NOVEMBER–DECEMBER 2002
NUMBER 223

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TR NEWS

Revised Elements of Highway Geometry

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The Transportation Research Board is a division of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's mission is to promote innovation and progress in transportation through research. In an objective and interdisciplinary setting, the Board facilitates the sharing of information on transportation practice and policy by researchers and practitioners; stimulates research and offers research management services that promote technical excellence; provides expert advice on transportation policy and programs; and disseminates research results broadly and encourages their implementation. The Board's varied activities annually draw on approximately 4,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities.

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TR NEWS

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Cover: Golden Gate Bridge, San Francisco, California, illustrates the geometric complexities of safe and efficient highway design, updated in a comprehensive revision of the American Association of State Highway and Transportation Officials' "Green Book."

TR NEWS

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

***TR News* is produced by the Transportation Research Board Publications Office**
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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/.

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Subscriptions: North America: 1 year $55.00; single issue $9.50. Overseas: 1 year $70.00; single issue $13.00. 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. Second-class postage paid at Washington, DC.

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

LETTERS

More To Learn on the Erie Canal

I enjoyed the feature article by Catherine T. Lawson, "Just About Everything You Need To Know About Transportation You Can Learn on the Erie Canal" (July–August 2002 *TR News* pages 4–9). Professor Lawson attributes the bulk of recent canal improvements to the U.S. Department of Housing and Urban Development (HUD). Although HUD developed a Canal Corridor Initiative, the contributions the agency made were relatively minor. Instead—much like New Yorkers did in the 19th century, when the federal government refused to assist in the building of the original Erie Canal—we did it ourselves.

Under the leadership of Governor George E. Pataki, New York has invested nearly $170 million in canal revitalization and major capital improvements—a sum that exceeds the total amount spent to build the entire Barge Canal in the early 20th century. Although HUD successfully completed a few projects on the canal system, once again it was the people of the Empire State who rolled up their sleeves and got the bulk of the work done. A new partnership with the Erie Canalway National Heritage Corridor may yield greater dividends than HUD's involvement did.

In the same issue, in the feature article by David V. Grier, "Measuring the Service Levels of Inland Waterways: Alternative Approaches for Budget Decision Making" (pages 10–16), a map depicting inland shipping routes omits the New York State Canal System. New York operates and maintains four canals with 524 miles of navigable channels. The people of New York take great pride in our waterways and in what we have done to ensure their future.

—John C. Callaghan
Boater Resource Specialist
New York State Canal Corporation
Albany, New York

David V. Grier replies:
The intent of the map—which should have been stated more clearly—was to depict the waterways that are legally designated as subject to the Inland Waterways Fuel Tax and that are operated and maintained by the U.S. Army Corps of Engineers. The Corps' operations and maintenance budget for these waterways was the subject of the article. The map therefore omitted not only the New York State Canal System but many others as well, such as the Cape Cod Canal, the Chesapeake and Delaware Canal, and the Okeechobee Waterway. The New York State Canal System is an engineering marvel and an historic treasure in which all New Yorkers rightly should take pride.

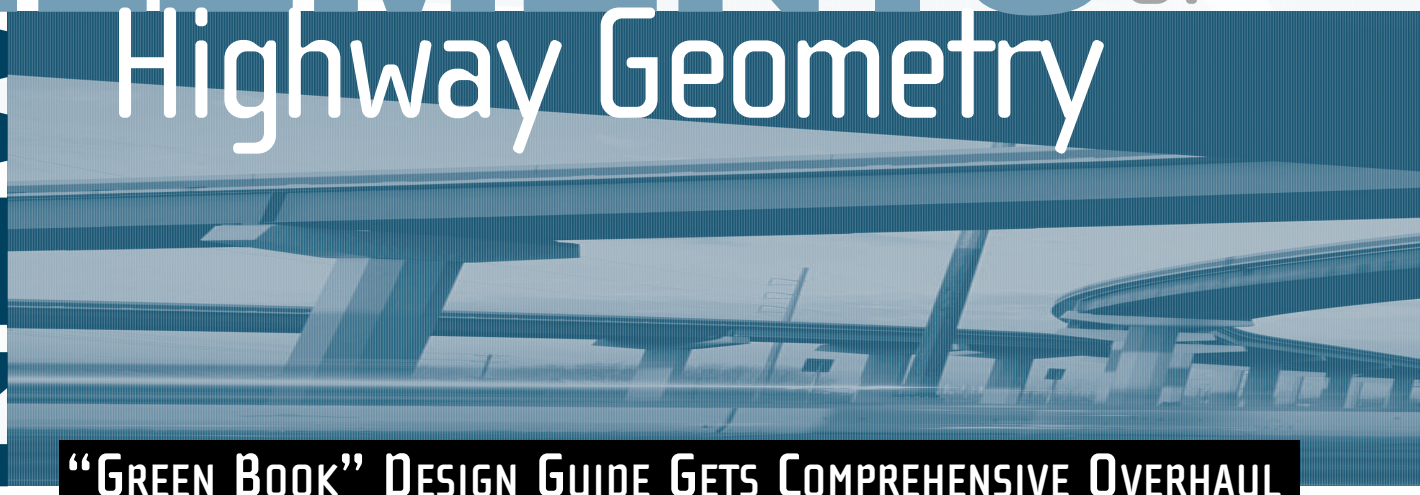
—David V. Grier
Navigation Analyst
U.S. Army Corps of Engineers
Alexandria, Virginia

COMING NEXT ISSUE

Update on transportation in U.S. National Parks, annual roundup of state transportation research projects and achievements, spatial technology applications, and more.

Phoenix Sky Harbor International Airport in Arizona was one of the sites included in TRB's 2002 field visits.

NEW ELEMENTS of Highway Geometry



"Green Book" Design Guide Gets Comprehensive Overhaul

DOUGLAS W. HARWOOD, INGRID B. POTTS, AND WILLIAM PROSSER

Harwood and Potts are traffic engineers with the Midwest Research Institute, Kansas City, Missouri. Harwood also chairs the TRB Committee on Operational Effects of Geometrics. Prosser is a highway engineer with the Federal Highway Administration, Washington, D.C.

A major event occurred in the field of street and highway design in the past year—in late 2001, the American Association of State Highway and Transportation Officials (AASHTO) published a long-awaited update to *A Policy on Geometric Design of Highways and Streets* (*1*), commonly known as "the Green Book." Green Book policies guide engineers in designing the physical layout and dimensions for safe and efficient highways.

The 2001 version—900-plus pages in an 8.5- x 11-in. softcover format (Figure 1)—is a comprehensive, substantive update of the 1994 edition. The AASHTO Subcommittee on Design and its Task Force on Geometric Design oversaw the updates to the Green Book, made with the assistance of National Cooperative Highway Research Program (NCHRP) contractor, Midwest Research Institute.[1] The revisions incorporate results of extensive research on geometric design, conducted under the auspices of NCHRP and the Federal Highway Administration (FHWA) since 1994.

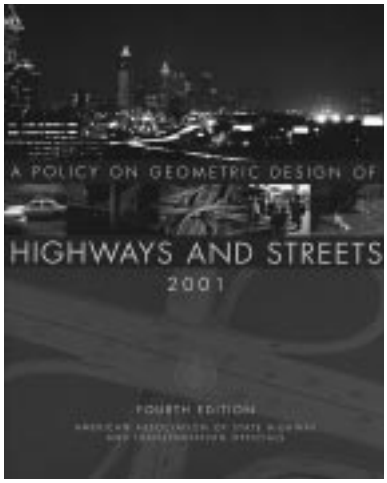


FIGURE 1 The 2001 Green Book.

Dual Units of Measure

A major change is the adoption of two measurement systems throughout the text and exhibits. The 1990 *Green Book* and previous editions used U.S. customary units exclusively, and the 1994 edition used only metric units. The 2001 edition employs both, with the metric units presented first in the text, followed by U.S. customary units in square brackets. When necessary for clarity, exhibits are presented separately in metric and U.S. customary units.

The relationship between the units of measure is neither an exact (or soft) conversion nor a completely rationalized (hard) conversion. Users are advised therefore to work entirely in one system of units and not to convert between the two measurement systems.

Key Revisions

[1] NCHRP Project 20-7(126), Production of the Year 2000 AASHTO Policy on Geometric Design of Highways and Streets.

TABLE 1 Outline of the Green Book

Chapter 1	Introduction
Chapter 2	Design Controls and Criteria
Chapter 3	Elements of Design
Chapter 4	Cross Section Elements
Chapter 5	Local Roads and Streets
Chapter 6	Collector Roads and Streets
Chapter 7	Rural and Urban Arterials
Chapter 8	Freeways
Chapter 9	Intersections
Chapter 10	Grade Separations and Interchanges

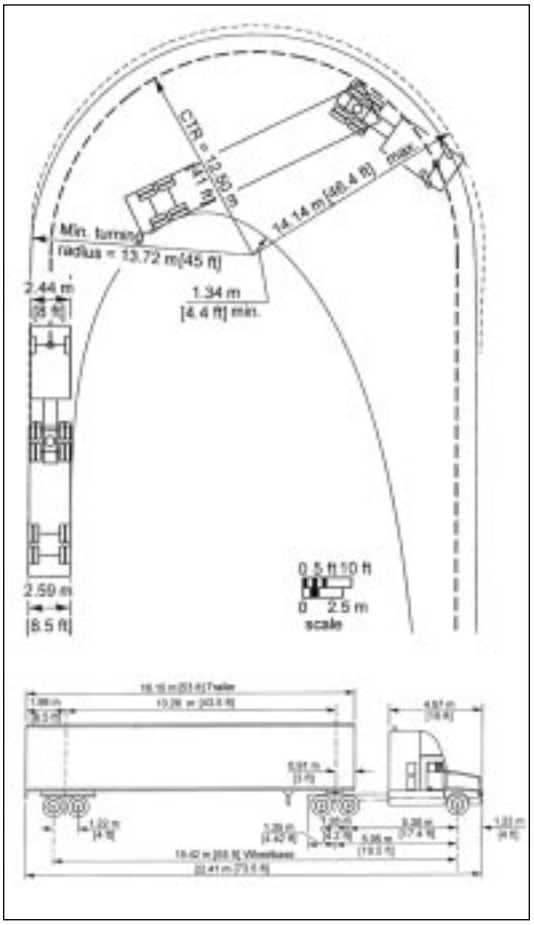


FIGURE 2 Sample turning plot: minimum turning path for Interstate semitrailer (WB-20 [WB-65 and WB-67]) design vehicle.

As in previous editions, the Green Book is organized into ten chapters covering key aspects of geometric design for the facility types in the functional classes of highways (Table 1). The first chapter, defining the basic functional classifications of highways and streets, required no significant changes. The key revisions for the other chapters of the Green Book are summarized below.

Design Controls and Criteria

Chapter 2 defines the fundamental design controls and criteria that constitute the framework for the geometric design of highways. The Green Book addresses four classes of design vehicles: passenger cars, buses, trucks, and recreational vehicles. The 2001 edition updates the dimensions of many of the design vehicles and revises the format for the turning templates, which assist in plotting the actual paths of turning vehicles (Figure 2).

Several new bus design vehicles are introduced, and new guidance is provided for selecting an appropriate design vehicle and for accommodating the needs of bicyclists. The chapter adds emphasis to design considerations for the needs of older drivers and presents countermeasures that may alleviate potential problems for older drivers.

Revised definitions of operating and design speeds focus on practical applications. Operating speed is the speed at which drivers operate vehicles in free-flow conditions. Design speed is the speed selected to determine a roadway's geometric design features. The new Green Book provides geometric design criteria for design speeds of 20 to 130 km/h (15 to 80 mph). Table 2 shows the correspondence of design speeds in metric and U.S. customary measures.

Traffic flow relationships are now consistent with those in the *Highway Capacity Manual 2000* (HCM) (2). The new Green Book has eliminated detailed material that duplicated HCM tables and procedures.

A rewritten and expanded section on access control and management incorporates material from NCHRP Report 420, *Impacts of Access Management Techniques* (3). The text presents basic principles, classifications, methods, and benefits of access management. Three new exhibits illustrate how access management measures may help reduce crash rates.

The consideration of pedestrian needs in geometric design receives new emphasis, with particular attention to accommodating persons with disabilities. The text offers seven specific measures to reduce pedestrian–vehicle conflicts.

Revised sections on safety in geometric design point out the need for adequate shoulders in narrow medians. The list of design considerations for rural intersections has been expanded.

Elements of Design

TABLE 2 Corresponding Design Speeds: Metric and U.S. Customary Units*

Design speed (km/h)	Corresponding design speed (mph)
20	15
30	20
40	25
50	30
60	40
70	45
80	50
90	55
100	60
110	70
120	75
130	80

** Based on Green Book Exhibit 2-29.*

Chapter 3 defines the design criteria for specific elements of geometric design, including sight distance (the driver's ability to see ahead), horizontal alignment (the design of roadway curves), and vertical alignment (the design of roadway grades, crests, and sags).

The new Green Book incorporates updated criteria for stopping sight distance from research findings in NCHRP Report 400, *Determination of Stopping Sight Distances* (*4*). Changes include a revised braking distance equation based on driver deceleration instead of locked-wheel braking friction. Each design speed now has a single value—instead of a range of values—for stopping sight distance.

The design value for driver eye height has increased from 1070 to 1080 mm (3.51 to 3.54 ft) to match the latest field data. Because crash studies have found almost no collisions with objects shorter than 600 mm (2.0 ft), the design value for object height has increased from 150 mm (0.5 ft) to 600 mm. An object height of 600 mm corresponds closely with the taillight height of a passenger car. All horizontal and vertical alignment criteria in the Green Book incorporate the new values for driver eye height and object height.

The treatment of superelevation for horizontal curves is unchanged; superelevation is the introduction of an increased cross slope or banking on a horizontal curve to help vehicles traverse the curve safely. However, some recommendations from NCHRP Report 439, *Superelevation Distribution Methods and Transition Designs* (*5*), may lead to changes in the next edition of the Green Book. Other recommendations already have been incorporated into the updates of design controls for transitions from roadway sections with superelevation to sections without superelevation.

The upper limit for low-speed design is now 70 km/h (45 mph) instead of 60 km/h (40 mph). For the design of vertical alignments, the criteria for critical length of grade remain unchanged, but revised speed-distance curves have been developed for a 120-kg/kW (200-lb/hp) truck traveling at a speed of 110 km/h (70 mph) at the foot of the grade. Under an NCHRP contract,[2] Midwest Research Institute is exploring the need for further revisions of these criteria.

Other changes in Chapter 3 include increasing the bed depth for emergency escape ramps to 1 m (3 ft), as well as new texts on sight distance at undercrossings and on fencing, plus a revised treatment of traffic control devices.

Cross-Section Elements

Chapter 4 presents the design criteria for cross-section elements, such as the widths of traveled ways and lanes, shoulder types and widths, curbs, and medians, as well as pedestrian and bicycle facilities. The section on curbs now stresses visibility for drivers. In addition, a change in terminology replaces the term "barrier curb" with "vertical curb" and the term "mountable curb" with "sloping curb."

FIGURE 3 Sidewalk curb ramp.

The discussion of surface types refers only to high- and low-type pavement surfaces, eliminating the intermediate pavement surface type. Also updated are the discussion of medians and the guidance on grades for parking areas in park-and-ride facilities.

A single section on pedestrian facilities incorporates material on sidewalks and is compatible with proposed criteria in the *Americans with Disabilities Act Accessibility Guidelines* (*6*). The updated section on sidewalk curb ramps (Figure 3) also corrects inconsistencies in the previous edition's terminology.

Designing to accommodate bicycles receives added emphasis throughout the Green Book, following guidance and information presented in the AASHTO *Guide for the Development of Bicycle Facilities* (*7*).

Local Roads and Streets

Chapter 5 presents the design criteria for local roads and streets. The chapter exhibits reflect the changes to fundamental design criteria in Chapters 3 and 9. The maximum superelevation for rural roads has increased from 10 to 12 percent. Clear zone widths—the areas that should be clear of roadside obstacles and steep roadside slopes—are now 2 to 3 m (7 to 10 ft) for local roads and streets.

In 2001, AASHTO also published *Guidelines for Geometric Design of Very Low Volume Local Roads* (*8*), which applies to local roads and to some collector roads with average daily traffic volumes of fewer than 400

[2] NCHRP Project 15-21, Review of Truck Characteristics as Factors in Roadway Design.

FIGURE 4 Design criteria for rural freeways underwent only minor revisions, with some streamlining.

vehicles. The next edition of the Green Book will incorporate these design guidelines.

Collector Roads and Streets

Presenting the design criteria for collector roads and streets—which provide links from local to arterial roads—Chapter 6 and its exhibits also reflect the changes to fundamental design criteria in Chapters 3 and 9. A minimum clear-zone width of 3 m (10 ft) is recommended for rural collectors. The discussion of median width on urban collectors has received minor modifications, and the widths of parking lanes on collectors in residential, commercial, and industrial areas have been revised.

