JULY–AUGUST 2003
NUMBER 227

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TR NEWS

Changes in the Air

- Clean Air Act Cleaning Up
- Conforming To Stricter Standards
- Targeting Air Toxics Locally
- Multimodal Approach To Curb Urban Emissions
- Preparing for Potential Impacts of Climate Change

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Transportation and Air Quality

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Cover: Air quality regulations have reduced emissions from transportation sources, but new standards are in place and new strategies are emerging to extend the successes—and to cope with other environmental changes.

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 (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 $55.00; single issue $9.50. Overseas: 1 year $75.00; single issue $13.50. 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.

Printed in the United States of America.

ALSO IN THIS ISSUE

COMING NEXT ISSUE

Highway infrastructure preservation—cost-effectively extending the service life of highway pavements and structures—is the subject of a series of feature articles in the September–October issue, covering the current state of the practice, the federal role, activities in Canada, training needs, and a case study of bridge preservation, plus special insights on techniques such as chip sealing and spray-applied rejuvenators, research needs and developments, site performance reports, and more.

INTRODUCTION

Changes IN THE Air

Meeting Stricter Emissions Standards, Preparing for Climate Effects

This issue of *TR News* focuses on transportation-related air quality concerns. In the 13 years since the enactment of the Clean Air Act Amendments of 1990 (CAAA), planning for transportation and air quality has evolved toward an integrated process. A major accomplishment has been increasing the awareness of elected officials and the public about the connections between healthful air and transportation. We have learned much about the strengths and the limitations of policies on air quality and transportation and must work to improve the planning processes in both sectors.

As we move forward in the second decade of CAAA implementation, issues are emerging that require research, leading to new strategies to reduce transportation-related emissions and to policies that work at the federal, state, and regional levels. Air toxics and global warming are major issues for the federal government, and both involve specific controls on emissions from transportation sources. Although research is a priority, especially to support these emerging areas, developing cost-effective strategies to reduce transportation-related emissions is another priority.

The articles in this magazine highlight initiatives associated with air toxics and global climate change; one feature provides practical information for state and regional implementation of the new National Ambient Air Quality Standards (NAAQS). Also presented is a call to focus on some of the least controlled transportation sources, including marine vessels, heavy-duty engines, and off-road equipment.

Finally, the challenge of implementing the new, tighter NAAQS for ozone and fine particulate matter is at hand. We must learn from the past decade and proceed aggressively and effectively to implement these new, health-based standards. Our children and future generations are counting on us to meet the standards and to develop sustainable, lasting ways to maintain healthful air.

Sarah J. Siwek and Associates
Los Angeles, California
Chair, TRB Committee on
Transportation and Air Quality

EDITOR'S NOTE: Appreciation is expressed to Stephen F. Maher, Engineer of Design, TRB, for his efforts in developing this issue of *TR News*.

Clean Air Act Success Story

Continuing Reductions in Transportation Emissions

GARY JENSEN

The author is Environmental Protection Specialist, Federal Highway Administration, Washington, D.C.

The Clean Air Act (CAA) has controlled pollutant emissions from all sources, yet its greatest success has been in controlling emissions from on-road mobile sources. For example, as of 2001, on-road motor vehicles accounted for 68 to 69 percent of the total reductions in emissions of nitrogen oxides (NOx) and volatile organic compounds (VOC) since 1980 (*1*). Moreover, the reduction in on-road motor vehicle emissions of carbon monoxide exceeded total emission reductions, because total emissions from other sources increased.

The automotive, fuels, highway, and transit communities have achieved this success in cleaning up the nation's air with the help of strict emissions standards and fuel requirements set by the U.S. Environmental Protection Agency (EPA). At the same time, increased demands for improved mobility and safety were being met.

CAA and Air Quality

Air pollution causes a variety of health and environmental problems, including respiratory illnesses and other diseases, crop damage, decreased visibility, and structural deterioration. Although air quality legislation was enacted during the 1950s and 1960s, the 1970 CAA addressed air pollution seriously on a national scale for the first time.

Significantly amended in 1977, and again in 1990, the CAA provides the principal framework for federal, state, and local efforts to protect air quality from all pollution sources, including

- Stationary, or point, sources, such as factories and power plants;
- Smaller area sources, such as dry cleaners and painting operations;
- On-road mobile sources, such as cars, buses, and trucks;
- Nonroad mobile sources, such as construction equipment, airplanes, boats, and trains; and
- Naturally occurring sources, such as wind-blown dust and volcanic eruptions.

The CAA established federal controls and standards to reduce emissions. States must develop and enforce state implementation plans (SIPs) to clean up polluted areas and to protect and maintain air quality. Motor vehicle controls are only one part of the strategy but play a significant role.

EPA has established increasingly strict national standards for cleaner—that is, less polluting—motor vehicles and fuels. In addition, state and local transportation officials in areas that do not meet CAA goals must find ways to reduce vehicle emissions, by reducing the number of single-occupant vehicles and by making alternative modes such as transit and bicycles an increasingly important part of the transportation network.

Air Quality Standards

The National Ambient Air Quality Standards (NAAQS) are established through extensive scientific review, setting allowable concentrations and exposure limits for certain pollutants. These federal standards are intended to protect public health and welfare.

EPA has published criteria documents for six pollutants: ozone (or smog), carbon monoxide, particulate matter, nitrogen dioxide, lead, and sulfur dioxide. On-road mobile sources contribute primarily to four of these so-called criteria pollutants: ozone, carbon monoxide, particulate matter, and nitrogen dioxide.

In 1997, EPA updated the air quality standards for ozone (the "8-hour standard," which measures average concentrations over an 8-hour period) and for fine particulate matter (the "$PM_{2.5}$ standard," for particles 2.5 micrometers in diameter or smaller). However, these standards were challenged in court, blocking implementation until recently. The U.S. Supreme Court has upheld the standards, and a lower court has dismissed additional challenges.

EPA is developing a plan to implement these standards and plans to designate nonattainment areas for the 8-hour ozone standard in April 2004 and for the $PM_{2.5}$ standard in December 2004. The nonattainment areas would have to develop SIPs to meet the standards within 3 years.

The updated standards could place many more areas in nonattainment. Identifying strategies and measures to meet the standards may become more difficult. Moreover, the contribution of transportation sources to $PM_{2.5}$ emissions is unclear, and further research will be necessary to determine transportation strategies to reduce $PM_{2.5}$ emissions.

Cleaning the Air

The nation has had great success with the CAA. Over the last 20 years, national levels of all criteria pollutants have decreased. One-hour ozone levels have dropped 18 percent, and this trend is reflected in every region of the country. Carbon monoxide is at the lowest recorded levels in the last 20 years—almost 62 percent lower than in 1982. Between 1992 and 2001, the national average concentrations of PM_{10} (particulate matter 10 micrometers in diameter or smaller) decreased 14 percent (Table 1).

TABLE 1 Decrease in Concentration of Criteria Pollutants (Percent)

Pollutant	1982–2001	1992–2001
Carbon Monoxide	62	38
Lead	94	25
Nitrogen Dioxide	24	11
Ozone (1-hour)	18	3
Particulate Matter (PM_{10})	n/a	14
Sulfur Dioxide	52	35

Nonattainment Areas

To determine which areas have air pollution problems, monitoring networks measure the concentration of the pollutants in the air. If monitored levels of any pollutant violate the NAAQS, EPA—in cooperation with the state—designates the contributing area as nonattainment. Once the area has met the standards and again has healthful air, as well as a plan to maintain the standards, EPA may redesignate that area as attainment; these areas also are known as maintenance areas. Since 1992, the number of nonattainment areas has decreased 46 percent (Table 2).

TABLE 2 Number of Areas Designated Nonattainment

Pollutant	1992	2003
Carbon Monoxide	78	13
Lead	13	3
Nitrogen Dioxide	1	0
Ozone	134	73
Particulate Matter (PM_{10})	84	66
Sulfur Dioxide	53	24
All Pollutants	363	195

But the number of nonattainment areas does not tell the whole story. Many areas are designated nonattainment for procedural reasons, although monitoring data show that air quality meets the standards. For example, the most recently available data for 1999 to 2001 showed that among areas previously designated nonattainment,

- Only 31 violated the 1-hour ozone standard,
- Only 1 violated the carbon monoxide standard, and
- Only 13 violated the PM_{10} standard.

An area may be designated nonattainment even if it is not violating the standards. For example, an area may need additional time to resolve technical issues associated with demonstrating that the standards will be maintained. Moreover, coordination issues often arise among transportation and air agencies and the public over which projects should receive funding priority or how future emissions should be allocated among stationary, area, and mobile sources. State and local legislative actions may be required, to demonstrate that control measures have adequate commitments and are enforceable.

ISTEA and TEA-21

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) revamped the federal highway and transit programs to give state and local officials additional tools for improving air quality, including flexible funding increases, a strengthened planning process, and programs directed to air quality improvement and transit. ISTEA gave state and local officials flexibility in choosing among highway, transit, and other transportation alternatives, allowing for the best mix of projects to address air quality.

ISTEA also required states and metropolitan planning organizations (MPOs) to carry out a comprehensive transportation planning process to coordinate the best mix of transportation projects to improve air quality. ISTEA created the Congestion Mitigation and Air Quality Improvement Program to address transportation-related emissions and to direct funds to projects and programs that reduce emissions in nonattainment and maintenance areas.

In 1998, the Transportation Equity Act for the 21st Century (TEA-21) continued the provisions of ISTEA, and significantly increased funding levels for transportation programs and projects that reduce motor vehicle emissions.

Planning and Conforming

ISTEA required states and MPOs to carry out a comprehensive process to develop transportation plans that could improve air quality. Provisions in the 1990 amendments to the CAA matched the ISTEA requirements, limiting federal transportation activities in nonattainment and maintenance areas under certain circumstances.

Known as "transportation conformity," this CAA provision is intended to integrate the transportation and air quality planning processes and to ensure that federal funding and approval goes to transportation activities that are consistent with air quality goals.

A conformity determination demonstrates that the total emissions projected for a planned transportation system are within the emissions limits (or "budgets") established under the SIP, and that transportation control measures (TCMs) are implemented in a timely fashion. In 2002, a very high percentage (96 to 100 percent) of nonattainment and maintenance areas had developed transportation plans that met emissions reduction goals (Figure 1).

Population and Travel Growth

Improvements in air quality have been achieved even with dramatic increases in population and in personal and freight travel. From 1980 to 2001,

- ◆ The population increased 26 percent (*2*);
- ◆ The number of people employed increased 33 percent (*2*);
- ◆ The gross domestic product, adjusted for inflation, increased 88 percent (*3*);
- ◆ The number of drivers increased 32 percent (*4*);
- ◆ The number of motor vehicles increased 48 percent (*4*);
- ◆ Total vehicle miles traveled (VMT) increased 82 percent (*4*); and

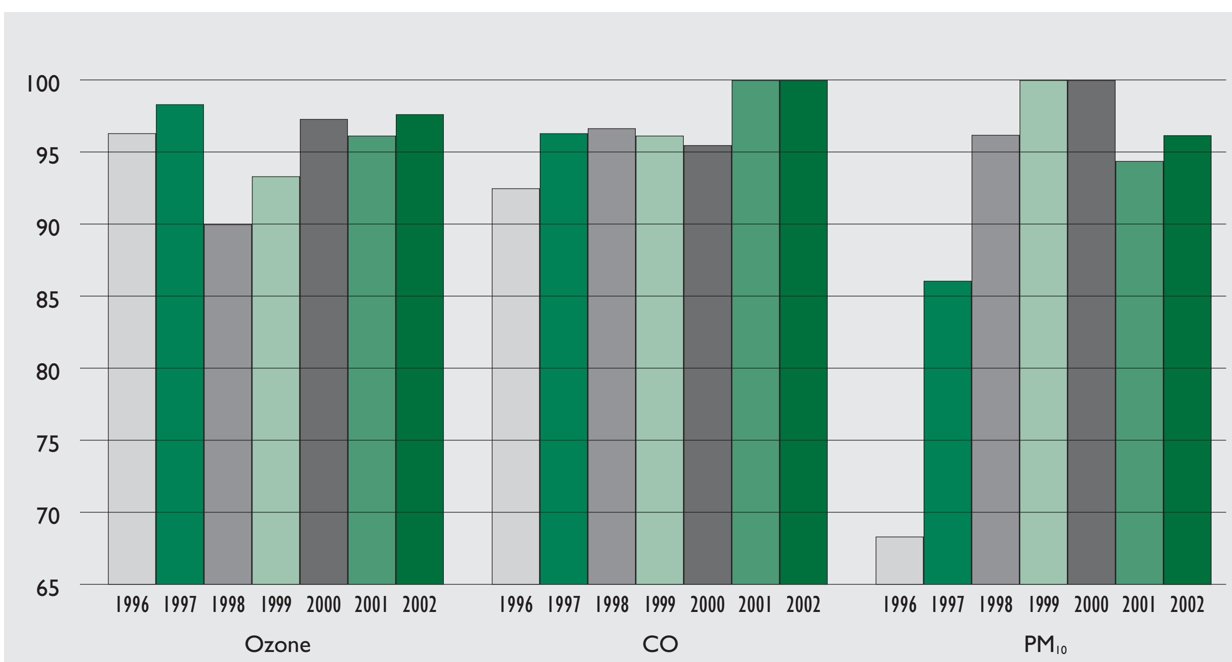


FIGURE 1 Percentage of areas meeting on-road mobile source emissions goals, 1996–2002. (Data for 1999 are incomplete; only 40 states provided information.)

MOBILE6 on the Move

In January 2002, the U.S. Environmental Protection Agency (EPA) released the new-generation emissions factor model, MOBILE6. Transportation agencies have two years to begin using MOBILE6 for transportation conformity purposes.

A data-dependent model, MOBILE6 offers many improvements to earlier versions, including more accurate assistance in estimating emissions from mobile sources. Work is under way to understand the sensitivity of local inputs to MOBILE6, and EPA and the Federal Highway Administration (FHWA) have posted information on MOBILE6 inputs and sensitivities at www.epa.gov/otaq/m6.htm.

In addition, FHWA is completing a scanning project to identify good examples of managing the transition to MOBILE6 for transportation conformity. The scan reports are available on the FHWA website, www.fhwa.dot.gov.

Finally, many areas are updating their state implementation plans with MOBILE6 before conformity, to ensure that planning assumptions, including vehicle data, are consistent between the air quality plans and the transportation plans. This is key to developing new motor vehicle emissions budgets, which transportation agencies must maintain—or risk interruption of federal transportation funds.

Fleet average and light- and heavy-duty vehicle emissions data from tunnel studies (*above*, Tuscarora Mountain Tunnel, Pennsylvania Turnpike) were used to determine and validate MOBILE 6 model performance.

◆ Heavy-duty truck travel increased 91 percent (*4*).

At the same time, however,

◆ On-road carbon monoxide emissions decreased 48 percent,
◆ On-road NOx emissions decreased 28 percent,
◆ On-road VOC emissions decreased 65 percent, and
◆ On-road PM_{10} emissions decreased 50 percent.

Transportation planners have faced additional challenges. For example, even with total VMT increases of 82 percent, construction of new and expanded lanes on the nation's highway system only increased total lane miles by 4 percent from 1980 to 2001 (*4*).

Not surprisingly, congestion has increased steadily during the last two decades in urban areas of every size. Severe congestion lasts longer and affects more of the transportation network. Averages in 75 areas studied by the Texas Transportation Institute (*5*) show that

◆ The time penalty for peak-period travelers jumped from 16 hours per year in 1982 to 62 hours in 2000,
◆ The periods of congestion increased from a total of 4.5 hours daily in 1982 to 7 hours in 2000, and
◆ The number of roadways with congested travel grew from 34 percent in 1982 to 58 percent in 2000.

Other challenges include the goals of decreasing travel by single-occupant vehicles and encouraging travel by other modes, as well as decreasing the number of trips. Although 76 percent of trips to work are made in single-occupant vehicles, only 14.8 percent of all travel is to and from work (*6*).

Emissions Trends

Despite large increases in population, personal travel, and freight transportation, and despite limited highway expansion and public mode choice, on-road motor vehicle emissions have declined 28 to 65 percent since 1980. EPA expects this downward trend to continue (see Figure 2).

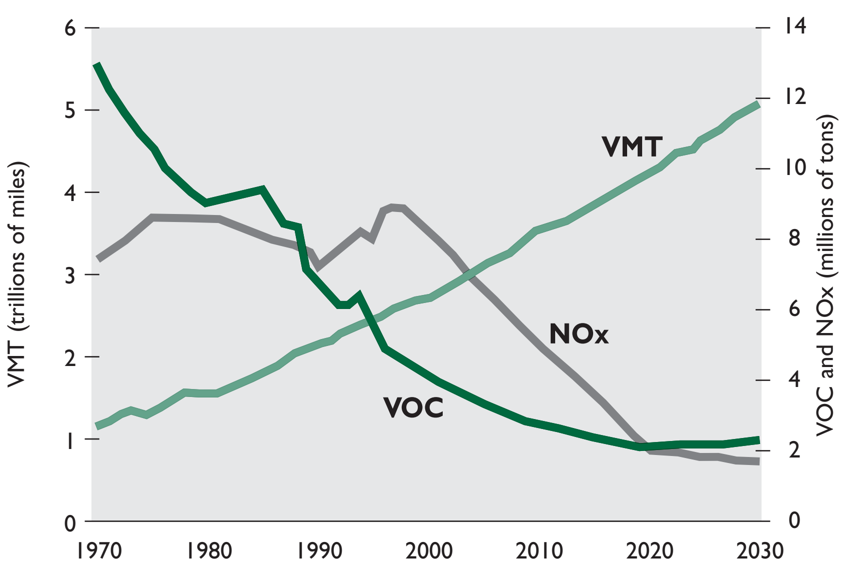


FIGURE 2 Vehicle miles traveled versus pollutant emissions, 1970–2030 (7).

In addition to the reduction in emission levels, on-road motor vehicle emissions have become a smaller percentage of total emissions. In 1980, on-road motor vehicles contributed 78 percent of total carbon monoxide emissions, 42 percent of NOx emissions, and 45 percent of VOC emissions. By 2001, however, the on-road motor vehicle portion of these pollutant emissions dropped to 62 percent for carbon monoxide, 37 percent for NOx, and 27 percent for VOCs (*1*).

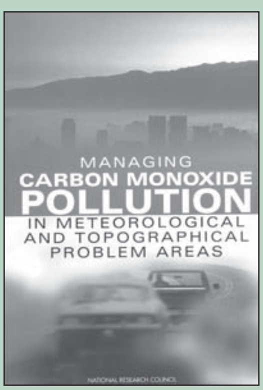
The majority of these emissions reductions are the result of stricter standards, improved engine technology, and cleaner fuels. Under recent EPA emissions standards and cleaner fuel requirements, engines and fuels must become even cleaner.

Between 2004 and 2007, more protective tailpipe emissions standards—known as Tier II rules—will be phased in for all passenger vehicles, including sport utility vehicles (SUVs), minivans, vans, and pickup trucks. For the first time, larger SUVs and other light-duty trucks will be subject to the same national pollution standards as cars.

In addition, EPA's lower limits for sulfur in gasoline will ensure the effectiveness of low emission-control technologies in vehicles and will reduce air pollution. The new tailpipe and sulfur standards will benefit Americans with the clean-air equivalent of removing 164 million cars from the road. The new standards require passenger vehicles to be 77 percent to 95 percent cleaner than those on the road today and establish reductions of up to 90 percent in the sulfur content of gasoline.

EPA also has issued new emissions standards for heavy-duty highway engines and vehicles starting in Model Year 2007. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies.

