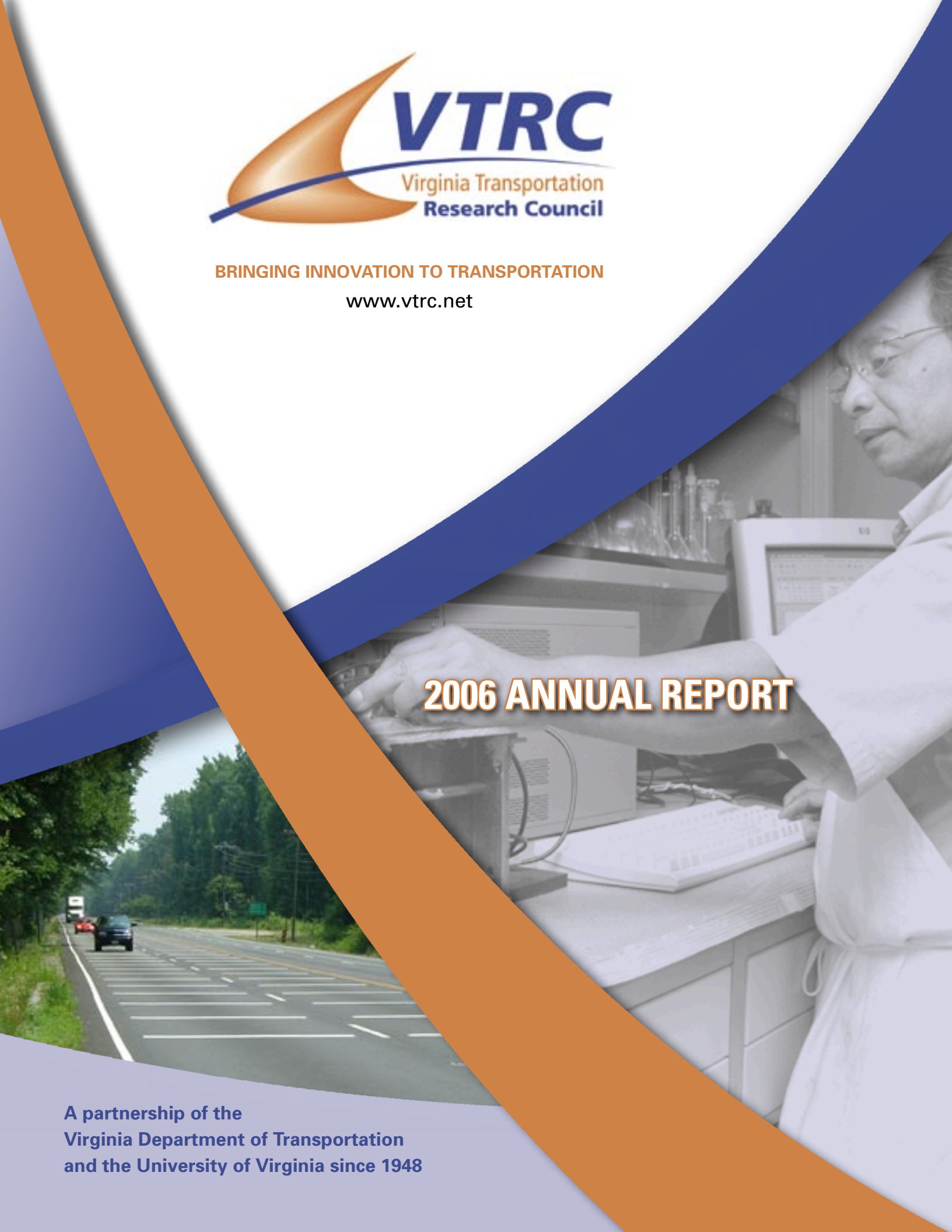
VTRC

Virginia Transportation Research Council

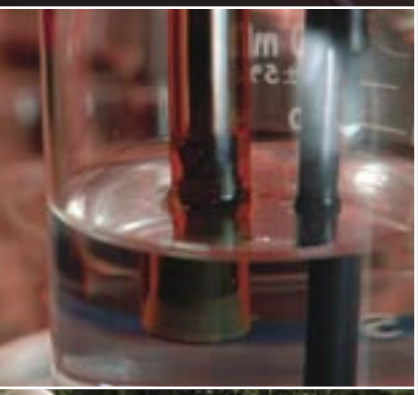
BRINGING INNOVATION TO TRANSPORTATION

www.vtrc.net



2006 ANNUAL REPORT

A partnership of the
Virginia Department of Transportation
and the University of Virginia since 1948