Rural and Urban Arterials

The recommended width of the traveled way—the portion of roadway in which vehicles are permitted to operate—has increased from 6.6 to 7.2 m (22 to 24 ft) for rural arterials with a design speed of 80 km/h (50 mph) and an average daily traffic volume of 1,500 to 5,000 vehicles. A minimum paved shoulder width of 0.6 m (2 ft) is recommended for pavement support, wide vehicles, collision avoidance, and bicycles.

A new section on bridges defines the minimum widths needed for the retention of bridges already in service. The text also updates the design criteria for highway medians in rural and in urban settings.

FIGURE 5 Guidance on modern roundabouts has entered the Green Book.

Freeways

The changes to the design criteria for rural and urban freeways in Chapter 8 are relatively minor. Exhibits are now consistent with information in Chapters 3 and 9.

The widespread use of cold milling technology has eliminated the need for vertical clearances to allow for changes that may result from resurfacing. The minimum vertical clearance above railroads has increased from 6.6 to 7.0 m (21.5 to 23 ft). Figure 4 illustrates a typical rural freeway.

Intersections

The revised Chapter 9 defines the functional—as distinguished from the physical—area of an intersection. Roundabouts (Figure 5) are a new topic in the Green Book, drawing on the recent FHWA report, *Roundabouts: An Informational Guide* (*9*), but without offering quantitative design criteria. The treatment of turning lanes and islands has been reorganized, and related exhibits have been updated to reflect changes in the design vehicles presented in Chapter 2.

Revised design criteria for intersection sight distance are presented, using research from NCHRP Report 383, *Intersection Sight Distance* (*10*). Several intersection sight distance cases now follow models for gap-acceptance—the process by which a driver entering traffic accepts an available gap for maneuvering into the flow of vehicles.

The discussion of median widths at divided highway intersections incorporates findings from NCHRP Report 375, *Median Intersection Design* (*11*). The chapter presents the advantages of offset left turns in reducing sight distance hindrances from opposing left-turn vehicles.

Grade Separations and Interchanges

Chapter 10 recommends the separation of bicycle and pedestrian movements from vehicle movements through interchange areas. Single-point urban interchanges—which control all left-turning traffic with a single traffic signal (Figure 6)—are now presented as a separate type of interchange.

The focus is on controlling access at interchanges, for example by minimizing traffic spillback on ramps and crossroads, providing sufficient length for merging maneuvers and for crossroad weaving maneuvers (i.e., when traffic flows cross one another), and providing storage (i.e., a temporary waiting area) for turning vehicles. Acceleration lengths for speed-change lanes have been recalculated and vary slightly from previous values. Designers are cautioned against using the minimum design requirements for tapered entrances, and against exceeding lane capacity on two-lane ramps.

Future Research

The AASHTO Task Force on Geometric Design has identified several topics for research to be incorporated into future editions of the Green Book. These include improved design criteria for freeway speed-change lanes; design criteria and warrants for right-turn deceleration, auxiliary through-lanes, and lane drops; and passing sight distance.

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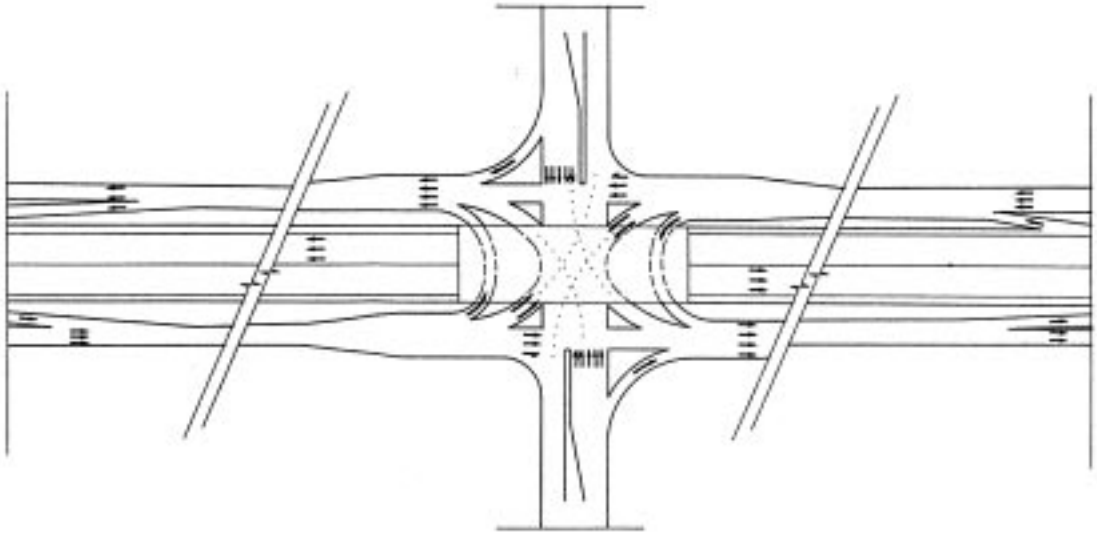

FIGURE 6 Diagram of single-point urban interchange shows complexity of movements and access points.

NOTE: Figures and tables are from AASHTO's *A Policy on Geometric Design of Highways and Streets* and are used with permission.

Transportation Group Produces International Benefits

IVAR SCHACKE AND ROD ADDIS

The authors are with the Forum of European National Highway Research Laboratories, Brussels, Belgium: Schacke is Chairman of the Executive Committee (representing the Danish Road Directorate), and Addis is Secretary General.

The Forum of European National Highway Research Laboratories (FEHRL) was formed on October 24, 1989, by the directors of the road research institutes in 13 European countries, at the initiative of the then-director of the United Kingdom's Transport Research Laboratory. Today FEHRL comprises the national road research laboratories in all member states of the European Union (EU)—Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom—as well as the European Free Trade Association countries of Iceland, Norway, and Switzerland, with affiliate members in Croatia, the Czech Republic, Hungary, Poland, Romania, Bulgaria, and Slovenia (Figure 1).

As stated in the organization's charter,

> The purpose of FEHRL is to encourage collaborative research between the member laboratories in the field of highway engineering infrastructure, leading to the provision of relevant knowledge and advice to governments, the European Commission, the road industry, and road users.
>
> The objectives of the collaborative research are to
>
> ◆ Provide input to EU and national government policy on highway infrastructure,
> ◆ Create and maintain an efficient and safe road network in Europe,
> ◆ Increase the competitiveness of European road construction and road-using industries,
> ◆ Improve the energy efficiency of highway construction and maintenance, and
> ◆ Protect the environment and improve quality of life.

At the initial meeting of FEHRL, directors agreed that collaborative research was a cost-effective way to ensure appropriate, practical results. Collaborative research would reduce duplication of effort and lead to the integration of European research resources, while permitting productive competition.

Most FEHRL laboratories are funded directly or indirectly by governments, but the trend is for laboratories to depend more and more on external funding. The full privatization of some national laboratories already has occurred or is under way.

In some countries, the FEHRL member institution remains part of the national road administration, but in others the member organization may be an independent road research institute or the road research department of a university. FEHRL laboratories comprise several thousand professional staff, with extensive laboratory facilities including heavy equipment for accelerated testing and bridge testing, as well as research tracks and other specialized devices.

The professional fields covered by FEHRL include

◆ Geotechnics,
◆ Pavement engineering,
◆ Bridge engineering,
◆ Construction materials,
◆ Telematics (electronic communications),
◆ Environmental issues,
◆ Traffic loading,
◆ Safety at road projects, and
◆ Maintenance management.

Fitting into the Framework

In the 1980s, EU launched the first of its comprehensive research programs, known as Framework Programs (FP). Each FP addresses several areas of scientific research and continues for a period of four years. The 5th FP, 1998–2002, is concluding. The budget for each program is large—approximately 16 billion euros (U.S. $15 billion). However, the resources available for specific research areas such as transportation are much less.

The 3rd FP was the first with a transportation research component, but the 4th FP, 1995–1998, included transportation research as a key activity. About 500 million euros (U.S. $505 million) was set aside, with approx-

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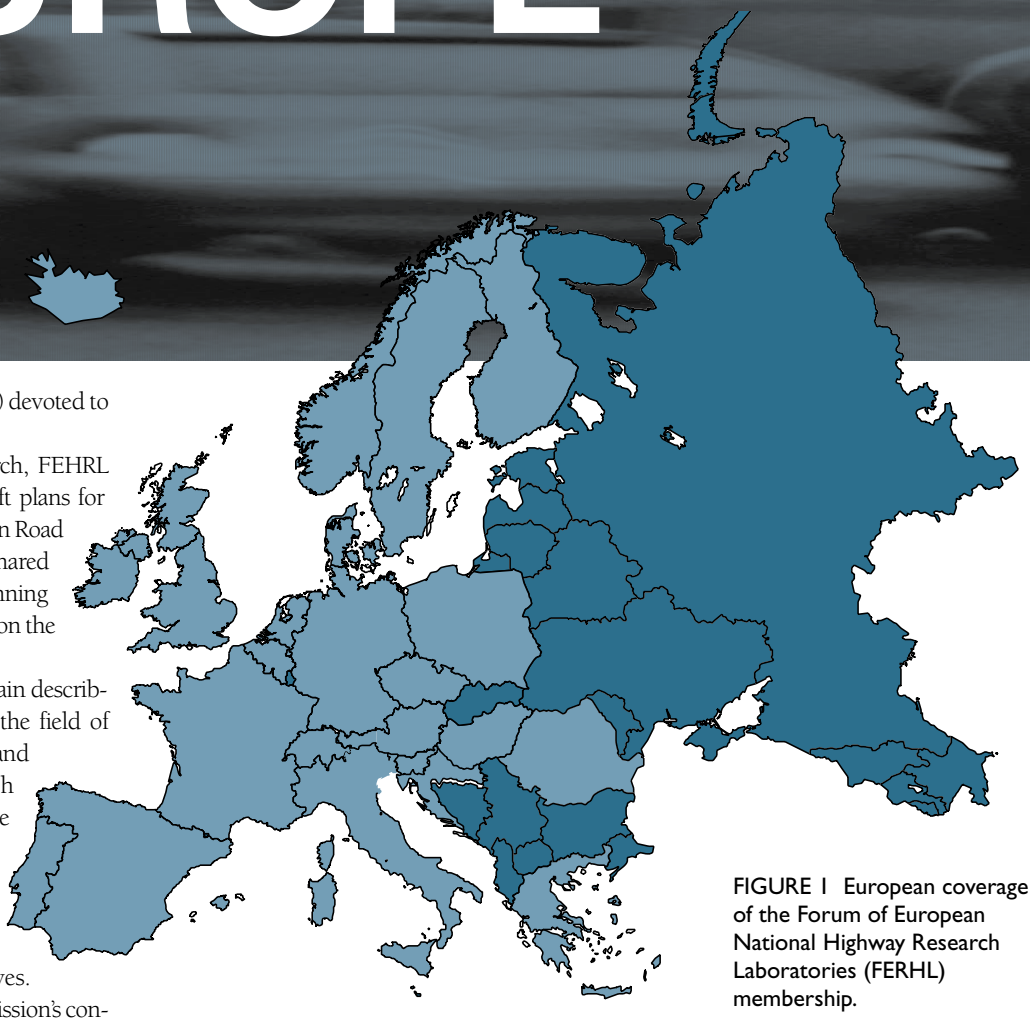


FIGURE 1 European coverage of the Forum of European National Highway Research Laboratories (FERHL) membership.

imately 22 million euros (U.S. $22.2 million) devoted to highway research.

To exploit the possibilities of the research, FEHRL convened a small group of directors to draft plans for what became the first-ever Strategic European Road Research Program (SERRP), addressing the shared needs of member countries. With this planning document, FEHRL was able to make a mark on the final version of the 4th FP.

In 1996, FEHRL developed SERRP II, again describing emerging European research needs in the field of road infrastructure and including related and timely topics, such as telematics and safety at road projects. The SERRP II definitions of research needs incorporated the results of consultations with research institution leaders, as well as the views of road construction industry and road authority representatives. SERRP II was ready for the European Commission's consideration in developing the 5th FP, and most of the SERRP II research problem statements were adopted.

FEHRL-led consortia have won bids on several projects, now under way. American research establishments also are participating in some of the transportation research projects under the 5th FP, through international agreement; however, a U.S. government agency must underwrite the cost. FEHRL project coordinators can invite U.S. participation; Donald Symmes at the Federal Highway Administration is the first point of contact. Currently two projects involve U.S. researchers: Cooperation in Science and Technology (COST) 343 (Reduction in Road Closures by Improved Pavement Maintenance Procedures) and FORMAT (Fully Optimized Road Maintenance and Techniques).

FEHRL recently completed development of SERRP III, partly for discussions with the Commission about the 6th FP, and partly to initiate cooperative efforts with other organizations, such as the Western European Road Directors. The program once again includes extensive research on road infrastructure, building on previous research developments, and proposes new topics identified by FEHRL members, road administrations, and the industry. The document also will be used for consultations with potential American partners and for cooperative research under agreements between EU and other countries.

Avenues of Research

In pursuing the objective of research cooperation, FEHRL employs several mechanisms: the submission of proposals for the FPs; the COST program; and FEHRL projects.

Submitting Proposals

The European Commission regularly issues calls for proposals of transportation research. A panel of independent experts evaluates the submissions. The European Commission provides up to 50 percent of the necessary funding for each research, technology, and demonstration project, with the remainder of the funding pro-

Members of the COST 343 Management Committee examine a newly constructed pavement in Ljubljana, Slovenia, during a May 2002 meeting.

vided by the consortium partners, road administrations, or—on some projects—by industry. In each case, the successful proposal must be in line with the objectives expressed in the Common European Transport Policy.

Through the proposal mechanism, FEHRL-led consortia undertook several projects in the 4th FP:

- Advanced Research on Road Work Zone Safety Standards in Europe (ARROWS);
- Performance Analysis of Road Infrastructure (PARIS);
- Construction with Unbound Road Aggregates in Europe (COURAGE);
- Bridge Management in Europe (BRIME);
- Pollution Mitigation (POLMIT);
- Alternative Materials for Road Construction (ALT-MAT);
- Automatic Weighing of Vehicles in Europe (WAVE);
- Pavement Economics (PAV-ECO);
- Advanced Method of Pavement Design (AMADEUS); and
- Prenormative Research on Methods of Compaction (SPECOMPACT).

Further information on these projects is available though the European Commission's website for the Community Research and Development Information Service (CORDIS), www.cordis.lu/.

Calling on COST

The COST program was established in the 1970s by Western European research ministers. Now administered by the European Commission, COST applies to almost all of the 40 countries in Europe. In contrast to the top-down administration of the FP transportation component, COST works bottom-up—a FEHRL consortium can propose a research project to the COST administration for evaluation by the COST Technical Committee on Transport, which consists of representatives appointed by the member states.

In principle, the system offers the opportunity for participation by any research establishment in a country that has signed the project's Memorandum of Understanding. The difference in the funding provided through the FP and COST is that under the FP, the Commission pays 50 percent of all costs associated with a project, but COST only pays expenses for international meetings, services of the joint secretariat, printing the final report, and conducting final seminars. In other words, under COST, the individual partners in the project finance the research.

FEHRL has undertaken 12 COST projects to date:

- Weighing in Motion (COST 323),
- Long-Term Performance of Road Pavements (COST 324),
- Pavement Condition Monitoring (COST 325),
- Development of New Bituminous Pavement Design Method (COST 333),
- Effects of Wide Single and Dual Tires (COST 334),
- Use of Falling-Weight Deflectometers in Pavement Evaluation (COST 336),
- Unbound Granular Materials for Road Pavements (COST 337),
- Reduction in Road Closures by Improved Pavement Maintenance Procedures (COST 343),
- Improvements to Snow and Ice Control on Roads and Bridges (COST 344),
- Procedures Required for Assessing Highway Structures (COST 345),
- Accelerated Load Testing for Road Pavements (COST 348), and
- Integrated Assessment of Environmental Impact of Traffic and Transport Infrastructure (COST 350).

Further information is available through the CORDIS website, www.cordis.lu/.

Working Through FEHRL

The FEHRL project has become an increasingly important mechanism for cooperation. FEHRL sets up a project after agreement at the board level on a proposal from one or more member institutions. Funding for the project comes from member resources, and the work is carried out under a partnership that has an agreed-on project coordinator, following a program of work defined by the board.

Completed FEHRL projects include

- Submerged Floating Tunnels (1996);
- Harmonization of the Use of Falling-Weight Deflectometers (1996);
- FEHRL Investigation of Longitudinal and Transverse Evenness of Roads (FILTER) (1999); and
- Harmonization of Friction, Texture, and Evenness Measurement Methods (HERMES) (ongoing since 2001).

