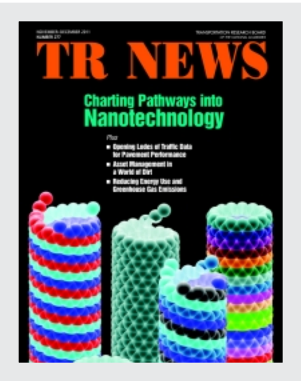

TR News November-December 2011: Charting Pathways into Nanotechnology

DETAILS

44 pages | | PAPERBACK
ISBN 978-0-309-43063-0 | DOI 10.17226/22829

TR NEWS

NUMBER 277 NOVEMBER–DECEMBER 2011

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COVER: Synthesized from atoms and molecules, nanoscale building blocks (*above*) are the basis of burgeoning transportation nanotechnology research.

TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

***TR News* is produced by the Transportation Research Board Publications Office**
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Lea Camarda, Assistant Editor
Jennifer J. Weeks, Photo Researcher
Juanita Green, Production Manager
Michelle Wandres, Graphic Designer

TR News (ISSN 0738-6826) is issued bimonthly by the Transportation Research Board, National Research Council, 500 Fifth Street, NW, Washington, DC 20001. Internet address: www.TRB.org.

Editorial Correspondence: By mail to the Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, by telephone 202-334-2972, by fax 202-334-3495, or by e-mail jawan@nas.edu.

Subscriptions: North America: 1 year $55; single issue $10. Overseas: 1 year $80; single issue $14. Inquiries or communications concerning new subscriptions, subscription problems, or single-copy sales should be addressed to the Business Office at the address below, or telephone 202-334-3216, fax 202-334-2519. Periodicals postage paid at Washington, D.C.

Postmaster: Send changes of address to *TR News*, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001.

The Transportation Research Board's 2011 Annual Report is included in this issue as a special insert between pages 22 and 23.

ALSO IN THIS ISSUE:

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COMING NEXT ISSUE

A roundup of findings from TRB's 2011 state partnership visits program—trends, problem-solving approaches, and emerging research needs and applications at transportation agencies throughout the country—highlights the January–February issue of *TR News*. Other main feature articles examine workforce management, including a practical toolkit and web-based knowledge-management system developed for transportation agencies through a National Cooperative Highway Research Program (NCHRP) project; strategies to attract and retain a capable transportation workforce; and a report on the effects of the U.S. domestic scan program—a joint effort of NCHRP, the American Association of State Highway and Transportation Officials, and the Federal Highway Administration—in spreading innovation.

Photo: Minnesota DOT

Workforce management strategies, techniques, and tools are on the docket and agenda at transportation agencies.

Nanotechnology IN TRANSPORTATION

Evolution of a Revolutionary Technology

MOHAMMAD S. KHAN

The author is Senior Vice President, Professional Service Industries, Inc., Herndon, Virginia.

Nanotechnology is the science and engineering of examining, monitoring, and modifying the behavior and performance of materials at nanoscale—that is, at the atomic or molecular level. The techniques and principles have gained recognition in the field of medicine and in several industries and are making their way into transportation applications.

Nanotechnology is multidisciplinary and has motivated collaboration among engineers, scientists, innovators, and researchers in sustainable development. Research centers, consortiums, committees, and task forces dealing with nanotechnology are emerging worldwide, reflecting the interest of individuals, organizations, and governments. The potential applications of nanotechnology in transportation offer key research opportunities for the 21st century.

How Nanotechnology Works

Nanotechnology is the process of creating a material or device with building blocks at the atomic and molecular scale, measuring from 1 to 100 nanometers (nm). One nanometer is one billionth of a meter or one millionth of a millimeter. A single sheet of paper, for example, is approximately 100,000 nm thick.

At the nanoscale, materials have an extremely large surface area, which facilitates interaction and reaction with surrounding materials. Any type of material—metal, concrete, ceramic, polymer, semiconductor, glass, or composite—can be created from nanoscale building blocks, known as nanotubes, nanolayers, nanoparticles, or clusters.

The nanoscale building blocks are synthesized from atoms and molecules. Nanotechnology starts by manipulating atoms and molecules in a controlled

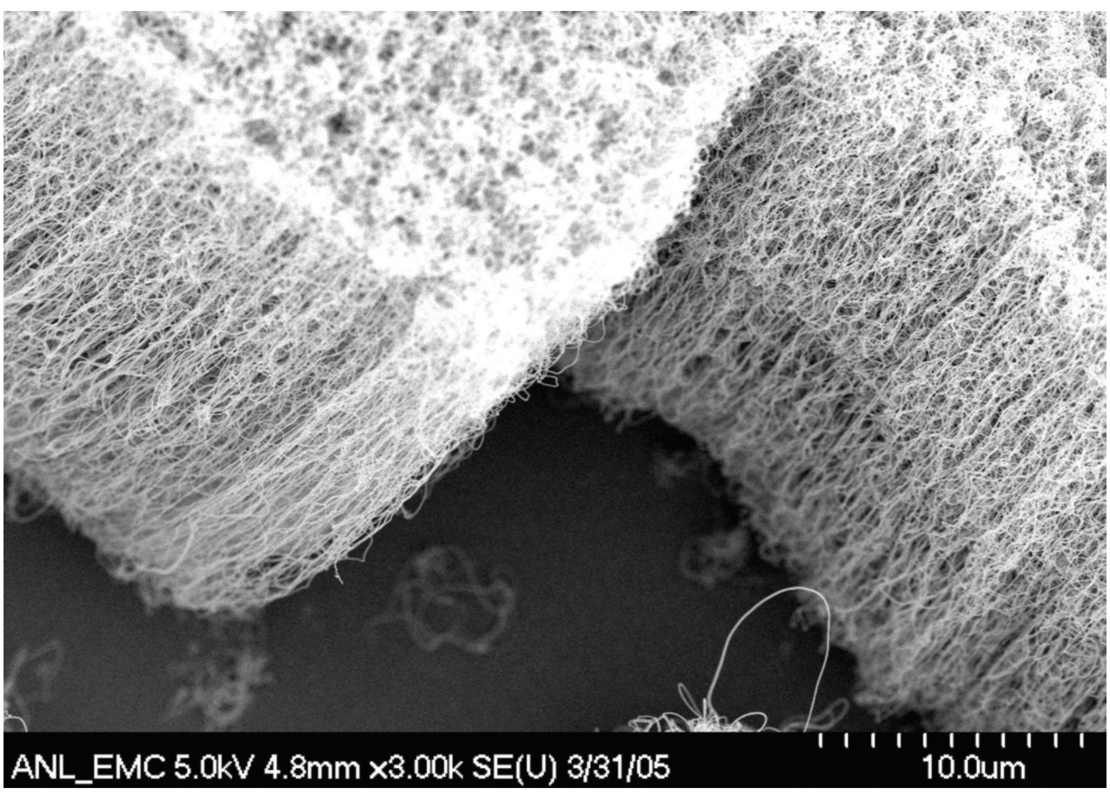
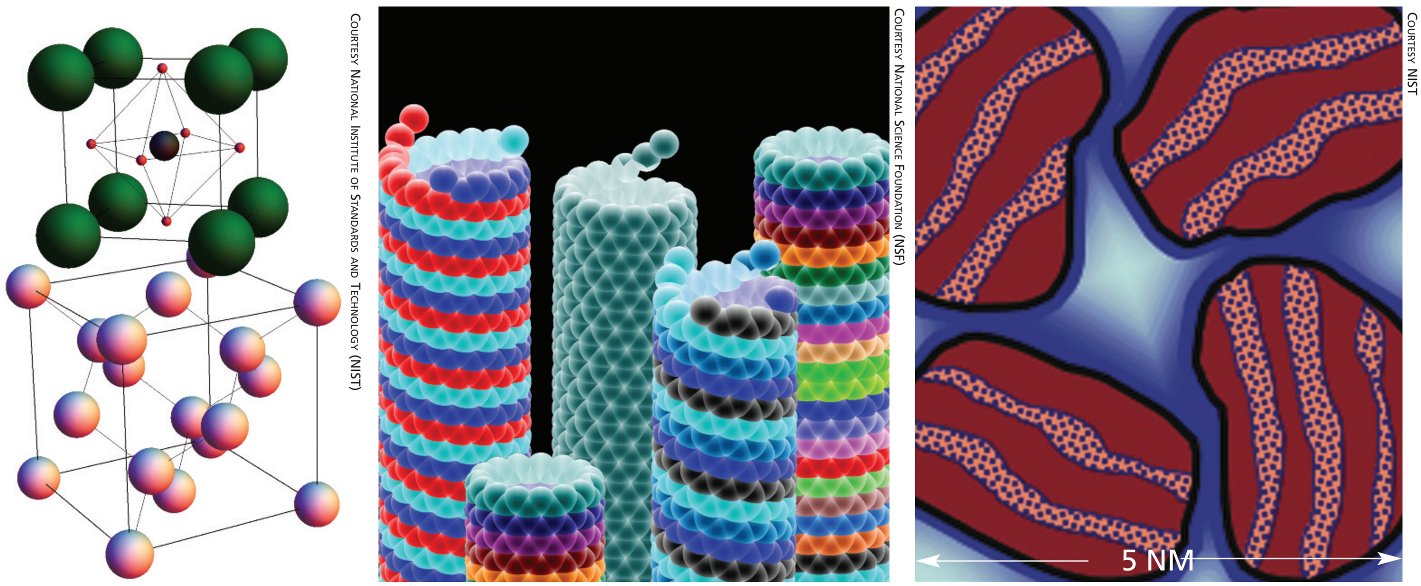


Photo: Junbing Yang, Argonne National Laboratory

Aligned carbon nanotubes, which are being investigated for energy storage and advanced battery development. Transportation applications of nanotechnology call for interdisciplinary collaboration and offer many research opportunities.



a b c

FIGURE 1 Cement structure at nanoscale: (*a*) atoms and molecules; (*b*) nanoscale building blocks; and (*c*) real application materials.

and calculated manner and ends up with real application materials and devices that have exceptionally superior properties (Figure 1, above).

Changing the structure of a material at nanoscale changes its physical, mechanical, electrical, and magnetic properties, heat conduction, and light reflection. These changes from nanostructuring can produce improved or new-generation construction materials. For example, researchers have duplicated the natural nanostructure of lotus leaves to create water-repellent surfaces. The same approach can be used to develop coatings for steel and concrete surfaces.

Combining carbon nanotubes with plastics could produce composites that are even stronger than steel and could be used in lightweight beams and girders for bridge applications or in corrosion-resistant bars for a variety of structures. Carbon nanotube-based membranes are now in use for water desalination, and nanosensors are helping identify contaminants in water systems.

A similar application may be used to keep aggressive chemicals away from concrete and steel surfaces, resisting several mechanisms of deterioration. The strength and flexibility of spider silk, which is naturally reinforced with nanoscale crystals, perhaps can be duplicated to strengthen materials for repair and retrofit applications (*1*).

Transportation Applications

The transportation applications of nanotechnology research received little attention before 2005. Since then, the challenge has been to formulate a long-

Nanotechnology
Some Historical Perspectives

Nanotechnology started about two decades ago with pioneering efforts in the United States, Europe, and Japan. In the United States, the focus of nanotechnology has been on critical areas such as the early detection and cure of life-threatening diseases. The U.S. National Nanotechnology Initiative, created in 2001, released a strategic plan in 2004 and updated the plan in 2007 and 2010. According to *Nature Nanotechnology* (March 2008), from 1976 to 2006, the U.S. Patent Office published 7,406 nanotechnology patents and the Japan patent Office 1,150; the European Patent Office published a total of 3,596 from 1978 to 2006.

In terms of the historical progression of other revolutionary technologies, nanotechnology is emerging from the discovery phase, a period of basic research and application development that typically lasts for 20 years. Nanotechnology had an impact on $254 billion worth of products globally in 2009, and this impact is forecasted to grow to $2.5 trillion by 2015. (Source: Lux Report, August 2010.)

term, sustainable strategy that promotes the development of nanotechnology and ensures the necessary funding. The 1999 International Technology Research Institute Report noted the interest of the U.S. Department of Transportation (DOT) in nanostructured coatings, sensors for physical transportation infrastructure, and smart materials. All of these were included in the themes and modes of the department's research and development (R&D) objectives in the fiscal year (FY) 2001 budget (2). Although these were good, broad themes for nanotechnology research, the lack of a well-defined and well-planned strategy hampered research progress.

The nanotechnology research themes identified by U.S. DOT in 2001 also did not focus on understanding the behavior of transportation materials at the nanoscale. The U.S. DOT budget request for FY 2010, however, included $3 million for nanotechnology research aimed at improving fundamental understanding of the structure and properties of highway construction materials at the nanoscale (*3*).

One area of research was the use of atomic force microscopy to characterize the morphology of asphaltenes, the nanoparticle component of asphalt. Another initiative was the investigation of nanoscale mechanisms that control the hydration and setting of portland cement concrete.

In 2009, the Federal Highway Administration (FHWA) solicited proposals for its Exploratory Advanced Research Program with several nanotechnology focus areas. These included mechanical and structural nanoscale modeling; nanoscale measurement devices to advance understanding of highway pavements; nanoscale sensors for structural health monitoring; and nanoscale approaches for inhibiting corrosion. Research projects awarded from this solicitation are under way, but the results and findings will not be available to the general public for several years.

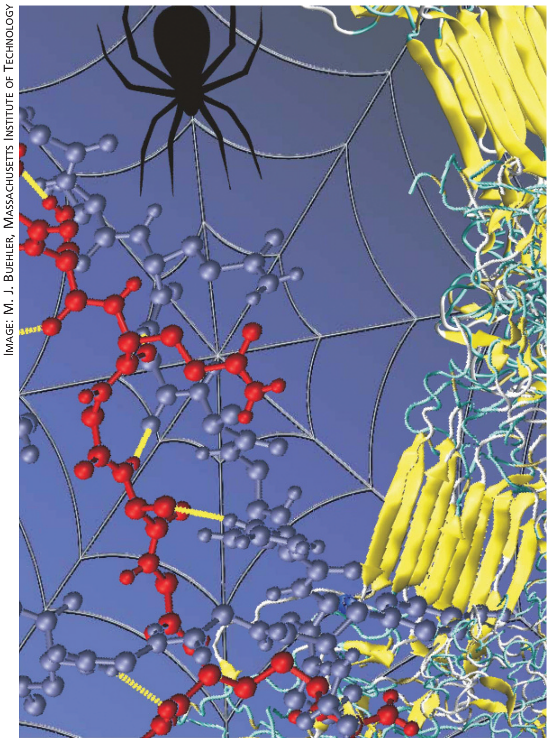


Image: M. J. Buehler, Massachusetts Institute of Technology

Through nanotechnology, researchers are seeking to duplicate the strength and flexibility of naturally occurring materials, such as spider silk, to strengthen materials such as concrete and steel.

On the international scene, nanotechnology research and its applications in transportation also have proceeded slowly; many discussions remain at the broad thematic level. For example, a 2008 paper from Pretoria, South Africa, explores the potential benefits of nanotechnology for the safety, durability, economics, and sustainability of the transportation infrastructure without offering many specific details (*4*).

Identifying Research Needs

In 2007, the Transportation Research Board (TRB) formed a Task Force on Nanotechnology-Based Con-

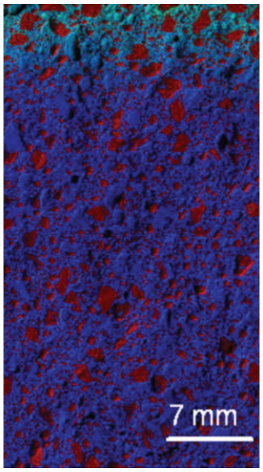
Government Support for Nanotechnology Research

Government support has proved critical in advancing nanotechnology research and development in the United States and in other countries.

◆ In 2003, the governments of Western Europe, Japan, the United States, and other countries invested $650 million, $800 million, $774 million, and $800 million, respectively, in nanotechnology research.

◆ The funding for nanotechnology research by federal agencies and departments within the United States increased from $850 million in 2004 to $1.64 billion in 2010.

◆ The 2010 U.S. funding included approximately $423 million for research by the National Science Foundation; $379 million by the Department of Defense; $347 million by the Department of Energy; $326 million by the National Institutes of Health; $92 million by the National Institute of Standards and Technology; $18 million by the Environmental Protection Agency; $17 million by NASA; $12 million by the Department of Homeland Security; $12 million by the National Institute of Occupational Safety and Health; $8 million by the Department of Agriculture; and $3 million by FHWA (*3*).



Courtesy NIST

X-ray image of nanomodified concrete with high resistance to chloride ion diffusion.

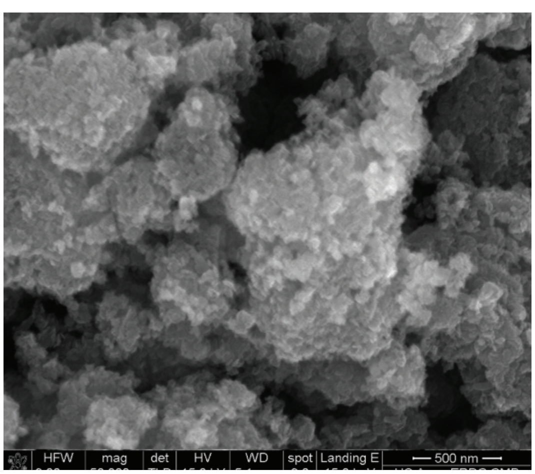
crete Materials. The charge to the task force was to expedite the identification of research needs and facilitate technology transfer activities related to nanomodified concrete and various analytical, experimental, and monitoring tools for the characterization and modeling of the materials. The task force has organized and sponsored sessions and workshops at TRB Annual Meetings and other venues and is preparing a state-of-the-art report on nanotechnology-based concrete materials for publication in 2012.

International Conference Highlights

The TRB task force sponsored the First International Conference in North America on Nanotechnology in Cement and Concrete in Irvine, California, May 5–7, 2010. The program attracted 100 researchers involved with nanotechnology from around the world; 37 of the peer-reviewed papers were published in two volumes of the *Transportation Research Record: Journal of the Transportation Research Board* (*5, 6*). Following are highlights of research findings presented at the conference.

