

***Annual
Progress
Report***

***Fiscal Year
1993***

Nationally

Coordinated

Program

**of Highway Research,
Development, and Technology**



U.S. Department of Transportation
Federal Highway Administration

Publication No. FHWA-RD-93-163

**Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296**

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof. This report does not constitute a standard, specification, or regulation.

The United States Government does not endorse products or manufacturers. Trade and manufacturers' names appear in this report only because they are considered essential to the object of the document.

Technical Report Documentation Page

1. Report No. FHWA-RD-93-163		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle NATIONALLY COORDINATED PROGRAM OF HIGHWAY RESEARCH, DEVELOPMENT, AND TECHNOLOGY: ANNUAL PROGRESS REPORT FISCAL YEAR 1993				5. Report Date December 1993	
				6. Performing Organization Code	
7. Author(s)				8. Performing Organization Report No.	
9. Performing Organization Name and Address				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
				13. Type of Report and Period Covered Progress Report Oct. 1, 1992 - Sept. 30, 1993	
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration 6300 Georgetown Pike, HRD-10 McLean, Virginia 22101-2296				14. Sponsoring Agency Code	
15. Supplementary Notes Bonny A. Falk, Editor, and Anne N. Barsanti, Managing Editor, Office of R&D Operations and Support, HRD-10					
16. Abstract <p>This progress report gives an overview of research and technology transfer being conducted under the Nationally Coordinated Program (NCP) of Highway Research, Development, and Technology (RD&T) from October 1, 1992 through September 30, 1993. The NCP is organized into categories, programs, and projects. The NCP categories covered in this 1993 report are: A. Highway Safety, B. Traffic Operations/Intelligent Vehicle-Highway Systems, C. Pavements, D. Structures, E. Materials and Operations, F. Policy, G. Motor Carrier Transportation, J. Planning, K. Environment, L. Right of Way, and M. Advanced Research.</p> <p>This report highlights the high priority areas to show the research emphasis of the NCP. Each NCP program has a program manager within the FHWA Headquarters (Washington, DC and the Turner-Fairbank Highway Research Center in McLean, VA). The program manager coordinates the Federal staff and contract activities with the State Planning and Research (SP&R) program, and the National Cooperative Highway Research Program (NCHRP), and networks with other groups, including the American Association of State Highway and Transportation Officials' Standing Committee on Research. This report covers research on all categories, RD&T transfer activities funded by the States, as well as other Government and special programs. This is the sixth NCP Annual Progress report since 1987.</p>					
17. Key Words Highway research, technology transfer, traffic operations, highway safety/intelligent vehicle-highway systems, pavements, highway materials, highway planning, policy, environment, right-of-way, and motor carrier transportation.			18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 170	22. Price

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH					LENGTH				
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
AREA					AREA				
in ²	square inches	645.2	square millimeters	mm ²	mm ²	square millimeters	0.0016	square inches	in ²
ft ²	square feet	0.093	square meters	m ²	m ²	square meters	10.764	square feet	ft ²
yd ²	square yards	0.836	square meters	m ²	m ²	square meters	1.195	square yards	yd ²
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi ²	square miles	2.59	square kilometers	km ²	km ²	square kilometers	0.386	square miles	mi ²
VOLUME					VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft ³	cubic feet	0.028	cubic meters	m ³	m ³	cubic meters	35.71	cubic feet	ft ³
yd ³	cubic yards	0.765	cubic meters	m ³	m ³	cubic meters	1.307	cubic yards	yd ³
NOTE: Volumes greater than 1000 l shall be shown in m ³ .									
MASS					MASS				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.202	pounds	lb
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")	Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact)					TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C	°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
ILLUMINATION					ILLUMINATION				
fc	foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²	cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS					FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N	N	newtons	0.225	poundforce	lbf
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RESEARCH,
DEVELOPMENT, AND TECHNOLOGY

ANNUAL PROGRESS REPORT
FISCAL YEAR 1993
FHWA-RD-93-163

TABLE OF CONTENTS

<i>Program</i>	<i>Page</i>
INTRODUCTION	1
CATEGORY A — Highway Safety	
1. Advanced Traffic Control Methods and Devices	6
2. Improving Driver Visibility of Roadway Environment	9
3. Highway Safety Information Management	10
4. Special Highway Users	12
5. Highway Safety Design Practices and Criteria	14
6. Human Factors Research for Highway Safety	17
9. Technology Transfer for Highway Safety	19
CATEGORY B — Traffic Operations/Intelligent Vehicle-Highway Systems	
1. Advanced Traffic Management Systems	24
2. Advanced Traveler Information Systems	27
3. Commercial Vehicle Operations	29
4. Advanced Vehicle Control Systems	31
7. IVHS Institutional, Legal, and Crosscutting Issues	34
9. Technology Transfer for Traffic Operations/Intelligent Vehicle- Highway Systems	37
CATEGORY C — Pavements	
1. Evaluation of Rigid Pavements	42
2. Evaluation of Flexible Pavements	45
3. Field and Laboratory Test Methods	48
4. Pavement Management Strategies	50
5. Construction Control and Management	53
6. Long-Term Pavement Performance Evaluation	56
9. Technology Transfer for Pavements	59
CATEGORY D — Structures	
1. Bridge Design	62
2. Bridge Management	67
3. Hydraulics and Hydrology	70

TABLE OF CONTENTS (Continued)

<i>Program</i>	<i>Page</i>
CATEGORY D — Structures (continued)	
4. Corrosion Protection	73
9. Technology Transfer for Structural, Geotechnical, and Hydraulic Technology	76
CATEGORY E — Materials and Operations	
1. Asphalt and Asphaltic Mixtures	80
2. Cement and Concrete	83
3. Geotechnology	86
4. Bridge Paints	89
5. Highway Maintenance	91
6. Snow and Ice Control	93
9. Technology Transfer for Materials and Operations	95
CATEGORY F — Policy	
1. Highway Financing	100
2. Freight Transportation	103
3. Highways and Economic Productivity	106
4. Improving Transportation Data Acquisition and Management	109
5. Strategic System Performance Analysis	112
9. Technology Transfer for Policy	115
CATEGORY G — Motor Carrier Transportation	
1. Driver Proficiency	118
2. Vehicle Safety/Performance	120
3. Motor Carrier Safety Analysis and Information	122
4. Regulatory Review and Enforcement	124
5. Regulatory Reform	125
6. Motor Carrier Industry Economic Health	126
CATEGORY J — Planning	
1. Ensuring the Efficiency of Future Transportation Systems	128
2. Strategic System Performance—HPMS/GIS	130
3. Congestion Management	132
4. Travel Model Improvement Program	134
5. Intermodal Transportation Planning	136

TABLE OF CONTENTS (Continued)

<i>Program</i>	<i>Page</i>
CATEGORY K — Environment	
1. Air Quality	140
2. Highway Traffic Noise and Vibration	142
3. Wetlands	144
4. Environmental Processes	147
5. Hazardous Materials	149
6. Historic Preservation and Archeological Resources	150
7. Water Quality	151
8. Community Impacts and Public Involvement	152
9. Technology Transfer for Environment	153
CATEGORY L — Right-of-Way	
1. Corridor Preservation	156
2. Right-of-Way—Hazardous Waste and Land-Use Management	157
CATEGORY M — Advanced Research	160

**NATIONALLY COORDINATED PROGRAM
LIST OF ABBREVIATIONS**

AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ACES	Automated Coastal Engineering System
AE	Acoustic Emission
ALF	Accelerated Loading Facility
AMS	Acceleration Monitoring System
AP	Application Project
APWA	American Public Works Association
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
ATIS	Advanced Traveler Information Systems
ATMS	Advanced Traffic Management Systems
ATR	Automated Traffic Recorder
AVCS	Automatic Vehicle Control Systems
BMS	Bridge Management System
BRI-STARS	Bridge Stream Tube Model for Alluvial River Simulation
CAAA	Clean Air Act Amendments of 1990
CDL	Commercial Drivers License
CFR	Code of Federal Regulations
CIAS	Connecticut Impact Attenuation System
CMA	Calcium Magnesium Acetate
CP	Cathodic Protection
CSIP	Corridor Safety Improvement Program
CTIP	Coordinated Federal Land Highway Technology Implementation Program
CVO	Commercial Vehicle Operations
DOT	Department of Transportation
EPA	Environmental Protection Agency
FEM	Finite Elements Model
FHWA	Federal Highway Administration
FMCSRs	Federal Motor Carrier Safety Regulations
FPL	Forest Products Laboratory
FRP	Fiber-Reinforced Plastics
FTA	Federal Transit Administration
GIS	Geographical Information System
GPR	Ground-Penetrating Radar
GRF	Grants for Research Fellowships
HEC	<i>Hydraulic Engineering Circular</i>
HPA	High Priority Area
HPMS	Highway Performance Monitoring System
HSIS	Highway Safety Information System
HYDRA	Highway Storm Drain Design
HYDRAIN	Highway Drainage Design System

NCP LIST OF ABBREVIATIONS (Continued)

IFTA	International Fuel Tax Agreement
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
IRDPC	International Research and Development Cooperation Program
IRF	International Road Federation
IVHS	Intelligent Vehicle-Highway Systems
LCV	Longer Combination Vehicle
LRFD	Load and Resistance Factor Design
LTAP	Local Technical Assistance Program
LTPP	Long-Term Pavement Performance
MAPCON	Methodology for Analyzing Pavement Condition
MCMIS	Motor Carrier Management Information System
MCSAP	Motor Carrier Safety Assistance Program
MCTRANS	Center for Microcomputers in Transportation
MPO	Metropolitan Planning Organization
MSMRTS	Mobile System for Measurement of Retroreflectivity of Traffic Signs
MUTCD	<i>Manual on Uniform Traffic Control Devices</i>
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act of 1969
NCHRP	National Cooperative Highway Research Program
NCP	Nationally Coordinated Program of Highway Research, Development, and Technology
NDE	Nondestructive Evaluation
NEMA	National Electrical Manufacturers Association
NETSIM	Network Simulation
NGA	National Governors' Association
NHI	National Highway Institute
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology (Department of Commerce)
NSF	National Science Foundation
NTIS	National Technical Information Service (U.S. Department of Commerce)
OECD	Organisation for Economic Co-operation and Development
OST	Office of the Secretary of Transportation
OTA	Office of Technology Applications
PAHC	Pan American Highway Congress
PCC	Portland Cement Concrete
PIARC	Permanent International Association of Road Congresses
PIH	Pan American Institute of Highways
PMS	Pavement Management System
PRORUT	Profiling and Rut Depth Measuring System
PTF	Pavement Testing Facility
R/C	Reinforced Concrete
R&D	Research and Development
RD&T	Research, Development, and Technology

NCP LIST OF ABBREVIATIONS (Continued)

R&T	Research and Technology
RSPA	Research and Special Programs Administration
RTCC	Research and Technology Coordinating Committee
RTEB	Research and Technology Executive Board
RTPC	Research and Technology Program Committees
RVM	Ram Velocity Measurement
SBIR	Small Business Innovation Research
SHA	State highway agency
SHRP	Strategic Highway Research Program
SP&R	State Planning and Research
STAA	Surface Transportation Assistance Act
T²	Technology Transfer
TFHRC	Turner-Fairbank Highway Research Center
TRB	Transportation Research Board
USCoE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTCS	Urban Traffic Control System
VMT	Vehicle Miles Traveled
VNTSC	Volpe National Transportation Systems Center
WDT	Weight-Distance Tax
WIM	Weigh-in-Motion

INTRODUCTION

The Nationally Coordinated Program of Highway Research, Development, and Technology (NCP) is a management framework of highway research activities for the Federal Highway Administration's (FHWA's) Research, Development, and Technology (RD&T) Program. The NCP coordinates the major highway research programs and is administered by the Office of the Associate Administrator for Research and Development at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, Virginia. President Clinton's Administration issued *Technology for America's Economic Growth, A New Direction to Build Economic Strength* in February 1993. This policy will provide a world-class transportation sector through increased investment in research for new technologies for smart highways, new materials, new structural assessment technologies, and renewal engineering. The Clinton Administration's Technical Initiatives also show that research and highway technology are vital to improve the Nation's transportation system. Transportation must be safe, efficient, and support our economy and international competitiveness.

