designed to disseminate and implement CSTI research on national and international levels; and 3) Enhance the transportation infrastructure workforce by increasing the number of graduate students in the pavement and infrastructure fields and strengthening the undergraduate transportation infrastructure track.

photo by Logan Wallace

New Projects

Sustainable Pavements

A priority for all transportation agencies is the construction and maintenance of a reliable and sustainable transportation infrastructure that is economically viable, minimizes the impact on the environment, and operates fairly. Highway construction, maintenance, and operation are the most important areas of infrastructure in which sustainability must be achieved. The National Sustainable Pavement Consortium brings departments of transportation (i.e., Mississippi, Pennsylvania, Virginia, and Wisconsin) and the Federal Highway Administration (FHWA) together to share ideas and experiences and to establish a common agenda encouraging the use and development of more sustainable pavements.

Topics that will be investigated are:

- Examining emerging sustainable materials, technologies, products, and pavement systems; facilitating their adoption; and testing approaches and methods needed to implement these technological improvements.
- Identifying an appropriate set of metrics that comprises all aspects of pavement sustainability and the adaption or development of tools designed to assess pavement sustainability on qualitative and quantitative scales.
- Examining how sustainability considerations will affect all aspects of pavement engineering, such as planning, design, construction, maintenance, management, and reclamation.
- Investigating the effect of climatic change on regional pavement engineering in terms of design, construction, maintenance, and management.
- Developing tools designed to assess pavement sustainability on qualitative and quantitative scales.

Structural Index II

One of the key business functions of network-level pavement management is to support the selection of pavement sections in need of work and the assignment of "general" pavement treatments to these candidate projects based on smoothness and surface distress data. This practice does not take into consideration the structural capacity, which results in inefficient maintenance strategies. The recent addition of a network-level falling weight deflectometer (FWD) to the data collected by the Virginia Department of Transportation (VDOT) has made possible the inclusion of pavement structural capacity in the design of treatments.

Phase I of this proposed project developed a structural index for flexible pavements to use in network-level pavement evaluation, which facilitates the inclusion of the pavement structural condition into pavement management applications. This proposed Phase II of the project focuses on the development of a similar index for composites and pavements.

The objective of this project (Phase I and Phase II) is to develop tools to analyze pavement structural capacity at the network level. The products of the effort include:

- A "structural" pavement condition index that can be used for network-level pavement management;
- An algorithm to scope pavement maintenance and rehabilitation projects at the network level; and
- A framework for specifying structural capacity thresholds based on non-destructive evaluation and analysis.

Ongoing Projects

Splash and Spray

This project is designed to develop an assessment tool for characterizing the propensity of highway sections to generate splash and spray during rainfall and for this propensity to be assessed in terms of impact on drivers. The project will deliver a robust model to predict splash and spray generation and will comprise three components: 1) Water-film model, 2) Splash/spray model, and 3) An exposure model. The final model

will be practical and applicable by all highway administrations throughout the country.

An emphasis is being placed on identifying the input parameters that are necessary for a robust model and how these parameters should be measured. The tool, which will subsequently be developed into an appropriate software application, will contribute to ongoing efforts of improving user satisfaction with public highways. The project scope includes: 1) Evaluation of prior work in the area of splash and spray mechanisms; 2) Development of a model to predict water-film thickness and splash and spray occurrence on pavement surfaces, encompassing an appropriate range of conditions; 3) Validation and refinement of the model developed; 4) Development of recommendations as to threshold criteria used to classify the impact of splash and spray on highway users; and 5) Documentation of the development efforts and preparation of technology transfer materials.

Pavement Surfaces Properties Consortium

This collaborative project establishes a research program focused on enhancing roadway transportation system services by optimizing pavement surface texture characteristics, including friction, splash and spray, and tire-pavement noise. Other organizations participating are the FHWA and the Connecticut, Georgia, Pennsylvania, South Carolina, Mississippi, and Virginia DOTs.

The program is designed to evaluate equipment used to measure pavement surface properties and other emerging technologies that show promise for improving measurements and innovative pavement surfaces and pavement preservation treatments. The collaborative research program provides an accessible and efficient way for highway agencies and other organizations to conduct research about pavement surface texture and smoothness. The program also helps participants verify the operation and accuracy of their equipment used for pavement evaluations and road construction quality control.

Current projects include: 1) An annual equipment "rodeo" to compare each partners' equipment used to measure pavement surface properties; 2) Seasonal monitoring of friction and macrotexture of different surfaces to investigate the need for seasonal correction factors; 3) Development of stereovision technology used to measure macrotexture; 4) Continuous Friction Measurements Technology Deployment; 5) Evaluation of high-friction surfaces; 6) Evaluation of the feasibility of implementing the International Friction Index in the U.S.; and 7) Organization of the 7th Symposium on Pavement Surface Characteristics SURF 2012, held September 19-22 in partnership with The Road World Association, American Association of State Highway and Transportation Officials (AASHTO), FHWA, and the Transportation Research Board (TRB).

Preventive Maintenance

The objective of this project is to improve the preservation of state pavements by compiling the main findings from current practices of pavement preservation, evaluating the most promising treatments, and developing guidelines and construction practices that can be used by VDOT to define the most appropriate pavement preservation methods and timing for roads in Virginia.

Project researchers participated in the VDOT Pavement Management System (PMS) training held in the Richmond Central Office by the Pavement Maintenance Division with the updated version of the program. The PMS

program will facilitate evaluations of the historical performances of several preservation treatments. This evaluation should produce ideal criteria for more effective implementation of the suggested preservation approaches to be made as part of this study. A simplified user's guide for the PMS suggesting possible alternatives for different preventive maintenance treatments will be created as part of the project.

Quiet Pavement

The objective of this research is to support the Virginia Center for Transportation Innovation and Research (VCTIR) efforts for documenting all aspects of the progression to "routine application of quiet pavement." Specific tasks include the determination of as-constructed functional and structural properties of the various technologies to be evaluated via performance monitoring during two full winters of service.

During this project, several different parameters described below will be measured to conduct performance monitoring of the five Quiet Pavement Test Sites built by VDOT:

- Onboard Sound Intensity (OBSI; noise);
- Continuous Friction Measurement Equipment (CFME) dynamic friction (Grip Tester);
- Static Friction with the Dynamic Friction Tester (DFT);
- Static Macrotexture with the Computerized Tomography (CT) Meter; and
- Pavement markings, retroreflectivity, and color measurements.

Additionally, data processing of other parameters (e.g., smoothness, locked-wheel skid, etc.) will be supported and used during the development of the Interim Report for The Virginia Quiet Pavement Implementation Program to the General Assembly.

The OBSI software developed for CSTI was recently updated to facilitate data processing and analysis. It was also used to compare results against a system that has participated in the national OBSI rodeos, having shown ideal correlation.

Reclaimed Asphalt Pavement

The use of reclaimed asphalt pavement (RAP) in asphalt mixtures has steadily increased during recent years. Furthermore, with growing awareness of greener and more sustainable practices and increases in oil prices, state DOTs have considered the economic and environmental benefits of integrating greater percentages of RAP into their mixes.

The objective of this project is to investigate the effect of increasing the amount of binder content on the performance of high-RAP surface mixtures. Because the aged binder in the RAP tends to improve rutting resistance and degrade cracking resistance, the latter effect may be offset by an increase in the percent of asphalt binder compared to the optimal asphalt content obtained using the Superpave mix design procedure. With the practice of many Virginia asphalt producers to fractionate RAP (FRAP), better control over mix gradation can be achieved, which allows greater RAP to be incorporated into the mixture.

The direct benefit of the project is the potential to increase mix stiffness, mix durability, and mix fatigue resistance with high-RAP content mixes. Furthermore, increasing RAP content has potential environmental and economic benefits that will result in more sustainable pavements. The benefits should be relevant to both asphalt producers and VDOT.

Center for Technology Development

The Center for Technology Development (CTD) develops, manufactures, implements, and maintains innovative data acquisition, collection, logistics, and analysis systems in support of transportation research.

Connected-vehicle hardware designed by CTD • photo by Logan Wallace

Overview

The Center for Technology Development (CTD) collaborates with other VTTI centers and groups to provide research support. CTD researchers continuously develop advanced systems for data collection with the goal of gathering a range of detailed data while remaining unobtrusive to participant drivers.

CTD comprises the following groups: Mechanical Systems, Data Acquisition, and Advanced Development. These groups provide technical support for various projects and the Smart Road.

CTD continues to create solutions in response to the ever-changing requirements of VTTI research centers and sponsors. CTD initiatives include, but are not limited to:

- The technical capability and reliability of the current VTTI data acquisition system (DAS), which provides increased data acquisition rates and throughput via updating of communication and processing hardware.
- The implementation, instrumentation, and recovery of data from vehicle- and infrastructure-based DASs and the performance of offsite repairs and initial data quality checks.
- Continued development of the highly integrated VTTI DAS, which offers increased research parameters and reduced unit size designed to significantly decrease installation times, increase data sampling rates and throughput, provide corrected vehicle dynamics data, and render improved video compression and quality.
- Continued development of machine-vision capabilities related to driver, vehicle, and roadway metrics.

Mechanical Systems Group

The Mechanical Systems group is responsible for extensive mechanical fabrication ranging from small to large hardware designed to suit the needs of all research projects. The group can tailor these fabrication techniques to research needs based on size and requirements by using various methods such as sheet-metal forming, vacuum-bagging composites and thermo-forming plastics to computer numerical control (CNC)-machined parts created using the group's four-axis Haas, and finishing in-house using the CTD anodizing/paint/power coat facilities. The group can also design complex components using low- and high-volume injection molding, urethane casting, and many of the current rapid prototyping technologies. The group uses three-dimensional laser scanning software and computer-aided design (CAD) technology to reproduce complex geometry and to design custom components featuring seamless integration. The group's ability to design, evaluate, and simulate in a digital environment results in the reduced developmental time of a project. The support, maintenance, and upgrades of all Smart Road facilities and equipment are also performed by the group.

Data Acquisition Group

The Data Acquisition Group is responsible for electronic hardware design. The group's capabilities span advanced circuit board design using arm processors, digital signal processors (DSPs), and field-programmable gate arrays (FPGAs) to system integration and project development from conception to completion. The group is a pioneer in the fields of distributed DASs, covert surveillance, and large-field DAS deployments. The group develops software and firmware for use in VTTI DASs as regulated by researchers' needs. The group also supplies and implements data triggers for use during data collection. CTD personnel install DASs in VTTI-owned, participant, and commercial fleet vehicles and in highway infrastructure locations (e.g., intersections). The group is responsible for tracking and locating subject vehicles and infrastructure locations and collecting research data. Preliminary quality control is performed in the field to identify and address

data acquisition issues; DASs are repaired as needed. CTD tracks and performs causal analysis and reports data loss for subsequent corrective actions.

Advanced Development Group

The Advanced Development Group is responsible for software development at VTTI. The group comprises specialists in real-time data acquisition hardware and software development, machine-vision road tracking, machine-vision head tracking, and data analysis advancements. In support of transportation research safety, CTD developed hardware, software, and firmware for the VTTI Next Generation DAS. The system is smaller in size and includes new and improved parameters for use during transportation research, including the development of advanced machine-vision algorithms that facilitate remote sensing of driver performance.

CTD has provided support for the following projects:

- Integration Requirements Definition for Connected-vehicle Interfaces
- Connected-vehicle Communications Safety Pilot Driver Clinics Supervisor
- Human Factors for Connected-vehicle Guideline Development
- Crash Avoidance Metrics Partnership Model Deployment
- Field Demonstration of an Advanced Heavy-vehicle Indirect Visibility System
- Enhancement of Camera/Video Imaging Systems (E-C/VIS) for Heavy Vehicles
- 511 Virginia, Software Development
- Design of the In-Vehicle Driving Behavior and Crash Risk Study
- Naturalistic Teenage Driving Study
- Assessment of a Drowsy Driver Warning System (DDWS) for Commercial Vehicle Drivers
- Human Performance Evaluation of Light-vehicle Brake Assist Systems
- Cooperative Intersection Collision Avoidance System for Violations (CICAS-V)
- Driver Distraction in Commercial Vehicle Operations
- Detection-control System (D-CS) Field Evaluation
- Disability Discomfort Glare Task
- Collision Warning System
- Proprietary Major Automotive Company (MAC) Research
- Development of the Luminance Camera System
- Older Driver Data Collection
- Product Development
- Evaluation of Enhanced Brake Lights Using Surrogate Safety Metrics
- Signalized Intersection Red Light Running and Dilemma Zone Study
- Commercial Motor Vehicle Driving Simulator Validation (SimVal) Study, Phase II
- Comparison of Object Detection and Identification with an Advanced C/VIS (A-C/VIS) and a Commercially Available C/VIS on Heavy Trucks
- Pilot Study of Instrumentation to Collect Behavioral Data to Identify On-road Rider Behaviors
- Enhanced Rear Signaling for Heavy Trucks
- Backing Countermeasures Mini-field Operational Test (FOT) – Naturalistic Observational Study
- Hardware-in-the-loop Evaluation of the Bendix ESP System for Tractor Semi-trailers

CTD performs data checks on equipped vehicles • photo by Logan Wallace

Center for Truck and Bus Safety

The Center for Truck and Bus Safety (CTBS) conducts research and development efforts to advance the state of knowledge in the truck and bus safety domains and provides pragmatic solutions to real-world problems. CTBS specializes in providing quality education and research focused on a variety of safety issues involving heavy-truck and bus operations.

CTBS comprises three groups specializing in the following areas:

- Advanced Systems and Applications
- Behavioral Analysis and Applications
- Safety and Human Factors

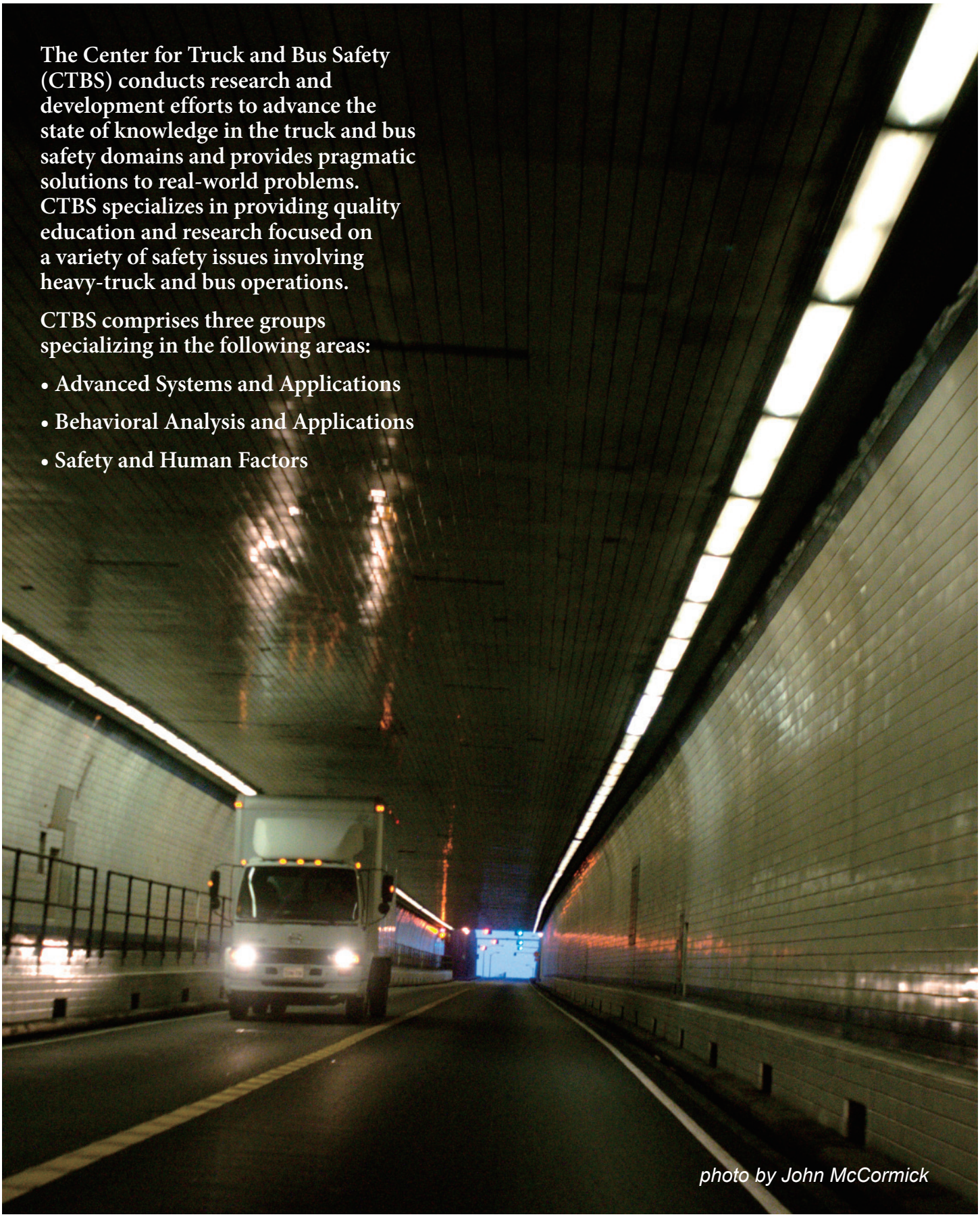


photo by John McCormick

New Projects

Winter Maintenance

Equipment operators working during winter events are exposed to long and stressful work hours, and fatigue associated with these operations results in higher accident rates, lower productivity, and increased health issues. This project is investigating the environmental stimuli that contribute to operator fatigue and is recommending practical, low-cost mitigation solutions. This project is focused on work and rest schedules and how they relate to driver fatigue when operating trucks with and without advanced in-cab instrumentation, as well as the causes of fatigue-related incidents and applicable functional countermeasures to reduce fatigue and potential fatigue-related incidents. This project is sponsored by the Minnesota Department of Transportation.

Establishing a Methodology to Evaluate Teen Driver Training Programs

Based on the higher crash risk level of teen drivers, the Wisconsin Department of Transportation (WisDOT) has been dedicated to implementing new driver education programs in hopes of improving the driving skills and behavior of their teen driver population. While WisDOT has established an exhaustive process to license driver training schools, the department does not have established methods to analyze the entire statewide construct of how young drivers are trained. To date, these programs have not undergone an objective evaluation of effectiveness. Therefore, a clear need existed for the development of methodologies to objectively analyze and evaluate the effectiveness of such new programs. For the current research project, VTTI is developing a methodology and identifying potential data sources to analyze and evaluate the effectiveness of driver training programs as they relate to the demonstrated safety and behavior of teen drivers in Wisconsin.