Nanomodification of Concrete

Nanomodification of concrete is analogous to modifying and controlling the genes and DNA in the human body. Nanomodification can change fundamentally the rheology, the calcium-silicate-hydrate gel, and the kinetics of hydration reactions to improve dramatically many of the properties of concrete, including its strength, ductility, shrinkage, and durability (photo at upper left, this page). Application of nanotechnology-based sealers in the surface layer of concrete can produce an almost waterproof concrete with strong resistance to many deterioration processes, such as reinforcing steel corrosion, sulfate attack, and alkali–silica reactivity.



Courtesy U.S. Army Corps of Engineers

Nano-TiO_2 has several beneficial applications in transportation.

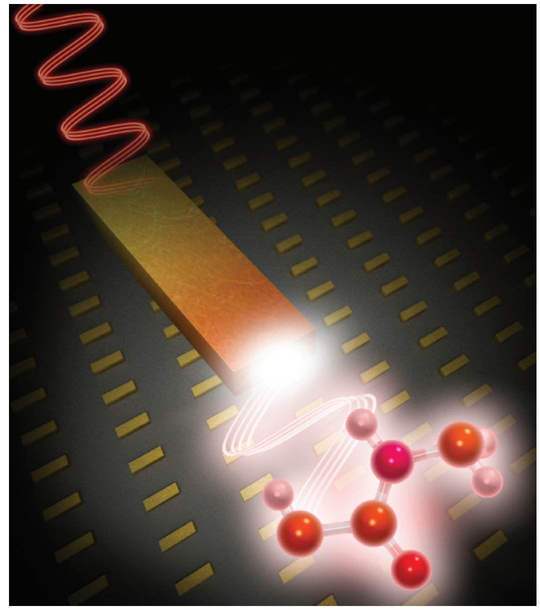


Image courtesy NSF

FIGURE 2 An ultrasensitive infrared absorption spectroscopy technique, developed to study protein molecules, can be explored for transportation applications.

Nanofibers incorporated into concrete can control the initiation and propagation of nanocracks and can produce a crack-free concrete with substantially enhanced flexural strength. Newer generations of concrete materials, such as improved self-consolidating concrete, will emerge as the nanotechnology progresses and matures.

Nanotechnology will make concrete materials more acceptable by eliminating or reducing several limitations. For example, supplementary cementitious materials contribute to sustainable development but their properties develop slowly because of delayed hydration reactions. The addition of nano–calcium carbonate ($CaCO_3$) to cementitious materials, however, can accelerate the hydration reactions and offset the disadvantages.

Nano–titanium dioxide (TiO_2) similarly can accelerate hydration reactions. In addition, concrete surfaces incorporating nanoparticles of TiO_2 powder, which have photocatalytic properties, can convert nitrogen dioxide (NO_2), a pollutant generally present in urban areas and in tunnels, to harmless nitrates (NO_3) that are easily washed away by rain (photo, left).

Modeling and Nanosensors

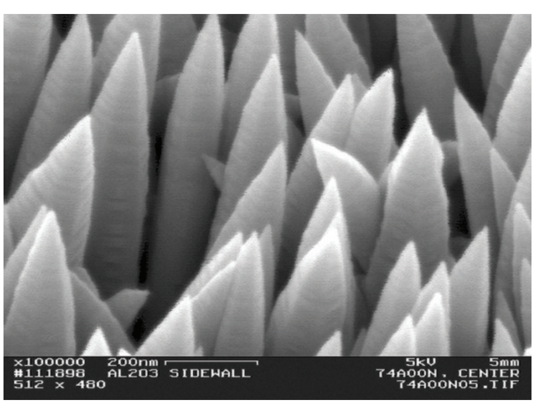
Advanced analytical techniques, such as computational fluid dynamics modeling, will play an important role in predicting and optimizing the composition and performance of nanotechnology-based concrete materials. Advanced measurement and testing techniques—such as nanoindentation and atomic force acoustic microscopy—capable of characterizing materials at nanoscale similarly will play key roles in advancing nanotechnology in concrete (Figure 2, page 6).

Nanosensors composed of polymers, particles, conductors, computer chips, and photonic materials in nanosizes can be embedded in concrete for quality assurance–quality control, monitoring and measuring the properties of fresh and hardened concrete in real time from project or central locations, allowing for corrective actions to be taken in a timely manner. Nanosensors also can be used to monitor the health of concrete elements and systems and can generate warning signals when the condition of these elements and systems deteriorates below a defined threshold, whether from natural loading, exposure, or extreme events such as earthquakes, hurricanes, or terrorist attacks (photo, below).

Setting an Agenda

As the conference highlights indicate, nanotechnology research and applications can have a revolutionary effect and a positive economic impact on transportation in the short and long terms. Nanotechnology researchers in the field of transportation are needed to participate in the agenda-setting activities of the U.S. National Nanotechnology Initiative (NNI) through the National Nanotechnology Coordination Office.

The NNI strategic plan should include nanotechnology research related to transportation. The next step is the allocation of adequate research funding, development of a long-term and sustainable strategy, establishment of research institutions and academic curricula with a nanotechnology focus, and finally a commitment from different segments of the transportation community to advance the technology to transform research findings into commercial products by 2020.



Courtesy NSF

Zinc oxide–based nanotips and other nanoscale structures have a variety of sensor applications.

Courtesy NSF

PULSTAR reactor, developed under the sponsorship of the National Science Foundation, can improve the characterization of the porosity of materials at nanoscale.

Expanding the Focus

Nanotechnology is gaining acceptance in the production, monitoring, and deterioration control of concrete and concrete-making materials, but its entry into other fields of transportation is limited. Similar progress is needed, for example, for asphalt, steel, composites, coatings, and sensors. The initial knowledge and experience gained from the use of nanotechnology in concrete can be transferred to these other fields.

Achieving the Promise of Nanotechnology

Nanotechnology has the potential of revolutionizing the transportation industry in the coming decades with stronger and longer-lasting materials and with inspection and monitoring techniques that assess the performance of infrastructure in real time. Achieving this potential requires the following:

- Developing a long-term and sustainable strategy for nanotechnology in transportation;
- Benefiting from the knowledge gained by other industries;
- Adopting a multidisciplinary approach, including all fields of science and engineering;
- Establishing and maintaining close communication among researchers, academics, scientists, engineers, and manufacturers in the public and private sectors;
- Exploring and applying nanotechnology throughout the range of construction materials and sensing devices used in transportation infrastructure;
- Maintaining a balance of basic and applied research;
- Rapidly deploying technologies;
- Establishing research centers focused on nanotechnology in transportation;
- Establishing a transportation nanotechnology curriculum at major colleges and universities; and
- Adequately funding nanotechnology research in transportation.

PHOTO: ANDREW GUYTON

The Marcus Nanotechnology Building at the Georgia Institute of Technology in Atlanta was dedicated in 2009. The creation of new nanotechnology research institutions and programs is a key element in the U.S. National Nanotechnology Initiative strategic plan.

Thirty-seven peer-reviewed papers from the 2010 nanotechnology conference were published in two volumes of the *Transportation Research Record: Journal of the Transportation Research Board*.

The basic framework of research and application needs to be similar and consistent. This includes nanoscale modeling; nanomodification of materials; tools and techniques for the measurement of properties; short- and long-term monitoring; understanding and control of deterioration; and continuous improvement of materials, techniques, and processes. Coatings and sensors specific to each construction material need to be developed. The emphasis should be on lighter, stronger, and more durable materials and on smart sensors.

Research Funding

Federal funding for transportation research ranks eighth among national priorities, after national defense; health; space research and technology; general science and basic research; natural resources and environment; energy; and agriculture.

In FY 2010, total federal funding for R&D was $147 billion, but only $3 million of this was for nanotechnology research related to surface transportation (3). Advancing nanotechnology research to the level at which results can be transformed into commercial products by 2020 would require an annual federal research investment of at least $15 million—comparable to the allocations for the nanotechnology research programs of the Environmental Protection Agency and the National Institute of Occupational Safety and Health.

Institutions and Curricula

Within U.S. DOT, the University Transportation Centers (UTC) program of the Research and Innovative Technology Administration could provide a strong base for transportation nanotechnology research. UTCs are internationally recognized centers of excellence, integrated into institutions of higher education, and offer a multidisciplinary program of coursework combined with analytical and experimental research.

UTCs are needed with a major focus on nanotechnology research. The partnership of these centers with other research and academic institutions and with private industry would be important for success.

In the field of medicine, highly interdisciplinary academic programs are emerging, such as nanobiotechnology and nanomedicine. The field of engineering could benefit from these kinds of programs as well. A transportation nanotechnology curriculum at major colleges and universities could yield practical benefits for this generation and for generations to come.

Increased Understanding

Nanotechnology will prove one of the most researched areas in the next decades. Activities will intensify in technology transfer and in the commercialization of nanomaterials and nanosensors. Some of the concerns associated with nanotechnology—such as cost and the potential health hazards of superfine nanomaterials—will receive increased attention.

Increased understanding of nanotechnology will improve the acceptance and application of nanomodified materials and sensors. Nanotechnology-derived innovations promise to increase the service life of transportation infrastructure to 100 and perhaps 150 years.

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PHOTO COURTESY FHWA

The Metamorphosis of Long-Term Pavement Performance Traffic Data

DEBORAH WALKER AND DAVID CEBON

Walker is Research Civil Engineer and LTPP Traffic Data Collection Manager, Federal Highway Administration, Turner–Fairbank Highway Research Center, McLean, Virginia. Cebon is Professor of Mechanical Engineering, Cambridge University, United Kingdom, and past Chair of the TRB Expert Task Group on LTPP Traffic Data Collection and Analysis.

The traffic data collection activities of the Long-Term Pavement Performance (LTPP) program have undergone a transformation. The original plan of the late 1980s envisaged the installation and management of low-cost traffic data collection systems by state highway agencies at approximately 2,500 LTPP test sites.

The plan proved unachievable and was revised to collect research-quality traffic data from a smaller number of test sites. The revised plan has generated the largest repository of high-quality traffic data ever collected.

Above: Workers install a bending plate for an LTPP program study site in Virginia. LTPP data collection began in 1989 under the first Strategic Highway Research Program; in 1992, the Federal Highway Administration assumed leadership of the program.

LTPP's History and Mission

The LTPP program started out as an ambitious, 20-year study of in-service pavements in North America to examine how and why pavements perform as they do. Approximately 2,500 pavement test sections in the United States and Canada were selected for monitoring the performance of different types of structures and materials in various climatic regions.

The need for information on how pavements perform over time came to the fore in the early 1980s, when highway agencies began to be concerned about the deterioration of highways built two or three decades earlier. The Transportation Research Board (TRB), the American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration (FHWA) advanced the mission to study performance data systematically across the country and to promote extended pavement life.

PHOTO COURTESY FHWA

A researcher checks an LTPP site in this image from the late 1990s. Early data collection lacked standardized procedures—a problem that was soon recognized and corrected.

Supported by Congress, the LTPP program was launched in 1987 under the first Strategic Highway Research Program (SHRP), a 5-year applied research program funded by the 50 states and managed by the National Research Council. The LTPP program's mission (*1*) was to

- Collect and store performance data from a large number of in-service highways in the United States and Canada over an extended period, to support analysis and product development;
- Analyze the data to understand how pavements perform and to explain why; and
- Translate the insights into knowledge and usable engineering products related to pavement design, construction, rehabilitation, maintenance, preservation, and management.

After the development of an experimental plan, data collection began in 1989. Since the conclusion of SHRP in 1992, the LTPP program has continued under the leadership of FHWA, with the participation of highway agencies in all 50 states and 10 Canadian provinces.

PHOTO COURTESY FHWA

A truck passes over a bending plate weigh-in-motion (WIM) sensor. The LTPP program monitors pavement performance in all 50 states and 10 Canadian provinces, gathering data from a full range of North American climates and environments.

Valuable Lessons

In the past 20 years, the LTPP program has monitored the performance of nearly 2,500 pavement test sections throughout the United States and Canada, representing the range of climatic and soil conditions across the continent. An array of fixed instrumentation and special measuring vehicles is used to monitor each test section until the end of its design life or until it is taken out of the study by the participating agency.

The performance of these pavements over time is providing researchers with insights into how and why pavements perform as they do. Valuable lessons are gained for building better, longer-lasting, more cost-effective pavements. Because the traffic input is needed to understand the pavement performance information, traffic data collection is critical to the success of the LTPP program.

Program Objectives

The goal is to extend the life of pavements by investigating the long-term performance of different pavement designs, as originally constructed or rehabilitated, under various conditions. The LTPP program established six objectives (*1*):

- Evaluate pavement design methods;
- Improve the design methods and strategies for rehabilitating pavements;
- Improve the design equations for new and reconstructed pavements;
- Determine the effects of loading, environment, material properties and variability, construction quality, and maintenance levels on pavement distress and performance;
- Determine the effects of specific design features on pavement performance; and
- Establish a national long-term pavement performance database.

Test Sections

Test sections are the heart of the LTPP program. State and provincial highway agencies nominated the sections in accordance with statistically robust experimental matrices designed to achieve the program objectives. The nearly 2,500 test sections, including asphalt concrete (AC) and portland cement concrete (PCC), were designated throughout all 50 states, Puerto Rico, the District of Columbia, and Canada.

Each test section is classified in the General Pavement Study (GPS), which analyzes existing pavements and overlays, or in the Specific Pavement Study (SPS), which analyzes newly constructed pavements and overlays (see list, page 11). GPS test sections were selected from in-service pavements designed and built according to good engineering practice by highway agencies. The SPS test sections, smaller in number, were designed and constructed to answer specific research questions (*1*).

Research-Quality Data

High-quality traffic data are needed to develop a robust relationship between traffic loading and pavement performance. The requirements for traffic data collection, operations, processing, and reliability, however, are demanding and burdensome. Midway through the 20-year LTPP program, the procedures for collecting traffic data at the LTPP test sites were reevaluated.

Highway agencies had been collecting traffic data in a nonuniform manner. Although other monitored data collected by LTPP—such as distress, profile, and falling weight deflectometer data—followed standard equipment requirements and quality control measures, none were in place for traffic monitoring. The traffic data came from a variety of collection equipment—some met quality control criteria, but most did not.

The highway agencies collected the traffic data with their own resources and knowledge of the equipment, but many lacked the time, money, and skilled staff to provide research-quality data. The early LTPP program managers under SHRP had thought that the states and Canadian provinces would be able to install permanent weigh-in-motion (WIM) systems for $5,000 at each LTPP test site to collect accurate axle loadings—but this was wishful thinking.

Collecting research-quality traffic data over an extended period requires considerably higher capital outlay, as well as substantial recurrent expenditure to manage the installation and the large amount of data generated. The early program objective to have all 2,500 LTPP test sites instrumented with permanent WIM equipment was not possible.

Photo courtesy FHWA

A pavement profiler gathers information at a Florida test site. LTPP traffic data collection has required the use of special measuring vehicles and instrumentation.

Photo courtesy FHWA

Researchers tested truck speed at a Maryland pilot site in 2001.

Pooled-Fund Study

The SHRP planners formed an expert task group to advise the LTPP program managers about collecting, processing, and storing traffic data from the test sites. Now under the auspices of TRB and its Long-Term Pavement Performance Committee, the Expert Task Group (ETG) for LTPP Traffic Data Collection and Analysis (Traffic ETG) continues to provide input to the LTPP program on all issues concerning traffic data collection, quality control, and storage and identifies traffic research projects and products.

With the realization that installing permanent WIM systems at every LTPP test site was impossible because of the costs and the additional staffing to maintain, calibrate, and operate the systems properly, the Traffic ETG and LTPP focused on collecting traffic loading data for the SPS test sections, to gain the "biggest bang for the buck." An action plan was developed in October 1999 (*2*).

The action plan recommended a centralized management of the traffic data collection and processing

LTPP Specific Pavement Study (SPS) Experiments

SPS-1. Strategic Study of Structural Factors for Flexible Pavements
SPS-2. Strategic Study of Structural Factors for Rigid Pavements
SPS-3. Preventive Maintenance Effectiveness of Flexible Pavements
SPS-4. Preventive Maintenance Effectiveness of Rigid Pavements
SPS-5. Rehabilitation of Asphalt Concrete Pavements
SPS-6. Rehabilitation of Jointed Portland Cement Concrete (PCC) Pavements
SPS-7. Bonded PCC Overlays on Concrete Pavements
SPS-8. Study of Environmental Factors in the Absence of Heavy Loads
SPS-9. Validation of SHRP Asphalt Specification and Mix Design (Superpave)

Note: For more information about the LTPP experiments: www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/index.cfm.

PHOTO COURTESY FHWA

Pilot studies in 2001 evaluated action plan protocols for the pooled-fund study that followed. A Specific Pavement Study site in Arizona tested the installation of weigh-in-motion systems.

to eliminate the quantity and quality issues associated with the earlier traffic data collections. The plan specified the type of WIM equipment to collect reliable loading data, described the ideal pavement structure for installing the WIM equipment, and suggested how frequently the equipment should be calibrated.

In accordance with the plan, LTPP and the Traffic ETG developed protocols for the calibration and verification of scale performance; requirements for pavement smoothness; specifications for WIM systems, including accuracy requirements and construction guidelines; and procedures for data collection and processing.

Approximately 2 years after the development of the action plan, a national pooled-fund study—combining the funds of several agencies to support the research effort—began to implement the ideas and protocols. The LTPP SPS Traffic Data Collection Pooled-Fund Study is led by FHWA in partnership with 28 states and one Canadian province.[1] Data collection began in earnest in 2003.

Validating Protocols

In 2001, before the official work began on the pooled-fund study, LTPP ran pilot studies in Arizona, Florida, Maryland, Michigan, and Texas to evaluate the protocols developed to implement the action plan (*3*).

The Arizona SPS-6 site tested the WIM installation process. In Florida, a side-by-side comparison of the performance of piezoelectric cable and bending plate sensors at a non-LTPP site showed that the piezoelectric cable did not perform as well as the bending plate. The remaining three pilot sites—Maryland SPS-5, Michigan SPS-1, and Texas SPS-1—tested the field procedures.

The results from the pilot studies showed that the protocols worked correctly. The equipment performance specifications were achievable, and the recommended field calibration methods—for accuracy, speeds, temperatures, and vehicle conditions—were validated.

The pavement smoothness specification, however, was too restrictive for field conditions and required revision (*3*). After testing in several states, the revised LTPP specification for smoothness became the AASHTO Standard Specification for Smoothness of Pavement in Weigh-in-Motion Systems, released in 2008.[2]

Many of the protocols tested in the pilot study were consolidated in the *LTPP Field Operations Guide for SPS WIM Sites* (*4*). The guide has served as the primary reference for collecting quality traffic data at the SPS sites since 2003.