Controls on Carbon Monoxide Emissions Achieving Results



The regulation of carbon monoxide has been one of the great success stories in air pollution control, according to a new report from the National Research Council (NRC) of the National Academies, *Managing Carbon Monoxide Pollution in Meteorological and Topographical Problem Areas,* published in April. Although a few areas are still susceptible to accumulating high levels of the pollutant and need to remain vigilant in controlling emissions and monitoring air quality, tightening current federal carbon monoxide emissions standards on motor vehicles is not necessary, the report adds.

When federal standards were set for carbon monoxide pollution in 1971, more than 90 percent of the monitored locations registered carbon monoxide levels that were in violation. But today violations have fallen to only a few, on a small number of days, and mainly in areas with unique meteorological and topographical conditions. National emissions standards have led to better controls on new cars and pickup trucks, which were responsible for most carbon monoxide pollution.

Congress requested the NRC report because of concern about the continuing vulnerability of a few locations to high carbon monoxide concentrations. Government officials in these localities can reduce the risk of violating carbon monoxide standards by planning for worst-case combinations of high emissions and atmospheric inversions, which trap the pollutant near ground level, the report says.

Local measures can complement federal vehicle-emissions standards with vehicle inspection and maintenance programs that target high-emissions cars and pickups; the use of cold weather engine-block heaters that reduce the time before a vehicle's emissions-control catalyst is fully functioning; and the use of low-sulfur gasoline that improves catalyst efficiency. Federal and state assistance should help implement these countermeasures in communities at risk of violating carbon monoxide standards, the report adds.

Continued progress toward meeting the carbon monoxide standards in at-risk locations also will reduce the potential for adverse health effects from carbon monoxide pollution, the report notes. Since carbon monoxide can indicate the presence of other pollutants with potential health risks—such as particulate matter—

These devices, however, are damaged by sulfur; therefore EPA is also reducing the level of sulfur in highway diesel fuel by 97 percent by mid-2006. As a result, each new truck and bus will be more than 90 percent cleaner than current models.

The clean air impact of this program is expected to be dramatic. The annual emissions reductions will be equivalent to removing the pollution from more than 90 percent of today's trucks and buses—or to removing approximately 13 million trucks and buses from the road.

Positive Trends

On a national level, air quality is improving, and this is true on a local level in almost every metropolitan area in the United States. From 1990 to 1999, only

- ◆ 9 percent of metropolitan areas had an upward trend in 1-hour ozone concentrations,
- ◆ 1 percent of metropolitan areas had an upward trend of PM_{10} concentrations, and
- ◆ No metropolitan areas had an upward trend of carbon monoxide concentrations.

Reducing pollutant emissions from motor vehicles has been a major contributor to this cleaner air trend and has enhanced the community and social benefits of transportation. Technological innovations, cleaner fuels, and highway and transit programs have reduced emissions significantly in the past 20 years, and this trend is projected to continue.

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www.epa.gov/oar/oaqps

PHOTO: EPA

Visibility impairment from air pollution *(left)*. Badlands National Park, South Dakota.

federal agencies should leave carbon monoxide monitors in place. Where carbon monoxide pollution continues to be a problem, the public should be educated about the health effects and be encouraged to participate in efforts to reduce emissions, according to the report.

The report was sponsored by the U.S. Environmental Protection Agency and involved a collaboration of NRC's Division on Earth and Life Studies, Board on Environmental Studies and Toxicology, Board on Atmospheric Sciences and Climate, and Transportation Research Board. Armistead G. Russell, Georgia Power Distinguished Professor of Environmental Engineering, Georgia Institute of Technology, chaired the authoring Committee on Carbon Monoxide Episodes in Meteorological and Topographical Problem Areas.

For more information contact Bill Kearney or Heather McDonald, National Academies Office of News and Public Information, 202-334-2138, news@nas.edu. To order copies of Managing Carbon Monoxide in Meteorological and Topographical Problem Areas, *contact National Academies Press, 202-334-3313 or 1-800-624-6242, or www.nap.edu.*

Conforming to the New Air Quality Standards

Tips for Transportation Agencies

JONATHAN MAKLER AND ARNOLD M. HOWITT

Makler is Project Manager and Howitt is Executive Director, Taubman Center for State and Local Government, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts.

The U.S. Environmental Protection Agency (EPA) promulgated new National Ambient Air Quality Standards (NAAQS) for ground-level ozone and particulate matter in July 1997, but litigation that reached the U.S. Supreme Court delayed judicial approval of the standards until March 2002. As implementation proceeds, the new NAAQS pose several challenges for transportation agencies in nonattainment areas—that is, areas with air quality that does not meet the standards.

These challenges may prove especially problematic for areas that have no experience in developing state implementation plans (SIPs) or in managing the transportation conformity process—demonstrating that transportation plans and programs will keep emissions within required limits. As many transportation agencies learned in the 1990s, developing SIPs and making conformity determinations are critical to effective transportation planning and investment under the requirements of the Clean Air Act (CAA).

A decade of experience provides clues to resolving the difficulties that loom for new nonattainment areas. Examining how three states—Georgia, North Carolina, and Oklahoma—have prepared for implementation of the new NAAQS illuminates the benefits of experience, as well as the challenges that remain.

Transportation Conformity

The CAA Amendments (CAAA) of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 tied the nation's air pollution regulation and transportation planning together more tightly than ever before, particularly through the revised SIP and transportation conformity requirements. The SIP includes a legally enforceable schedule of emission reductions to meet the NAAQS and establishes a motor vehicle emissions budget, setting a maximum permissible amount of transportation-related pollution.

A conformity determination is required for every regional transportation plan (RTP) and transportation improvement program (TIP) adopted by a metropolitan planning organization (MPO) in a nonattainment area. Other triggers for conformity determinations include a designation of nonattainment, approval of new motor vehicle emissions budgets, and the release of a new mobile-source emissions model.

Conformity procedures are complex, but the core analytic process involves a 20-year, computer-simulated forecast of emissions from the transportation system. The predicted levels of pollutants must fall within the budgets established in the SIP. Alternative tests are available in the absence of motor vehicle emission budgets. In addition, an MPO must demonstrate timely implementation of transportation control measures in SIPs and must fulfill ISTEA's fiscal constraint requirement that transportation plans and programs have sufficient financial resources.

To ensure accountability, the CAAA mandates the withholding of federal transportation funds if conformity between the RTP or TIP and the SIP cannot be demonstrated. During a conformity lapse, only transportation control measures from the SIP and exempt emissions-neutral projects may proceed.

Conformity Lessons

When the conformity regulations went into effect in the early 1990s, transportation agencies—particularly MPOs and state departments of transportation (DOTs)—faced difficulties not only in meeting the requirements but also in coping with other changes in the newly enacted CAAA and ISTEA. Several lessons are apparent:

1. Mastering the conformity process and requirements requires a significant start-up period.
Even without the conformity requirements, transportation and air quality agencies in the 1990s faced substantial increases in workloads, as well as the need to develop new skills and to build interagency relationships. For conformity, MPOs usually had to expand technical and human resources, learn the requirements of a complex federal regulatory procedure, and figure out applications to specific situations.

MPOs also had to develop approaches to

- Complete the work in a timely fashion,
- Secure inputs from—and gain the confidence of—institutional partners, and
- Obtain federal approval for the conformity determination.

State air quality agencies also were endeavoring to learn conformity while adjusting to the abundant new requirements of the CAAA.

2. Transportation and air quality professionals must be involved across disciplines in critical planning activities.
Air quality planning staff had to be involved in framing transportation plans. Similarly, MPOs and state DOTs had to participate in developing the mandatory SIP, a process typically led by the state air quality agency.

Most MPOs and state transportation departments recognized that the CAAA had profound implications for policies, operations, and funding. As a result, more attention was devoted to air quality issues, to understanding the technical issues and workings of the regulatory system, and to participating in policy debates over how to reduce pollution.

3. Strong interagency and interpersonal relationships among the regional, state, and federal transportation and air quality agencies are vital to managing the conformity requirements.
Formal consultation and informal day-to-day working contacts among agencies were a necessity. Despite strong interagency and interpersonal ties, agencies frequently had differing objectives and stakeholder considerations; moreover, satisfying the conformity requirement could be substantively difficult.

Ties did not eliminate political contention among agencies and various stakeholder groups. Strong interagency working relationships, however, did make the conformity process work more effectively by reducing suspicion, facilitating jointly developed solutions and step-by-step compliance with the regulations, and solving some potential problems early. Strong interagency ties facilitated otherwise difficult tradeoffs, because the participants had established a foundation of understanding, trust, and credibility.

4. Inviting nongovernmental stakeholders, such as environmental advocacy groups, to participate in the full range of conformity discussions, not only in the formal public hearing and comment process, can be effective.
Transportation agencies frequently were wary of advocacy groups as possible sources of contention, delay, and subsequent litigation. When advocacy groups did have opportunities to observe and express concerns about data and modeling practices early in the conformity determination process, however, transportation and air quality agencies sometimes were able to make adjustments to avoid later disputes. A more transparent process made advocacy groups more likely to trust the technical analysis. Despite these efforts, a few areas experienced chronic conflict between planners and advocates.

5. The technical complexities of the conformity process and the regulations are difficult for senior policy and elected officials, as well as the general public, to understand.
Typically only a core group of agency participants and stakeholder representatives mastered the regulatory details. When conformity problems were encountered, the core group frequently had difficulty explaining the problems and helping senior officials to focus on workable solutions. Too often, only a crisis that threatened federal transportation funding provided the impetus to understand the issues.

Some nonattainment areas continue to have difficulty meeting the requirements of the conformity regulations. Nevertheless, after a decade of experience, nearly all have established regular procedures for conducting the analysis, holding interagency consultations, improving cross-professional understanding, and increasing awareness by policy officials and, in some cases, the public.

The New NAAQS

The designation of new nonattainment areas under the new NAAQS, intended for the summer of 2000, was delayed for years by a legal challenge led by the American Trucking Associations. Ultimately, a consent decree between EPA and the American Lung Association (ALA), November 13, 2002, established the timeline for implementation of the 8-hour ozone standard (measurements averaged over an 8-hour period), which in turn determines the schedule for $PM_{2.5}$ (fine particulate matter 2.5 micrometers in diameter or smaller).

As Figure 1 illustrates, a complicated process leads to determination of the new nonattainment areas in 2004, and sets the SIP deadlines in 2007 and subsequent attainment deadlines. Under the ALA consent decree, the deadline for designating nonattainment areas for ozone is April 15, 2004. In April 2003, EPA established a comparable timeline for $PM_{2.5}$ nonattainment areas, with final designations due December 15, 2004.

The conformity regulation goes into effect for the new NAAQS at the end of a 1-year grace period after a nonattainment designation and is the focal point of preparations by the affected areas. EPA's Office of Transportation and Air Quality administers the conformity requirement and is currently determining which elements need to be revised to meet the new air quality standards.

Nonattainment Areas

The CAA requires designations of new nonattainment areas to be based on the most recent three years of monitoring data for each pollutant. A national monitoring infrastructure was established in 1999 for $PM_{2.5}$, and the first 3-year set of data

Implementation Schedule Lingo

NAAQS: National Ambient Air Quality Standards are created and enforced by EPA

8-Hour Ozone: EPA created a tighter standard for ground-level ozone based on an 8-hour measurement rather than the existing 1-hour technique.

$PM_{2.5}$: EPA created a standard for particulate matter under 2.5 microns to supplement the existing 10-micron NAAQS.

EAC: Early Action Compact is a special arrangement supported by EPA that allows areas to defer and possibly avoid nonattainment status by taking early corrective actions.

SIP: State Implementation Plans must be submitted to EPA for every nonattainment area. Each SIP includes pollution control strategies.

Nonattainment Area: A region, often metropolitan but sometimes rural, that is designated by EPA for not meeting one or more NAAQS.

Conformity: A federal requirement for nonattainment areas to connect transportation and air quality plans.

Implementation Rule: A protocol, created by EPA via federal rulemaking, that guides implementation of new NAAQS.

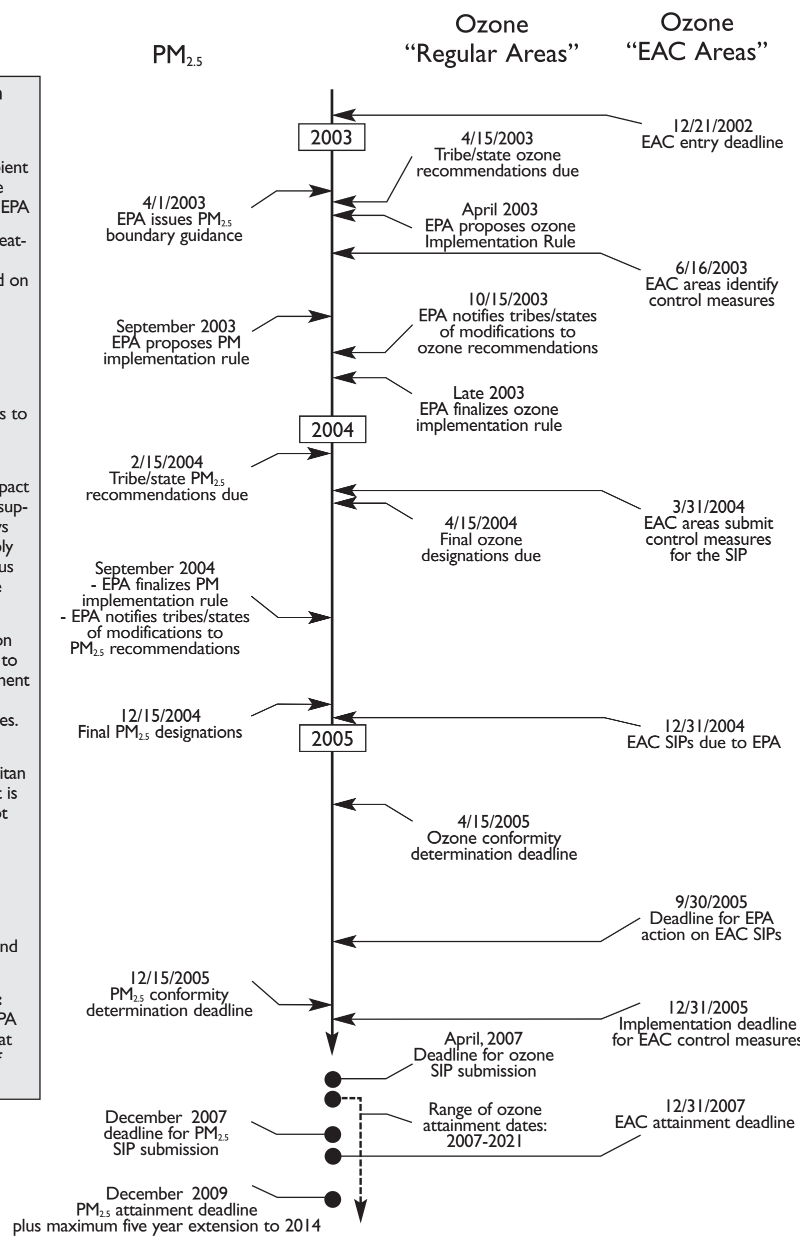

FIGURE 1 Implementation schedule: new NAAQS for ozone and $PM_{2.5}$.

became available in 2001. Because ozone monitors were already in place, 8-hour ozone data were available immediately, so that prospective nonattainment areas were identified earlier.

Figures 2 and 3 illustrate prospective nonattainment areas for 8-hour ozone and $PM_{2.5}$, respectively. The maps show nonattainment or maintenance areas for 1-hour ozone and PM_{10}, as well as new areas.

The designations indicated on these maps are provisional, but the maps suggest that the 8-hour ozone and $PM_{2.5}$ data will reinforce nonattainment patterns (ozone in the Northeast, for example) and simultaneously will create new ones, primarily in the Southeast. The maps also indicate a significant overlap between 8-hour ozone and $PM_{2.5}$ nonattainment areas. Prospective nonattainment areas can be divided into two categories: those that have experience with nonattainment status and with meeting the requirements, and those that do not.

Because the new designations may expand the boundaries of nonattainment or maintenance areas, these may be subdivided into unchanged areas and expanded areas. In contrast to the 1-hour ozone standard, the new standards will create nonattainment areas in rural as well as metropolitan settings. Therefore, the inexperienced group may be subdivided into new urban areas and new rural or isolated areas.

This categorization highlights each area's experience with or ability to perform transportation and air quality planning functions. Nonattainment areas, for example, have been subject to CAA regulation and have an institutional infrastructure for the planning requirements, as well as experience with the transportation conformity process. The new portions of expanded areas and the entirely new areas, in contrast, have little or no air quality experience, and the rural and isolated areas are unlikely to have any exposure to the CAA or to the requirements of ISTEA and the Transportation Equity Act for the 21st Century (TEA-21).

Double designation of areas for both $PM_{2.5}$ and 8-hour ozone is a likely scenario in many states, as the maps indicate. The Southeast has almost no previous experience with particulate matter, making a second designation a potentially substantial burden. Experience dealing with one pollutant, however, can apply to another in terms of both SIP development and conformity determinations.

Anticipating the Challenges

The past decade's experience with transportation conformity in nonattainment areas can aid regions dealing with the regulation for the first time. Experience is easily applicable to ozone, but less useful for particulate matter, because differences between PM_{10} and $PM_{2.5}$ hamper extrapolation of experience with PM_{10} to preparations for $PM_{2.5}$.

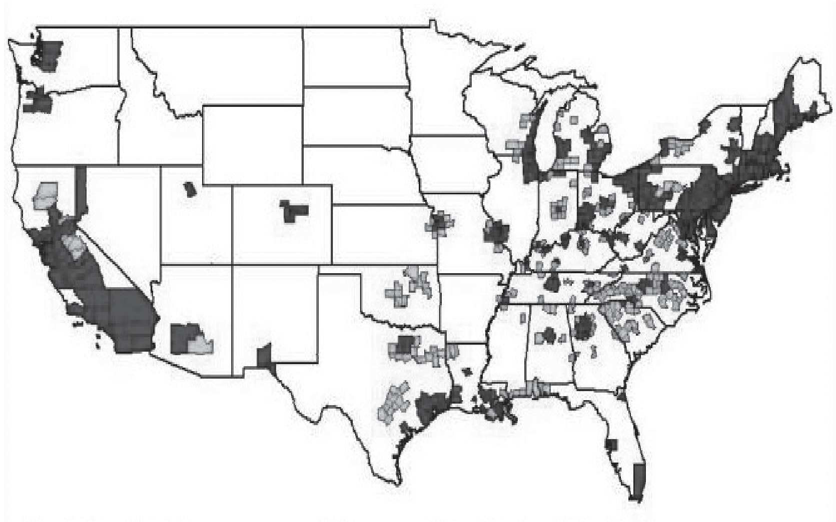

FIGURE 2 Prospective nonattainment areas for ozone (light areas are new).

Unchanged Areas

For the unchanged areas, the new designations are only one of several major technical changes in the next few years. Others include a new version of the emissions factors model, MOBILE6, used in the conformity analysis; incorporation of the 2000 census data into transportation planning models; and the reauthorization of TEA-21, including any changes in the transportation planning regulations.