The VIRGINIA TRANSPORTATION RESEARCH COUNCIL:

- Is a **partnership** of the **Virginia Department of Transportation** and the **University of Virginia**, created in 1948 and located on the U.Va. Grounds in Charlottesville
- Ranks among the nation's most highly regarded transportation research institutes
- Conducts a **comprehensive program of engineering, planning and policy research** for transportation agencies in the Commonwealth of Virginia
- Carries out **nationally focused research** for various federal programs, including the U.S. Department of Transportation, the Federal Highway Administration and American Association of State Highway Transportation Officials (AASHTO) through the National Cooperative Highway Research Program (NCHRP)

PURPOSE

- The Research Council conducts **applied, practical research** with the goal that the Virginia Department of Transportation will implement the results of this work to improve transportation in the Commonwealth, and that transportation agencies across the nation will benefit from the knowledge developed through this research.
- Research is one of VDOT's eight **corporate tenets**. In implementing this program for VDOT, the Research Council's focus is to:
  - > Improve transportation safety;
  - > Build and maintain a better transportation infrastructure;
  - > Make the transportation system operate more efficiently and effectively;
  - > Introduce new technologies into practice;
  - > Advance the state of the art in transportation;
  - > Strengthen business and organizational policies and practices;
  - > Protect environmental resources; and
  - > Provide a high return on VDOT's investment in the Research Council.

GUIDING THE RESEARCH PROGRAM

- **The Advisory Board**
  - > A high-level advisory body established in the VDOT–U.Va. partnership agreement; it includes executives from VDOT, U.Va. and the director of the Research Council.
- **Research Advisory Committees**
  - > Advise the Research Council on the content and direction of its program; membership includes staff from VDOT, federal, state and local agencies, and appropriate university faculty from throughout Virginia.

Gary R. Allen, Ph.D.
Chief of Technology, Research and Innovation, VDOT

Michael A. Perfater
Acting Director of Research, VTRC

I AM PLEASED TO present this 2006 annual report, which focuses on a range of successes the Virginia Transportation Research Council accomplished during the past year. We develop our program every year mindful that the Virginia Department of Transportation's business and strategic plans list research as a key component of its mission.

In its 2006 business plan, VDOT committed to "increase its emphasis on using the latest research, engineering and technology to design and build longer-lasting facilities, reduce costs and improve practices." Long recognized for our materials, pavements and structures studies, the Research Council also includes in its focus developing new transportation technologies and informing departmental and state policies through research.

Here are a few highlights from 2006:

A MULTIDISCIPLINARY TEAM from the Research Council developed a unique methodology whereby VDOT determined how best to consolidate maintenance facilities and staff statewide to deliver more efficient highway maintenance throughout Virginia. The team members analyzed factors including traffic volume and lane miles, population and growth, and incident response time and de-icing chemical storage requirements in developing the formulas that drove their conclusions.

To my knowledge, this is the first time a state department of transportation has undertaken such a far-reaching, comprehensive analysis of maintenance facilities. As a result of this review, VDOT will reduce its maintenance facilities from 335 to 248 without sacrificing its ability to ensure necessary and emergency maintenance services for the people of the Commonwealth.

WITH "SYSTEM OPERATIONS" as a core VDOT business, our research program now includes a strong systems component for moving traffic more efficiently by using technology-based solutions. As the state looks to VDOT to squeeze every inch of capacity from the existing road system, we collect and analyze the data needed to feed intelligent transportation technologies. These include developing traffic-flow parameters and archiving and sharing information throughout VDOT and in accessible applications. *continued next page*

The Research Council's 'area headquarters consolidation study' is probably the first time a state department of transportation has undertaken such a far-reaching, comprehensive analysis of maintenance facilities.

Much of our system-operations research involves providing reliable data to create the technological infrastructure for "smarter" transportation in the 21st century. One such recent project showed that better placement of detector stations in urban areas could save more than $1 million for each 100 roadway miles of coverage, while simultaneously providing more accurate data to VDOT. The data that flow from these counters and roadside cameras into Virginia's Smart Traffic Centers allow VDOT to monitor and manage congestion in real time and adjust the system's operations as needed to improve travel-time reliability.