[1] TPF-5(004), www.pooledfund.org/.
[2] AASHTO MP 14-08, www.techstreet.com/cgi-bin/detail?doc_no=aashto%7Cmp_14_08;product_id=1583807.

A load cell WIM system in Ohio. The pooled-fund study collects data for volumes, classifications, and weights at its test sites.

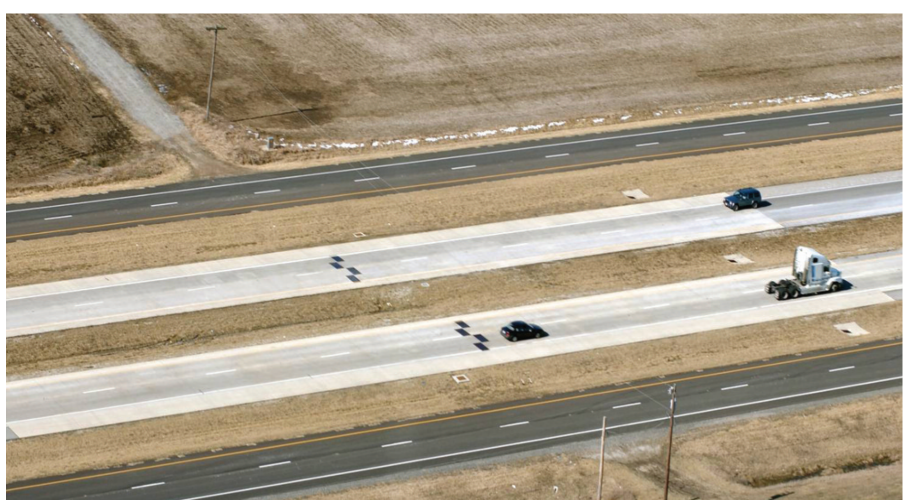

PHOTO COURTESY FHWA

Traffic Data Collection

The objective of the traffic pooled-fund study is to collect research-quality traffic data for volumes, classifications, and weights at LTPP SPS test sites. The sites include the structural factors of flexible and rigid pavements (SPS-1 and SPS-2), as well as the rehabilitation of both pavement types (SPS-5 and SPS-6). Installation of WIM systems was excluded from the SPS-8 test sites, which are used to investigate environmental effects on a pavement structure in the absence of heavy loads.

To meet the study's research-quality standards, data of known calibration, meeting LTPP's accuracy requirements—for steering and tandem axles, gross vehicle weight, bumper-to-bumper vehicle length, vehicle speed, and axle spacing—must be collected for 210 days within a year.

The WIM technologies recommended and used by the pooled-fund study include bending plate, load cell, and quartz sensors, all of which meet the specifications for a Type I WIM system.[3] These WIM sensors are now collecting research-quality data for 28 of the 64 LTPP SPS-1, -2, -5, and -6 test sites in 22 states.

Many pooled-fund studies use the funds contributed by participating states for any area of the study. In the LTPP traffic data collection pooled-fund study, however, each state's contribution goes to its own data collection needs at its SPS sites. An SPS site was included in the study if a state contributed funds and if adequate pavement performance and materials data were available for the site.

Six of the 28 states recognized the value of the multiyear study—as well as the potential for advancing their own traffic data collection activities—and decided to become donor states. This allowed FHWA to use the donor money for other states that needed additional funds.

Field Calibration and Validation

The LTPP program decided that the contractor installing the WIM system should not also validate the system. Two contractors therefore were solicited for the two different but concurrent aspects or phases of the research. Although the activities for each phase are distinct, together they ensure that the equipment is installed, calibrated, maintained, and operated correctly to generate the highest quality of data at each site.

The Phase I activities involve site assessment, performance evaluation, and calibration of WIM sites. In the early years of the study, the WIM systems were assessed for their ability to meet LTPP accuracy requirements and to produce at least 5 years of quality data. If the assessment indicated that a site would not meet the requirements, the Phase I contractor would recommend a correction. The contractor, however, was only responsible for reporting the issue, not resolving it. The highway agency would have to make any correction.

PHOTO COURTESY FHWA

A Class 9 test truck drives over a new WIM scale at the Arizona SPS-6 site.

If the corrective action called for replacing the WIM system, then either the highway agency or LTPP—through the Phase II contractor—was responsible for installing a new WIM system to meet LTPP's accuracy requirements for quality loading data.

With the national data collection now well under way, assessments at the SPS test sites are no longer necessary. The Phase I contractor's primary focus is to make sure that the WIM systems collecting traffic data at the SPS test sites are operating at peak performance by calibrating when necessary and by validating the systems annually.

For the field calibrations and validations, two test trucks drive over the WIM site—a fully loaded, Class 9, 5-axle tractor-semitrailer and a partially loaded truck of the configuration predominant in traffic at that site. The trucks are measured and weighed on certified scales. The drivers then drive down the center of the traffic lane at or below the posted speed limit without stopping or braking. Without adjusting the WIM system, the contractor evaluates the initial performance by having the drivers make a

PHOTOS COURTESY FHWA

WIM technologies used in the study include bending plates (*left*) and quartz sensors (*right*).

[3] ASTM E1318-02: Standard Specification for Highway Weigh-in-Motion Systems with User Requirements and Test Methods, Section 4.1.1.

PHOTO COURTESY FHWA

Phase II contractors install an inductive loop at a Kansas test site.

minimum of 20 runs per test vehicle; the speeds can range from 40 mph to 65 mph and the temperatures from 10°F to 116°F, as outlined in the field operations guide (*4*).

If the initial performance evaluation shows that the WIM system is functioning with sufficient accuracy, calibration is not necessary. The runs from the initial performance evaluation are used to complete the validation process. If the initial performance evaluation shows insufficient accuracy, however, the system is calibrated according to the equipment manufacturer's recommended procedures to achieve the best possible accuracy.

Immediately after calibration, validation of the WIM system begins. At minimum, 10 additional test vehicle passes—five passes per truck—are performed. The data are analyzed and the WIM system is recalibrated, if necessary. After successful calibration, the validation process is completed with a minimum of 20 additional runs per vehicle.

If a WIM system does not calibrate after three attempts, the validation activities stop. The Phase I contractor records the statistical accuracy of the WIM system before leaving the site and provides LTPP with a detailed report on the field activities and findings.

PHOTOS COURTESY FHWA

In 2001, data from the Florida pilot site were collected with ceramic piezoelectric sensors (*above*) and in 2005 with quartz piezoelectric sensors (*below*).

Installation, Maintenance, and Data Services

The Phase II contractor is responsible for site evaluation, equipment installation, ongoing maintenance, and daily quality control (QC) checks. At the beginning of the pooled-fund study, the Phase II contractor evaluated sites for suitability for WIM system installation. The evaluations considered the pavement condition and surface profile; the grade and alignment of the test section; the access to utilities such as power and telephone lines; and the observation of entry and exit ramps near the WIM site.

Other Phase II activities involved installing, calibrating, and maintaining the WIM system at the SPS test site and providing a 5-year warranty. Once the work began, LTPP staff noted that the data from these sites needed to be checked frequently. With input from the Traffic ETG, LTPP modified the Phase II contract to include daily QC checks of the data. The daily QC checks are listed in the box on this page.

This contract modification also required the Phase II contractor to provide the vendor software to the traffic engineers in the highway agencies when a new WIM system was installed. This ensures that the highway agencies are able to access the systems for current and future use. At the conclusion of the pooled-fund study, the highway agencies will assume responsibility for maintaining and calibrating the WIM systems.

Phase II activities recently have focused on maintaining and providing on-call repairs of the WIM systems and on the daily QC checks of the data. The Phase II contractors perform semiannual maintenance on the WIM systems they installed; the high-

Daily Quality Control Checks of Weigh-in-Motion Data

1. Total daily count by vehicle.
2. No lane has a value of 0 in a specific hour.
3. No lane has a traffic count of 2,500 or more in any specific hour.
4. Percent of error vehicles per day—errors detected in weighing a vehicle or an unreliable measurement can prevent the WIM system from generating a vehicle record.
5. Percent of status clear vehicles per day—that is, a valid vehicle record was created, showing weights and axle spacing.
6. Total daily count of Class 9 vehicles.
7. Percent of Class 9 vehicles per day.
8. Percent warning count of Class 9 vehicles per day—although a valid vehicle record with weights and axle spacing may be created, a warning message can indicate some irregularity in how the vehicle passed over the system.
9. Average gross vehicle weight of Class 9 vehicles per day.

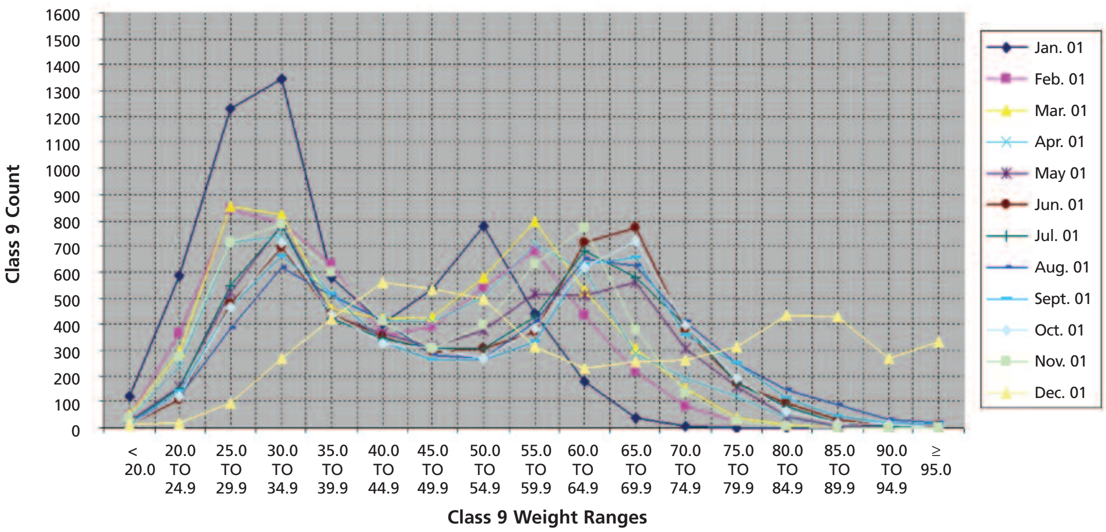

FIGURE 1 Weight data in 2001: histogram of gross weights of Class 9 trucks at an LTPP site in Florida before the Traffic Pooled-Fund Study protocols were developed.

way agencies maintain any agency-installed WIM systems.

Data Quality Improvement

The resources resulting from the pooled-fund study, listed in the box on page 16, are used by LTPP and are available to highway agencies. Developing resources solely for collecting quality traffic monitoring data reflects the philosophy of data integrity that LTPP has practiced for 20 years with other pavement performance data.

Figures 1 and 2 (on this page) show histograms of gross vehicle weights for Class 9 trucks—a 3-axle tractor pulling a 2-axle semitrailer—for the Florida pilot site in 2001 and 2005. Both figures show monthly totals through the year. The data in 2001 were collected with ceramic piezoelectric cable sensors, and the data in 2005 with quartz piezoelectric sensors, installed and calibrated according to the pooled-fund study's protocols.

Both graphs show two peaks in the histograms. The peak at a weight of approximately 30,000 lb corresponds to unladed vehicles, and the peak at approximately 80,000 lb to laded vehicles. The main difference between the two figures is that the results in Figure 2 show more consistency from month-to-month than the results in Figure 1. The WIM system that generated the data in Figure 1 was installed before standards were adopted and is typical of the data reported by ceramic piezoelectric cable sensors. The data in Figure 2 are typical of those collected at the 28 pooled-fund sites for the past 5 years of the study. Table 1 (page 16) compares the accuracy of the Phase I validation tests in 2001 and 2005.

Study Statistics

The Phase I contractor conducted the first field calibration and validation in 2003 at two agency-

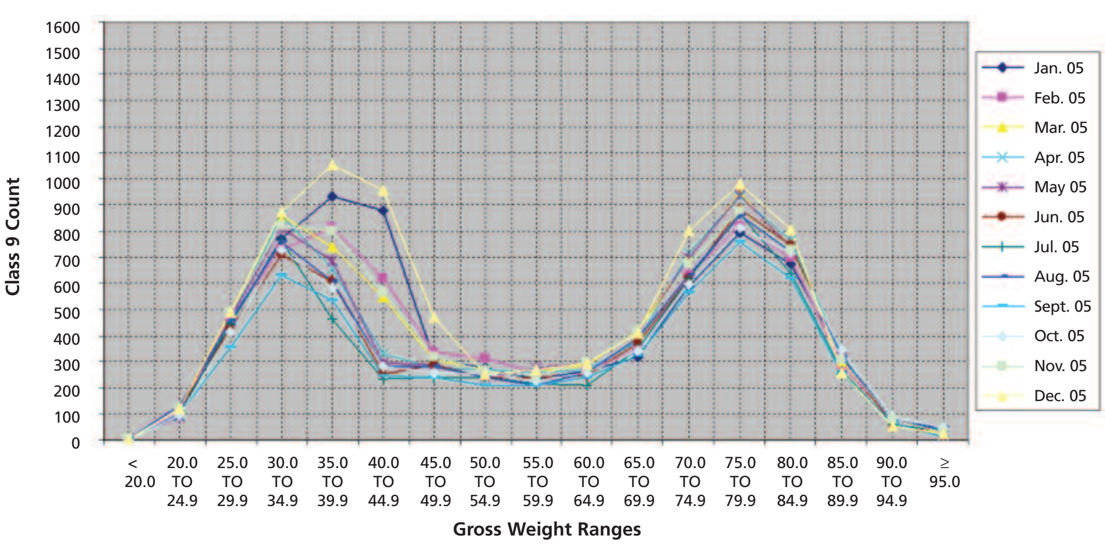

FIGURE 2 Weight data in 2005: histogram of gross weights of Class 9 trucks at an LTPP site in Florida using Traffic Pooled-Fund Study equipment and protocols.

The Florida pilot site tested gross vehicle weights using Class 9 test trucks.

Resources from the Traffic Pooled-Fund Study

- *LTPP Field Operations Guide for SPS WIM Sites* (*4*)
- Glossary of WIM Terms*
- LTPP Classification Scheme*
- WIM Smoothness Specification*
- WIM Workshops (arranged on request)

* www.pooledfund.org/.

installed WIM systems at the Florida SPS-1 and SPS-5 sites; the Phase II contractor installed the first WIM system in 2005 at the Illinois SPS-6 site. Since the beginning of the pooled-fund study, the Phase I contractor has performed 107 field validations; the Phase II contractor has performed 41 site assessments to determine suitability for installing a WIM system, has installed 19 systems, and continues to maintain and provide daily QC checks of the data for the 19 sites.

A few highway agencies have played an active role in the study by installing the approved WIM sensors at the SPS sites in their states. Seven agency-installed WIM systems are part of the study. All 26 installations are providing research-quality traffic data for 28 SPS sites—two locations have an adjacent SPS site and share the traffic data.

Table 2 (page 17) summarizes the traffic data collected at the pooled-fund study test sites through September 2011. Annual totals are shown for the Arizona SPS-1 and SPS-2 sites, as examples. These results show high levels of data availability from the WIM systems, which is typical of all of the pooled-fund traffic data collection sites.

For most years, research-quality classification and weight data have been collected for more than 90 percent of the days. This represents a dramatic improvement from equivalent statistics collected before the pooled-fund study, when data availability of zero to 10 percent was the norm. Table 2 also shows project totals for the other 26 sites. These sites show similarly high levels of data availability throughout the study years.

A total of 40,287 site-days of traffic data were collected through September 2011. This corresponds to approximately 400 million vehicle records and 2.3 billion individual axle-load records—the largest quantity of research-quality traffic data ever assembled. LTPP's database stores all of the data, which are available to researchers on request, in raw form or summarized as axle-load probability distributions.

Productive Metamorphosis

The LTPP SPS Traffic Data Collection Pooled-Fund Study has succeeded as a collaboration between FHWA, 28 highway agencies, and many other participants and stakeholders. The study has transformed the quality and quantity of the traffic data collected for 28 LTPP SPS test sites.

Many important lessons have been learned about collecting traffic data. Protocols have been developed for site selection; surface smoothness; equipment installation, calibration, and validation; and quality control checks. In addition, the study created novel contracting arrangements so that two contractors could perform mutually exclusive but complementary phases of the project and could verify each other's work.

Although the study turned out to be more challenging and costly than expected, it has shown that

TABLE 1 Accuracy of Data from Phase I Validation Tests (95% Confidence Level)

Parameter	Accuracy Guideline[a]	Data from 2001[b]	Data from 2005[c]
Gross weight	10%	–18% to +30%	0.2% ± 8.2%
Tandem axles	15%	–26% to +41%	0.0% ± 10.2%
Single axles	20%	–31% to +38%	1.2% ± 10.0%

[a] From specification (*4*).

[b] Data collected on the Florida SPS WIM site in 2001 using ceramic piezoelectric sensors (same system as used to collect the data in Figure 1).

[c] Data collected on the same WIM site in 2005 using quartz piezoelectric sensors and the procedures specified by the SPS Traffic Pooled-Fund Study protocols (same system as used to collect the data in Figure 2).

PHOTO COURTESY FHWA

Concrete slab grinding at an Arizona test site. Surface smoothness is one of the protocols developed for the pooled-fund study.

collecting research-quality traffic data with high availability over an extended period is possible. By the end of the study in December 2015, all 28 sites will have generated at least 5 years of research-quality data, with each site-year comprising at least 210 days of classification and loading data.

The action plan assembled in 1999, piloted in 2001, and implemented in 2003 has transformed traffic data collection, not only for LTPP, but for the entire traffic community. Although most highway agencies do not have the resources to implement all of the protocols for collecting research-quality data on their own test sites, many are able to apply and benefit from some of the protocols.

In addition to analysis of the performance of the SPS test sections, two traffic analysis projects are using the data collected from the pooled-fund study sites. The projects include the development of new traffic defaults for the *Mechanistic–Empirical Pavement Design Guide* and verification and enhancements to the LTPP classification scheme in use at nearly all of the pooled-fund study sites. Such projects would not be possible otherwise—the traffic data needed to complete them are not available elsewhere.

The metamorphosis of the LTPP traffic data project has yielded traffic data of unprecedented quality and quantity and has provided data that users can trust. The success of this work is a result of the unending support and commitment by the participating highway agencies, current and past members of the Traffic ETG, the LTPP contractors, TRB, and FHWA.