Furthermore, the 6-year Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 has increased activities within the NCP RD&T programs. The act provides strong support for intelligent vehicle-highway systems (IVHS), the applied research and technology program, intermodal transportation systems, the seismic research program, collaborative research, commercial motor vehicle safety, international outreach, and expanded education and training programs. The ISTEA also endorses President Clinton's initiative to convert defense-related research resources and technologies for civilian use.

PROGRAM OVERVIEW

This NCP fiscal year 1993 progress report provides details about individual programs in the following categories:

- A. Highway Safety
- B. Traffic Operations/Intelligent Vehicle-Highway Systems
- C. Pavements
- D. Structures
- E. Materials and Operations
- F. Policy
- G. Motor Carrier Transportation
- J. Planning
- K. Environment
- L. Right-of-Way
- M. Advanced Research

FHWA RD&T programs are directed by the Associate Administrators for Research and Development, Policy, Program Development, Safety and System Applications, and Motor Carriers.

Under the NCP, the FHWA works with its State partners on highway research, development, and technology transfer activities supported by the Highway Trust Fund. The NCP is broadly structured to coordinate and catalog federally supported RD&T activities within the programs. The FHWA designates research emphasis —high priority areas— for staff and contract efforts. The FHWA believes that plans for future highway research must address critical program high priority areas that are focal points for research and are given the FHWA's long-term commitment. They are directly related to the NCP since the high priority areas fall under major categories of the NCP. In this report, the FHWA high priority areas are indicated wherever applicable in the NCP descriptions and at the beginning of each category section.

In March 1993, the high priority areas for research in Policy, Planning, Environment, and Right-of-Way underwent consolidation and revision, resulting in five streamlined high priority areas that offer improved coordination among individual offices. These five improved high priority areas are described in the October 1993 publication, *Research Agenda: Fiscal Years 1993-1995, Policy, Information Management, Planning, Environment, and Right-of-Way Research Council* (FHWA-PL-94-002).

The NCP also sets the framework for networking among other groups, including the American Association of State Highway and Transportation Officials' (AASHTO's) Standing Committee on Research, and the National Cooperative Highway Research Program (NCHRP). Within the categories of the NCP, the FHWA (collaborating with AASHTO and NCHRP) recommends national priorities for State Planning and Research (SP&R) work, and designates lead agencies, States, or groups of States in selected research areas. The NCP has the following objectives:

- Ensure resource concentration on common problems.
- Minimize duplicated efforts among researchers.
- Identify and highlight gaps in research.
- Provide lists of all highway research activities.

FEDERAL HIGHWAY ADMINISTRATIVE CONTRACT AND STAFF RESEARCH

The FHWA, primarily through its Research and Technology Program, sponsors a broad range of contract and staff research, as well as programs to assess, disseminate, and implement innovations from all of the NCP research activities and other sources, both domestic and foreign.

Contract Research Studies. The majority of the FHWA's research is performed by contract with private consultants, nonprofit research organizations, universities, State highway agencies, and Federal laboratories. The contract program is planned by the FHWA research staff with guidance from six FHWA technical coordinating groups representing Safety, IVHS, Pavements, Structures, Motor Carriers, Policy, Planning, Right-of-Way, and Environment. A Research and Technology Executive Board of FHWA executives advises the FHWA Executive Director who is responsible for approving proposed projects. Annually, about 300 projects are contracted with most studies varying from 2 to 4 years, emphasizing practical results that can be applied to transportation system problems that are common to highway agencies.

FHWA Staff Research. In fiscal year 1993, the FHWA's inhouse staff performed research at the Turner-Fairbank Highway Research Center amounting to over \$2 million. The staff, using laboratories and outdoor test facilities, investigates operational problems that require action or preliminary investigation of problems that are evolving or are not well-defined. Staff studies also evaluate the results of contract work and allow researchers to maintain technical competence and to increase awareness of current research issues and technologies. About 50 studies are conducted annually by the TFHRC research staff. Most studies are small in size, and the results of the studies are frequently in preliminary test and evaluation reports, feasibility analyses, or synthesis reports.

Technology Transfer Program. FHWA Technology Transfer Program is administered by the National Highway Institute (NHI) under the Associate Administrator for Research and Development; the Office of Technology Applications (OTA) under the Associate Administrator for Safety and System Applications; and internationally, the Office of International Programs under the Associate Administrator for Policy.

The ISTEA authorizes NHI (in cooperation with State highway agencies) to expand State education and training programs related to highways to include not only Federal, State, and local

highway agencies, but also U.S. citizens from the private sector, and foreign nationals involved in highway work of interest to the United States. In fiscal year 1993, the NHI had the following programs:

- Short Course Program—Technical training presented to States on highway and transportation subjects.
- Dwight David Eisenhower Transportation Fellowship Program—Attracts the Nation's brightest minds in transportation to enhance transportation professionals' careers and to retain top talent in the U.S. transportation community. The program has six elements for graduate and undergraduate students.
- R&D Liaison for the University Transportation Centers Program—National U.S. DOT program facilitating transportation research among universities.
- Pan American Institute of Highways (PIH) Program—Technology exchange program with Central and South American countries. PIH publishes a catalog of annual courses and a quarterly newsletter entitled *Caminos*.
- International Program for Foreign Visitors—Hosts more than 200 engineers annually from countries around the world who visit the TFHRC.

The OTA works with the Office of the Associate Administrator for Research and Development, program offices, and field staff, and communicates with partners and users to determine technology needs and priorities with the State and local governments; and to access technology, new products, and programs as well as to move the state of the art to the state of the practice.

The OTA uses Demonstration Projects, Application Projects, Test and Evaluation Projects, and Special Projects to transfer technology to users by providing hands-on contact with new technologies and by facilitating the use of the technology on highway projects. The OTA also includes the Local Technical Assistance Program (LTAP) and the Strategic Highway Research Program Product Implementation Program.

The LTAP provides technical assistance to State and local highway agencies to meet the growing demands placed on rural roads, bridges, and public transportation. The 51 LTAP Technology Transfer Centers have helped local agencies to improve their transportation networks by:

- Increasing rural transportation expertise at the State and local levels.
- Promoting the effective use of research findings and innovations for improving transportation in rural areas.
- Meeting transportation personnel needs in local areas with tailored resource materials and programs.

ISTEA established an education and training function that continues and expands LTAP. The new program includes urban areas with a population of up to 1 million, and Native American tribal governments, as well as rural areas already covered by the LTAP. During 1993, four new regional Technology Transfer Centers were established to serve America Indian tribal governments.

The Office of International Programs serves to increase the U.S. highway community's awareness of foreign technological advances and fosters the international exchange of U.S. technology, education, and training. Through a combined series of ongoing projects, foreign technologies are identified for implementation in the U.S., and, through the scanning program, technologies are promoted abroad.

OTHER DOT AGENCIES AND PARTNERS

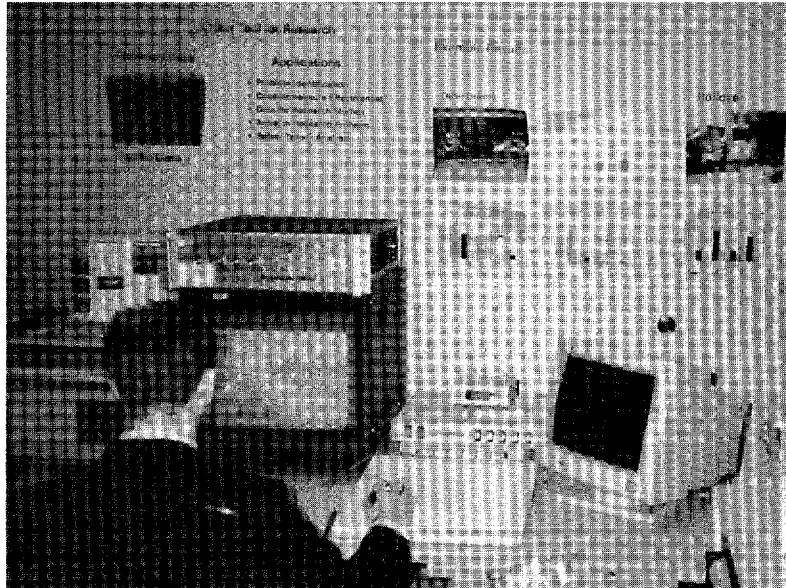
Other agency participation in NCP has been enhanced by the ISTEA, which also created the following programs: the Applied Research and Technology Program to accelerate testing, evaluation, and implementation of technologies designed to improve the structure and safety of highway, transit, and intermodal transportation systems; and the International Highway Transportation Outreach Program to inform the United States highway community of foreign transportation innovations. These programs have increased the involvement of most of the following agencies with NCP:

The *National Highway Traffic Safety Administration (NHTSA)* supports the accident data bases that permit increased understanding of accidents in relation to roadway and vehicle characteristics, and also supports substantial programs in the IVHS and human factors areas. The *Federal Aviation Administration (FAA)* conducts pavement research for runways that is related to highways. The *Federal Transit Administration (FTA)*, formerly the Urban Mass Transportation Administration, does research for traffic and street operations. The *Research and Special Programs Administration (RSPA)* conducts special studies involving highway transportation issues, such as hazardous waste materials transportation, and it also runs the *Volpe National Transportation Systems Center (VNTSC)* in Cambridge, Massachusetts. The Center conducts highway-related research for DOT, and administers the 13 university transportation centers that include support for surface transportation research at their universities.

The *Small Business Innovation Research (SBIR) Program*, administered by the VNTSC, reviews innovative research proposals submitted by small businesses. The *Office of the Secretary* conducts policy research related to highways and highway users. The *Coordinated Federal Land Highway Implementation Program (CTIP)* supports research. CTIP also shares highway-related technology with the Federal Lands Highway Program (FLHP) between the FHWA and the Federal land management agencies. The program is managed by the Federal Lands Highway Office (FLHO) and work is coordinated through a CTIP Council with representation from other Federal agencies committed to providing quality transportation for their users.

States. The partnership between the Federal Government and the States in the Federal-aid highway program is active in R&D, with many State-administered research programs contributing to national research priority activities as well as focusing on local and regional problem areas. The FHWA works closely with State and local governments to plan the overall impact of new highway projects.

State Planning and Research is supported cooperatively by individual States and the Federal Government. SP&R studies are usually short in duration (1 to 2 years) and emphasize practical solutions. The NCHRP, a State pool-funded research program, combines States' research resources through FHWA, AASHTO, and the Transportation Research Board (TRB). NCHRP projects are normally problem-oriented and designed for immediate use.



A. Highway Safety

High Priority Areas

- Condition-Responsive Traffic Control Devices
- Retroreflectivity of Traffic Control Devices
- Information Resources
- Truck/Highway Safety
- Pedestrian and Bicyclist Safety
- Improved Highway Travel for an Aging Population
- Highway Safety Design Practices and Criteria

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: A.1
PROGRAM TITLE: Advanced Traffic Control Methods and Devices
PROGRAM MANAGER: Howard H. Bissell, P.E.

This program researches and develops traffic control operations for the Office of Highway Safety. The goals are to establish and implement safety standards and to improve traffic control devices. The research supports the *Manual on Uniform Traffic Control Devices*. This program also includes the research that was in the A.2 program on "Improving Driver Visibility of Roadway Environment."

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Condition-Responsive Traffic Control Devices

- "Installation of Prototype Automatic Truck Warning Systems" (FHWA) provided three systems installed on the Capital Beltway: two in Virginia and one in Maryland.

High Priority Area: Developing Performance Specifications for Retroreflective Devices

- "Minimum Visibility Requirements for Signs" (FHWA Staff) provided recommended sign retroreflective requirements based on sign size, purpose, message (text or symbol), speed limit, placement, and color.

Other Studies:

- "Trade-Off Between Delineation and Lighting on Freeway Interchanges" (FHWA) found that visual glare occurred if more than three luminaires were installed. Sharp cut-off luminaires could be installed to improve transient visual adaptation.