Through the three mechanisms of FP proposals, COST, and FEHRL projects, FEHRL has effected an increased level of international cooperation in highway

research (Figure 2). In addition, FEHRL has developed a publication series to ensure high-quality reports on each project, as well as the effective dissemination of research results to the principal customers.

Further information on FEHRL research activities is available through the website, www.fehrl.org/, which also provides contact addresses for the member institutions.

Defining the Vision

In 1996, FEHRL produced a five-year development plan, covering key activities to direct the organization. Implementation of the plan, undertaken in three phases from 1998 to 2002, is nearing completion. The plan has generated 35 wide-ranging activities, from promoting, administering, and implementing research, to improving means of cooperation with related organizations, to solidifying the organizational structure by developing FEHRL into an association with a staffed, permanent secretariat.

Structuring the Organization

In accordance with the development plan, FEHRL became an association under Belgian law on January 1, 2000, with headquarters in Brussels. The association pursues its work at three levels:

- The FEHRL Board, the most senior level, consists of the directors of the member laboratories;
- The FEHRL Executive Committee, which addresses day-to-day issues, comprises five members elected by the board;
- The FEHRL Research Coordinators, who effect research cooperation—the director of each member laboratory nominates one representative.

The board meets twice a year to deal with budgets, accounts, and policy matters. The executive committee assembles approximately six times a year to oversee the business affairs of the association, the preparation for the board meetings, and the implementation of board decisions.

The research coordinators assist the executive committee in gathering information on research needs, identifying topics of interest to laboratories for cooperative research, and assisting in other matters such as gathering data on research and implementing the development plan—for example, by producing a publication policy.

The secretary general serves each of these groups. Specified contributions from the member laboratories underwrite the budget for the secretary general.

Answering the Challenges

After more than 10 years of organizational growth and maturation, FEHRL has gained recognition in the European road sector. The national road administrations remain the primary customers for research, but the road construction industry increasingly is involved both as customers and as partners.

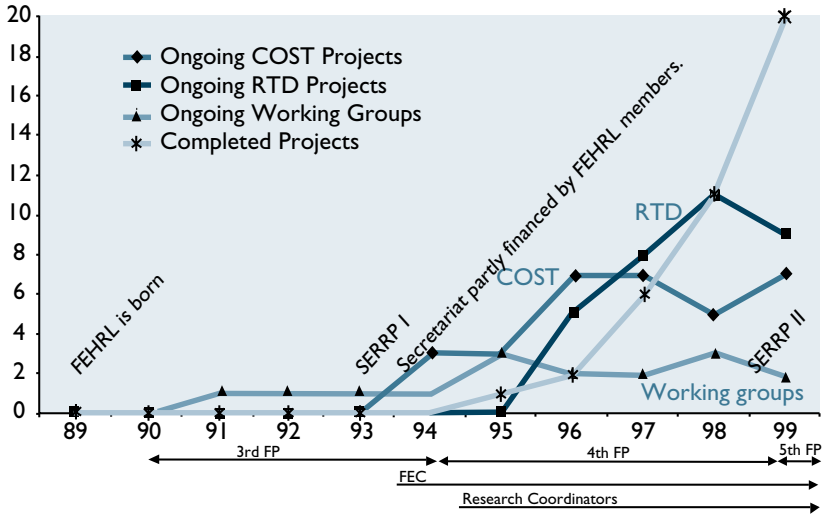


FIGURE 2 FEHRL's increased level of cooperation (RTD = research, technology, and demonstration; FP = Framework Program).

FEHRL is facing new challenges with rising traffic levels, reduced road budgets, increasing concerns about the environment and ecology, road safety problems, and the almost limitless possibilities of digital technology. Road administrations throughout Europe are eager for solutions, and FEHRL has initiated a reevaluation of its agenda.

FEHRL directors recently held an internal workshop to discuss emerging issues. Using this input and results from a survey of member laboratories, the FEHRL Executive Committee is developing a new five-year strategic plan for 2003–2007. The plan will address such issues as adding professional fields to FEHRL's purview, identifying targets for research cooperation, securing resources, establishing competencies, and initiating cooperative efforts with other groups.

Above all, FEHRL will continue to provide high-quality research and advice on road infrastructure. FEHRL will accomplish this goal not only by fostering cooperation among member institutions, but also by stimulating cooperation and interaction with other organizations that have distinct interests in the road sector.

Websites

Community Research and Development Information Service
www.cordis.lu

Forum of European Highway Research Laboratories
www.fehrl.org

Traveling by Magnetic

New Technology on the Move at Home and Abroad

Mongini, a transportation consultant, recently retired as Deputy Associate Administrator of the Federal Railroad Administration (FRA). Kupferman is Manager and Harding is Chief Scientist with FRA's Maglev Development Program.

Recent developments in Germany, Japan, China, and the United States have increased public awareness about the deployment of magnetic levitation—or "maglev"—transportation systems. What is maglev, how does it work, how has it developed, what is the status of the maglev projects planned in the United States and abroad, and what role will maglev play in the transportation system of the future?

What Is Maglev?

Magnetically levitated vehicles operate on guideways using noncontact, magnetic forces for support, guidance, propulsion, and braking. Maglev systems are designed for high-speed service and can provide an alternative to high-speed rail in intercity corridors. With a high rate of acceleration, maglev is well-suited for commuter passenger routes and offers hill-climbing ability for rugged terrain. Maglev also can serve as a mode for connecting urban areas to remote airports. Low-speed applications are under consideration.

Maglev vehicle systems fall into two basic design categories. Both categories use electric power and linear motors for propulsion, but each utilizes electromagnetic forces in different ways.

In an *attractive-force system* (Figure 1a), onboard, conventional electromagnets suspend the vehicle from the guideway by attracting the vehicle upward to steel rails mounted on the underside of the guideway. Additional onboard electromagnets attract the vehicle toward steel rails mounted on the sides of the guideway, steering and keeping the vehicle centered.

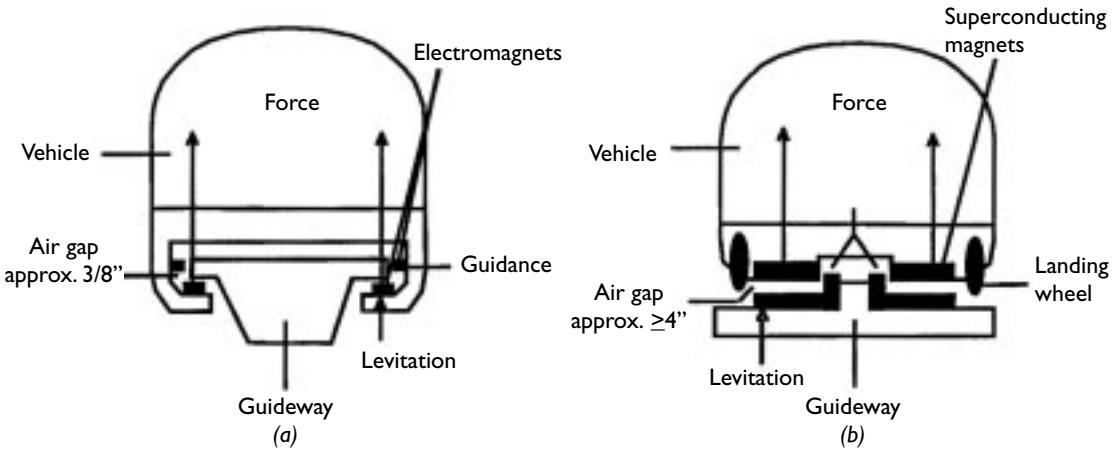


FIGURE 1 Maglev systems: (a) attractive force; (b) repulsive force.

Levitation

ARRIGO MONGINI, ARNOLD KUPFERMAN, AND JOHN HARDING

Because this form of levitation is unstable, however, a servo control regulates the magnets' current, preventing the magnets from clamping onto—or from dropping off—the steel rail. The Transrapid system developed in Germany, the High-Speed Surface Transportation (HSST) system in Japan, and the American Maglev Technology, Inc., system employ this design.

The *repulsive-force system* (Figure 1b) uses the powerful magnetic fields of onboard superconducting magnets to induce electric currents in conductors mounted on the guideway. The interaction between the currents and the magnetic fields produces repulsive forces that lift and guide the vehicle.

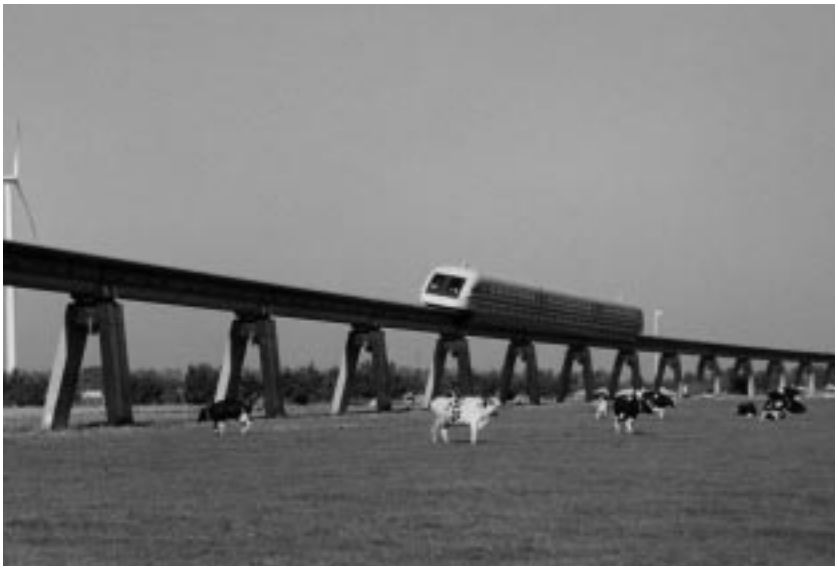
This form of levitation is stable because the repulsive forces increase as the magnets approach the reaction surface. This design characterizes the JR Maglev system developed in Japan and the Maglev 2000 system under development in Florida.

Maglev concepts have been around since the early teens of the 20th century. Nonetheless, attractive-force maglev designs became practical only with the development of high-power semiconductor electronics, and repulsive-force maglev designs became possible with the development of superconductors that can produce high magnetic fields with minimal losses of resistance.

German Initiatives

During the 1970s, German initiatives in high-speed ground transportation encompassed a range of advanced technologies—the air cushion vehicle and the attractive-force and repulsive-force maglev. All three were demonstrated on specially constructed tracks, and the attractive-force maglev system was selected as most promising—largely because the technology was most readily available.

A series of test vehicles led to the improvements and increased sophistication of the TR-08. Originally a single set of electromagnets had lifted, guided, and propelled the vehicle, but the final configuration employed one set of magnets and controls for guidance and another for levitation and propulsion.



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German initiatives like the TR-08 (*above:* at Emsland testing facility) have been pivotal in the development of maglev technology and implementation.

Early vehicles also used a short primary, or stator, linear-induction motor with a passive aluminum reaction rail along the guideway. However, because the weight of the onboard propulsion system became a hindrance as speeds approached 500 km/h (310 mph), developers adopted the linear synchronous motor with levitation magnets serving as the secondary (rotor) of the motor. This necessitated the installation of powered primary windings along the guideway but eliminated the catenary or third rail—the tradeoff was beneficial.

With substantial government funding, a private consortium in Germany has brought a high-speed attractive-force maglev system into the deployment stage. Test runs on a 39-kilometer (24-mile) circuit at Emsland in northwest Germany have accumulated more than 800 000 kilometers (500,000 miles) since 1988 and have carried more than 400,000 passengers.

Japanese Developments

Japan has developed both kinds of maglev systems.

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Provisions for building an American high-speed maglev system are included under the Transportation Equity Act for the 21st Century.

The attractive-force system, HSST, is based on an earlier version of the German maglev and has been relegated to slow-speed applications, such as airport access. The repulsive-force system is being developed for high-speed operation over long distances.

JR Maglev, the high-speed system, uses superconducting magnets for lift, guidance, and propulsion. Normal conducting, passive or short-circuited, copper or aluminum coils are mounted in the sidewalls of a U-shaped, channel guideway that supports and guides the vehicle. A separate set of powered coils mounted on the sidewalls form the primary (stator) windings of the linear-synchronous motor; the onboard superconducting magnets form the secondary (rotor) windings.

The high magnetic-field, superconducting magnets greatly reduce the amount of conductor required on the guideway. With significant government funding, the Central Japan Railway and Japan's Railway Technical Research Center have built a maglev test center in Yamanashi Prefecture and have conducted manned testing of a superconducting levitated prototype trainset at speeds up to 552 km/h (342 mph) on a remarkably short, 18.4-kilometer (11-mile) guideway. The test trainset has logged more than 180 000 kilometers (110,000 miles) and has carried more than 27,000 passengers.

Central Japan's objective is to build a 500-kilometer (300-mile) Chuo maglev line, connecting Tokyo and Osaka by a route distinct from that of the Tokaido ***Shinkansen***, or bullet train. The ***Shinkansen*** line is at capacity with more than 300,000 passengers per day. In addition, quicker trip times are required to maintain market share in the face of airline competition. The Japanese Ministry of Land, Infrastructure, and Transportation has deferred the decision about proceeding with maglev or with high-speed rail for the Chuo line until March 31, 2005.

American Efforts

U.S. federal government support for maglev technology began in the early 1970s—the U.S. Department of Transportation (DOT) and the National Science Foundation provided funding to SRI International, Ford Motor Company, and the Massachusetts Institute of Technology to conduct theoretical studies and laboratory experiments. The federal support terminated in 1975.

In June 1989, the Maglev Technology Advisory Committee, organized by Senator Daniel Patrick Moynihan (New York), published a favorable report on the feasibility of running maglev lines along Interstate highway rights-of-way. The National Maglev Initiative (NMI) followed, with the U.S. DOT, the Department of Energy, the U.S. Army Corps of Engineers, and the Environmental Protection Agency working together to establish a competition for the development of a prototype maglev system with U.S. technology.

In the meanwhile, Congress authorized a similar program to finance the NMI under the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 but later rescinded the $725 million set aside. The NMI final report, released in 1993, again recommended a prototype development plan as called for in Section 1036 of ISTEA.

These early efforts envisioned a new U.S.-based technology. In 1998, however, recognizing that maglev technology was already well developed in Germany and Japan, Congress included the Maglev Deployment Program as part of the Transportation Equity Act for the 21st Century (TEA-21). Administered by U.S. DOT, the program aims at building a high-speed maglev system that can fill a transportation need and demonstrate the technology to the public.

Competitive Edge

The Maglev Deployment Program was designed to establish a competition among sponsors of projects to plan and build the first high-speed maglev system in the United States. In February 1999, the Federal Railroad Administration (FRA) solicited applications from states and state-designated authorities to participate in preconstruction planning for a maglev project to be planned, designed, financed, constructed, and operated by a public–private partnership. Stipulations were that the project must

- Deploy trainsets that can attain a top speed of at least 240 mph;
- Meet the costs of operation and maintenance

entirely through operating revenues;

- Produce benefits that exceed total costs; and
- Receive financing through a public–private partnership with limited federal funding.