TABLE 2 Summary of Data Available from SPS Traffic Data Pooled-Fund Study Through September 2011

Participating SPS Site		Year	Total Days in Period	Classification Data		Weight Data	
				Days Used	% Used	Days Used	% Used
1. Arizona	SPS-1	2007	241	235	98	99	41
		2008	366	366	100	366	100
		2009	365	315	86	322	88
		2010	365	358	98	359	98
		2011	273	260	95	260	95
2. Arizona	SPS-2	2007	244	239	98	64	26
		2008	366	355	97	358	98
		2009	365	326	89	333	91
		2010	365	352	96	347	95
		2011	273	265	97	267	98
3. Arkansas	SPS-2	2007–2011	1,734	1,439	83	1,026	59
4. California	SPS-2	2008–2011	1,369	1,254	92	1,292	94
5. Colorado	SPS-2	2006–2011	1,982	1,876	95	1,872	94
6. Delaware	SPS-1	2007–2011	1,510	1,397	93	1,409	93
7. Delaware	SPS-2	2007–2011	1,510	1,397	93	1,409	93
8. Florida	SPS-1	2006–2008	843	606	72	608	72
9. Florida	SPS-5	2006–2009	1,078	993	92	996	92
10. Illinois	SPS-6	2005–2011	2,238	2,156	96	2,159	96
11. Indiana	SPS-6	2008–2011	1,170	1,143	98	1,146	98
12. Kansas	SPS-2	2006–2011	1,941	1,668	86	1,693	87
13. Louisiana	SPS-1	2008–2011	1,369	1,299	95	1,303	95
14. Maine	SPS-5	2007–2011	1,529	1,423	93	1,453	95
15. Maryland	SPS-5	2006–2011	2,040	1,931	95	1,975	97
16. Michigan	SPS-1	2005–2011	2,464	2,251	91	2,110	86
17. Minnesota	SPS-5	2006–2011	1,795	1,733	97	1,754	98
18. New Mexico	SPS-1	2008–2011	1,236	1,177	95	1,095	89
19. New Mexico	SPS-5	2008–2011	1,235	1,136	92	1,089	88
20. Ohio	SPS-1	2004–2011	2,830	1,572	56	1,464	52
21. Ohio	SPS-2	2004–2011	2,830	949	34	1,013	36
22. Pennsylvania	SPS-6	2007–2011	1,585	1,492	94	1,507	95
23. Tennessee	SPS-6	2007–2011	1,605	1,495	93	1,454	91
24. Texas	SPS-1	2006–2011	1,971	1,251	63	1,431	73
25. Virginia	SPS-1	2007–2011	1,731	1,640	95	1,649	95
26. Washington	SPS-2	2006–2011	2,099	1,877	89	1,785	85
27. Wisconsin	SPS-1	2007–2011	1,426	1,409	99	1,410	99
28. Wisconsin	SPS-2	2007–2011	1,426	1,409	99	1,410	99

NOTE: Annual data shown for Arizona SPS-1 and -2 for illustration; total results are shown for all other sites.

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ASSET MANAGEMENT IN A WORLD OF DIRT

Emergence of an Underdeveloped Sector of Transportation Asset Management

DAVID A. STANLEY

The application of asset management techniques to geotechnical assets such as flexible rockfall protection systems has so far been mostly unexplored by transportation agencies.

PHOTO: DAVID A. STANLEY

Transportation agencies in the United States and worldwide are adopting transportation asset management (TAM) to focus strategically on the long-term management of government-owned assets (*1, 2*). As TAM concepts and tools have developed, however, they have not addressed all classes of assets—in particular, geotechnical assets such as retaining walls, embankments, rock slopes, rockfall protection barriers, rock and ground anchors, soil nail walls, material sites, tunnels, and geotechnical instrumentation and data.

Some state agencies have attempted to press forward in applying asset management principles to geotechnical assets, but the efforts have been isolated and limited. Many have not applied the gamut of the TAM process, starting from asset inventories and moving on to condition assessment and service-life estimates, performance modeling, alternative evaluation with life-cycle-based decision making, project selection, and performance monitoring (see Figure 1, page 19).

Most geotechnical asset management (GAM) efforts have halted at inventorying and conducting condition surveys, without progressing along the TAM spectrum. For example, agencies are unlikely to have specific performance standards for their geotechnical assets, and information about determining or estimating the service life of geotechnical assets is sparse. Nonetheless, much has been accomplished in the areas of assessing the corrosion and degradation of buried metal reinforcements in retaining walls and in estimating their remaining service life (*3–5*).

Promoting the Principles

Recent efforts have begun to promote GAM. For example, the TRB Engineering Geology Committee formed a Geotechnical Asset Management Subcommittee to address research needs in this area. The subcommittee held its first formal meeting at the January 2011 TRB Annual Meeting.

In addition, efforts are under way to incorporate GAM principles into ongoing research and management programs:

- National Cooperative Highway Research Program (NCHRP) Project 24-35 is developing guidelines for the certification and management of flexible rockfall protection mechanisms that will include development of an asset management plan, long-

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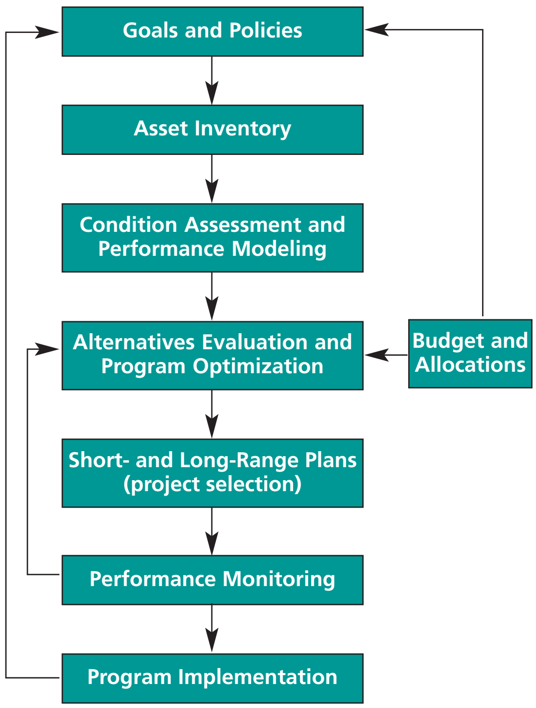

FIGURE 1 Generic asset management system (*1*).

term performance and condition measures, life-cycle cost estimating, and cost–benefit analyses for maintenance, repair, and replacement decisions.

◆ The Alaska Department of Transportation and Public Facilities (DOT&PF) is conducting research for a program that will apply asset management principles to the management of unstable slopes.

◆ Wyoming DOT has created a geology database to track and manage geologic maps, aggregate sources, and project information.

◆ The National Park Service has developed a Retaining Wall Inventory and Condition Assessment Program.

◆ Ohio DOT has a Retaining Wall Asset Management Program.

These efforts and others are starting points, but most are not integrated into a larger TAM program. Most states do not have geotechnical policies, goals, or performance measures. For the geotechnical asset programs that are in place, therefore, the nexus to agency goals remains tenuous.

In a World of Dirt

TRB sponsored a symposium, Asset Management in a World of Dirt, in Oklahoma City in August 2010 in conjunction with the annual Highway Geology Symposium. The purpose of the TRB symposium, cosponsored by the TRB Engineering Geology and the Exploration and Classification of Earth Materials Committees, was to help practitioners address geotechnical assets in TAM initiatives. The symposium featured a keynote speech by Erik Loehr of the University of Missouri–Columbia, an early proponent of GAM and coauthor of key GAM publications (*6, 7*). Loehr reviewed the basics of asset management and addressed several GAM problem areas and research needs.

The six main speakers provided an overview of asset management principles and a perspective on GAM and its role. Other presentations addressed the issues associated with creating databases for conducting asset inventory and condition surveys and how GAM can provide a framework for managing the problem of the early degradation of buried structural components in retaining walls. Another presentation described the National Park Service's retaining wall inventory and the lessons learned in implementing the project. Two presentations were published as papers in the proceedings of the 61st Highway Geology Symposium (*8, 9*).

GAM Goals

The goal of applying asset management principles to geotechnical assets is to reduce life-cycle costs (*3*). Agencies spend a significant portion of their funds on geotechnical assets. Every transportation asset rests on or is affected by a geotechnical asset—such as the ground and embankments on which roads are built and the rock slopes that adjoin roadways. Nevertheless, the length of service provided by a well-built embankment or an unseen bridge foundation receives little consideration—geotechnical assets often are neglected until they fail.

When geotechnical assets deteriorate, most transportation agencies resort to a "worst first" approach

A tieback wall on Richardson Highway in Alaska. Research on geotechnical asset management (GAM) is under way in Alaska, Wyoming, and Ohio.

Photo: C. T. Boeckman

Installation of soil nails along Alaska's Glenn Highway. An August symposium sponsored by TRB focused on managing degradation of buried structural components in retaining walls and other geotechnical assets.

in determining whether to repair, rehabilitate, or replace the asset and when. For example, rockfall inventory programs in many states rank rockfall sites so that the most dangerous receive first attention (*10*). Expending limited funds on worst-case problems, however, guarantees steadily declining conditions for transportation systems; asset management principles dictate spending to gain the most long-term, positive effects.

Research Needs

Agencies implementing geotechnical measures in parallel with TAM efforts or integrated into those efforts face daunting hurdles. The possibilities for research are ample, and several aspects of GAM need explication. Although GAM practitioners have been conducting inventories and condition surveys for many years (*10*), progress into other areas of asset management for geotechnical assets has been slow. The following are critical needs:

- Devising performance standards and measures and establishing minimum levels of service; and
- Understanding the expected performance of geotechnical assets.

Some preliminary efforts have sought to identify performance standards specifically for geotechnical

When a rockslide blocked the eastbound lanes of I-84 near Rufus, Oregon, in December 2010 (*left*), crews had to wait until morning to clear the debris and stabilize the slope (*right*). GAM allows transportation agencies to direct funds efficiently and reduce life-cycle costs.

Photos: Oregon Department of Transportation assets, such as the unstable slope performance standards for Alaska DOT&PF (*11*). Most state DOTs, however, are not likely to have identified specific GAM performance standards. Creating performance standards may not necessarily be a complex task—logical standards can be derived from agency policies, goals, and consumer expectations.

After establishing the standards for geotechnical assets, the next step is to develop an understanding of the life cycle. Managers must be able to predict the condition of an asset at a certain time in the future. For some asset classes, such as pavement, deterioration curves can be created to chart the future life of the asset. The useful life of many geotechnical assets, however, cannot be charted on a neat curve.

One option for projecting the future condition of geotechnical assets is to start with a theoretical curve and then to perform a regression analysis to fit the curve. This process, however, can take many years. Formulas are available to calculate the expected service life of some geotechnical assets, such as buried retaining wall reinforcements and rock bolts (*3–5*). Considerable research is needed, however, to determine theoretical and actual service life and asset performance over time.

Next Steps

Progress is under way in identifying and resolving inventory and condition survey issues for geotechnical assets. Many agencies have one or more inventory programs for retaining walls and for rock slopes. Nonetheless, agencies nationwide do not yet have a clear understanding of the next steps after completing a geotechnical asset inventory. GAM needs a framework and a roadmap to clarify how agency strategic goals and performance measures can be met through the implementation of GAM programs and to outline the steps to implement these programs.

Some of the framework for GAM was put in place several years ago (*6*), and the authors of the early work acknowledged the challenges, particularly in relation to agency goals and analysis tools. Minimal follow-up has built on these efforts to formulate a usable framework.

Research is needed to continue the development of GAM. The focus should extend beyond methods of conducting inventories and condition surveys to creating performance standards for geotechnical assets and finding ways to link agency goals to GAM implementation. Several research efforts are getting under way and show promise in integrating geotechnical concerns as key elements of TAM.

Improved understanding is needed about changes in geotechnical assets over time, which could allow for projections that can determine the optimum time to repair, rehabilitate, or replace an asset. Determining the characteristics of an asset's life will take many years of research projects. Some projects have taken the first steps, but more work is needed.

PHOTO: DAVID A. STANLEY

Larry Pierson, Landslide Technology, examines Nenana Canyon rockfall barrier, Parks Highway, Alaska, near Denali National Park.

Down the Road

The TRB subcommittee on GAM is formulating research needs statements, focusing on how to move GAM beyond the initial steps. Research will look for ways to relate performance standards for geotechnical assets to the projected condition of the assets and will look further to the availability of analysis tools and their application to rational decision making about geotechnical assets, in accordance with asset management principles. The goal is to provide agencies with the optimal course of action for geotechnical assets.

Continued development of asset management for geotechnical assets is a critical part of the asset management puzzle. As asset management in transportation practice continues to mature, GAM must continue to make similar advances. When developed

PHOTO: DAVID A. STANLEY

Many states that have inventory programs for retaining walls and rock slopes often may lack a framework for implementing GAM principles to meet performance measures.

Photo: Pete Hardcastle

A materials site in Brooks Range, Alaska. The goal of GAM is to offer a framework for monitoring and predicting performance, enabling transportation agencies to make life-cycle cost–based decisions about geotechnical assets.

and implemented, GAM will offer a framework for monitoring performance to assure understanding of the current condition and to project the performance of geotechnical assets.

GAM offers transportation agencies the ability to make life-cycle cost–based choices about monitoring, rehabilitating, repairing, or replacing significant assets. As efforts continue to integrate geotechnical assets into the broader TAM effort, opportunities will arise for researchers in the world of dirt.

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Photo: John Duffy

Installation of soil nails and wire mesh in California.

NEW TRB SPECIAL REPORT

Policy Options for Reducing Energy Use and Greenhouse Gas Emissions from U.S. Transportation

EMIL H. FRANKEL AND THOMAS R. MENZIES, JR.

Frankel is Director of Transportation Policy, Bipartisan Policy Center, Washington, D.C., and a former Assistant Secretary for Policy, U.S. Department of Transportation; he chaired the study committee. Menzies, who served as study director, is Senior Program Officer, TRB Division of Studies and Special Programs.

Scientific analyses and models indicate a need to stabilize atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHGs) by the middle of this century to reduce the risks of climate change. Controlling GHG buildup will require major reductions in CO_2 emissions from the economic sectors that are the predominant users of carbon-rich fossil fuels.

A response by the transportation sector to this energy and emissions challenge will be important because the sector produces between one-quarter and one-third of all the CO_2 emitted from the country's energy consumption. In addition, because transportation accounts for more than two-thirds of the petroleum consumed in the United States, saving energy in transportation also can have important implications for the cost of access to the world's oil supplies.

Setting Targets

A study committee appointed by the National Research Council of the National Academies under the auspices of the Transportation Research Board (see box, page 26) examined the potential for policies targeting cars and light trucks, medium and heavy trucks, and commercial airliners to yield major changes in transportation energy use and emissions trends. These three modes account for the vast majority of passenger trips and freight movements and are by far the largest users of energy in U.S. transportation.

In Special Report 307, *Policy Options for Reducing Energy Use and Greenhouse Gas Emissions from U.S. Transportation*, the committee examines fuel taxes, vehicle efficiency standards, fuel standards, infrastructure investments, and coordinated transportation and land use planning as ways to bring about

PHOTO: JEREMY NOBLE

Transportation accounts for more than two-thirds of the petroleum consumed in the United States and between one-quarter and one-third of the nation's energy-based carbon dioxide emissions.

Photo: P. Pigeyre, Airbus S. A. S. © 2011

Sharklet wing tips on an Airbus A320 development aircraft are among the energy-saving features under testing by aircraft manufacturers in response to airline demands for energy efficiency. Passenger aircraft account for approximately 6 percent of transportation energy use.

large energy and emissions savings from the three modes over time. Each option, however, presents particular challenges with respect to the scope and timing of its impacts. A combination of policy options to improve the timeliness and expand the scope of the response may be warranted.

Policy Challenge

U.S. transportation is powered almost entirely by petroleum. Transportation is the country's largest user of oil and a major source of GHG emissions and is central to commerce and to daily routines. Transportation allows people to access more places of work, obtain a wider range of goods and services, and connect socially over broader areas. Transportation allows businesses to situate in the most economically efficient locations and reach a larger number of suppliers and customers.

Today's transportation modes and systems cannot be easily or quickly altered, having evolved over many decades and reflecting countless decisions about where and how Americans live and businesses operate. The diversity and ubiquity of the nation's transportation system present both opportunities and challenges for policy making.

The amount of petroleum consumed in transportation and the associated emissions of GHGs are a function of the fuel economy of transportation vehicles, their operating environment, the frequency and intensity of vehicle use, and the GHG characteristics of the fuels. Policies to curb transportation energy consumption and emissions will need to focus on the sector's dominant modes—cars and light trucks for personal travel and medium and heavy trucks for moving freight.

Cars and light trucks account for approximately two-thirds of the sector's petroleum consumption and a comparable share of GHG emissions. Because of anticipated increases in federal fuel economy and GHG performance standards, light-duty vehicles are projected to account for a decreasing share of the transportation sector's total energy use and emissions over time; yet even by 2030 they still will account for the majority share, or 55 to 60 percent.

Medium- and heavy-duty vehicles, including large trucks that carry freight, contribute 20 to 25 percent of the sector's energy use and emissions. These vehicles also are projected to account for a similar percentage in 2030. All motor vehicles together will continue to account for more than 75 percent of transportation's total energy use and emissions.

The next-largest contributor is the passenger airline industry, with a share of emissions projected to increase from roughly 6 percent to 8 percent over the 20-year period. The three types of vehicles—cars,

Photo: Greg Hickman

Cars and light trucks account for approximately two-thirds of the sector's petroleum consumption and a comparable share of GHG emissions; discretionary shopping trips are a rapidly increasing reason for car use.

trucks, and commercial airliners—will be the main sources of the sector's energy use and emissions for many years to come.

Exploiting Opportunities

Any policies aimed at making major changes in transportation energy use and emissions trends will almost certainly need to find and exploit opportunities to reduce the energy and emissions intensity and the activity of these vehicles.

For cars and light trucks, the opportunities are likely to include the following:

◆ Increasing the energy efficiency of vehicles introduced after 2020 to exceed the goal of 35 miles per gallon, required by current legislation;

◆ Moderating the rate of growth in private-vehicle use by households, particularly for the fastest-growing reasons for personal trip making, such as discretionary trips for shopping and services; and

◆ Diversifying the fuel supply to reduce dependence on gasoline and to favor energy sources that yield lower emissions of GHGs in fuel production and consumption.