Furthermore, these areas have been coping with new and evolving regulatory requirements since the enactment of the CAA. Therefore, implementation

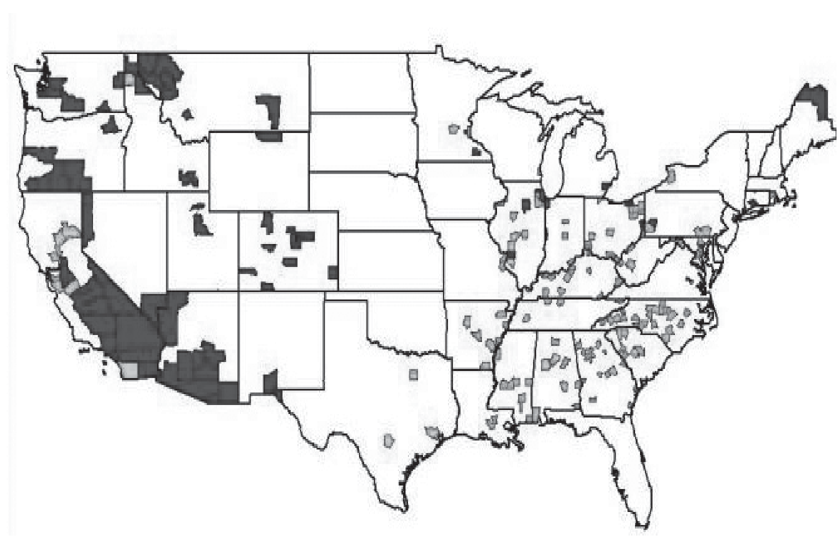

FIGURE 3 Prospective nonattainment areas for $PM_{2.5}$ (light areas are new).

of the 8-hour standard can be addressed with available tools and interorganizational relationships. With minor differences, this also applies to areas that have attained the 1-hour ozone standard in the last 10 years but that will return to nonattainment under the 8-hour standard.

Expanded Areas

For expanded areas, the primary challenge will be integrating new stakeholder interests into the air quality, transportation planning, and conformity processes. Well-established relationships among planning partners will have to be open to new participants, and veteran stakeholders will need to exercise patience with and accommodate novice counterparts.

The staff of the MPO, state, and federal agencies will need to introduce planners and elected officials from new counties and municipalities to conformity and the SIP process. Obtaining buy-in from county elected officials is likely to increase staff willingness to participate openly. Political support also will be critical for the expansion of air quality control measures, especially if county or state legislative action is needed.

New Urban Areas

New urban areas face challenges similar to those of the nonattainment areas in the early 1990s. Perhaps the most significant difference is that most of these states have had experience with other nonattainment areas.

For example, although MPOs will have to develop the necessary technical capacities and protocols for performing conformity determinations, their partners in the state transportation and air quality agencies, as well as in EPA, the Federal Highway Administration (FHWA), and the Federal Transit Administration, can provide assistance. State agencies, however, are facing budget cuts and resource constraints, so MPO staff in nonattainment areas may not receive adequate attention.

Because the state agencies have more experience than MPO planners from new nonattainment areas, the MPO representatives will need to assert themselves in the SIP development process. MPOs have found direct involvement in this process valuable, whether to influence emissions budgets and controls or to increase awareness of upcoming responsibilities and deadlines. In addition, involvement engages the MPO's data and modeling resources, such as travel time and vehicle mix information, although this may vary.

Because these new nonattainment areas have a decade of experience with ISTEA, they may have relationships with some of the planning partners and advocacy groups crucial for achieving conformity. Nonetheless, these areas will go through a regulatory learning period similar to that experienced by nonattainment areas in the early 1990s and will need to connect with EPA and state or local air agencies, as well as adjust to a 3-year, instead of a 5-year, planning cycle.

New Rural Areas

New rural and isolated areas face all the challenges of their urban counterparts but with additional obstacles. Some of these areas exceed the limits because of sources beyond control—for example, high biogenic emissions—and generally lack the institutional infrastructure of urban areas. Moreover, many of the laws and regulations, including the CAA, were framed for urban instead of rural applications, creating mismatches in requirements and capabilities.

Without an MPO to perform technical tasks such as emissions analyses, rural areas will have to rely on technical assistance from state transportation agencies. Nonetheless, local officials and staff will want to monitor how their interests are being represented, especially in the SIP and emission budget development for rural areas with limited options for controlling man-made emissions.

Concurrent Designation

Concurrent designation for $PM_{2.5}$ and 8-hour ozone intensifies the issues for each of the four types of nonattainment areas. As the maps indicate, the Southeast includes many new $PM_{2.5}$ areas, urban and rural, often overlapping the 8-hour ozone nonattainment areas, some of which are also new.

Adapting to the New Standards

To find out how states are preparing for designation and for changes in transportation planning, the authors conducted interviews during 2002 and 2003 with local, state, and federal officials, as well as with other stakeholders in three states likely to be affected by the new ozone standard: Georgia, North Carolina, and Oklahoma. The case studies dealt only with the 8-hour ozone standard, but many of the issues apply as well to $PM_{2.5}$.

Under the 8-hour ozone standard, Georgia is likely to have three new urban nonattainment areas and an expanded nonattainment area for Atlanta. Atlanta's 2-year conformity lapse (1998–2000) made the state acutely aware of the transportation planning difficulties that may arise, so that state, local, and federal officials have prepared aggressively for implementation of the 8-hour ozone standard. A common concern is the strain of the additional workload on state—as well as federal—agencies.

Roundtable Clearing North Carolina's Air

DAVID HYDER

After the U.S. Environmental Protection Agency (EPA) set the 8-hour ozone and fine particulate matter ($PM_{2.5}$) standards, North Carolina faced the formidable prospects of tripling nonattainment areas, adding a new pollutant—$PM_{2.5}$—to the air quality mix, and introducing many inexperienced partners to the rigors of transportation conformity.

The anticipated nonattainment areas are mostly rural, although adjacent to regions with metropolitan planning organizations (MPOs). However, most do not have well-defined transportation planning processes. At the same time, adding staff to either the North Carolina Department of Transportation (DOT) or to the Department of Environment and Natural Resources was not likely. The state needed to leverage its air quality expertise to meet the new standards.

In response, the state DOT, the Department of Environment and Natural Resources, North Carolina State University's Center for Transportation and the Environment, the Federal Highway Administration, and EPA cosponsored the North Carolina Air Quality Roundtable. The Roundtable's ongoing workshops convene representatives of 30 stakeholder groups to cooperate on improving state air quality. Stakeholders have identified three areas for emphasis: educating decision makers and the media, educating the public, and assuring agencies' technical capacity.

The Roundtable's immediate focus is on educating decision makers about their role in meeting federal air quality requirements and improving air quality. A train-the-trainer program, called the Air Quality Gold Circle, has recruited policy staff from such organizations as the North Carolina Rural Center, the League of Municipalities, the Association of MPOs, and the Association of County Commissioners.

The Gold Circle members serve as local experts on air quality, briefing local-level decision makers on the relationship between air quality, land use, and transportation. They also place experts on meeting agendas for more detailed briefings.

An introductory meeting acquainted the Gold Circle members with air quality issues in North Carolina. Future meetings will examine the designation process, state implementation plan development, early action plans, and transportation conformity.

The Center for Transportation and the Environment at North Carolina State University has provided much of the administrative support for the Roundtable. More information is available on the Roundtable website, http://itre.ncsu.edu/cte/NCAirQuality/index.html.

The author is Transportation Engineer, Office of Human Environment, North Carolina Department of Transportation, Raleigh.

PHOTO: GEORGIA DOT

Traffic outside of Atlanta, Georgia. Local, state, and federal officials have been preparing to implement the new air quality standards.

North Carolina's three 1-hour ozone maintenance areas—Charlotte–Gastonia, Greensboro–Winston-Salem–High Point, and Raleigh–Durham—will return to nonattainment status under the 8-hour standard, joined by four new urban nonattainment areas, many new ozone areas in rural counties, and isolated areas at high elevations. Prompted by Charlotte's 20-month lapse and Atlanta's experience, state and local agencies formed an Air Quality Roundtable in 2001 (see sidebar, page 15). The Roundtable has dealt with the challenges posed by the state's rural 8-hour ozone nonattainment areas, among other issues.

With Tulsa violating the 8-hour ozone standard and Oklahoma City on the borderline of attainment, Oklahoma has pursued early action compacts (EAC), which allow the state to avoid nonattainment by making an early commitment to accelerating reductions in emissions. Shortages of monetary and technical resources, however, have threatened the state's ability to perform some of the mandatory tasks.

Other considerations also may have limited the interest in the EAC approach: the state has not had a nonattainment problem since before the 1990 CAAA; the air quality problem in nearby Dallas, Texas, has not constrained transportation investments; and the legal wrangling and regulatory uncertainty in Washington, D.C., have made politicians cautious about acting prematurely.

Preparing for Conformity

Georgia and North Carolina have used the more than 4 years of litigation-caused delay to prepare for the 8-hour ozone nonattainment designations and the transportation conformity requirements. Both states have worked to create institutional infrastructure in areas with no experience in conformity, establishing interagency committees and providing training and technical assistance to planners and stakeholders who will be involved.

The two states also have gathered more information about the extent and nature of the air quality problems, to help in developing control strategies to reduce pollution. In contrast, Oklahoma has focused on the EAC strategy and may be underprepared if conformity is required. Nonetheless, the delay in implementation made many of these preparatory actions possible.

On the other hand, the implementation delays also have had some harmful effects on preparations for transportation conformity. The lack of firm deadlines—EPA announced and then abandoned deadlines—has made it difficult to motivate the reluctant or skeptical.

The lack of urgency also may have bred complacency. One official noted that decision makers in some of the areas likely to be affected were satisfied with a general awareness of the issues but as yet had no impetus for a deeper understanding of the complexities of conformity.

Preparation, however, also entails risks. Observers in North Carolina, for example, pointed out that diligent preparation of procedures and possible pollution control strategies sometimes became moot when the federal policy shifted.

Finally, almost every interview subject noted that the implementation schedule calls for a conformity determination before the SIPs are due, obliging each nonattainment area to use an emission reduction test (ERT) in the absence of a motor vehicle emissions budget. Some have described one ERT, the "build/no-build" test, as "a disaster waiting to happen," because of the difficulties that most fast-growing metropolitan areas experienced when the test was used for 1-hour ozone in the 1990s.

The feasibility of the alternative "less-than-baseline" test depends on updating the baseline, possibly to 2002. Although this would apply to both the 8-hour ozone and $PM_{2.5}$ standards, the lack of experience and precedent with $PM_{2.5}$ has created anxieties for transportation and air quality planners.

Sharpening Focus

Despite recommendations for early involvement and proactive scrutiny, planners must await federal guidance on many complex issues and many contingencies. What, then, should be the focus of state, regional, and federal agencies now and after the rules are final and the designations are made?

1. Aim at two moving targets: conformity and SIP development.

MPO and state DOT planners who focus on the conformity determinations of transportation plans, which will follow the 1-year grace period after designation, may miss the opportunity to participate in SIP development. This participation involves creating motor vehicle emission budgets, selecting transportation control measures, and forming strong interagency relationships—all of which will be critical in the years ahead.

Air quality planners have a similar opportunity to participate actively in the first conformity determination. Particularly if emission reduction tests are necessary initially, involvement of air quality officials will help assure that the results are regarded as legitimate.

2. Approach conformity as a management issue, emphasizing participation.

In preparing new nonattainment areas for designation, the emphasis on technical skill development and boundary setting can distract from establishing interagency relationships and procedures. Building on embryonic coalitions, regions can develop conformity protocols to get a head start on some of the required tasks, such as forming interagency working groups and identifying data and technical resource needs for conformity determinations. As many 1-hour nonattainment areas have learned, good management of the conformity process can reduce the likelihood of problems and can improve the quality of the outcome.

Outreach and education to engage local elected officials and environmental advocacy groups should begin early, cultivating stakeholder relationships for the conformity process. In some 1-hour ozone nonattainment areas, advocates have sued to increase leverage in the planning process. Early engagement in constructive dialogue can avert antagonism and lessen the likelihood of litigation by offering opportunities for meaningful participation.

Involving elected officials and other key decision makers, however, is difficult, because conformity measures are highly technical and hard to understand. Nonetheless, conformity problems often end up before the same decision makers, who should have some conception of what is involved and how the process can generate problems. There are many approaches to educating stakeholders about conformity; North Carolina, for example, is reaching elected officials through several agencies' planners.

3. Learn to navigate the federal regulatory procedures.

One-hour ozone nonattainment areas have indicated that one of the greatest challenges was mastering the maze of regulatory requirements for conformity, along with the procedures and requirements for SIP development, adoption, and federal approval. New nonattainment areas may benefit from help on these matters.

For example, in dealing with EPA, MPOs can seek advice from other nonattainment areas under the same regional EPA office, to avoid any barriers to resources, information, and technical assistance, and to ease compliance with the conformity requirements. The same is true for state agencies and FHWA division offices.

4. Handling 8-hour ozone and $PM_{2.5}$ standards together will require interdisciplinary collaboration.

Experience with ground-level ozone varies among regions and states, but fine particulates put transportation and air quality professionals alike at square one. Moreover, the combined effect of documenting both pollutants adds substantially to the preparation of SIPs and RTPs.

The interagency and interpersonal relationships that aid collaboration in good times are especially valuable in difficult episodes, which many states will encounter in the next few years. The signs of preparation in many areas are encouraging. Continued collaboration will benefit both disciplines as implementation proceeds.

Websites

Environmental Protection Agency:
Air Quality Planning and Standards
www.epa.gov/air/oaqps/index.html

Environmental Protection Agency:
Memoranda on new standards
www.epa.gov/ttn/oarpg/t1pgm.html

Environmental Protection Agency:
New NAAQS on ozone
www.epa.gov/ttn/naaqs/ozone/o3imp8hr/

Environmental Protection Agency:
New NAAQS on $PM_{2.5}$
www.epa.gov/ttn/naaqs/pm/pm25_index.html

Environmental Protection Agency:
Office of Transportation and Air Quality
www.epa.gov/otaq/

Federal Highway Administration:
Transportation conformity
www.fhwa.dot.gov/environment/conform.htm

Kennedy School of Government, Harvard University:
Transportation and air quality research
www.ksg.harvard.edu/taubmancenter/research/trenv.html

North Carolina Air Quality Roundtable
http://itre.ncsu.edu/cte/NCAirQuality/index.html

Reducing Air Toxics from Transportation Sources

Standards and Strategies To Protect the Public Health

KATHRYN A. SARGEANT

The author is Director, Air Toxics Center, U.S. Environmental Protection Agency Office of Transportation and Air Quality, Ann Arbor, Michigan.

Toxic air pollutants are emerging as an issue for transportation planners. Air toxics from highway vehicles and nonroad equipment—including aircraft, locomotives, marine vessels, and construction machinery—contribute significantly to the risk of cancer and other health problems. Evidence is increasing that areas near roadways register elevated concentrations of air toxics and high incidences of adverse health effects.

Communities and individual citizens are concerned about the levels and the unhealthy effects of toxic air and are looking for ways to reduce or avoid pollution. The public is requesting information about the air toxics impacts of transportation projects in the planning stages, often during the environmental justice or National Environmental Policy Act (NEPA) review. A recent high-profile example is the US-95 project in Las Vegas—the Sierra Club sued to halt the project for failure to consider air toxics in drafting the environmental impact statement.

What Are Air Toxics?

Air toxics are pollutants known to cause—or that are suspected of causing—cancer or other serious health effects, such as reproductive problems or birth defects. Many toxics are known to cause respiratory, neurological, immune system, or reproductive problems, particularly in more susceptible and sensitive populations, such as children.

The Environmental Protection Agency (EPA) has designated 21 chemicals (see box, page 19) as mobile-source air toxics emitted by motor vehicles, locomotives, aircraft, ships, and various types of nonroad equipment (*1*). Six mobile-source air toxics are of primary concern: benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, and diesel exhaust—that is, diesel particulate matter and organic gases. EPA's recent National-Scale Air Toxics Assessment identified these pollutants as posing the greatest health risks and noted that mobile sources are large contributors to the total emissions (*2*).

Epidemiologic studies show increased adverse health effects among people who reside near major roadways.

Related Pollutants

Mobile-source air toxics are emitted as gases (volatile organic compounds or VOCs) or as particulate matter (PM). VOCs contribute to the formation of ozone, and emissions of VOCs are regulated to control ozone. As a result, programs for mobile-source toxics and the more well-known programs to control ozone and PM have considerable overlap.

Emissions of mobile-source air toxics are reduced by engine, vehicle, and fuel standards that address VOCs and PM. In addition, reducing vehicle miles traveled reduces toxic emissions. Transportation demand management strategies, therefore, can reduce the amount of toxics released into the air, in addition to producing other more commonly cited benefits—such as congestion relief, improved quality of life, and reduced ozone.

Ozone is considered a regional pollutant, in contrast with carbon monoxide, which often has more local impacts. Mobile-source air toxics affect air quality at both the urban and local levels. Benzene is stable in the atmosphere, but formaldehyde, acetaldehyde, acrolein, and 1,3-butadiene are reactive. Formaldehyde, acetaldehyde, and acrolein are emitted directly from mobile sources and also are formed secondarily in the atmosphere.

Setting Standards

Unlike the more familiar pollutants—such as ozone, carbon monoxide, and PM—air toxics are not subject to a national ambient air quality standard. States have not been required to achieve an identified level of air toxics in the ambient air. This has several ramifications.

First, state air quality implementation plans do not need to address air toxics, and the Clean Air Act's conformity requirements do not apply. Similarly, NEPA documents historically have not addressed air toxics. In addition, the lack of a standard complicates discussions of acceptable levels of toxics and the likelihood of adverse health effects.

In setting a national ambient air quality standard for a pollutant, EPA considers population exposure and the health effects at different levels of exposure to identify an ambient concentration of the pollutant that is acceptable for public health. Subsequent analyses focus on emissions and ambient concentrations, making comparisons against the standard. Without an ambient standard, a robust analysis of air toxics impacts must follow the whole chain of risk-assessment: emissions, ambient concentration, exposure, and adverse health effects.

EPA's MOBILE model is used to estimate emissions of air toxics from on-highway mobile sources, as well as emissions of VOC, nitrogen oxides, and carbon monoxide. Toxic emissions usually are estimated as fractions of total organic gases, or in some cases, as a fraction of PM.

A variety of air quality dispersion models can be used for toxics, and some are familiar to transportation and air quality planners (for example, CAL3QHC, CALINE, and ISC). The tools for modeling air toxics exposure and characterizing risk, however, are available but less familiar to the transportation planning process.

Health Concerns

Traditionally, concerns about air toxics have focused on cancer risk. Mobile sources are responsible for approximately half of the total lifetime cancer risk attributed to air toxics.[1]

Benzene and 1,3-butadiene are known human carcinogens. In 1996, mobile sources accounted for 76 percent of benzene emissions and 60 percent of 1,3-butadiene. Formaldehyde, acetaldehyde, and diesel exhaust are probable human carcinogens. In 1996, direct formaldehyde emissions from mobile sources accounted for 50 percent of total emissions of the pollutant; direct acetaldehyde emissions from mobile sources accounted for more than 70 percent of total acetaldehyde emissions. Total nationwide emissions of air toxics (excluding diesel PM) were 4.6 million tons in 1996, and mobile sources accounted for half of this total (see Figure 1).

Mobile sources are almost exclusively responsible for diesel exhaust. In addition, nearly the entire United States is exposed to levels of acrolein that may produce adverse health effects such as respiratory irritation. Mobile sources account for more than 40 percent of total direct acrolein emissions.

Hot Spots

Recent studies show elevated concentrations of mobile source toxics near roadways. Concentrations of air toxics in commuter vehicles can be substantially higher than average concentrations (*3–6*).

Epidemiologic evidence that adverse health effects are associated with proximity to major roadways is increasing. Residence near busy roadways has been associated with risk of cardiopulmonary death, diag-

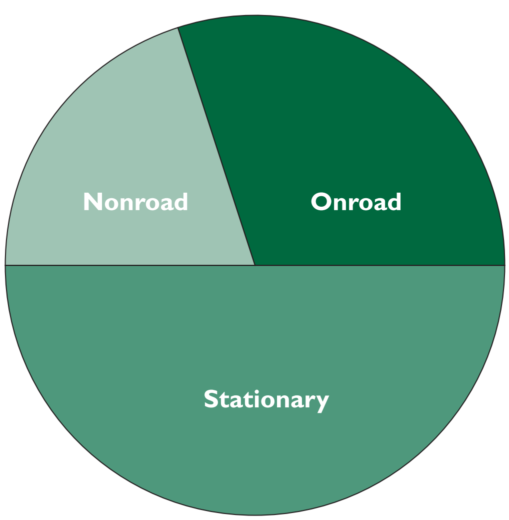

FIGURE 1 National contribution of source types to air toxics emissions, 1996 (excluding diesel particulate matter).