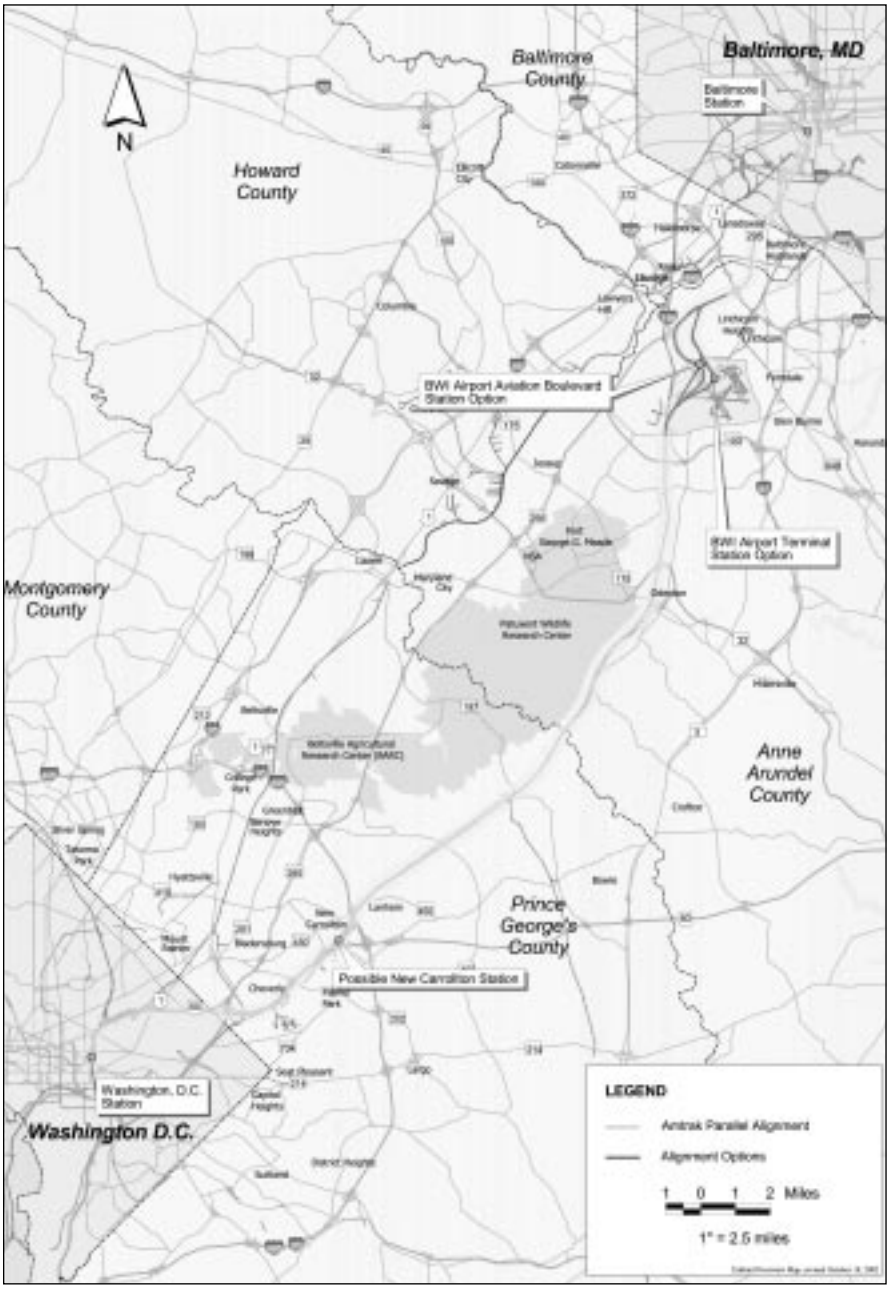
Up to $950 million in federal funds were authorized to cover as much as two-thirds of the project's capital cost.

Eleven proposal applications were submitted, and seven projects—in California, Florida, Georgia, Louisiana, Maryland, Nevada, and Pennsylvania—were selected to participate in the competition. In June 2000 each sponsor submitted a detailed project description addressing the maglev technology, route alignment, station location, services to be provided, ridership and revenue forecasts, capital and operating cost estimates, organization of a public–private partnership, a financial plan, and an environmental assessment.

In January 2001, U.S. DOT selected the projects in Maryland and Pennsylvania to conduct additional planning. The selected projects

- Met the stringent eligibility standards of the legislation;
- Gained high ratings in the criteria specified by FRA;
- Were considered likely to start construction with the federal funds authorized for the program; and
- Were projected to operate successfully through a public–private partnership.

The sponsors of the two projects are completing environmental impact statements, investment-grade revenue estimates, financial plans, and detailed partnering agreements. In 2003, U.S. DOT may recommend selection of one of the projects for design and construction. The decision to proceed then depends on Congressional appropriations and on financing commitments from other sources.



Proposed maglev project connecting Baltimore and Washington, D.C., could become the first link in services extending to Philadelphia, New York, and Boston.

Northeast Corridor Cornerstone

Maryland's Baltimore–Washington, D.C., project will provide a center city–to–center city connection between the downtown vicinity of Camden Yards in Baltimore and Union Station in Washington, D.C., with stops at Baltimore-Washington International Airport (BWI) and possibly at the Capital Beltway (I-495). The project will reduce travel time between downtown Baltimore and Washington, D.C., from about 1 hour by car, or 40 to 60 minutes by train, to less than 20 minutes. Maglev travel time from Baltimore to BWI Airport will be 6 minutes, and from BWI to Union Station, 12 minutes. Peak-period service will maintain 10-minute headways between three-car maglev trains.

In 2010—the first projected year of revenue service—ridership is estimated to reach 11.5 million passengers per year (31,700 trips per day). The planned average operating speed over the 62.5-kilometer (39-mile) route is 187 km/h (117 mph), with a top speed of 440 km/h (275 mph).

The Mass Transit Administration of the Maryland DOT, in cooperation with Baltimore City, Baltimore County, and the District of Columbia, is planning for project construction and operation by a public–private partnership. The capital cost of the project (in constant 2002 dollars) is estimated at $4.2 billion ($107 million per mile). The financing plan anticipates $1.6 billion in

federal grants and loans (including the $950 million from the Maglev Development Program), $500 million in state and local funds, and the remainder from tax-exempt revenue bonds and private equity. Construction is projected to begin in 2005.

The project would stand on its own as an operationally, functionally, and financially viable transportation system, without requiring further extension. However, by successfully demonstrating the technology, the project could become the first segment of a very high-speed successor to Amtrak's *Acela* service in the Northeast Corridor. Extended to New York, the maglev service would reduce the travel time between Washington, D.C., and New York City to 80 minutes—less than half the current 2 hours and 45 minutes on *Acela Express*.

All Terrains, All Seasons

The Pittsburgh Project is an 87-kilometer (54-mile) four-station system linking Pittsburgh Airport to downtown and the eastern suburbs of Monroeville and Greensburg. The project will reduce a 45-minute automobile or taxi trip during peak periods between the airport and downtown to 8 minutes, and the 60-kilometer (37-mile) trip between Greensburg and downtown—which can take 1.5 hours during peak periods—will take only 25 minutes.

Peak service will maintain 7.5-minute headways for three-car trains. The planned top speed is 415 km/h (258 mph), with an average of 166 km/h (103 mph). In addition, the project sponsors aim to develop a precision steel fabrication technology for implementing maglev anywhere in the United States.

The Port Authority of Allegheny County is carrying out preconstruction planning for the project in association with a private partner, Maglev Inc. The capital cost of the project (in constant 2000 dollars) is estimated at $3.5 billion. The financing plan anticipates $2.1 billion in federal grants and loan guarantees, $555 million in state and local grants, and the remainder from tax-exempt revenue bonds and private equity. Revenue operation of the first 30-kilometer (19-mile) segment, to be constructed between downtown and the airport, is scheduled for the end of 2007, with full service by the end of 2009.

The rugged physical terrain of the Pittsburgh area, a full four-season climate, and stops at an airport, downtown, and in the suburbs would demonstrate the potential of maglev technology to provide service in a variety of environments. As a stand-alone, the project will serve a regional transportation need but also can become the first stage of a high-speed intercity system linking Cleveland in the west with Philadelphia in the east.

Maglevs on the Horizon

Sponsors of the projects not selected as finalists in the Maglev Deployment Program have continued to pursue studies with limited federal financial assistance. These include

- An 85-mile project in Southern California, connecting Los Angeles International Airport, downtown Los Angeles, Ontario Airport, Riverside, and March Inland Port;
- A 32-mile project linking Hartsfield Airport, Atlanta, and the northern suburbs;
- A 48-mile project through New Orleans, New Orleans International Airport, and suburbs north of Lake Pontchartrain;
- A 269-mile project from Las Vegas, to Anaheim, California; and
- A project at Florida's Space Coast Regional Airport.

Although the other projects are relying on German Transrapid technology, the Space Coast project is exploring a refinement to the U.S.-based superconductive maglev technology invented in 1966 by Gordon Danby and James Powell and later adapted by Japanese Railways. Through the Maglev 2000 venture, Danby and Powell are now developing a prototype vehicle and guideway section.

Various innovations not only enable the vehicle to levitate at a standstill but also achieve cost savings on the guideway. The goal is to extend the system for transporting visitors to the Kennedy Space Flight Center with an eventual link to Orlando International Airport.

Low-Speed Attractions

TEA-21 also provided for the development of low-speed magnetic levitation technology that would offer a cost-effective, reliable, and environmentally sound transit option for U.S. urban mass transportation. The Federal Transit Administration has organized, funded, and undertaken the Urban Maglev Program in discrete phases:

- Evaluation of the proposed system concept,
- Development of prototype subsystems, and
- System integration and deployment planning.

Although the expectation is that federal funding would be used to develop U.S. components and technology, foreign technology transfer is permissible. Under this program, General Atomics of San Diego, California, is developing a maglev system employing a linear synchronous motor and permanent magnets. Other initiatives include the following:

CHUCK THOMAS, OLD DOMINION UNIVERSITY

Maglev vehicle is maneuvered to position on guideway on campus of Old Dominion University, Norfolk, Virginia, but awaits funds for completion and operation.

◆ The Maglev 2000 of Florida Corporation is adapting the high-speed, superconducting Maglev 2000 for low-speed application.

◆ Earth Tech Incorporated of Baltimore has teamed up with Chubu HSST Development Corporation of Japan to explore the viability of the Japanese low-speed version of HSST in the United States.

◆ MagneMotion of Acton, Massachusetts, is developing a maglev technology with the linear motor, magnetic guidance, switching, and multilevel control technologies of an automated material transport system for implementation in a maglev system serving traffic-congested urban areas.

In addition, a low-speed maglev project under construction by American Maglev Technology of Edgewater, Florida, uses a technology similar to the low-speed HSST system. The system will be deployed to link three areas on the campus of Old Dominion University in Norfolk, Virginia. A 3,400-foot (1036-meter) guideway was completed in August 2001; although plans called for routine operation by midyear 2002, the project has stalled for a lack of funding. The state of Virginia, Dominion Electric Power Co., and American Maglev Technology Co., have supported the project, and additional funds are being solicited from the federal government.

Germany's Stakes

The Federal Republic of Germany had planned to build the first maglev line between its two largest cities, Hamburg and Berlin, with the private sector assuming 40 percent of the cost. However, the government abandoned the plan in 1999, opting not to increase the project budget to meet the latest cost estimate.

Since then, the German government has decided to sponsor a project competition and to choose one or two alternative projects for implementation, as in the U.S. Maglev Deployment Program. Two projects were selected in the first round of the competition, and detailed feasibility studies have been completed:

◆ North Rhine–Westphalia—A 79-kilometer (50-mile), $3.2 billion project, Metro Rapid, would serve as a regional transportation system, connecting Dortmund to Duesseldorf, with stops at three other cities in the Ruhr region, as well as at Duesseldorf airport. The regional system would achieve maximum speeds of 190 mph.

◆ Bavaria—A 37-kilometer (23-mile), $1.6 billion project would connect Munich's airport with the downtown Central Railroad Station. Trains would travel at maximum speed of approximately 250 mph.

The German government has decided to construct both projects, pending availability of local matching funds.

China's Fertile Ground

In China, a high-speed maglev project is under construction in Shanghai. A 30-kilometer (19-mile), two-station project will link Pudong International Airport to the city center with a travel time of less than 10 minutes. The maximum operating speed in revenue service will be 430 km/h (about 270 mph), although demonstration runs at 505 km/h (315 mph) are planned.

In January 2001, a consortium administered by the city of Shanghai signed a contract with Transrapid International for vehicles and for propulsion, guidance, and control systems. Construction began in spring 2001. The first vehicles arrived in summer 2002 and are undergoing testing in Shanghai on the completed guideway. A public demonstration is scheduled for December 31, 2002, with revenue service expected by the end of 2003. Two extensions are under discussion: a 200-kilometer (125-mile) link to Hangzhou, and a 1300-kilometer (800-mile) extension to Beijing.

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A high-speed maglev vehicle undergoes inspection in Shanghai, China.

Scanning Maglev's Future

In the United States, maglev service can form the backbone of an intercity corridor serving either the Northeast Coast or California, the two corridors with the highest density of travel. The capacity of other transportation facilities in these corridors—highway, rail, and air—will be overwhelmed in the next few years, and major investment in additional facilities will be necessary.

In the Northeast Corridor, as commuter trains and *Acela* require more rail system capacity, maglev may serve as an alternative. In California, maglev service connecting large cities may provide access also to less populated but growing areas. As traffic demands build in other U.S. corridors, maglev may become the solution.

Maglev also can be used in the United States to create a high-speed regional commuter system in several large metropolitan areas with possible links to large airports. Most of the projects in the Maglev Deployment Program fit this description, including the large-scale Southern California project. Even with a modest peak speed of 350 km/h (210 mph) and an acceleration of 0.2 g, the 117-mile trip between Pennsylvania Station in New York City and Montauk at the eastern end of Long Island, which now takes 3 hours and 21 minutes via Long Island Railroad, could be reduced to 55 minutes via maglev, including stops at the 17 intermediate stations.

The German government has directed $100 million in research and development into regional or short-distance applications of maglev, emphasizing not the high speed but the high-acceleration capability and low-noise characteristics of maglev. The regional systems in planning for the U.S. Maglev Deployment Program are taking a similar approach.

In Europe, with the successful completion of one of the short-distance regional projects in Germany, applications for maglev could develop for longer corridors. However, because of the substantial investment in long-distance high-speed rail, the maglev projects are likely to be regional.

Japan will not decide on construction of the maglev Linear Train until 2005. Influencing the decision are considerations such as recovery from the current economic recession, continuing pressure on the capacity of the Tokaido *Shinkansen*, as well as need for an alternate transportation facility in case of earthquake or other emergency along the nation's most heavily traveled route.

With the Shanghai system already under construction and no previous investment in high-speed ground transportation, China may prove fertile not only for construction of new high-speed lines but also for further maglev technology development in a fast-growing economy not yet dependent on automobile or air travel.

In summary, maglev technology could gain use in a variety of applications in the future, possibly including a mixture of passenger and high-value freight movement. With deployment, the technology can be refined and the cost reduced, making implementation of new routes more attractive.

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www.transrapid-usa.com

Iowa Department of Transportation

VIBRATOR MONITORS

Concrete Paving Technology Generates Buzz

ROBERT STEFFES AND SHANE TYMKOWICZ

During the roadway paving process, vibrator monitor technology can record and display data such as vibrator frequency, paver location, travel speed, and air temperature for all vibrators at all times. This information can lead to improved portland concrete cement pavement quality, reduced deterioration, and alleviation of maintenance time and costs.

Steffes is Research Assistant, Office of Materials Research, Iowa Department of Transportation, and Tymkowicz is Materials Engineer, District 3, Iowa Department of Transportation.

Consolidation of the entire area of concrete pavement is essential for good quality. During the paving process, concrete vibrators contribute to consolidation by producing rapid vibratory impulses, liquefying the mortar and reducing the internal friction between the aggregate particles. In liquid condition, concrete settles under the action of gravity. When vibration is discontinued, friction is reestablished. Vibrators must operate at specified frequencies to achieve proper consolidation and to avoid premature deterioration.

Problem

Premature deterioration of portland cement concrete (PCC) pavements has been a concern for the Iowa Department of Transportation (DOT). In the early 1990s, deterioration was observed in some projects only 3 years after construction. The deterioration appeared throughout the panels as a longitudinal pattern of lines spaced about 18 inches apart—a spacing that corresponded to paver vibrator positions (see Figure 1).

FIGURE 1 Early deterioration of concrete pavement shown by longitudinal cracks.

Solution

An Iowa DOT in-house research project evaluated the longitudinal lines of premature concrete deterioration. Researchers examined cores extracted from areas of deteriorated pavement. The conclusion was that excessive vibrator frequency during concrete consolidation had contributed to this deterioration.

Spot checks with a handheld tachometer revealed that the frequency was often outside the specified range of 5,000 to 8,000 vibrations per minute. Using the tachometer to determine vibrator frequency is a cumbersome, time-consuming procedure. Errors are not uncommon, and continuous measurements are difficult to obtain.

Paving operations were observed on several projects to determine how much control was maintained over the operating frequencies of the paver vibrators. A vibration system consists of a bank of approximately 20 individual, uniformly spaced vibrators positioned under the front of the paver (see Figure 2). The vibrators fluidize and consolidate the concrete that is being molded into shape by the moving paver.

The frequency-measuring procedure involves probing into the concrete below the paver, to make contact and sense the frequency for each vibrator. In general, paver operators and field inspectors did not have a thorough knowledge of the actual operating frequencies or the means for controlling vibrator frequency. No indicators warned of frequency changes or equipment failure. As a result, paver vibrators often operated at different frequencies, resulting in nonuniform consolidation of the concrete across the pavement.

Inability to control vibrator frequency caused excessive vibration, leading to concrete segregation, loss of entrained air, and subsequently to premature concrete deterioration. The handheld tachometer could measure the frequency only for one vibrator at a time. Subsequent changes of frequency, whether caused by equipment adjustments or failure, were not detected until another frequency measurement was made. It became apparent

FIGURE 2 Bank of vibrators on a concrete vibration system.

that an automated frequency monitor that could provide a continuous visual readout and a recording of all vibrators' frequencies would address the lack of information on operating frequency.