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Condition-Responsive Traffic Control Devices

- "Development of Prototype Adverse Visibility Warning and Control Systems for Operational Evaluations" (FHWA) will install and evaluate systems in Georgia and Utah.
- "Condition-Responsive Traffic Control in Work Zones" (FHWA) is applying new techniques for real-time, work-zone traffic control in Maryland.
- "Changeable Message Sign Visibility" (FHWA) is looking at visibility requirements to include letter size, spacing, and brightness.
- "Changeable Message Sign—Control and Warning Messages" (FHWA) is developing standard work and symbol messages to be used on portable changeable message signs.
- "Environmental Sensor Systems for Safe Traffic Operations" (FHWA) is testing existing visibility measuring systems for driver warning systems.

High Priority Area: Developing Performance Specifications for Retroreflective Devices

- "Completion of Sign Management System" (FHWA) is incorporating the predictive equations into the software and will fieldtest the sign management system with retroreflective measurement devices.
- "Validation of Minimum Sign Luminance Requirements" (FHWA Staff) is being conducted in the Photometric and Visibility Laboratory using subjects of all ages to document sign retroreflective values needed for recognition of selected signs. Data will be compared with the values recommended in the *Minimum Visibility Requirements for Signs* report.

Other Studies:

- "Feasibility of Ultraviolet Activated Sign and Marking Materials" (FHWA) is looking at the practicality, durability, and possible safety benefits associated with the use of fluorescent materials for traffic control devices.
- "Visibility Requirements for Symbolic Traffic Signals" (FHWA) is looking at developing guidelines for walk, left-turn, and lane-control signals.
- "Safety Benefits of Roadway Lighting Using Small Target Visibility" (FHWA) is evaluating the application of a new standard for determining lighting requirements.
- "Relative Visibility of Increased Legend Size vs. Brighter Materials" (FHWA) has looked at the effects of sign size, letter height and stroke width, and retroreflectivity levels on the legibility and conspicuity, particularly for older drivers.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Condition-Responsive Traffic Control Devices

- "Evaluation of Prototype Automatic Truck Warning System" (FHWA) will evaluate the three systems installed and operating on the Capital Beltway in Virginia and Maryland.

High Priority Area: Developing Performance Specifications for Retroreflective Devices

- "Implementation Guide for Minimum Retroreflective Requirements for Traffic Signs" (FHWA) is to determine and test the guidelines for implementing the retroreflective requirements at the State and local levels.

Other Studies:

- "Overhead Guide Sign/Headlighting Study" (FHWA) will determine the amount of illumination needed from headlamps to see and react to overhead signs and other traffic control devices.
- "Work Zone Labor Injury Evaluation" (FHWA) will study problems of work-related injuries to construction laborers employed on highway projects.

PUBLICATIONS AND PRODUCTS:

- *Feasibility of an Automatic Truck Warning System* (FHWA-RD-93-039).
- *Potential Safety Applications of Advanced Technology* (FHWA-RD-93-080).
- *Minimum Visibility Requirements for Signs, Summary* (FHWA-RD-93-152) and *Final Report* (FHWA-RD-93-077).

- *Trade-Off Between Delineation and Lighting on Freeway Interchanges: Investigation of Transient Visual Adaptation (FHWA-RD-91-041).*

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: A.2
PROGRAM TITLE: Improving Driver Visibility of Roadway Environment
PROGRAM MANAGER: Howard H. Bissell, P.E.

This program provides research and development for traffic operations personnel. The purpose is to determine whether the lighting, signing, delineation, and signal variables are sufficient to meet the information needs for a specific driving environment. Emphasis is on improving retroreflective traffic control devices by developing inservice visibility performance requirements for the *Manual on Uniform Traffic Control Devices (MUTCD)*.

Starting in fiscal year 1993, all new and ongoing activities previously included in this program area have been transferred to Advanced Traffic Control Methods and Devices (see program number A.1) and include:

High Priority Area: Developing Performance Specifications for Retroreflective Devices

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: A.3
PROGRAM TITLE: Highway Safety Information Management
PROGRAM MANAGER: Jeffrey F. Paniati, P.E.

The goal of this program area is to develop improved methods for gathering and using accident, geometric design, roadway inventory, and traffic count data for highway safety problem analysis. This includes improving the utility of existing highway safety data, developing advanced technologies for safety data collection, and creating improved analysis techniques.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Information Resources

- "Demonstration/Evaluation of the HSIS" (FHWA) improved the Highway Safety Information System (HSIS) by adding the 1991 data; incorporated videodisc photologs for safety analysis; and provided data for more than 15 FHWA, NCHRP, and Staff research efforts.
- "The Association of Median Width and Highway Accident Rate" (FHWA) used the HSIS to quantify the relationship between median width and accident rates. The study indicates that median widths of 9.1 m (30 ft) or more are desirable for safety and that the safety benefits of medians increase until widths of 18.3 to 24.4 m (60 to 80 ft) are reached.
- "Comparison of the Effectiveness of Full and Partial Lighting for Urban Freeways" (FHWA Staff) used the HSIS to compare the safety benefits of full roadside lighting with interchange-only lighting on urban freeways. This study found a 19 percent higher night/day accident rate ratio on unlighted non-interchange sections than on the lighted non-interchange sections.
- "Adaptation of Geographic Information Systems for Transportation—Phase I" (NCHRP) developed a top-level design and implementation plan for geographic information systems for transportation. A management guide that provides a basic explanation of GIS and discusses the keys to successful GIS planning and implementation was also prepared.
- "Data Integration to Support GIS-Based Safety Analysis Applications" (FHWA Staff) consisted of a 6-month staff assignment with the New Mexico Alliance for Transportation Research. This study focused on identifying, acquiring, and modifying existing data to be GIS-compatible and identifying the basic GIS tools necessary to support safety application development.

Work Underway: The following is a partial list of these studies with interim results:

- "Development, Operation, and Maintenance of HSIS II" (FHWA) is incorporating the 1992 data into the system and expanding the system to add three or four additional States to the five States currently in the data base. This effort is also utilizing new computer hardware and data base management techniques to improve the user-friendliness of the system.
- "Economic Analysis of Highway Safety Data" (FHWA) is determining the costs of collecting and processing highway safety data. This study will identify short-term and long-term

strategies that can be implemented at the State and/or local level to reduce the data costs and/or improve the data quality.

- "Evaluation of Accident Analysis Methodology" (FHWA) is applying a newly developed safety analysis method to a wide range of highway safety studies. The advantages and disadvantages of the methodology are being identified, and its potential for improving the accuracy of highway safety analyses is being evaluated.
- "Demonstration of Emerging Technologies" (FHWA) is evaluating new technologies (Global Positioning System receivers, pen-based computers, magnetic stripe readers, etc.) for accident data collection. The most promising technologies are being fieldtested in cooperation with State and local jurisdictions to document their costs and benefits.
- "Development of Safety Applications for GIS" (FHWA/State) is a cooperative FHWA/State effort to develop GIS-based safety analysis tools that can be used to identify high accident locations as well as analyze systematic highway safety problems.
- "Improved Procedures for Estimating Exposure for Safety Analysis" (FHWA) is identifying new data sources and developing innovative analysis procedures that can be used to obtain more accurate estimates of exposure for use in safety analysis efforts.

Other Studies:

- "Evaluation of All-Weather Pavement Markings" (FHWA/State) is a cooperative effort to test and evaluate the safety and performance of a wide variety of pavement marking materials under both dry and wet weather conditions.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Information Resources

- "Improved State Data Systems—Phase I" (FHWA) will select and evaluate the most promising low-cost, short-term improvements in State data systems identified in the ongoing "Economic Analysis of Highway Safety Data" (FHWA) study.
- "Feasibility of User-Friendly Systems for Safety Data Collection" (FHWA) will identify and prioritize areas where expert systems could be used to improve the collection, processing, or analysis of highway safety data. A prototype development effort will be undertaken.
- "Adaptation of Geographic Information Systems for Transportation—Phase II" (NCHRP) will build upon the earlier NCHRP work by demonstrating how GIS can be used to effectively implement the management systems mandated by the ISTEA.

PUBLICATIONS AND PRODUCTS:

- *HSIS Summary Report: Analysis of Commercial Bus Crashes* (FHWA-RD-93-018).
- *HSIS Summary Report: The Association of Median Width and Highway Accident Rate* (FHWA-RD-93-046).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: A.4
PROGRAM TITLE: Special Highway Users
PROGRAM MANAGER: Justin True

This program provides research and development for a safe and efficient operating environment for special highway users such as large trucks, pedestrians, bicycles, mopeds, and motorcycles. The majority of existing geometric design and traffic operations criteria are based on the physical and operational characteristics of passenger cars. These criteria need to be reevaluated in terms of other highway users and appropriate revisions need to be made.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Truck Highway Safety

- "Development of Relationships Between Truck Accidents and Geometric Design: Phase I" (FHWA) developed preliminary relationships between truck accidents and geometric design variables such as horizontal curvature, vertical curvature, shoulder width, and annual average daily traffic (AADT).
- "Safety Impacts of Different Speed Limits for Cars and Trucks" (FHWA) found that the mean speed of trucks was 3.9 km/h (2.4 mi/h) lower when the speed limit for trucks was lower than the speed limit for cars. No different accident patterns could be shown to exist.

High Priority Area: Pedestrian and Bicyclist Safety

- "Pedestrian/Bicyclist Research Program" (FHWA) will provide support in the planning, development, and conducting of further pedestrian and bicyclist research under the guidance of the FHWA and in cooperation with NHTSA. Responsibilities involve developing a long-range research plan and conducting individual studies. A 5-year research and development program has been developed. Fifteen research studies covering all phases of pedestrian and bicyclist activities have been identified and prioritized.

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Pedestrian and Bicyclist Safety

- "Trends and Crashes Involving Older Pedestrians" (FHWA) is being conducted under an interagency agreement with the Centers for Disease Control. Existing data bases are being used to classify various pedestrian accidents by type and location. Contributing factors (such as alcohol, drugs) will be identified for the various types of accidents. The candidate accident variables considered relevant to the study have been identified. Hard copies of police accident reports have been obtained for a pilot sample of 1,700 North Carolina pedestrian crashes. These accidents have been typed according to a predetermined scheme and an interim report has been prepared.

- "Older Pedestrian Characteristics for Use in Highway Design" (FHWA) has developed distributions of speeds at which pedestrians walk when crossing the street and the perception/reaction time of pedestrians with regard to the walk signal. This information will be useful in determining pedestrian signal intervals and phases.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Pedestrian and Bicyclist Safety

- "Development of Pedestrian and Bicyclist Injury Data Bases" (FHWA) will develop a data base capturing information on the full range of injuries to bicyclists and pedestrians. This data base will be used to determine the incidence and characteristics of pedestrian and bicyclist non-motor vehicle collisions as well as collisions involving motor vehicles.
- "Development of Local Planning Guidelines for Bicycling and Walking Facilities" (FHWA) will develop an integrated on-road and off-road network planning methodology or model for pedestrian and bicyclist facilities and will compile a synthesis of traffic management/calming strategies.
- "Development of a National Awareness Campaign for Pedestrian and Bicyclist Safety Problems" (FHWA/NHTSA) will develop a program to increase awareness of pedestrian and bicyclist safety problems on a nationwide level to establish a base of support for existing and future safety programs aimed at reducing these problems.

PUBLICATIONS AND PRODUCTS:

- *Development of the Relationship Between Truck Accidents and Geometric Design: Phase I* (FHWA-RD-91-124).
- *Safety Impacts of Different Speed Limits for Cars and Trucks* (FHWA-RD-93-161).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: A.5
PROGRAM TITLE: Highway Safety Design Practices and Criteria
PROGRAM MANAGER: Justin True

This project conducts and promotes research to improve highway safety through the development and use of improved geometric design standards and safer roadside hardware.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Highway Safety Design Practices and Criteria

- "Conceptual Requirements for an Interactive Highway Design Model" (FHWA) developed a framework for an Interactive Highway Safety Design Model (IHSDM) for evaluating the safety impacts of alternative highway designs.
- "Grants for Highway Safety Research" (FHWA) were awarded to five colleges: University of Pennsylvania, Vanderbilt University (Nashville, TN), University of Michigan, Tennessee State University (HBC&U), and Texas A&M. The grants are supporting graduate student research in highway safety.
- "The FHWA/NHTSA National Crash Analysis Center (NCAC)" (FHWA) was established at The George Washington University's suburban campus in Ashburn, VA. The NCAC is sponsored by FHWA and NHTSA as well as with contributions from The George Washington University (Washington, DC). The Center serves as a repository for crash-test films and videotapes. The NCAC staff is analyzing accident data and crash-test results to study how injuries are produced by various vehicle intrusion mechanisms.