[1] EPA has determined that the data to quantify the cancer risk from diesel exhaust are not adequate; therefore this source is not included in the estimate.

Mobile-Source Air Toxics

- 1,3-butadiene
- Acetaldehyde
- Acrolein
- Arsenic compounds
- Benzene
- Chromium compounds
- Diesel particulate matter plus diesel exhaust organic gases
- Dioxin/furans
- Ethylbenzene
- Formaldehyde
- Lead compounds
- Manganese compounds
- Mercury compounds
- MTBE (methyl tertiary butyl ether)
- Naphthalene
- n-Hexane
- Nickel compounds
- POM (polycyclic organic matter)
- Styrene
- Toluene
- Xylene

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Gasoline dispensing equipment helps to control unburned hydrocarbon emissions, which account for as much as 2% of pollution from automobiles.

nosis and symptoms of asthma, and childhood leukemia and other cancers (*7–10*). New studies also associate traffic density with birth outcomes such as preterm birth and low birth weight (*11–12*). The results are consistent with what is known about the physical effects of mobile source pollutants such as benzene, polycyclic aromatic hydrocarbons, and PM.

EPA has identified hot spots and high-end exposure as critical gaps in the understanding of air toxics. The agency made a commitment to further research with the technical analysis plan that was included in the 2001 mobile-source air toxics rule.

Exposure Research

Much of the work that assesses air toxics today focuses on average exposure and risk across broad geographic areas, not on high-end exposures and populations. Local assessments are needed, using refined data and modeling tools, monitoring designed to capture mobile-source-related ambient hot spots, and monitoring of personal exposure. Together these efforts will improve toxics assessments by covering the full range of exposure.

EPA is participating in several research projects to assess hot spot exposure. The projects include indoor and outdoor monitoring—as well as personal exposure monitoring—in homes and schools near heavily traveled roadways. The studies are designed to assess how concentrations of air toxics vary across a city, throughout a day, and between seasons; the prevalence of hot spots; the contributions of mobile sources to hot spots; and what exposures people experience at home, at school, and outdoors.

In addition, EPA is working with several communities to apply more refined modeling tools and local inputs to assess toxics. Unlike EPA's recent national-scale screening analysis, the assessments use local transportation data and more refined air quality models. These assessments reflect more clearly the variability of concentrations across an urban area and the range of exposures; this improves the ability to predict hot spots and high-end exposures.

Federal Controls

EPA's program of motor vehicle, engine, and fuel standards will reduce emissions of motor vehicle air toxics significantly. By 2007 EPA expects a reduction of approximately 1 million tons of toxic emissions from mobile sources, or about 40 percent, from 1996 levels (*13*). This projected reduction results from programs that will go into effect in the near future, such as the Tier 2 light-duty vehicle standards, low-sulfur gasoline requirements, and the standards for heavy-duty engines and diesel fuel.

In addition, the Clean Air Act gives EPA authority to set standards for motor vehicles and fuel to reduce emissions of mobile-source air toxics. EPA issued a mobile-source air toxics rule in March 2001, establishing a toxic emissions performance standard for gasoline. The standard preserves the industry's overcompliance with the reformulated gasoline program between 1998 and 2000. The rule also commits EPA to conduct further research and to evaluate in another rule the need for and feasibility of additional controls on air toxics.

EPA expects to finalize standards in 2004 for nonroad diesel engines and fuel. This is likely to be the most significant remaining federal control for reducing emissions from mobile-source air toxics.

Local Strategies

Standards that take effect in the future, however, do not address the current fleet. Trucks, buses, and nonroad equipment remain in use for a long time, slowing the changeover to an environmentally cleaner fleet. Options to reduce emissions from the currently operating fleet include retrofitting vehicles and equipment with advanced pollution control devices, using low-sulfur diesel fuel, or accelerating replacement with cleaner models.

Reducing the unnecessary idling of diesel vehicles also improves local air quality. This may involve education and outreach efforts to drivers and operators, the introduction of local ordinances, or technological options such as auxiliary power units. EPA has a voluntary retrofit program for businesses and state and local governments. Other local-level strategies include transportation demand management and transportation and land use decisions that minimize exposure to mobile source exhaust.

Plans at Hand

Air toxics are a concern at both the metropolitan and project levels. Although more research is needed to improve assessments and to quantify the risks of mobile-source air toxics, reducing exposure to air toxics is desirable now.

Transportation planners have many opportunities to reduce the public's exposure. One way is through careful attention to the siting of transportation facilities. How many people are in the vicinity of the project? Are there sensitive subpopulations, like children and the elderly? How far is the facility from homes, offices, schools, and hospitals? Can the distance be maximized, and can the traffic volume be minimized?

Areas with concentrations of idling diesel vehicles—such as bus and truck terminals and depots—also merit attention. Although new facilities should be located carefully, mitigation should be considered at operating facilities. Retrofits and anti-idling measures would improve air quality in the immediate vicinity. Ports and airports also are potential hot-spot areas that could benefit from targeted mitigation such as cleaner equipment and methods of operation.

Reducing vehicle miles traveled is an air toxics reduction strategy that can be implemented systemwide or in areas with particularly high exposure. In residential areas with high levels of truck traffic, for example, ways to minimize the traffic through rerouting or other means should be considered.

State and local governments can retrofit transit buses and other fleets or accelerate replacement of the vehicles. Construction contracts specifying that equipment must be retrofit and operated with ultralow-sulfur diesel fuel or operated on highway diesel fuel also can reduce exposure. The lower sulfur levels in highway diesel fuel will reduce PM and toxics without requiring modification of the equipment.

Finally, states and communities that undertake more refined assessments of the air toxics problem at the local level will need the partnership of the transportation community in supplying information on vehicle miles traveled and other travel activity inputs for air quality analysis.

Addressing Concerns

The issue of air toxics is increasingly prominent in transportation project-level discussions with citizens and communities. Transportation planners should consider how to respond to concerns about air toxics and should know what mitigation methods are possible and appropriate. Planners should prepare to discuss air toxics along with other air quality impacts. In addition, transportation planners should be able to discuss the potential impacts of major new projects in the context of any local community analyses of air toxics levels.

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National Air Toxics Assessment for 1996
www.epa.gov/ttn/atw/nata

EPA Mobile Source Air Toxics, www.epa.gov/otaq/toxics.htm

EPA's Voluntary Diesel Retrofit Program
www.epa.gov/otaq/retrofit

POINT OF VIEW

Improving Urban Air Quality Requires Multimodal Measures

CHRISTOPHER D. GRANT

The author is Associate Chair of Civil Engineering, Embry-Riddle Aeronautical University, Daytona Beach, Florida.

Despite considerable progress since the Clean Air Act (CAA) of 1970, many metropolitan areas across the nation register unhealthy levels of air pollution. More than 85 million people are exposed to air that contains pollutants above the levels set by national standards (*1*). Development and urban sprawl have created new sources of pollution and have contributed to a doubling of vehicle travel, as well as to significant increases in other modes of travel since the mid-1970s (*2*).

The CAA assigned specific responsibilities to government and private industry to reduce emissions from vehicles, factories, and other sources of pollution. Criteria air pollutants—regulated by the U.S. Environmental Protection Agency or by states—have been reduced in many metropolitan areas to levels permissible under health-based standards (*1*). From 1992 to 2001, total emissions of carbon monoxide have decreased by 14 percent; oxides of nitrogen (NOx), by 12 percent; and volatile organic compounds (VOC), by 22 percent (Table 1).

The transport of people and goods is one of the most easily recognized major contributors to emissions in urban areas. The CAA Amendments and subsequent regulations strengthened the requirements for controlling tailpipe emissions and established new rules for metropolitan areas developing transportation and air quality plans. As a result, concentrations of carbon monoxide and 1-hour ozone measurements have decreased across most metropolitan areas (*1*).

Reduction in transportation emissions has played a key role in the reduction of ozone emissions, in spite of a 22 percent growth in passenger-miles and a 22 percent increase in ton-miles from 1990 to 1999 (Tables 2 and 3).

In the past decades, regulations have reduced the amount of emissions that on-road vehicles contribute to the overall inventory (Figure 1). During the same period, the relative contribution of nonroad transportation emissions (such as gas or diesel nonroad engines, air, marine, and rail emissions) has increased to 15 to 20 percent of total emissions (Figure 2). Nonroad tonnage of carbon monoxide has increased 10 percent in the past 10 years; nonroad tonnage of NOx has increased 6 percent; and nonroad tonnage of VOC has decreased 5 percent.

Control of nonroad transportation emissions is a key to air quality improvement in urban areas. The contribution of on-road emissions to urban air quality is diminishing. Figure 1 shows minimal changes in the on-road contribution to overall emissions over the past years, although carbon monoxide and NOx show slight increases. Improvement in transportation air quality will occur by addressing the issue as a multimodal problem—that is, by addressing emissions from rail, marine vehicles, air transport, and nonroad engines.

TABLE 1 Emissions from All Sources (thousands of short tons)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total of All CO	140,896	135,901	133,559	126,777	128,860	117,913	115,382	117,229	123,568	120,759
Total of All NOx	25,260	25,357	25,349	24,956	24,790	24,712	24,349	23,671	23,199	22,349
Total of All VOC	23,066	22,730	22,569	22,041	20,870	19,534	18,783	19,378	19,704	17,963
Total of All $PM_{2.5}$	7,198	7,150	7,541	6,929	6,726	6,257	6,263	6,813	8,175	7,380
Total of All PM_{10}	27,097	27,364	28,610	25,819	22,862	22,912	22,900	21,632	24,699	24,104

Source: U.S. Environmental Protection Agency, *National Air Quality and Emission Trends Report*, February 2003. http://www.epa.gov/air/data/

TABLE 2 U.S. Passenger-Miles by Mode (millions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Air	358,873	350,185	365,564	372,130	398,199	414,688	446,652	463,112	476,362	501,857
On-Road	3,582,814	3,622,061	3,718,749	3,789,063	3,857,108	3,912,390	4,029,420	4,153,256	4,266,147	4,326,474
Maritime	410	430	453	511	492	533	604	663	735	779
Rail	25,185	24,807	24,849	24,075	25,418	25,208	25,888	26,295	27,420	28,204

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 2001*, BTS02-06, July 2002.

Air Transportation

Transport of air passengers and air cargo has increased significantly in the past four decades (Tables 2 and 3). Passenger-miles of travel on airplanes peaked at 508 billion in 2000 and slipped back to 480 billion in 2001, equivalent to passenger mileage in 1999. Forecasts project a short-term decline in passenger-mile growth before a return to positive rates (*3*).

Many sectors of the airline industry already are experiencing positive growth in monthly traffic. Cargo growth also has increased at dramatic rates during the past decade, with 14.2 billion ton-miles of cargo moved in 1999 (Table 3), a net growth rate of 5 percent per year from 1990 levels.

The major sources of emissions are vehicles operating at airports—not only the aircraft, but also the surface vehicles, such as transit and private automobiles, as well as the ground support equipment for aircraft towing, baggage handling, refueling, and food service. Air quality at airports is predicted to become a significant environmental concern (*4*).

International and U.S. regulations have set minimum levels of carbon monoxide, hydrocarbons (HC), and NOx emissions from aircraft. Production of emissions from aircraft is a function of aircraft and engine type, landing and take-off cycles, cruise mileage, and airport characteristics—for example, congestion and taxi times.

Criteria air pollutants from aircraft contribute relatively small amounts—less than 1 percent—to the nationwide transportation emissions inventory (*5*). However, emissions have increased with increased

TABLE 3 U.S. Ton-Miles of Freight by Mode (millions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Air	9,064	8,860	9,820	10,675	11,803	12,520	12,861	13,601	13,840	14,202
On-Road	735,000	758,000	815,000	861,000	908,000	921,000	972,000	996,000	1,027,000	1,093,000
Maritime	1,033,969	1,038,875	1,066,781	1,109,309	1,200,701	1,305,688	1,355,975	1,348,926	1,376,802	1,433,461
Rail	833,544	848,399	856,685	789,658	814,919	807,728	764,687	707,410	672,795	655,862
Pipelines	584,100	578,500	588,800	592,900	591,400	601,100	619,200	616,500	619,800	617,700

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 2001*, BTS02-06, July 2002.

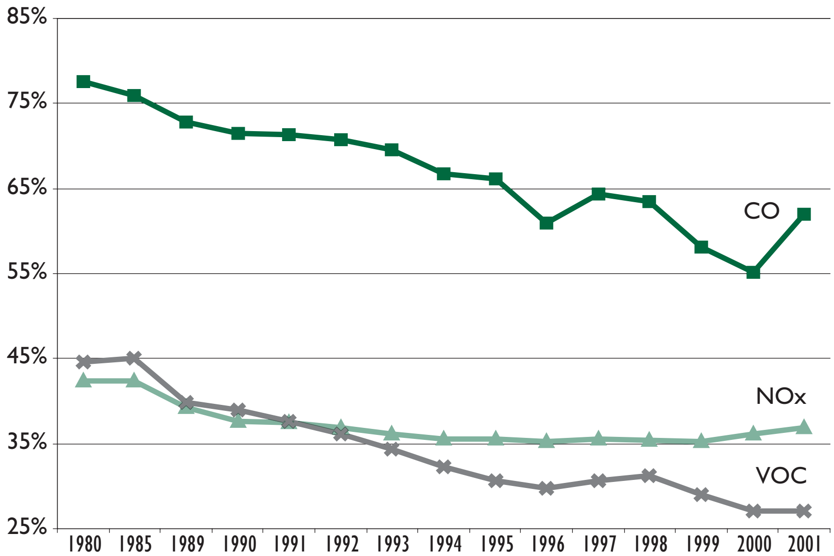

FIGURE 1 On-road vehicle contribution to total emissions.

aircraft activity, and the problem is more pronounced at the metropolitan level, because the largest airports are located in areas prone to air quality problems.

The 20 largest airports in the United States serve more than 50 percent of all enplaned passengers. Of these 20 airports, 13 are located in the largest nonattainment metropolitan statistical areas, contributing to poor air quality for 67 million people.

Marine Transportation

All forms of motorized water transportation produce air emissions. Passenger travel by water modes contributes minimally to emissions, but cargo shipping and recreational boating contribute significantly (*5*). As with aviation, regional contributions of HC and NOx from marine sources vary according to the level of activity. Other factors influencing water transport emissions are demand for travel, numbers of trips, trip characteristics, engine and vessel age, fuel efficiency, and emissions controls.

Emissions from marine vessels occur over dispersed spaces, in contrast with more concentrated on-road emissions. Water transportation contributes less than 1 percent of carbon monoxide and VOC emissions, yet 8 percent of the transportation-related NOx in 2000 issued from waterborne vehicles. The total contribution to NOx has remained steady over the past decade, at approximately 1 million short tons of emissions (*5*).

Pollution control standards for marine engines are based on engine power. New rules are reducing engine emissions with stringent controls on HC and NOx in the near term and with technological requirements in the long term. Although emissions from waterborne freight are relatively steady, recreational boat emissions have increased rapidly and can affect metropolitan air quality. The combined controls on marine engines are expected to decrease primary pollutant emissions and the resulting concentrations (*6*).

Rail Transportation

Rail moves 38 percent of freight ton-miles—the largest share of any mode (Table 3). Market share of freight movement by rail has increased over the past decade. Total tonnage increased by 38 percent from 1.034 trillion tons to 1.434 trillion tons. This growth rate has occurred as industry consolidation and changes have reduced the number of rail companies from 71 in 1970 to 9 in 2000, and as the mileage of track owned by rail companies has decreased by 50 percent to 99,430 miles (*7*).

Passenger rail service via Amtrak, heavy rail, commuter rail, and light rail carries less than 1 percent of the total passenger traffic in the United States. Light, commuter, and heavy rail have grown as passenger modes, as urban rail systems have expanded. In larger metropolitan areas, where air quality problems are the highest, rail is an alternative to the private automobile.

Estimated emissions from rail activity in an urban area are based on locomotive type, engine characteristics, fuel type and efficiency, and trip characteristics. Generally, freight transportation relies on diesel engines, and urban rail systems are electric. Carbon monoxide and VOC emissions from rail are less than 1 percent; however, in 2000, 4 percent of total NOx emissions were attributed to rail, a proportion that has remained steady for the past decade (*5*).

Modal Impacts

These trends and emissions contributions focus on modal activity estimates and the direct results for urban air quality. A life-cycle analysis can provide additional insights into the modal impacts.

Increased use of a mode of transportation has a downstream impact on total emissions. For example, shifting trips from the personal automobile to rail transit may have direct emissions benefits for an urban area. But the savings and costs associated with the manufacturing and disposal of the rail transit vehicle, the construction of the facility needed for the vehicle, and the maintenance of the facility also should be considered among the large-scale impacts of transportation on the environment (*8*).

Regional and national emissions analyses therefore should account for cumulative and indirect impacts, which are important in the urban intermodal transportation plan. For example, the construction or capacity expansion of an airport has direct air quality impacts but also has impacts on other modes. As a result of changes at an airport, the surrounding roads will support increased activity and possibly will need construction to support the new demand. In addition, the on-road—and downstream—emissions will have increased.

The emissions levels highlight the importance of nonroad vehicles and engines for air quality. Nonroad transportation activity will continue to increase, and regulation of the engines of each mode is critical to slowing the growth of pollutants produced.

These data are on a national scale, but in many instances, the modal issues are greater at the local level. Aviation is a small contributor nationwide, but the concentration of commercial aviation at the largest airports in the largest cities increases the importance of the mode in controlling urban emissions. Marine and rail contributions to urban emissions are also site-dependent, with levels varying according to each city's intermodal network.

The transportation component of urban air quality is a multimodal problem, with the growth rates of nonroad activity and nonroad emissions surpassing onroad rates. Policies and analyses of urban air quality must address multimodal transportation activity to achieve continued improvement of air quality within metropolitan areas.

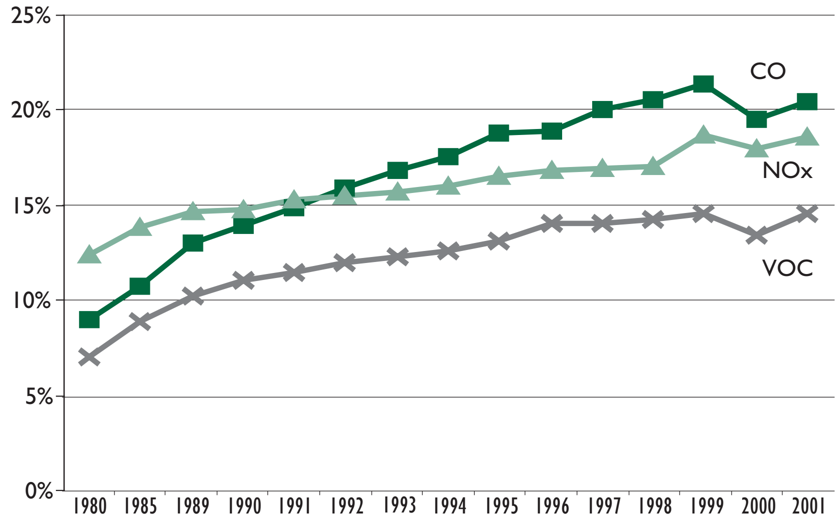

FIGURE 2 Nonroad engine and vehicle contribution to total emissions.

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www.epa.gov/airs/nonattn.html

Transportation in an Age of Climate Change

What Are the Research Priorities?