A meeting of paver and vibrator manufacturers, paving contractors, and Iowa DOT Research and Construction personnel was convened to discuss the basic needs and requirements for a vibrator monitor. All participants agreed that a vibrator monitor in full view should show the operating frequencies of all vibrators at all times during paving. Participants identified the need for a system to record data such as vibrator frequency, paver location, travel speed, and air temperature in a way that would facilitate downloading.

Two major manufacturers of vibrators soon developed prototypes of vibrator monitors that were field-tested on two pavers in Iowa in 1996. Second-generation prototypes were tested the following year, and federal funding was provided through the Priority Technologies Program for further field evaluations. The two brands of monitors proved reliable and were found to be beneficial by paver operators and field inspectors. The improved control of vibrator frequency led to more uniformly consolidated concrete and a higher quality PCC pavement.

Application

Iowa DOT specified use of vibrator monitors on paving machines in 1999, and current specifications require the use of vibrator monitors on pavers for projects of 50,000 yd^2 or more. The specification was applied to 3 projects in 1999, 9 projects in 2000, and 15 projects in 2001. Use of monitors has provided appropriate control of vibrators and has eliminated trails of segregated, low-air content, deterioration-prone concrete.

Benefits

With vibrator monitors, paver operators and field inspectors can conveniently see and know the operating frequencies of all the paver vibrators at all times during paving. This information contributes to a better quality paving operation and helps eliminate vibrator trails.

The time-consuming handheld tachometer tests are no longer necessary, and the safety risks of maneuvering around the paver to obtain frequent readings while in operation have been eliminated. The continuous display of frequency readings alerts the operator to possible equipment failure or to vibrator problems when unexpected changes are noticed.

The initial prototype monitors provided only the basic information on vibrator frequencies. Second-generation monitors have added a variety of data, such as paver station location, forward speed, and air temperature. The current generation of vibrator monitors also offers full-screen displays of menu options and equipment performance and the option of setting and controlling vibrator frequency by preprogrammed settings. The paver operators, mechanics, and field inspectors can have a clear view—watching an instrument panel—of the performance of every vibrator on a paver during concrete placement and consolidation. The technology contributes to substantial savings of time in obtaining the vibrator frequency data for assessing the quality of the paving and the concrete consolidation.

The increased knowledge of vibrator performance will help to avoid inadequate or excessive vibration and to ensure that the concrete consolidation is uniform and adequate. Use of vibrator monitors can reduce the occurrence of premature concrete pavement deterioration from segregation or from loss of air content, as well as the need for related reconstruction and repair expenditures.

For example, a partial depth repair would be appropriate for repairing deteriorated joints. However, if longitudinal cracks caused by improper vibration also develop, an asphalt concrete overlay would be necessary, at repair costs of $66,000 per mile. Vibrator monitoring technology also provides a market for the export of U.S. technology, and several systems have been exported to paving contractors in other countries.

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EDITOR'S NOTE: Appreciation is expressed to Amir Hanna, 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, 2101 Constitution Avenue, NW, Washington, DC 20418 (telephone 202-334-2952, e-mail gjayapra@nas. edu).

POINT OF VIEW

Preserving America's Aqueducts

ABBA G. LICHTENSTEIN

The author, a consulting engineer in Tenafly, New Jersey, is founder and former Chairman of the Board of Lichtenstein Consulting Engineers, Paramus, New Jersey, and is a longtime TRB affiliate, currently serving on the Committee on Dynamic and Field Testing of Bridges.

Structures that carry water over water are fascinating. To perform efficiently, canals and water-supply systems throughout the ages have required aqueducts. For example,

- In 1847 the mule-towed boats that arrived at the Delaware River via the Delaware and Hudson Canal had to wait for low water conditions and stormless days before crossing the stream. The famous Roebling Aqueduct was built to solve this problem.
- When the Chesapeake and Ohio Canal reached the Monocacy River in Maryland in 1832, the equally noted Monocacy Aqueduct was built to cross the stream just below the confluence with the temperamental Potomac River.
- The Conococheague Creek Aqueduct, now maintained by the National Park Service, was built in 1834 as part of the same waterway system, near Williamsport, Maryland.
- The Schoharie Aqueduct similarly solved crossing problems for the Erie Canal, as did the Fox River Aqueduct on the Illinois and Michigan Canal.

Repurposing Structures

There are two basic types of aqueducts: water-supplying conduits and navigational canals. The active water-carrying and boat-accommodating canals generally are being maintained and kept in service as part of ongoing enterprises. Repairs and improvements to these aqueducts should be effected in a historically correct manner whenever possible.

However, when the canal or water conduit is no longer in service, the problem of preserving the aqueduct structure becomes acute. Usually the structures or their remnants are no longer owned by canal operators but by recreation and park organizations that must find ways to protect and extend the life of these historic artifacts. The new owner also must find new uses to justify the aqueduct's existence.

The Roebling Aqueduct is now a highway crossing that preserves important original features. The wrought iron cables, the stone masonry piers, the ice breakers, and the towpath remain on the bridge, which doubles as a pedestrian crossing. The Monocacy Aqueduct is a pedestrian and bicycle crossing with magnificent stone masonry arches as originally constructed; the owner, the National Park Service, intends to keep the structure's appearance and other significant features intact and protected. The state of Pennsylvania has reconstructed the wooden arches of the Tohickon Aqueduct, at Point Pleasant on the Delaware Canal, in a show of good historic sense and appreciation of the original timber prism.

Nevertheless, many abandoned and partially neglected aqueducts are being allowed to deteriorate to the point that they must be destroyed—or they just disappear. With such losses, we are reducing our heritage. All deserving aqueducts merit preservation, just as we must preserve all historic bridges.

Remedial First Steps

The Secretary of the Interior's guidelines for the preservation of historic structures must be applied to the restoration of aqueducts and canal locks. This should be the first step in the United States. The American Canal Society and several of the state canal societies should create subcommittees to address the issues involving aqueduct preservation.

Aqueduct preservation should be a topic for discussion and for research. Specialty seminars on aqueduct and lock construction, repair, and operation should be initiated. Articles, journal papers, and conference presentations also would keep the topic alive. Moreover, the general public should be enlisted to find and report forgotten aqueducts in the countryside. Several groups already have assembled and sponsored informative program sessions: the Cleveland, Ohio, section of the American Society of Civil Engineers; the National Canal Museum in Easton, Pennsylvania; and the Roebling Chapter (New Jersey–New York) of the Society for Industrial Archaeology.

All canal lovers in the United States should consider the historic significance of these water-carrying structures carefully and assemble and implement a plan of action dedicated to the preservation of America's aqueducts.

PHOTO BY ABBA LICHTENSTEIN.

Schoharie Aqueduct on the Erie Canal system remains impressive even as a fragment—the remaining structure soon will be stabilized.

NEW TRB SPECIAL REPORT

Future Flight

A Review of NASA's Small Aircraft Transportation System Concept

THOMAS R. MENZIES

Most people associate the National Aeronautics and Space Administration (NASA) with space travel and exploration. Yet aeronautics figures prominently in the organization's name, and each year NASA sponsors hundreds of millions of dollars of research and development related to aeronautics, on topics ranging from fuel-saving, quieter jet engines to materials and technologies for making aviation safer and more efficient.

NASA's goal is to "revolutionize aviation…[enabling] people to move faster and farther, anytime, anywhere." The agency is working to "reduce intercity doorstep-to-destination transportation time by 50 percent in 10 years and by 67 percent in 25 years."

Inspired by these goals, NASA's General Aviation Program Office produced a 25-year strategy for the development of a national small aircraft transportation system. The plan anticipates major advances in avionics, engines, airframes, flight control, manufacturing, communications, and navigation systems. Applied to small fixed-wing aircraft of a size common in general aviation (GA), the advances are expected to supply a new mode of transportation for individuals, families, and business travelers.

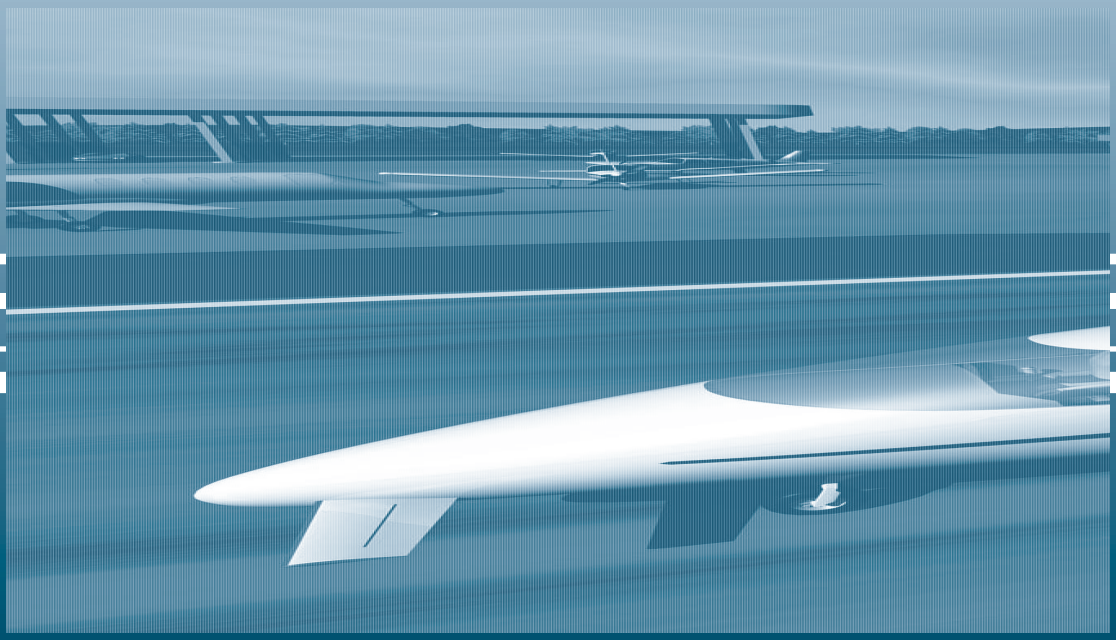
The idea is that these advanced small aircraft will be much safer and easier to operate, as well as much more comfortable, reliable, and affordable to the general public, than GA aircraft today. NASA envisions tens of thousands of the new aircraft—many self-piloted—flying between the more than 5,000 small GA airports across the country in the next two to three decades.

Launching SATS

As a first step, NASA has launched the 5-year, $69-million Small Aircraft Transportation System (SATS) program. The SATS program involves a series of technology research and demonstration partnerships with the public and private sectors.

With the goal of creating an affordable, environmentally acceptable, and easy-to-use small aircraft transportation system, NASA will work with public

Illustrations show envisioned SATS aircraft.



NASA Langley Research Center

and private partners to identify the basic capabilities and the specific technologies necessary to achieve the vision. SATS researchers are examining automated control, synthetic vision, and "highway in the sky" guidance, along with the supporting software, hardware, and methods of operation. Also under exploration are aircraft materials, designs, and manufacturing processes to make small aircraft less expensive to build, operate, and maintain.

Through a "down selection" process employing engineering, environmental, economic, and other criteria, SATS researchers plan to identify the capabilities and candidate technologies that hold the most promise. NASA then will demonstrate many of the new technologies in the final year of the program.

Seeking Advice

At NASA's request, the Transportation Research Board held a workshop in the summer of 1999 to examine the SATS concept; at the time, the 5-year program was still awaiting funding. The agency sought insight from the transportation community on the plausibility and desirability of the SATS concept as a guide for NASA's general aviation research and development program.

Representatives of the aviation, transportation infrastructure, public policy, and financial communities participated in the workshop. The sessions raised many questions about the transportation needs that the system would meet, about the practicality of defining and planning an end-state transportation system so far in advance, and about the rationale for NASA's involvement in planning and promoting a transportation system.

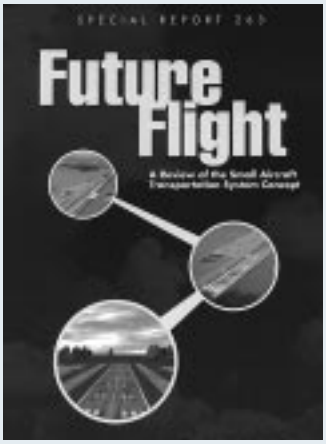
Nevertheless, most workshop participants were impressed by the advanced technologies and capabilities that were presented. Participants urged NASA to sponsor a more comprehensive assessment of the SATS concept by TRB through the National Research Council (NRC). After receiving initial funding for the 5-year SATS program from Congress in 2000, NASA tasked TRB with convening a special committee to examine the plausibility and desirability of the SATS concept and to judge the concept's suitability for guiding technology research and development.

TRB assembled a 15-member committee to provide a range of expertise and a balance of perspectives on issues pertinent to the study topic (see box, page 22). In six meetings within 18 months, the committee carefully studied plans and documents for the SATS program, received detailed briefings and technology demonstrations from NASA researchers and program officers, interviewed representatives of companies designing small aircraft and components, and conferred with experts on such topics as aircraft engineering and manufacturing, airport management and planning, air traffic control, aviation safety, and travel demand.

Examining the Vision

The committee's first task was to examine the plausibility of the ultimate SATS vision. NASA's mission is to engage in long-range research, which carries an inherent risk—therefore the guiding vision should be sufficiently plausible from economic and technical standpoints to determine which projects merit special attention and a concentration of resources. For example, the committee considered such questions as

- What is the scale and scope of the technical challenge in producing the needed capabilities?



Special Report 263: Future Flight: A Review of NASA's Small Aircraft Transportation System Concept is available from TRB (see Publications Order Form in this issue).

NASA Langley Research Center

Committee for a Study of Public-Sector Requirements for a Small Aircraft Transportation System

H. Norman Abramson, Southwest Research Institute, San Antonio, Texas, *Chair*
Donald W. Bahr, GE Aircraft Engines (retired), Cincinnati, Ohio
Marlin Beckwith, California Department of Transportation (retired), Sacramento
Max E. Bleck, Raytheon Corporation (retired), Benton, Kansas
Daniel Brand, Charles River Associates, Inc., Cambridge, Massachusetts
Walter S. Coleman, Regional Airline Association (retired), McLean, Virginia
James W. Danaher, National Transportation Safety Board (retired), Alexandria, Virginia
John J. Fearnsides, George Mason University, Fairfax, Virginia
John D. Kasarda, University of North Carolina, Chapel Hill
Charles A. Lave, University of California, Irvine
Nancy G. Leveson, Massachusetts Institute of Technology, Cambridge
Robert G. Loewy, Georgia Institute of Technology, Atlanta
James G. O'Connor, Pratt Whitney Company (retired), Coventry, Connecticut
Herbert H. Richardson, Texas A&M University System, College Station
Daniel T. Wormhoudt, Environmental Science Associates, San Francisco, California

◆ Does evidence suggest that advanced small aircraft can be made affordable to large numbers of users?

◆ Would large numbers of travelers be attracted to using small aircraft to fly between small airports?

◆ Can the aviation infrastructure, including the small airport and air traffic control systems, accommodate the added flights?

The second task before the committee was to determine if the SATS concept—even if technically plausible—was sufficiently desirable to warrant the dedication of public resources. What benefit would SATS offer the public, and at what cost socially, environmentally, and economically?

Drawing Up the Findings

The committee's analyses questioned both the plausibility and the desirability of the SATS outcome as envisioned by NASA. Specifically, the committee found

◆ Limited likelihood that SATS aircraft would be affordable to the general public. To attract leisure travelers, the envisioned aircraft would need to be far more sophisticated and reliable than even the highest-performing small aircraft today, but at a fraction of the cost.

◆ Limited potential for SATS to attract large numbers of users, because the concept was oriented to travel markets outside the nation's large metropolitan areas.

◆ Significant obstacles to SATS deployment, because of the infrastructure and ancillary service limitations at small airports, as well as the potential for noise and other environmental concerns at GA airports.

◆ The implausibility of an expeditious, nonevolutionary deployment of the SATS technologies, because of the technical challenges and the need for high levels of safety assurance.

◆ The potential for many undesirable congestion, safety, and environmental effects from SATS deployment, including more complications for air traffic management and the possibly negative net effects on the environment in shifting from larger aircraft to greater numbers of small aircraft.

Adjusting the Guidance

These findings, however, did not convince the committee that SATS would be wholly implausible or undesirable. Nonetheless, the findings raised sufficient concern for the committee to conclude that NASA should not use the SATS vision to guide technology research and development.

The committee observed that NASA's technology research holds the potential for significant benefits—for example, by reducing the probability of air traffic conflicts in more places, by permitting more reliable and safe operations during inclement weather at more airports, and by enhancing the safety of single-pilot operations.

In paying too much attention to the desired outcome of SATS, NASA runs the risk of overlooking or ignoring immediate potential benefits to the ways in which aircraft are used today. The committee therefore recommends that NASA reorient the program goals to realistic views of transportation operations and needs, instead of further pursuing the questionable SATS concept.