Evaluating the Potential Safety Benefits of Electronic Logging Devices (ELD)

Electronic logging devices (ELDs) are primarily designed to improve efficiency. However, Cantor et al. (2009) used a survey, combined with state crash data from the Federal Motor Carrier Safety Administration (FMCSA) Safety and Fitness Electronic Records and hours-of-service (HOS) violations from the FMCSA Safety Management Measurement System, to model the potential impact of full ELD adoption on crashes and HOS violations. Cantor et al. (2009) found that full ELD adoption could potentially reduce HOS violations by 12.4 percent and total crashes by 15.6 percent. Moreover, FMCSA (2011) estimated that electronic onboard recorders (EOBRs) have the potential to reduce HOS violations by up to 40 percent. Although the Cantor et al. (2009) and FMCSA (2011) studies were able to show that EOBRs could reduce HOS violations and crashes, these studies have several methodological limitations that reduce the validity and generalization of their findings. For example, the Cantor et al. (2009) study only used state crash data. During an analysis of carrier-collected crash data, Hickman et al. (2011) found that almost 20 percent of crashes were not reported to the state in which the crash occurred (mainly because these were low severity crashes). The Cantor et al. (2009) study also did not include a measure of exposure (miles or driving hours), nor could the authors identify if the truck involved in a crash or HOS violation had an ELD (for those carriers without full EOBR adoption). Thus, the estimates of EOBR effectiveness provided by Cantor et al. (2009) should be viewed with caution. The current study will attempt to address several of the limitations of the Cantor et al. (2009) and FMCSA (2011) studies. First, the current study will use carrier-collected crash data to obtain a more representative picture of how ELDs perform under real-word driving conditions. Second, the analysis will be at the truck level; thus, trucks with EOBRs

will be compared to trucks without ELDs (i.e., VTTI will be able to differentiate crashes and HOS violations involving a truck with an ELD and those without). Third, a measure of exposure will be calculated (miles traveled) at the truck level. Lastly, although the sample of participating carriers in the current study will be a convenience sample, every attempt will be made to obtain a sample that is representative of the general commercial motor vehicle (CMV) population.

Field Study on the Efficacy of the New Restart Provisions for Hours of Service

VTTI is the prime contractor on this project, with the Washington State University Sleep and Performance Research Center serving as the subcontractor. It is well known that, at times, commercial truck drivers are at a high risk of driver fatigue due to irregular sleep cycles, inadequate rest breaks, and tight delivery schedules. During 2011, FMCSA adopted an updated HOS rule that, among other changes, allows truck drivers to "restart the clock" on their weekly on-duty period by going off-duty for at least 34 consecutive hours at their home terminal. This option may only be used once every seven days, and the restart period must include two periods that span the 1 a.m. to 5 a.m. time frame. Sponsored by FMCSA, the research team is charged with conducting a naturalistic investigation of the efficacy of the new 34-hour restart provision for truck drivers, which went into effect with a compliance date of July 1, 2013. Data about the duty schedules and sleep cycles of more than 100 truck drivers will be collected during a period of several months. Data will then be analyzed to determine if the flexibility of this updated rule directly translates into not only better health and a more sustainable working environment for truck drivers, but safer roadways for all.

Multiple Sources of Safety Information from V2V and V2I: Redundancy, Decision-Making, and Trust

VTTI is the prime contractor on this project, with Battelle Memorial Institute serving as the subcontractor. This project seeks to enhance the understanding of how drivers handle critical safety information received from multiple sources. This includes in-vehicle sources (e.g., vehicle-to-vehicle [V2V]) and external sources (e.g., vehicle-to-infrastructure [V2I]). Areas of interest include how drivers deal with different sources of information and how they decide which source to trust, consistency in messages, timing, and differences in definitions and terminology/symbology. This project is being sponsored by the National Highway Traffic Safety Administration (NHTSA).

Field Study of Light Vehicle Crash Avoidance Systems

VTTI is the prime contractor on this project, and the University of Michigan Transportation Research Institute (UMTRI) is serving as the subcontractor. This project is focused on collecting and analyzing performance and operational data about production crash avoidance systems being offered on new light-duty vehicles. This research seeks to better understand driver responses to crash warnings, variables associated with crash avoidance systems, and reliability and practicality of these systems. This project is being sponsored by NHTSA.

Heavy Truck Crashworthiness

VTTI is the prime contractor for this project, and UMTRI is serving as the subcontractor. While safety in the operations and functioning of heavy vehicles has increased, the fatalities and injuries from truck crashes are still high and continue to reinforce that truck driving is one of the more dangerous jobs in the United States. This project is analyzing and evaluating existing data sets for a more detailed understanding of the scope and details of truck driver injury in traffic accidents in relation to cab crashworthiness. UMTRI is also investigating regulations and industry trends related to truck occupant protection. The

goal of this project is to assemble information about truck driver injury in crashes to assist in the understanding of injury mechanisms and to review regulatory and industry initiatives concerned with reducing the number of truck occupant fatalities and the severity of injuries. This project is being sponsored by NHTSA.

Enhancements to Safety Benefits Estimator Tool Kit for Heavy Vehicle Collision Mitigation Braking Systems

VTTI is the prime contractor for this project, and UMTRI is serving as the subcontractor. NHTSA, in consort with leading industry crash avoidance system suppliers and a research university, completed the development of a methodology and associated "toolkit" that can be used to estimate the safety benefits of forward collision warning (FCW) and collision mitigation braking (CMB) systems. Through this project, UMTRI is working to address accuracy, confidence levels, and transparency of the existing toolkit for CMB systems. Through the research team efforts, the toolkit will be more beneficial and will improve the output capability of the model. The overall documentation of the toolkit will be improved. This project is being sponsored by NHTSA.

Effects of Detention Times on Commercial Motor Vehicle Driver Safety and Operations

Long detention times have potential safety and operational impacts, including HOS violations. The purpose of this FMCSA-sponsored project is to better understand the nature of the problem of detention times in the CMV industry and the potential safety and operational impacts that can occur as a result of long detention times and to develop strategies to mitigate driver risks. The study will seek objective measures of detention time and the extent to which it: (i) is associated with increased crashes and other factors that lead to crashes and (ii) contributes to drivers violating HOS violations. As such, the study is envisioned to have two phases. During Phase I, the average detention time will be assessed by the type of trucking operation (e.g., short, line, long haul) and the size of trucking operation (e.g., small, medium, large). A methodology will also be developed for evaluating the safety and operational implications of driver detention times on work hours (e.g., fatigue), HOS violations, out-of-service violations (OOS), and crashes. During Phase II, a yet-to-be determined contractor will implement the methodology developed in Phase I to assess the safety and operational impacts of driver detention time on work hours, HOS and HOS violations, and crashes. The selected contractor will also conduct focus groups to assess driver, carrier, and shipper opinions and perceptions regarding detention times and potential means that could be used to reduce detention times.

Ongoing Projects

Evaluation of Heavy Vehicle Crash Warning Interfaces

While commercially available crash warning systems have been available for some time, the implementation of such systems has varied widely with regard to the human-machine interface. The purpose of this project is to examine aspects of the human-machine interface of heavy-vehicle crash warning systems and determine the potential benefits or disbenefits associated with certain display properties. The final product of this project will include comprehensive interface design guidelines for heavy-vehicle crash warning systems. This project is being sponsored by NHTSA.

Onboard Monitoring System Field Operational Test

The objective of this FMCSA-sponsored project is to determine whether an onboard monitoring system (OBMS) will reduce at-risk behavior among commercial drivers and improve driver safety performance. This project will determine if safe driving behavior may be enhanced by recording and reporting

safety-critical events (SCEs), with safety managers subsequently coaching the driver using these safety events as feedback. This system will also contain an EOBR that will be evaluated. Operator monitoring and feedback can be characterized as a behavior-based safety method. Safe behavior is rewarded, and unsafe behavior is coached, thereby proactively improving overall safety. The OBMS to be used during this study will record, through snippets of video and other performance/kinematic measures, unsafe driving behaviors and will provide real-time feedback to drivers. Recorded driver problems (e.g., hard braking) will then be transmitted to and reviewed by the driver's fleet safety manager. Depending on the judgment of the fleet safety manager, the recorded incident can then be shown to the driver during a coaching session with the goal of pinpointing the problematic behavior and providing instruction about how to avoid that problem in the future. Corrected action and improved behavior are the expected results of drivers viewing their recorded errors alongside their safety managers and receiving instruction as to the nature of the problematic behavior. Hypothetically, successful implementation of the OBMS program may significantly reduce the number and severity of crashes involving CMVs.

Case-Control Commercial Driver Individual Differences Study

Sponsored by FMCSA, the objective of the Case-Control Commercial Driver Individual Differences Study (CDIDS) is to examine an array of driver and situational factors and

determine the prevalence of these factors and their relationships to crash involvement. The goal of CDIDS is to identify and prioritize commercial driver individual differences with respect to risk factors. These risk factors will comprise personal elements such as demographic characteristics, medical conditions, personality traits, personal attitudes, and behavioral history. Risk factors will also include conditions of the work environment, such as carrier operations type and compensation methods. The study will identify risk factors by linking the characteristics of individual drivers with their driving records during the duration of the study, especially the occurrence or absence of safety-related events (e.g., preventable crashes, crashes regardless of preventability, moving violations, and vehicle inspection violations).

Testing and Recommended Best Practices for Nurse Tank Safety

VTTI is the prime contractor on this project, and Iowa State University is serving as the subcontractor. This project aims to support the enforcement and possible rulemaking for the USDOT Modal Administrations. FMCSA and the Pipeline and Hazardous Materials Safety Administration (PHMSA) both have responsibilities in the safe transportation of hazardous materials and are responsible for nurse tank regulation. As a result of the National Transportation Safety Board (NTSB) investigation of the April 15, 2003, hazardous materials accident involving nurse tanks near Calamus, IA, NTSB made a safety recommendation regarding periodic, nondestructive testing of nurse tanks. This project is aimed at developing the testing and recommended best practices designed to address this recommendation. This project is sponsored by FMCSA.

Distribution of Stress Corrosion Cracks and Testing Specifications

VTTI is the prime contractor on this project, and Iowa State University is serving as the subcontractor. The main task of this project was to conduct ultrasonic testing on a range of agricultural nurse tanks during the summer of 2012. This study will provide data as to the extent of cracking that currently exists in the nurse tank population, the location of the cracking as it exists in each tank, and a measure of the size of indications found. With this data, valid statistical statements can be made for the first time concerning the distribution of cracks as a function of year of manufacture and location of cracking. Currently, only anecdotal information exists concerning where cracking can be expected to occur. The data will also provide a basis for subsequent recommendations concerning best practices for inspection. Finally, the study provides the foundation for further research about crack growth. Crack growth can be monitored during subsequent years via regularly scheduled inspections to determine how crack growth that occurs due to actual service conditions compares to predicted growth models developed during previous research. This project is sponsored by FMCSA.

Completed Projects

The Development of Guidelines and Materials to Enable Motor Carriers to Implement a Fatigue Management Program

Commercial carriers, regulators, and commercial vehicle drivers have historically responded to fatigue management by working/driving within prescribed HOS rules. Recent fatigue management research indicates that other factors are involved in driver fatigue and safety performance. There was sufficient knowledge available to facilitate the development of a guide for motor carriers that addresses the design of a Fatigue Management Program (FMP) and implementation into ongoing carrier operations. This project, sponsored by the Canadian Council of Motor Transport Administrators, developed an FMP as a series of modules, each covering required

topics and directed at specific audiences.

Performance-based Testing of Driving Skills/Capability

VTTI was the prime contractor on this project, and the University of Alabama at Birmingham (UAB) Edward R. Roybal Center for Translational Research on Aging and Mobility served as the subcontractor. The study focused on the analysis of crash statistics to determine whether older commercial drivers were at increased risk of crash involvement relative to their younger counterparts. Crash statistics from the 2011 commercial driver records were analyzed, and results indicated that commercial drivers aged 66 years or older had elevated risks for both fatal and injurious crashes relative to their younger counterparts. A literature review was conducted and reduced to those peer-reviewed studies in which a performance-based measure was used to predict prospective crash involvement. Few relevant publications were identified, indicating a need for additional data collection. A meta-analysis of the existing studies was conducted, and several performance-based measures were found to be associated with increased crash risk among older drivers. Based on the findings of this Phase I study, a Phase II study may be warranted to evaluate the costs and benefits of including performance-based tests that supplement the fit-for-duty exam mandated every two years for commercial drivers by the federal government.

Heavy Vehicle Crash Data Collection and Analysis to Characterize Rear and Side Underride and Front Override

VTTI was the prime contractor for this project, and UMTRI served as the subcontractor. While much analysis has been completed on crash and causation in heavy-vehicle crashes, front override and side underride have not been systematically studied. The purpose of this project was to enhance data collection and the understanding of the standards governing override and side underride guards by collecting and analyzing Trucks Involved in Fatal Accidents (TIFA) data. This effort was combined with a detailed clinical analysis of the Large-Truck Crash Causation Study (LTCCS) to develop an understanding of and critical features associated with rear and side underride SCEs. The final product of this project will expand the data available to assist in establishing better guidelines for fleets, identify gaps in existing data for analysis, and provide insight into safety risks associated with these heavy-vehicle components. This project was sponsored by NHTSA.

Driver Distraction: Eye-glance Analysis and Cognitive Distraction

This research project involved an analysis of existing naturalistic data collected and owned by SmartDrive Systems, Inc. Methods included the collection of these data to assess the prevalence of cell phone use and other distractions while driving a truck or bus. SmartDrive also assessed visual distraction and conversation workload. The objective of this FMCSA-sponsored project was to better understand the relationship of conversation load and visual distraction during mobile phone conversations or interactions while the driver is experiencing real-world driving conditions and pressures. The data set provided by the technology vendor only included vehicles with a gross vehicle weight of >10,000 pounds (e.g., trucks, buses, and three- [or more] axle trucks). Approximately 14,350 vehicles from 117 distinct fleets that

had a gross vehicle weight >10,000 pounds were in the database of the technology vendor. Approximately 20,000 crashes and near-crashes and 100,000 baselines were made available for analysis.

Expanded Research and Development of the Enhanced Rear Signaling System for Commercial Motor Vehicles

This project, sponsored by FMCSA, investigated methods designed to mitigate those crashes during which a heavy truck has been struck from behind by another vehicle. A series of static and dynamic empirical data collection efforts were made during a prior study (Phase III) to test and evaluate potential countermeasures. The most promising candidate was an enhanced rear signaling (ERS) system comprising 12 light-emitting diode (LED) units positioned on the rear of a trailer and a radar-based, collision warning activation system. Results indicated that the system performed well at detecting and signaling rear-end crash threats, drawing the gazes of distracted following-vehicle drivers back to the forward roadway, and did not result in any unintended safety-related consequences for surrounding traffic. The results were derived from controlled testing performed during fair weather and daylight hours on public roadways in Virginia. Although the prototype ERS system performed well, three system refinement efforts were identified as necessary prior to the ERS system being slated for real-world deployment. The objective of the current project was to conduct three development efforts towards the completion of a stand-alone ERS system ready for implementation in a field operational test. The first effort involved the refinement of the radar target identification firmware to reduce the likelihood of false alarms in lower speed, high-traffic scenarios. The second effort involved the design and modification of the ERS system into a unit designed for simple truck and trailer installation. The third effort involved testing the eye-drawing capability and associated discomfort glare of the rear warning-light system during nighttime conditions.

Linking Carrier Descriptive Attributes to Crash Patterns – An Untapped Tool in State Motor Carrier Safety Improvement Programs (Phase II)

This project was the second phase of a joint Virginia Department of Motor Vehicles (DMV) and Virginia DOT (VDOT) project that began in November 2010. A recommendation that resulted from the Phase I combination-unit truck (CUT) effort was that a separate analysis was warranted of single-unit truck (SUT)-involved fatal crashes similar to that conducted for CUTs. A preliminary analysis of the Virginia SUT-involved fatal crash data from 2005 to 2009 showed that 199 SUTs were involved in fatal crashes. That represents more than 40 percent of the total large-truck fatal crashes. More than 80 percent of these SUT fatal crashes occurred on non-interstate roads. A preliminary analysis also showed that almost 70 percent of the fatal crashes that occurred on non-interstate roads involved Virginia-domiciled carriers. To better understand the problem of non-interstate crashes, an analysis was conducted of the SUT fatal crashes that occurred in Virginia from 2005 to 2009.

Center for Vulnerable Road User Safety

VTTI Teen Driver Safety Days • photo by John McCormick

Center for Vulnerable Road User Safety (CVRUS) personnel conduct research and outreach activities focused on enhancing safety for all vulnerable road users, including senior and teen drivers, bicyclists and other vehicle riders, and pedestrians (especially the very young and the elderly). Vulnerable road users comprise all age groups and a variety of demographics. Their one shared trait is that they are all at increased risk of suffering a traffic-related crash or injury. They all require special concern and warrant research to support their continued safe transportation needs. The Center currently encompasses two groups: Teen Risk and Injury Prevention (TRIP) and Senior Mobility Awareness, Safety, and Health (SMASH).

Ongoing Projects

Practice Driving Study

This research, sponsored by the National Institute of Child Health and Human Development (NICHD), assesses the factors that are important during the practice driving phase when a teenager is driving with a learner's permit. The study will be an observational one of the nine months of the learner's permit (practice driving) phase and the first 12 months of independent driving. Driving skills and safety outcomes will also be assessed. The study will be conducted using the VTTI naturalistic data collection method and continuous data recording.

Previous research has shown that crash rates of novice teenage drivers are elevated during the first six months and 1,000 miles of independent driving. The amount of supervised practice driving has not been carefully measured, and little is known about the amount, nature, and timing of practice driving that adolescents obtain prior to licensure. The purpose of this study is to determine the effects of greater and lesser amounts of supervised practice driving on the driving performance of newly licensed teens.

Ninety teenaged participants were recruited to participate in this study prior to obtaining their learner's permits. All participants completed a series of questionnaires and surveys before and during their participation. A naturalistic method was used in which the participants' vehicles were instrumented with cameras, sensors, and radars. Instrumentation occurred on the vehicle in which most practice driving was anticipated to occur. Teenage driving was continuously recorded during the nine-month learner's permit phase and for 12 months after study participants received their licenses. Cameras were mounted unobtrusively to facilitate naturalistic driving behavior. Participants were instructed to drive the vehicles as they normally would throughout the learner's permit phase and the first 12 months of licensure. This resulted in a maximum of 24 months of data collection. Data were downloaded regularly from the vehicles without requiring any special effort from participants.

Study participants and their parents/supervisors were not instructed to practice in any particular way. However, the amount and variety of practice provided by the parent/supervisor and compliance with state laws (i.e., 45 supervised practice hours, 15 of which must be at night) will be analyzed. The first nine months of practice driving will then be compared with the outcomes of the first 12 months of independent driving.

Comparing the Driving Safety Benefits of Brain Fitness Training Programs for Senior Drivers

There is now substantive evidence that targeted training and training-related activities can improve the efficiency of the brain and that neural plasticity (i.e., changes in the structure, function, and organization of neurons in response to new experiences) is the mechanism that affords and supports cognitive changes throughout a person's life. Recent research efforts have indicated that older individuals can enjoy fairly long-term driving safety benefits from a variety of cognitive-training protocols. If such enhancements due to training can be successfully verified during actual driving, a breakthrough may be made in terms of maintaining safe mobility and independence among the older population.

The goal of the current study is to evaluate the efficacy of two different training-related protocols. The evaluation will be based on key performance metrics of driver behavior and safety to be measured initially and during a one-year,

post-training period.