Data from these Smart Traffic Centers also are archived daily, based on work in the Smart Travel Lab, a partnership of the Research Council and the University of Virginia. The facility provides the ideal learning environment where U.Va. students can observe the principles of traffic flow from this vast amount of data and also develop new data-mining tools to apply this information to real-world congestion problems.

FOR THE THIRD CONSECUTIVE YEAR, we received, on behalf of VDOT, more than $1 million under the Federal Highway Administration's Innovative Bridge Research and Construction Program. Virginia was the only state to receive more than $1 million in this program during the latest funding cycle.

This FHWA program helps state and local governments incorporate new materials and other technologies in their bridge work to reduce traffic congestion and maintenance and increase savings and productivity by lowering life-cycle costs for bridges and enhancing safety. VDOT will use this $1.15 million grant to test new materials at three locations throughout the Commonwealth: two bridges on Tangier Island in the Chesapeake Bay and individual bridges in Scott and Prince William counties.

VDOT'S RESEARCH LIBRARY became, during 2006, the nation's largest library at a state DOT in terms of holdings catalogued in the Online Computer Library Center (OCLC), the standard by which this ranking is measured. As home to the library, we are quite proud of this achievement.

The Research Library began its electronic conversion only three years ago and now has 26,000 cataloged records, representing more than 36,000 volumes in this online cooperative. It joined OCLC in mid-2003 to expand its access primarily to all VDOT employees and to University of Virginia faculty and students.

OUR PARTNERSHIP WITH THE UNIVERSITY OF VIRGINIA continues to grow. In 2006, we had 17 contracts for research projects with U.Va. that totaled $2.03 million.

As part of our robust graduate program at U.Va., we provide state-of-the-art laboratories for pavements, corrosion, soils and concrete; teaching expertise; and financial support to faculty and students. VDOT, in turn, benefits from the high caliber of staff we attract and retain through our strong partnership with and proximity to U.Va.

In the graduate pavements program we initiated with U.Va. in 2005, our scientists design and teach the curriculum and are visiting faculty at U.Va. The program is expected to have its first graduates in the spring of 2007.

VIRGINIA TECH'S RESEARCH RELATIONSHIP with VTRC continues to expand, specifically through the Virginia Tech Transportation Institute (VTTI), site of VDOT's Smart Road. The Research Council and other public and private entities use the Smart Road to conduct human-factors and other intelligent transportation re-

For the third consecutive year, the Research Council received more than $1 million under the FHWA's Innovative Bridge Research & Construction program to test new materials on bridges in Virginia.

search to improve driver safety. We also perform pavement and structures research on the Smart Road. In 2006, we partnered with Virginia Tech for $3.24 million in nationally focused research.

The Research Council and VTTI are stakeholders in the **National Surface Transportation Safety Center for Excellence**, located at VTTI and created in 2006 through SAFETEA-LU (the "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users," the latest federal transportation authorization). This new center will focus on driver performance and, specifically, older, younger and fatigued drivers as well as pavement markings and lighting.

I am proud of the high-quality work and results the Research Council continues to produce as a way to help transform VDOT from a public works to a mobility-focused agency.

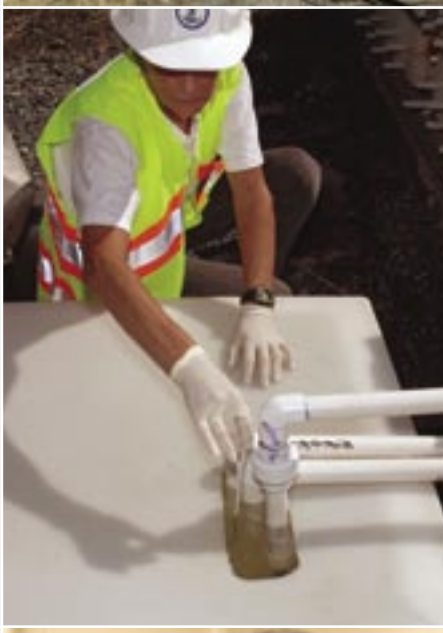
A NOTE ON RECENT TRANSITIONS: William E. Kelsh, VTRC's long-time assistant director, retired after nearly three decades of dedicated service to the Commonwealth. His quiet genius in overseeing the administration of VTRC and his broad institutional memory will be sorely missed.