The technologies and capabilities that are developed for SATS may prove useful in other ways—for instance, by increasing the safety and utility of general and commercial aviation. However, many system and vehicle configurations that are not envisioned as part of SATS also may prove useful. The committee urges NASA not to neglect these possibilities.

Thomas R. Menzies, Senior Program Officer, TRB Division of Studies and Information Services, served as study director for this project.

CALENDAR

TRB Meetings

2003

January

12–16 TRB 82nd Annual Meeting
Washington, D.C.
Mark Norman

March

17–19 National Asphalt Pavement Conference: Superpave 2003*
Nashville, Tennessee
Frederick Hejl

April

6–10 9th Application of Transportation Planning Methods Conference
Baton Rouge, Louisiana
Kimberly Fisher

28–30 9th International Bridge Management Conference
Orlando, Florida
Frank Lisle

May

18–21 Statewide Transportation Planning Conference
Florida Keys, Florida
Kimberly Fisher

June

22–25 8th International Conference on Low-Volume Roads
Reno, Nevada
G. P. Jayaprakash

July

Joint Summer Meeting of the Planning, Economics, Finance, Freight, and Management Committees
Portland, Oregon
Kimberly Fisher

28th Annual Summer Ports, Waterways, Freight, and International Trade Conference
Portland, Oregon
Joedy Cambridge

11 Data Analysis Working Group Forum on Pavement Performance Data Analysis
Guimarael, Portugal
A. Robert Raab

15–18 10th AASHTO/TRB Maintenance Management Conference*
Duluth, Minnesota
Frank Lisle

20–23 42nd Annual Workshop on Transportation Law
New Orleans, Louisiana
James McDaniel

23–26 Highway Capacity and Quality of Service Committee Midyear Meeting and Conference
Buckhead, Georgia
Richard Cunard

27–30 2nd Urban Street Symposium
Anaheim, California
Richard Cunard

September

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

November

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

2004

January

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

April

13–17 Fifth 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

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 at 202-334-2934, fax 202-334-2003, or e-mail lkarson@nas.edu/.

*TRB is cosponsor of the meeting.

John J. Fearnsides

MJF Strategies, L.L.C.

Currently Chief Strategist for MJF Strategies, L.L.C., John J. Fearnsides has had a long involvement at the intersections of technology and public policy, as well as of the public and private sectors. The technology and public policy strategies he develops with his clients encompass the entire innovative process: from idea through implementation, not stopping at the invention. He specializes in the "how"—not just the "what"—of technology and public policy. These principles not only guide the formulation of business and governmental strategies but also are integral to Fearnsides' teaching philosophy at the George Mason University School of Public Policy, where he is a Research Professor of Public Policy.

Fearnsides' focus on innovation derives from 40 years of experience, most recently as Senior Vice President and General Manager of the MITRE Corporation. At MITRE, he was Director of the Center for Advanced Aviation Systems Development (CAASD), a federally funded research and development center (FFRDC) sponsored by the Federal Aviation Administration (FAA).

The technology and public policy strategies Fearnsides develops with his clients encompass the entire innovative process.... He specializes in the "how"—not just the "what"—of technology and public policy.

Fearnsides worked for MITRE from 1980 until his retirement in 1999. During this time, CAASD expanded from its original engineering orientation to a multidisciplinary organization with a wide range of scientific, analytic, economic, legal, and public policy expertise.

In addition to overseeing the development of many of the air traffic control (ATC) technologies now in operation, Fearnsides chaired the FAA Administrator's 1997–1998 Modernization Task Force, which accelerated the implementation of many of the efficiency-enhancing ATC technologies now being deployed as part of the FAA's Free Flight Program. Under his leadership, CAASD gained international recognition, serving as adviser to governments throughout the world.

Fearnsides was a founding member of Mobility 2000, which evolved into ITS America, and served on the ITS America Board of Directors for almost 10 years. He also was a member of the Board of Directors of RTCA, Inc., a federal advisory committee chartered by the U.S. Congress to develop minimum operational performance standards for the safety of new aircraft avionics, and evolving to provide a forum for government–industry consensus on the roadmap to a modernized ATC system.

Before his tenure at MITRE, Fearnsides worked at the U.S. Department of Transportation from 1972 to 1980 in various capacities, concluding with political appointments as Deputy Undersecretary, Chief Scientist, Acting Assistant Secretary for Policy and International Affairs, and Acting Administrator of the Research and Special Programs Administration. He was integral to numerous technology and public policy initiatives, including trucking and rail deregulation, the regulation of the Alaska Oil Pipeline, the early research into intelligent transportation systems, and the formulation of early considerations of the Global Positioning System and its transportation implications.

As leader of an FFRDC—a not-for-profit entity chartered in the public interest—and as a veteran of government service, Fearnsides readily responded to calls for external public service. Much of this external activity has consisted of participation in activities of the National Academies. In 1973, he was government liaison to the National Academy of Engineering Committee on Transportation. Since then, he has served on many NRC and TRB study committees. Some of the topics the committees have addressed include the environmental impact of supersonic transport, the safety and service implications of airline deregulation, the 55 mile-per-hour speed limit, intelligent transportation systems, NASA's Small Aircraft Transportation System, and the technological possibilities for ensuring transportation safety after the September 11, 2001, disaster.

Fearnsides is a Life Fellow of the Institute of Electrical and Electronics Engineers and a National Academy of Public Administration Fellow; he has received Secretarial Awards for Outstanding Performance at the U.S. Department of Transportation. He earned a doctorate in electrical engineering from the University of Maryland and holds a master of science degree and a bachelor of science degree in electrical engineering from Drexel University.

Paul A. Toliver

Computer Intelligence², Inc.

Paul A. Toliver, Vice President, Transportation, for Computer Intelligence² (CI²) Incorporated, is a proponent of technology and innovation. He paraphrases Albert Einstein: "You cannot solve the problems of tomorrow with the technologies of yesterday." Since 1973, Toliver has been a leader in the public transit industry, using his computer savvy to guide projects and to advance new technologies.

In his previous post as Director of Transportation for King County, Washington, Toliver was responsible for all modes of transportation, including the 12th largest transit system in the country, with a fleet of more than 1,300 transit coaches in active service. The system also operates the nation's largest vanpool program.

Toliver managed a full-scale fixed-signpost automatic vehicle location monitoring system—the center of the King County Department of Transportation's (DOT) transit operations, tracking and directing more than 1,000 vehicles during peak periods. The system provides real-time bus arrival information to customers at major transit centers and to customers by means of the Internet, cell phones, or handheld computers.

"I believe that information is power—the more and faster information is shared, the more powerful one becomes."

Before the merger of King County DOT and Seattle Metro in 1994, Toliver was Director of Transit for Seattle Metro, responsible for the operation of King County's integrated public transportation system.

Throughout his career, Toliver has served as both an official and unofficial spokesman for advancing the use of technology within the industry. He practices what he preaches: "I believe that information is power—the more and faster information is shared, the more powerful one becomes."

During his 30-year tenure in various management positions in the public transit industry, Toliver has nurtured his belief in technology and has used it to improve transportation services. The positions he has held include deputy general manager and chief transportation officer, San Francisco Municipal Railway, California; assistant general manager, Regional Transit Authority, New Orleans, Louisiana; principal adviser to the Mayor's Office of Transit Administration, New Orleans; general manager, South Bend Public Transportation Corporation, Indiana; assistant general manager, Metropolitan Tulsa Transit Authority, Oklahoma; and director of operational planning and research, Southwest Ohio Regional Transit Authority, Cincinnati.

Toliver recently completed 6 years of service on Transit Cooperative Research Program's (TCRP) Oversight and Project Selection Committee. He remains active on several TCRP project panels, covering Public Transit Policy Boards: Organization and Characteristics, Options for Financing Public Transportation Capital Projects, and the e-Transit Research Program. Previously he participated on TCRP's project panel on Transit Innovations Deserving Exploratory Analysis.

Toliver's dedication to improving transit has earned him recognition from his peers. He has received many awards, including the American Public Transportation Association's (APTA) 1999 Jesse L. Haugh Award, presented to the transit executive who has contributed the most to advance the urban transit industry in the United States and Canada. As head of Seattle Metro, Toliver accepted APTA's Outstanding System Award, the William T. Coleman Safety Award (awarded twice). In December 1998, he was cited as one of the most influential people in the bus industry, and most recently, in the September–October issue of *Metro*, was named one of the 25 most interesting people in transit. He has been listed in *Who's Who Among African Americans*.

In 1995, for his lifelong work as a mentor, Toliver received a Martin Luther King, Jr., individual award from King County for his continued recruitment and promotion of minority managers. "I believe strongly in developing the leadership capabilities of younger managers in the industry," says Toliver.

Currently a member of the Board of Directors and immediate past chair of the Norman Y. Mineta International Institute for Surface Transportation Policy Studies, Toliver previously participated as a member of the board of directors for ITS America, as vice president of management and finance for APTA, as national president and chair of the Conference of Minority Transportation Officials, and as a member of the Washington State Intelligent Transportation Society's board of directors.

Toliver has authored several articles on the use of computers in transportation, including "Why ITS in the First Place: ITS About Time," "Information Technology and the Transit Manager: Is Transit Ready To Get on the Information Superhighway?" "More for Less: A New Technology Dilemma," and "Getting Transit Executives To Use Microcomputers,"

Toliver received his bachelor's and master's degrees in business administration from the University of Cincinnati.

Tacoma Narrows Bridge, Tacoma, Washington.

Tacoma Narrows Bridge Gets the Go-Ahead

The Tacoma Narrows Bridge Project, in Tacoma, Washington, will be the first major suspension bridge to be built in the United States in more than 35 years. The bridge is the first large-scale project under Washington State's private–public initiatives program, as well as the first design–build project for the Washington State Department of Transportation (DOT).

The new bridge will extend parallel to, and south of, the current Tacoma Narrows Bridge and will provide three standard-width lanes for eastbound traffic, with shoulders and a separate bicycle–pedestrian pathway. The design will accommodate a future second deck.

The older bridge is undergoing seismic retrofit and other improvements, and the approaches of State Route 16 on both sides of the bridges will include new interchanges. Manual and automatic toll collection facilities will be designed and built to toll eastbound traffic. Under the design–build contract, the new toll bridge will be completed in approximately 4-1/2 years.

Award-Winning Bridges Go the Distance—And Beyond

Smart Bridge Honored

The Smart Road Bridge over Wilson Creek and Ellet Valley near Blacksburg, Virginia, has been named one of America's top 10 structural designs for 2002 by the Concrete Reinforced Steel Institute. Chosen from among 76 projects, the Smart Road Bridge is the only structure east of the Mississippi River to receive the national award and one of just two bridges to win this year.

Featuring cantilever construction with cast-in-place segments and concrete-embedded, posttensioned steel cable, the bridge has three 472-foot spans and two 283-foot spans. It is 2,000 feet long and 40 feet wide. Featuring tan-colored beams that taper in height from 35 feet at the piers to about 12 feet at midspan, the bridge is hollow beneath its riding surface.

The concrete in the bridge's massive piers is twice as strong as most bridge decks require, and the reinforcing steel is twice as thick as the rebar used in most bridges. The bridge was built with about 9,647 cubic yards of high-strength concrete, more than 1.5 million pounds of reinforcing steel, and more than 780,000 pounds of steel cables.

Broadway Bridge Gains Medal

The Broadway Bridge, located in Daytona Beach, Florida, has received the 2002 Gustav Lindenthal Medal, for meeting such criteria as

◆ **Technical and material innovation.** The use of glass tile mosaics provides durability, a range of colors, and affordability. Broadway Bridge is one of the first projects in Florida to use statnamic load tests for large-diameter drilled shaft foundations, with both lateral and vertical load tests completed. The bridge is designed as a single structural unit of 2,690 feet but uses only two expansion joints, minimizing construc-

The Smart Bridge was recognized for innovative use of concrete spans and construction methods, as well as aesthetics.

tion and maintenance costs.

◆ **Aesthetic merit.** The colorful mosaics make a strong visual impact—18 seven-foot-tall glass tile mosaics line the pedestrian walkways on each of the twin spans, and mosaics wrap around the bridge piers. A custom handrail links the walkway mosaics and repeats the wave pattern from the pier mosaics and the railings in the plazas at bridge landings. Decorative light poles along the center of the bridge accommodate banners celebrating community and cultural events. The bridge was commended for its "elegant" shape, featuring long spans, submerged footings, and a superstructure with varying depths.

◆ **Harmony with the environment.** The bridge rises high above the flat coastal terrain to allow the passage of large boats. After the realignment of the bridge, Florida DOT donated ten acres of newly available land to the city for redevelopment. The riverfront park in the middle of Daytona Beach provides residents and visitors with greater access to the Intercoastal Waterway.

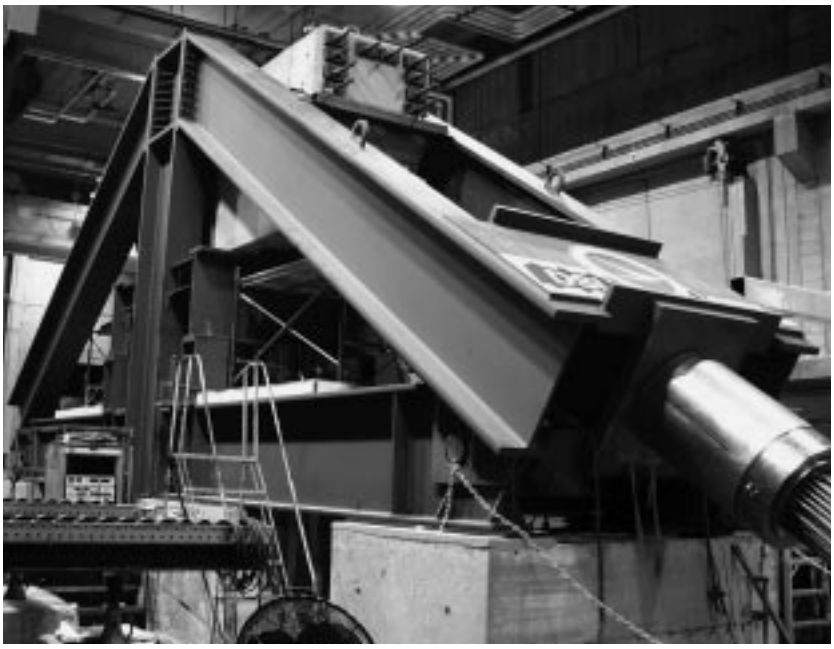
◆ **Successful community involvement.** Two public charettes shaped the design of the bridge, with consensus votes selecting the theme of "Timeless Ecology." The community then voted on more than 40 other items, including bridge shape, color, railing, lighting, landscaping, and aesthetic elements. Participants also voted to incorporate into the bridge design images of wildlife indigenous to the Florida Atlantic Coast.

Cable-Stayed Cradle System Improves Bridge Aesthetics

A revolutionary cradle system for cable-stayed bridges improves aesthetics by decreasing the size of the pylons. Ohio DOT will use the new cradle system on Toledo's Maumee River Bridge, which boasts a 1.2-million-ft^2 (110 000-m^2) deck and is scheduled for completion by 2006.

In contrast with typical stay-cable systems that anchor to the bridge's pylon, the new cradle system provides a continuous cable stay from the bridge deck through the cradle on the pylon and back down to the bridge deck. Each cable strand passes through its own individual stainless steel sleeve in the cradle assembly and is housed within the stainless steel sheathing for its free length. The primary benefit of this new system—slender and aesthetically pleasing pylons—is made possible by the elimination of the anchors required in a typical stay-cable system.

Additional benefits of the cradle system include cost-effectiveness, reduction in construction time, and the availability of test strands, which Ohio DOT may remove and inspect at 25, 50, and 75 years to verify the condition of the stays without compromising the bridge's integrity.



Acceptance testing of cable-stayed cradle system consisted of axial fatigue and ultimate static tests of 82- and 156-strand specimens, an axial fatigue and leak test of a 119-strand specimen, a cradle test of a 119-strand specimen, and single-strand axial testing.

An independent laboratory completed tests on the cradle system in December 2001. The laboratory validated all design parameters with full-size samples of the anchors and cables used in the new cradle system. The system and the components of the stay cables underwent material, production, and acceptance testing, along with fatigue and strength testing of the full-scale cable assemblies. All tests complied with the Post-Tensioning Institute requirements and were approved by FHWA.

Summarized from American Concrete Institute's Concrete International *July 2002 issue.*

Ohio Showcases Perpetual Pavement

State and national industry leaders claim that a new type of pavement currently under construction on a stretch of I-77 in Canton, Ohio, will eliminate construction-related traffic jams and save tax dollars in the future. Engineers and road construction industry officials from around the state and the nation gathered at an open house event in Canton in September to learn more about Ohio's first perpetual pavement. The event featured educational sessions and a tour of the construction site.