For freight-carrying trucks, the opportunities are likely to include the following:

◆ Accelerating the development and introduction of fuel-saving truck designs and technologies,

◆ Encouraging the widespread adoption by fleet operators of more energy-efficient operations and maintenance practices, and

◆ Diversifying the fuel supply to reduce diesel consumption and to favor energy sources that yield lower emissions of GHGs in fuel production and consumption.

For passenger airliners, the opportunities include the following:

◆ Accelerating fleet turnover to hasten the early entry of next-generation aircraft that are more energy efficient and that produce fewer emissions and

◆ Enabling more efficient airline routing and operations through improved air traffic management procedures and systems.

Keys to Success

The successful exploitation of opportunities for saving energy and reducing emissions in these dominant modes will require policies that influence the decisions and actions of those who (*a*) supply the vehicles, fuels, and infrastructure; (*b*) own and operate the vehicles and provide commercial freight and passenger services; and (*c*) demand these transportation services.

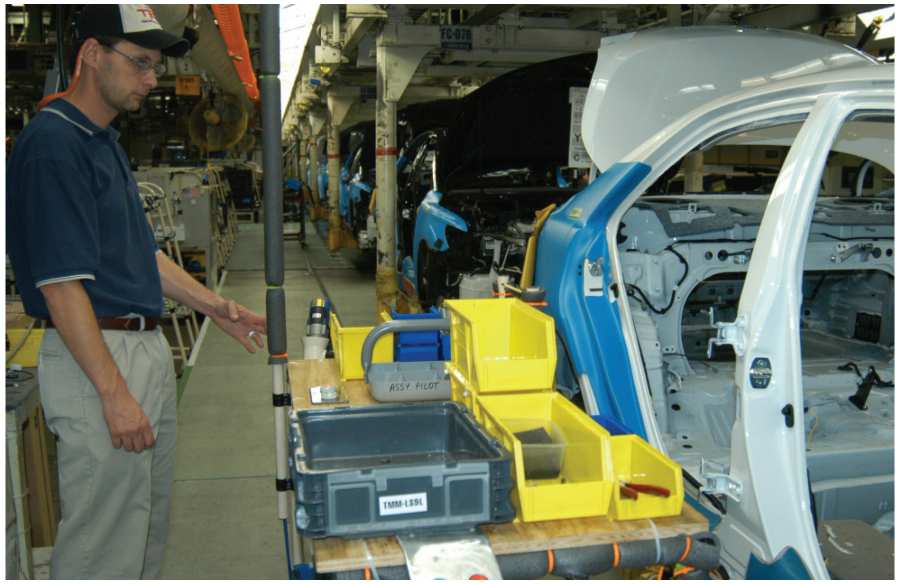


PHOTO: TOYOTA MOTOR CORPORATION

The study committee examined financial incentives such as feebates and fuel taxes to encourage the purchase of more energy-efficient vehicles. Above, a hybrid vehicle on the assembly line.

A policy approach that does not influence the incentives and actions of all of these target groups is likely to fall short of the desired outcome. The debate is over the types and combinations of policies that are best suited to making early progress in controlling emissions and that can increase the scope and amount of emissions reductions by the middle of this century.

Policy Options Explored

The committee reviewed several policy options:

◆ Transportation fuel taxes;

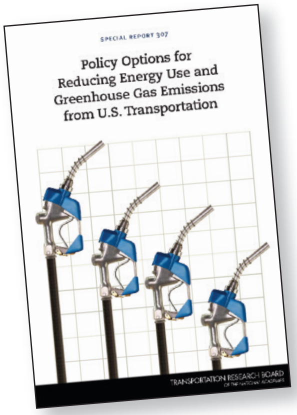
◆ Vehicle efficiency standards and feebates—that is, using fees charged to purchasers of low-efficiency vehicles to fund rebates to purchasers of high-efficiency vehicles—as well as other financial incentives to motivate interest in vehicle efficiency;

◆ Low-carbon standards for transportation fuels;

◆ Land use controls and travel demand management measures aimed at curbing private household vehicle use; and

◆ Public investments in transportation infrastructure to increase vehicle operating efficiencies.

The report examines how each policy option influences transportation energy use and GHG emissions, whether by affecting the amount of energy- and emissions-intensive transportation activity, the energy efficiency of vehicles and their operations, or the GHG characteristics of the transportation energy supply. Policies that affect all three areas and that can be applied across modes are likely to have the most influence on transportation energy use and



Special Report 307, *Policy Options for Reducing Energy Use and Greenhouse Gas Emissions from U.S. Transportation*, is available from the TRB online bookstore, www.trb.org/bookstore; to view the book online, go to http://onlinepubs.trb.org/onlinepubs/sr/sr307.pdf.

emissions. How quickly each policy can be put into effect is an important consideration, because early actions that slow the rate of growth in emissions will allow more time for developing and implementing responses to reverse the upward trend.

No Silver Bullet

Achieving timely, sustained, and increasing cuts in GHG emissions may require a variety of policy measures acting in combination and synergistically. According to the report, fuel taxes have the greatest applicability across modes, although raising fuel prices is unpopular with the public. In addition to having sectorwide applicability, fuel taxes can prompt a varied energy- and emissions-saving response by consumers and by the suppliers of fuels, vehicles, and transportation services.

Efficiency standards have a more focused impact, increasing the energy and emissions performance of vehicles and fuels but without prompting vehicle operators to engage in more energy-efficient operations or to scale back their energy- and emissions-intensive activities. The key advantage is that efficiency standards have a history of implementation.

Few of the policies examined in this report are likely to be adopted quickly or to remain in place for long unless they do more than reduce GHG emissions. Interest in reducing dependence on petroleum, much of it supplied from politically unstable regions of the world, has been an important reason for adopting vehicle fuel economy standards, and this will continue to motivate the introduction of other policies aimed at curbing transportation's energy use.

Other public interests also must align with these goals. For example, if investments in transportation infrastructure and operating practices to make the system more energy efficient also can reduce congestion and delays, they will be desirable to consumers. The coordination of land use planning and transportation investments likewise can yield more effective and efficient energy-saving responses by consumers. The introduction of fuel taxes and other measures to raise energy prices would require infrastructure-related policies to support the ensuing demand for system efficiencies to save fuel.

Role of Research

Although the study committee was not tasked with developing a research agenda, the challenges discussed in the report point to the long-term importance of making near- and medium-term policy choices on a well-informed, strategic basis. A policy-making approach that is strategic requires research that goes beyond the traditional role of supporting technology advances.

Strategic policy making requires information and analytical techniques drawn from multiple disciplines—for example, economics research on the connections between transportation and productivity, political research on how policies can be coordinated across jurisdictions, and behavioral research that yields a better understanding of how consumers value future streams of energy savings. With this information, policy makers will be able to assess alternative policies and their likely interactions, the lead times that specific measures will require for maximum effectiveness, and the actions that can put favored policies into effect.

Strategic Alignment

Whichever strategic combination of policies is pursued, success in introducing and sustaining the initiatives will depend on the public's resolve to conserve energy and reduce GHG emissions from transportation and from other sectors. For decades, the reasons for the public to care about saving energy in transportation have been ample—from the need to improve air quality to concern about the world's oil supplies. Climate change has added to—and elevated—this public interest. The calls for a strategic alignment of public policies to address these challenges may not be new but are becoming more urgent.

Committee for a Study of Potential Energy Savings and Greenhouse Gas Reductions from Transportation

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NATIONAL RESEARCH COUNCIL REPORT

National Water Resources Challenges Facing the U.S. Army Corps of Engineers

JEFFREY W. JACOBS AND SOLMAZ SPENCE

Jacobs is Scholar and Study Director, Water Science and Technology Board, and Spence is Communications Officer, Division on Earth and Life Studies, National Research Council of the National Academies, Washington, D.C.

The U.S. Army Corps of Engineers faces a water planning paradox: strong demands for federal water resources projects, yet shrinking federal funds for water resource infrastructure. Moreover, the agency's traditional work program over the years has assumed additional responsibilities—namely, ecosystem restoration. Providing reliable services to traditional and newer constituents raises many planning and decision-making difficulties, according to *National Water Resources Challenges Facing the U.S. Army Corps of Engineers*, a March 2011 report from the National Research Council of the National Academies.

Historically, the Corps' mission emphasized the construction and operation of a vast water resources infrastructure, including approximately 700 dams and 12,000 miles of levees, as well as locks, navigation channels, and port and harbor facilities. But the Corps' duties have broadened and shifted. The agency is less active in building new civil works and more involved in operating and maintaining the infrastructure and in allocating limited water supplies to meet demands. The nation also relies on the Corps for emergency response, as in the reconstruction and strengthening of flood walls and levees in the greater New Orleans area after Hurricane Katrina.


Photo: George Stringham, U.S. Army Corps of Engineers

A gate bay is dewatered at Melvin Price Locks and Dam near Alton, Illinois. The duties of the U.S. Army Corps of Engineers now include maintenance of many water resource projects, ecosystem restoration, and emergency response.


Photo: Robert Etzel, USACE

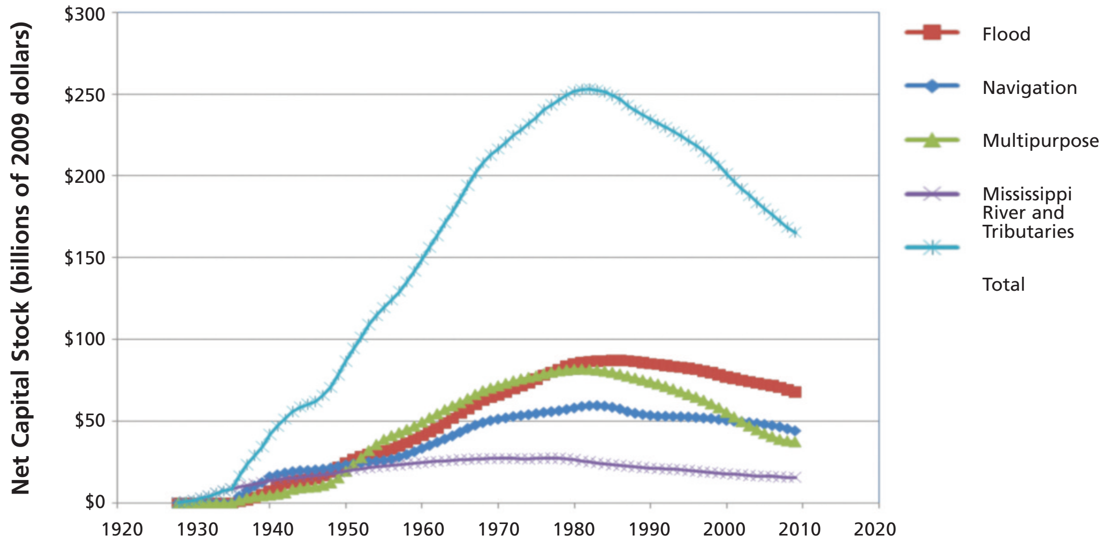
Montana's Fort Peck Dam, part of the mainstem dam system on the Missouri River. Floods along the river in 2011 highlighted the competing demands of reliable river flows for commercial and municipal needs with varied flows for environmental requirements.

Competing Goals

With these expanded responsibilities, the Corps has multiple—and sometimes competing—goals. For example, the Corps may receive requests to maintain steady, reliable river flows to meet the needs of commercial navigation simultaneously with requests to vary river flows to benefit aquatic ecosystems and endangered species. As a result, the Corps often is mired in controversies over shared water resources that are beyond its mandates to resolve.

The Missouri River mainstem dam and reservoir system is an example. When the Corps constructed the six major dams along the river, the priorities were flood control and navigation. New environmental laws and increased water demands, however, have enlarged and broadened expectations for the river's resources. Major floods along the Missouri River in

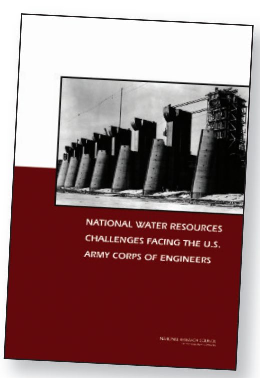
FIGURE 1 Net capital stock estimates of U.S. Army Corps of Engineers civil works projects, 1928 to 2009 (in 2009 dollars), showing a significant decline in the past three decades from a peak value of $250 billion in 1983 to $165 billion in 2009. (Source: Steven Stockton, U.S. Army Corps of Engineers, personal communication, 2010.)



spring and summer 2011 highlighted the challenges the Corps faces in trying to meet competing demands.

At the same time, federal investments in national water resource infrastructure have declined steadily since the mid-1980s. Many crucial water management works, such as levees, locks, and dams, are aging and in need of upgrades and repairs.

To gain advice on meeting these many challenges, the Corps requested the National Research Council to convene a committee of experts to identify emerging water resource issues. *National Water Resources Challenges Facing the U.S. Army Corps of Engineers* is the first of five reports from the Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning. The report surveys the key water resource issues for the Corps and the nation, the limits of what might be expected from the Corps, and the prospects.



National Water Resources Challenges Facing the U.S. Army Corps of Engineers ($27, ISBN 978-0-309-21132-1) is available from National Academies Press. To order, go to www.nap.edu.

Creative Approaches

An overarching message is that the current mode of federal water project construction, operations, and maintenance is not sustainable. The declining investment in federal water infrastructure, coupled with increasing responsibilities for the Corps, prevents the Corps from consistently meeting the demands and expectations for its work program.

In addition, budget constraints often delay Corps projects authorized by Congress for many years until the appropriation of funds—the backlog of projects authorized but not yet funded is estimated at roughly $60 million. Newly authorized projects typically are not funded until projects in the backlog receive funding, which could take years, if not decades—a frustrating situation for communities that need federal support for new water project construction or for upgrades or maintenance of infrastructure.

The National Research Council report affirms a need for strong Corps of Engineers leadership in the management and operations of the nation's major river and aquatic systems. The Corps must remain innovative and responsive in addressing national water planning challenges.

The report concludes that the challenges also present the U.S. Army Corps of Engineers with opportunities to implement more efficient and more effective water management approaches. These creative means to overcome budget constraints and achieve water-related objectives and projects are likely to include stronger collaboration with—and support from—project cosponsors and other interested parties.

Photo: Michael Nevins, USACE

An aged walnut tree on a levee along the Sacramento River in California. A 2009 Corps study examined the effects of the root systems of trees and vegetation on levees and slurry walls.

Illinois Department of Transportation

Automated Speed Enforcement Slows Down Drivers in Work Zones

PRISCILLA TOBIAS

The author works for the Bureau of Safety, Illinois Department of Transportation, Springfield.

In 2009, the United States recorded 667 fatalities and more than 40,000 injuries in highway work zones—a rate of one fatality every 13 hours and one injury every 13 minutes. Crashes are more likely in work zones than on regular highways. Work zone safety must improve to achieve the national goal of zero deaths from traffic crashes.

Problem

More than 7,000 crashes occur annually in highway work zones in Illinois, causing approximately 2,000 injuries. The number of work zone fatalities in the state reached a peak of 44, including 5 workers, in 2003. The percentage of work zone–related fatalities in Illinois is higher than the national average. Speeding is one of the most important contributors, affecting the frequency and severity of work zone crashes. Improving compliance with speed limits in work zones therefore is a pressing need.

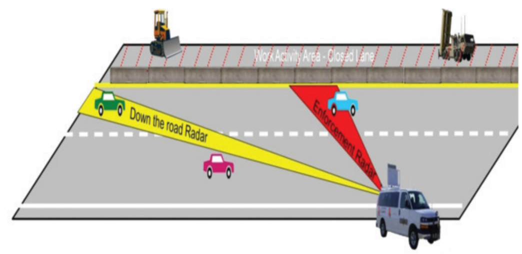
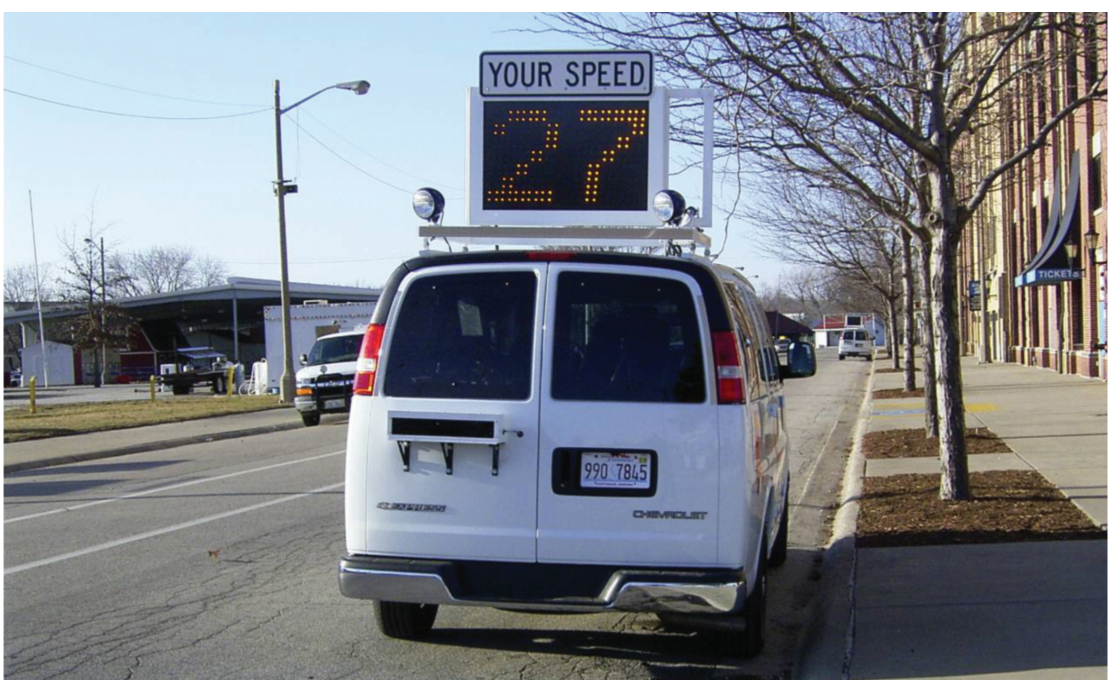


FIGURE 1 Operation of speed-radar photo enforcement.