In November 2006, I decided to step away from my dual role as VTRC's Director of Research and VDOT's Chief of Technology, Research & Innovation. Michael A. Perfater agreed to serve as Acting Director of Research Operations. I will continue to be involved in the research program from a strategic standpoint in my role as Chief. This change allows several other staff members to tackle new leadership challenges, thus ensuring a solid succession plan for the Virginia Transportation Research Council.

The '100-Car Naturalistic Driving Study' that the Research Council co-sponsored with the Virginia Tech Transportation Institute and the federal government found that driver inattention is the leading factor in most crashes and near crashes.

Along with VDOT, we are working with VTTI to establish the **Virginia Cooperative Center for Transportation & Safety Excellence** to leverage similar research that focuses on Virginia issues. We are only starting to map the research possibilities these centers will produce.

We co-sponsored VTTI's "100-Car Naturalistic Driving Study," conducted with the National Highway Traffic Safety Administration. The project equipped 100 private vehicles in Northern Virginia with sophisticated monitoring equipment to record the actions of drivers for one year. The study found that driver inattention is the leading factor in most crashes and near-crashes. These results will help make roads safer because of the immense amount of data they added to the growing knowledge bank regarding driver behavior.



Gary R. Allen, Ph.D.
Chief of Technology, Research & Innovation
Virginia Department of Transportation

WORK OF THE RESEARCH TEAMS

A list of completed 2006 research projects follows this synopsis of each team's highlights

ENVIRONMENTAL AND BUSINESS PRACTICES

Amy A. O'Leary, Ph.D., Associate Director

This team completed another study in its work to address how VDOT **manages and reduces stormwater runoff** with high salt concentrations from winter deicing chemicals. The pilot investigation examined whether it is feasible for VDOT to use reverse osmosis to treat the salt-laden stormwater captured at its maintenance facilities.

An earlier project found that while VDOT was capturing large volumes of saltwater statewide to protect the environment, disposal options are limited and costly – as much as $7.8 million annually. While the research concluded that reverse osmosis is not yet suitable for wider use, the findings added to the knowledge base of practicable options for lowering the costs of saltwater disposal. The team initiated another study in 2006 to explore using the saltwater captured in detention ponds as a "pre-wetting solution" in snow and ice operations.

The team also published its report that investigated **how well deer and other wildlife use highway underpasses** to get to the other side of the road. Data from remote cameras at seven underpasses throughout Virginia revealed that animals do use these structures to safely traverse roads, proving that properly designed animal passageways are a good investment.

Approximately 43,000 deer-vehicle collisions occurred in Virginia in 2005, a 13 percent increase from 2004 and the sixth-highest rate in the nation. Based on the 2006 average of $2,800 in damages per incident, these collisions can cost Virginians more than $120 million in a single year. Construction of a single animal underpass is approximately $200,000.

The Research Council is completing two other related projects as a follow-up to this significant study. The first introduces a GIS wildlife corridor analysis for VDOT to use in future transportation planning.

The second project involves using a VDOT maintenance crew to record carcass pick-ups with GPS-enabled personal data assistants (or PDAs). The research so far has found that the amount of carcass pick-up data recorded from these devices far exceeds the information that can be ascertained from police accident reports alone.

MATERIALS

Michael M. Sprinkel, P.E., Associate Director

The Materials team had the lead on three projects that provided significant benefits.

The first, a "life-cycle cost analysis of stone matrix asphalt (SMA)" demonstrated an estimated $29,000-per-mile lifetime savings when SMA is used instead of conventional-graded hot-mix asphalt on heavily traveled roads. If the cost savings identified continue to hold true, this research could contribute to more than $14 million per year in savings.

In another project, a Materials scientist developed the lightweight, high-performance concrete used on the deck, girders and piers of the new Route 33 bridge over the Mattaponi River that saved VDOT approximately $2 million during its construction. This innovative material, 20 percent lighter than normal-weight concrete, was used to support the extra-long bridge span because of the composition of the marshy riverbed soil and its surrounding banks. It also allowed the designers to construct fewer piers to buttress the bridge than if they had used normal-weight concrete.