PHOTO: BOB MCMILLAN/ FEMA NEWS PHOTO

JOANNE R. POTTER AND MICHAEL J. SAVONIS

Potter is Senior Associate, Cambridge Systematics, Chevy Chase, Maryland; Savonis is Team Leader for Air Quality, Federal Highway Administration, Washington, D.C.

As scientists learn more about climate change, public awareness about risks to the planet from rising temperatures, climatic shifts, and dwindling glaciers is growing. Increased concentrations of greenhouse gases in the atmosphere—most notably, of carbon dioxide—are causing warmer surface temperatures and are triggering complex and global climatic interactions.

Examining the consumption of carbon-based fuels and identifying strategies to reduce greenhouse gas emissions is a challenge for all sectors. In the past decade, transportation's role in contributing to anthropogenic emissions has received increased attention, but few researchers have focused on what climate changes mean for transportation. In the past year, transportation professionals and climate change researchers have started a dialogue on this topic.

Working with the Environmental Protection Agency, the Department of Energy, and the U.S. Global Change Research Program, the U. S. Department of Transportation's (DOT) Center for Climate Change and Environmental Forecasting[1] hosted a workshop of leading experts and decision makers, October 1–2, 2002, to discuss the potential impacts of climate change on transportation. Convened at the Brookings Institution in Washington, D.C., the Potential Impacts of Climate Change on Transportation Research Workshop had a twofold purpose:

1. To consider the implications of a changing climate on the future of transportation—and how the transportation community could prepare to avoid or adapt to these potential impacts; and
2. To gain input and perspectives on the research necessary to understand these impacts.

The 64 invited participants included senior transportation professionals, regional and national stakeholders, and some of the nation's foremost experts in climate change and assessment research, the environment, planning, and energy. Following is an overview of what science suggests about the implications of climate change for transportation, along with a summary of the results of the workshop.[2]

Reading the Evidence

Scientific evidence shows that the world's climate is changing. Although the reasons for the changes are the subject of ongoing research and discussion, the changes are the impetus for the transportation community to examine the impacts and necessary adaptations. The most significant climate trends include changes in temperature, hydrologic patterns, and incidences of severe weather. Each of these changes may affect transportation.

[1] Established in 1999, the Center for Climate Change and Environmental Forecasting coordinates U.S. DOT efforts to understand and address transportation and climate change issues and mitigation strategies. Eight U.S. DOT operating administrations and the Office of the Secretary guide the multimodal virtual center. Further information is available at http://climate.volpe.dot.gov.

[2] A complete workshop report is available at http://climate.volpe.dot.gov.

The world is getting warmer, but not all regions are warming at the same rate. Northern climates are warming faster, and the impacts are evident in the Arctic, including Alaska and northern Canada (*1*). Moreover, nighttime lows currently are increasing faster than daytime highs.

The world's hydrologic cycle is evolving in response to changes in temperature, also with regional variations (*1*). In some rivers and lakes, water levels are high because of increased precipitation. Yet in other areas, levels have dropped—for example, evaporation and other climate changes have contributed to lower water levels in the Great Lakes. The southeastern United States shows increasing rates of precipitation (Figure 1). Although these changes are complex and hard to predict, the impacts can be significant and devastating.

Extreme weather events—such as hurricanes, blizzards, and droughts—have destructive effects:

◆ In October 2002 tropical storm Lily caused flooding and economic damage to the New Orleans, Louisiana, area. Already below sea level, the region is particularly vulnerable.

◆ Hurricane evacuations of the North Carolina Barrier Islands were commonplace in the late 1990s, causing day-long traffic backups, environmental damage, and economic losses.

◆ In March 2003, Colorado was blanketed by more than 4.5 feet of snow, stranding residents for days.

The possibility that severe weather events such as these, associated with ongoing climate change, might become more frequent, more destructive, or affect more regions that are less prepared, demands attention. Significant research already has been completed.

Climate Change Impacts Research

At the request of Congress, the U.S. Global Change Research Program (USGCRP) organized the U.S. National Assessment, a multiyear research effort to understand and assess the consequences of climate variability and change.[3] A November 2000 USGCRP report provides a snapshot of the potential impacts of climate change on the United States, along with the relative degree of certainty in the projections (*2*). The box on page 28 summarizes the range of impacts identified.

Under the auspices of USGCRP, partnerships among universities, government agencies, and stakeholders have undertaken regional and sectoral impact assessments. As of February 2003, 11 regional assessments have been published, and additional studies are forthcoming.[4] Also completed are five sectoral assessments exploring impacts on water resources, human health, coastal areas and marine resources, forests, and agriculture.[5] Additional USGCRP research initiatives are profiled in a 2003 report (*3*).

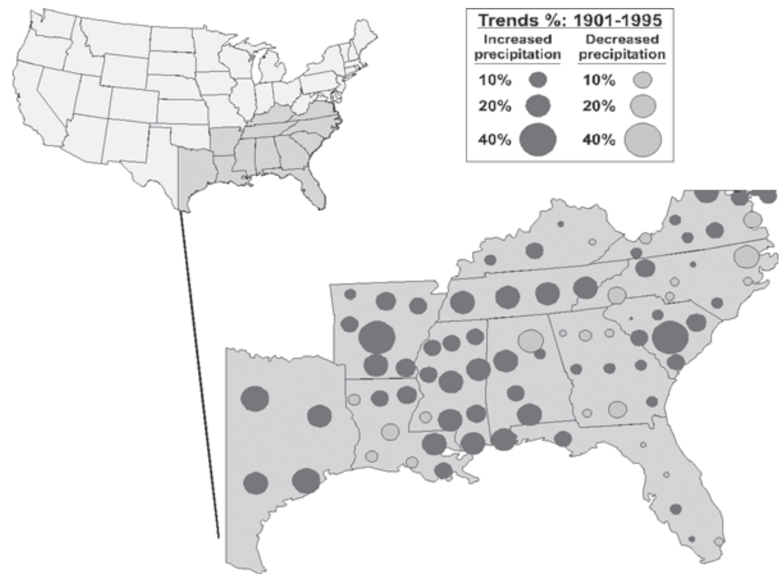

FIGURE 1 Trends in precipitation in the Southeastern United States.

Source: National Climatic Data Center, National Atmospheric and Oceanic Administration, Asheville, North Carolina, 2000.

Elaborating on the USGCRP assessments, other studies have explored various aspects of climate change—for example,

◆ Researchers have examined sea level rise and other impacts of climate change in the New York metropolitan area (*4, 5*).

◆ The National Research Council has provided an overview of key questions about climate change (*6*).

◆ The Pew Center on Global Climate Change has sponsored a related series of studies, detailing changes in precipitation patterns and the water cycle, sea-level rise, forests, and agriculture.[6]

A Federal Emergency Management Agency report on the effects of shoreline erosion in coastal communities and the Great Lakes regions (*7*) is one of several investigations into the possible effects of climate and weather phenomena on emergency preparedness and property loss.

Internationally, the impacts of climate change have been the subject of studies prepared in Canada (*8*) and

[3] www.usgcrp.gov/usgcrp/nacc/default.htm.

[4] For links to regional assessments: www.usgcrp.gov/usgcrp/nacc/default.htm and www.usgcrp.gov/usgcrp/nacc/allreports.htm.

[5] For links to sectoral assessments: www.usgcrp.gov/usgcrp/nacc/default.htm.

[6] www.pewclimate.org/projects

Impacts of Climate Change on the United States

1. Increased warming and more intense precipitation.
2. Differing regional impacts, with greater warming in the western United States, but a greater rise in heat index in the East and South.
3. Increased vulnerability of ecosystems, particularly in alpine areas, barrier islands, and forests in the Southeast.
4. Decreased water supply across the country, with increased competition for available resources, and the potential for more droughts and floods, as well as reduced winter snowpack, in some areas.
5. Increased availability of food, with increased crop productivity; accompanying economic stress for farmers in marginal areas, because of lower commodity prices.
6. Increased forest growth in the near term and increased susceptibility of some forests to fire, pests, and other disturbances in the long term.
7. Increased damage to coastal regions as the sea level rises and storms increase in intensity; and to other areas from melting permafrost.
8. More adaptations to improve health outcomes, including strengthening the nation's community and health infrastructure.
9. Increased adverse impacts on coral reefs, wildlife habitats, and air and water quality.
10. Continuing uncertainties in understanding changes and greater potential for unanticipated changes.

Adapted from MacCracken, M. C. National Assessment of the Consequences of Climate Variability and Change for the United States. In *The Potential Impacts of Climate Change on Transportation*, Center for Climate Change and Environmental Forecasting, U.S. Department of Transportation, Washington, D.C., forthcoming. [Condensed from National Assessment Synthesis Team (2).]

the United Kingdom (*9*). The Intergovernmental Panel on Climate Change (IPCC), an organization formed by the United Nations and the World Meteorological Organization to provide international assessments of climate change issues, also has published an examination of global impacts (*10*).

Transportation Concerns

Few studies have focused primarily on transportation concerns in the United States, but assessments suggest far-reaching implications. For example, in the long term,

◆ Changing coastlines and rising sea levels could require, in the long term, relocation of roads, rail lines, or airport runways and could have major consequences for port facilities and coastal shipping.

◆ Underground tunnels for transit systems, roads, and rail could be subject to more frequent or severe flooding (*11*).

◆ In Alaska, thawing permafrost could damage roads, rail lines, pipelines, and bridges.

◆ Declining water levels in the Great Lakes could have an adverse impact on shipping.

◆ An increase in the number of hurricanes and other extreme weather events would have implications for emergency evacuation planning, facility maintenance, and safety management for surface transport, marine vessels, and aviation.

◆ Changes in rain and snowfall, and in seasonal flooding patterns, could affect safety and maintenance operations.

In addition to the planning, siting, design, and management of transportation facilities, the prospect of climate change raises other, less obvious, questions. For example, some research suggests that increasing temperatures could exacerbate near-surface ozone concentrations, making it more difficult for metropolitan areas to maintain air quality standards.

Shifts in climate that affect ecosystems and the viability of natural resources would have an impact on agriculture, fisheries, and forestry production, which could have long-term implications for freight transport. If climate change causes the relocation of these and related industrial and business activities, significant investments in transportation and other infrastructure can be expected.

With all the many possibilities, assessing the implications of climate change for transportation is not a straightforward task. Social and economic factors—including technology development, demographic shifts, and the rate of economic growth or contraction—will influence future transportation needs, the location of transportation networks, and investment in the nation's infrastructure.

Furthermore, although the state of science in modeling climatic changes has advanced rapidly, significant uncertainties remain about how global climate change will unfold. As studies project what could happen at specific regional and local areas, the level of uncertainty increases. In addition, the National Assessment notes the high potential for "surprises"—major, unexpected events with significant impacts.

In sum, the possible effects of climate variability and change could have implications at each stage of transportation decision making, from planning to operations to maintenance. The variety of potential impacts is illustrated in Figure 2.

Research Directions

Projecting the impacts of climate change presents a complex challenge for transportation decision makers. Managers may need to incorporate a range of possible effects into investment decisions and management strategies.

Objective information about the possible impacts, the potential severity, and the probability of the effects must inform decision making. Further, long-range transportation plans and investment strategies must be sufficiently robust to accommodate unanticipated events.

Transportation decision makers need to know the policy and management options and be able to assess the strengths and weaknesses of the options. This will require research that builds on climate change science focused on transportation concerns.

Research Framework

The U.S. DOT Center for Climate Change has initiated research in this area and has encouraged the consideration of transportation concerns in other research projects. The Potential Impacts of Climate Change on Transportation workshop kicked off U.S. DOT's research endeavor.

Several experts were invited to develop papers to provide background information and to introduce case examples of issues and research related to climate changes and infrastructure. The 18 informative and thought-provoking papers introduced both the research community and transportation decision makers to the variety of connections between climate change and transportation and opened the door to further interdisciplinary study and dialogue.

Workshop participants broke into interdisciplinary working groups to discuss specific aspects of the research challenges. The six groups—each with a particular geographic and modal perspective (Table 1)—addressed three questions:

- ◆ What are the most significant potential problems that climate change poses for transportation?
- ◆ What are the priority research topics?
- ◆ Who should take the lead in the research?

Research Priorities

Six key themes for research emerged through the day and a half of workshop discussions. The research can help transportation planners and managers prepare for and manage the impacts of climate change on the transportation system. At the same

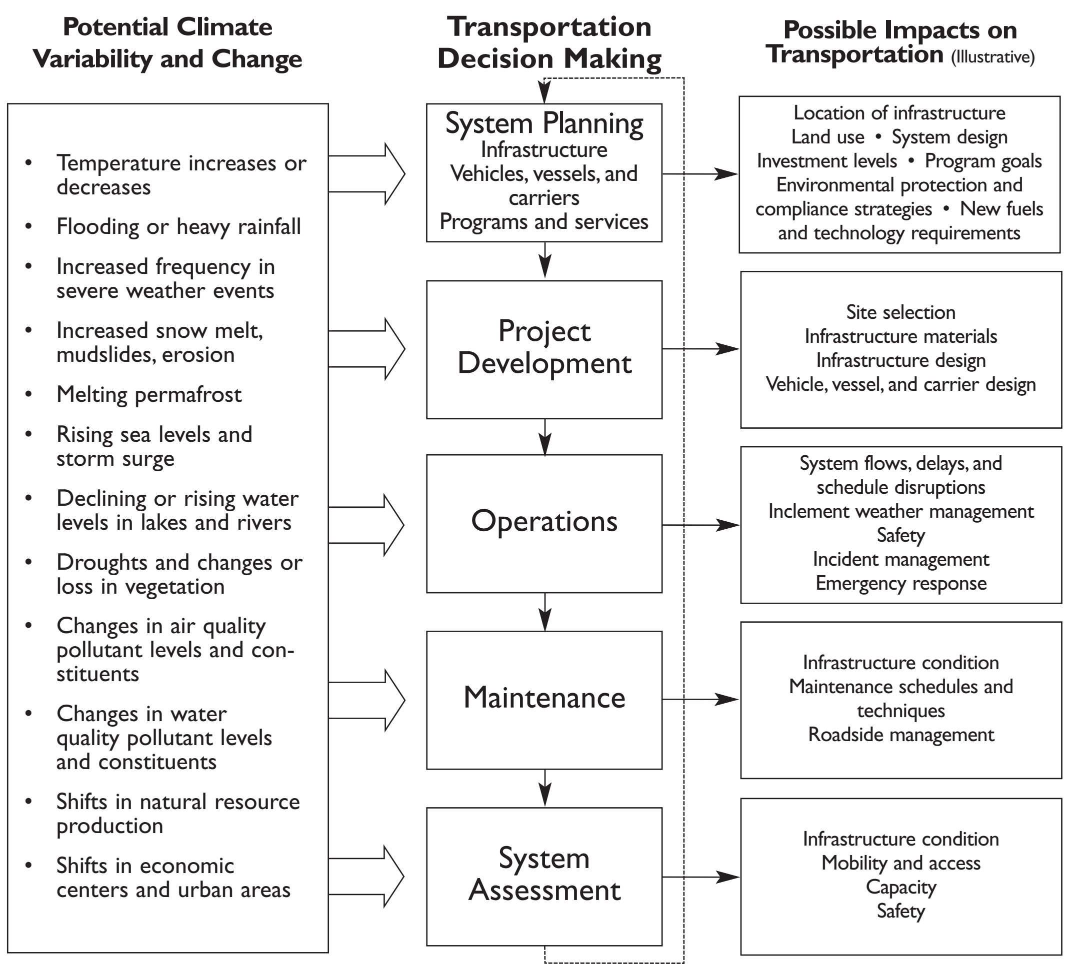

FIGURE 2 Effects of potential climate change on transportation decision making.

TABLE 1 Research Framework for Regional and Modal Analysis

	REGIONAL FOCUS		
MODAL FOCUS	COASTAL	INTERIOR	GREAT LAKES and RIVERS
Marine	X		X
Rail, Road, and Pipeline	X	X	
	NATIONAL FOCUS		
Aviation	X		
Transportation Systems Perspectives	X		

time, the research and transportation communities need to make research findings available to transportation decision makers.

1. Develop tools for making regional and local climate and weather projections.

The need for improved regional-level modeling and scenario development was a recurring theme in the breakout groups and in the full-group discussions. Although better use of available information can help to inform some transportation decisions today, transportation planners and managers need more refined models and projections.

Because transportation decisions and investments are made most often at local and regional levels, models and scenarios should incorporate and respond to specific local and regional climate and weather projections. Regional and local-level models should allow analysis of the variation in risks to transportation systems in different parts of the country.

2. Assess the impacts on critical infrastructure locations and facilities.

Improved regional-level climate and weather projections would improve modeling and analysis of the potential climate impacts on transportation infrastructure. Planners and transportation managers could identify the facilities and locations that may be affected. Of particular interest to transportation are hydrologic changes, changes in the patterns and location of extreme events, changes in coastal geography and storm activity, and changes in prevailing climate and weather.

3. Analyze the impacts on operations, maintenance, and safety.

Climate changes have implications not only for the built transportation infrastructure but also for the safe and efficient management and operation of the transportation network. Research to understand the potential effects of long-term climate change on adverse weather conditions, temperatures, and seasonal precipitation patterns, as well as the meaning of these shifts for seasonal and real-time management of the transportation system, will improve understanding of the challenges to system operation.

4. Improve tools for risk assessment and decision making.

Transportation managers need improved tools to incorporate climate change data and projections into decisions about planning, asset management, and operations. Techniques to assess the relative risks of climate change to different components of the transportation network will allow decision makers to target resources appropriately to the most significant infrastructure and systems. Geographic information system technologies and scenario modeling could assist in identifying key concerns and evaluating response strategies.

5. Integrate climate change assessment into other transportation decisions.

Transportation decision makers need frameworks to integrate consideration of climate changes with other key dynamics, including development patterns, technological advances, economic trends, and ecological changes. Tools are needed to integrate impacts assessments with environmental assessments and with transportation planning across all modes.

6. Assess response strategies.

Research is needed to improve understanding of the range of response strategies that enable transportation managers to avoid or adapt to the impacts of climate changes on transportation and to develop new responses. Decision makers will need tools to evaluate an array of strategies—including changes in infrastructure location, engineering and design responses, operational strategies, and modal shifts—and to assess the direct costs and benefits of each option. Also needed are insights into each strategy's long-range effects on ecological systems, its economic and social effects, and its economic implications.

Maximizing Research Results

In addition to research priorities, workshop participants identified key actions to advance the state of knowledge, support transportation managers in making sound decisions, and enable researchers to be more effective.

1. Improve sharing of data and knowledge.

Workshop discussions highlighted the considerable amount of research already completed by federal agencies and private organizations, producing valuable data and research products for use by transportation decision makers. Yet much of this information has not reached transportation managers or the general public. Customizing and disseminating available data and knowledge for use by policy makers and by other researchers warrants increased attention.

2. Coordinate strategic priorities with the U.S. Climate Change Science Program.
Many participants suggested that U.S. DOT and other federal agencies should coordinate research priorities with the U.S. Climate Change Science Program (CCSP), which is developing the interagency strategic plan for federal climate change research. U.S. DOT is a federal partner of CCSP and is involved in developing the strategic plan, recently released in draft (*12*) and evaluated by the National Research Council (*13*).

3. Leverage ongoing and completed research.
Participants emphasized opportunities for transportation professionals to work more closely with colleagues in the climate and weather research communities, to share knowledge and resources in this emerging research field, and to pursue multidisciplinary approaches. Many participants encouraged U.S. DOT to collaborate with research partners to tap expertise in other fields and to leverage the investments of other organizations in climate change research. Working with other federal agencies, international agencies, industry, and academia can help make the best use of limited resources.