Sixty-three male and female licensed drivers aged 70 and older will be recruited from the VTTI area to participate in the study. The training programs include:

• DriveSharp™ by Posit Science, an "at home," computer-based training program aimed at improving seniors' driving safety;

• An in-vehicle tool and protocol created by Toyota engineers that incorporates constructs related to useful field of view; and

• A control group that will undergo no protocols.

A 2012 Toyota Camry has been procured to serve as the experimental vehicle for this project, and experimental hardware, software, and protocols have been established. Pilot testing has been completed, and participant recruiting will soon commence.

This project is closely related to the Comparing the Driving Safety Benefits of Brain Fitness Training Programs for Senior Drivers project within the VTTI National Surface Transportation Safety Center for Excellence (NSTSCE).

Driver Distraction: Operational Definitions and Data Set Creation

The Second Strategic Highway Research Program (SHRP 2) naturalistic driving data set provides an unprecedented opportunity to investigate distracted driving behavior. The goal of this project, funded by the Toyota Collaborative Safety Research Center (CSRC), is to develop a data set of distracted-driving epochs and an associated data set of non-distracted baseline epochs. This data set will be provided to the SHRP 2 research community in the future to enable targeted investigation of distracted driving.

To enable the creation of such a data set, it was first necessary to operationally define distraction. This was the subject of a workshop in Washington, DC, which was followed by a report from VTTI expanding the results and placing them in the context of prior research. These operational definitions will be used to identify and code distracted driving events. The final data sets will comprise verified epochs of distracted driving and non-distracted, baseline driving.

Canada Naturalistic Driving Study

The Canadian Deputy Ministers of Transport and Safety have funded a large-scale naturalistic driving study (NDS) to be conducted in Canada. The deputy ministers have selected one data collection site in Saskatoon, Saskatchewan, and 125 participants will be recruited to drive either 24, 18, or 12 months. This staggered data collection will result in 175 data-years of driving on Canadian roadways. The sampling plan for subject recruitment has yet to be decided.

The study role of VTTI is similar to the one it performed during the SHRP 2 S06 project (i.e., the team will provide coordination and oversight during the data collection process). Unlike SHRP 2, VTTI will be directly involved in data collection and will be responsible for data storage during the Canada NDS. It is anticipated that, by storing both SHRP 2 and Canada NDS data, researchers will be able to query both data sets to answer important highway safety research questions.

VTTI Teen Driver Safety Days • photo by John McCormick

Automated Vehicle Systems

The Automated Vehicle Systems (AVS) initiative pursues an interdisciplinary approach to studying all aspects related to the automation life cycle in the transportation field. This initiative is anchored in applied research and strengthened by collaborations with national and international partners in vehicle automation. AVS partners include groups involved in research, planning, and policy, as well as the production of automated vehicles. The growth and variety of automated vehicles currently being developed, and already implemented around the world, should be anchored in research. AVS offers pragmatic research based on a scientific approach that emphasizes the importance of safety, security, reliability, and user acceptance. The goal is to strengthen the safety benefits of automation across all levels of the transportation industry.

Google partners with VTTI for automated vehicle research • photo by Steven Mackay

New Projects

Field Study of Heavy-vehicle Collision Avoidance Systems

Substantial advancements have been made in collision avoidance system (CAS) technology, including advanced radar sensors, better camera and vision technologies, improved object detection algorithms, and automatic braking. Heavy vehicles can now be equipped with the following CASs: 1) Forward collision warning (FCW) systems, which generate audible and visual alerts when a rear-end conflict emerges; 2) Collision mitigation braking (CMB) systems, which automatically decelerate the vehicle when a driver fails to respond to a rear-end conflict; and 3) Lane-departure warning (LDW) systems, which alert the driver when the vehicle drifts past the lane markings. In an effort to evaluate the reliability of these systems, the National Highway Traffic Safety Administration (NHTSA) has contracted VTTI to perform a field study of heavy-vehicle CASs. This field study is designed to evaluate CAS performance by measuring its operation on 150 trucks. Two CAS suppliers are involved in this study: Bendix® and Meritor WABCO. These vendors will install their CAS technologies on approximately 75 trucks each. Each truck will be equipped with the VTTI Mini Data Acquisition System (MiniDAS). The MiniDAS records both video of the roadway and the driver. It also records parametric data from the CAS and vehicle network. Participating drivers will drive the instrumented vehicles for up to 12 months each. The participating fleets' satisfaction and acceptance levels with the collision mitigation technologies will be assessed at the end of the test period. This study will generate an unprecedented amount of insight into CAS reliability, driver response performance when using the CAS, and fleet acceptance of the technology.

Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts

Automation has the potential to improve highway safety by supporting or supplementing the driver, thereby providing precise vehicle control during normal driving, and by maintaining appropriate driver attention to traffic and roadway conditions. This project aims to answer some of the most fundamental human factors research questions focused on the issue of drivers transitioning into and out of automated driving states enabled by Level 2 and Level 3 automated vehicles. Collaborating with General Motors, Google, Southwest Research Institute, Battelle Memorial Institute, and Bishop Consulting will ensure that the issues addressed by this work are those resulting from emerging real-world applications and system concepts. This effort will help both identify the fundamental human factors research questions related to automated driving and further the community's understanding of the education, development, deployment, and assessment needs of automated vehicle systems.

Ongoing Projects

Evaluation of Heavy-vehicle Collision Warning Interfaces

While commercially available crash warning systems have been available for some time, the implementation of such systems has varied widely with regard to the human-machine interface. The purpose of this project is to examine aspects of the human-machine interface of heavy-vehicle crash warning systems and determine the potential benefits or disbenefits associated with certain display properties. The final product of this project will include comprehensive interface design guidelines for heavy-vehicle crash warning systems. This project is being sponsored by NHTSA.

I-81 Corridor Coalition

The I-81 Corridor Coalition is committed to making I-81 a safe, efficient, environmentally sensitive, economically viable, and intermodal transportation corridor. I-81 runs from the Knoxville, TN, area to the Canadian border, serving the eastern portion of the U.S., primarily within the Appalachian region. It parallels I-95 to the western side and is a growing alternative to I-95 for freight movement. The primary concern of the Coalition is safety along the corridor, particularly incident management and freight route choices.

The I-81 Corridor Coalition was originally established in 2007 and is governed by a Steering Committee that includes representatives from state, local, federal, and nonprofit organizations.

Members of the I-81 Corridor Coalition are committed to working together to improve freight and passenger movement through the corridor via sharing of information and coordinated decision making, management, and operations.

Targeted Research Areas

Safety

I–81 is a major truck freight corridor. There are frequent crashes involving trucks that cause lengthy periods of congestion. Previous studies have shown that driver distraction and long hours behind the wheel are root causes in many cases. The Coalition partners with regional Public Safety Working Groups to host incident management workshops that provide technical instruction about proper safety procedures and quick crash clearance.

Strategic Transportation Visioning

The Coalition intends to collect data about traffic and planning efforts related to I–81 and build a database of information relevant to the corridor.

As a first initiative, the Appalachian Regional Commission (ARC) has contracted with the Coalition to research opportunities for transportation facilities in the Appalachian region. The goal is to more fully integrate Appalachian Development Highway System (ADHS) corridor segments with other regional highway, rail, and navigable waterway transportation resources. This will be accomplished in a way that increases coordination and cooperation and maximizes the social mobility of Appalachia and its domestic and international access.

As a second initiative, the Coalition will work with the six state departments of transportation (DOTs) through which I-81 runs to house and maintain a central data repository for state transportation data, plans, and studies relevant to the corridor. This initiative is a direct result of the I-81 Multistate Corridor Study, a pooled-fund study led by the Virginia DOT (VDOT).

Administrative Planning

An operating structure (or a procedural guideline) is currently being developed that will enable the Coalition to move forward with additional funding strategies. Other efforts include building upon the existing website and visiting public jurisdictions and private organizations involved in corridor-related initiatives to continue expanding the membership base and stabilize funding.

Research Initiatives

A large part of the interest of the Coalition is researching issues of importance in the corridor, including freight movement, intermodal relationships, environmental planning, safety, and corridor-wide information and coordination efforts. Each of these subject areas will be explored for additional funding opportunities.

Motorcycle equipped with VTTI data collection unit • photo by Logan Wallace

Group Leader: Dr. Shane McLaughlin

The Motorcycle Research Group was founded in 2007 with the objective of applying the multidisciplinary research capabilities of VTTI to real-world motorcycle riding. The group was born from a history in transportation research; concern about increasing numbers of motorcyclist fatalities and injuries; and the excitement of a large number of VTTI engineers, staff, researchers, and family who are riders. The Motorcycle Research Group focuses on the rider and his or her machine while considering other factors in the surrounding transportation system.

New Projects

Motorcycle Safety Foundation Naturalistic Study

The Motorcycle Safety Foundation (MSF) and its members partnered with VTTI for the first large-scale, naturalistic motorcycle riding study. The study includes seven models of motorcycles that provide a range of engine sizes and bikes categorized as cruisers, sport, or touring. One hundred motorcycles have been instrumented at four sites: California, Florida, Virginia, and Arizona. Participants will ride with instrumentation for six to 18 months to create a comprehensive picture of factors contributing to both crashes and near-crashes. Approximately 330,000 miles of data have been collected to date; more than 500,000 miles are expected to be included when the study is complete. All participants will be completed by November 2013. The data analysis is already under way.

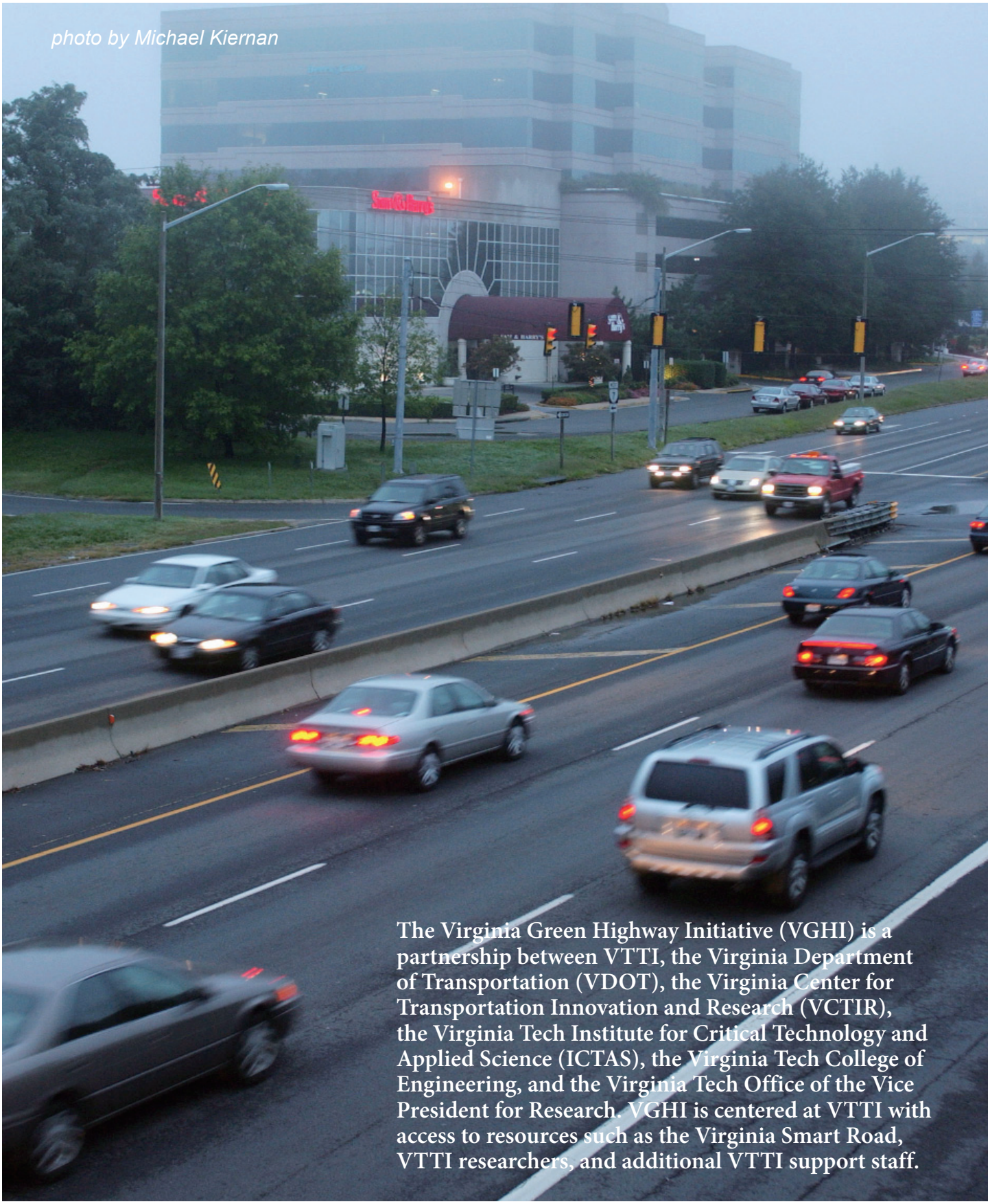
NHTSA Instrumented On-road Study of Motorcycle Riders

This study will instrument 160 motorcycles in Southern California with the objective of collecting real-world motorcycle riding behaviors to identify countermeasures that reduce unsafe riding behavior. There will be two approaches to instrumentation: 1) 60 of the bikes will use the VTTI Next Generation data acquisition system (DAS) with radar, independent brake lever sensing, and five camera views; and 2) 100 of the motorcycles will use the MiniDAS with two cameras.

Hardware for the 60 Next Generation DASs is produced and ready for use. The MiniDASs are being produced. Currently, the project is on hold while an application for a Certificate of Confidentiality is under review by the National Institutes of Health.

photo by Logan Wallace

Virginia Green Highway Initiative



The Virginia Green Highway Initiative (VGHI) is a partnership between VTTI, the Virginia Department of Transportation (VDOT), the Virginia Center for Transportation Innovation and Research (VCTIR), the Virginia Tech Institute for Critical Technology and Applied Science (ICTAS), the Virginia Tech College of Engineering, and the Virginia Tech Office of the Vice President for Research. VGHI is centered at VTTI with access to resources such as the Virginia Smart Road, VTTI researchers, and additional VTTI support staff.

The objectives of the Virginia Green Highway Initiative (VGHI) include:

- Creation of innovative approaches designed to increase energy efficiency and reduce carbon emissions in the surface transportation domain.
- Establishment of Virginia at the forefront of the sustainable transportation revolution.
- Exploration and development of new technologies, methods, and policies that will minimize the negative impacts associated with surface transportation on Virginia ecosystems.

These goals will be achieved using the capabilities of Virginia Tech, VDOT, and other Virginia universities to pursue federal, state, and private sources of research funding and program investment. The success of VGHI will make an economic impact on Virginia, resulting in research, development, and manufacturing jobs.

New Projects

Blacksburg Transit Dynamic Bus Routing and Scheduling Study

Traditional transit operations use scheduled routes and on-demand, or "tripper" buses, in their daily operations to address normal and unexpected system loads. These strategies have long been the best approach to serving the needs of the commuting public while working within the constraints of limited resources. Recent technological advances in computing and communications and the advent of connected vehicles have paved the way for a real-time assessment of bus capacity and rider demand. Coupled with the increased usage of smartphone and web applications, these capacities may well enable a paradigm shift with respect to how transit operators can increase the dependability of their services while best using their limited resources.

An accurate, real-time measurement of bus passengers and bus stop queue counts and dynamic dispatch and re-routing of buses may allow transit operators to better serve the riding public while decreasing operating expenses and adverse environmental impacts. Technology that allows accurate real-time determination of bus loading is currently available and used. Magnetic card reading, near-field communication (NFC), radio frequency identification (RFID), or machine-vision technologies may be used either actively or passively (dependent upon the technology) to assess demand in real time through a measurement of bus queues. Using the information collected via these technologies, innovative new models for bus routing can be developed that either eliminate traditional scheduled routing through dedicated, on-demand routing only or allow application of a hybrid model where both traditional scheduled and on-demand routing are employed with temporal and/or spatial variations. Real-time data about bus occupancy can also be used to dynamically adjust traffic signal preemption priorities for transit precedence to enhance system reliability.

This project is funded through the Federal Transit Administration Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) program and is being conducted in collaboration with Blacksburg Transit.

Prediction of Roadway Surface Conditions Using On-Board Vehicle Sensors

A method for the prediction of compromised roadway conditions is proposed. The differential rotational displacement of driven versus free-rolling wheels of a vehicle traveling along a stretch of roadway is used to predict the relative coefficient of friction between the tire and pavement. This method does not rely upon initiation of onboard safety systems, such as antilock brakes. Instead, the method provides for notification of diminished tire traction before safety system activation thresholds are attained. As roadway conditions change due to pavement properties, weather, or contamination, this information can be shared across the connected-vehicle network to provide alerts to approaching drivers and modified operational parameters for use by onboard safety systems. Such real-time data will also enable optimized roadway maintenance operations, such as salt application and cleaning, to reduce costs and improve safety and sustainability.

This project is funded through the Road Weather Management Division of the Federal Highway Administration (FHWA).

National Surface Transportation Safety Center for Excellence

VTTI works to ensure the safety of all transportation users • photo by John McCormick

The National Surface Transportation Safety Center for Excellence (NSTSCE) at VTTI was established by the Federal Public Transportation Act of 2005 to develop and disseminate advanced transportation safety techniques and innovations in rural and urban communities. NSTSCE uses a synergistic approach across four research focus areas to maximize resources. These research focus areas comprise safety devices and techniques that enhance driver performance, evaluations of the built roadway environment and infrastructure-based safety systems, safe mobility for vulnerable road users, and driver impairment.

The vision of the National Surface Transportation Safety Center for Excellence (NSTSCE) is to become recognized as The National Center for Surface Transportation Safety, make a significant impact in improving surface transportation safety, and leverage partner and sponsor relationships to disseminate results.

NSTSCE has formed a Stakeholders' Committee comprising organizations that share its vision for improving road-user safety locally and nationally. The Stakeholders' Committee members represent the Federal Highway Administration (FHWA), General Motors Corporation (GM), the Virginia Department of Transportation (VDOT), the Virginia Center for Transportation Innovation and Research (VCTIR), the Federal Motor Carrier Safety Administration (FMCSA), Travelers, and VTTI.

New Projects

The Effects of Adverse Conditions on Senior Drivers' Vehicle Control

Adverse driving conditions (e.g., rain, darkness, fog, etc.) pose risks for all drivers. However, senior drivers may be differentially at risk due to the physical and cognitive challenges associated with aging. Few research endeavors have been conducted to determine the real-world driving behavior of drivers of different ages in adverse conditions, but the Second Strategic Highway Research Program (SHRP 2) data set provides an unprecedented opportunity to do so. This study will use numeric SHRP 2 variables to create a data set of vehicle network and kinematic variables during driving epochs in four lighting and weather conditions. Driver behavior will be compared across young, middle-aged, and elderly participants. The goal of this study is to understand how driver vehicle control changes across weather and age. Such understanding could lead to improvements in driver training and licensing, roadway/signage design, and/or in-vehicle technology.