The project that investigated "the impact of smoothness incentives and disincentives (or the potential construction pay adjustments) on hot-mix asphalt resurfacing costs" saved VDOT approximately $4.68 million in a single year. In addition to the construction costs associated with the possible repaving contract incentives for smoothness, the study examined the financial value of the resulting product (presumably smoother pavements). It found that the trucking industry could save approximately $220 million per year in fuel costs on Virginia's interstates with smoother pavements.

In an ongoing project, Materials researchers are testing a new bridge overlay capable of reducing ice and snow buildup on bridge driving surfaces. The overlay's 3/8-inch-thick layer of aggregate can absorb, store and slowly release, through several snow storms, deicing chemicals that may decrease ice buildup on a bridge deck. The Research Council has installed the new overlay on two bridges on Interstate 81 near Staunton and also on sections of VDOT's Smart Road at Virginia Tech where winter weather conditions can be simulated for better evaluation of the product.

SAFETY, PLANNING AND LEGAL

Wayne S. Ferguson, Associate Director

While all VTRC teams contribute their expertise to inform both VDOT- and state-level policy decisions with the best available research results, this group often is tapped to staff high-level commissions to help produce reports for the General Assembly and the offices of the Governor and Secretary of Transportation. It also provides the state with vital information as VDOT becomes more involved in coordinating land use and transportation planning.

The team made significant contributions during FY 2006 to the report issued by the **Governor's Commission on Transportation in Urbanized Areas**. The report recommended improving transportation and encouraging redevelopment in Virginia's urban areas and called for additional transit funding, enabling legislation for regional cooperation, and incentives to change how agencies conduct their transportation planning.

In-house forecasting of future traffic-related deaths and injuries plus other related data on traffic-safety improvements contributed to Virginia's new **Strategic Highway Safety Plan**, a collaborative effort of several state agencies and other organizations, that team members again consulted on and helped develop. The plan set a 2010 goal of ensuring that 100 more lives are saved and 4,000 more injuries prevented over current levels (900 and 76,000 respectively in 2005) throughout the Commonwealth.

Additional research included a report on the **alternative transportation funding sources** available to Virginia localities that compiles in one document the diverse sources of money that localities can pursue for transportation projects if they are not included in VDOT's annual update of the Six-Year Improvement Program. Another project involved the review of county comprehensive plans, which state law requires VDOT to conduct. The report evaluated 59 such plans and provided guidance to VDOT staff on what to look for when reviewing these plans.

Finally, in collaboration with the University of Virginia, the team has produced several studies that support VDOT's move into long-range **multimodal** planning to ensure more transportation choices, better accessibility and increased mobility for Virginians. Among the projects, one developed and offered methods to prioritize, estimate costs and assess the feasibility of multimodal transportation policies across the state's major corridors.

STRUCTURAL, PAVEMENT AND GEOPHYSICAL ENGINEERING

Jose P. Gomez, Ph.D., P.E., Associate Director

VDOT's business plan directs the department to use the Research Council to "develop materials and engineering and construction techniques to build longer-lasting, less costly pavements and bridges, and to identify best practices to help reduce construction and maintenance costs." The Structural, Pavements & Geophysical Engineering team does this in all its work, especially to increase the service life of structures and pavements, often collaborating across research teams and throughout VDOT on its projects.

As this team's scientists add to the 21st-century technologies they produce for VDOT, it is important to note how their research can employ these innovations to preserve parts of Virginia's cultural heritage, specifically its historic bridges.

The team collaborated with VDOT's Knowledge Management Office and the VTRC Environmental & Business Practices team to produce a much-heralded report outlining the "best practices for the rehabilitation and moving of **historic metal truss bridges**." Researchers interviewed active and retired VDOT engineers, consultants, field personnel, environmental specialists and architectural historians to collect these best practices related to pin-connected and riveted truss bridges.

The research team organized its report using the process followed for VDOT's recent rehabilitation of the Goshen historic truss bridge in Rockbridge County and discussed the issues faced by those moving and rehabilitating historic metal truss bridges. Historians and transportation professionals from across the country are now making the recommendations contained in this report the standard for such projects.