4. Engage in public education and outreach.
Participants stressed the need to improve public access to—and awareness of—research findings, noting the responsibility of the transportation and research communities to provide this information through readily understood formats and tools. Improved availability of information on the range of potential climate changes will help the public participate effectively in transportation planning and will support sound community decisions and investments.

Multidisciplinary Challenge

The Potential Impacts of Climate Change on Transportation workshop has stimulated a new level of dialogue between the climate change and transportation research communities—the beginning of a multidisciplinary discussion that can guide scientists and practitioners in both arenas. The challenge is to

◆ Develop tools to improve prediction of the impacts of changing weather,
◆ Identify regional climate changes,
◆ Determine transportation facilities and services responsive to those impacts, and
◆ Identify strategies for adaptation.

This research will lead to a more robust and resilient transportation network, reducing delays and avoiding unnecessary costs and economic losses.


PHOTO: MARY HOLLINGER/NOAA

Flooding of low-lying areas by extreme high tides, Lower Patuxent River, Maryland.

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TRB SPECIAL REPORT

Freight Capacity for the 21st Century

JOSEPH R. MORRIS

In every sector of the U.S. freight transportation industry in the past decade, service providers and customers sounded the alarm that facilities were inadequate for the demands of traffic growth. Trucking companies saw highway congestion eroding performance and profits, rail customers experienced service disturbances in the aftermath of industry mergers, and port operators sought federal assistance to cope with unprecedented growth in international trade. Responding to capacity demands, however, is complicated by conflicts between the requirements of passengers and freight sharing the same facilities and by the needs to balance demands for environmental quality, to preserve communities, and to accommodate economic growth.

The National Research Council of the National Academies convened the Committee for the Study of Freight Capacity for the Next Century (see box, page 34), under the auspices of the Transportation Research Board (TRB), to consider how government policy can allow more efficient provision of freight transportation system capacity. The committee's study was sponsored by the Federal Highway Administration, the U.S. Army Corps of Engineers, the state departments of transportation (DOTs) through the National Cooperative Highway Research Program, and TRB.

The committee's conclusions, published in *Special Report 271: Freight Capacity for the 21st Century*, address the implications of historical developments for freight system capacity and performance in the coming decades. The committee's recommendations identify opportunities to improve government decisions on operating and expanding transportation facilities.

Prospects for Freight Capacity

The committee examined trends in traffic, performance, capital expenditures, and capital stock for the freight modes and noted an unprecedented pattern of tight capacity in parts of the system. Extrapolating the trends magnifies the concern: by 2020, the nation's total output probably will increase by 70 percent, highway travel and all domestic freight traffic will increase by 40 percent, and international container traffic will double.

The strong economic growth of the 1990s placed exceptional demands on the transportation system but may not represent the trend of the next several decades. Nonetheless, even modest growth will cause a deterioration of performance if freight capacity is allowed to stagnate.

Prominent developments have included increased highway congestion and a slowdown in adding highway capacity; downsizing of the rail infrastructure, with disturbances of service; congestion at terminals and border crossings; lengthening lead times and rising costs of infrastructure projects; and freight–passenger conflicts in cities. These trends present challenges to public and private providers of freight transportation services and facilities.

Capacity is being added. For highways, improvements to current facilities are more frequent than construction of new routes. Overall, highway capital stock is being added faster than it is wearing out.

Railroads and ports have reported ambitious infrastructure spending plans. Market developments, including future global patterns of trade and commodities production, will determine the scale and locations of rail and port markets expansion.

Congestion in the freight transportation system remains localized, but congestion at a bottleneck can have systemwide repercussions. The growth of international trade may exacerbate bottlenecks by concentrating freight traffic at a small number of nodes, including certain ports and border crossings.

Productivity growth in freight transportation historically has been impelled by technological and institutional breakthroughs. Improvements in vehicle and infrastructure technology will continue to be important, as will information technology applications to coordinate operations. Timely and appropriate reforms in management, operations, and finance could yield dramatic gains in transportation efficiency.

Increasing population density, urbanization, and wealth ensure increases in conflicts between freight and passenger traffic; in conflicts between freight transportation and residential, recreational, and other competing land uses; and in requirements to control pollution. These will increase the cost of expanding capacity and add to the risk of investment.

Choosing a Course

The United States has ample resources for expanding the transportation system; however, if capacity addition lags, traffic grows, and congestion worsens, the long-run consequence will not be massive breakdown. Instead, users will adjust to accommodate or avoid congestion. Shippers will change logistics practices. Workplaces and residences will move away from congestion within regions and to other less-congested regions. Production will move abroad if congestion costs cause the United States to lose comparative advantage in some industries.

Therefore, one plausible course of development is to continue to accommodate growing freight traffic by increasing capital spending, by accepting more congestion, and by moving activity away from the most congested locations. This may be tolerable but will be far from optimal, because capacity will be used poorly on parts of the system if users do not pay prices that reflect costs and if operators lack incentives to be responsive to user costs and preferences. Moreover, the targeting of capital expenditures faces obstacles, particularly in the public sector.

Public capital spending will dissipate much of its impact because some high-payoff projects are passed by and some low-payoff ones are carried out. Changes in government policy that would allow the nation to make better use of current capacity and better investment decisions would have important economic benefits.

Lessons from Case Studies

The committee examined transportation projects as case studies to illuminate the institutional setting of project-level decision making. The cases suggest that certain basic questions about the management of public transportation programs are not being examined adequately.

Governments often fail to recognize and take advantage of the link between project finance and performance. Consequently, public agencies usually do not evaluate how alternative funding mechanisms or user fee arrangements would affect the performance of transportation programs and do not follow funding practices that maximize the chance of producing successful projects.

The case studies indicate that, in project evaluation, governments usually do not compare returns from the selected freight-related projects with returns from alternative transportation uses of the funds. The cases, however, illustrate that solutions to freight and passenger capacity problems often may be complementary, because capacity problems often originate in operating practices that are not optimal.

General Principles

The study committee offered a general recommendation about principles to guide decisions on government programs affecting freight capacity. Specific recommendations addressed investment, management of facilities, decision-making methods, and regulation.

Comprehensive Freight Program

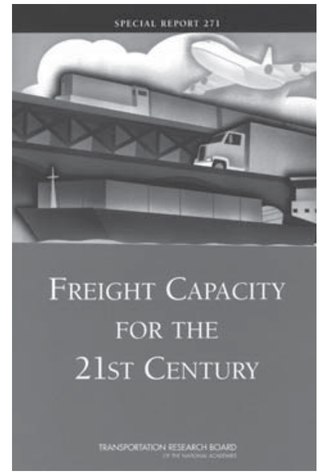
The performance of the system and the adequacy of freight capacity in the next decades will reflect the outcomes of government decisions on spending, regulations, and operations. Decisions on these matters, however, often address narrow concerns, guided by short-run considerations. A coherent government effort is needed at the national level, taking into account the cumulative, long-run consequences of government decisions and applying consistent principles in decision making.

Guiding Principles

Experience in the United States and other countries demonstrates that respecting the following four principles will enable the freight infrastructure to provide the capacity and performance with the greatest contribution to the nation's economic well-being:

◆ The primary goal of government transportation policy should be economic efficiency—capital improvements and operating practices should yield the greatest net economic benefit, considering all costs.

◆ Government involvement should be limited to circumstances in which market-dictated outcomes are far from economically efficient—for example, preventing monopoly power and dealing with non-



Special Report 271: Freight Capacity for the 21st Century is available from TRB (see Publications Order Form in this issue).

Committee for the Study of Freight Capacity for the Next Century

Benjamin J. Allen, Provost in the Interim, Iowa State University, Ames, *Chair*
Paul H. Bingham, Principal, Global Insight, Inc., Washington, D.C.
Lillian C. Borrone, Avon by the Sea, New Jersey
Kenneth J. Button, Professor of Public Policy, The Institute of Public Policy, George Mason University, Fairfax, Virginia
Joseph J. Catto, President, Professional Representation, Inc., Morris Plains, New Jersey
G. Edward Dickey, Consultant, Baltimore, Maryland
Stephen W. Fuller, Professor, Department of Agricultural Economics, Texas A&M University, College Station
Cameron Gordon, Executive Director, American Council on Intergovernmental Relations, New York
Randall K. Halvorson, Assistant Commissioner for Transportation Research and Investment Management, Minnesota Department of Transportation, St. Paul
James R. Hertwig, President, Landstar Logistics, Jacksonville, Florida
James W. McClellan, Senior Vice President, Norfolk Southern Corporation, Norfolk, Virginia
Edward K. Morlok, UPS Foundation Professor of Transportation, University of Pennsylvania, Philadelphia
Carmine Palombo, Director, Transportation Programs, Southeast Michigan Council of Governments, Detroit
Evelyn A. Thomchick, Associate Professor of Business Logistics, Pennsylvania State University, University Park

market costs. Government also should be responsible for facilities it has historically managed and should exercise leadership in complex institutional settings. The federal government should be responsible if a conflict arises between national and local interests and for ensuring transportation facilities for the nation's defense.

◆ Government's responsibility to provide facilities or leadership in a project does not necessarily justify government subsidy of the costs. If a public-sector freight-related project directly benefits the users of the facilities by reducing transportation and logistics costs, the users should pay the costs.

◆ Finance provisions in public-sector transportation programs determine performance, affecting both the quality of investment decisions and the efficiency of operations. Relying on revenue from users, and from local matching funds in federal grant programs, will increase the likelihood that the most worthwhile improvements will be carried out and that facilities will be operated and maintained efficiently.

Many government investment and operating decisions are not consistent with these principles, and applying them may be controversial. Nonetheless, applying these principles affords the only realistic prospect for the nation to continue to enjoy the benefits of freight transportation productivity growth in the long run.

By themselves, technology, better planning, and increased spending levels will be unable to achieve comparable results. Keeping up with growth within the constraints that will be imposed on the transportation system in the future will be possible only if operators extract more service from facilities and higher returns on investment by selecting better projects. Finance reform in government programs and greater reliance on markets can help attain both of these goals.

The current inefficient use of transportation capacity should be regarded as a large, hidden reserve to be tapped through improved management. Revenues from appropriate user fees in many circumstances would be the best indication of where capital expenditure to expand capacity would be most valuable.

Specific Recommendations

The committee offered recommendations on specific programs to illustrate how the principles can be applied to government decisions on federal infrastructure programs, decision-making processes and planning, and regulatory issues.

Federal-Aid Highway Program

Because trucking accounts for the majority of U.S. freight transportation expenditures and the federal government has a leading role in national highway programs, no federal activity has greater significance for freight capacity than the federal-aid highway program. Highway services are essential to the functioning of the rail, air freight, port, and waterway systems. The next federal surface transportation program should further three goals:

◆ Maintain and reinforce the principle of user financing, reforming the structure of fees to relate more closely to the costs each highway user imposes.
◆ Support improved operation and maintenance of highway facilities.
◆ Provide funding to ensure that states have the resources to maintain the overall performance of the highway system.

The report details the provisions that Congress should enact to promote these goals.

Any programs that Congress enacts to redirect state and local government project selection toward freight-related projects should satisfy the following criteria:

◆ Sustain the user-pays principle that underlies the federal-aid program.

◆ Sustain support by funding projects that fee payers recognize as having value.

◆ Rely primarily on adjusting user fees instead of offsetting subsidies to competing modes, to ensure that the market outcomes of competition between trucking and other modes are in the public interest.

◆ Require ongoing and retrospective evaluation of the performance of the programs receiving federal multimodal credit assistance.

New Systems

Congress should direct U.S. DOT, in cooperation with the states and the private sector, to study the costs and market potential of exclusive truck facilities.

The committee recommends that the Administration and Congress reexamine the planning process for new projects as well as the present rules on funding formulas and sources for harbor and channel improvements, to ensure that available funding is concentrated on the projects with greatest net benefits. The committee urges Congress to recognize that tying channel capacity expansion and maintenance to project-specific user fees would have economic benefits.

Congress and the Administration should direct the U.S. Army Corps of Engineers to improve the efficiency of congested locks on inland waterways through demand management. Congress should begin to rely on revenues from user fees to fund inland waterways operation and maintenance, as well as capital expenditures.

Public–Private Funding

States and local governments should conduct routine, quantitative evaluations of the economic rationale for government involvement in their freight transportation infrastructure projects, prospectively for each new proposal and retrospectively for each completed project. Program rules should require such evaluations of projects that receive federal assistance. Congress should base its decisions on whether to adjust the federal-aid program rules after reviewing the outcomes of prospective and retrospective evaluations of past projects.

Governments have experimented recently with nontraditional projects involving public–private joint undertakings and complex financing packages with support from multiple sources. These projects often center on intermodal facilities and often entail public support for facilities commonly provided by the private sector.

An analysis of these kinds of proposals, however, should compare the estimated benefits, costs, and government budgetary impacts with alternative means of serving freight and with alternative institutional arrangements. If the proposal is for government support of a project that cannot obtain private-sector financing, the evaluation should demonstrate that the public benefits would raise the public rate of return above the private rate.

Decision Making and Planning

Congress also should continue to support the development of U.S. DOT capabilities for economic analysis of the federal-aid highway program and should provide for joint state–federal efforts to transfer and adapt the federally developed policy guidance tools to state and local needs.

Congress should create a clearinghouse for evaluation methods within U.S. DOT, so that program agencies and local and state governments can share and compare methods and evaluations. The clearinghouse would contribute to streamlining project development by clearly defining accepted methods and by providing staff expertise.

Public infrastructure investment choices are made more difficult by the lack of an explicit evaluation framework, political incentives that discourage evaluation, and failure to devote resources to research and data collection. The report proposes guidelines for government evaluations of freight-related infrastructure projects.

Regulatory Issues

Changes in practices and policies that shorten delivery time would reduce the difficulty of matching capacity to demand. Reforms should speed project delivery without compromising environmental safeguards. The committee recommended actions to reduce excessive delay.

The committee endorsed past U.S. government efforts to liberalize the international air freight market. Increased competition and increased carrier flexibility should improve efficiency in the international air cargo system.

The author is Senior Program Officer in the TRB Division of Studies and Information Services and served as study director for this project.

Bicycle Path to Rural Roads

The lead article in the March–April 2003 *TR News*, "The Trip to Town: Rural Transportation Patterns and Developments Since 1900," by Peter Schauer, makes an oversight in describing the transition in rural transportation from the horse to the motorcar. For a full generation before the automobile, the bicycle was the state-of-the-art road vehicle, driving the improvement of rural roads. Mr. Schauer implies that the first paved rural roads did not appear until the motorcar became common after 1900. Yet a generation of cyclists, led by the League of American Wheelmen (LAW), created the Good Roads Movement in the 1890s.

The American bicycle generation started in 1876 when the English Penny-Farthing bike was first displayed at the Philadelphia Centennial celebration. Within a year, manufacturers, such as Columbia Bicycles, were turning out bikes in the United States. Bike clubs formed throughout the country. LAW became a national organization in 1880 and soon grew to tens of thousands of members. The growth and intensity of the bicycle movement far exceeded the intensity of the personal computer movement a century later.


LEAGUE OF AMERICAN BICYCLISTS

The bicycle also played a role in opening up personal transportation to women and in providing everyone with personal transport cheaper than the horse and more flexible than the trolley. The bicycle industry played a role in creating the infrastructure for the automobile: ball bearings; Dr. Dunlop's pneumatic tires; lightweight wheels and rims; high-strength steel frames; shaft drives; multispeed transmissions; and the hub brakes and differentials required for tricycles and quadracycles. The cars of 1900 were not simply motors mounted on farm wagons, but motors mounted on a mechanical platform drawn directly from state-of-the-art bicycle technology.

The article covers touring by motor car, but again, LAW had created the maps, route guides, and hotel and restaurant ratings that are now the hallmark of the American Automobile Association—which was founded by the leadership of LAW. In the 1880s, cyclists were traveling as much as 100 miles a day, often on poorly paved rural roads. Cyclists carried their wheels on railroads and took day trips far from home and cities. Improving roads was a cyclist's priority.

LAW established *Good Roads Magazine* in 1891, which led directly to Congress creating the Bureau of Public Roads, now the Federal Highway Administration. The Spring 2003 *League of American Bicyclists Magazine* (LAB is the current name for LAW) includes a short article, "Present at the Creation: The Good Roads Movement," that concisely lays out this connection. The paved rural highway may have come of age after 1900, but the Good Roads Movement was birthed and delivered by bicycle.

—Steven F. Faust
Brooklyn, New York
Active friend and past member, TRB Committee on Bicycle Transportation

Peter Schauer, Peter Schauer Associates, Boonville, Missouri, replies:
Mr. Faust has noted an important part of our transportation history. My article set the starting date of the retrospective as 1900, and the activities he has noted happened earlier. In addition, I was taking the perspective of rural agricultural travel. Although the bicycle was important for a period early in urban America, its impact on farmers taking crops to town and traveling rural roads is uncertain. I had to set a date to start the article, and the influence of the automobile was picking up speed about 1900, so off I went. Thanks to Mr. Faust for giving thought to an important part of our history.

CALENDAR

TRB Meetings
2003

September

8-10 International Conference on Pavement Performance, Data Analysis, and Design Applications*
Columbus, Ohio
G. P. Jayaprakash, Stephen Maher, Frederick Hejl

9-12 Community Impact Assessment: Putting It All in Context*
Indianapolis, Indiana

17-19 Tenth National Highway/Utility Conference*
Orlando, Florida

29-30 5th National Conference on Asset Management: Moving from Theory to Practice*
Atlanta, Georgia
(also being held in Seattle, Washington, October 21-22)

October

8-10 Driving Simulation Conference: North America 2003*
Dearborn, Michigan
Richard Pain

21-22 5th National Conference on Asset Management: Moving from Theory to Practice*
Seattle, Washington
(also being held in Atlanta, Georgia, September 29-30)
Thomas Palmerlee

November

12-15 Rail Passenger Caucus
San Francisco, California
Peter Shaw

16–18 9th National Light Rail Transit Conference*
Portland, Oregon
Peter Shaw

19-22 International Symposium on Road Pricing
Key Biscayne, Florida

2004

January

10 Pavement Performance Data Analysis Forum
Washington, D.C.
A. Robert Raab

11–15 TRB 83rd Annual Meeting
Washington, D.C.
Mark Norman, Linda Karson

April

13–17 5th International Conference on Case Histories in Geotechnical Engineering*
New York, New York
G. P. Jayaprakash

May

5–8 5th International Conference on Cracking in Pavements: Risk Assessment and Prevention*
Limoges, France
Frank Lisle

23–26 10th International Conference on Mobility and Transport for Elderly and Disabled People
Hamamatsu, Japan
Claire Felbinger

June

6th International Symposium on Snow Removal and Ice Control Technology
Spokane, Washington

July

21–24 Highway Capacity and Quality of Service Committee Midyear Meeting and Conference
State College, Pennsylvania
Richard Cunard

August

29–Sept. 1 6th National Meeting on Access Management
Kansas City, Missouri
Kimberly Fisher

September

13-17 Structural Materials Technology: NDE/NDT for Highways and Bridges*
Niagara Falls, New York
Stephen Maher

22-24 9th National Conference on Transportation Planning for Small and Medium-Sized Communities: Tools of the Trade
Colorado Springs, Colorado
Kimberly Fisher

25-29 2nd International Conference on Accelerated Pavement Testing*
Minneapolis, Minnesota
Stephen Maher

October

19-22 2nd International Conference on Bridge Maintenance, Safety, and Management*
Kyoto, Japan

19–24 6th International Conference on Managing Pavements*
Brisbane, Queensland, Australia
Stephen Maher

Additional information on TRB conferences and workshops, including calls for abstracts, registration and hotel information, lists of cosponsors, and links to conference websites, is available online (www.TRB.org/trb/calendar). Registration and hotel information usually is available 2 to 3 months in advance. For information, contact the individual listed, telephone 202-334-2934, fax 202-334-2003, or e-mail lkarson@nas.edu.