The pavement is constructed in three layers, designed to force distress to the surface for quick and easy maintenance. The maintenance process involves milling off the surface layer, recycling the removed material, and replacing it with a fresh layer of asphalt.

To avoid inconveniencing motorists, the work can

Asphalt crews work on the I-77 perpetual pavement project.

be done when roads are used the least, including at night, so that all lanes may be ready for traffic by rush hour. The cost of the periodic maintenance is far less than the cost of completely removing and rebuilding a road, which becomes necessary when distress reaches the base of the pavement.

New Research Lab for Large-Scale Construction

Purdue University is building an $11 million civil engineering laboratory for studying large structures such as bridges and buildings. The laboratory will enable engineers to use sophisticated environmental chambers to test and develop construction materials and designs.

The West Lafayette, Indiana, facility will be large enough to test beams, structural members, and subassemblies of bridges and buildings that weigh thousands of pounds. The laboratory also will be used to study a variety of materials used in the construction of buildings, highways, and other large-scale projects.

The two-floor building will house a special testing area 60 feet high and the length of a football field. The testing gallery will be equipped with two overhead cranes to position large parts for study. The heart of the testing area will be an L-shaped corner—a special "strong floor" and "reaction wall" of 10-foot-thick concrete blocks with holes for anchoring large structures undergoing tests. Structures will be bolted to the blocks and subjected to forces from powerful hydraulic equipment.

The L-shaped corner of Purdue University's civil engineering laboratory—now under construction—will feature a special floor and walls for testing large structures.

Groundbreaking for the new Robert L. and Terry L. Bowen Laboratory for Large-Scale Civil Engineering Research took place in late September, and construction is scheduled for completion in July 2003.

Pennsylvania Laboratory Earns International Certification

Pennsylvania DOT's Materials and Testing Division, Laboratory Testing Section, achieved certification under the ISO 9002 international quality standard in April. This achievement, a first for a state DOT, stems from the laboratory's commitment to meet customers' requirements for timely and accurate testing of roadway construction and maintenance materials.

When Pennsylvania DOT adopted the Malcolm Baldridge model for organization excellence several years ago, the Bureau of Construction and Materials searched for a practical tool to drive change and improve operations. The ISO concept of "say what you do, do what you say, and prove it" became the practical approach of the laboratory testing section. In July 2000, the section began implementing the ISO 9000 quality program to provide a bridge between the Baldridge model and the business needs of the laboratory.

The ISO 9000 series of quality management and quality assurance standards traces its roots to the founding of the International Organization for Standardization in 1946 to promote common sets of manufacturing, trade, and communication standards. The Switzerland-based organization first published the ISO 9000 standards in 1987 and revised and reissued the standards in 1994 and again in 2000. The American National Standards Institute represents the United States on the ISO Technical Committee.

The Pennsylvania DOT Laboratory Testing Section's ISO certification has generated additional benefits such as increased employee morale, pride in the workplace, and key process improvements.

—William J. Miller, Manager, Testing Laboratory, Pennsylvania DOT.

FHWA Looks at Red-Light Running Countermeasures

Since 1995 the Federal Highway Administration's (FHWA) Stop Red-Light Running Program has used a "3-E" approach—education, engineering, and enforce-

ment. The program is a community-based safety initiative to raise awareness of the dangers of red light running and to help reduce fatalities. Following are several recent initiatives:

◆ In September, the annual National Stop Red Light Running Week program provided communities with an opportunity to tie their message to the national program. Plans for public education campaigns to reduce red light running, radio and television public service announcements that highlight the red light running problem, and tabletop displays for press conferences, meetings, and other public venues were made available.

◆ Jointly prepared by FHWA and the Institute of Transportation Engineers, *Making Intersections Safer: A Toolbox of Factors and Countermeasures to Prevent Red-Light Running*—a resource for engineers, red light camera system designers, and law enforcement agencies—will be released by the end of 2002.

◆ FHWA is conducting research under the auspices of the Intelligent Vehicle Initiative on intersection collision avoidance. The research is intended to produce infrastructure-based systems that can warn drivers who are about to violate a signal or who are approaching an intersection where a crossing driver may be about to violate the signal. The program will build on these technologies to develop cooperative systems that could provide in-vehicle warning and other information to prevent crashes.

◆ New enforcement techniques—including red light signal indicators and red light cameras—are available that can reduce the cost of enforcement, decrease the danger to the enforcement, and heighten the driver's perception of getting caught. More than 70 communities in 12 states and the District of Columbia use red light camera technology. FHWA is working with other U.S. DOT agencies on guidelines that would encourage wider use of the technology by state and local agencies.

For further information visit the following websites: FHWA (http://safety.fhwa.dot.gov/), the American Trauma Society (www.amtrauma.org/), the Institute of Transportation Engineers (www.ite.org/), and the Insurance Institute for Highway Safety (www.iihs.org/).

Summarized from Patrick Hasson's article "Red Lights Mean Stop" in the September–October 2002 issue of Public Roads.

Freight Analysis Database Delivers

U.S. DOT has released the Freight Analysis Framework (FAF), a database and analytical tool to improve planning, operations, and decision making in the management of freight movement across the country. FAF is a collaborative effort by FHWA, the Federal Railroad Administration, the Federal Maritime Administration, the Bureau of Transportation Statistics (BTS), and the Office of Intermodalism.

U.S. DOT estimates that by 2020 the nation's transportation system will handle cargo valued at almost $30 trillion, compared with $9 trillion today. Volumes, in tons, will increase by nearly 70 percent over the current level of 15 billion tons. According to U.S. DOT, international freight volumes are growing faster than domestic volumes, increasing congestion and inefficiencies throughout the transportation system.

FAF examines the four key transportation modes—highway, rail, water, and air—and evaluates the effect of expected volumes on the transportation network. FAF translates data from economic forecasts for 2010 and 2020 into transportation demand, and then assigns that demand to the networks.

FAF also is a policy analysis tool that helps decision makers understand the geographic relationships of domestic and international trade flows and the nation's

Guided Walk-Through of Pedestrian Safety Issues

Pedestrian Facilities Users Guide—Providing Safety and Mobility is one component of the Federal Highway Administration's study on pedestrian facilities.

FHWA has published the *Pedestrian Facilities Users Guide—Providing Safety and Mobility*, to help transportation engineers, planners, and safety professionals make cities safer and more pedestrian-friendly. The guide is one component of a larger FHWA study, "Evaluation of Pedestrian Facilities."

The guide provides case studies and tools to identify the causes of pedestrian crashes, implement countermeasures to prevent future crashes, and enhance the walkability of the communities. The guide provides

◆ An overview of how to create a walkable environment;

◆ National pedestrian crash trends and the examination and classification of crash types to determine appropriate countermeasures;

◆ More than 45 engineering improvements for pedestrian facilities, related to roadway design, intersection treatments, traffic calming, traffic management, and signals and signs;

◆ A simplified list of improvements to address general objectives (e.g., reducing vehicle speed or volume on neighborhood streets);

◆ Direction on setting priorities for pedestrian facility improvements; and

◆ Strategies for securing funds for pedestrian-friendly projects.

To obtain copies of the *Pedestrian Facilities Users Guide—Providing Safety and Mobility*, contact Ann H. Do, FHWA (telephone 202-493-3319, e-mail ann.do@fhwa.dot.gov/).

Summarized from Ann H. Do's article "Walking the Safety Walk" in the September–October 2002 issue of Public Roads.

intermodal transportation system. With this tool, state and local governments and the private sector can determine which transportation corridors are or are about to become heavily congested and can plan solutions in advance to alleviate bottlenecks in the intermodal transportation network.

Additional information on FAF is available at the Office of Freight Management and Operations website, www.ops.fhwa.dot.gov/freight/.

Muscling Mussels: Testing Mechanical Relocation

More than two dozen workers from seven different agencies recently experimented with a new method of relocating mussels in the Tennessee River, as required before dredging in mussel habitats. The experimental procedure used a clamshell dredge to make shallow-scoop and full-scoop lifts of substratum, depositing the contents on a flat-top barge, collecting samples to study for damage, and then relocating the mussels.

The conventional method of relocation is expensive and time-consuming, using divers who survey the surface area to be dredged and retrieve the mussels by hand. An alternative is to collect mussels via a diver-operated suction pump. A suction dredge with a 4- to 8-inch intake pipe can remove more mussels than a diver can collect by hand. With both methods, mussels die from handling, during the temporary storage before relocation, or in relocation.

According to Andrew Miller, limnologist with the U.S. Army Engineer Research and Development Center in Vicksburg, Mississippi, and Barry S. Payne, co-author of *An Evaluation of Methods to Safely Remove Freshwater Mussels Prior to Maintenance Dredging*, divers can collect and remove live mussels from approximately 270 square meters during a single working day. At this rate, a crew could cover approximately 1 acre in 15 days. Removing mussels by hand

U.S. Army Corps of Engineers (U.S. ACE) Lead Biologist Patty Coffey examines a Papershell mussel with Tennessee Valley Authority (TVA) Senior Mollusk Biologist John Jenkinson.

From left: Tennessee Wildlife Resources Agency Biologist David Sims, TVA Senior Mollusk Biologist John Jenkinson, and U.S. ACE Biologist Joy Broach sift through sand, gravel, and cobble deposited on a barge by a clamshell dredge.

from the 4.3 acres requiring dredging near Diamond Island in the Tennessee River could take 64 days at a cost of $3,000 to $5,000 per day—a total bill of $192,000, not including the time required to transport and replace the mussels.

The current experiment, when completed and evaluated in March 2004, may reveal a better and more cost-effective method with less stress to the mussels. The work was the culmination of more than three years of planning by the U.S. Army Corps of Engineers, the Tennessee Valley Authority, the U.S. Fish and Wildlife Service, the Tennessee Wildlife Resources Agency, the Tennessee Department of Environment and Conservation, and Wolf River Conservancy.

Summarized from "Agencies Test New Mussel Relocation Method" by Dave Treadway, U.S. Army Corps of Engineers.

TranStats: One-Stop Data Shopping

U.S. DOT's BTS has unveiled TranStats, a new website to provide transportation researchers and analysts one-stop data shopping, with access to more than 100 transportation-related databases.

"[BTS] is making data more accessible for the entire transportation community," said Ashish Sen, the recently retired BTS Director. "Ultimately, TranStats should result in more timely and more informed decisions, and a better transportation system."

Reducing the time for data gathering can allow more attention to analysis, and with easy links across many data sets, more insights can be achieved.

Before TranStats, the process of compiling data to analyze a problem commonly involved searching for data sources, contacting various data providers and often following up to get more information about the data, sorting through the data, and integrating data from various sources for analysis. The process can be labor-intensive and time-consuming. TranStats aims at streamlining the process.

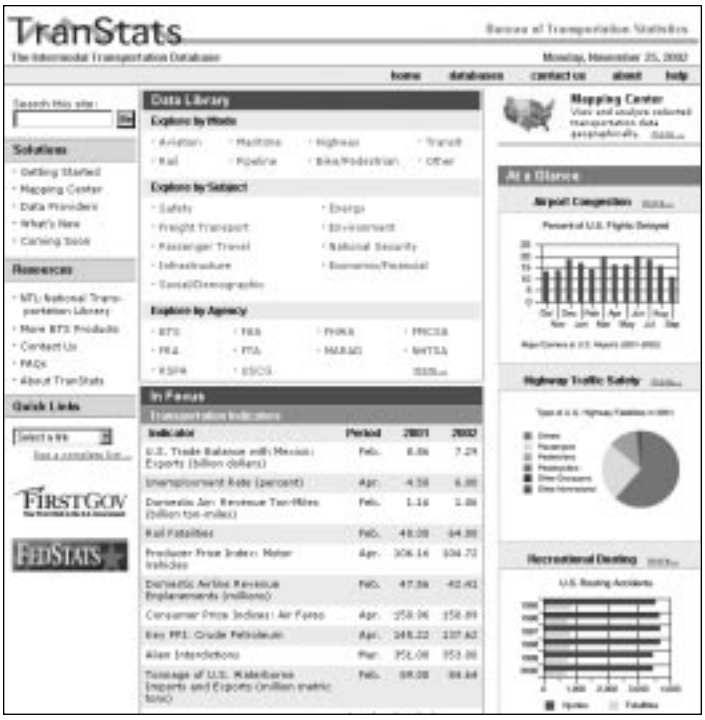
TranStats offers analysts several unique features:

◆ **A searchable index** with more than 100 transportation-related databases across every mode of transportation—with the social and demographic data sets commonly used in transportation analysis.

◆ **Selective download**—the ability to choose variables of interest and download the data directly to the computer for analysis using any database, spreadsheet, or statistical package.

◆ **Online data documentation**—profiles of each database, summary information about the tables in a database, data definitions, and code information for data variables.

◆ **Interactive analytical tools**—the ability to assemble simple statistical summaries, create time series or cross tabulations, generate graphics online, and cut and paste results into reports.



The TranStats website can streamline data compilation and analysis.

◆ **Interactive mapping** to help visualize geographic data.

◆ **A mapping center** with the full National Transportation Atlas Database, as well as applications for easily mapping DOT grants and other key data sets.

Users can explore the data by transportation mode or by subject area, use keyword searches to find relevant data sets, and get online help. The data are indexed with a transportation thesaurus, streamlining links to other transportation research via the National Transportation Library.

Having all of the data in one location provides new opportunities for improving data quality, comparability, and coverage, and should facilitate the development of standards for presentation and documentation, to make transportation data more usable, according to BTS. The TranStats homepage is at www.transtats.bts.gov/; click on *Getting Started.*

For further information contact Jeff Butler (telephone 202-366-9259).

Research Website Fills Local, State, and Global Needs

TRB's revised and revamped Research in Progress (RiP) website registered more than 5,600 visitors in October, its first full month of operation. Research staff from 23 state departments of transportation (DOTs) visited the website and 10 submitted new project descriptions online. In addition, 134 subscribers from around the world signed up to receive e-mail alerts of new projects in specific subject areas.

The RiP website facilitates the exchange of information on current transportation research projects. The website contains the RiP database (with more than 6,600 new and recently completed project statements) and a data entry system that allows users in state DOTs to add, modify, and delete information on their current research in progress postings.

The updated website allows users to

- Search the entire RiP file by key word or by various data fields;
- Link and perform a search of RiP in the TRIS Online Database;
- Browse project records by subject;
- Locate projects by individuals and organizations;
- Subscribe to receive e-mail notification of new RiP records in specific subject areas; and
- Submit current research projects for entry into the system.

Authorized DOT staff also will be able to

- Add, modify, and delete state RiP records;
- Submit RiP records using an online data entry form; and
- Access detailed contact information.

For further information visit the RiP website (http://rip.TRB.org/) or contact Barbara Post, TRB (telephone 202-334-2990, e-mail bpost@nas.edu).

Workshop Forecasts Aviation Activities

"Strategies for Recovery" was the main theme of the 12th International Workshop on Future Aviation Activities, conducted by TRB in September in Washington, D.C. Part of a biennial series initiated in 1979 under the sponsorship of the Federal Aviation Administration (FAA), the workshop convened to assist public and private-sector managers and decision makers in forecasting long-term trends and developments in commercial, business, and personal air transport.

Topics discussed included the domestic and international outlook; the structure and operating patterns of major and regional U.S. air carriers; expected developments in international aviation, including air freight and aircraft and engine manufacture; and trends in business aviation, including fractional ownership, civil helicopter transport services, and the improving outlook for personally owned and operated light aircraft.

The primary purpose of the workshop was to review and critique FAA's draft forecasts and to provide comments and insights from researchers and practitioners across the aviation spectrum. More than 145 participants from government, industry, academic institutions, and private consulting firms attended, including representatives from Europe, Asia, Latin America, and foreign firms with offices in the United States.

The broad cross-section of experience represented by the participants ensures that FAA has direct access to current and future trends in aviation. The results of the workshop are incorporated into FAA's forecast planning process.

Six New Appointees to Marine Board

Six new members have accepted appointment to the TRB Marine Board, effective November 1. The 20-member board includes top-level researchers, executives, and practitioners from the public and private sectors. The new and continuing members reflect the many disciplines and areas of expertise within the maritime sector. The new members are

- Larry L. Daggett, engineer and principal at

Waterway Simulation Technology, Inc.;

- Paul S. Fishbeck, Director of the Center for the Study and Improvement of Regulation, and Associate Professor of Engineering and Public Policy and Social and Decision Sciences at Carnegie Mellon University;
- Ronald K. Kiss, President of Wedd Institute;
- Rear Admiral Robert C. North, retired from active duty with the U.S. Coast Guard, and President of North Star Maritime, Inc.
- Jerry R. Schubel, President and Chief Executive Officer of the Aquarium of the Pacific, and Visiting Professor of Biology and Environmental Studies at Washington College; and
- Richard H. Vortmann, Vice President of General Dynamics and President of National Steel and Shipbuilding Company.