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 parent(s) 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 to compile 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.

Application of Proximity Sensors to In-vehicle Data Acquisition Systems

There is a new suite of sensors coming to market that provides novel driving-related data. Specifically, these sensors measure the position and motion of particular parts of the human body. These sensors are enabling user interfaces based on gestures performed in the air. One example of such technology is employed in the Microsoft Xbox game system under the name Kinect. There are additional sensor technologies coming to market with similar capabilities and low price points. These technologies can be applied to provide detection and tracking of the 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 sensor technologies that are now emerging at lower prices to establish their viability of adoption from a cost/performance perspective.

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. Currently, 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 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 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.

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 naturalistic driving studies (NDSs) but need to be validated and improved for use in 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 emotion displayed and the intensity of the emotions. Ratings will be compared across reductionists to evaluate the level of agreement between them. Disagreements in the reduction will be used to assess how the protocols can be improved.

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 [e.g., mirror use] or unrelated [e.g., reaching for an object] to driving).

3. An unexpected traffic event, such as unexpected stopping of the lead vehicle.

NDSs 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 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 safety-critical events (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 NDSs 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, given the three crash trifecta elements, the probability of a crash 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 these 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 NDSs). 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 Bocanegra 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.

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.

Effective Use of Commercially Available Onboard Safety Monitoring Technologies: Guidance for Commercial Motor Vehicle Carriers

Motor vehicle crashes are often predictable and preventable, yet 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 and thus require 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.

However, various OSM technologies exist, each with their own strengths and weaknesses. Moreover, less is known about the safety efficacy of these 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 or 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 these OSM technologies.

This study will pursue the possibility of working with several OSM providers, such as 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 the development of materials for the creation of 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 of the potential topics to be addressed include: training, safety culture, development of a steering committee, employee involvement and commitment, etc.

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

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, used in the Large Truck Crash Causation Study (LTCCS), uses post hoc reconstructions based on physical reconstruction and interviews with drivers and witnesses. Another approach, naturalistic driving, is a proactive approach that 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, there is a great opportunity to learn about crash causation by analyzing and comparing data from both approaches.

Currently, there are several commercially available onboard monitoring systems (OBMSs) in use with thousands of CMVs. Thus, there are likely many more crashes 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 OBMSs (e.g., DriveCam, SmartDrive, etc.). However, before such comparisons can be made, 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 OBMS technologies typically code only a few variables. However, as video and kinematic data from the crash are available, it is 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 OBMSs. It is likely that a few of the LTCCS and naturalistic driving variables are defined similarly or identically. However, there will be many occasions where the naturalistic driving data require additional data reduction to make this data set consistent with the LTCCS. The research team will work with the leading OBMS vendors to assess their current data reduction processes; the research team has already established relationships with the top two vendors, DriveCam and SmartDrive. Comparisons 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. Currently, this is not part of the existing data reduction approach used by the vendors.

Access Maintenance

VTTI has made portions of the 100-Car and 8-Truck data sets publicly available. Support activities for the data distribution website include culling invalid user accounts, responding to user questions, and rectifying errors as they are discovered.

Ongoing Projects

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 Institutional Review Board (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 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.

Secure Feedback for Onboard Monitoring System Training

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

Programmers have established the Driver Coach database. Software work has continued on the web-based data reduction tool and the feedback website. This effort was focused on working towards a final product for the pilot study.

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 comprises: 1) Parent-teen contracts with elements of an enhanced graduated driver's licensing (GDL) program, 2) Training of specific skills at a specially designed training facility, and 3) A teen driver monitoring and coaching program that uses advanced in-vehicle technology. This project will support all three approach elements with emphasis placed on the driver monitoring and coaching program. The driver monitoring and coaching will be accomplished via an unobtrusive data collection system designed to provide both real-time monitoring (i.e., instantaneous feedback for the teen driver) and delayed summary feedback (for the parent).

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

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

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

Past research conducted by the Centers for Disease Control has shown teenaged drivers with attention deficit hyperactivity disorder (ADHD) have five times the number of traffic tickets and are seven times more likely to be involved in more than one accident compared to non-ADHD teens. To better assess the rate of driver errors and crash/near-crash rates of ADHD teenagers, this study will instrument 10 vehicles of clinically diagnosed ADHD teenagers. Data will be collected through the learner's permit phase during the first six months of independent driving. Driving performance for these ADHD teenage drivers will be compared to non-ADHD teenagers and borderline ADHD teenagers (as identified in 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 teenage driving study.

Impacts of Safety-critical Events on Driver Behaviors

The objective of this study is to evaluate the impacts of crashes on driving behavior. Specifically, the driving behavior is measured by two primary metrics: 1) The near-crash and 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.

A time-to-event method was implemented to analyze critical event risk before and after a crash. This approach overcomes one major drawback of the previous time-window-based approach (i.e., the window has to be arbitrarily defined and is sensitive to the censoring caused by the ending of data collection). The results show a significant difference before and after a crash.

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 spatial/temporal correlation, the ability to incorporate prior information, and a natural hierarchical structure in modeling multi-center/group studies. This project focuses on developing robust Bayesian models for two types of primary approaches for the NDS: the case-crossover and the case-control method.

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 the 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, which essentially only uses a small proportion of the 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.

The team is currently working on the second part of the study during which drivers are divided into different groups based on demographic characteristics. It is hypothesized that driver distractions such as cell phone use will have different impacts on each group. Several Bayesian hierarchical models have been proposed to evaluate the distraction risk for different age and gender groups. The detailed model specification and conditional posterior distribution have been completed.

Generic Motorcycle Bracketry and Housings

VTTI is currently conducting two safety-related naturalistic motorcycle studies. The first study for the Motorcycle Safety Foundation (MSF) fielded 100 motorcycles in four states (California, Florida, Virginia, and Arizona). This data collection is nearing completion, and all bikes are being de-instrumented over several months. The second study (the NHTSA Instrumented On-road Study of Motorcycle Riders) is nearing initiation in Southern California and will include 160 motorcycles. The original bracketry and accessory housings (e.g., radar, global positioning system [GPS], cameras) were designed for a small number of motorcycles with no accessories or modifications. This second naturalistic project will make use of bracketry and housings that can be used on a range of motorcycle models.

Through a process of reviewing current bracketry, bike design, and common bike accessories, photo and tabular reference libraries were

developed that quantified dimensional differences between bikes. Off-the-shelf bracketry was being reviewed, and samples purchased and selections made could support research needs. Where off-the-shelf components were not sufficient, prototype work was completed for generic bracketry, especially in the areas of cameras and radar mounts. The parts were reviewed by installers, and designs were finalized. Production parts were manufactured according to the design for an upcoming naturalistic study. The output of this work is currently being shipped to California for use on the 160 motorcycles in the NHTSA study. It will support both the Next Generation data acquisition system (DAS) and components and the first motorcycle use of the MiniDAS.

Attention and Drowsy Driver Assist

This project was redefined to focus on automated detection of driver drowsiness and driver attention to or away from the forward roadway. The literature review conducted as part of this project was used to support development of a strategy for detection and a preliminary algorithm design. The algorithm will integrate eye-gaze data with driver performance to characterize driver attention and drowsiness. Data from distracted driving studies are currently being reviewed to guide code development. Subsequent steps include code development and testing, video review and validation, and algorithm finalization and documentation.

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 behav-

VTTI older driver study

iors and performance metrics in addition to the 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: 1) DriveSharp™, a Posit Science desktop computer program designed to enhance older driver safety; and 2) 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 distance and 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 interact with the effectiveness of the various programs evaluated.

This project is closely related to the Comparing the Driving Safety Benefits of Brain Fitness Training Programs for Senior Drivers project within the Center for Vulnerable Road User Safety.

FMCSA's Advanced System Testing using a Data Acquisition System on the Highway

The safety objective of FMCSA is to save lives and reduce injuries by preventing and minimizing the severity of truck and bus crashes (FMCSA, 2010). According to FMCSA, the development, evaluation, and deployment of advanced safety technology will be necessary to realizing this objective.

Currently, there are numerous safety systems in development that have the potential to significantly reduce crashes on the nation's roadways. For a variety of reasons, however, including lack of supporting tests and evaluations, the potential benefits that these systems may provide in reducing crashes may never be realized. The FMCSA envisions, through cooperation with the commercial vehicle industry, an influx of commercial vehicle safety technologies that support the expanding role of the commercial vehicle industry to safely, securely, and efficiently transport the nation's goods, products, and people. Information from motor carriers and other organizations about the effectiveness of these systems in improving safety will be valuable in

advancing their further use in the commercial vehicle industry.

The objective of the FMCSA's Advanced System Testing using a Data Acquisition System on the Highway (FAST DASH) program is to perform a quick turnaround of independent evaluations of promising safety technologies aimed at commercial vehicle operations (CVOs). The goal of the FAST DASH program is to determine the efficacy of the safety system using the following high-level metrics:

- Crash reduction effectiveness (e.g., safety improvements),
- Unintended consequences (e.g., safety disbenefits), and
- User (e.g., driver, safety manager) acceptance (e.g., subjective opinions).

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

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

Investigating Drivers' Compensatory Behavior when Using a Mobile Device

This study comprises a re-analysis of existing NDS data sets and has two goals. The first goal was to determine whether the drivers of light vehicles and CMVs compensated for the increased workload when conversing on a cell phone by changing their driving performance. The second goal was to investigate the relationship between drowsiness and the SCE risk from mobile device use.

With respect to the first goal, a controlled investigation was performed by comparing driver performance when conversing on a cell phone to driving performance 30 seconds prior to initiating the call. Overall, both light-vehicle and CMV drivers were not found to change their longitudinal safety margins when conversing on a cell phone. However, all drivers were found to look forward more frequently when conversing on a cell phone. This behavioral change alone may be why multiple NDSs have not found conversing on a cell phone to increase SCE risk.

With respect to the second goal, all analyses regarding the relationship between drowsiness and the SCE risk of mobile device use were completed. A main finding was that commercial drivers had more mobile device use between 2 a.m. and 4 a.m. than any other time interval examined. However, it was also found that drivers' mobile device use did not differ based on how much sleep they obtained during the previous 24 hours. The results of this study generate insight into commercial drivers' use of

cell phones when they are drowsy. A final report documenting the results is being prepared.

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 involvement in an SCE associated with using a mobile device 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 mobile device use and its subtasks were then computed. During low task demands, only dialing was associated with an increased risk for light-vehicle drivers. During moderate task demands, cell phone use (collapsed across subtasks) was associated with an increased risk for CMV drivers. During this condition, texting and dialing were associated with an increased risk, while talking/listening was not. Furthermore, talking/listening on a hands-free phone or CB radio was associated with a decreased risk. During high task demands, cell phone use (collapsed across subtasks) was associated with a decreased 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 risk. Overall, the risk related to talking/listening on a mobile device was not found to increase during the three driving task demand conditions examined. Furthermore, unlike light-vehicle drivers, CMV drivers' mobile device use was lowest during high task demands, suggesting that CMV drivers may regulate their mobile device use differently than light-vehicle drivers as the driving task demands vary.

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

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

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.

Color Camera

This project focuses on the development of a camera system that accurately defines color in a driver's environment and allows for color analysis during projects. The camera 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 the Roadway Lighting Mobile Measurement System (RLMMS).

To confirm the calibration quality of the Color Camera, the spectral distribution of multiple light sources needed to be further investigated. Of particular interest were the reflections of both high-pressure sodium and daylight reflecting off the squares of a color checker chart and how these squares are ultimately rendered under such light sources.

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. The colors of squares were split into their X, Y, and Z color components. An image of these same squares was taken and analyzed with the Color Camera as calibrated in the daylight.

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. Following this, a route was driven, and images were recorded with the camera.

Active and Adaptive Roadway Delineation Systems

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

A selected vendor has pre-agreed (though not final yet) to loan VTTI a system that will comprise 100 units across 2,000 ft., which is the length of the Smart Road all-weather system. The markings will be temporarily placed just outside the edge line to avoid being hit by the participant vehicle. The equipment includes light-emitting diode (LED) markers that use ultra-bright 1.6 million candela/m^2 LEDs for full daytime visibility and includes the following characteristics: a flat profile (snowplow and bike safe), maintenance-free design, a variety of available activation devices and methods, environmentally friendly, low-power consumption, solar-power option, and compliant with the Manual on Uniform Traffic Control Devices (MUTCD). Some specific characteristics that will be studied are:

- Sequencing/Chasing: The delineators are capable of sequencing under different speeds and patterns.
- Flashing: Though not typically used on straight roadways, the team is considering testing the delineators for different flashing rates.
- Spacing: A spacing of 20 ft. was requested along with the capability to "deactivate" some of the markers, thus resulting in 40, 60, or 80 ft. of spacing.

• Luminous Intensity: It is expected that the delineators will be dimmable.

• Color (amber).

Surrogate measures that will be used to determine the effect of different delineation conditions include vehicle speed and lane position. Additional data will be collected by subjective ratings of the systems provided by participants.

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 of summing the lighting in roadways and over-lighting the intersection. New strategies can be investigated, including the impact of broad-spectrum sources and peripheral pedestrian detection strategies.

A literature review of current intersection lighting design methods is nearing completion. Alternate lighting designs are being assessed for testing. This project will be linked with the results of the Rural Intersection Lighting Safety Analysis project.

photo by Rebecca Craig

Visual Information Modeling

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

The results from this project have been extensively presented.

Nighttime Bicycle Visibility

The Bicycle Visibility project will analyze the conspicuity of certain types of visibility aids displayed by both 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 that was incorporated into the Headlamp Sag study was completed. This project included the evaluation of lighting alternatives as a bicycle crossed the path of a vehicle. The 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. The data have been analyzed, and a report of the analyses has been initiated.

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

A third part of the nighttime bicycle investigation will be incorporated into the NSTSCE Roundabout study. The study will involve 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 will verbally identify the presence of cyclists who will either be 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 into a naturalistic setting (e.g., a public road). A comprehensive literature review of bicycle visibility is ongoing.

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

The purpose of this study is to conduct a comprehensive analysis of CMV drivers' prescription and over-the-counter (OTC) drug uses and their relationships to involvement in SCEs. 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 (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 significant crash risks. More data are needed to support this contention, including: a) Base rate of prescription and OTC drug use in non-crash-involved truck drivers, 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 abilities, d) If the illness itself or the drug contributed to these decrements, e) If the critical reason or primary contributing factor is related to the drug's adverse effect on performance, attention, or decision-making capabilities, 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 relationships 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 had taken, 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.

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

This project will: 1) Assess the overall effectiveness of the Schneider National, Inc. (SNI) sleep apnea program; 2) Document two different sleep apnea programs implemented by truck carriers (SNI and J.B. Hunt [JBH]); and 3) Develop a sleep apnea implementation manual to include a set of best practices for a successful obstructive sleep apnea (OSA) treatment program. 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 will be to distribute the OSA treatment manual to other trucking fleets. To this end, VTTI has enlisted the assistance of several other agencies, including the National Institute for Occupational Safety and Health (NIOSH), the Federal Transit Administration (FTA), the National Sleep Foundation (NSF), the American Transportation Research Institute (ATRI), and the American Sleep Apnea Association (ASAA). The research team anticipates the manual produced during this study will be beneficial to other transportation modalities and industries.

The goals of the current study are:

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

2. Assess the safety and health benefits of treating OSA (e.g., reduced crashes and improved health profile);

3. Evaluate the overall return-on-investment (in terms of reduced healthcare premiums, lower crash rates, and increased driver retention compared to the costs of treatment);

4. Develop models to predict beneficial health and safety outcomes (e.g., compliance rates, age, gender, etc.); and

5. Develop a set of best practices for implementing and maintaining a successful OSA program for the trucking industry.

Focus 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 programs and to gain insight from those who participated in these programs. Findings from this study will provide recommendations as to how carriers should implement an OSA program in an effective and cost-efficient manner.

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

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

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

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

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

Distraction Index Framework

A number of surrogate measures of distraction exist, but their contributions to the overall construct have not been quantified. The goal of this research was to examine the relative contribution of the most important surrogate indicators of distraction to the occurrence of different crashes and near-crashes and to the types of avoidance maneuvers that are attempted by drivers. The long-term goal is to establish a framework for the creation and validation of a "Distraction Index." The concept is similar to that of the widely used (in the musculoskeletal arena) NIOSH Lifting Index. When fully developed, the concept will be implemented as a published research guideline that can be used as a common measure across studies.

Crash/Near-crash Algorithm

A common problem in working with naturalistic driving data is the large number of false alarms observed when extracting events of interest from a large data set. Identifying events is typically accomplished through an iterative process of threshold triggering on kinematic data followed by video validation with trained reviewers.

In an attempt to improve the accuracy of 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 with a 100-Car Study analysis, algorithm performance will be evaluated using other naturalistic data sets.

MiniDAS

The MiniDAS prototype has been developed. Procurement plans are in place to purchase 100 systems. This DAS allows epoch and continuous recording. It contains many of the same features as the Next Generation DAS, including:

- A three-axis accelerometer,
- GPS technology,
- Both forward and driver video,
- Network variables, and
- Machine-vision applications, such as 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 on both traditional vehicles and nontraditional vehicles.

Current estimates on procurement plans are to receive the systems during the third quarter of 2013.

Publication Analysis

VTTI maintains the largest repository of naturalistic driving data in existence: more than 100 terabytes (TB) and counting. The goal of this project is to develop a comprehensive and cohesive data-mining, analysis, and publication plan for this ever-growing data set in a manner that synergistically addresses the foundational concerns of NSTSCE: age-related driving issues, fatigue, lighting and infrastructure, driver decision making and performance, and devices and techniques designed to enhance driver performance. While all publications reflect VTTI safety studies, the current focus is on those featuring naturalistic data.

Completed Projects

Supporting Commercial Motor Vehicle Driver Distraction Outreach

The FMCSA-hosted, VTTI-developed "CMV Web-Based Driving Tips" site provides CMV drivers with practical guidance for the safe operation of a heavy vehicle. This site has proven to be popular, gathering more than 100,000 views since its creation. Due to increased attention about distracted driving, the site pages dealing specifically with this topic have received more traffic. This presents a unique opportunity to expand and enhance the driver distraction section of the site. This project involved reviewing the distracted driving information available on the existing site in comparison to research published after the creation of the site and updating the site with information about distraction risks as needed.

Oversight of the Driving Healthy resources was transferred to Travelers and Northland. The project team has been working with Travelers and Northland to increase the visibility and use of the Driving Healthy resources in a mutually beneficial manner.

Older Driver Fitness-to-drive Study

The fitness-to-drive project was a follow-up work of Antin et al. (2012). In that paper, the researchers compared the fitness profiles of older drivers and non-drivers in an initial effort to develop fitness-to-drive assessment models. The current project used the same fitness profile data collected for the project. The objectives

VTTI MiniDAS

of this study were twofold: 1) Investigate the relationship between fitness profiles of older drivers and their crash and 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 (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, the driver's risk was measured by the crash and near-crash events. The data analysis and statistical modeling comprised two stages. During each stage, a principal component analysis was performed to reduce the dimensionality of a large number of metrics. This was followed by the Poisson regression and negative binomial (NB) regression designed to model the relationship between crash/near-crash risks and driver fitness characteristics.