Solution

Because state resources are limited, novel approaches were needed to make the most from minimal investment. In 2004, Illinois passed the Automated Traffic Control Systems in Highway Construction or Maintenance Zones Act, authorizing speed-radar photo enforcement (SPE) in work zones on highways. For the first time, a state department of transportation

PHOTO: ILLINOIS DOT



Speed-radar photo enforcement vehicle; enforcement radar unit is mounted on the rear door; down-the-road radar generates the "Your Speed" reading on the rooftop display.

(DOT) was authorized to implement SPE in work zones on the Interstate Highway System. The objective was to improve speed limit compliance and work zone safety.

Illinois DOT initially deployed two self-contained vans to implement the program (*1*). The speeds of vehicles approaching the SPE are monitored with two radar systems: down-the-road radar and across-the-road radar (Figure 1, page 29). The speed obtained from the down-the-road radar is displayed on a light-emitting diode display on top of the SPE van (see photo, page 29). The display gives speeding drivers a final chance to reduce speed and comply with the work zone speed limit. The range of a down-the-road radar is similar to that of a radar typically used in work zones—approximately one-quarter to one-half mile.

Across-the-road radar measures the speeds of vehicles at approximately 150 feet upstream from the van. If the speed of the vehicle, measured by across-the-road radar, is greater than a specified value, the two onboard cameras are activated to take pictures of the driver and rear license plate of the vehicle. Operation of the SPE van is shown in Figure 1; trained Illinois State Police officers staff the vans.

Regular speeding fines in work zones apply to violations detected by SPE. The fine for the first violation is $375; for the second, $1,000, along with a

TABLE 1 Average Speeds of Vehicles

		Data Set	Shoulder Lane			Median Lane		
			Mean Speed, mph (Sample Size)		Speed Reduction, mph	Mean Speed, mph (Sample Size)		Speed Reduction, mph
			Base	SPE		Base	SPE	
Treatment location	Passenger cars	1	61.4 (204)	53.7 (218)	7.7	63.9 (106)	56.0 (101)	7.9
		2	51.2 (135)	47.0 (191)	4.2	57.0 (119)	50.6 (146)	6.4
		3	50.2 (141)	44.8 (71)	5.5	55.4 (181)	49.1 (95)	6.3
	Heavy vehicles	1	57.4 (39)	51.3 (44)	6.1	56.2 (120)	52.2 (100)	4.0
		2	50.3 (41)	46.1 (54)	4.1	53.7 (40)	50.3 (41)	3.4
		3	48.8 (42)	44.8 (40)	4.0	53.2 (40)	46.3 (41)	7.0
Downstream location	Passenger cars	1	59.8 (207)	57.2 (226)	2.6	62.5 (102)	60.5 (102)	2.0
		2	58.6 (188)	57.9 (209)	0.6*	61.8 (98)	61.6 (126)	0.2*
		3	58.6 (165)	55.6 (125)	3.0	63.5 (158)	59.7 (107)	3.8
	Heavy vehicles	1	56.5 (40)	55.6 (35)	0.9*	56.2 (134)	55.4 (107)	0.7*
		2	57.3 (57)	56.4 (73)	1.0*	59.4 (43)	56.8 (52)	2.5
		3	57.8 (57)	53.0 (39)	4.8	59.5 (33)	54.2 (32)	5.2

*Not significant at 95 percent confidence level.

90-day suspension of license. A court appearance is mandatory for each violation. The vans are provided under contract by a vendor at a cost of $2,950 per month each—this includes the vehicle, equipment, maintenance, upgrades, and training—plus a processing fee of $15 per ticket.

Application

SPE was pilot-tested in two work zones in Illinois—one on Interstate 64 in summer 2006 and the other on Interstate 55 in summer 2007. Both work zones were part of major reconstruction projects.

Under the supervision of faculty member Rahim Benekohal, a research team from the University of Illinois at Urbana–Champaign led by Madhav Chitturi collected three data sets in the two work zones. The team evaluated the effectiveness of SPE in reducing motorist speeds in work zones and compared the results with those of traditional enforcement approaches, such as police presence with and without patrol lights, speed display trailers, and a combination of police presence and a speed display trailer.

The spatiotemporal effects of SPE and traditional approaches also were measured. To evaluate the spatial effect, speeds were measured at a location 1.5 miles downstream. For temporal effect, speeds were measured immediately after enforcement was removed from the work zone for a period of 1 hour.

Benefits

SPE significantly reduced the speeds of cars and trucks by 3 to 8 mph in work zones (2). At the work zone location, SPE reduced the average speeds significantly below the speed limit of 55 mph in all but one scenario, as shown in Table 1 (page 30).

The percentage of free-flowing vehicles—with headways greater than 4 seconds—exceeding the speed limit at the treatment location was reduced drastically (Figure 2, this page). The percentage of speeding free-flowing cars decreased from 93, 40, and 30 percent to 45, 8, and 4 percent, respectively, for the three data sets. The percentage of speeding heavy vehicles dropped from 69, 17, and 6 percent to 15, 4, and 1 percent, respectively.

SPE reduced the speeds of vehicles 1.5 miles downstream of the van location by 2 to 5 mph, as shown in Table 1. SPE had a limited halo effect—that is, influence after the departure of the van—reducing the speeds of vehicles by 2 mph or less. Details of the results are available in the final report from this study (3).

Aggressive law enforcement, including the use of SPE vans, in conjunction with educational campaigns and improvements to work zone traffic control, have reduced work zone fatalities from a high of 44 in 2003 to 31 in 2009. Illinois DOT has expanded the SPE program to five SPE vans, one for each region in the state.

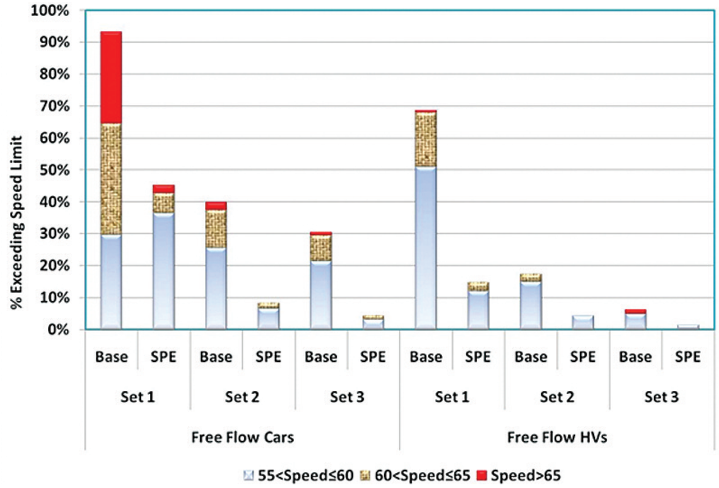


FIGURE 2 Percentage of free-flowing vehicles exceeding speed limit at the treatment location (HVs = heavy vehicles).

The success of SPE in Illinois led to similar initiatives in Maryland, Oregon, and Washington. The Research Advisory Committee of the American Association of State Highway and Transportation Officials recognized “Speed Photo Enforcement in Illinois Work Zones” as a high-value research project at the regional level.

Acknowledgments

The Illinois Center for Transportation, a joint partnership of Illinois DOT and the University of Illinois at Urbana–Champaign, supported and funded the evaluation of SPE.

For additional information, contact Priscilla Tobias, Bureau of Safety, Illinois Department of Transportation, 2300 South Dirksen Parkway, Springfield, IL 62764; telephone 217-782-3568; e-mail Priscilla.Tobias@illinois.gov.

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Editor’s Note: Appreciation is expressed to G. P. Jayaprakash, Transportation Research Board, for his efforts in developing this article.

Suggestions for “Research Pays Off” topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2952; gjayaprakash@nas.edu).

Phil Demosthenes

Consultant

Phil Demosthenes can recall the moment he began his career-long study of access management using planning and design to reduce roadway conflicts and preserve roadway function. In 1977, the director of the Colorado Department of Transportation (DOT) met with the City of Denver planning director to discuss economic impacts of downtown congestion—and returned with an assignment for Demosthenes to research strategies for arterial access control. Thirty-four years later, he affirms, "I still am creatively engaged in access management design and implementation."

Access management involves everything from traffic operations and road design to human factors and the legislative process. Its multidisciplinary nature brings together many subject areas and stakeholders, but Demosthenes—a self-described generalist—is dedicated to ensuring safe roadway operations. "My approach has been to integrate these subject areas, but also to keep it as simple as possible, practicable, user-friendly—and effective," he reflects.

"The application of access management techniques on a crash-prone corridor can achieve a 20 percent to 60 percent drop in crashes and injuries."

Just over half of all vehicle accidents are related to maneuvers on roadway access points; this percentage is higher in urban areas and can reach up to 70 percent, Demosthenes comments. Although human error is a major factor in crashes, roadway design can and should be altered to accommodate driver error, he observes: "The application of access management techniques on a crash-prone corridor can achieve a 20 percent to 60 percent drop in crashes and injuries. The behavior and demographics of the drivers have not changed—the roadway has changed."

A major focal point in access management is the spacing and frequency of traffic signals, which often are sites of traffic accidents. Demosthenes finds roundabouts to be a significant safety improvement compared with signaled intersections and cites a 1999 project in Golden, Colorado, that replaced four arterial intersections with roundabouts, with a decline of injurious crashes from 10 per year to one in 42 months. In 2007, he volunteered for TRB's Task Force on Roundabouts and currently chairs the National Cooperative Highway Research Program (NCHRP) Project Panel on Roundabout Corridors.

While pursuing what was to be an engineering career at the University of California, San Diego, Demosthenes felt himself drawn to such subjects as marine biology, plate tectonics, computer languages, and social anthropology. In 1970 he went to the California Institute of the Arts to study design for the real world under designer and educator Victor Papanek. As a graduate student, Demosthenes switched to environmental planning. At the time, the master plan for North Los Angeles County was in progress; he became involved in his local community association and later was appointed vice chair of the North Los Angeles Citizen Planning Council. "I particularly liked the transportation element of the plan and could see how crucial transportation design was becoming in urban growth areas," he recalls.

Demosthenes joined Colorado DOT as a planner in 1976. He helped develop and enact a new state statute for improved access control on state highways, guided a new access management program, and obtained a $10.5 million Federal Highway Administration grant for an access control demonstration project. His most rewarding endeavor, however, was the Colorado Access Code—a regulation managing access to the state's highway system that was adopted in 1981 and remains in effect.

From 1982 to 2004, Demosthenes was Administrator of the DOT's Access Management Program, overseeing its creation, implementation, and operation. Now an independent principal transportation planner, he advises clients on such matters as access management and roundabout planning, program and policy development, design criteria, and corridor planning. Among his current projects are an access management manual for the Department of Transport, Abu Dhabi, United Arab Emirates; the next-generation Kansas DOT Access Management Policy; and context-sensitive access management planning for SR-49 in Angels Camp, California.

Since 2002, Demosthenes has been a part-time instructor at the University of California, Berkeley. He has taught access management courses in Canada, Greece, Dubai, and China; in 2001, he delivered the keynote address at a national conference in Athens, Greece. In his presentations on access management, Demosthenes often opens with statistics on fatalities and injuries. "What drives me is public safety," he notes.

In an ideal world, Demosthenes muses, he would be an independent advocate for safer roads, with a focus on road design. But he adds that in road safety there are few independent organizations that can act as a critical voice. "There are great ideas out there, especially from longtime professionals, who cannot raise their voices because they are inside the industry and depend on that industry to employ them," he observes.

John M. Mason

Auburn University

Throughout his career, John M. Mason has brought his engineering expertise to bear in private practice and in academia—sometimes both at once. After graduating from the Pennsylvania State University (Penn State) in 1972, he simultaneously worked as a highway design engineer with STV, Inc., and completed a master's degree in transportation engineering at Villanova University. After obtaining his Professional Engineer license, Mason taught civil and construction technology at what is now Lehigh Carbon Community College in Allentown, Pennsylvania—while practicing civil and highway engineering at an Allentown firm. Mason enjoyed working with students and soon realized that an advanced degree also would allow him to pursue research-related activities. With encouragement from a faculty mentor, he enrolled in the Ph.D. program at Texas A&M University (TAMU) with the opportunity to participate in research at Texas Transportation Institute (TTI).

"It is essential for our research results to be introduced to our students, who will become the future transportation workforce. It also is essential that these results enhance the practice of current transportation professionals."

Mason began his university career in 1982 as assistant professor in TAMU's Civil and Environmental Engineering Department and as manager of TTI's Implementation and Design Program. The same year, he joined TRB's Geometric Design Committee, which he chaired from 1997 to 2001 and now serves as an emeritus member. Mason had attended his first TRB meeting as an undergraduate student and recalls his faculty supervisor referring to it as "the annual place to be if you want to understand where highway engineering practice is headed." Ever since his first TRB paper was published in 1983, Mason has been active on TRB technical committees and task forces, National Cooperative Highway Research Program (NCHRP) project panels, and second Strategic Highway Research Program expert task groups.

To gain practical management experience, Mason returned to transportation consulting with Post, Buckley, Schuh, & Jernigan, Inc., in 1986 as district transportation manager for western Florida. But although consulting provided many professional development opportunities, Mason was drawn back to academia. "I felt my professional calling was to return to teaching, learning, research, and technology transfer," he comments. "The development of the transportation workforce became a core focus of my academic career."

Recruited to Penn State as associate professor of civil engineering and director of the Transportation Operations Program at Larson Transportation Institute—then called the Pennsylvania Transportation Institute (PTI)—Mason actively engaged in academic programs, research projects, training initiatives, and professional societies. He was promoted to full professor and served in leadership roles such as research program director, center director, director of PTI, and director of the Middle Atlantic University Transportation Center, guiding collaboration with state transportation agencies and partner universities. In 1997, Mason was named Associate Dean for the College of Engineering.

In 2008, he took a position at Auburn University in Alabama as Vice President for Research, Associate Provost, and President of the Auburn Research and Technology Foundation. As the institution's chief research officer, Mason works with a variety of academic units to provide guidance in research development and technology transfer and to promote interdisciplinary research initiatives across the university. In addition, for the past 10 years Mason has continued to provide consulting services as a professor partner with Kittelson and Associates, Inc.; he recently was named to the firm's board of directors.

In his research, Mason has investigated highway issues that range from roadway geometric design to highway infrastructure elements to traffic engineering and safety. He also has devoted much effort to transportation workforce development, curriculum, and continuing education training activities. "I have attempted to integrate research efforts into the formal classroom curriculum and, subsequently, to extend the practical knowledge gained from these efforts to professional development programs," he notes. "It is essential for our research results to be introduced to our students, who will become the future transportation workforce. It also is essential that these results enhance the practice of current transportation professionals."

Along with his nearly 30 years on the Geometric Design Committee, Mason's other TRB activities include membership on the Tort Liability and Risk Management Committee, the NCHRP Project Panel on Synthesis of Information Related to Highway Problems, and the Highway Safety Performance Committee. He was the 2010 winner of the Wilbur S. Smith Distinguished Transportation Educator Award.

CALENDAR

TRB Meetings 2012

January

21 Data Analysis Working Group Forum on Pavement Performance Data Analysis
Washington, D.C.

22–26 TRB 91st Annual Meeting
Washington, D.C.
www.TRB.org/AnnualMeeting

February

7–9 2nd Biennial National Evacuation Conference
New Orleans, Louisiana

29 Emergency Medical Services Systems, Safety Strategies, and Solutions Summit
Washington, D.C.

April

16–18 9th National Conference on Asset Management
San Diego, California

17–19 Joint Rail Conference: Technology to Advance the Future of Rail Transport*
Philadelphia, Pennsylvania

22–24 Symposium on Mileage-Based User Fees and Transportation Finance Summit*
Philadelphia, Pennsylvania

30–May 2 Innovations in Travel Demand Forecasting
Tampa, Florida

30–May 3 International Conference on Winter Maintenance and Surface Transportation Weather
Coralville, Iowa

May

TBD Transportation Knowledge Workshop
Irvine, California

7 Relationship Between the Design and Construction of Rock Fall Mitigation Techniques
Redding, California

20–25 14th International Conference on Alkali–Aggregate Reactions
Austin, Texas

22–24 14th International HOV–HOT and Managed Lanes Conference
Oakland, California

23–25 International Society for Asphalt Pavements Symposium on Heavy Duty Pavements and Bridge Deck Pavements*
Nanjing, China

June

2–8 11th International and 2nd North American Symposium on Landslides*
Banff, Alberta, Canada

4–7 North American Travel Monitoring Exposition and Conference (NATMEC): Improving Traffic Data Collection, Analysis, and Use
Dallas, Texas

18–20 North American Transportation Statistics Interchange 2012
Washington, D.C.

19–22 Innovations in Traffic Flow Theory, Highway Capacity, and Quality of Service Symposium
Fort Lauderdale, Florida

20–22 7th RILEM International Conference on Cracking in Pavements
Delft, Netherlands

24–27 4th Urban Street Symposium*
Chicago, Illinois

24–28 Equipment Management Workshop*
Mobile, Alabama

26–28 Diagnosing the Marine Transportation System: Measuring Performance and Targeting Improvement*
Washington, D.C.

July

8–11 TRB Joint Summer Meeting
Irvine, California

8–12 6th International Conference on Bridge Maintenance, Safety, and Management*
Lake Como, Italy

11 Measuring the Transportation System from a Supply Chain Perspective
Irvine, California

14–19 13th AASHTO–TRB Maintenance Management Conference*
Seattle, Washington

17–19 10th National Conference on Asset Management*
Dallas, Texas

August

TBD Harbor Safety Committee and Area Maritime Security Committee Conference*
Pittsburgh, Pennsylvania

28–30 7th International Conference on Maintenance and Rehabilitation of Pavements and Technological Control*
Auckland, New Zealand

September

10–12 2nd International Conference on Transportation Geotechnics*
Sapporo, Hokkaido, Japan

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar). To reach the TRB staff contacts, telephone 202-334-2934, fax 202-334-2003, or e-mail TRBMeetings@nas.edu. Meetings listed without a TRB staff contact have direct links from the TRB calendar web page.

*TRB is cosponsor of the meeting.

NEWS BRIEFS

Photo: Maersk Line

Maersk container ship in shallow waters near a port; low-sulfur fuels and slower speeds can reduce near-shore pollution, a new study shows.