Work Underway: The following is a partial list of these studies with interim results:

- "Pre-VISTA Program" (FHWA) is in the code development phase. The NIKE3D vehicle handling code is being linked with the DYNA3D finite element code so the pre-impact and post-impact trajectories of vehicles impacting barriers can also be simulated. The MADYMO occupant model is being linked to the DYNA3D code to simulate dummy responses in frontal and side impacts. Improvements are being made to a finite element model of a 1983 Honda Civic sedan using crush data obtained from crash tests at the FOIL facility.
- "Vehicle Dynamics Programs for Roadway and Roadside Studies" (FHWA) will select vehicle dynamics model(s) for incorporation into the IHSDM and for related research application.
- "Geometric Design Laboratory—Operations/Support" (FHWA) will provide technical and administrative support in the development and operation of the Geometric Design Laboratory being established at TFHRC.

Other Studies:

- "Guardrail Testing Program II" (FHWA) crash-tested and developed a steel-backed log guardrail for use on park roads. Two aesthetic bridge rails—the Natchez Trace and the Foothills Parkway aluminum rail—were also tested and developed.
- "Testing of New Bridge Rail and Transition Designs" (SP&R Pooled Fund) has designed, tested, and developed two new 1.07-m (42-in) high bridge rails that can be used in urban areas behind raised sidewalk and curb combinations. A three beam transition to a vertical concrete parapet was tested with an 8150-kg (18,000-lb) single-unit truck. New end shoes with slanted bolt holes were developed to facilitate connecting three beam and W-beam rails to bridge rails.
- "Testing of State Roadside Safety Systems" (SP&R Pooled Fund) tested and developed the Washington DC Historic Bridge Rail. This curb-mounted bridge rail protects pedestrians while making it possible to leave aesthetic, but deficient, old bridge rails in place. A concrete bridge rail with a constant sloping face was tested with an 8150-kg (18,000-lb) single-unit truck. The Minnesota swing-away mailbox was crash-tested. This mailbox support system is intended to minimize damage from snowplows.
- "Evaluation of Recycled Materials for Roadside Appurtenances" (FHWA) showed that guardrail blockouts can be made of Timbrex®, a proprietary mixture of sawdust and recycled plastic.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Highway Safety Design Practices and Criteria

- "Development of Highway Safety Design Model" (FHWA) will develop a model or series of models for assessing the safety impacts of alternative highway designs for use at the planning or preliminary design stage.
- "Intersection Accident Study" (FHWA) will be performed only if an experimental design currently being prepared determines that the study is feasible. Depending on feasibility, the study will identify which combination of geometric design elements result in "safe" intersection design.

Other Studies:

- "Assessment of Motor Vehicle Characteristics" (FHWA) will develop and carry out a laboratory crash-test program to collect current data on motor vehicle crash characteristics for use in both geometric design and in the development of improved roadside hardware.
- "Maintenance and Support of the Federal Outdoor Impact Laboratory" (FHWA) will provide support in developing and testing improved roadside hardware.
- "Guardrail Testing Program III" (FHWA) will crash-test a stone barrier wall that will be used on the Going-to-the-Sun Road in Glacier National Park. A series of aesthetic guardrail-to-bridge-rail transitions will also be tested and developed.

PUBLICATIONS AND PRODUCTS:

- "Impact Performance of Glass Fibre Composite Materials for Roadside Safety Structures," paper presented at the First International Conference on Advanced Composite Materials in Bridges and Structures, Canadian Society for Civil Engineering, Sherbrooke, Quebec, Canada, October 7-9, 1992.

- "Crash Tests of Traffic Barriers and Other Roadside Features," paper presented at the Annual Meeting of the Transportation Association of Canada, Ottawa, Ontario, Canada, September 20, 1993.
- "Harmful Events in Crashes," *Accident Analysis and Prevention*, Vol. 25, No. 2, pp. 139-145, 1993.
- *Safety Effectiveness of Highway Design Features – Volume I: Access Control* (FHWA-RD-91-044).
- *Safety Effectiveness of Highway Design Features – Volume II: Alignment* (FHWA-RD-91-045).
- *Safety Effectiveness of Highway Design Features – Volume III: Cross Section* (FHWA-RD-91-046).
- *Safety Effectiveness of Highway Design Features – Volume IV: Interchanges* (FHWA-RD-91-047).
- *Safety Effectiveness of Highway Design Features – Volume V: Intersections* (FHWA-RD-91-048).
- *Safety Effectiveness of Highway Design Features – Volume VI: Pedestrians and Bicyclists* (FHWA-RD-91-049).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: A.6
PROGRAM TITLE: Human Factors Research for Highway Safety
PROGRAM MANAGER: Truman M. Mast, Ph.D.

This program area will address the problems of highway design related to features and operations that involve direct driver interactions. Motorist information systems will receive major emphasis because of their critical role in the motorist-highway interaction process. Research will be conducted to improve existing fixed roadway signs and markings, where compatibility with driver characteristics is an issue, as well as to develop and evaluate the technology for modern vehicle-based information systems.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improved Highway Travel for an Aging Population

- "Older Driver Perception-Reaction Time for Intersection Sight Distance and Object Detection" (FHWA) evaluated older driver perception-reaction time in a variety of intersection, stopping, and decision sight-distance situations. Results were compared to current standards, and the utility of using other models for sight distance was investigated.

Other Studies:

- Proceedings from the Human Factors Research for Highway Safety Conference were published. Jointly sponsored by the Transportation Research Board and the Federal Highway Administration, this conference brought together experts from many disciplines to define critical research required in the human factors-highway safety area. The proceedings include problem statements in a wide variety of areas, and the document will be used to further human factors program development.

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Improved Highway Travel for an Aging Population

- "Symbol Signing Design for Older Drivers" (FHWA) is investigating the utility of symbol signs for older drivers, making recommendations regarding changes to current signs, and developing guidelines to be used in future symbol sign design.
- "Intersection Geometric Design for Older Drivers and Pedestrians" (FHWA) is investigating geometric needs of older road users at intersections.
- "Delineation of Hazards for Older Drivers" (FHWA) is determining, based on the needs and capabilities of older drivers, design and implementation characteristics of hazardous object markers and other similar roadside hardware.

- "Synthesis of Human Factors Research on Older Drivers and Highway Safety" (FHWA) is reviewing and synthesizing research findings in the older driver area, developing a preliminary older driver handbook, and providing input for future human factors programs.

Other Studies:

- "Understanding Driver Performance Variability and Perception of Risk" (FHWA) is conceptualizing and defining research programs to: measure and quantify demographic variables related to driver performance, and measure and quantify driver perception of risk.
- "Human Factors Research Vehicle" (FHWA) is developing and procuring a fully equipped field-research vehicle to be used in human factors research efforts.
- "Driving Simulation Studies of Raised Pavement Markers (RPM) Systems" (FHWA) is investigating the effects of novel RPM applications on driver performance.
- "Automated Reduction of Video-Based Data" (SBIR) is investigating the feasibility of applying computer algorithms to reduce and analyze video data.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improved Highway Travel for an Aging Population

- "Night Driving and Highway Lighting Requirements" (FHWA) will use laboratory and field methods to evaluate the utility of suitable lighting technologies to assist drivers with the nighttime driving task, with an emphasis on accommodating the needs of older drivers.
- "Human Factors Study of Traffic Control in Construction and Maintenance Zones" (FHWA) will develop and test countermeasures to ameliorate problems encountered by drivers in construction and maintenance zones, especially those of older drivers.

Other Studies:

- "Driver Information Overload" (NCHRP) will investigate driver workload issues as they relate to geometric design and highway signing.

PUBLICATIONS AND PRODUCTS:

- *Highway Operations Problems of Elderly Drivers in Illinois* (FHWA-IL-023).
- *Transportation Needs of the Older Driver* (FHWA-VA-93-R14).
- *Traffic Maneuver Problems of Older Drivers* (FHWA-RD-92-092).
- *A Preliminary Laboratory Investigation of Passive Railroad Crossing Signs* (FHWA-RD-93-153).
- *Proceedings of Human Factors Research in Highway Safety* (TRB Circular, 1993).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: A.9

PROGRAM TITLE: Technology Transfer for Highway Safety

PROGRAM COORDINATORS: Peter Hatzi—Technology Applications
Harry H. Hersey—National Highway Institute
Janet Coleman—Local Technical Assistance Program

The objectives of this program are to assess the usefulness of newly completed research, new materials, products, and procedures; to promote the adoption of safe and cost-effective technology in highway safety; to provide technical assistance to the users of such new technology; and to develop technology transfer products such as guidelines, computer programs, technical manuals, audiovisual products, demonstration projects, and training courses in highway safety for use by Federal, State, and local highway agencies.

EXECUTIVE SUMMARY AND PROGRAM STATUS

This program is intended to accelerate the adoption of new technology in subjects related to roadway and roadside safety. The Office of Technology Applications (OTA) in conjunction with the program offices and the National Highway Institute (NHI) carry out this function. The OTA develops useful application aids and training materials from completed research. Demonstration projects promote the adoption of selected items through field presentations and pilot installations, and test and evaluation projects evaluate new technology. The NHI follows through with presentations of the developed training courses. The Local Technical Assistance Program (LTAP), which is administered by the OTA, channels the technology to rural and small urban jurisdictions, primarily through a national network of Technology Transfer Centers.

TECHNOLOGY APPLICATIONS

The following major activities were conducted during fiscal year 1993:

- *Guidelines for Evaluating Fluorescent Strong Yellow-Green Crossing Signs* (FHWA-SA-93-035) provides guidelines for conducting a before-and-after study to determine the effects of fluorescent strong yellow-green crossing signs on motorist behavior.
- The results of Test and Evaluation Project 11, Ice Detection and Weather Information Systems have been summarized in *Ice Detection and Highway Weather Information Systems* (FHWA-SA-93-053). The project showed that by having real-time information, crews can be called in and released in a much more efficient manner, resulting in monetary savings far exceeding the system's cost.
- Test and Evaluation Project 25, Strategic Highway Research Program Work Zone Safety Devices, complements the work of the Strategic Highway Research Program (SHRP) staff to showcase and solicit first users of the work zone traffic-control devices developed by SHRP. Some of the devices being showcased are the Portable Crash-Cushion, the Infrared Intrusion Alarm, the Portable Speed Bump, the Opposing Traffic Lane Divider, and the Alarm Flashing Stop/Slow Paddle. The FHWA has initiated test and evaluation projects in 37 States.
- The Corridor Safety Improvement Program (CSIP), Demonstration Project 92, a cooperative FHWA/National Highway Transportation Safety Administration project, addresses severe

accident problems on arterial corridors. Presentations are made to States to encourage them to adopt the CSIP concept. Financial startup assistance has been provided to three additional States this year to implement and evaluate CSIP projects.

- Test and Evaluation Project 29, Retroreflectivity was initiated to acquire new and innovative retroreflection measurement devices for test and evaluation, and to determine the feasibility of establishing retroreflectivity (i.e., nighttime visibility) guidelines to identify when pavement markings and highway signs have reached the end of their useful life. Many transportation agencies have indicated an interest in participating in the evaluation.
- Application Project 115, Technologies for Traffic Signal Compliance was initiated to accelerate the testing, evaluation, and implementation of automated technologies that support compliance with traffic control devices.
- Under Test and Evaluation Project 24, Field Evaluation of Breakaway Timber Utility Poles (BTUP's), a summary evaluation report was issued. The project contributed to BTUP's being declared operational. A contract is being developed to produce two 10- to 15-minute videos on BTUP's. One will be technical, updating an existing video on the concepts and installation of utility poles as breakaway poles. The other will be a marketing video to stimulate State and utility company interest in the concept of BTUP's.
- The FHWA and the NHTSA continued development of promotional activities for a comprehensive, community-based pedestrian safety program consistent with the "Walk Alert" program under Application Project 18, Application of Pedestrian Safety Program.
- A brochure and poster were developed under Application Project 15, Pennsylvania Truck Escape Ramps to inform truck drivers nationwide of the safety of using truck escape ramps.
- Under Application Project 88, Training for Police Officers in the Collection of the National Governors' Association Truck Accident Data Elements, the FHWA has completed the initial train-the-trainer sessions in all regions. The training course manual *National Governors' Association Truck Accident Data Collection Program Officers Manual* is available from the National Technical Information Service (PB93-205714). A computer-based training version using a compact disc-interactive system is under development.