During initial stages 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. The Poisson and NB regressions 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 and near-crash risk. Moreover, within these four components, 13 metrics had significant factor loadings (i.e., made significant contributions).

During the second stage of analysis, a principal component analysis was performed for these 13 metrics. As expected, four significant components were identified (Components 1-4). The exhaustive model selection on the Poisson model 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, the total number of color-vision plates correct, and right-eye contrast sensitivity.

In summary, initial analyses indicated that some visual characteristics may have a significant impact on older drivers' crash/near-crash risks.

International Driver Behavior Comparison Using Shanghai NDS

China has become one of the world's most important auto markets. However, the traffic conditions and driver behaviors in China could be dramatically different from the United States. This difference will affect vehicle design and control parameters, such as forward collision control settings and adaptive cruise control settings. NDSs are by far the most powerful method to collect those characteristics during real-life driving. This study, conducted in partnership with the General Motors Company (GM) and Tongji University (Tongji), instrumented five vehicles and collected NDS data in Shanghai, China.

NSTSCE researchers provided and installed the Next Generation DAS developed by VTTI. The Tongji team managed the data collection process. The collected data were transferred to the VTTI secure data server for data decryption and processing. The collected data provided crucial information about the traffic flow characteristics and driver behaviors in one of the major cities in China.

Driving Scenario Classification

During this period, a method was developed that uses GPS data in combination with digital map data to address the bulk of the objectives of the scenario classification effort. The method reveals when participant vehicles are tran-

sitioning from one road segment to another (e.g., turning at intersections, taking ramps off freeways, traveling on interstates or rural roads, etc.). The association with additional descriptors in digital map data provides further scenario-related quantification, including factors such as number of lanes, road class, speed limit, etc. In addition to being accurate, the method has other benefits. It is more efficient with respect to computational and database query demands than previously used roadway classification methods. It also only uses latitude and longitude, so research questions that are reliant upon kinematic-dependent measures are not affected.

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 and has begun the patent review process (U.S. Patent Application No: 61/829,024). The next step will be to finalize a description of the method in an NSTSCE report.

Senior Mobility Day

The Senior Mobility Awareness Symposium was a community outreach activity held December 6, 2012. Its purpose was to channel the latest 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), AARP Virginia, Virginia Department of Motor Vehicles (DMV), the Massachusetts Institute of Technology (MIT) AgeLab, VTTI, and the Virginia Tech Center for Gerontology. The Inn at Virginia Tech and Skelton Conference Center served as the venue, 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.

Age-related Driver Difficulties at Intersections III

This project represented 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 indicated that visual scanning differs between age groups during unprotected T-shaped intersections. In particular, there was a significant difference in visual entropy for drivers of all age groups while negotiating a left turn in the presence of traffic in intersecting streams. The analysis showed that young drivers scan more narrowly than other driver groups when no traffic is present at an intersection but scan more broadly (and more randomly) when in the presence of traffic at the intersection. A link analysis revealed that younger teen 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 looking at the direction (or directions) from which traffic could strike them during a turn if they were to emerge towards the intersection than did other driver age groups. Further, the individual glances made by older drivers to these areas were longer, perhaps suggesting that it took these drivers longer to extract the information they needed.

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, collected naturalistic driving data about older drivers. The team compared key aspects of driving behavior across two continents. Metrics included those related to secondary task engagement and distraction at unprotected turns-across-path intersections. Finding commonalities and/or differences between the two continents and driving environments assisted in making a statement about the universality of seniors' driving behaviors.

Data analysis plans were coordinated, refined, and finalized with Australian colleagues. Data reduction and data analyses of the reduced data set were completed. 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 the use of a cell phone 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).

Light Sources in Fog

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

The objects required to build the fog measurement system were acquired, and preliminary tests were conducted as a proof of concept. The system underwent construction by the Hardware Engineering Lab at VTTI. This system comprises a laser that emits light in a plane and a camera with a filter tuned to the same wavelength of the laser. The fog caught within the plane of the laser light refracts light towards the camera. The denser the fog, the more light is refracted, thus creating a brighter image. A computer analysis of images captured this way in natural fog conditions provided a means for calibrating the Smart Road all-weather system to similar densities. This effort is gaining priority as VTTI has been requested to measure the visibility of changeable speed limit signs in fog conditions.

Identifying Cognitive Load from Naturalistic Data

The goal of this project was to develop a methodology that used naturalistic data to identify epochs of cognitive activity during driving. The input measures for the algorithm comprised eye-behavior indicators typically present in the stream of data derived from naturalistic studies. The project leveraged previous findings that relate cognitive load while driving with drops in blink rate, concentration of long glances on the forward roadway, and narrowed breadth of scanning. The results showed 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 focused on long glances to the forward roadway and reduced peripheral scanning.

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 were two primary objectives for 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 data distribution website for the SHRP 2 NDS (forums.shrp2nds.us). This website will be used to support many aspects of this study, including S08 analysis proposals, user workshops, and access to analysis tools (e.g., the open-source Community Viewer).

Supporting Commercial Motor Vehicle Driver Health Outreach Efforts

The project website (www.drivinghealthy.org) was redesigned and updated to improve the utility of the site. A detailed Driving Healthy analytics report was prepared and presented to Travelers Insurance for its consideration. Additionally, the team fostered a relationship established with Crete Carrier Corporation through which the Driving Healthy daily tips Rich Site Summary (RSS) feed is shared with Crete Facebook and Twitter users. Daily tips reflect feedback received about previous Driving Healthy tips posted on Facebook.

The research team updated the Driving Healthy website, Facebook, and Twitter sites. Taking advantage of the new Facebook timeline, the team worked to increase driver engagement and sought feedback and recommendations for future health focus topics and resources.

VTTI vehicle instrumentation • photo by John McCormick

Market Guide to Fleet Telematics Services

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

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

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

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

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

National Tire Research Center/SoVa Motion

National Tire Research Center LTRe machine • photo by Logan Wallace

The National Tire Research Center (NTRC) commenced operations during Fiscal Year 2013, celebrated by a grand opening of its renovated building in October 2012 and the first earned revenue in February 2013. The NTRC will serve as an advanced tire research center and test facility specializing in independent research, testing, and assessments that supplement activities performed by global tire and vehicle manufacturers.

Force and Moment Machine

During the first half of the fiscal year, work was completed on the $11.2 million force and moment machine (LTRe) created for passenger-car, light-truck, and motorsport tires. The LTRe is a superior product representing a transformational leap in technology by offering at least twice the capability in major performance areas across current tire test machines.

The LTRe was tested by the manufacturer during early summer; it was then loaded onto eight tractor trailers to be shipped to Alton, Va., where it was re-assembled. The machine was deemed ready for external customer use during February. The LTRe has since generated more than $1 million of revenue (twice the budgeted amount). The operation now has 20 employees and runs two shifts per day.

Economic Impact

It is expected that the unique capabilities offered by the NTRC will attract other companies in the automotive or racing industries to locate in the Southern Virginia region. Using a methodology developed by SRI International, a study projected that the NTRC will have an economic impact of $147 million on the Southern Virginia region during its initial 10 years of operation, creating 183 jobs in the region by 2020 (direct jobs created were estimated at 87; indirect and induced jobs were estimated at 96).

The NTRC is working to enhance visibility and offer expertise in support of this expectation through travel to national and international conferences and trade shows, website improvements, publications, facility tours, and interaction with the regional community. Global customers are already joining regional industry leaders coming to Southern Virginia to see this facility and to tap into the unique capabilities offered. These visits carry associated benefits to the regional economy that result from the simple acquisition of goods and services from other firms during NTRC-related visits.

Research Endeavors

The NTRC provides the transportation industry the research and testing capabilities needed to engineer and develop tires that will provide greater fuel economy and lower emissions while meeting federal vehicle requirements and customer expectations. For example, researchers are pursuing the application of innovative materials and design to create a super tire. This tire can adjust on the fly with the car and road without sacrificing wear or traction and can increase fuel efficiency, potentially saving billions of gallons of fuel annually. This level and breadth of research, development, and testing in one location does not currently exist anywhere else for automotive and tire manufacturers.

The NTRC will create additional research and funding opportunities for vehicle manufacturers, tire manufacturers, the motorsports industry, local educational institutions, and government agencies. Transportation industry engineers and scientists will continue to work together to conduct research and testing that enable the industry to more rapidly introduce vehicles with newly developed technology.

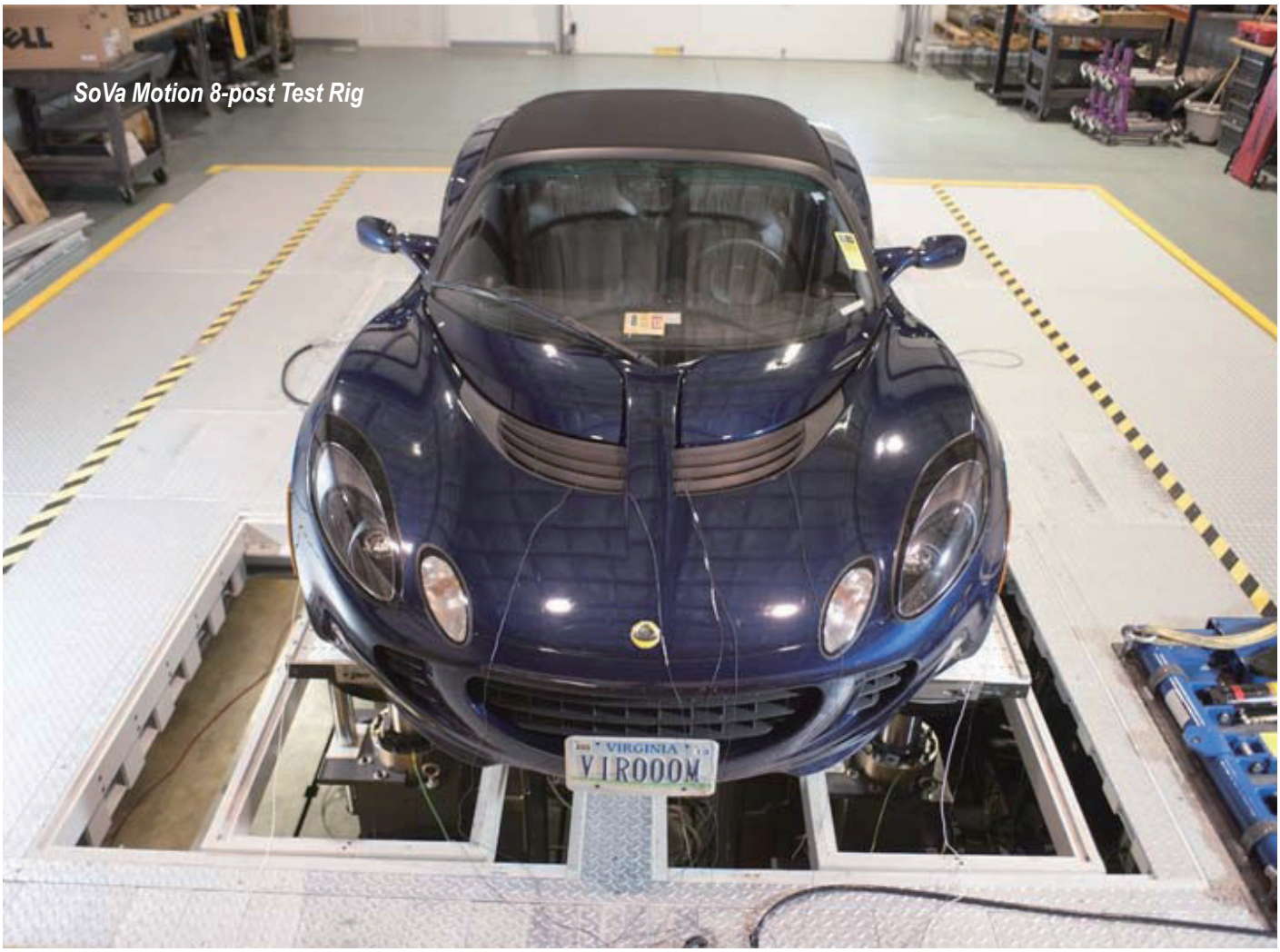
SoVa Motion and Future Equipment Plans

The NTRC has partnered with the Southern Virginia Vehicle Motion Labs (SoVa Motion), which features an 8-post Test Rig, Wheel Force Transducers, and two of Cruden's Simulators.

This equipment encompasses the tools needed to address virtual components prior to conducting ride and handling tests on the Virginia International Raceway world-class circuit and designated local roads.

The NTRC plans to incorporate state-of-the-art rolling resistance machinery that will enable tire and automotive manufacturers to accelerate the development of green tire technology, reproduce real-world events, and improve vehicle handling and stability. Additionally, the NTRC has a long-term goal of expanding equipment and facilities targeted at the development of related markets, such as heavy-truck and military-vehicle tires.

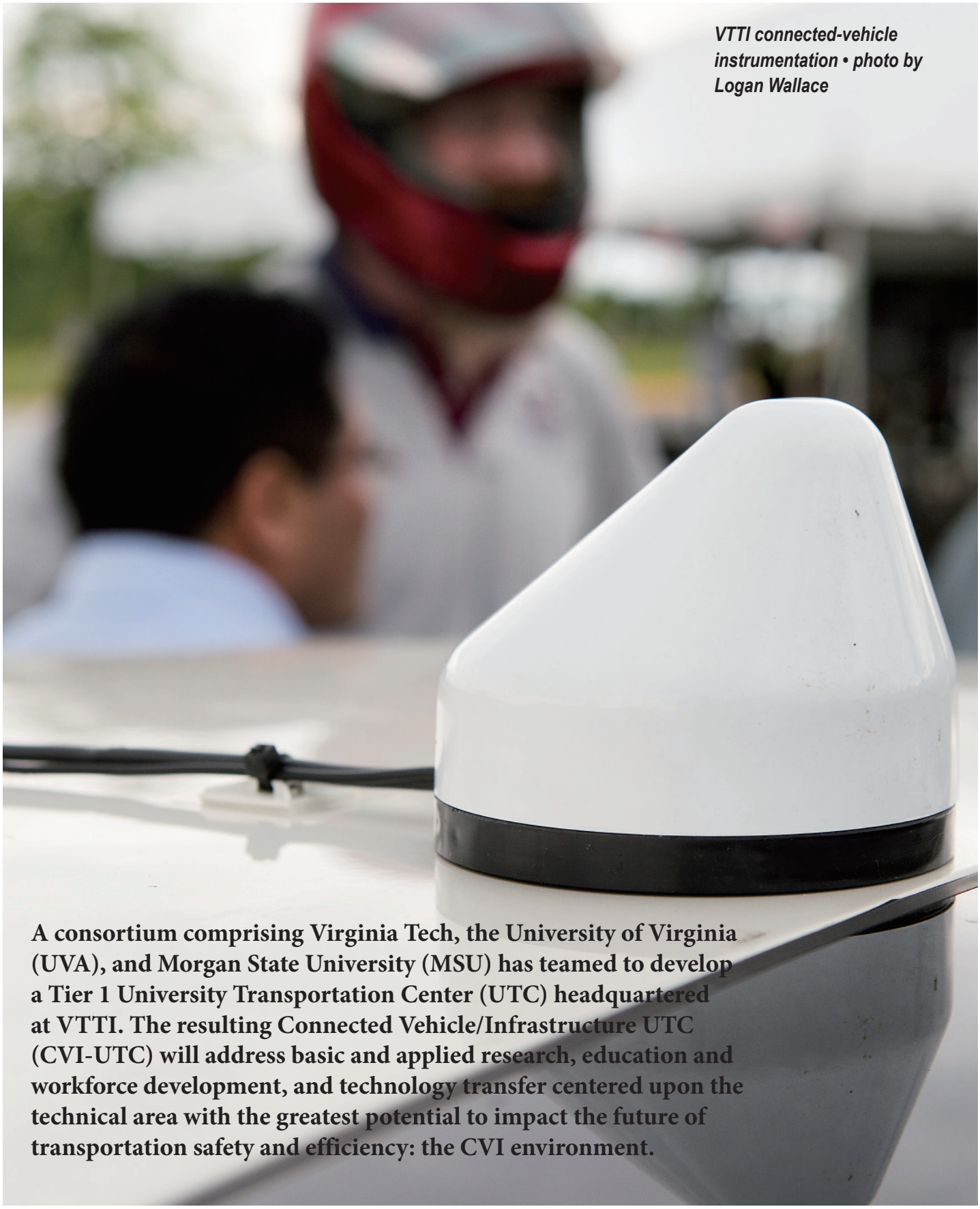
The NTRC is a collaborative effort led by VTTI in alliance with the Institute for Advanced Learning and Research (IALR), General Motors, and the Virginia Tobacco Indemnification Commission for the purpose of advancing the strength and quality of life in Southern Virginia. This initiative is in keeping with the Virginia Tech mission of "transforming knowledge to practice through technological leadership and by fueling economic growth and job creation locally, regionally, and across Virginia."



SoVa Motion 8-post Test Rig

SoVa Motion Cruden's Simulator • photo by Logan Wallace

Connected Vehicle/Infrastructure University Transportation Center



VTTI connected-vehicle instrumentation • photo by Logan Wallace

A consortium comprising Virginia Tech, the University of Virginia (UVA), and Morgan State University (MSU) has teamed to develop a Tier 1 University Transportation Center (UTC) headquartered at VTTI. The resulting Connected Vehicle/Infrastructure UTC (CVI-UTC) will address basic and applied research, education and workforce development, and technology transfer centered upon the technical area with the greatest potential to impact the future of transportation safety and efficiency: the CVI environment.

The connected vehicle/infrastructure (CVI) environment provides an unprecedented opportunity to solve a number of transportation problems by enabling the sharing of real-time information across vehicles and infrastructure elements. Robust communication between vehicles, infrastructure, and devices will facilitate applications designed to address the U.S. Department of Transportation (USDOT) strategic goals of safety, state of good repair, economic competitiveness, livable communities, and environmental sustainability.

CVI-UTC Core

VTTI has assembled a notable core of Consortium members, partners, and stakeholders with the capabilities and experience required to conduct state-of-the-art research, education, and technology transfer in the area of connected vehicles.

Consortium Members

- The University of Virginia (UVA) Center for Transportation Studies (CTS)
- The National Transportation Center (NTC) at Morgan State University (MSU)

Center Partners

- Virginia Center for Transportation Innovation and Research (VCTIR)

Supporting Stakeholders

- Nissan
- Volvo Trucks
- Virginia Department of Rail and Public Transportation
- The County of Fairfax, VA

New Projects

Safety and Human Factors of Adaptive Stop/Yield Signs using Connected-vehicle Infrastructure

Adaptable stop/yield signs have been proposed by some traffic professionals to improve travel time, reduce air pollution, increase fuel economy, and adjust to different traffic conditions, such as peak hours, weather, or emergency vehicles. With the advent of connected-vehicle technology, the ability exists to change these signs based on vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications. The placement of a sign type has been traditionally based upon traffic conditions. However, more and more stop signs are being placed instead of yield signs due to liability risks, resident concerns, and potential worst-case crash scenarios.