Similarly, VDOT rehabilitated another historic bridge, this time in Covington, Virginia, using a new type of bridge deck, made of fiber-reinforced polymers (FRP), that the Research Council is piloting in a study with Virginia Tech.

Thanks to an FHWA Innovative Bridge Research and Construction grant of $346,000 the Research Council received in 2004 for this project, VDOT installed a lighter-weight bridge deck on the deteriorating metal truss bridge built in the late 19th century. The new deck, 75 percent lighter than a comparable concrete deck, increased the bridge's load rating from seven tons to 20 tons.

SYSTEM OPERATIONS AND TRAFFIC ENGINEERING

Catherine C. McGhee, P.E., Acting Associate Director

During 2006, VDOT continued its focus on moving traffic and managing incidents more efficiently along Virginia's five major transportation corridors, putting System Operations research more in the forefront as a key part of VDOT's business.

Since traffic incidents cause much of our traffic congestion, VDOT's **Safety Service Patrols**, along with the state's Smart Traffic Centers, can help reduce incident duration and thus tie-ups. A Research Council project found that 75 percent of Safety Service Patrol-recorded incidents in Northern Virginia are cleared within 15 minutes, and approximately 23 percent are removed within 15 to 90 minutes. Response by the Safety Service Patrols reduced the average incident duration by approximately 17 percent, saving drivers significant time and money lost to traffic delays and fuel consumption.

In another research success, VDOT has begun implementing proposals contained in the Research Council's "**hurricane evacuation route analysis**." The report recommended alterations to existing traffic-control plans on Hampton Roads interstates that will allow smoother traffic flow and reduce congestion at entrance ramps during evacuations inland.

VDOT also has upgraded its lane-reversal plan, another of the report's recommendations, including new ramp-metering rates. The department began installing 67 gates that would close interstate on- and off-ramps and reverse traffic flows on Interstate 64 during a major evacuation of Hampton Roads.

An ongoing System Operations project will determine whether certain safety practices used successfully in other countries will work as well in the United States and Virginia. Two practices under review are **optical speed bars** and a **flashing stop sign**.

Optical speed bars are a series of lines painted at decreasing intervals on the roadway that give drivers the visual perception they are moving faster than they intended. The pattern of lines is also meant to get drivers' attention so they will slow down.

The flashing stop sign is a standard stop sign with very bright red-flashing LEDs (light-emitting diodes) at each corner. The hope is that these bright flashing lights will send a strong message to drivers at intersections to obey the sign rather than not coming to a full stop.

2006 COMPLETED REPORTS

ALL REPORTS AVAILABLE AT **WWW.VTRC.NET**

VTRC 06-R1 Sprinkle, K., and Beaton, J. *Intellectual Property: A Handbook for Employees of the Virginia Department of Transportation*

VTRC 06-R2 Donaldson, B.M. *The Use of Highway Underpasses by Large Mammals in Virginia and Factors Influencing Their Effectiveness*

VTRC 06-R3 McGhee, K., Clark, T., and Reid, R. *A Performance Baseline for Stone Matrix Asphalt*

VTRC 06-R4 Lynn, C.W., and Kennedy, J.L. *Safety Belt and Motorcycle Helmet Use in Virginia: The Summer 2005 Update*

VTRC 06-R5 Diefenderfer, S. *Creep and Fatigue of Superpave Mixtures*

VTRC 06-R6 Pegues, J.A., and Demetsky, M.J. *The Role of Smart Traffic Centers in Regional System Operations Performance: A Hampton Roads Case Study*

VTRC 06-R7 Beaton, J.S. *The Potential Impact and Legal Feasibility of Requiring Alcohol Testing of All Drivers in Fatal Crashes in Virginia*

VTRC 06-R8 Diefenderfer, B.K., and Bryant, J.W., Jr. *Development of a Pavement Warranty Contract and Performance Specification for a Hot-Mix Asphalt Resurfacing Project*

VTRC 06-R9 Hossain, S., and Elfino, M. *Forensic Investigation of Concrete Pavement, U.S. 460, Appomattox Bypass*

VTRC 06-R10 McGhee, K.K., Deeds, T.M., and Rorrer, T.M. *Comparison of Alternative Devices to Determine Aggregate Shape*

VTRC 06-R11 Ozyildirim, C. *High-Performance Fiber-Reinforced Concrete in a Bridge Deck*