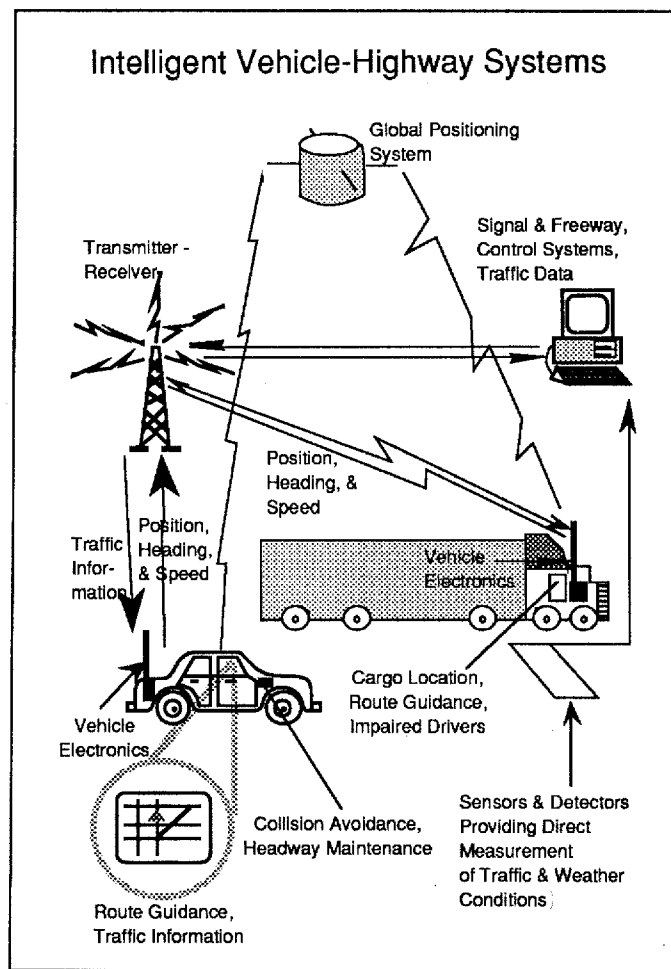
NATIONAL HIGHWAY INSTITUTE

- Offered training courses on 9 different topics related to highway safety and conducted a total of 98 presentations. The courses in highest demand were:
 - ◆ AASHTO Roadside Design Guide
 - ◆ Design and Operation of Work Zone Traffic Control
 - ◆ Work Zone Safety for Maintenance Operations on Rural Highways
 - ◆ Railroad-Highway Grade Crossing Improvement Program

LOCAL TECHNICAL ASSISTANCE

- *Maintenance of Drainage Features for Safety—A Guide for Street and Highway Maintenance Personnel*, which was developed by the Iowa State University Technology Transfer Center, was distributed. It is fully illustrated and prepared in outline style.
- A contract will be awarded by the end of calendar year 1993 to develop a *Risk Management Program Manual* for use by local transportation agencies. This safety-related training product will be tailored to the needs of local transportation agencies. It will be designed to be taught by LTAP Technology Transfer Center personnel or by the local transportation agencies.
- Contracts for safety-related training products for the LTAP are under development. The two products, a work zone safety package and a marketing package containing successful

highway safety projects implemented by LTAP Technology Transfer Centers nationwide, are under development. Each product will be tailored to the needs of local transportation agencies and will be designed to be taught by LTAP Technology Transfer Center personnel or by the local transportation agencies.



B. Traffic Operations/Intelligent Vehicle-Highway Systems

High Priority Areas

- Advanced Traffic Management Systems
- Advanced Traveler Information Systems
- Commercial Vehicle Operations
- Advanced Vehicle Control Systems

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: B.1
PROGRAM TITLE: Advanced Traffic Management Systems
PROGRAM MANAGER: Alberto J. Santiago, M.S.C.E.

This program addresses the highway congestion problem by enhancing existing traffic management techniques and control systems and developing new ones. Examples of candidate activities include integrated urban traffic management; improved traffic signal system control strategies; and more extensive freeway control with an emphasis on areawide traffic flow monitoring, surveillance systems, and incident management.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Advanced Traffic Management Systems (ATMS)

- "Traffic Models to Support Advanced Traveler Information Systems (ATIS)" (FHWA) completed the design of a dynamic traffic assignment model. Such a model will enable the real-time development of diversion strategies in response to recurrent and non-recurrent congestion. This design will be implemented into a deployable model starting in fiscal year 1994.
- "Development of EXPERT-SIG" (FHWA) completed the development of an expert system for isolated intersection traffic signal design. The system interfaces signal timing optimization models, accepts a wide variety of detector placement designs, and is interfaced by a user-friendly input preprocessor. This system was released to the public late in 1993.
- "TRAF-NETSIM, Version 4.0" (FHWA) is a simulation model that enables the analysis of traffic control strategies and geometric configurations for grid networks. This new version increases the dimensions for the number of links, nodes, and vehicles; incorporates graphics post-processing automatically; and provides online descriptions of error messages. This version was released to the public in August 1993.

Work Underway: The following is a partial list of these studies with interim results:

- "Design of Support Systems for ATMS" (FHWA) is developing and field-evaluating the support systems required within mature ATMS control centers to be installed in mid- to large-size urban areas. These include warning systems, data reduction and analysis systems, malfunction management systems, and predictive models. This study will produce an overall system design and prototype for testing. The study will be completed by late 1996.
- "Real-Time Adaptive Control for IVHS" (FHWA) is developing and field-evaluating a real-time, traffic-adaptive signal control system suitable for use in an Intelligent Vehicle-Highway Systems (IVHS) environment by 1997.

- "Human Factors in ATMS Design Evolution" (FHWA) is focusing on human factors research and development needs for ATMS control centers, developing an analytically based human factors handbook, and assessing the human factors needs of traffic management center operators.
- "Detection Technology for Intelligent Vehicle-Highway Systems (IVHS)" (FHWA) is developing functional requirements for IVHS surveillance systems, assessing the state of the art, and determining whether new technology needs to be developed. The study will also determine the need for and feasibility of establishing self-supporting national IVHS detector testing centers.
- "Incident Detection Issues" (FHWA) is examining the deficiencies of current incident detection systems and/or practices, assessing the need for a new generation of detection algorithms, and establishing a uniform methodology for reporting incidents and quantifying their detrimental effects.
- "Revisions of *Highway Capacity Manual*, Chapters 9 and 11" (FHWA) is developing specific recommendations on text, tables, and illustrative materials in order to revise chapters 9 and 11 of the Transportation Research Board's *Highway Capacity Manual* (HCM) and develop a more appropriate traffic analysis model for the delay equation used in chapter 11. Publication of the final report will be completed by early 1995.
- "Revised Planning Methodology for Signalized Intersections and Operational Analysis of Exclusive Left-Turn Lanes" (FHWA) is developing specific recommendations on text, tables, and illustrative materials in order to revise the methodology for analyzing exclusive left-turn lanes in chapter 9 of the *Highway Capacity Manual* (HCM) and develop a more appropriate traffic model for the operational analysis of exclusive left-turn lanes. Publication of the final report will be completed by early 1995.
- "CORFLO Training Course and User Manual" (FHWA) is developing a 4-day training course that teaches practicing engineers and planners how to effectively use the FHWA's Corridor Flow (CORFLO) simulation software. The training course development includes up to 10 presentations over the next 2 years.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Advanced Traffic Management Systems (ATMS)

- "Deployment Issues of Surveillance Systems for IVHS" (FHWA) will investigate the deployment issues of surveillance systems from the following perspectives: cost-effectiveness analysis, compatibility with existing facilities/systems, flexibility to be upgraded, and systems' malfunction management.
- "Models to Evaluate Traffic Operations under IVHS" (FHWA) will develop traffic models to simulate IVHS operations. These models will be used to support development and testing of IVHS concepts.
- "Development of Dynamic Traffic Assignment (DTA) Model" (FHWA) will implement the DTA design completed in 1993 to develop a deployable system. The study will also pursue automated means of developing synthetic Origin-Destination Matrices from detector data.
- "Traffic Model Verification, Validation, and Data Bases" (FHWA) will establish procedures and collect the necessary data to facilitate the verification, validation, and calibration of traffic models. All data will be stored on electronic data bases that will be made available to traffic model developers.
- "Incident Detection Issues for Surface Streets" (FHWA) will investigate the complex issue of detecting and managing incidents on surface streets and will develop detection algorithms for alternate surveillance system technologies and deployment practices.

PUBLICATIONS AND PRODUCTS:

- *FRESIM User Guide*, Beta Version 3.1, November 1992.
- "ATMS Technology—What We Know and What We Don't Know," *Public Roads*, December 1992.
- *TRAF Graphics User Guide*, April 1993.
- *TSIS User Guide*, April 1993.
- *TRAF User Reference Manual*, Version 4.0, April 1993.
- "ATMS Laboratories: A Requirement for Program Delivery," paper presented at the Third IVHS America Annual Meeting, Washington, DC, April 1993.
- *IVHS: FHWA's Program*, American Association of Artificial Intelligence, July 1993.
- "Using TRAF-NETSIM to Analyze Clean Air Impacts," paper presented at the ITE Sixty-Third Annual Conference, The Hague, The Netherlands, September 1993.
- "Simulating DART's North Central Light Rail Line Using TRAF-NETSIM," paper presented at the ITE Sixty-Third Annual Conference, The Hague, The Netherlands, September 1993.
- "A Real-Time Network Traffic Simulation Model for ATMS Applications: Part I — Simulation Methodologies," to be published in the *IVHS Journal*, 1993.
- "A Real-Time Network Traffic Simulation Model for ATMS Applications: Part II — Massively Parallel Model," to be published in the *IVHS Journal*, 1993.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: B.2
PROGRAM TITLE: Advanced Traveler Information Systems
PROGRAM MANAGER: Frank J. Mammano

This program involves a wide range of opportunities for providing travelers with information to enhance the efficiency, safety, and convenience of their travel. These mechanisms will be designed to reach as broad a segment of the traveling population (private, public, and commercial) as possible and will include information regarding travel modes and options. Major functional elements of the Advanced Traveler Information Systems (ATIS) include: real-time information on current traffic conditions, navigation and route guidance, onboard availability of trip services information, invehicle display (visual/audio) of trip-related highway guidance and warning signs, invehicle safety advisory warnings, use of vehicles as probes to transmit traffic status, mayday information, and personal portable traveler information.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Advanced Traveler Information Systems (ATIS)

- The Orlando, FL TravTek (FHWA, FL, City of Orlando, General Motors, American Automobile Association) operational test and data collection was completed. Data analysis is to be completed by spring 1994. To date, drivers of the system report a favorable impression of TravTek. The most favorable impressions are from drivers who had the route guidance capability.
- "Subcarrier Traffic Information Channel (STIC)" prototype (FHWA) was developed and tested. STIC makes use of the subcarrier of the commercial FM broadcast band to transmit digital traffic information for Intelligent Vehicle-Highway Systems (IVHS) communications. The system was tested at two FM radio broadcast stations and proved to be feasible. Additional testing is scheduled for fiscal year 1994.
- A Stage-1 Spectrum Planning Subcommittee (SPS) application for IVHS radio frequencies was prepared and submitted to the National Telecommunications and Information Administration (NTIA) (FHWA). Five pairs of frequencies have been allocated to FHWA nationwide for testing and evaluation of IVHS communication systems.

Work Underway: The following is a partial list of these studies with interim results:

- A major rural ATIS effort has been initiated to investigate applying ATIS functions in non-urban areas (FHWA). The study will develop conceptual designs for expanding ATIS to rural and small urban areas. Some conceptual designs will be ready for operational testing at an early stage. Other designs will require prototyping and operational testing at a later time.
- "Invehicle Safety Advisory Warning System (IVSAWS)" (FHWA) has reexamined users needs through focus group meetings and has identified alternate system concepts in order to define architectures with varying levels of functionality and cost. A preliminary functional specification has been generated for the optimum technical approaches. The

final functional specifications will be in sufficient detail to guide followup product development work.