While adaptable signs have great potential, they must be properly designed and tested to ensure that: 1) The net safety benefits are positive, 2) Drivers interpret and respond correctly to the signs, 3) Drivers pay appropriate attention to signs without adaptation in the form of relying on past history (e.g., the sign may be different than the prior 10 times the intersection was crossed), 4) There are no other unintended consequences when signs are deployed, and 5) Driver acceptance of the technology is high.

Connected-vehicle Applications for Adaptive Overhead Lighting

Adaptive lighting refers to an emerging technology in which lighting systems are tailored to the needs of the environment. In the case of roadway lighting, this would imply dimming or shutting off lighting when it is not required. This technology is enabled through the use of recently developed electronic ballasts for the lighting system and controllers that can provide dimming capability. In addition to dimming, an instant on-and-off capability can be achieved through the implementation of solid-state or induction lighting technology, which does not require the warm-up period that traditional lighting systems do. This instant on-and-off capability leads to the ultimate extension of adaptive lighting: "lighting on demand," during which the lighting system is triggered by the presence of a vehicle. This adaptive lighting

process requires a selection of the light output level based on a series of inputs. These inputs include the traffic volume, vehicle speed, ambient weather conditions, and the presence of pedestrians. Once the lighting level is selected, it is then implemented on the roadway through a luminaire control system. A fully controllable lighting system has already been implemented on the Smart Road, which coincides with one of the connected-vehicle test beds. In terms of refining this process, VTTI is performing a major research project funded by the Federal Highway Administration (FHWA). The project includes an evaluation of crashes under a variety of traffic and lighting conditions and a series of *in situ* measurements of the lighting system performance. This effort is designed to establish the link between lighting level and traffic safety. This project will also set the criteria used to select the required lighting level that establishes the required inputs for the lighting system. The application of connected-vehicle technologies will gather the required roadway usage data as inputs to the system. Traffic volume, vehicle speed, and pedestrian volume all have the potential to be captured through connected-vehicle technologies. There are a multitude of benefits that result from the implementation of adaptive lighting, including a reduction in light pollution and maintenance. The most significant result of adaptive lighting technology is energy savings. It is estimated that a lighting system can be dimmed to a 50 percent level for at least 50 percent of the system burn time. This represents a 25 percent energy savings in the lighting system cost. In 2001, it was estimated that outdoor lighting in the U.S. used 57.35 Terawatt-hours of electricity, thus costing $5.9 billion. With a 25 percent savings, this represents $1.49 billion in savings.

Intersection Management Using In-vehicle Speed Advisory/Adaptation

Since the initialization of research based on vehicle infrastructure integration (VII) and connected vehicles, numerous in-vehicle technologies are being deployed that use wireless communications. These advanced technologies lay the foundation for the proposed research effort to test vehicle speed advisories and adaptation systems on intersection performance. The main idea of the speed advisory system is to display a suggested speed to the driver, who has the choice to follow or ignore the advice. Alternatively, the speed adaptation system entails automatic control of the vehicle speed using advanced cruise control systems. The research group has developed a simulation/optimization tool that manages intersection operations, entitled iCACC. The main idea of this tool is to optimize the trajectories of vehicles approaching an intersection to prevent crashes and to reduce the total intersection delay simultaneously. Simulations using this tool showed significant savings in total delay and fuel consumption when compared to traditional intersection control. Consequently, this research effort proposes a field test of the iCACC tool using the Smart Road connected-vehicle test bed. The research will attempt to study five different cases in the field experiments: signal control with no exchanged information (base case), signal control with displayed speed advisory and green/red time countdown, flashing signal control with speed advisory, flashing signal control with speed adaptation, and a roundabout case study. The research findings are expected to provide researchers, automobile manufacturers, and decision makers with information regarding the degree of acceptance of drivers and the potential of such systems for use in intersection control.

Field Testing of Eco-speed Control Using V2I Communication

This project, which is sponsored by the AERIS program under the FHWA Research and Innovative Technology Administration (RITA), and the Eco-Cooperative Adaptive Cruise Control (ECACC) project laid ample foundation for the feasibility of reducing vehicle fuel consumption levels in the vicinity of signalized intersections when signal phasing and timing (SPaT)

information is communicated to approaching vehicles. Informed drivers/vehicles can alter their speeds in the vicinity of such intersections to minimize idling and, in many cases, loss of inertia. Two approaches to this logic were studied using agent-based simulations in MATLAB: 1) Eco-speed control, during which an in-vehicle device receives SPaT information, performs the calculations, and provides instantaneous speed advisories to drivers. If followed accurately, this can benefit the driver by lowering the vehicle fuel consumption; and 2) ECACC, which uses SPaT information and lead/queued vehicle information and automatically controls the vehicle speed to achieve the "advised fuel-optimum velocity trajectory." Fuel consumption reductions of up to 23 percent were found based on simulation studies of a single vehicle.

Connected test bed roadside unit • photo by Logan Wallace

However, these simulations make some assumptions that may not be realistic, where either the driver perfectly follows the speed advisory or the ECACC is 100 percent accurate. This is in addition to the neglected uncertainties regarding the dedicated short-range communication (DSRC) and any communication latencies. Field tests are sought for further analysis and research regarding eco-speed control, and the connected-vehicle test beds of Montgomery County and potentially Northern Virginia are deemed to be an ideal candidate for this effort.

The objective of this research is to implement the eco-speed control system using connected-vehicle test beds and to gain hands-on experience of the implementation issues for this system. The proposed experiments are anticipated to provide valuable information about the following: 1) Actual benefits sought when eco-speed control or ECACC is implemented and the feasibility of the system, 2) Error functions when a typical driver follows a proposed speed profile, 3) Deviation from the proposed speed profile when an automated cruising unit is used, 4) The human-machine interface needed for an eco-speed control unit, and 5) The effect of non-test vehicles in the traffic mix on (a) fuel benefits of the test vehicle and (b) the feasibility of speed adjustments.

Innovative "Intelligent" Awareness System for Roadway Workers Using Dedicated Short-Range Communications

The movement of vehicles (e.g., traffic, dump trucks, and powered mobile construction equipment) around a work zone poses a significant safety risk to nearby workers-on-foot (WOFs). Each year, more than 20,000 injuries and more than 100 fatalities occur at road construction zones. Nearly two-thirds (62 percent) of these incidents involved a worker being struck by a vehicle. This project will use the expertise of

the research team in the fields of V2V communication and pervasive computing to develop an innovative "intelligent" awareness system. The system will comprise DSRC technology mounted on vehicles and worn by WOFs. Since WOFs are required to wear Class 2 or 3 apparel (e.g., reflective vests) while working in right-of-ways on federal-aid highways, the DSRC technology will be embedded within these garments and present on roadway workers during dangerous situations. The objectives of this study are twofold. The first is to develop and test an "intelligent" system of awareness device, called InZoneAlert, to be deployed on both vehicles and WOFs. The system will alert WOFs and vehicle operators of impending struck-by incidents. This system will alert workers only in the case of accidental close interactions and will not provide false alarms for intentional close interactions between traffic and the equipped worker. The alert system should provide warnings in sufficient time to allow the accident to be avoided and should require minimal, cost-effective redesign of both vehicles and workers' clothing. The second objective is to evaluate the functional effectiveness of the developed InZoneAlert system under operational conditions. This evaluation will occur on the Smart Road. This project will provide a solid research-to-practice approach to mitigating work zone struck-by incidents via the development of a novel countermeasure specific to the problem and verification of its effectiveness under realistic operational conditions.

Connected Vehicle-Infrastructure Application Development for Addressing Safety and Congestion Issues Related to Public Transportation, Pedestrians, and Bicyclists

The concepts of connected-vehicle, V2V, and V2I communications will result in a new generation of highway infrastructure, traffic controls, and vehicle/driver functions. These concepts will revolutionize the traditional role of the drivers, which has been to perceive the surroundings, evaluate the situation, make a decision, and execute it. This is a passive role given the operating environment. Further, individual drivers perform these processes independent of one another. The lack of coordination among the drivers has annually resulted in 1.6 million rear-end crashes and 634,000 side crashes (Consumer Reports, April 2012). How connected vehicles will specifically change the traditional concept of driving is yet to be seen, although many components of connected vehicles are already being tested and marketed today (e.g., advanced warning of a vehicle braking ahead, forward collision warning, and blind spot/lane-change warning).

How these technologies will be integrated into the connected-vehicle system is not precisely known at this time. Hence, it is timely to explore ideas about all aspects of connected vehicles and to identify implications. It appears that, at this time, the application of the connected-vehicle concept is concentrated on the operations of cars and trucks. The proposed research examines how the connected-vehicle concept can include the operations of public transportation vehicles (including school buses), transit passengers, pedestrians and school children, and bicyclists. The research will develop a smartphone-based application for addressing some of the safety and congestion issues related to public transportation, pedestrians, and bicyclists.

Emergency Vehicle-to-vehicle Communication

V2V communication can be used to improve the safety and efficiency of emergency response. With driver compliance to guidance, such communication can ease driver stress associated with trying to accommodate an approaching emergency vehicle but encountering roadside obstacles or limited space to maneuver to the right. The communication can also aid emergency vehicle turning movements, particularly right turns, by clearing the right lane rather than the left. Based on instrumented vehicle data, this project will develop and test algorithms for guiding personal vehicles out of the path of the emergency vehicles and will develop a message communication prototype.

Emergency vehicles must often navigate through congested conditions to reach the people requesting assistance or to bring them to hospitals for treatment. While these vehicles may travel on shoulders, against traffic, or proceed through red lights, these are risky situations for which the emergency vehicle driver will be held liable if a crash occurs. Other vehicles on the road are supposed to slow down and pull over to the right to facilitate the travel of the emergency vehicle. However, not every driver does so. In some situations, there is little room for drivers to pull to the right as traffic may be gridlocked or shoulders may have obstructions. On arterials, the emergency vehicle may need to turn right but may find it difficult to do so because of the drivers on the right. V2V communication can help alert vehicles to the presence of an emergency vehicle and can provide information about the desired maneuvers of emergency vehicles. Personal vehicles can be better directed to accommodate the emergency vehicle. This cooperative behavior will make emergency vehicle travel safer and will allow police and first responders to reach those in need faster.

The goal of this study is to facilitate emergency vehicles reaching their destinations. Specific objectives include: 1) Identifying roadside obstructions with instrumented vehicles, 2) Determining the best location for vehicles to stop so the emergency vehicle may pass, 3) Determining the best path for the emergency vehicle through traffic, and 4) Developing a message display prototype for personal vehicles.

Infrastructure Pavement Assessment and Management Applications Enabled by the Connected Vehicles Environment Research Program - Phase I: Proof-of-Concept

A fundamental role of transportation agencies is to effectively manage the enormous public investment in pavement. This includes developing strategies and systems to periodically assess pavement conditions, developing maintenance plans to maximize pavement life within limited budgets, and making tactical decisions regarding treatment during adverse weather conditions to keep roadways functional. A fundamental requirement in this management activity is to collect data to assess the condition of the pavement. The current state of the practice in pavement condition data collection is to use specialized sensors and equipment. This represents a significant cost burden on agencies, and this technical approach to data collection scales poorly. In other words, given the need for specialized equipment and sensors, it is difficult to collect data at more locations in a timely, cost-effective manner. A potential advantage offered by connected vehicles is that this program promises to closely tie the infrastructure to the vast vehicle fleet using the infrastructure. Given the large set of sophisticated sensors integrated into modern vehicles, it is possible that these vehicular sensors may be used as a means to assess pavement conditions. In other words, the entire vehicle fleet can be transformed into probes measuring pavement conditions at all locations during frequent time intervals. The purpose of this collaborative research program between Virginia Tech and UVA is to conduct the applied research necessary to investigate the feasibility of this concept through component and system prototyping and testing on the CVI-UTC Virginia Connected Test Bed. The work will specifically address pavement applications, roughness measurement, and friction assessment during snow and rain.

Connected Motorcycle Crash Warning Interfaces

This study is testing potential auditory, visual, and tactile connected-vehicle displays for motorcyclists. The project will focus on the following primary objectives:

- Refine the base connected motorcycle system to include warning capabilities;
- Design and develop the warning interface for riders; and
- Evaluate prototype interfaces.

Hardware and firmware are currently being developed that will permit demonstration of

these three interface modes on participant motorcycles. Participants will ride with the connected-vehicle technology in a backpack, and the various warning modes and sample connected-vehicle scenarios will be demonstrated. Participants will provide feedback about the different implementations.

Developing and Evaluating a Smartphone Application Aimed at Reducing Crashes Involving Motorcycles and Bicycles

Per current statistics, fatal crashes are considerably more likely to happen when riding on motorcycles than any other means of transportation. Bicycles, which are similar to motorcycles in structure, also account for a significant number of crashes. Connected-vehicle technologies have enabled researchers to develop safety applications using DSRC. A highlighted characteristic of DSRC is its low latency, which is critical for real-time applications. However, recent developments in cellular technologies, as reported by cell phone provider companies, introduced Fourth Generation, Long Term Evolution (4G LTE), which also provides low latency services. To reduce and mitigate crashes involving motorcycles and bicycles, a smartphone application is proposed to gather required information and to inform riders and drivers of potential conflicts in real time. The goals of this research are twofold: 1) Safety improvements regarding crashes involving motorcycles/bicycles, and 2) Use of cellular communication. In developing the smartphone application, the Appcelerator titanium and PhoneGap mobile development platforms will be considered. The application will require a server for which Python and PHP programming languages will be considered. Two processing methods for server design will be evaluated, namely centralized and distributed approaches. Image processing will be applied to improve the accuracy of built-in global positioning system (GPS) receivers of smartphones. Five scenarios will be

VTTI connected vehicles • photo by Logan Wallace

developed and examined to test the applicability of the application. Scenarios will be constructed with regard to the following factors: 1) Use of 4G LTE, 2) Use of DSRC, 3) Use of high sensitivity GPS receivers, and 4) Data processing method. To compare the scenarios, the following features will be taken into account: 1) Latency, 2) Accuracy, 3) Cost, and 4) Convenience.

By creating a smartphone application that all drivers can download at a minimal cost that will offer both general state and infrastructure notifications (e.g., bad weather) and small-vehicle specific warnings (e.g., motorcycle ahead), this offers all drivers more time to make adjustments and better decisions in their driving behavior. This, in turn, will improve safety with minimal temporal or fiscal adjustments from original equipment manufacturers, drivers, and state DOTs. Cellular technology as a means of communication needs to be compared with developed warning systems that use DSRC to study and quantify the benefits of both systems.

The objectives of this study can be summarized as follows:

- Identify significant factors leading to crashes involving motorcycles and bicycles,
- Develop a smartphone application to reduce/mitigate these crashes,
- Test and evaluate the applicability of the application using Smart Road facilities, and
- Compare cellular communication versus DSRC.

Reducing School Bus/Light-vehicle Conflicts through Connected-vehicle Communications

In 2010, 249 buses were involved in fatal crashes, and approximately 12,000 buses were involved in crashes that resulted in injuries. The total number of buses involved in crashes with other motor vehicles, pedestrians, or objects was approximately 54,000 in the United States. Of the 249 fatal crashes reported above, 114 involved school buses, 37 involved cross-country/intercity buses, 83 involved transit buses, and 15 involved other or unknown bus types. Buses are particularly susceptible to rear-end conflicts due to their frequent decelerating and stopping behaviors in traffic. Statistics indicate that the rear of the bus is the most frequent initial point of impact during a crash (approximately 28 percent of the 54,000 crashes). The rear-end collisions that occurred during 2010 resulted in 35 fatalities, 2,000 injuries, and 13,000 incidents of property damage. Fatalities resulting from collisions with passenger buses are often the light-vehicle motorists. When analyzing Buses Involved in Fatal Accidents (BIFA) data, Blower et al. found that driver error leading to the crash was more likely to have occurred in the striking vehicle than the vehicle being struck. Therefore, rear-end collisions with buses are a concern for the entire motoring public. Blower et al. stated that the high proportion of rear-end crashes during which the bus was struck suggested that improved conspicuity and increased awareness of the stopped bus could enhance the safety of the situation. While today's vehicles are equipped with safety technologies (e.g., collision warning systems, forward collision warnings [FCW], adaptive cruise control), it is recognized that these current safety technologies have limitations around curves and over hills. For instance, when an FCW-equipped vehicle is traversing a sharp curve, the stopped vehicle may not be within the sensor range of the system due to its limited azimuthal coverage. The same can be said for situations during which an FCW-equipped vehicle crests a hill, at which point the FCW sensor coverage is aimed above the descending roadway on the other side. Connected-vehicle communications, particularly DSRC, could be used to provide following traffic with in-vehicle notifications of a stopped bus, especially when the bus is stopped over a hill or around a blind curve. DSRC provides an "extended information horizon" and lets the drivers "see over hills and around curves." This project will provide a novel opportunity to apply this enhanced capability designed to facilitate increased awareness of stopped buses during moments when they are obscured from the flow of traffic.

Although connected-vehicle communications (e.g., DSRC, cellular, WiFi) could be applied to all passenger bus types (e.g., transit, school, motorcoach), this work will focus on school buses engaged in pupil transportation.

School bus drivers face unique safety concerns as professional drivers. They carry what is perhaps the nation's most precious cargo: our children. Every school day, more than 25 million school-aged children are transported to and from school on nearly 480,000 school buses. This annually equates to approximately 20 billion boardings and de-boardings of school buses throughout the United States. Many of these boardings and de-boardings result in school buses stopped in the roadway. This scenario is considered one of the most dangerous situations for a school bus and its student riders. Connected-vehicle technology could be the solution for improving bus conspicuity and increasing awareness among other roadway users of a stopped school bus.

The objectives of this 12-month study are threefold. First, the research team will develop a Concept of Operations (ConOps) for the connected school bus. Second, the research team will develop a prototype, in-vehicle message display for following vehicles to alert them of a stopped school bus. Finally, the team will conduct preliminary testing of the prototype driver-vehicle interface (DVI) on the Virginia International Raceway (VIR) in Southern Virginia.

Using connected-vehicle technology, VTTI is working to reduce rear-end crashes with school buses

Connected Motorcycle System Performance

This study is testing the effectiveness of connected technology on motorcycles. The project will focus on the following objectives:

- Characterize the impact of antenna configurations on communications and positioning performance.
- Characterize the target classification performance of vehicles when communicating with a motorcycle across varied terrain and roadway geometries.
- Compare motorcycle-mounted system performance to performance found in automotive testing.
- Compare differences between two automobiles communicating versus mixed vehicle communications.
- Report observations and provide recommendations.