VTRC 06-R12 Ozyildirim, C., and Gomez, J.P. *First Bridge Structure with Lightweight High-Performance Concrete Beams and Deck in Virginia*

VTRC 06-R13 Miller, J.S. *Multimodal Statewide Transportation Planning: A Survey of State Practices*

VTRC 06-R14 Lucas, J., Cousins, T.E., and Brown, M.C. *Structural Load Testing and Flexure Analysis of the Route 701 Bridge in Louisa County, Virginia: Supplemental Report*

VTRC 06-R15 McGhee, C.C., and Grimes, M.C. *An Operational Analysis of the Hampton Roads Hurricane Evacuation Traffic Control Plan*

VTRC 06-R16 Sharp, S.R., and Virmani, Y.P. *Factors That Influence the Efficiency of Electrochemical Chloride Extraction During Corrosion Mitigation in Reinforced Concrete Structures*

VTRC 06-R17 Grimes, M.C., Mattingly, K.M., and Miller, J.S. *Alternative Transportation Funding Sources Available to Virginia Localities*

VTRC 06-R18 Diefenderfer, S. *Detection of Polymer Modifiers in Asphalt Binder*

VTRC 06-R19 Mokarem, D.W. *Hot-Mix Asphalt Placement: Virginia's Move to a Two-Inch Drop-Off*

VTRC 06-R20 Mattingly, K.M., and Beaton, J.S. *The Benefits and Pitfalls of Strengthening Virginia's Open-Container Laws*

cont'd next page

VTRC 06-R21 McGhee, C.C. *Inventory of System Operations Data Collection and Use in the Virginia Department of Transportation*

VTRC 06-R22 Hossain, S., Ozyildirim, C., and Tate, T.R. *Evaluation of Precast Patches on U.S. 60 Near the New Kent and James City County Line*

VTRC 06-R23 Hoppe, E.J., and Whitehouse, D.H. *Implementation of the Rock Slope Management Project at the Virginia Department of Transportation*

VTRC 06-R24 Sharp, S.R. *Nondestructive Evaluation of Epoxy-Coated Reinforcing Bars in Concrete Using Bi-Electrode Half-Cell Techniques*

VTRC 06-R25 Edara, P. *Estimation of Traffic Impacts at Work Zones: State of the Practice*

VTRC 06-R26 Fitch, G.M., Craver, V.O., and Smith, J.A. *Potential Use of Reverse Osmosis in Managing Saltwater Waste Collected at Road-Salt Storage Facilities*

VTRC 06-R27 Lane, D.S. *Laboratory Investigation of Air-Void Systems Produced by Air-Entraining Admixtures in Fresh and Hardened Mortar*

VTRC 06-R28 McGhee, K.K., and Gillespie, J.S. *Impact of a Smoothness Incentive/Disincentive on Hot-Mix Asphalt Maintenance-Resurfacing Costs*

VTRC 06-R29 Weyers, R.E., Sprinkel, M.M., and Brown, M.C. *Summary Report on Performance of Epoxy-Coated Reinforcing Steel in Virginia*

VTRC 06-R30 Fontaine, M.D., and Read, S.W. *Development and Evaluation of Virginia's Highway Safety Corridor Program*

VTRC 06-R31 McKeel, W.T., Jr., Miller, A.B., Clark, K.S., Saufley, R.W., Jr., Bushman, W.H., and Lester, T.F. *Best Practices for the Rehabilitation and Moving of Historic Metal Truss Bridges*

VTRC 06-R32 Tilley, M.R., Barton, F.W., and Gomez, J.P. *Dynamic Analysis and Testing of a Curved Girder Bridge*

VTRC 06-R33 Dougald, L.E., and Demetsky, M.J. *Performance Analysis of Virginia's Safety Service Patrol*

VTRC 06-R34 Kweon, Y.-J. *Evaluation of a Proposal to Set a Goal for the Virginia Strategic Highway Safety Plan of a Forty Percent Reduction in Traffic Fatalities and Injuries by 2010*

VTRC 06-R35 Hoppe, E.J. *Field Measurements on Skewed Semi-Integral Bridge with Elastic Inclusions: Instrumentation Report*

VTRC 06-R36 Hoppe, E.J., and Hite, S.L. *Performance of a Pile-Supported Embankment*