*TRB is cosponsor of the meeting.

Ecopassage Reduces Roadkills

Barrier and Underpass in Florida Preserve Animal Lives

J. DARRYLL DOCKSTADER AND PETER D. SOUTHALL

Dockstader is Technology Transfer Manager, Florida Department of Transportation, Tallahassee; Southall is Environmental Scientist, Florida Department of Transportation, Lake City.

A wildlife barrier and underpass in Paynes Prairie, a biodiverse Florida State Preserve, has reduced the numbers of animals killed on a section of U.S. 441, which transects the parkland, by 64.2 percent.

In 1971, Paynes Prairie was established as the first state preserve in the Florida park system. Encompassing 21,000 acres south of Gainesville, the preserve is home to 20 distinct ecological communities, including wet prairie, pine flatwoods, hardwood hammocks, and ponds. Paynes Prairie supports a biodiversity of more than 720 plant species—one-fifth of the total in the state—plus more than 100 types of animals, including waterfowl, hawks, snakes, alligators, rodents, bobcats, wild horses, and bison.

Problem

Two major highways, Interstate 75 and U.S. 441, transect Paynes Prairie. Constructed in the 1920s, U.S. 441 carries more than 10,000 cars daily. The abundant wildlife and the heavy traffic have rendered this segment of U.S. 441 one of Florida's deadliest roads for animals. A 2-mile (3.2-kilometer) stretch of the highway has more documented roadkills than any other roadway segment in the state.

The primary reason for the high rate of animal mortality is that the roadway crosses prime habitat, or home range. The animals must be able to move back and forth across the roadway to preserve the viability of their species—to gain dispersal and to prevent genetic isolation.

PHOTO: U.S. GEOLOGICAL SURVEY.

Profile of barrier wall during construction.

In 1996, the Florida Department of Transportation (DOT) investigated constructing an ecopassage—a wildlife barrier and underpass system—to reduce the high rates of animal mortality. In 1998, Florida DOT convened a multidisciplinary working group with representatives from the department, natural resource agencies, environmental groups, and the University of Florida to provide suggestions on ways to reduce the animal mortality rate.

With feedback from the working group, Florida DOT District Two engineers designed and constructed a 1.8-mile (2.9-kilometer) ecopassage. The structure consists of a 3.5-foot-high (1.1-meter-high) gravity wall with a 6-inch (15.24-centimeter) lip, to prevent animals from climbing over, and a series of culvert underpasses to facilitate animal crossings. Florida DOT, however, needed to determine the effectiveness of the system.

Solution

In July 1998, Florida DOT contracted with the U.S. Geological Survey to conduct a two-phase study to investigate pre- and post-construction highway-related animal mortality and animal movement through existing and added culverts. Under the leadership of C. Kenneth Dodd, Jr., the research team first established preconstruction roadkill levels and determined the kinds and numbers of animals that were using the box culverts already in place.

Researchers conducted weekly, 3-day-sampling-period road surveys along the entire 2-mile road segment from August 1998 through August 1999. The sampled area included the median and the entire road surface in both directions, extending 10 to 13 feet (3 to 4 meters) into the grassy shoulders.

On the first day of the sampling period, the investigators marked and counted all road kills; on days two and three, they recorded all of the road kills from the previous 24-hour periods. Researchers recorded a total of 3,365 vertebrates killed: 1,333 frogs, 1,291 snakes, 374 turtles, 265 birds, 72 mammals, 29 alligators, and 1 lizard.

The investigators were not able to monitor all of the existing box culverts [each 7 ft 10.5 in. × 7 ft 10.5 in. (2.4 m × 2.4 m)], because two box culverts were completely inundated throughout the study. Funnel traps and hardware cloth traps were used at the other sites. In addition, researchers examined animal tracks and used active infrared cameras at the dry culverts.

Researchers documented 28 species that used the culverts, with river otters, nine-banded armadillos, raccoons, and opossum making frequent crossings. This demonstrated that a significant variety of animals were using the culverts and that the construction of additional structures would be beneficial.

The ecopassage construction was completed in February 2001. Phase 2 of the study began in March 2001 and ended in March 2002. The four new culverts, 3 feet (0.9 meter) in diameter, were sampled using commercial crayfish traps; otherwise, the general survey methods were similar to those in Phase 1.

The survey area extended 200 meters beyond the ecopassage at either end of the barrier wall and included a 400-meter section that bordered private property with a thrie-beam guardrail barrier instead of a concrete wall, because of the limited right-of-way. The barrier is a standard guardrail installed backwards, with the bottom of the guardrail touching the ground.

During Phase 2, 1,992 vertebrates were found dead along U.S. 441: 1,647 frogs, 149 snakes, 101 birds, 83 mammals, 7 turtles, 4 lizards, and 1 alligator. If the numbers of birds and tree frogs—affected minimally by the wall—are excluded, 157 animals were killed after construction, compared with the 2,411 animals killed before construction.

Researchers found that 64 percent of the non–tree frog deaths occurred along the guardrail fencing and at an access gate access adjacent to the southbound lanes on the north side of the prairie. Another finding was that small mammals, snakes, and frogs could cross the barrier along vegetation that grew up the wall from the prairie side.

After construction, the number of species using the culverts increased from 28 to 51, including 9 fish species. One of the new culverts was wet regularly, but the others were wet or dry according to prairie water levels. Although the total number of animals using the culverts after construction of the ecopassage has not been documented, the decrease in animals crossing the road suggests an increase in the number of culvert users.

Benefits

Eliminating highway-related animal mortality may be impossible, particularly for species that can fly, climb, or jump over constructed barriers. Nevertheless, the research confirmed the need for—and proved the general effectiveness of—the Paynes Prairie ecopassage.

Overall, researchers recorded a 41 percent reduction in wildlife mortality between the pre- and post-construction survey periods for the entire survey area, which extends beyond the ecopassage. But if the survey area is limited to the prairie basin directly adjacent to the concrete wall, the effects of the ecopassage become more pronounced, achieving an overall 64.2 percent reduction in mortality. Excluding tree frogs raises the figure to 90.1 percent, and excluding tree frogs and birds raises the effectiveness of the system to 93.5 percent. The finding that most of the roadkills—except for tree frogs—occurred in the limited area in which the wall was not installed increases confidence in the effectiveness of the structure.

Regular maintenance and improved drainage at the guardrail barrier to eliminate washout from erosion will improve the effectiveness of the system, as will routine maintenance of the vegetation. Motorists will benefit from the reduction of collisions with wildlife and from the improved aesthetics of far fewer animal carcasses along the roadside.

Previous, unpublished research by Richard Franz of the University of Florida determined that only 1 of 17 snakes that attempted to cross the road was successful. The ecopassage barrier deters animals from attempting to cross and forces use of the culverts. Animals are no longer crossing on the highway surface of U.S. 441 at the barrier wall area.

The demonstrated success of the ecopassage system, which received a Globe Engineering Award, may justify use as a model for similar efforts, both nationally and internationally.

For further information contact Peter Southall, Environmental Scientist, Florida Department of Transportation, 1901 South Marion Avenue, MS 2007, Lake City, FL 32025-5814 (telephone 386-961-7470, fax 386-961-7508, e-mail peter.southall@dot.state.fl.us).

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, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-2952, e-mail gjayaprakash@nas.edu).

PHOTO: U.S. GEOLOGICAL SURVEY.

Motion-sensor photographs of animals in box culvert; *from top*, bobcat, alligator, and otter.

C. Ian MacGillivray

Iowa Department of Transportation

"Research is the key to knowledge, and transferring knowledge is what education is about," notes Ian MacGillivray. "And education is the key to progress." Over the years, MacGillivray, recently retired Director of the Research Management Division of the Iowa Department of Transportation (DOT), has charted various courses to progress.

His career in transportation and engineering has taken him from Alberta, Canada, to Lafayette, Indiana; from Michigan to Louisville, Kentucky; and finally to Ames, Iowa. What MacGillivray describes as a life-altering event took place after college while he was working as a city engineer in Canada—he saw a news magazine cover of Harold Michael, head of Civil Engineering at Purdue University and former chair of the TRB Executive Committee, shaking hands with then-President Lyndon Johnson at the creation of the President's National Highway Traffic Safety Advisory Committee.

"Mobility is a substitute for location.... So mobility research is really about jobs, health care, education, and support of our economy."

"I thought, I'd like to know more about traffic and safety and go back to graduate school," MacGillivray recalls. "So I applied to Purdue, got accepted and met Michael—who became my major professor and lifelong influence."

MacGillivray considers "seeing the application of research in practice" as his most satisfying career achievement. "My largest contribution has been providing support for creating research opportunities," he says.

But in reviewing his achievements, MacGillivray turns to his "planning roots." In Iowa, his home for the last 25 years, he spent 16 years as Director of the Iowa Department of Transportation Planning and Research Division from 1977 to 1993; from 1994 to 1999 he was Engineering Division Director; and from 2000 to 2002 he was Director of Research Management.

A self-described planner, MacGillivray got into policy and economic research and helped create an environment to support transportation research. He observes, "Mobility is a substitute for location, and as our rural society evolves, the accessibility that mobility brings is how we're going to maintain a standard of living for rural and smaller communities. So mobility research is really about jobs, health care, education, and support of our economy."

He adds that the research "identified how important freight transportation activity was to the social and economic fabric of the whole state. Our policy became 'freight first.'"

An accomplishment MacGillivray is most proud of is the establishment, with the Iowa Legislature, of a traffic safety fund, which set aside .5 percent of all state highway funds for traffic safety research, education, and improvement.

The circle of research and practice ranks next on the list: "The connection between research, education, and practice is illustrated by the researcher who brings knowledge into the classroom and students who come out of the classroom, work on research projects, gain a perspective on research, and become outstanding young engineers and principal candidates to hire into our ongoing engineering program."

An "object lesson" MacGillivray learned is that "you can do much more by working together." He cites his involvement with the Enterprise group, a consortium of four U.S. states, established in 1991 to share interest in intelligent transportation systems. Enterprise has grown into a multistate, international association, allowing "small states like Iowa to gain the resources and knowledge of states like California, New York, and Texas," MacGillivray notes.

Another key lesson for MacGillivray was the benefit of public–private collaborations. He points to Iowa's concrete pavement technology research program as a prime example. "It's the type of longstanding approach that brings support from different interests together to negotiate and develop and exchange knowledge."

MacGillivray has served on the committee for TRB's Scoping Study for National Strategic Plan for Transportation Information Management, to hone ways "to make information available to the practitioner." He chaired the National Cooperative Highway Research Program's panel for Project 20-05, Synthesis of Highway Practice, and calls the Synthesis series "perhaps the most important single activity that TRB does today to support transportation."

He served on the American Association of State Highway and Transportation Officials' Standing Committees on Research, Planning, and Rail Transportation. He is also a member of the Future Strategic Highway Research Program Panel on Planning for Research on Providing Highway Capacity, as well as a member of the Surface Transportation Environmental Cooperative Research Program Advisory Board, and the U.S. DOT's Science and Technology Advisory Committee.

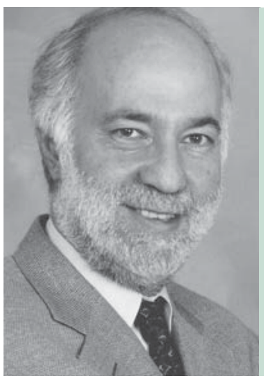
MacGillivray earned a bachelor of science degree in civil engineering from the University of Alberta, Canada, and a master of science degree in civil engineering from Purdue University.

Daniel Sperling

Institute of Transportation Studies, University of California, Davis

"An aggressive commitment to cross-disciplinary training and research is critical to the future of the transportation profession," states Daniel Sperling, founding director of the Institute of Transportation Studies (ITS) at the University of California, Davis (UC-Davis), and professor of Environmental Science and Policy and Civil and Environmental Engineering. He adds, "My specific goal is to attract students from social sciences and from a variety of engineering and environmental disciplines to help build a strong cross-disciplinary educational and research program."

Sperling founded ITS-Davis in 1991 as a means of bringing together economists, engineers, anthropologists, and ecologists to collaborate on critical research issues facing the transport sector. Then, in 1997, he gained university approval for a new interdisciplinary graduate program in Transportation Technology and Policy. The National Science Foundation recognized the program as an education model in 1998, awarding ITS-Davis a prestigious $2.6 million Integrated Graduate Education Training and Research grant.



"My most important research contribution has been leadership in creating and maintaining a research environment that allows others to be productive."

In its short history, ITS-Davis and its expanding community of 100 faculty, students, and staff have achieved worldwide recognition as leaders in advanced vehicle technologies, travel behavior, and the environmental impacts of transportation. Research is funded by government, industry, and foundations, and corporate sponsors include ExxonMobil, ChevronTexaco, Toyota, Honda, and Nissan.

Sperling has dedicated his professional career to understanding the interplay of technology and policy. After engineering and urban planning studies at Cornell University, he spent two years as an urban planner with the Peace Corps in Honduras, and two years as an environmental scientist with the U.S. Environmental Protection Agency. He then earned a doctorate from the University of California, Berkeley, specializing in alternatives to petroleum-based fuels, and began his academic career at the University of California, Davis.

In 1998, Sperling launched the Fuel Cell Vehicle Center at ITS-Davis, with initial funding from the U.S. Department of Energy. Currently 35 graduate students and 10 faculty members are at work at ITS-Davis on electric-drive vehicle research, including projects on market demand, emissions and energy use, advanced vehicle modeling, hydrogen fuel infrastructure, and fuel cell auxiliary power units. "My most important research contribution has been leadership in creating and maintaining a research environment that allows others to be creative and productive—especially graduate students," Sperling says.

Sperling has taken his commitment to environmental quality and electric-drive vehicle research to the highest public policy level, testifying to Congress and government agencies. He was a leader in questioning the design and effectiveness of a high-profile research partnership between the federal government and the automobile industry.

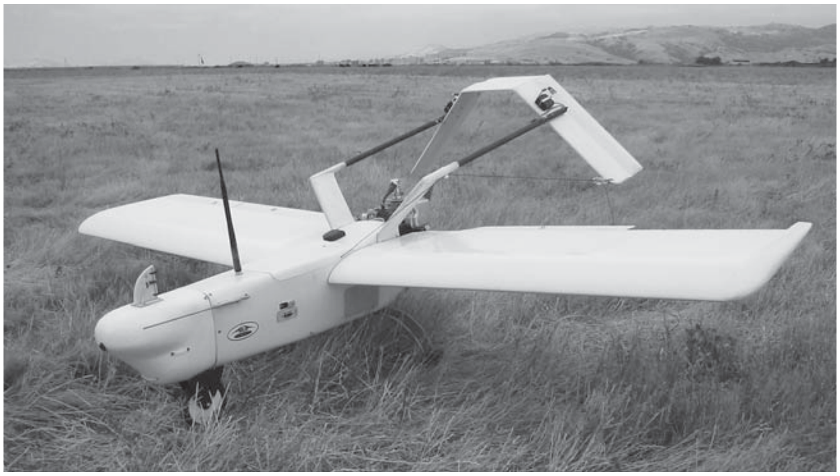
"It's important for academics to participate in the policy process in a public way because academics are among the few people in society who are independent, credible, and knowledgeable," he told *UC Davis Magazine* in 1997. Participation can risk loss of funding, but academics must be careful not to cross the line between science and advocacy, Sperling observes—"credibility vanishes when an academic takes positions not well supported by research."

Sperling has devoted his prolific research career—including eight books and more than 160 papers—to serving the policy world. His vision is to build a research foundation for the development of good transportation, energy, and environmental policy. He is particularly concerned about petroleum use and greenhouse gas emissions.

He recently headed a 3-year project for the Pew Center on Global Climate Change, coauthoring a series of reports—on Shanghai, China; Delhi, India; South Africa; and Chile—documenting the transportation and environmental crises in each region, and offering local, national, and global strategies. Finding that emissions could climb fourfold in Delhi and sevenfold in Shanghai by 2020, his team produced recommendations, from building more sidewalks and better bus services, to improving the fuel efficiency of motorcycles, to technology transfer possibilities.

Sperling is the recipient of many awards, including the Clean Air Award from the American Lung Association and the UC Davis Award for Distinguished Public Service. This spring ITS-Davis and Sperling were nominated for the 2003 World Technology Awards in Energy, and ITS-Davis was selected as a finalist.

Sperling is founding chair and now emeritus member of TRB's Committee on Alternative Transportation Fuels, and is a member of TRB Committees on Transportation Energy, Sustainable Transportation, and New Transportation Systems and Technology. In the past few years, he also has served on several National Research Council committees, contributing to studies on such topics as Alternatives and Strategies for Future Hydrogen Production and Use, Transportation and a Sustainable Environment, and the Future of Personal Transport in China.



Mini-UAV bat or drone ready for take-off. Launching can be by hand or by lightweight bungee-powered catapult.

Mini-Unmanned Aerial Vehicles Take to the Airways

The mini-unmanned aerial vehicle (UAV) weighs about 10 lbs., is powered by a gasoline engine, and folds into a compact tube the size of a golf bag. On a rainy day in May, the vehicle flew along I-95 near Springfield, Virginia, demonstrating use of its remote sensing platform, controlled from a highway weigh station. The mini-UAV is capable of flying in a survey configuration and hovering around a point. The larger UAV traditionally is used for defense and security.

The demonstration, sponsored by the U.S. Department of Transportation's (DOT) Research and Special Programs Administration, showcased the spatial and temporal resolution necessary for traffic monitoring and homeland security, as well as fail-safe features, such as the "go-home" software, automatic parachute deployment, and engine shut-off. The mini-UAV can take off, fly to up to 6 hours, and land unassisted with preprogrammed instructions.

Currently, a study made possible by a technology applications grant is enabling the Moakley Center for Technological Applications at Bridgewater State College in Bridgewater, Massachusetts, to examine and test mini-UAVs for monitoring transportation infrastructure and operations.

Aerial view of major highway from mini-UAV.

At the same time, Ohio transportation officials and university researchers are testing pilotless planes for efficacy in pinpointing highway congestion. UAVs or "drones" may be able to watch traffic, route trucks, and fix stoplights so that traffic can flow better. Drones, picking up and beaming images down to the ground, also could track cars as they turn, to reveal patterns of traffic through a network of roads. This could help emergency vehicles find the best route to an accident site.

The GeoData Systems drone weighs about 55 pounds, with a wingspan of 12 feet. Above congested metropolitan areas like Columbus or Cincinnati, drones have to fly at least 1,000 feet above the ground.

A 1998 highway bill ordered U.S. DOT and the National Aeronautics and Space Administration to work with universities to find ways to improve traffic flow. To that end, Ohio State University is leading a university consortium on a $600,000-a-year project. The GeoData Systems drone costs $150,000 with ground station and software.

For more information on the mini-UAV, contact Lawrence J. Harman at lharman@bridgew.edu; for general information go to www.artimis.org, www.geodatasystems.com, www.spyplanes.com, and www.ncrst.org.

Cost of Rough Riding

One out of every four major urban roads in the United States provides unacceptable ride quality, costing motorists $396 extra annually in operating costs, according to a report, "Keep Both Hands on the Wheel: Cities with the Bumpiest Roads and Strategies to Make Our Roads Smoother," issued by The Road Information Program, also known as TRIP, a nonprofit organization promoting policies to improve traffic conditions.

"Without additional federal investment, our nation's roads are going to get worse, and motorists are going to pay a higher 'hidden tax' in the form of additional vehicle operating costs," states William M. Wilkins, TRIP's executive director.

A 30 percent increase in urban traffic from 1991 to 2001 is responsible for the high level of pavement deterioration on major roadways. According to a 2002 U.S. DOT report, a 49 percent increase in annual funding, from $13.6 billion to $20.2 billion, would be necessary to improve urban road and highway pavement conditions.