Information and materials from recent Marine Board activities are posted on TRB's website (click on Marine Board).

Gearing Up for TRB's 82nd Annual Meeting

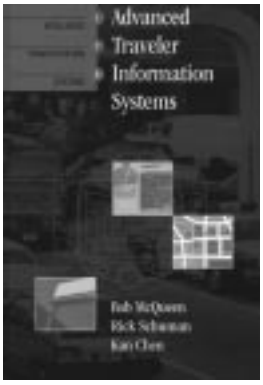
The program for TRB's 82nd Annual Meeting, January 12–16, 2003, in Washington, D.C., features more than 494 podium sessions, including 117 spotlight sessions, 48 poster sessions, 40 workshops, and 300 committee meetings. Spotlight topics include Security: One Year Later, Congestion: What Does the Future Hold?, New Tools for Improving Safety, and The Route to Reauthorization.

Admiral James M. Loy, Under Secretary of Transportation for Security, will be the featured speaker at the Chairman's Luncheon, and Thomas B. Deen, former TRB Executive Director, will deliver the 2003 Distinguished Lecture, which has been renamed in his honor.

For a complete listing of the sessions and meetings planned and to create a personal Annual Meeting itinerary, browse the TRB Annual Meeting Interactive Program online (click on Interactive Program at www.TRB.org/).

TR News Queues Up Online

Missing a back issue of *TR News*? Complete issues are being posted on TRB's website on a four-month delay. Now available are all 2002 issues through July–August. The most recent editions will continue to post only the cover, table of contents, "Research Pays Off," and selected features. Visit the site at www.TRB.org/; click TR News, under Programs and Services.



Proceedings of the Marine Transportation System Research and Technology Coordination Conference
U.S. Army Corps of Engineers. Marine Transportation Systems, U.S. Department of Transportation. Washington, D.C.: 2002; softcover.
The Marine Transportation System (MTS) Research and Technology (R&T) Coordination Conference, held in November 2001 in Washington, D.C., was the sixth biennial conference to focus on R&T in the MTS, but the first to be sponsored by the new Interagency Committee on the Marine Transportation Systems. The theme of this year's conference was "Meeting the Needs of the Marine Transportation System Through Research and Technology."

The three primary purposes of the conference were to identify new or changing research and technology needs of the MTS; to present recent progress in scientific and technological advances that could be applied to marine transportation and waterway management; and to foster new partnerships between federal, state, private, and academic institutions to improve the MTS.

The conference comprised 6 plenary panels, 12 technical sessions, and addresses by several speakers. An electronic copy of the proceedings is available at www.dot.gov/mts/. The web version includes hyperlinks to additional materials, such as session transcripts, visual aids from the presentations, abstracts, and other items of interest.

Alaska's Ocean Highways: A Travel Adventure Aboard Northern Ferries
Mark Kelley and Sherry Simpson. Graphic Arts Center Publishing Company, Portland, Oregon: 1995; $32.95, hardcover, $19.95, softcover; ISBN 0-945397-31-3; 111 pp.
This photographic document of the Alaska Marine Highway System sails readers through the Inside Passage, across Prince William Sound and Cook Inlet, to Kodiak Island and the Alaska Peninsula en route to the remote Aleutians. The photographic subjects include people and cultures, mountains and glaciers, and a vast array of wildlife. The accompanying text describes lifestyles onboard ferries, the history of the Alaska Marine Highway System, and the character and feel of port communities.

Advanced Traveler Information Systems
Bob McQueen, Rick Schuman, and Kan Chen. Artech House. Norwood, Massachusetts: 2002; $85, hardcover; ISBN 1-58053-133-4; 260 pp.
The authors explore the traveler information supply chain—from needs analysis and data collection to information processing and dissemination—and provide a comprehensive view of the public and private sides of the traveler information business.

Also addressed is the need to provide information to support traveler behavior changes and make the best use of limited public funds. Perspectives are offered on the fair valuation of traveler informa-

TRB Publications

Transportation Network Modeling 2001
Transportation Research Record 1771
Topics relate to calibration and path dynamics issues in microscopic simulation for advanced traffic management and information systems, estimation of origin–destination demand for dynamic assignment with simultaneous route and departure time choice, assessing performance reliability of road networks under nonrecurrent congestion, and advances in discrete-time dynamic data representation with applications to intelligent transportation systems.

2001; 228 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber category: planning and administration (IA).

Soil Mechanics 2001
Transportation Research Record 1772
This four-part volume examines issues, procedures, and findings on geotechnical instrumentation and construction; drilled shaft, micropiles, and other foundation issues; pavement subsurface drainage; and geosynthetics in transportation facilities.

2001; 210 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber category: soils, geology, and foundations (IIIA).

Part 1: 2001 TRB Distinguished Lecture; Part 2: Bicycle and Pedestrian Research
Transportation Research Record 1773
Part 1 features "Building Communities with Transportation," the 2001 TRB Distinguished Lecture by Dan Burden. Part 2 focuses on pedestrian research, including the development of bicycle-friendly rumble strips, operational needs and characteristics of inline skaters, the safety effects of marked versus unmarked crosswalks at uncontrolled locations, and relating the severity of pedestrian injury to impact speed in vehicle– pedestrian crashes.

2001; 126 pp.; TRB affiliates, $30; nonaffiliates, $40. Subscriber category: safety and human performance (IVB).

tion–related data, and new approaches are presented for practitioners.

Design and Construction Practices to Mitigate Cracking
American Concrete Institute (ACI). Farmington Hills, Michigan: 2002; $25 for ACI members, $45.50 for nonmembers, softcover; 208 pp.
This volume contains 13 papers from a national symposium sponsored by ACI Committee 224, which deals with concrete cracking. Papers cover a range of topics, including

- Design for crack control in reinforced and prestressed concrete beams, two-way slabs, and circular tanks;
- Early-age thermal cracking in laser-screeded concrete slabs;
- Crack control provisions in the new Eurocode;
- Use of external prestressing to mitigate seismic-induced diagonal cracks in concrete columns;
- Flexural crack control in reinforced concrete;
- The effects of shrinkage-reducing admixtures on crack reduction;
- Use of fibers to reduce plastic shrinkage cracking;
- A review of crack width limitations for structures subject to leakage;
- An analysis of cracking in concrete repair structures; and
- Cracking in concrete structures after the 1999 earthquake in Turkey.

This publication, a companion to ACI's *Control of Cracking in Concrete Structures*, is for design engineers, builders, and others working to improve the long-term cracking behavior and performance of concrete. To order, contact ACI (telephone 248-848-3800, visit www.concrete.org/).

A Guide for Hot-Mix Asphalt Pavement
National Asphalt Pavement Association (NAPA). Lanham, Maryland: 2002; $30, plus shipping and handling, CD-ROM.

This interactive CD-ROM contains the equivalent of a 350-page book on hot-mix asphalt (HMA) technology. Photos, animations, and movie clips illustrate key points. The guide presents an overview of HMA technology, including materials, mix design, mix selection, structural design, construction, pavement evaluation, and pavement maintenance and rehabilitation. The text contains links between topics, other related terms, and a glossary, and it is searchable by topic.

The CD-ROM is intended for specifiers, designers, and construction engineers who lack formal training in HMA technology or who may benefit from a refresher course. For more information, contact NAPA (telephone, 888-468-6499; e-mail publications@hotmix.org, fax 301-731-4621, or visit www.hotmix.org/).

The books listed in this section are not TRB publications. For ordering information, contact the publisher listed.

Artificial Intelligence and Intelligent Transportation Systems
Transportation Research Record 1774
Papers focus on autonomous agents for traffic simulation and control; findings from a Washington, D.C., case study on the time management impacts of pretrip advanced traveler information systems; the environmental effects of intelligent cruise control vehicles; implementing adaptive driving systems for intelligent vehicles through neuro-fuzzy networks, and more.

2001; 122 pp.; TRB affiliates, $30; nonaffiliates, $40. Subscriber category: planning and administration (IA).

Concrete 2001
Transportation Research Record 1775
Michigan's approach to a statewide investigation of materials-related distress in concrete pavements, petrographic analysis of concrete deterioration, lightweight fly ash–plastic aggregates in concrete, and performance characteristics of synergy fiber-reinforced concretes are among the topics addressed.

2001; 139 pp.; TRB affiliates, $34.50; nonaffiliates, $46. Subscriber category: materials and construction (IIIB).

Traffic Flow Theory and Highway Capacity 2001
Transportation Research Record 1776
Results are reported for research on freeway quality of service, the effect of driver population at freeway reconstruction zones, the capacity at unsignalized intersections as derived from conflict technique, multivehicular traffic flow prediction, and the characteristics of passing and meeting maneuvers on exclusive bicycle paths.

2001; 236 pp.; TRB affiliates, $51.75; nonaffiliates, $69. Subscriber category: highway operations, capacity, and traffic control (IVA).

TRB Publications

Passenger Travel Demand Forecasting, Planning Applications, and Statewide Multimodal Planning
Transportation Research Record 1777
This volume presents research on quantifying spatial characteristics for travel behavior models, spatial microassignment of travel demand with activity trip chains, computational issues in increasing spatial precision of traffic assignments, and planning for megacontainerships.

2001; 145 pp.; TRB affiliates, $34.50; nonaffiliates, $46. Subscriber category: planning and administration (IA).

Design and Rehabilitation of Pavements
Transportation Research Record 1778
Pavement issues examined in this volume include benefits and costs of jointed plain concrete pavement design features, layer thickness variability for flexible pavements in North Carolina, effects of interface condition and horizontal wheel loads in the life of flexible pavement structures, and repair of ultrathin whitetopping pavements.

2001; 200 pp.; TRB affiliates, $42.75; nonaffiliates, $57. Subscriber category: pavement design, management, and performance (IIB).

Traffic Safety 2001: Americans with Disabilities Act; Driver and Vehicle Modeling; Situation Awareness; Licensing; Driver Behavior; Enforcement; Trucks; and Motorcycles
Transportation Research Record 1779
An array of research considers the modeling of driver behavior with mind's eye coordinates; radar detection of vehicles in a string; winter-weather speed variability in sport utility vehicles, pickup trucks, and passenger cars; the effectiveness of truck rollover warning systems; wheelchair securement; and more.

2001; 208 pp.; TRB affiliates, $42.75; nonaffiliates, $57. Subscriber category: safety and human performance (IVB).

Land Development and Public Involvement in Transportation
Transportation Research Record 1780
The implications of urban development on travel demands in the Netherlands, a survey to measure customer views of transportation planning services, contractor-led public relations for a design–build highway project, and accessibility in a metropolis are among the paper topics.

2001; 164 pp.; TRB affiliates, $36; nonaffiliates, $48. Subscriber category: planning and administration (IA).

Comprehensive Specification for the Seismic Design of Bridges
NCHRP Report 472
This Report contains the findings of a study to recommend specifications for the seismic design of highway bridges. The research leading to the recommended specifications is described, along with critical and conceptual issues such as design philosophy and performance criteria, seismic loads and site effects, analysis and modeling, and design requirements. The specifications are nationally applicable with provisions for all seismic zones and are being considered for integration into *AASHTO LRFD Bridge Design Specifications*.

2002; 47 pp.; TRB affiliates, $12.75; TRB nonaffiliates, $17. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

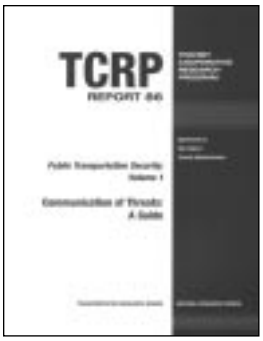
Recommended Specifications for Large-Span Culverts
NCHRP Report 473
Recommended design and construction specifications for metal and concrete large-span culverts are presented. The Report includes information on field testing and computer modeling, as well as the methodology for developing simplified design equations. The analysis and compilation of experience with long-span culverts forms the basis for the recommended specifications, which are consistent in approach and format with *AASHTO LRFD Bridge Design Specifications*.

2002; 140 pp.; TRB affiliates, $15.75; TRB nonaffiliates, $21. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

Assessing the Impacts of Bridge Deck Contaminants in Receiving Waters—Volume 1: Final Report; Volume 2: Practitioner's Handbook
NCHRP Report 474
The two-volume set guides practitioners in assessing the impacts of bridge deck runoff on receiving waters and in identifying the most appropriate method of mitigation. The Final Report includes findings from a literature review, a survey of highway agency practice, stakeholder consultations, and biological testing at freshwater and saltwater sites. The Practitioner's Handbook presents the assessment process based on the findings in the Final Report and guides the user step-by-step in collecting data, identifying areas of concern, selecting the best analysis method, assessing results, and developing a management plan.

2002; Vol. 1: 70 pp., Vol. 2: 94 pp.; TRB affiliates, $18; TRB nonaffiliates, $24. Subscriber categories: planning and administration (IA); energy and environment (IB).

Estimating the Benefits and Costs of Public Transit



Projects: A Guidebook for Practitioners
TCRP Report 78
Developed to support transit planners in state, regional, and local government in evaluating transit investments and presenting the results to decision makers, the media, and the public, this guide explains the theory and methods for estimating the benefits and costs of public transportation projects and provides practical tools for practitioners. Included with the report is *CRP-CD-18,* which contains the guide, along with downloadable analytical tools, presentation templates, and a resource library.

2002; 142 pp. plus CD-ROM; TRB affiliates, $15.75; TRB nonaffiliates, $21. Subscriber categories: planning and administration (1A); public transit (VI).

Effective Approaches to Meeting Rural Intercity Bus Transportation Needs
TCRP Report 79
This three-part Report addresses funding for intercity bus projects; discusses barriers to implementation; and identifies strategies for initiating, preserving, and enhancing effective intercity bus transportation. Part I provides background on the research and on rural intercity bus services in the United States. Part II presents a series of questions that arise when states and others plan, program, and sponsor intercity bus projects. Part III consists of detailed project descriptions. Three appendixes contain FTA guidance on the Section 5311(f) Program, a compendium of intercity bus projects, and a bibliography.

2002; 184 pp.; TRB affiliates, $18.75; TRB nonaffiliates, $25. Subscriber categories: public transit (VI); planning and administration (1A).

A Toolkit for Self-Service, Barrier-Free Fare Collection
TCRP Report 80
Many rail transit operators are looking to adopt lower-cost, less-infrastructure-intensive methods of carrying out fare collection. The toolkit addresses the range of issues an agency must consider in determining the applicability of self-service fare collection systems. The toolkit is designed for use at various points in the decision-making process. Each chapter addresses key design parameters and decisions associated with specific types of situations. The toolkit is also included electronically as *CRP-CD-19.*

2002; 211 pp. plus CD-ROM.; TRB affiliates, $22.50; TRB nonaffiliates, $30. Subscriber category: public transit (VI).

Toolbox for Transit Operator Fatigue
TCRP Report 81
The role that operator fatigue plays in mass transit safety has become a central issue for U.S. bus and rail transit agencies. The toolbox documents principles, techniques, and strategies for the development of fatigue-mitigation plans; includes a five-step "how to" component on the design, implementation, and evaluation of fatigue-mitigation plans; and describes fatigue-management programs from organizations in all transportation modes. *CRP-CD-21* contains the toolbox, tools, promotional materials, and other aids.

2002; 234 pp. + CD-ROM; TRB affiliates, $24.75; TRB nonaffiliates, $33. Subscriber category: public transit (VI).

Public Transportation Security—Volume 1: Communication of Threats: A Guide
TCRP Report 86
Rapid, accurate information-sharing is a critical operational need in coping with threats to public transportation systems. Volume 1 presents a variety of approaches to improve the sharing of threat information. Current practices, operational needs, technologies for disseminating threat information, and system functional requirements are discussed. Effective strategies are described for sharing analyzed and unanalyzed reports of suspicious activities, and a path to an interoperable set of national, regional, and local threat-information forums is proposed.

2002; 41 pp.; TRB affiliates, $11.25; TRB nonaffiliates, $15. Subscriber categories: public transit (VI); planning and administration (1A).

Public Transportation Security—Volume 2: K9 Units in Public Transportation: A Guide for Decision Makers
TCRP Report 86
The use of canine (K9) units to support police patrols and narcotics- and explosives-detection activities is routine in major metropolitan areas. Heightened awareness of explosives threats has led to consideration of the use of trained dogs to detect threats against public transportation systems. Volume 2 offers information on fielding K9 programs, based on interviews with public transportation agencies that deploy K9s and with agencies that recently disbanded K9 programs. K9 deployment practices, issues to address in establishing a K9 program, and explosives-detection information are discussed.

2002; 120 pp.; TRB affiliates, $13.50; TRB nonaffiliates, $18. Subscriber categories: public transit (VI); planning and administration (1A).

Customer-Focused Transit

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