Develop and Test Connected-vehicle Freeway Speed Harmonization Systems

The objective of speed harmonization is to dynamically adjust and coordinate maximum appropriate vehicle speeds in response to downstream congestion, incidents, and weather or road surface conditions to prevent/reduce vehicle crashes and maximize traffic throughput. The proposed research effort builds on and extends existing research efforts being conducted at FHWA by developing a novel speed harmonization algorithm that is predictive as opposed to reactive in nature. Specifically, the speed harmonization algorithm extends research being conducted at the Saxton Traffic Operations Laboratory (STOL) by developing an algorithm that predicts the occurrence of shockwaves up to five minutes before their occurrence using a combination of macroscopic traffic modeling and Bayesian filtering techniques. The wireless communications between vehicles and vehicle-to-roadside equipment (RSE) provide a unique environment in which to collect traffic data in addition to traditional sensor data. Traffic data gathered from connected vehicles as probes will be combined with fixed-location traffic sensor data to predict downstream recurrent and non-recurrent traffic conditions, including speed and shockwave temporal-spatial evolutions. Based on the predicted traffic conditions and weather and road surface conditions, the speed harmonization algorithm will make recommendations about the optimum course of action in an attempt to reduce vehicle crashes, maximize traffic throughput, and reduce vehicle emissions. A field test will be conducted to validate the proposed algorithm using the test vehicles that will be developed as part of the FHWA STOL effort and the connected-vehicle test bed in Northern Virginia.

The goal of this research effort is to develop a dynamic speed harmonization (SPD-HARM) application that uses the frequently collected and rapidly disseminated multi-source data drawn from connected travelers, roadside sensors, and infrastructure. The application may be a vehicle-integrated device (e.g., a vehicle manufacturer-installed or aftermarket integrated device); a personal wireless application (e.g., a smartphone or other handheld device); or another application capable of collecting, receiving, and disseminating movement and location information. The goal of SPD-HARM is to improve the nature, accuracy, precision, and speed of dynamic decision making by both system managers and system users.

In reaching the identified goal, the objective of the project is to develop speed decision algorithms to achieve the mobility, safety, and environmental goals of dynamic speed harmonization. A connected-vehicle environment will enable systems and algorithms that can generate traffic condition predictions, alternative scenarios, and solution evaluations in real time. This will entail developing a simulation-based optimization tool to compute the optimum speed recommendations. Note that this requires an increase in computational capability and long-term storage of historical data. Performance measurements will play an important role in evaluating and improving dynamic speed harmonization algorithms and methods.

VTTI data collection unit • photo by Logan Wallace

Ongoing Projects

Technical Coordination and Quality Control for the SHRP 2 NDS (S06)

The Transportation Research Board (TRB) of the National Academy of Sciences (NAS) administers the Safety Area of the Second Strategic Highway Research Program (SHRP 2). VTTI is a key player in helping TRB achieve its goals in the safety arena via the institute's leadership role in the SHRP 2 Naturalistic Driving Study (NDS), the largest such research study ever undertaken and the model for similar efforts being pursued internationally. VTTI is working closely with SHRP 2 staff and site contractors who are staffing each of six data collection sites in the following areas: Buffalo, NY; Tampa, FL; Seattle, WA; Durham, NC; Bloomington, IN; and State College, PA.

The overall goal of the VTTI effort is to ensure that all study data are collected accurately and stored securely while maintaining human subjects protections. VTTI's responsibilities include: design and acceptance testing of the data acquisition system (DAS); overseeing procedures for protection of participant data; coordinating study protocols; developing the more than 100 approved consent forms and related supplemental materials; facilitating successful Institutional Review Board (IRB) submissions across all IRBs involved; training of S07 project personnel in terms of administering driver assessments, DAS installation, and data handling; overseeing participant recruitment and screening; adhering to the sampling plan; managing the triage response to all remote DAS self-"health" check and automated collision notification messages; monitoring the process and progress of hard drive removals and data uploads to the VTTI data center; maintaining the data collection schedule; and processing, storing, and providing access to study data for use in ongoing and subsequent research projects. As part of its oversight role, VTTI produces several reports each month about inventory tracking, data quality, data accumulation,

Camera instrumentation on motorcycle • photo by Logan Wallace

and projections. VTTI also manages the distribution of available study hardware across the six data collection sites in a manner that best supports TRB goals.

The first DAS was installed in a vehicle during October 2010. Approximately 1,900 vehicles are currently on the road, and nearly 1,260 participants have completed the study. To date, more than 3,400 vehicle-years of data have been collected; an additional five to six vehicle-years are daily added to that total. Collected data comprise several continuous video images, including the driver's face and the forward roadway. Other data streams being continuously collected include acceleration in three dimensions, global positioning system (GPS) information, forward radar, the presence of alcohol in the cabin, and ambient illumination. Onboard machine-vision algorithms produce lane-tracking and head pose/rotation data. For security reasons, all data are encrypted on the solid-state data drive of the DAS.

DAS Procurement

The goal of the DAS Procurement project (under the SHRP 2 S12A) is to obtain all DASs and related warranties needed to support the SHRP 2 NDS (S06 and S07 projects) within budget and within a timeframe that considers project scheduling constraints. A viable contract manufacturer was awarded with the assistance of the selection committee, which included VTTI- and SHRP 2-nominated personnel. This selection committee reviewed and approved all procurement processes, documentation, Requests for Information (RFI), and the Request for Proposal (RFP). Following the initial equipment orders, supplemental replacement components have been ordered as needed to fulfill the data collection needs. Acceptance testing is completed except in those cases where new or novel situations occur.

Completed Projects

Portable Devices

While existing industry and government guidelines discuss appropriate levels of distraction arising from integrated in-vehicle devices, the potential effects of portable devices has yet to be fully addressed. The purpose of this project was to review existing literature and guidelines on distraction related to portable aftermarket and voice-controlled devices and determine their relevance in application to the in-vehicle environment. The final deliverable of this project will be a compendium and review of academic articles, technical reports, guidelines, and standards related to portable device use and their potential effects on in-vehicle distraction. This project was sponsored by the National Highway Traffic Safety Administration (NHTSA).

A Continued Investigation into Secondary Task Alternatives: Purely Speech-based versus Combined Speech/Vision Methods

Agero, an independent provider of personalized telematics services, sponsored a research effort designed to evaluate speech-based alternatives to in-vehicle tasks that are traditionally vision-based. This research incorporated three approaches: manual, speech-only, and a combination of speech and manual inputs. These approaches were compared in terms of their effects on driving performances while executing destination-entry tasks. Measurements of lateral and longitudinal impacts on driving while engaged in these secondary tasks included both speed and lane maintenance. An eye-glance analysis was expected to determine which approach requires the least amount of eyes-off-road time.

Subjective feedback was expected to classify a perceived favorite, but objective data will ultimately dictate which approach should be used to inform future applications.

Usage and Risk Differences When Using Hands-Free and Hand-Held Cell Phones: Data Analysis And Documentation

Existing data on distraction has been an excellent starting platform for improving our understanding of driver distraction. NHTSA's Driver Distraction Program (DOT HS 811 299) aims to improve our understanding of driver distraction when using cell phones. This study investigated drivers' interactions with three types of cell phones – hand-held, portable hands-free, and integrated hands-free – to determine the relative exposure and risk of each type. This study involved reducing NDS data to identify the following three aspects of this interaction: how much drivers use a cell phone while driving; their driving performance while using the cell phone; and the risk of a safety-critical event associated with using the cell phone. This project was sponsored by NHTSA.

VTTI researcher Greg Fitch conducts distraction research • photo by Logan Wallace

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Lam, J.C., James M. Bryce, J.M., Lucy P. Priddy, L.P., Flintsch G.W., "Development of Infrastructure Management Strategies for Small and Mid-Size Airfields," ASCE T&DI 2013 Airfield and Highway Pavements Conference, Jun 9-12, 2013, Los Angeles, CA.

Li H., Rakha H., and El-Shawarby I. (2012), "Designing Yellow Intervals for Rainy and Wet Roadway Conditions," International Journal of Transportation Science and Technology, Vol. 1, no. 2, ISSN 1475 472 X, pp. 171-189.

Lijie, T., and Flintsch, G.W., "Use of Precipitation Records in Drainage Design of Porous Asphalt Surface Layer," presentation 13-2720, 92nd Annual Meeting of the Transportation Research Board, Jan 13-17, 2013, Washington, DC.

Litsas S. and Rakha H. (In press). "Evaluation of Continuous Green T-Intersections on Isolated Under-Saturated Four-Lane Highways," Transportation Research Record: Journal of the Transportation Research Board.

Mabry, J. Erin, Baker, S., Hickman, J., Hanowski, R. Case Study on the Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers. http://scholar.lib.vt.edu/VTTI/. September, 28, 2012. National Surface Transportation Safety Center for Excellence (NSTSCE) Report No. 12-UI-017, http://scholar.lib.vt.edu/VTTI/reports/TreatingSleepApneaFinalReport08022012.pdf. Blacksburg, VA: NSTSCE.

Mabry, E., Baker, S., Hickman, J., & Hanowski, R. (August 2012). Case study on the impact of treating sleep apnea in commercial motor vehicle (CMV) drivers. Poster session presented at the Third International Symposium on Naturalistic Driving Research, Blacksburg, VA.

Mabry, J. E., S. Baker, J. Hickman and R. Hanowski. (2012). Case Study on the Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers—Sleep Apnea Programs from Two Leading U.S. Carriers and Focus Group Findings. National Surface Transportation Safety Center for Excellence. Blacksburg, VA, Virginia Tech Transportation Institute. 12-UI-017: 1-74.

Maddox, M. E., Fitch, G. M., Kiefer, A., Mortimer, R., & Muttart, J. (2012). Implications for Forensic Practice of Human Factors Research Findings and Case Data Related to Rear-End Collisions. Proceedings of the 56th Annual Meeting of the Human Factors and Ergonomics Society.

Martinez Arguelles, G., Crispino, M., Giustozzi, F., Flintsch, G.W., "Environmental Analysis on asphalt pavement maintenance using modified binders in Developing Countries: Bogota Case Study" paper 13-3475, 92nd Annual Meeting of the Transportation Research Board Jan 13-17, 2013, Washington, DC.

McGhee, K., de León Izeppi, E.D.; Flintsch, G.W., Mogrovejo, D., "Virginia Quiet Pavement Demonstration Projects: Initial Functional Assessment," Journal of the Transportation Research Board, 2013 (paper 13-3150, accepted for publication).

Mogrovejo, D.E., Flintsch, G.W., de León Izeppi, E.D., and McGhee, K.K. "Effect of Air Temperature and Vehicle Speed on Tire/Pavement Noise Measured with On-Board Sound Intensity Methodology," paper 13-3765, 92nd Annual Meeting of the Transportation Research Board, Jan 13-17, 2013, Washington, DC.

Morgan, J.F., Blanco, M., & Hanowski, R.J. (In press). Driver opinions of simulator-based commercial vehicle training. Paper accepted for publication in the Washington Academy of Science Journal.

Park S., Donoughe K., and Rakha H. (2012), "Safety Benefits of Stability Control Systems for Tractor-Semitrailers Using Hardware-in-the-Loop Simulation," Transportation Research Record: Journal of the Transportation Research Board, No. 2281, pp. 99-108. DOI: 10.3141/2281-13.

Park S., Rakha H., Ahn K., Moran K., Saerens B., and Van den Bulck E., (2012), "Predictive Eco-cruise Control System: Model Logic and Preliminary Testing," Transportation Research Record: Journal of the Transportation Research Board, No. 2270, pp. 113-123, DOI: 10.3141/2270-14.

Priddy, L.P., Bly, P.G., Flintsch, G.W., "Review Of Precast Portland Cement Concrete Panel Technologies For Use In Expedient Portland Cement Concrete Airfield Pavement Repairs," paper 13-2956, 92nd Annual Meeting of the Transportation Research Board, Jan 13-17, 2013, Washington, DC.

Qiao, Y., Flintsch, G.W., Dawson, A., and Parry, T., "Examining the Effects of Climate Change on Pavement Deterioration and Service Life," Journal of the Transportation Research Board, 2013 (paper 13-4859, accepted for publication).

Rakha H., Arafeh M. and Park S. (2012), "Modeling Inclement Weather Impacts on Traffic Stream Behavior," International Journal of Transportation Science and Technology, Vol. 1, no. 1, pp. 25-48.

Rakha H., Ahn K., Faris W., Moran, K. (2012), "Simple Vehicle Powertrain Model for Modeling Intelligent Vehicle Applications," IEEE Transactions on Intelligent Transportation Systems, Vol 13(2), June 2012, ISSN 1524-9050, pp. 770-780.

Rakha H., Ahn K., and Moran K., (2012), INTEGRATION Framework for Modeling Eco-routing Strategies: Logic and Preliminary Results, International Journal of Transportation Science and Technology, Vol. 1, no. 3, pp. 259-274.

Rakha H., Ahn K. and Park S. (2013), "Predictive Eco-Cruise Control (ECC) System: Model Development, Modeling and Potential Benefits," U.S. Department of Transportation's University Transportation Centers Program, 92p.

Rakha H., Sangster J. and Du J. (2013), "Naturalistic Driving Data for the Analysis of Car-following Models," U.S. Department of Transportation's University Transportation Centers Program, 48p.

Rakha H., Zohdy I. and Kamalanathsharma R. (2013), "Agent-Based Game Theory Modeling for Driverless Vehicles at Intersections," U.S. Department of Transportation's University Transportation Centers Program, 43p.

Rakha H., Chen H., Haghani A., and "Assessment of Data Quality Needs for use in Transportation Applications," U.S. Department of Transportation's University Transportation Centers Program, 123p.

Reagan, Ian J., McClafferty, Julie A., Berlin, Sharon P., Hankey, Jonathan M. (2013). Using naturalistic driving data to identify variables associated with infrequent, occasional, and consistent seat belt use, Accident Analysis & Prevention, Volume 50, January 2013, Pages 600-607, ISSN 0001-4575, http://dx.doi.org/10.1016/j.aap.2012.06.008.

Saerens, B., Rakha, H., Ahn, K., and Van den Bulck, E. (2013), "Assessment of Alternative Polynomial Fuel Consumption Models for use in ITS Applications," Journal of Intelligent Transportation Systems: Technology, Planning, and Operations, DOI:1 0.1080/15472450.2013.764801.

Saerens B., Rakha H., Diehl M., Van den Bulck E. (2013), "Eco-Cruise Control for Passenger Vehicles: Methodology," Transportation Research Part D: Transport and Environment, Vol. 19, pp. 20-27.

Sangster J., Rakha H., and Du J. (In press). "Application of Naturalistic Driving Data to the Modeling of Driver Car-following Behavior," Transportation Research Record: Journal of the Transportation Research Board.

Schaudt, W.A., Bowman, D., Baker, S., Hanowski, R. J., and Flanigan, C. (2013). Field evaluation of an enhanced rear signalling system for heavy trucks. IET Intell. Transp. Syst., pp. 1-6, doi: 10.1049/iet-its.2012.0025.

Schaudt, W.A., Bowman, D., Trimble, T.E., Medina, A.F., Bocanegra, J., Baker, S., Marinik, A., Wierwille, W.W., and Hanowski, R.J. (In press). Enhanced rear signaling (ERS) for heavy trucks: Phase III – development of field operational test; final report. Contract No. DTMC75-07-D-00006, Task Order 2. Washington DC: U.S. Department of Transportation, Federal Motor Carrier Safety Administration.

Tang, L., Flintsch, G.W., and Viner, H., "Exposure Model For Predicting Splash and Spray," Proceedings of the 7th Symposium on Pavement Surface Characteristics (SURF 2012), Sep. 18-21, 2013, Norfolk, VA.

Tawfik A. and Rakha H. (In press). "A Latent Class Choice Model of Heterogeneous Drivers Route Choice Behavior Based on a Real-World Experiment," Transportation Research Record: Journal of the Transportation Research Board.

Tawfik A. and Rakha H. (2012), "Network Route-Choice Evolution in a Real-Life Experiment: A Necessary Shift from Network to Driver Oriented Modeling," Transportation Research Record: Journal of the Transportation Research Board, No. 2322, pp. 70-81.

Tawfik A. and Rakha H. (2012), "Human Aspects of Route Choice Behavior: Incorporating Perceptions, Learning Trends, Latent Classes, and Personality Traits in the Modeling of Driver Heterogeneity in Route Choice Behavior," U.S. Department of Transportation's University Transportation Centers Program, 203p.

Trimble, T. E., & Bowman, D. S. (2012). Market Guide to Fleet Telematics Services: Creating a Consumer's Guide to Currently Available Aftermarket Solutions (NSTSCE Report No. 12-UT-018). Blacksburg, VA: Virginia Tech Transportation Institute.

Tsoi A, Hinch J, Ruth R, and Gabler HC (April 2013). "Validation of Event Data Recorders in High Severity Full-Frontal Crash Tests," SAE Paper 2013-01-1265.

Tsoi, A., Hinch, J., Ruth, R. and Gabler, H. (2013). "Validation of Event Data Recorders in High Severity Full Frontal Crash Tests," SAE International Journal of Transportation Safety 1(1):2013, doi: 10.4271/2013-01-1265.

Uslu, B., de la Garza, J.M., and Flintsch G.W. "Discrete Event Simulation Model for Project Selection Level Pavement Maintenance Policy Analysis." Proceedings of the 14th International Conference on Computing in Civil and Building Engineering (ICCCBE), June 27-29, Moscow, Russia.

Viner, H., Hargreaves, D., Dunford, A., Nesnas, K., Parry T., and Flintsch, G.W., "Development of a Prediction Model for Splash and Spray," proceedings of the 7th Symposium on Pavement Surface Characteristics (SURF 2012), Sep. 18-21, 2013, Norfolk, VA.

Wu, Z., Flintsch, G.W., Ferreira, A., and Picado-Santos, L., "Framework for Multi-Objective Optimization of Physical Highway Assets Investments," Journal of Transportation Engineering, 2012, Vol. 138(12), pp. 1411-1421.

Yin W., Murray-Tuite P., and Rakha H. (2012), "Imputing Erroneous Data of Single-Station Loop Detectors for Non-incident Conditions: Comparison between Temporal and Spatial Methods," Journal of Intelligent Transportation Systems: Technology, Planning and Operations, Volume 16, Issue 3, pp. 159-176.

Zohdy I. and Rakha H. (2012), "Framework for Intersection Decision Support in Adverse Weather Conditions: Use of Case-Based Reasoning Algorithm," Transportation Research Record: Journal of the Transportation Research Board, No. 2324, pp. 20-28.

Zohdy I. and Rakha H. (2012), "Agent-Based Framework for Modeling Driver Left-Turn Gap Acceptance Behavior at Signalized Intersections," Transportation Research Record: Journal of the Transportation Research Board, No. 2316, pp. 1-10.

Zohdy I. and Rakha H. (In press). "Enhancing Roundabout Operations via Vehicle Connectivity," Transportation Research Record: Journal of the Transportation Research Board.

Works published since the 2012 Annual Report or works published in a new format.

Presentations/Honors

Kyoungho Ahn

Ahn K., Rakha H., and Park S. (2013), "ECO-Drive Application: Algorithmic Development and Preliminary Testing," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-0401].

Jon Antin

Antin, J. F. (2013). Life Beyond Driving – Extending Safe Driving for Seniors. Panel discussion presentation given at 2013 Lifesavers Conference, April 16, Denver, CO.