VTRC 06-R37 Diefenderfer, B.K., Mokarem, D.W., and Sharp, S.R. *Use of Nondestructive Evaluation to Detect Moisture in Flexible Pavements*

VTRC 06-R38 Lane, D.S. *Laboratory Comparison of Several Tests for Evaluating the Transport Properties of Concrete*

VTRC 06-R39 Shin, G.T. *A Qualitative Study of the Core Functions of Smart Traffic Centers at the Virginia Department of Transportation*

VTRC 06-R40 Hossain, S., and Elfino, M.K. *Field Demonstration of Magnetic Tomography Technology for Determination of Dowel Bar Position in Concrete Pavement*

VTRC 06-CR1 Al-Qadi, I.L., Diefenderfer, S.R., and Loulizi, A. *Fatigue Life Characterization of Superpave Mixtures at the Virginia Smart Road*

VTRC 06-CR2 Smith, B.L., Qi, Y., and Tang, Y. *Phase III AUTOTRACK: Integrated CCTV/VIVDS Prototype Field Test: System Refinement and Development of Shoulder Detection*

VTRC 06-CR3 Newhouse, C.D., Roberts-Wollmann, C.L., and Cousins, T.E. *Development of an Optimized Continuity Diaphragm for New PCBT Girders*

VTRC 06-CR4 Yoon, J. *Development of Bilateral Data Transferability in the Virginia Department of Transportation's Geotechnical Database Management System Framework*

VTRC 06-CR5 Cousins, T.E., and Lesko, J.J. *Construction of a Virginia Short-Span Bridge with the Strongwell 36-inch Double-Web I-Beam*

VTRC 06-CR6 Rakha, H., and Ahn, K. *Transit Signal Priority Project: Phase II: Field and Simulation Evaluation Results*

VTRC 06-CR7 Burns, S.E., and Tillman, K.A. *Evaluation of the Strength of Cement-Treated Aggregate for Pavement Bases*

VTRC 06-CR8 Park, B., and Agbolosu-Amison, S.J. *Investigation of Schedules for Traffic Signal Optimization*

VTRC 06-CR9 Popovics, J.S., Gibson, A., and Gallo, G. *Development of Nondestructive Methods for Measurement of Slab Thickness and Modulus of Rupture in Concrete Pavements*

VTRC 06-CR10 Neale, V.L., Perez, M.A., Doerzph, Z.R., Lee, S.E., Stone, S., and Dingus, T.A. *Intersection Decision Support: Evaluation of a Violation Warning System to Mitigate Straight Crossing Path Collisions*

VTRC 06-CR11 Smith, B.L., Qi, Y., and Park, H. *A Methodology to Estimate Vehicle Miles Traveled (VMT) Fractions as an Input to the Mobile Emission Model*

VTRC 06-CR12 Filz, G.M., and Smith, M.E. *Design of Bridging Layers in Geosynthetic-Reinforced, Column-Supported Embankments*

VTRC 06-CR13 *Filz, G.M., and Navin, M.P. Stability of Column-Supported Embankments*

2006 VTRC BUDGET

2006 CORE BUDGET BY SOURCE	
SPR*	$ 3,496,156
State	$ 3,099,928
Grants	$ 3,449,828
Enhanced pavements program	$ 1,000,000
Systems Operations	$ 1,200,000
Total	$12,245,912
VDOT'S TOTAL 2006 RESEARCH EFFORT	
VTRC core budget	$12.25 M (total from above)
Smart Road agreement	$ .37 M
NCHRP/TRB (estimated)	$ 1.03 M
Miscellaneous pooled-fund studies	$ .20 M
University transportation centers	$ .24 M
Other VDOT divisions	$ .27 M
Local technical assistance program	$ .34 M
Total	$14.70 M

* State Planning & Research funds from Federal Highway Administration

A partnership of the Virginia Department of Transportation
and the University of Virginia since 1948

Gary R. Allen, Ph.D.
Chief of Technology, Research and Innovation, VDOT

Michael A. Perfater
Acting Director of Research, VTRC

Report production by Ann Overton
VTRC public affairs manager

VTRC | 530 Edgemont Road
Charlottesville, Virginia 22903-2454
(434) 293-1900 | fax (434) 293-1990
www.vtrc.net