Low-Sulfur Ship Fuels Reduce Pollution

New clean-fuel regulations in California, along with voluntary slowdowns by shipping companies, have reduced air pollution from near-shore ships, according to a study from the National Oceanic and Atmospheric Administration (NOAA) and the California Air Resources Board (ARB). Researchers studied a container ship adhering to a voluntary state slowdown policy and to a 2009 California ARB regulation that ordered ships to switch to low-sulfur fuels when approaching the California coast. According to NOAA, emissions of pollutants such as sulfur dioxide and particulate matter dropped by more than 90 percent.

The commercial container ship, Maersk Line's *Margrethe Maersk,* was approximately 40 miles off California's coast when NOAA research aircraft flew over it in May 2010. Researchers on the aircraft used custom instruments to sniff the ship's emissions before the ship switched to low-sulfur fuels and slowed down voluntarily. Once the vessel had come within 24 miles of the coast—the distance cited in the 2009 rule—and as it cruised within the low-sulfur, regulated zone, scientists sampled additional emissions.

Results indicated that sulfur dioxide levels had plunged 91 percent, from 49 grams of emissions per kilogram of fuel to 4.3 grams. Particulate matter pollution decreased 90 percent, from 3.77 grams of emissions per kilogram of fuel to 0.39 grams, and the levels of black carbon—dark-colored particles that can contribute to global warming—also dropped by 41 percent.

The full paper, *Impact of Fuel Quality Regulation and Speed Reductions on Shipping Emissions: Implications for Climate and Air Quality*, can be found at the Environmental Science and Technology website, http://pubs.acs.org/journal/esthag.

Report Links Traffic Problems and Economy

Economic stagnation in the United States is providing temporary relief from a trend of worsening traffic congestion, according to the *2011 Urban Mobility Report* published by the Texas Transportation Institute (TTI) at Texas A&M University. The study suggests that not enough is being done to ensure long-term solutions to the congestion problem.

According to the report, the average commuter sat in 34 hours of traffic in the year 2010—at a cost of more than $700 per commuter per year and more than $100 billion total. Congestion also is growing in hours not traditionally associated with the rush hour—about 40 percent of traffic delays occur in midday and overnight hours.

TTI researchers estimate that when economic growth returns, the average commuter will experience more delay—an additional 3 hours per year by 2015 and 7 hours by 2020. By 2015, the cost of gridlock is estimated to increase to $133 billion and the amount of wasted fuel to 2.5 billion gallons per year.

The *2011 Urban Mobility Report* uses traffic volume data from states and traffic speed data from INRIX, a private-sector provider of travel time information. A copy of the full report is available at http://mobility.tamu.edu.

Search for Shipwreck Enters Second Phase

The Maryland Historical Trust, the U.S. Navy, and the Maryland State Highway Administration (SHA) have initiated a second season of surveying for a War of 1812 shipwreck in the Patuxent River in Maryland. Researchers are excavating, mapping, and filming the vessel thought to be the *USS Scorpion*, which was deliberately sunk to avoid its capture just before the Battle of Bladensburg.

Last year, archaeologists employed a magnetometer to relocate the 200-year-old submerged ship and then used a hydroprobe to pinpoint the wreck's location. This summer, the thick layer of sand atop the wreck was dredged to help determine the ship's dimensions and to locate its bow and stern. These measurements will help researchers place a cofferdam over the wreck in 2012 or 2013, enabling the area to be excavated as a dry site. The full excavation of the ship and the retrieval of personal belongings will reveal whether this artifact is the *USS Scorpion* or if it is one of Barney's gun barges. So far, found objects at the site include a pair of scissors, a stoneware bottle, a corncob, and a glass bottle.

Maryland SHA oversees the project with partial funding from the federal Transportation Enhancement Program. For more information and updates on the search for the *USS Scorpion*, visit www.scorpionarchaeology.blogspot.com.

TRB HIGHLIGHTS

Workshop Explores How Americans Travel

KATHERINE F. TURNBULL

Turnbull is Executive Associate Director, Texas Transportation Institute, the Texas A&M University System, College Station, Texas, and Chair, TRB Technical Activities Council.

For more than 40 years, the National Household Travel Survey (NHTS) of the Federal Highway Administration (FHWA) has helped answer the question, "How do Americans travel?" Originally known as the Nationwide Personal Transportation Survey, NHTS is the only data source that links individual trips made by household members to the demographics of the traveler, the socioeconomic characteristics of the household, and the type of vehicle used in each trip.

In June 2011, nearly 200 agency representatives, researchers, consultants, and other transportation professionals gathered at the National Academies' Keck Center in Washington, D.C., to discuss the use of NHTS data to answer key policy questions. The workshop, Using National Household Travel Survey Data for Transportation Decision Making, was supported by the FHWA's Office of Highway Policy Information and organized by TRB. Keynote speakers, more than 50 breakout session presentations, and an interactive poster session highlighted the survey's diverse applications.

Opening speakers set the stage for the workshop by recounting the 40-year history of NHTS and its use in national- and state-level decision making, as well as sharing information on official NHTS publications and online analysis tools. Also discussed were trends in conducting the NHTS and trends in travel behavior; speakers noted that more data points are needed to determine if recent findings, such as declines in vehicle miles of travel and average trip length, are trends or reflections of the economic downturn.

The workshop's breakout sessions illustrated the wide-ranging, innovative application of NHTS data. Consultants, agency personnel, researchers, and graduate students used the data to model state and metropolitan travel demand, examine travel patterns of different socioeconomic groups, and assess the use of hybrid vehicles and bicycle and walking trips. Other presentations demonstrated ways to combine NHTS data with other data sets to examine energy and fuel efficiency, as well as using new visualization tools to display the data—illustrating the value of NHTS data in diverse applications beyond formal federal, state, and metropolitan agency uses and adding richness and diversity to transportation research and policy development.

Also highlighted were methods to leverage NHTS data for decision making. Speakers noted the importance of turning data into information and then into knowledge, interpreting data to tell a story, and the need to answer policy makers' questions concisely, quickly, and accurately. Building ongoing support for NHTS—ensuring that data are properly referenced, noting the importance of the data set to diverse stakeholders, and leveraging the data for multiple purposes—were stressed.

Workshop proceedings will be released as a Transportation Research Circular on TRB's website. Many presentations are posted at http://onlinepubs.trb.org/onlinepubs/conferences/2011/NHTS1/program.pdf.

RESEARCH FOR SAFE ROADS—Monique R. Evans, Federal Highway Administration, evaluates necessary tools and skills for effective collaboration between university transportation centers (UTCs) and transportation agencies at TRB's UTC Spotlight Conference, Nov. 2 at the National Academies' Keck Center in Washington, D.C. The conference, Improving Roadway Safety Programs Through University–Agency Partnerships, brought together practitioners and researchers from across the country to review new safety tools and concepts and to explore and learn from successful university–agency collaborations.

The Worldwide Reach of Low-Volume Roads

G. P. JAYAPRAKASH

Low-volume roads make up the world's largest road network, connecting rural or underdeveloped areas with economic opportunity. In developing countries, low-volume roads serve as lifelines that provide access to education, medical facilities, and markets. But the network of low-volume roads faces challenges in planning, design, construction, operations, maintenance, the environment, and safety. As low-volume roads compete with higher-volume urban roads, inadequate funding presents significant challenges.

To tackle these challenges, in 1975 TRB initiated the Low-Volume Roads Conference series. In July 2011, TRB conducted the 10th International Conference on Low-Volume Roads in Orlando, Florida. Hosted by the Florida Transportation Technology Transfer Center at the University of Florida with the Florida Association of County Engineers and Road Superintendents, the International Union of Forest Research Organizations, and the University of Naples Federico II, Italy, the conference facilitated the exchange of information on the worldwide network of low-volume roads. Presenters and attendees from across the globe participated in the conference's four workshops, along with a delegation of 20 students from the Escuela Politecnica de Ejercito in Sangolquí, Ecuador.

Jayaprakash is Senior Program Officer and Soils, Geology, and Foundations Engineer in TRB's Technical Activities Division.

A student delegation from the Escuela Politecnica de Ejercito in Sangolquí, Ecuador, attended the 10th Low-Volume Roads Conference.

World Bank consultant Asif Faiz delivered a keynote address on rural roads' potential. Carl M. Ochoa and Tania A. Ochoa received the Yoder Award for their paper, "Guardrail Optimization for Rural Roads." Workshops included Low-Volume Roads and Earthquakes: The Experiences in Chile, Haiti, and New Zealand; Simple Low-Cost Soil Testing: How to Do It and How to Use the Results; Low-Volume Roads Best Practices and Gravel Management; and Road Safety

(continued on next page)

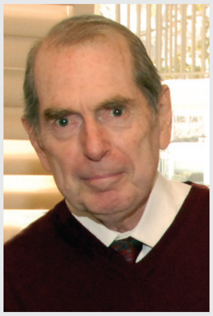
IN MEMORIAM

Peter G. Koltnow, 1929–2011

Past TRB Executive Committee Chair Peter G. Koltnow died November 28, 2011, in Sandy Spring, Maryland. He was 82.

Koltnow devoted his career to highway safety as a transportation consultant and as president of the Highway Users Federation—now the American Highway Users Alliance—from 1974 to 1985. He received a bachelor's degree from Antioch College and a master's degree from the University of California, Berkeley. Koltnow was the first traffic engineer in Fresno County, California; he later left his position at the Automobile Club of Southern California to move to the Washington area in 1967 with his family.

Actively involved with TRB since 1968, Koltnow served as Executive Committee Chair in 1979. Among the many other committees to which Koltnow contributed were the Social, Economic, and Environmental Factors of Transportation Committee; the Evaluation of Urban Transportation Alternatives Committee; the Intergovernmental Relations and Policy Processes Committee; the Task Force on Advanced Vehicle and Highway Technologies; and the Transportation History Committee, of which he was an emeritus member. He also cochaired the Study of Geometric Design Standards for



Highway Improvements Committee, which in 1987 produced Special Report 214, *Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation*. In retirement, Koltnow became a consultant to the American Trucking Associations. He also was a member of the American Public Works Association and the American Society of Civil Engineers (ASCE) and was a fellow of the Institute of Transportation Engineers.

Koltnow received TRB's W. N. Carey, Jr., Distinguished Service Award in 1982. Other honors included ASCE's James Laurie Prize in 1984 and the Road Gang's P. D. McLean Award in 2005. In 1971, he authored the book *Successful Cities*.

In his youth, he documented one of his many cross-country hitchhiking trips via postcards he sent to Dorothy Witter, whom he married in 1950—the postcards now are part of a collection at the National Museum of American History, "America on the Move."

"All in all, that year I hitched 10,000 miles. Sometimes the going was easy; I made the trip by thumb from New York to the Chicago area in the same time as a good passenger train," Koltnow wrote for the exhibit.

TRB HIGHLIGHTS

The Worldwide Reach of Low-Volume Roads
(continued from page 37)
Audits: Working Together to Make Your Roads Safer. Participants also could venture on field trips to the Hubbard Construction Company Asphalt Plant, the University of Central Florida's Stormwater Management Academy, a road safety audit site, and the Florida Department of Transportation's (DOT) State Materials Office in Gainesville.

Conference sponsors included the Federal Highway Administration, U.S. DOT; Forest Service, U.S. Department of Agriculture; Bureau of Indian Affairs, U.S. Department of the Interior (DOI); Fish and Wildlife Service, U.S. DOI; Engineer Research and Development Center, U.S. Army Corps of Engineers; and the U.S. Environmental Protection Agency. The 11th Annual Conference on Low-Volume Roads will convene in Pittsburgh, Pennsylvania, in 2015.

COOPERATIVE RESEARCH PROGRAMS NEWS

Understanding Aircraft Noise Annoyance and Sleep Disturbance

Historically, community exposure to aircraft noise has led to public opposition to airport development. Since Theodore J. Schultz's 1978 study about the correlation between transportation noise exposure levels and public annoyance, however, research on the effects of aircraft noise has lagged—as the nature of aircraft noise has changed with quieter aircraft but higher traffic volume. An aircraft noise exposure–annoyance response relationship based on currently available data may not represent conditions today; also, a widely accepted exposure–response relationship for sleep disturbance should be determined.

Establishing up-to-date exposure–response relationships for community annoyance and sleep disturbance requires a well-designed study and an extensive data acquisition campaign that covers a variety of airport types and geographic locations. Harris Miller Miller & Hanson Inc. has received a $599,993, 24-month contract [Airport Cooperative Research Program Project 02-35, FY 2011] to develop and validate a research protocol for a large-scale study of exposure–response relationships across the country and to propose alternative research methods for field studies to assess the relationship between aircraft noise and sleep disturbance.

For further information, contact Joseph D. Navarrete, TRB, 202-334-1649, jnavarrete@nas.edu.

Mobile Lidar in Transportation Applications

Allowing rapid and economical data collection in the roadway environment, mobile lidar—light detection and ranging—technology promises benefits to transportation agencies in such areas as project planning, project development, construction, operations, maintenance, safety, research, and asset management. At present, however, no standards or guidelines for the application of mobile lidar are available to state departments of transportation (DOTs). Until clear guidelines emerge, prospective users may be reluctant to embrace lidar and other advanced mobile road data collection technologies.

Research is needed to provide guidance to DOT program managers, project engineers, and other transportation professionals on the utility of mobile lidar technology in a range of business practices. Oregon State University has received a $249,902, 18-month grant [National Cooperative Highway Research Program (NCHRP) Project 15-44, FY 2011] to develop guidelines for the use of mobile lidar technology in transportation applications.

For further information, contact Edward T. Harrigan, TRB, 202-334-3232, eharriga@nas.edu.

PHOTO COPYRIGHT DAVID MONNIAUX

Leica HDS-3000 terrestrial lidar scanner.

Intellectual Property Management Guide for State Departments of Transportation

Many state DOTs are unfamiliar with the requirements governing intellectual property rights and the benefits of appropriately managing those rights. According to the Federal Highway Administration and American Association of State Highway and Transportation Officials, safeguarding intellectual property is critical to the entire research process—spurring innovation, encouraging investment in new technologies, and fostering national and international commercialization. Ambiguous policies and a failure to understand intellectual property rights can impede development and hamper incentives for innovation. Research is needed to develop practical guidance that state DOTs can use to manage intellectual property effectively.

Applied Research Associates has received a $350,000, 18-month grant (NCHRP Project 20-89, FY 2011) to develop a practical guide for state DOTs on the management of intellectual property. The guide will define the nature and types of intellectual property—copyrights, patents, trademarks, and trade secrets—and will provide practical assistance for determining strategies and business practices.

For further information, contact Crawford F. Jencks, TRB, 202-334-2379, cjencks@nas.edu.

Enabling and Promoting Use of Fixed-Route Transit by People with Disabilities

As part of the Americans with Disabilities Act of 1990 (ADA), complementary paratransit was created as a safety net for people whose disabilities prevented them from using fixed-route service. Since ADA's passage, public transit agencies have reported significant growth in paratransit ridership, despite improvements in the accessibility of many fixed-route transit facilities—resulting in dramatic cost increases. The American Public Transportation Association has requested research to identify factors preventing people with disabilities from using fixed-route services and to provide guidance for promoting the use of this route service by people with disabilities for some or all of their public transportation trips.

TranSystems Corporation has received a $300,000, 24-month grant [Transit Cooperative Research Program (TCRP) Project B-40, FY 2011] to prepare a practitioner's strategy guide for encouraging the use of fixed-route services by people with disabilities.

PHOTO: DALLAS AREA RAPID TRANSIT

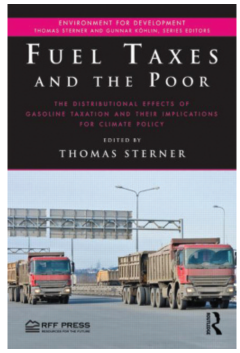
For more information, contact Dianne S. Schwager, TRB, 202-334-2969, dschwager@nas.edu.

Quantifying Transit's Impact on Greenhouse Gas Emissions and Energy Use

By facilitating fewer automobile trips and more nonmotorized trips, high-density, mixed-use development and greater transit use can contribute to reducing transportation-related greenhouse gas (GHG) emissions. Transit may support compact land use by reducing the need for parking and roadway vehicle capacity, enabling clustered development, encouraging bicycle and pedestrian travel, facilitating trip chaining, and reducing household automobile ownership. The characteristics and magnitude of the interaction between transit and land use and the resulting changes in transportation-related GHG emissions and energy use may occur in different ways; land use changes and public transportation investments also may occur interactively and reinforce each other.

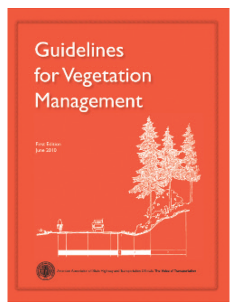
ICF International has received a $400,000, 24-month grant (TCRP Project H-46, FY 2011) to develop a methodology to quantify the transportation-related GHG emissions and energy use related to transit-driven land use changes and to identify, describe, and attempt to quantify the synergistic interaction between transit and land use and the effects on transportation-related GHG emissions and energy use.

For more information, contact Dianne S. Schwager, TRB, 202-334-2969, dschwager@nas.edu.



Fuel Taxes and the Poor
Edited by Thomas Sterner. Resources for the Future Press, 2011; 320 pp.; $99.95; 978-1-61726-0-926.

The reports collected in this book reexamine the conventional wisdom that gasoline taxation has a disproportionately detrimental effect on poor people. Increased fuel taxes can mitigate carbon emissions, reduce congestion, and improve local urban environments, but have been resisted as a form of regressive taxation. Presenting research from more than two dozen countries, *Fuel Taxes and the Poor* concludes that although fuel taxation can be regressive in some high-income countries, it generally is a progressive policy in low-income countries, if residents spend a small share of their income on fuel for transportation.



Guidelines for Vegetation Management, 1st Edition
American Association of State Highway and Transportation Officials (AASHTO), 2011; 164 pp.; AASHTO members, $80; nonmembers, $96; 1-56051-500-5.

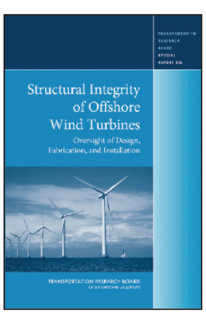
Roadside vegetation managers throughout the United States must deal with dwindling resources, increasing environmental and legal constraints, and growing public pressure to provide safe and aesthetically pleasing roadsides. Drawing on the long-term experience and expertise of vegetation managers, these guidelines provide the fundamentals for establishing a program for managing roadside vegetation. Supplemental appendices online include a survey of 30 state departments of transportation, a detailed list of 40 common invasive weeds and how to treat them, and a list of technical terms with definitions.