Antin, J. F. (2013). Neuroplasticity in Senior Drivers: Can Brain Training Lead to Safer Driving? Poster presented at The Labile Brain: Neuroplasticity Across the Lifespan 25th Annual Symposium of the Central Virginia Chapter of the Society for Neuroscience, Virginia Tech Carilion Research Institute, Roanoke, VA.

Antin, J.F. (2013). Update on SHRP 2 NDS Progress, Sample Descriptive Statistics, and Data Dissemination, Presentation given at TRB Annual meeting, Washington, D.C.

Antin, J.F. (2012). Discussant at Closing Panel Discussion, Senior Mobility Awareness Symposium, Blacksburg, VA.

Antin, J. F. (2012). Training Approaches to Enhance Senior Mobility. Presentation given at the Senior Mobility Awareness Symposium, Dec 6, Blacksburg, VA.

Antin, J. F. (2012). Senior Mobility Awareness Symposium: Integrating Science, Policy, and Practice. Opening presentation given at the Senior Mobility Awareness Symposium, Dec 6, Blacksburg, VA.

Antin, J. F. (2012). Comparing the Driving Safety Benefits of Brain Fitness Training Programs for Older Drivers. Presentation and Demonstration given at the Toyota Safety Symposium, Sep 12th, Washington, D.C.

Antin, J. F. (2012). Older Drivers, Intersection and Distraction: Background and Naturalistic Investigation. Presentation given at the 3rd International Symposium on Naturalistic Driving Research, Aug, 30, Blacksburg, VA.

Antin, J. F. (2012). SHRP2 Naturalistic Driving Study S06 Update. Presentation given at the 7th Annual SHRP 2 Summer Safety Symposium, Transportation Research Board of the National Academies, July 12, Washington, D.C.

Myra Blanco

September 2012: Virginia Tech Scholar, given by VT Office of the Vice President for Research

April 2013: J. Cordell Breed Award for Women Leaders, given by Society of Automotive Engineers (SAE) at the 2013 World Congress & Exhibition (Detroit, MI)

April 2013: ORGANIZER AND MODERATOR for the Safety Through Automation session at the Intelligent Transportation Society of America 2013 Annual Meeting (Nashville, TN)

April 2013: SPEAKER for the Transformative Innovations: Connected Vehicles and Beyond session at the Intelligent Transportation Society of America 2013 Annual Meeting (Nashville, TN)

April 2013: PANELIST for the Human Factors Issues of Automated Driving session at the Society of Automotive Engineers 2013 World Congress & Exhibition (Detroit, MI)

October 2012: TECHNICAL PROGRAM Session CHAIR for the Driver Attitudes Toward Monitoring and Perspectives on Automation session at the Annual Meeting of the Human Factors and Ergonomics Society – Surface Transportation Technical Group (Boston, MA)

James Bryce*

Recipient of a Dwight David Eisenhower Transportation Program Grant for Research Fellowships

Recipient of one of the five "best paper awards" at the Ninth Annual Inter-University Infrastructure Management Symposium, Atlanta, GA (2012)

Matt Camden

Camden, M., Hickman, J.S., Joslin, S., & Hanowski, R.J. (2012). Methods to examine the relationship between drug use and involvement in a safety-critical event. Poster presented at the Third International Symposium on Naturalistic Driving Research, Blacksburg, VA.

Hao Chen*

Recipient of ITSVA scholarship (May 2013)

Chen H. and Rakha H., (2012), "Prediction of Dynamic Freeway Travel Times based on Vehicle Trajectory Construction," 15th IEEE Intelligent Transportation Systems Conference, Alaska, USA; September 16-19, 2012.

Chen H. and Rakha H. (2013), "A Data-driven Particle Filter for Travel Time Prediction," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-4392].

Chen H. and Rakha H. (2013), "Forecasting Freeway Dynamic Travel Times by Constructing Trip Trajectories," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-2128].

Tom Dingus

Named White House Champion of Change in Transportation, United States of America White House, May 2013.

Invited Speaker: Association for the Advancement of Automotive Medicine, Distracted Driver Expert Panel; Chicago, IL, April 2013.

Invited Speaker: Commonwealth of Virginia Governor's Transportation Conference, New Developments in Transportation Research; Vienna, VA December 2012.

Invited Speaker: ITS America 22nd Annual Meeting and Exposition, Driver Distraction Policy: Recommendations, Promulgations, and Supporting Science; National Harbor, MD May 2012.

Invited Speaker: ITS America 22nd Annual Meeting and Exposition, SHRP 2 Huge Steps Forward in Systems Operations Strategies; National Harbor, MD 2012.

Vehicle Test and Evaluation Consultant, Google, Inc., CA (July 2012), Consultation on test planning for autonomous vehicles.

Zac Doerzaph

Named Scholar of the Week by the Virginia Tech Office of the Vice President for Research

Muqing Du*

Du M., Rakha H., and Chen L. (2012), "Sensitivity Analysis for Network Traffic Equilibria: A Reduction Method," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-0557].

Du, M., Cheng, L., and Rakha H. (2012), "Sensitivity Analysis of Combined Distribution-Assignment Model with Applications," Transportation Research Board 91st Annual Meeting, Washington DC, January 22-26, CD-ROM [Paper # 12-1978].

Naomi Dunn

Nominated for the 2013 IEHF Liberty Mutual Award for the best paper published in Ergonomics in 2012

Ihab El-Shawarby

El-Shawarby I., Abdel-Salam A., and Rakha H. (2013), "Evaluation of Driver Perception-Reaction Times for Rainy/Wet Roadway Conditions at the Onset of a Yellow Indication at Signalized Intersections," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-1683].

Greg Fitch

WDBJ7 (2013). Experts: Texting is the most dangerous thing you can do on your phone behind the wheel. http://www.wdbj7.com/news/wdbj7-experts-texting-is-the-most-dangerous-thing-you-can-do-on-your-phone-behind-the-wheel-20130621,0,539045.story

CBC News (2013). CBC News Interview with Greg Fitch on Driver Distraction. http://www.cbc.ca/player/News/Canada/NB/ID/2383169992/

WWL FM 105.3 (2013). "4-2 6:45AM Tommy Talks To Greg Fitch About Texting & Driving" http://audio.wwl.com/a/72678611/4-2-6-45am-tommy-talks-to-greg-fitch-about-texting-driving.htm?q=fitch

Fitch, G.M. (2012). Driver Distraction and Using Technology to Improve Transportation Safety. Lecture given to the Lexington Insurance Company's Transportation Client Advisory Board Meeting on August 6, 2012 in Boston, Massachusetts.

Fitch, G.M. (2012). Driver Distraction and Using Technology to Improve Transportation Safety. Lecture given to the Explore Information Services Customer Advisory Board on March 9, 2012 in St-Petersburg, Florida.

Fitch, G.M. and Tijerina, L. (2012). Gedankenexperiment on Driver Distraction: Exploring Potential Outcomes of Technology to Mitigate Driver Distraction. Workshop given at the 91st Transportation Research Board Annual Meeting on Sunday, January 22, 2012 in Washington, D.C.

Fitch, G. M., Schaudt, W. A., Soccolich, S. A., and Hanowski, R. J. (2012). Introduction to the Reduction and Analysis of Naturalistic Driving Data. Workshop given at the 3rd International Symposium on Naturalistic Driving Research on Monday August 27, 2012 in Blacksburg, Virginia.

Fitch, G.M. and Hanowski, R.J. (In press). Exploring drivers' compensatory behavior when conversing on a mobile device. Proceedings of the 4th International Conference on Applied Human Factors and Ergonomics 2012.

Fitch, G. M., Hanowski, R., Burnett, G., & Crundall, D. (In press). Development of a Protocol to Classify Drivers' Emotional Conversation. Proceedings of the 3rd International Conference on Driver Distraction and Inattention.

Fitch, G. M. & Hankey, J. M. (2012). Investigating Improper Lane Changes: Driver Performance Contributing to Lane Change Near-Crashes. Proceedings of the 56th Annual Meeting of the Human Factors and Ergonomics Society.

Fitch, G.M., Monk, C., Sherony, R., LeBlanc, D., & Ward, N. (2012). Evaluation of Driver Assistance Systems. Proceedings of the ITS America 22nd Annual Meeting and Exposition.

Fitch, G.M. and Gabbard, J.L. (2013). Augmented Reality: Opportunities and Challenges for Transportation. Webinar presented on May 3rd, 2013 for ITS America Human Interaction with ITS committee. http://safety.itsa.wikispaces.net/file/detail/AR%20Opportunities%20and%20Challenges%20for%20Surface%20Transportation%20V3-compressed.pdf

Maddox, M. E., Fitch, G. M., Kiefer, A., Mortimer, R., & Muttart, J. (2012). Implications for Forensic Practice of Human Factors Research Findings and Case Data Related to Rear-End Collisions. Proceedings of the 56th Annual Meeting of the Human Factors and Ergonomics Society.

Gerardo Flintsch

Flintsch, G.W. "Interaction between the Road Infrastructure and the Vehicles, Smart Highways and their Impact on Transportation Sustainability" (Interacción de la Infraestructura Vial con los Vehículos, Carreteras Inteligentes y su Impacto en la Sostenibilidad del Transporte), invited presentation, Jornadas Internacionales del Asfalto, Bogotá, Colombia, Oct 8-12, 2012.

Flintsch, G.W. "Tire-pavement Friction Management Programs for Improving Road Safety" (Programas de gestión de la fricción entre el neumático y el pavimento para mejorar la seguridad vial," invited presentation, Jornadas Internacionales del Asfalto, Bogotá, Colombia, Oct 8-12, 2012.

Participated (supported the planning and organization and taught one module) in organization of the 2nd Advanced Infrastructure Management course organized by University of Delaware, Virginia Tech, University of Texas, Austin, University of Waterloo, and University of Iowa in Atlanta, Georgia, Jun, 2012.

Delivered a workshop (with other Instructors) about Transportation Asset Management for the International Road Federation in Abu Dhabi, United Arab Emirates, Feb 18-20, 2012.

Clay Gabler

Elected as Fellow, Association for the Advancement of Automotive Medicine (October 2012)
Governor's UTC Event

Ron Gibbons

Gibbons R., Medina-Flintsch A., Williams B., Du J., and Rakha H. (2013), "Sag Vertical Curve Design Criteria for Headlight Sight Distance," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-3815].

Feng Guo

Guo F., Li Q., and Rakha H. (2012), "Multi-state Travel Time Reliability Models with Skewed Component Distributions," Transportation Research Board 91st Annual Meeting, Washington DC, January 22-26, CD-ROM [Paper # 12-1910].

Rich Hanowski

2012 (December 3) Virginia Tech "Scholar of the Week" award: http://www.research.vt.edu/scholar-of-the-week/rich-hanowski

2012 Paul S. Richards Endowed Distinguished Visiting Lecture in Occupational Health (Awarded at NORA Symposium, University of Utah, Salt Lake City)

Scientific committee member for SomnoAlert 2014, Brussels, Belgium (February, 2014).

Scientific committee member for Third International Conference on Driver Distraction and Inattention. Gothenburg, Sweden (September, 2013).

Driver Distraction: The Eyes Have It!. Sprint, Enforcing the Code (fleet event). Concord, NC. (October, 2012).

Perception vs. Reality: How Expectations (and Other Factors) Influence Our Beliefs. American Trucking Association's Litigation Center's Forum for Motor Carrier General Counsel. San Francisco, CA (July, 2012)

Jeff Hickman

Chairperson, TRB Truck and Bus Operator Health and Wellness Subcommittee (ANB70-3)

Hickman, J.S., Hanowski, R.J. Guo, F., Medina, A., & Kwan, Q. (2012). Efficacy of roll stability control, lane departure warning, and forward collision warning using carrier-collected crash data. Presented at the annual Society of Automotive Engineers Commercial Vehicle Engineering Congress in Chicago, IL.

Hickman, J.S., Guo, F., Camden, M.C., Hanowski, R.J., Medina, A., Mabry, J.E., & Kwan, Q. (2012). Efficacy of roll stability control, forward collision warning, and lane departure warning using carrier-collected crash data. Paper presented at the annual Transportation Research Board Conference in Washington, D.C.

Hickman, J.S. (2012). Overview of the North American Fatigue Management Program. Department of Transportation Safety Council Technical Team Meeting, December 14, 2012.

Hickman, J.S. (2012). The Naturalistic Study of Distracted Driving. Executive Briefing on Fleet Driving Performance to be held in Houston, TX.

Hickman, J.S. (2012). Overview of Truck Safety Research at the Virginia Tech Transportation Institute. Network of Employers for Traffic Safety Fleet Safety Benchmark Conference in Charlottesville, NC.

Raj Kishore Kamalanathsharma*

Recipient of ITSVA scholarship (May 2013)

Kamalanathsharma R., and Rakha H., (2012), "Agent-based Modeling of Eco-Cooperative Adaptive Cruise Control Systems in the Vicinity of Intersections," 15th IEEE Intelligent Transportation Systems Conference, Alaska, USA; September 16-19, 2012.

Robert Kluger*

"Student of the year award" at the TRB Annual Banquet (January 2013)

Erin Mabry

Mabry, J.E., Hickman, J.S., Camden, M.C., Marburg, T.L., Hanowski, R.J. (2012). Safety Manager and Commercial Driver Opinions and Acceptance of Onboard Safety Systems. Paper presented at the annual Transportation Research Board Conference in Washington, DC.

Mabry, J.E., Baker, S., Hickman, J., & Hanowski, R.J. (2012, August). Case study on the impact of treating sleep apnea in commercial motor vehicle drivers. Poster presented at the Third International Symposium on Naturalistic Driving Research, Blacksburg, VA.

Case Study on the Impact of Treating Sleep Apnea in Commercial Motor Vehicle Drivers. Presented at the TRB Annual Meeting, January 14, 2013 in Washington, D.C.

Appointed Secretary of the Committee on Truck and Bus Safety, ANB70. June 17, 2013

Daniel Mogrovejo*

Recipient of the 2012 IRF Student Essay Competition best paper award in the Pavement Technology, Maintenance and Management

Justin Morgan

October 2012: SESSION Co-CHAIR for the Driver Distraction and Drowsy Driving session at the Annual Meeting of the Human Factors and Ergonomics Society – Surface Transportation Technical Group (Boston, MA)

Alejandra Medina-Flintsch

Medina, A., Hickman, J.S., Hanowski, R.J., Guo, F., & Kwan, Q. (2012). A formal economic analysis of roll stability control and lane departure warning using carrier-collected crash data. Presented at the annual Society of Automotive Engineers Commercial Vehicle Engineering Congress in Chicago, IL.

Medina-Flintsch, A., Hickman, J.S., Guo, F., Camden, M.C., Hanowski, R.J. (2012). Cost benefit analysis - onboard safety systems effectiveness evaluation. Paper presented at the annual Transportation Research Board Conference in Washington, DC.

January 2013: POSTER Medina-Flintsch, A., Clarke, R. M., Hughes, R., Trimble, T., & Scott, J. Linking Carrier Descriptive Attributes to Fatal Crash Patterns: An Untapped Tool in State Motor Carrier Safety Improvement Programs. Poster presented at the Transportation Research Board 92nd Annual Meeting, Washington, DC.

Miguel Perez

Workshop Moderator, Introduction to the SHRP 2 NDS Dataset (Third International Symposium on Naturalistic Driving Research), The Inn at Virginia Tech: August 30, 2012, Blacksburg, VA.

Identifying cognitive load from naturalistic data (presented as part of the Third International Symposium on Naturalistic Driving Research), The Inn at Virginia Tech: August 29, 2012, Blacksburg, VA.

Perez, M. A., McLaughlin, S. B., Wu, S., McClafferty, J. A., Lee, S. E., and Soccolich, S. A. (2012). Introduction to the SHRP 2 NDS Dataset. Workshop given at the 3rd International Symposium on Naturalistic Driving Research on Monday August 27, 2012 in Blacksburg, Virginia.

Hesham Rakha

Badillo B., Rakha H., Rioux T., and Abrams M., (2012), "Queue Length Estimation using Conventional Vehicle Detector and Probe Vehicle Data," 15th IEEE Intelligent Transportation Systems Conference, Alaska, USA; September 16-19, 2012. Park S., Rakha H., and Ahn K. (2013). "Fuel Economy Impacts of Manual, Conventional Cruise Control, and Predictive Eco-Cruise Control Driving," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-0407].

Li H., Rakha H., and El-Shawarby I. (2012), "Designing Yellow Intervals for Rainy and Wet Roadway Conditions," Transportation Research Board 91st Annual Meeting, Washington DC, January 22-26, CD-ROM [Paper # 12-0834].

Litsas S. and Rakha H. (2013), "Evaluation of Continuous Green T-Intersections on Isolated Under-Saturated Four-Lane Highways," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-0591].

Park S., Rakha H., and Ahn K. (2013). "Virginia Tech Comprehensive Power-based Fuel Consumption Model (VT-CPFM): Model Validation and Calibration Considerations," Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-0461].

Rakha H. (2012). "Transportation Sustainability: What can ITS Offer?" ITS World Congress, Vienna, Austria, Oct. 22-26. (Session SIS06 Emerging ITS Strategies and Sustainability - Tuesday 11:00 - 12:30).

Rakha H. (2012). "Case Study Evaluation of the Environmental Impacts of Adaptive Traffic Signal Control and Transit Signal Priority," ITS World Congress, Vienna, Austria, Oct. 22-26. (Session SIS35 - Demonstrating the environmental contributions from demand responsive traffic control - Wednesday 16:00 - 17:30).

Rakha H. (2012). “Energy Impacts of Cooperative Vehicle Systems,” ITS World Congress, Vienna, Austria, Oct. 22-26. (Session TSIS78 - Global perspectives - Cooperative energy efficiency applications - Friday 9:00 - 10:30).

Tawfik A. and Rakha H. (2013), “A Latent Class Choice Model of Heterogeneous Drivers Route Choice Behavior Based on a Real-World Experiment,” Presented at the 92nd Transportation Research Board Annual Meeting, Washington DC, January 14-17, CD-ROM [Paper # 13-1367].

Tawfik A. and Rakha H. (2012), “Network Route-Choice Evolution in a Real-Life Experiment: A Necessary Shift from Network to Driver Oriented Modeling,” Transportation Research Board 91st Annual Meeting, Washington DC, January 22-26, CD-ROM [Paper # 12-1640].

Tawfik A. and Rakha H. (2012), “Modeling Driver Heterogeneity in Route Choice Behavior based on a Real-life Naturalistic Driving Experiment,” ITS World Congress, Vienna, Austria, Oct. 22-26. (Session TS064 - Navigation system and digital maps (1) - Thursday 11:00 - 12:30).

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Member, Transportation Research Board Committee on Traffic Flow Theory

Member, Transportation Research Board Highway Capacity and Quality of Service Committee

Member, Transportation Research Board Sub-Committee on Traffic Modeling

Member, Transportation Research Board Committee on Air Quality

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John Sangster*

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Vicki Williams

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Ismail Zohdy*

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Denotes student honors/presentations

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