- "Electromagnetic Compatibility (EMC) Testing for IVHS Systems" (FHWA) has been initiated with the Institute for Telecommunications Sciences of the National Telecommunications Information Administration. This effort will address a broad array of issues concerning EMC for IVHS, including spectrum usage and characterization, and communications standards development.
- "ATIS and CVO Human Factors" (FHWA) was initiated for traveler information and commercial vehicle operations (CVO) systems. This study will facilitate resolution of certain safety issues related to invehicle systems and will provide basic human factors research on driver performance information needs and user acceptance of these systems.
- "Roadway Link Identification Formats" (FHWA) is examining various methods of identifying segments of roadways (links) that can be associated with traveler and traffic information systems. A format for uniquely denoting links for any part of the country/North America will be recommended. This format can then be used by agencies interested in implementing geographically based traveler information systems.
- "Concept Development for Invehicle Signing" (FHWA) is developing and examining alternative concepts for invehicle signing. Invehicle signing is expected to offer significant benefits to older drivers and enhance safety and reduce stress for all drivers.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Advanced Traveler Information Systems (ATIS)

- "ATIS Communications Alternatives" (FHWA) will be initiated to support the national IVHS system architecture effort. The capabilities of alternative communication technologies (wide-area radio frequency, cellular, beacon, satellite, etc.) will be analyzed against the requirements and candidates selected for and/or included in operational field tests. Electromagnetic compatibility testing for IVHS and an indepth evaluation of selected ATIS communication protocols will also be included.
- "Consortium to Develop Invehicle Signing Prototypes" (FHWA), in partnership with industry, will develop prototypes based on the ongoing concept development work. These prototypes will be evaluated through fieldtesting, and promising designs will be documented to support operational testing in a future effort.
- "Prototype Testing of an Invehicle Safety Advisory Warning System" (FHWA) will build upon the functional specifications generated in the current IVSAWS effort to develop a prototype system and evaluate performance through extensive fieldtesting.

PUBLICATIONS AND PRODUCTS:

- *Invehicle Safety Advisory and Warning System (IVSAWS), Final Report*, October 1993.
- "Pathfinder Evaluation Report" *Caltrans*, February 1993.
- "Communication Concepts to Support Early Implementation of IVHS in North America," *IVHS Journal*, Vol. 1, No. 1, 1993.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: B.3
PROGRAM TITLE: Commercial Vehicle Operations
PROGRAM MANAGER: Michael D. Freitas

This program is involved in the application of advanced technology to improve Commercial Vehicle Operations (CVO). This includes efforts to reduce the regulatory burden on commercial fleets, to improve the efficiency of commercial fleet operations, and to improve the safety of commercial vehicles.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Commercial Vehicle Operations

- "Commercial Vehicle Safety Systems" (FHWA) completed an examination of the feasibility of several concepts for applying advanced technology to improve the safety of commercial vehicle operations.
- Phase I of "Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems" (FHWA) was completed. This phase involved the identification of the various regulatory requirements imposed on trucks and the current efforts to reduce the burden of these requirements.

Work Underway: The following is a partial list of these studies with interim results:

- "Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems" (FHWA) is currently in its second phase, which involves developing functional requirements for automated regulatory systems for commercial vehicles and establishing a plan for developing those systems.
- "Commercial Vehicle Safety Systems" (FHWA) is pursuing the development of systems using IVHS technology to improve the safety of commercial vehicle operations.
- "Selection of a Commercial Vehicle-to-Roadside Communication Standard" was initiated to assess current vehicle-to-roadside communication (VRC) technologies and needs for commercial vehicles and to determine a course of action for establishing a commercial vehicle VRC standard.
- "Commercial Vehicle Fleet Management and Information Systems" (FHWA) will identify the fleet management and information needs of commercial vehicle dispatchers and managers, review current efforts to provide information, and develop conceptual techniques for providing information. Operations to be examined include interstate shipping, urban goods movement, and intermodal operations.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Commercial Vehicle Operations

- "Electronic Commercial Vehicle Credential Systems" (FHWA) will determine the functional requirements for CVO systems, identify alternative architectures, and assess those alternatives.
- A Commercial Vehicle Program Forum (FHWA) would bring together CVO experts in a highly structured format to provide initial input to the design of a national CVO system.
- "Requirements for Preclearance and Other CVO Services" (FHWA), under the auspices of an appropriate national organization, would establish a formal input and consensus structure for State regulatory officials in the development of a national CVO system design.
- "Commercial Vehicle Operators Consortium" (FHWA) would provide a continuous mechanism for a representative group of motor carriers to input and participate in the development of the national CVO system design.

PUBLICATIONS AND PRODUCTS:

- *Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems, Interim Report* (FHWA), unpublished.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: B.4
PROGRAM TITLE: Advanced Vehicle Control Systems
PROGRAM MANAGER: J. Richard Bishop, Jr.

Advanced Vehicle Control Systems (AVCS) combine sensors, computers, and control systems in vehicles and in the infrastructure to warn and assist drivers or to intervene in the driving task. AVCS include collision warning and avoidance systems, infrared vision enhancement systems, and fully automated vehicle-highway systems. Full-scale deployment of AVCS systems offers the promise of dramatic benefits, such as vastly increased highway capacity through the use of closely spaced automated vehicles traveling at freeway speeds, and increased safety by reducing the potential for driver error. Within AVCS, the major program component is the Automated Highway System (AHS) development program. In response to the Congressional mandate in the Intermodal Surface Transportation Efficiency Act of 1991 to demonstrate a prototype automated highway system on a test track by 1997, the FHWA and the NHTSA have jointly developed a long-term program with the goal of generating a performance specification of an AHS through extensive system development and testing. This performance specification will then be used by automotive product developers and transportation agencies to deploy AHS's early in the 21st century. The 1997 demonstration is a major milestone in this overall program and will provide proof-of-concept feasibility of an AHS system. The AHS vision can be summarized as a system of instrumented vehicles and highways that provides fully automated (i.e., "hands-off") operation at better levels of performance (safety, efficiency, and comfort) than on today's highways and is financially affordable, where vehicles can operate in both urban and rural areas on highways that are both instrumented and noninstrumented.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Advanced Vehicle Control Systems (AVCS)

- "Advanced (Vision-Based) Vehicle Control Systems—Phase II" (FHWA) demonstrated machine vision technology developed for the Department of Defense that is applied to the task of road following. The use of machine vision techniques in autonomous vehicle systems has the potential to greatly reduce infrastructure impacts. This research, performed by the National Institute of Standards and Technology, culminated in a vehicle autonomously following local roads, with the driver operating only the accelerator and the brakes, with steering commands provided by the machine vision system. This vehicle was supported by vision processing equipment in a chase van, with data exchanged via a radio link.

Work Underway: The following is a partial list of these studies with interim results:

- "Human Factors Design of Automated Highway Systems" (FHWA) is addressing the critical area of human factors in automated highway systems (AHS) development. This effort is an extensive study of the major human factors issues pertinent to the vehicle operator, using

driving simulators and other tools to simulate representative AHS system configurations and test driver reactions. This effort will result in a human factors handbook to guide design engineers in AHS prototype development.

- "Precursor Systems Analyses of Automated Highway Systems" (FHWA) will consist of multiple parallel analyses that will provide the DOT and others in the IVHS community with a realistic range of AHS configurations and a better understanding of AHS applications, technology, design, deployment, operation, and practicality. The results of these studies will constitute a foundation of unique knowledge that will be available to the developers of the AHS prototype. Each study lasts 1 year so that the results will be available during the process of defining and evaluating alternative system concepts. Fifteen separate studies were initiated in late fiscal year 1993, each of which addresses one or more of the following study areas: Urban and Rural AHS Comparison, Automated Check-In, Automated Check-Out, Lateral and Longitudinal Control Analysis, Malfunction Management Analysis, Commercial and Transit AHS Analysis, Comparable Systems Analysis, Alternative Propulsion Systems Impact, AHS Roadway Deployment Analysis, Impact of AHS on Surrounding Non-AHS Roadways, AHS Entry/Exit Implementation, AHS Roadway Operational Analysis, Vehicle Operational Analysis, AHS Safety Issues, Institutional and Societal Aspects, and Preliminary Cost/Benefit Factors Analysis.
- "AVCS Research in Platooning for Highway Automation" (FHWA, Caltrans) is an ongoing effort of the California PATH program to develop technology to support high-speed platooning (packs of vehicles follow each other closely, using electronic sensing and communications to increase highway capacity and safety). Current efforts are focused on advancing the state of knowledge of the performance that is achievable in vehicle-follower longitudinal control. These efforts include characterization of the performance of vehicle-to-vehicle sensors, vehicle-to-vehicle communications systems, and braking actuation systems, as well as extensive on-the-road testing.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Advanced Vehicle Control Systems (AVCS)

- "Cooperative Agreement for an AHS Consortium" (FHWA) will establish a partnership with a consortium of key AHS stakeholders for the purpose of developing a prototype AHS, performing the 1997 demonstration, and refining this prototype to ultimately define an optimum system configuration. Thus, this cooperative agreement will form the centerpiece of the AHS program. At a minimum, the consortium would consist of automobile manufacturers and transportation agencies as these entities are key stakeholders in the future widespread deployment of AHS systems.
- "Studies of Infrastructure and Traffic Impacts of AVCS Systems" (FHWA) will be conducted in close coordination with the NHTSA Collision Avoidance Research Program. As concepts are developed within the NHTSA program for systems such as collision avoidance, vision enhancement, and intelligent cruise control, the FHWA effort will analyze the potential impacts of these systems on the highway infrastructure and traffic flow.

PUBLICATIONS AND PRODUCTS:

- *Human Factors Design of Automated Highway Systems: First Generation Scenarios* (FHWA-RD-93-123).
- "Human Factors and the Automated Highway System," *Proceedings of the 36th Annual Meeting of the Human Factors Society, 1992.*

- "Intelligent Travel: The Automated Highway System," *Proceedings of the Intelligent Autonomous Systems Conference*, Pittsburgh, PA, February 1993.
- "Precursor Systems Analyses of an Automated Highway System," *Proceedings of the Institute of Electrical and Electronics Engineers (IEEE) Vehicular Technology Society Annual Meeting*, Secaucus, NJ, May 1993.
- "Status Report on the Automated Highway System Program," *Proceedings of the Annual Meeting of the Autonomous Unmanned Vehicle Society*, Washington, DC, June 1993.
- "Autonomous Road Following: A Vision-Based Approach for AVCS," *Proceedings of the Intelligent Autonomous Systems Conference*, Pittsburgh, PA, February 1993.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: B.7
PROGRAM TITLE: IVHS Institutional, Legal, and Crosscutting Issues
PROGRAM MANAGER: Cindy Elliot

This program addresses those nontechnical issues that may assist in facilitating Intelligent Vehicle-Highway Systems (IVHS) deployment. Examples of issues include multi-jurisdictional coordination, public/private partnerships, funding, education and staffing needs, procurement, liability, privacy concerns when implementing certain IVHS technologies, public acceptance of IVHS, marketing IVHS technologies, and environmental concerns. The program also includes crosscutting issues such as university participation in the IVHS program and small innovative research initiatives. The Institutional Issues Program is currently being restructured to incorporate a range of projects in the policy and applications area. The objective is to develop those projects that will facilitate IVHS deployment.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

- "Legal Constraints to the Research, Development, and Deployment of IVHS Technology in the United States" (FHWA) examined various potential legal constraints to IVHS deployment and provided recommendations for further IVHS legal research.
- Conference proceedings on IVHS Public/Private Partnerships—Managing the Legal Issues (FHWA) highlighted such issues as the challenges of government and business working together, forming a partnership, special considerations of multi-jurisdictional issues, and the project agreement.
- "IVHS Education and Staffing Needs" (FHWA) examined current beliefs as to IVHS educational and staffing needs for both the short and long terms; assessed the current job market to determine the availability of the technical and program skills (program management, legal, and policy) to adequately address those needs; and provided recommendations on strategies for public agencies, the private sector, and academic institutions to ensure that the necessary technical and program skills will be available in the U.S. market.
- "Qualitative Assessment of IVHS Emission and Air Quality Impacts" (FHWA) examined the potential impacts of different IVHS technologies on air quality.
- "Metropolitan Traffic Management" (Office of the Secretary of Transportation) assessed institutional impediments to the introduction of IVHS technologies in metropolitan management coordination and recommended solutions in areas where the potential for serious problems exist.