TRIP recommendations include the following:

◆ In building critical routes, use pavement designs that provide longer-lasting service;

◆ Consider a pavement preservation program that

Pavement patches in Washington, D.C.

offers initial maintenance on road surfaces still in good condition;

◆ Maintain an aggressive pothole repair program with the best patching material available; and

◆ Invest to ensure that 75 percent of local surfaces are in good condition.

More information is available at www.tripnet.org.

Streamlining Environmental Review

In a recent agreement with FHWA, the Ohio Department of Transportation (ODOT) has begun streamlining environmental documentation for transportation projects, foregoing FHWA approval. An average of seven environmental documents a month has been approved by ODOT under the arrangement, expediting completion of highway projects that improve safety. Quality assurance tests are still given and FHWA may concur with or reject an ODOT decision within a 15-day period.

Roadway Environments Contribute to Vehicle Crashes

The roadway environment was a contributing factor in about one-third of the nearly 6.3 million motor vehicle crashes in 2001, according to a U.S. General Accounting Office (GAO) report released March 31, 2003. Poor roadway environments include bad design, roadside hazards, and adverse roadway conditions.

The GAO report is available at http://www.gao.gov/new.items/d03436.pdf.

"This agreement provides a way to decrease review time while maintaining oversight responsibilities," said David Snyder, Ohio FHWA environmental programs coordinator.

"Quick Clear" Program Offers Best Practices

Weather, crashes, spilled loads, and disabled vehicles account for more than half of all traffic delays from congestion in Ohio, according to the Ohio DOT and other state transportation organizations. The Quick Clear program, in effect since March 2003, outlines procedures to clear crashes and other incidents from the roadway. The procedures include

◆ Reducing the duration of traffic incidents;
◆ Protecting traffic incident responders;
◆ Reducing risks posed by secondary crashes; and
◆ Managing traffic flow past the accident site.

The procedures apply to transportation, law enforcement, fire, emergency, medical, and towing and recovery agencies. In addition to implementing these best practices, Ohio DOT now utilizes "freeway service patrols" in Akron, Dayton, Toledo, Cincinnati, Cleveland, and Columbus on roads with the heaviest traffic volume.

Among the problems hindering better incident management are broken-down vehicles on the roadway shoulder and local government contracts with towing companies. To solve these problems, Ohio DOT endorses policies to limit the time a vehicle may remain on a shoulder; using signs to direct motorists to move impaired vehicles; and checking towing company capabilities and equipment.

More information is available at www.dot.state.oh.us/quickclear.

Click It or Ticket

In May U.S. Transportation Secretary Norman Y. Mineta launched this year's month-long seatbelt campaign, Click It or Ticket. In its third year, the campaign consists of 2 two-week-long enforcement periods in May and November, supported by 12,000 law-enforcement agencies around the country.

In the United States, teens are twice as likely to die in a car crash as people 35 years old or older, and according to the National Highway Traffic Safety Administration, young people ages 16-19 are less likely to use safety belts than drivers and passengers in other age groups. Generally, safety belt use includes only 75 percent of U.S. motorists, and an even lower 69 percent among teens and young adults.

Two recent Quick Clear challenges: (*top*) metal culvert looming out into highway; (*bottom*) coal spill.

Study Examines Needs of Mid-Atlantic Transportation System

With an increase in passenger and freight movement in the Mid-Atlantic corridor—Virginia, Maryland, Delaware, Pennsylvania, and New Jersey—during the last 20 years, ton-miles of rail freight increased by 55 percent, although mileage and returns from transportation initiatives have declined. Serving 47 million people, the Mid-Atlantic corridor is a gateway to major international seaports but faces a "transportation capacity crisis," according to an April 2002 study sponsored by rail carriers Amtrak, CSX Transportation, and Norfolk Southern; the Delaware, Maryland, New Jersey, Pennsylvania, and Virginia Departments of Transportation; and the I-95 Corridor Coalition.

The study outlines strategies for improving rail's role in transportation, formulating a five-state, systemwide investments program, eliminating "choke points," and forging public–private partnerships. The estimated cost of the 71 infrastructure and information system improvements recommended in the study is $6.2 billion, which neither the railroads nor the states can afford.

A cooperative approach among federal, state, regional, and local governments, for example, could eliminate choke points such as bridges, tunnels, and inadequate vertical clearances, and thus increase passenger capacity, enhance safety and emergency response, and allow the rail network greater ability to recover from service disruptions, the study maintains. Steps such as refining program elements, developing a process to guide the planning of improvements, involving stakeholders, and developing a network model to quantify the improvements are other recommendations.

For more information, www.i95coalition.org.

Education Center Offers Diverse Resources

The U.S. Army Corp of Engineers (USACE) operates an educational resource center for kindergarten through high school students, teachers, librarians, and other educators, supporting online as well as classroom learning, promoting understanding of USACE, networking, and an interest in applied sciences. The Center comprises four parts: (*a*) Young Engineers' Online Club; (*b*) Corps Classroom Connection, with information about engineering, environmental biology, chemistry, physics, geosciences, archaeology, mathematics, computer technology, history, geography, and safety; (*c*) Classroom Resources, including model lesson plans, activities, and web links; and (*d*) USACE Mission Lessons, with classroom activity suggestions, puzzles, glossaries, government links, and more.

The Education Center website is http://education.usace.army.mil.

PEOPLE IN TRANSPORTATION

Samuel G. Bonasso

New Acting Chief at Research Agency

Former West Virginia Secretary of Transportation Samuel G. Bonasso is the Acting Administrator of the U.S. DOT Research and Special Programs Administration, succeeding Ellen G. Engleman, who has become chair of the National Transportation Safety Board.

Bonasso has more than 36 years of experience as a professional engineer, including positions as founder of Ski Lift International and later as president of Alpha Associates, an architectural and engineering design firm in West Virginia. He was West Virginia Secretary of Transportation, responsible for the highway, motor vehicle, and transportation authorities. He also has served as adjunct professor of civil engineering at West Virginia University.

Bonasso received a bachelor's degree in civil engineering from the University of Miami and a master's degree in civil engineering from West Virginia University. He is an ex officio member of the TRB Executive Committee.

INTERNATIONAL NEWS

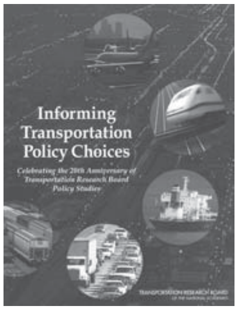
Leisure Travel and Tourism Help Public Transport

Growing leisure travel and tourism rates can be paired in transportation strategies to improve and further develop public transport, according to a March 2003 brief released by the Union Internationale des Transports Publics (UITP), headquartered in Brussels.

With increased roadway congestion, leisure travelers are looking for new transportation solutions, such as environmentally friendly public transport appropriate for trips to ecologically valuable areas. Also needed is good public transport accessible to people with special needs, in financial straits, without a driver's license, ill, or disabled.

According to a survey of 22 public transport companies across Europe, by UITP and Aare Seeland Mobil, leisure travel constitutes nearly 64 percent of public transport journeys. The most important public transport markets are the local areas (35 percent) and the surrounding regions (23 percent); international travelers make up 19 percent of users. UITP recommends partnerships in the leisure and tourism market, among recreational park authorities, tourist offices, and outdoor-activity providers for a more profitable transport service.

TRB Celebrates 20 Years of Policy Studies



To commemorate and document its extensive work and influence in the area of policy studies, TRB has published an 80-page, full-color book, *Informing Transportation Policy Choices: Celebrating the 20th Anniversary of Transportation Research Board Policy Studies.*

The publication samples, summarizes, and showcases TRB's more than 70 policy studies requested by Congress, executive-branch federal agencies, and the states on diverse transportation topics. These studies range from improving passenger travel, managing risk, and providing for security against terrorism to protecting the environment and achieving energy conservation.

"TRB's policy studies have been highly influential," notes Stephen Godwin, Director of Studies and Information Services at TRB. "This publication revisits the major conclusions and recommendations reached by the committees that guided the preparation of the reports, and it credits the hundreds of experts who served, *pro bono*, on the study committees."

This report is available on the web at gulliver.trb.org/publications/policy/itpc.pdf

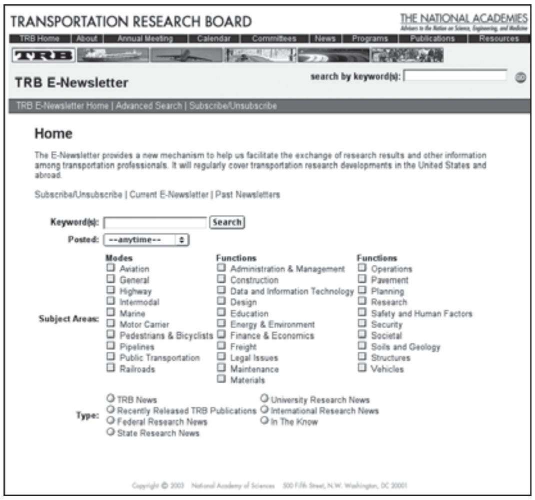
Online Newsletter Gains E-Readership

With a response rate of about 11 percent, 82 percent of recipients view the information contained in the TRB E-Newsletter as useful or very useful.

The E-Newsletter provides a way to keep up with all TRB publications, according to 76 percent of the respondents, who indicate they find the sections on TRB Publications, TRB News, or Federal News the most important parts of the newsletter. In addition, 82 percent find a publication, report, or notice featured in the E-Newsletter useful to their career at least once per month. Subscription circulation recently passed 10,000.

The E-Newsletter also offers a search engine to search for a news item by keyword or phrase, as well as a browsing bar to browse the material by mode, function, or type.

To find the E-Newsletter online, go to http://gulliver.trb.org/news/. To subscribe to the newsletter, send an e-mail to rhouston@nas.edu with "TRB E-Newsletter" in the message's subject field. Confirmation of subscription to the "transresearch e-news" is sent within 5 business days. Subscriptions are free.



Ignition Sparks Innovative Transportation Solutions

The newly launched TRB news magazine, *Ignition*, highlights new, innovative project ideas in surface transportation systems. These projects, promising but untested, are part of the Innovations Deserving Exploratory Analysis (IDEA) program, begun in 1998.

The four areas of innovative research considered in IDEA and covered in *Ignition* are high-speed rail, highway research, transit, and safety. According to IDEA staff, the programs differ from more traditional research programs by (*a*) offering an arena for innovation; (*b*) fostering good ideas at a critical early developmental stage; (*c*) providing advice as available from topic area experts and potential users; and (*d*) simplifying the proposal writing requirements.

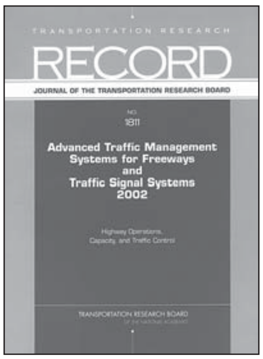
Ignition is produced four times a year. Each issue features an interview with an IDEA award recipient, sharing views on the project process; or with potential project funders hoping to advance efficiency and safety in surface transportation. Promising projects are also described, as well as the business side of developing concepts.

"Ignition in an engine is that moment when progress becomes possible," notes Linda Mason, Communications Manager of the TRB Special Programs Divisions and Editor of *Ignition* magazine. "Similarly, the IDEA programs, because they fund the earliest stages of investigations, can spark innovative solutions that otherwise might be lost. We hope that *Ignition* will reach people with good ideas, agencies willing to test new products, and corporate partners who recognize promising possibilities."

To read past issues of Ignition, *go to www4.trb.org/trb/onlinepubs.nsf/web/ignition?OpenDocument*

Issue No. 3 of *Ignition* features insights on technology to improve driving safety.

TRB PUBLICATIONS



Access Management Manual

Access management is the systematic control of location, spacing, design, and operation of driveways, interchanges, and street connections to a roadway, including roadway design applications such as median treatments and spacing of traffic signals. This comprehensive manual—available separately as a CD-ROM—provides information on techniques of access management, with information on how to develop and administer access management programs effectively.

The publication, 10 years in development, addresses issues relevant to state, regional, and local practitioners, as well as circumstances or situations that agencies may encounter. Also presented are approaches to integrating planning and engineering practices, as well as the transportation and land use decisions that contribute to access outcomes.

Practical information on topics and applications is incorporated in the 15 chapters, drawing on the knowledge of the experienced practitioners who participated in the development of the text, under the guidance of TRB's Committee on Access Management.

2003; 373 pp.; manual and CD-ROM: TRB affiliates, $75; TRB nonaffiliates, $100; manual alone: TRB affiliates, $60; TRB nonaffiliates, $80; CD-ROM alone: TRB affiliates, $45; TRB nonaffiliates, $60.

Bituminous Binders 2002
Transportation Research Record 1810

The latest findings on the strength, characteristics, and performance of asphalt and asphalt binders are reviewed in these papers. Topics include effects of incorporating hydrated lime to reduce oxidative aging characteristics, using a range of loading modes to measure and define fatigue behavior, findings from a long-term creep test to determine zero shear viscosity, and a statistical distribution of failure stress values from the Superpave® tension test.

2002; 77 pp.; TRB affiliates, $24.75; nonaffiliates, $33. Subscriber category: materials and construction (IIIB).

Advanced Traffic Management Systems for Freeways and Traffic Signal Systems 2002
Transportation Research Record 1811

Research on advanced traffic management systems range...from detection and false alarm rates of mobile sensor and freeway incident-detection algorithms, to a freeway performance system in California that helps planners and architects alleviate congestion, to the use of algorithms to monitor commuter congestion on surface streets, to optimizing adaptive control systems to reduce delays, and more.

2002; 175 pp.; TRB affiliates, $37.25; nonaffiliates, $50. Subscriber category: highway operations, capacity, and traffic control (IVA).

Environmental Information Management and Decision Support System: Implementation Handbook
NCHRP Report 481

This handbook is for use with an environmental information management and decision support system (EIM&DSS) that departments of transportation, metropolitan planning organizations, and others can apply to multimodal transportation planning, programming, project development, operations, and maintenance. The EIM&DSS complies with international environmental management system standards (ISO 14001). The handbook guides practitioners through a step-by-step approach for implementing the EIM&DSS and provides a foundation for the development, application, and ongoing implementation of effective environmental stewardship in a transportation setting.

2003; 144 pp.; TRB affiliates: $17.25; TRB nonaffiliates: $23. Subscriber categories: planning and administration (IA); energy and environment (IB); aviation (VA); public transit (VIA); rail (VIIA); freight transportation (VIIIA).

Bridge Software: Validation Guidelines and Examples
NCHRP Report 485

The report presents analysis software and a process for validating bridge design, documents the methodology to develop the validation process, and provides instructions for implementation. *CRP-CD-29* contains the testbed of bridges with well-defined parametric inputs and outputs developed in this research, all common tables necessary to implement the process, and software to view the databases.

2003; 152 pp. plus CD-ROMs; TRB affiliates: $30; TRB nonaffiliates: $40. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

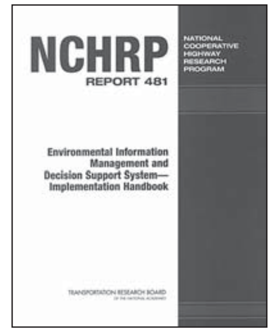
e-Transit: Electronic Business Strategies for Public Transportation—Volume 4: Advanced Features of Transit Websites
TCRP Report 84

A hyperlinked electronic report, *CRP-CD-34*, Volume 4 of TCRP Report 84 explores the potential of advanced transit website features: automated itinerary planners, real-time customer information, e-mail notification systems, and customer relationship management. The report concludes that advanced website features offer significant benefits to the customer and the transit industry.

2003; 6 pp. plus CD-ROM; TRB affiliates, $11.25; TRB nonaffiliates, $15. Subscriber category: public transit (VIA).

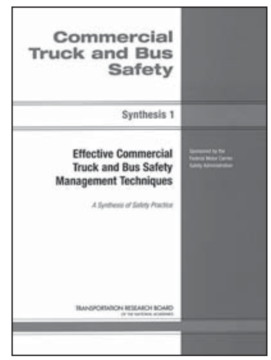
Public Transportation Security—Volume 3: Robotic Devices—A Guide for the Transit Environment
TCRP Report 86
Volume 3 of TCRP Report 86 is a guide to robotic devices for public transportation environments. The first section identifies the conditions a device must operate in and navigate through and develops a specification for prototypical requirements. The second section is a primer on the features available for robotic devices and includes a market survey of available systems and appropriate environments. The third section demonstrates how to perform a selection analysis by matching requirement specifications to the market.

2003; 23 pp.; TRB affiliates, $12.75; TRB nonaffiliates, $17. Subscriber categories: public transit (VIA); planning and administration (1A).



Effective Commercial Truck and Bus Safety Management Techniques
CTBSSP Synthesis 1
This synthesis—the first in the Commercial Truck and Bus Safety Synthesis Program (CTBSSP) series—summarizes commercial truck and bus safety management techniques. The focus is on problems confronting fleet managers and on methods to address the problems, which include driver safety knowledge, skills, and behaviors, as well as vehicle-related problems. Major safety management approaches include driver recruiting and selection, carrier-based training, management-driver communications, safety incentives, and others. The synthesis is based on a literature review and a survey of 139 commercial motor vehicle safety managers and 57 experts in motor vehicle safety.

2003; 96 pp.; TRB affiliates, $12.75; TRB nonaffiliates, $17. Subscriber categories: public transit (VIA); operations and safety (IV); freight transportation (VIIIA).



Security Measures in the Commercial Trucking and Bus Industries
CTBSSP Synthesis 2
This synthesis reports on the status of terrorist-related security measures in the commercial truck and bus industries. Addressed are key security threats to the industries, risk management techniques to assess potential threats, employee hiring procedures, current security procedures at training schools, security procedures and technologies used by carriers, issues associated with implementation and use of security measures, ongoing security research activities, and international experience with security measures for commercial truck and bus carriers.

2003; 48 pp.; TRB affiliates, $11.25; TRB nonaffiliates, $15. Subscriber categories: public transit (VIA); operations and safety (IV); freight transportation (VIIIA).

Systems Engineering Processes for Developing Traffic Signal Systems
NCHRP Synthesis 307
Transportation agencies are developing, redesigning, or upgrading traffic signal systems, but with different processes and with varying degrees of success. The systems engineering processes, steps, and methodologies—including those developed and used by transportation agencies—are summarized, identifying the traffic engineering community's experiences with different systems of engineering approaches, traffic signal systems processes and deficiencies, and the relative importance of various issues in traffic signal systems engineering.

2003; 87 pp.; TRB affiliates, $12.75; nonaffiliates, $17. Subscriber category: highway operations, capacity, and traffic control (IVA).

Transportation Planning and Management for Special Events
NCHRP Synthesis 309
Special events can increase the amount of traffic in a given area dramatically. Special event planning may involve a range of stakeholders, including transportation agencies at federal, state, regional, and local levels, as well as law enforcement agencies, the media, and fire and emergency medical services. This synthesis identifies transportation-related activities regarding the planning and management of special events, and covers both large- and small-scale events that occur frequently (e.g., sporting events and concerts) and infrequently (e.g., conventions and parades). The report discusses the role of stakeholders in planning and management; the tools and techniques for planning and managing special events, including motorist information, traffic management, and travel demand management; performance review; and funding. Unplanned events, such as natural disasters, are not covered.

2003; 71 pp.; TRB affiliates, $12; nonaffiliates, $16. Subscriber categories: planning and administration (IA); highway operations, capacity, and traffic control (IVA).

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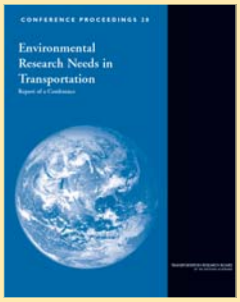

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