Practitioner's Handbook 12: Assessing Indirect Effects and Cumulative Impacts Under NEPA
AASHTO, 2011; 28 pp.; AASHTO members, $20; nonmembers, $24; 1-56051-446-6.

This handbook helps practitioners assess the indirect effects and cumulative impacts of transportation projects in terms of the National Environmental Policy Act (NEPA). Topics include definitions of direct effects, indirect effects, and cumulative impacts; deciding the appropriate scope and level of detail; gathering information for, executing, and documenting an analysis; identifying mitigation opportunities; and using the transportation planning process to support NEPA-level impact studies.

The books in this section are not TRB publications. To order, contact the publisher listed.

TRB PUBLICATIONS



Structural Integrity of Offshore Wind Turbines: Oversight of Design, Fabrication, and Installation
Special Report 305

This report examines the oversight by the U.S. Department of the Interior's Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) of the development and operation of offshore wind turbines and recommends goals and objectives for structural integrity, environmental performance, and energy generation of wind farms. Because these wind farms usually are unmanned and contain few hazardous substances, the risks they pose to human life and the environment are much lower than for industries such as offshore oil and gas, offshore wind farms therefore would not require a significant amount of regulatory oversight. The domestic industry can apply and adapt the standards, guidelines, and practices developed in Europe—where offshore wind energy is more developed—but will have to address factors such as wave and wind loadings caused by hurricanes. Also included in the report are findings on the role of third-party evaluators in reviewing standards and project-specific proposals.

2011; 164 pp.; TRB affiliates, $28.50; nonaffiliates, $38. Subscriber categories: energy; bridges and other structures.

TRB PUBLICATIONS *(continued)*

Naval Engineering in the 21st Century: The Science and Technology Foundation for Future Naval Fleets
Special Report 306

This report examines the state of basic and applied research in the scientific fields that support naval engineering and investigates whether the activities of the Office of Naval Research, under its National Naval Responsibility for Naval Engineering (NNR-NE) initiative, have effectively sustained these fields. The committee proposes a series of conclusions on and recommendations for the state of science and technology supporting naval engineering, the NNR-NE research portfolio, opportunities for the enhancement of research and education, and the initiative's value and effectiveness.

2011; 241 pp.; TRB affiliates, $30.75; nonaffiliates, $41. Subscriber categories: marine transportation; research; administration and management.

Economics, Demand Management, and Parking Policy
Transportation Research Record 2187

Topics explored in this volume include tax increment financing, flexible-term highway concessions, a vehicle mileage–based user fee, equitable congestion pricing, drivers' opinions of congestion pricing, economic incentives to influence route choices, dynamic ridesharing markets, and carsharing parking policy.

2010; 156 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: highways; pedestrians and bicyclists; public transportation; finance; economics; policy; society; planning and forecasting.

Traffic Flow Theory and Characteristics 2010
Transportation Research Record 2188

Presented in this volume are findings on the effects of freeway merging and diverging on traffic oscillations, a multiclass kinematic wave model, a multistate model of travel time reliability, merging behavior at freeway on-ramps, modeling vehicular merging behavior, the effect of light from vehicle windows on traffic flow, traffic density estimation along signalized arterials, and other topics.

2010; 186 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories: highways; operations and traffic management; planning and forecasting.

Intelligent Transportation Systems and Vehicle–Highway Automation 2010
Transportation Research Record 2189

The papers in this volume address such subjects as real-time parking information, in-vehicle and infrastructure-based collision warnings to nonviolating drivers, a rural variable speed limit system, microscopic traffic simulation of vehicle-to-vehicle hazard alerts, a collision-avoidance system for arterial red light running, and advanced driving alert systems.

2010; 115 pp.; TRB affiliates, $44.25; nonaffiliates, $59. Subscriber categories: highways; operations and traffic management; safety and human factors; vehicles and equipment.

Bicycles 2010
Transportation Research Record 2190

The influence of the built environment on route selection for bicycle and car travel, the effects of gender on commuter cycling and accident rates, the effect of on-street bicycle facility configurations on bicyclist and motorist behavior, and the effect of parking lane width on bicycle operating space are subjects of papers in this volume.

2010; 50 pp.; TRB affiliates, $32.25; nonaffiliates, $43. Subscriber categories: pedestrians and bicyclists; safety and human factors; planning and forecasting; design; operations and traffic management.

Energy and Global Climate Change 2010
Transportation Research Record 2191

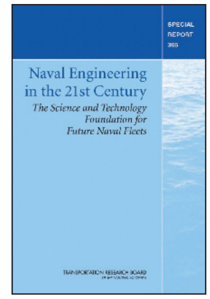
Authors present research on miles-per-gallon illusions and corporate average fuel economy distortions, the impact of electric vehicle charging on electricity costs, the cost hurdles of the plug-in hybrid battery, compressed air vehicles, cash-for-clunker programs, climate change and urban transportation in Latin America, a macroscopic model of greenhouse gas emissions, and more.

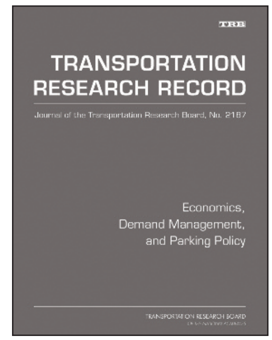
2010; 181 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories: highways; public transportation; pedestrians and bicyclists; energy; environment; planning and forecasting; policy; transportation, general.

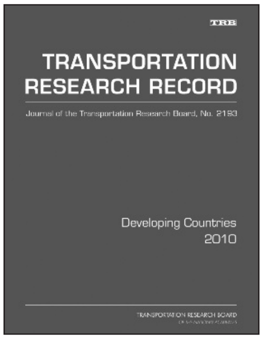
Traffic Signal Systems 2010
Transportation Research Record 2192

Wireless magnetometer vehicle detectors at signalized intersections, arterial signal coordination, crosswalk detection in loop detectors at signalized intersections, railroad-preempted intersections, robust signal timing for arterials, and adaptive signal control are among the topics covered in this volume.

2010; 193 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories: highways; railroads; public transportation; operations and traffic management; safety and human factors; environment.







TRB PUBLICATIONS *(continued)*

Developing Countries 2010
Transportation Research Record 2193

Research is presented on bus rapid transit systems, pedestrian safety, spatial and social characteristics of urban transportation, a motorization case study, linking travel behavior and location, a safety analysis of urban arterials under mixed-traffic patterns, short-term traffic forecasting, carbon dioxide emissions from passenger travel, and more.

2010; 139 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: highways; public transportation; pedestrians and bicyclists; safety and human factors; freight transportation; operations and traffic management; environment.

Vehicle Safety: Truck, Bus, and Motorcycle
Transportation Research Record 2194

Hours of service and truck crash risk, freeway truck lane restriction and differential speed limits, the condition of trucks and their crash involvement, noise levels, and air quality and whole-body vibration inside heavy-duty diesel truck cabs are among the subjects covered in this volume.

2010; 114 pp.; TRB affiliates, $44.25; nonaffiliates, $59. Subscriber categories: motor carriers; highways; safety and human factors; design.

Highway Design 2010
Transportation Research Record 2195

The papers in this volume explore topics that include risk-based design, truck acceleration speeds at weigh stations, rural expressway intersection design, the effects of freeway design elements on safety, stone masonry guardwalls, roadway departure and impact conditions, an anchor design for high-tension cable guardrails, improved wayshowing for American byways, and the hydraulic conductivity of permeable pavements.

2010; 187 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories: highways; design; environment; hydraulics and hydrology; operations and traffic management; safety and human factors.

The TRR Journal Online website provides electronic access to the full text of more than 11,000 peer-reviewed papers that have been published as part of the Transportation Research Record: Journal of the Transportation Research Board *(TRR Journal) series since 1996. The site includes the latest in search technologies and is updated as new TRR Journal papers become available. To explore the TRR Online service, visit www.TRB.org/TRROnline.*

Network Modeling 2010, Vol. 1
Transportation Research Record 2196

Research in this volume explores such subjects as evacuation network modeling, optimal refueling station location and supply planning for hurricane evacuation, an algorithm for determining the most reliable travel time path, generating origin–destination matrices from mobile phone trajectories, identifying competing and feeder links and routes on a toll road, and route change decision making by hurricane evacuees facing congestion.

2010; 184 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories: highways; public transportation; pedestrians and bicyclists; planning and forecasting; passenger transportation; freight transportation; security and emergencies; data and information technology.

Network Modeling 2010, Vol. 2
Transportation Research Record 2197

Examined in this volume are departure time slots allocated to optimize dynamic network capacity; optimal all-stop, short-turn, and express transit services under heterogeneous demand; a column generation method for U.S. Army logistics air fleet scheduling; new modifications to bus network design; a policy-making tool for transit priority optimization in an urban network; bilevel highway route optimization; and other topics.

2010; 128 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: highways; public transportation; pedestrians and bicyclists; planning and forecasting; passenger transportation; freight transportation; security and emergencies; data and information technology.

Pedestrians 2010
Transportation Research Record 2198

The papers in this volume examine subjects including high-visibility school crosswalks, the safety effectiveness of leading pedestrian intervals, driver and pedestrian behavior at uncontrolled crosswalks, pedestrian traffic flow in confined passageways, a real-time system for the tracking and classification of pedestrians and bicycles, multimodal driveway design, pedestrian safety retraining for young students, and modeling the evacuation of crowded pedestrian facilities.

2010; 160 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: safety and human performance; planning and forecasting; education and training; design, operations, and traffic management.

TRB PUBLICATIONS *(continued)*

Research and Education 2010
Transportation Research Record 2199

Authors present research on students' understanding of sight distance in geometric design, learning styles in an engineering laboratory, the design of transportation curriculum materials with examples, a traffic control game for teaching high school students, outsourcing decision making in a department of transportation, and performance measures for road infrastructure research programs.

2010; 53 pp.; TRB affiliates, $37.50; nonaffiliates, $50. Subscriber categories: highways; public transportation; pedestrians and bicyclists; research; transportation, general; education and training; administration and management; society.

Bridge Engineering 2010, Vol. 1
Transportation Research Record 2200

Research is presented on accelerated bridge construction, steel bridges, bridge rating and testing, concrete bridges, and timber bridges.

2010; 168 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories: bridges and other structures; geotechnology.

Bridge Engineering 2010, Vol. 2
Transportation Research Record 2201

The 18 papers in this volume investigate bridge scour, nondestructive evaluation of bridges, bridge culverts and soil stabilization and analysis, bridge engineering case studies, and bridge structural health monitoring.

2010; 161 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: bridges and other structures; geotechnology.

Bridge Engineering 2010, Vol. 3
Transportation Research Record 2202

Examined in this volume are bridge foundations; concrete bridge decks; the assessment and evaluation of bridge extreme events such as explosions, wave loading, and earthquakes; bridge management; and bridge seismic analysis.

2010; 211 pp.; TRB affiliates, $56.25; nonaffiliates, $75. Subscriber categories: bridges and other structures; geotechnology.

Low-Volume Roads 2011, Vol. 1
Transportation Research Record 2203

Topics examined in this volume's 27 papers include environmentally sensitive road maintenance practices, reducing sediment production during wet-weather hauling, guardrail optimization, a case study of the Qinghai–Tibet Highway in China, financing low-volume road improvement, and storm damage risk reduction.

2011; 225 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories; design; environment.

Low-Volume Roads 2011, Vol. 2
Transportation Research Record 2204

Constructing high-quality chip seals, an analysis of gravel road corrugation factors, combined lime–cement stabilization for longer road life, a case study on turning a road surface from asphalt paving maintainable gravel, and repair of storm-damaged slopes in California are among the subjects covered in this volume.

2011; 266 pp.; TRB affiliates, $55.50; nonaffiliates, $74. Subscriber categories: geotechnology; maintenance and preservation; pavements.

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities
NCHRP Report 674

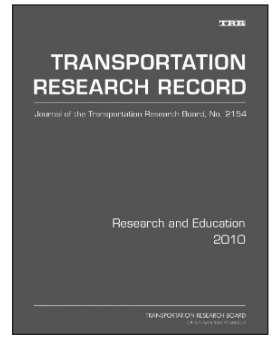
This report examines safe crossings at roundabouts and channelized turn lanes for pedestrians who have vision disabilities. Guidance is offered on the causes of crossing problems for visually impaired pedestrians and on treatment solutions for specific crossing challenges. Also featured are pedestrian– vehicle studies to identify performance problems and appropriate treatments, ways to quantify pedestrian accessibility at a particular crossing, and a discussion of implications for treatment selection and facility design.

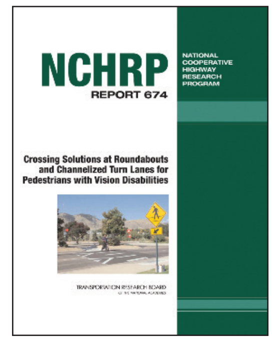
2011; 140 pp.; TRB affiliates, $45; nonaffiliates, $60. Subscriber categories: highways; pedestrians and bicyclists; design; operations and traffic management; safety and human factors; and society.

Design of Fiber-Reinforced Polymer Systems (FRP) for Strengthening Concrete Girders in Shear
NCHRP Report 678

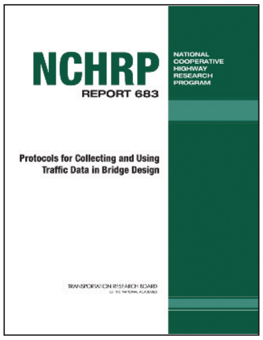
Technical and economic benefits have led some state highway agencies to adopt externally bonded fiber-reinforced polymer (FRP) systems for the repair and strengthening of reinforced and prestressed concrete bridge structures. This report suggests design guidelines for concrete girders strengthened in shear with externally bonded FRP systems, addresses their strengthening schemes and application, and examines their contribution to the shear capacity of reinforced and prestressed concrete girders.

2011; 120 pp.; TRB affiliates, $42.75; nonaffiliates, $57. Subscriber category: bridges and other structures.





TRB PUBLICATIONS *(continued)*



Protocols for Collecting and Using Traffic Data in Bridge Design
NCHRP Report 683

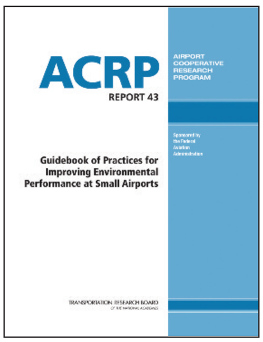
This report explores a set of protocols and methodologies for using available recent truck traffic data to develop and calibrate vehicular loads for superstructure, fatigue, deck, and overload permit design.

2011; 116 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber categories: highways; bridges and other structures.

Enhancing Internal Trip Capture Estimation for Mixed-Use Developments
NCHRP Report 684

An improved methodology is presented for estimating the number of internal trips generated in mixed-use developments. Available as a spreadsheet model online, the methodology estimates peak morning and afternoon trips to and from six specific areas within a development: office, retail, restaurant, residential, cinema, and hotel.

2011; 154 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber categories: highways; planning and forecasting.



Guidebook of Practices for Improving Environmental Performance at Small Airports
ACRP Report 43

This report outlines federal environmental regulations and requirements, identifies activities in which airport operators can promote environmental stewardship, and presents five case studies of environmental initiatives undertaken at airports. Also included is a searchable spreadsheet on CD-ROM.

2011; 356 pp.; TRB affiliates, $69.75; nonaffiliates, $93. Subscriber category: aviation.

Optimizing the Use of Aircraft Deicing and Anti-Icing Fluids
ACRP Report 45

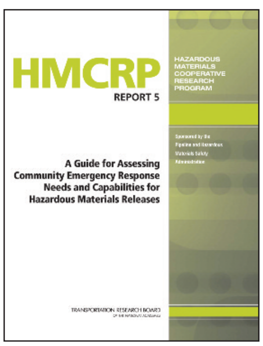
Guidance is presented on procedures and technologies to help reduce the use of aircraft deicing and anti-icing fluids (ADAF) while maintaining safe aircraft operations across the range of winter weather conditions in the United States and Canada. Also presented are best management practices, as well as findings and recommendations for evaluating holdover time determination systems, spot deicing for aircraft frost removal, and ADAF dilutions.

2011; 157 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber categories: aviation; maintenance and preservation; environment; operations and traffic management.

Handbook for Analyzing the Costs and Benefits of Alternative Aviation Turbine Engine Fuels at Airports
ACRP Report 46

This report consists of the Alternative Fuel Investigation Tool (AFIT), an analytical model for airport operators and fuel suppliers to assist in evaluating the costs and benefits of introducing drop-in alternative turbine engine fuel at airports. AFIT, included as a CD-ROM, takes into account options for using alternative fuel for other airside equipment—including diesel-powered ground support equipment.

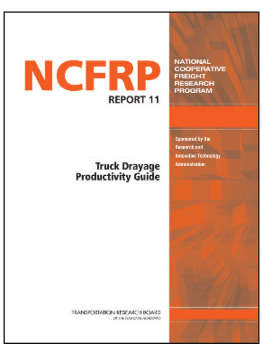
2011; 67 pp.; TRB affiliates, $44.25; nonaffiliates, $59. Subscriber categories: energy; environment; aviation.



Guide for Assessing Community Emergency Response Needs and Capabilities for Hazardous Materials Releases
HMCRP Report 5

This step-by-step guide assists in assessing hazardous materials emergency response needs at the state, regional, and local levels. Also addressed is the matching of state, regional, and local capabilities with potential emergencies involving different types of hazardous materials. The guide also assesses the issue of how quickly resources can be expected in an emergency.

2011; 108 pp.; TRB affiliates, $50.25; nonaffiliates, $67. Subscriber categories: administration and management; education and training; environment; highways; marine transportation; motor carriers; planning and forecasting; public transportation; railroads; security and emergencies.



Truck Drayage Productivity Guide
NCFRP Report 11

With suggestions to address inefficiencies, control costs, and reduce associated environmental impacts of truck drayage, this report offers guidance on improving drayage productivity and capacity while reducing emissions, costs, and port-area congestion at deepwater ports. A CD-ROM is included.

2011; 97 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: environment; marine transportation; motor carriers.

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FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 words (12 double-spaced, typed pages). Authors also should provide charts or tables and high-quality photographic images with corresponding captions (see Submission Requirements). Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may improve a reader's understanding of the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographs or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information appears. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

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◆ All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word, on a CD or as an e-mail attachment.

◆ Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi. A caption should be supplied for each graphic element.

◆ Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

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