Work Underway: The following is a partial list of these studies with interim results:

- "Case Studies of IVHS Operational Tests" (FHWA) will track and examine various nontechnical issues in developing U.S. IVHS operational tests. This project consists of external evaluations by a contractor not associated with the operational tests. A case study guide that the contractor will use to evaluate the tests has been completed.

- "Lessons from Other Technologies—Overcoming Barriers to IVHS Deployment" (FHWA) will compare the institutional issues surrounding the deployment of IVHS with issues surrounding the deployment of telecommunications and other advanced technologies. This research will also examine various issues related to franchising private sector provision of certain IVHS services.
- "Public Acceptance and Markets for Various IVHS Technologies and Services" (FHWA) will analyze public acceptance and potential markets for IVHS services and users' willingness to pay for various bundles of services.
- "Legal Research for the Nontechnical Constraints Report" (Office of the Secretary of Transportation) will examine such issues as antitrust, privacy, environmental law, intergovernmental cooperation, privatization, hazardous materials transportation, and the potential tort and product liability claims and defenses involving ATIS, ATMS, and AVCS technologies.
- "Legal Research on the Application of Privacy Laws" (FHWA) will examine the application of privacy laws to IVHS technologies and will lead to the development of guidelines to safeguard personal privacy.
- "The Enterprise Program" (Multistate IVHS) is currently sponsoring or conducting several independent research studies with the primary focus on rural IVHS.
- "IVHS-IDEA" (Transportation Research Board) provides grants to fund the development of innovative IVHS concepts using emerging technologies. The solicitation for proposals was issued this past year. Selection of the first grantees is expected early in fiscal year 1994.
- "IVHS Research Centers of Excellence" (FHWA) will provide IVHS funding to several universities in order to establish long-term IVHS research programs that focus on basic or long-term research activities. These grants are expected to be awarded late in fiscal year 1993.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Evaluation Support for Operational Tests" (FHWA) will provide support staff to assist the FHWA in guiding and monitoring the evaluation phase of the IVHS operational test.
- "Procurement Issues and Their Impact on IVHS" (FHWA) will be directed towards developing alternative procurement models for IVHS technology that will be more efficient and effective than current practices.
- "Metropolitan Traffic Management" (Office of the Secretary of Transportation) will serve as a follow-on for work completed in fiscal year 1993 and will analyze opportunities in the metropolitan planning process for developing multi-jurisdictional cooperation in deployment of traffic management systems.
- "Workplan Guidelines for Implementing Advanced Traffic Management Systems" (FHWA) will provide a generic workplan to help metropolitan areas with implementation of ATMS from the concept to the contractual stage with suggested forms and procedures.
- Joint IVHS Contracting Course (FHWA) will cover various aspects of contracting, including drafting of specifications or statements of work, allocation of intellectual property rights, ways to minimize or avoid protests and claims, and alternative procurement or funding mechanisms.
- "Liability" (FHWA) will examine liability risks and risk management for IVHS.
- "User Response and Market Potential for IVHS Deployment" (FHWA) will serve as a follow-on for work completed in fiscal year 1993 on public acceptance, including analyzing market evaluations of operational tests and identifying future IVHS market research needs.
- "Societal Impact Study of Transportation and Advanced Technologies" (Office of the Secretary of Transportation) will review the income distribution impact of IVHS and other social impacts of IVHS.

- "Institutional Issues Research" (FHWA) includes a number of studies that George Mason University (Fairfax, VA) is completing on IVHS institutional issues, including market-related factors of Advanced Traveler Information Systems, investment and financing issues, and social and environmental impacts.
- "Operational Test Solicitation on Small Business, Consortia Opportunities" (FHWA) will fund feasibility studies to generate involvement in IVHS from disadvantaged business enterprises, defense companies, and Historically Black Colleges and Universities.
- "IVHS and the Environment" (FHWA) will examine policy tools for studying nontechnical, IVHS environmental issues at the State, local, and metropolitan planning organization level.
- "Institutional and Legal Innovative Projects in Operational Tests and Deployment Projects" (FHWA) will examine new organizational and legal processes to implement IVHS, including new mechanisms for partnership cooperation, innovative procurement methods, innovative financing methods, and insurance.

PUBLICATIONS AND PRODUCTS:

- *Qualitative Assessment of IVHS Emission and Air Quality Impacts, Final Report*, July 1993 (for Volpe National Transportation Systems Center).
- *Department of Transportation's Intelligent Vehicle-Highway Systems Institutional and Legal Issues Program* (FHWA-SA-93-039).
- *Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment* (FHWA-PL-92-024).
- *Intelligent Vehicle-Highway Systems Public and Private Partnerships: Managing the Legal Issues, A Summary of Conference Proceedings* (FHWA-SA-93-062), January 25-26, 1993.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: B.9

PROGRAM TITLE: Technology Transfer for Traffic Operations/Intelligent Vehicle-Highway Systems

PROGRAM COORDINATORS: Charles R. Stockfisch—Technology Applications
Harry H. Hersey—National Highway Institute
Janet Coleman—Local Technical Assistance Program

Improved high-technology traffic systems and operations play a major role in mitigating traffic congestion and thus reducing the inherent delays on our overcrowded roads. The objectives of this program are to assess the usefulness of new systems, products, and procedures, promoting the implementation of high-potential, cost-effective technology in improving traffic operations and in being a strong backbone of Intelligent Vehicle-Highway Systems (IVHS). Under this program, technical assistance to the users of this new technology is provided and technology transfer products such as guidelines, computer programs, technical manuals, audiovisual products, demonstration projects, and training courses in traffic operations are developed for use by Federal, State, and local highway agencies.

EXECUTIVE SUMMARY AND PROGRAM STATUS

The technology transfer program accelerates the implementation of new technology related to the promotion of traffic management systems and traffic analysis and operational design. Research and development items are translated into products that can be directly implemented by the traffic engineering community. Face-to-face promotion of new technology occurs through demonstrations at field locations nationally. New technologies are evaluated through the construction of experimental application or test and evaluation projects. When the technology transfer product is a training course, the National Highway Institute (NHI) conducts presentations in the State and local agencies based on demand. Studies, demonstrations, and training are primarily generated from problem statements submitted by Federal, State, and local highway agencies and the private sector. Interaction with local jurisdictions occurs through the Local Technical Assistance Program (LTAP) and the 55 technology transfer centers nationwide.

TECHNOLOGY APPLICATIONS

The following major activities were conducted during fiscal year 1993:

- Demonstration Project 85, Geographical Information System/Video Imagery Applications includes hands-on classroom training in Geographical Information System (GIS) software and workstations, laser disc software, and a videologging van equipped with a shuttered video camera to record images directly onto laser discs. The project was announced in January 1992 and presentations have been made in over 30 States.
- Over 21 workshops of Demonstration Project 86, Relieving Traffic Congestion through Incident Management have been conducted so far to more than 1,100 personnel. This 2-day workshop demonstrates concepts and techniques of incident management to reach persons from varied disciplines, such as police, fire, rescue, highway maintenance, and traffic emergency response, who respond to incidents on freeways and surface streets.

- Presentations of this workshop began in April 1992 and are expected to continue into 1994.
- Demonstration Project 93, Traffic Control Equipment and Software is a 2-day workshop including hands-on demonstrations of recently developed electronic traffic control equipment and software used at intersections. Twenty-five manufacturers are providing technology displayed in a 14.6-m (48-ft) tractor/semitrailer that has toured 23 States over the past 12 months. These jurisdictions have control over 60,000 intersections. Presentations have also been made to 24 equipment manufacturers. The response has been overwhelming with more than 90 requests for presentations.
- Application Project 121, Advanced Traffic Controller Training Course and Video includes presentations on recent technology developments in microprocessor-based traffic controllers: NEMA TS1 Standards and 170 Controller Assemblies.
- Test & Evaluation Project 26, Loop Detector Tester Field Tests entails an improved digital test instrument for both quickly diagnosing inductive loop detector systems and for helping with preventive maintenance. Prototype development was completed and the instrument was fieldtested in five States (California, Florida, Idaho, Ohio, and South Dakota) under actual operating conditions. Results of these tests were used to implement improvisations in the design of the test instrument. Information on the test instrument is expected to be disseminated to State and local agencies.
- Development of a *Communications Handbook* on the use of state-of-the-practice communications technology in traffic control systems has been completed.
- The *Traffic Control Systems/Intelligent Vehicle-Highway Systems Handbook* is expected to be updated in 1994. The revised handbook will include IVHS technology and an updated compendium of existing traffic control technology. The completed handbook will be distributed to State and local highway agencies.
- An update on the 1981 *Traffic Models Handbook* was completed through a contractor and a training course on the uses of traffic signal optimization and simulation models was developed. Pilot presentations were made in April 1993 and the course became available in 1993. After eight presentations are made by the contractor, the course will be offered through the NHI.
- A CORFLO (Corridor Traffic Simulation Model) training course and users manual is being developed. The objective is to simulate the flow of vehicles on a large urban area network containing freeways and arterials. Pilot presentations will be made in late 1993 and the course is expected to be ready for full presentation by spring 1994. There will be nine presentations over 3 years, after which the course will be available from the NHI.
- A FRESIM (Freeway Traffic Simulation Model) training course is being developed to update the existing simulation model as well as instruct traffic engineers on the effective usage and interpretation of the simulation results. Pilot presentations are scheduled for late 1993 as well as nine presentations over the next 3 years, after which the course will be available from the NHI.
- A Traffic Software Users Workshop is being developed to evaluate the utility and effectiveness of traffic simulation and signal optimization software developed by the FHWA and others between 1980 and 1991. McTrans at the University of Florida has indicated a willingness to cooperatively sponsor and conduct this workshop. The workshop is tentatively scheduled for January 1994.
- A telecommuting project is underway and involves two activities: (1) transfer of funds to the Office of the Secretary to help support the Department of Transportation (DOT) "Telecommuting Study" and (2) a competitive contract to support the "FHWA Telecommuting Pilot Study." A National Telecommuting Bulletin Board System (BBS) is being developed.
- Work is continuing on "Expert System for Incident Management." The system was completed in September 1993 and work on the project is expected to continue until the

summer of 1995. The purpose of this project is to develop an expert system for coordinating multi-agency response to multiple highway incidents in an urban corridor consisting of freeways and arterial highways.

NATIONAL HIGHWAY INSTITUTE

- Offered training courses on 7 different topics related to traffic operations and conducted a total of 34 presentations. The courses in highest demand were:
 - ◆ Computerized Traffic Signal Systems
 - ◆ TRAF-NETSIM Training Course
 - ◆ Access Management and Traffic Analysis of Highways

LOCAL TECHNICAL ASSISTANCE PROGRAM

- Fifty copies of AASHTO's *CD-I ROM Computer-Assisted Transportation Training (CATT) Program on Work Zone Traffic Control* were distributed to the 12 LTAP Technology Transfer Centers participating in a pilot project to evaluate the effectiveness of CD-I ROM as a training media to supplement their circuit-rider programs. The 12 pilot centers were provided with 50 Phillips' Model CDI220BK01 CD-I players.
- Two contracts for traffic-related training products are being developed for the LTAP. The two product contracts—development of a traffic safety assessment course and field guide for local officials and development of a training videotape on traffic sign installation, hardware, and maintenance—were expected to be awarded at the end of calendar year 1993. A third product, a training course on local agency work zone traffic control was combined with NHI Course No. 38060, Work Zone Safety for Maintenance Operations on Rural Highways. The contract for development of this course should be awarded at the end of fiscal year 1993. These products will be tailored to the needs of local transportation agencies. The products will be designed to be taught by LTAP Technology Transfer Center personnel or by the local transportation agencies.



C. Pavements

High Priority Areas

- Truck/Pavement Interaction
- Accelerated Evaluation of Pavement Performance
- Performance-Related Specifications for Highway Construction
- Long-Term Pavement Performance
- Asphalt Materials and Mixtures
- Construction Quality Technology
- Pavement Performance Evaluation for Network Pavement Management

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: C.1
PROGRAM TITLE: Evaluation of Rigid Pavements
PROGRAM MANAGER: James A. Sherwood

About 50 studies are included in this program on portland cement concrete pavements. The studies are classified into three projects: pavement performance, design and drainage, and maintenance and rehabilitation. Pavement performance refers to condition. The effectiveness of alternative drainage systems and the cost-effectiveness of preventive maintenance and rehabilitation methods are evaluated. Most research studies in this program are empirical in nature, for instance, based on field data. Several studies are theoretical in nature, including development of a new faster finite element method, a computer model for thermal-induced stress, and laboratory tests for mechanical concrete material properties.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

- "Performance Evaluation of Experimental Rigid Pavements, Data Collection, and Analysis (SP&R Pooled Fund) summarized the field data collected on 270 test sections, and developed to address critical design issues (for example, drainage, erosion, curling, joints, slab dimensions, reinforcement design, and concrete durability).
- "Laboratory Evaluation of Prefabricated Highway Edge Drains" (IN SP&R) developed guidelines for the selection of edge drains from field studies, laboratory tests, and theory.
- "Concrete Pavements Design Update (AASHTO)" (TX SP&R) developed AASHTO drainage coefficients for three subbase types in a range of climates. A mechanistic model was programmed to predict punchouts in continuously reinforced concrete pavement (CRCP). A procedure was developed to compute CRCP load transfer factors and CRCP end movements were analyzed with a mechanistic model (PSCP2). Improved design and construction procedures were developed for jointed reinforced concrete pavements.
- "Finite Element Analysis of Bonded Concrete Overlays" (TX SP&R) suggested materials and construction to reduce the delamination phenomena. Thermal and surface loads on concrete overlays were also analyzed.
- "Rehabilitation Procedures for Faulted Rigid Pavement" (NY SP&R) proved that retrofit joint load transfer devices were essential to retard fault recurrence provided the slabs are in good condition and a careful subseal process has filled any voids.
- "Nondestructive Testing of Load-Transfer Devices" (NY SP&R) proved that transverse joint load transfer devices used in New York (I-beams and dowel bars) prevent the development of significant faults.
- "Comparison of Rigid Pavement Thickness Design Methods" (KY SP&R) recommended that the 1984 Kentucky Concrete Thickness Design Curves be used for routine State use after comparisons with the 1986 AASHTO, the American Concrete Pavement Association, and the Portland Cement Association rigid pavement design procedures.

- "Implementation of the OAF and OAR Programs in the Mechanistic Design of Flexible and Rigid Pavement Overlays" (OH SP&R) produced a draft final report to cover modifications to the flexible and rigid overlay analysis program suggested by evaluations in four States.
- *Performance Monitoring of Joint Load Transfer Restoration* (FHWA unpublished report) was developed to describe the 5-year performance history of experimental load transfer restoration on Interstate 10 in Florida.

Work Underway: The following is a partial list of these studies with interim results:

- "Cost-Effective Concrete Pavement Rehabilitation Techniques" (NJ SP&R), the final year of a 5-year study, is evaluating the field performance of slab subseals, full-depth slab replacement, expansion joint repair, grinding, and installation of longitudinal underdrains.
- "Pavement Drainage and Pavement Shoulder Joint Evaluation and Rehabilitation" (IN SP&R) developed subdrainage requirements for new and retrofit systems.
- "Performance Evaluation of Drained Pavement Structures" (WI SP&R) monitored 38 test sections to determine which features were most effective.
- "Investigation of the Effectiveness of Oklahoma's Internal Pavement Drainage System" (OK SP&R) includes four different base courses with edge drains.
- "Performance Evaluation of Pavement Structures with Doweled Transverse Joints and Constructed over Open-Graded and/or Dense-Graded Bases" (WI SP&R), a 7-year study, will investigate three possible solutions to correct fault problems.
- "Preventive Maintenance and Rehabilitation Techniques to Mitigate the Effects of Corrosion-Related Deterioration in CRCP" (WI SP&R), 7-year study, will determine the most effective maintenance and rehabilitation methods. Alternatives include cathodic protection, edge drains, corrosion inhibitors, and rubble CRCP with 40-, 80-, and 130-mm (1.6-, 3.1-, and 5.1-in) AC overlays, with and without impervious membranes, patches, epoxy-coated rebars, and bond agents.
- "Evaluation of the Crack and Seat Method of Portland Cement Concrete Rehabilitation," (VA SP&R), a 14-year study, will evaluate the effectiveness of crack and seat to reduce and/or delay reflection cracks.
- "Development of a 3-D Finite Element Program for Pavement Analysis" (IN SP&R) is developing a three-dimensional finite element solution procedure that will include element, materials, and load libraries.
- "Variation in Dowel Basket Design" (CO SP&R) is monitoring the performance of three different dowel basket designs to test the belief that lighter gauge wire assemblies will adequately maintain dowel bar alignment during paving.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Performance Evaluation of Experimental Rigid Pavements—Data Collection and Analysis" (SP&R Pooled Fund) will continue to enter data in the long-term pavement performance data base developed by the SHRP. In addition, about 100 test sections from several European and South American countries will be added. These sections have designs different from those in the U.S. and include some pavement response data.
- "Low-Cost Solution to Rigid Pavement Joint Faulting" (NY SP&R) will investigate methods and the costs to repair and retard joint faults.
- "Support Under Portland Cement Concrete Pavements" (NCHRP) will study how to select subgrade k-values for design, especially with loss of support.

PUBLICATIONS AND PRODUCTS:

- *Laboratory Evaluation of Prefabricated Highway Edge Drains (IN 92/20).*
- *Terminal Movements in Continuously Reinforced Concrete Pavements (TX 1169-4).*
- *Improved Design and Construction Procedures for Concrete Pavements Based on Mechanistic Modeling Techniques (TX 1169-5F).*
- *Rehabilitation Procedures for Faulted Rigid Pavement (NY 92/158).*
- *Nondestructive Testing of Load-Transfer Devices (NY 92/106).*
- *Comparison of Rigid Pavement Thickness Design Systems (KY 88-14).*

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: C.2
PROGRAM TITLE: Evaluation of Flexible Pavements
PROGRAM MANAGER: Kevin D. Stuart, M.S.C.E.

This program evaluates materials based on their performance in pavements; develops models to predict performance; and estimates the service life of various pavement designs and rehabilitation alternatives.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

- "Performance Characteristics of Open-Graded Friction Courses" (NCHRP) is a synthesis of current highway practice for these mixtures.
- "A Study of Re-Use of Moisture-Damaged Asphalt Mixtures" (SC SP&R) showed that reclaimed asphalt pavement (RAP) that is moisture damaged can be recycled without increasing the risk of having moisture damage occur in the new pavement when the new pavement contains 15 to 20 percent RAP.
- "Factors that Affect the Voids in the Mineral Aggregate in Hot Mix Asphalt" (CO SP&R) provides the effects of material and mixture properties on the voids in the mineral aggregate of asphalt mixtures and discusses where to draw the maximum density line.
- "Use of RAP in Routine Maintenance Activities" (TX SP&R) identified economical and effective uses for asphalt pavement millings. Guidelines were developed on the use of milled RAP in routine maintenance activities.
- "Pavement Deflection Evaluations" (KY SP&R) developed a procedure to evaluate structural condition (layer moduli) from Road Rater deflections.

Work Underway: The following is a partial list of these studies with interim results:

- "Evaluation of Stone Mastic Asphalt" (GA SP&R) is evaluating construction aspects and the performances of stone mastic asphalts (SMA) under heavy truck loads. Several pavements have been built with SMA's in the surface layer or in both the surface and binder layers.
- "Evaluation of a Stone Mastic Asphalt Overlay Over PCC" (GA SP&R) is evaluating the performance of SMA and dense-graded mixtures over a cracked portland cement concrete (PCC) pavement.
- "Performance of Recycled Mixture in Georgia" (GA SP&R) is evaluating the aging characteristics of virgin hot mixtures vs. hot mixtures containing recycled asphalt pavement.
- "Asphalt Concrete Mix Design and Specification for Improved Rut Resistance" (FL SP&R) has completed the draft final report documenting the design of asphalt mixtures using shear strengths provided by the Gyrotory Testing Machine.
- "Use of Antistripping Additives in Asphaltic Concrete Mixtures—Phase II" (NCHRP) is determining the effectiveness of liquid antistripping additives used in 19 pavements that are 5 to 6 years old.
- "Uses of Recycled Tires in Highways" (NCHRP) is a synthesis currently being published on the use of tire rubber in asphalt pavements, geotechnical applications, and safety hardware.

- "Hot In-Place Recycling of Asphalt Concrete" (NCHRP) is a synthesis currently being published on hot in-place recycled mixtures.
- "Evaluation of Hot In-Place Recycling" (MS SP&R) is monitoring the performance of a major asphalt recycling project, and will use the results to help establish future State policies and procedures.
- "Evaluation of 100 Percent RAP Recycled Mix Using Microwave Technology" (GA SP&R) is evaluating the use of microwave heating for producing recycled mixes.
- "Comparative Study of Performance of Different Designs for Flexible Pavements" (NC SP&R) is developing a mechanistic pavement performance predictive model and comparing the field performances of pavements of known design with predicted performances.
- "Rut-Resistant Asphalt Pavement" (NJ SP&R) is developing bituminous mixtures that will resist permanent deformation.
- "Evaluation of Open-Graded Binders" (IN SP&R) is attempting to determine if pavements constructed with open-graded binder courses have the ability to resist rutting.
- "Performance of New Rut-Resistant Asphalt Concrete Overlay" (WI SP&R) is evaluating the performance of new mixture designs intended to resist premature rutting in pavements.
- "Overlays on Faulted Concrete Pavements" (NY SP&R) developed the computer program NYTEMP to model temperature distribution within pavement layers. Temperature gradients can be estimated when either hourly surface temperatures or hourly air temperatures and solar radiation are known.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Test Pit Evaluation of Resilient Modulus Measurements of Subgrade Soils and Untreated Base/Subbase Materials" (FL SP&R) will compare the resilient moduli of these materials obtained through prototype pavement layers built in a test pit to those obtained through triaxial testing.
- "Performance of Crumb Rubber Modified Asphalt (CRM) Pavements" (SP&R Pooled Fund) will evaluate the inservice performance of many of the currently available CRM technologies over the next several years.

PUBLICATIONS AND PRODUCTS:

- *A Study of Re-Use of Moisture-Damaged Asphalt Mixtures* (FHWA-SC-92-05).
- *Performance Characteristics of Open-Graded Friction Courses* (NCHRP Synthesis 180).
- *Factors that Affect the Voids in the Mineral Aggregate in Hot Mix Asphalt* (CDOT-DTD-R-92-13).
- *Use of RAP in Routine Maintenance Activities* (FHWA/TX-1272-1F and FHWA/TX-1272-2F).
- *Fiber Pave, Polypropylene Fiber* (CDOT-DTD-R-92-9).
- *Crack Reduction, Pavement Reinforcement—Glasgrid* (CDOT-DTD-R-93-6).
- *Evaluation of the Effects of Aggregate on Rutting and Fatigue of Asphalt* (FHWA-GA-92-8812).
- *Performance Evaluation of Single Pass Thin Lift Bituminous Overlays* (PRR-11; Illinois).
- *Pavement Deflection Evaluations* (KTC-92-1).
- *Flexible Pavement Evaluation/Design* (FL/DOT/RMC/0521-3363).
- *Engineering and Environmental Aspects of Recycled Materials for Highway Construction* (FHWA-RD-93-088).
- *Expansion of FDOT Test Pit Evaluation of New Flexible Pavement Bases, 1991-1992* (FL/DOT/RMO/0286-4067).

- *A Study of Stiffness and Strength Characteristics of Subgrade Soils Blended With Aggregate (FHWA/NC/92-002).*
- *Development of New Test Methods for Determination of Relative Compaction of Untreated and Treated Soils and Aggregates (CA/TL-93/08).*

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: C.3
PROGRAM TITLE: Field and Laboratory Test Methods
PROGRAM MANAGER: Rudolph R. Hegmon, Ph.D.

This program develops equipment, instrumentation and procedures for measuring pavement conditions on the network, and project levels, including methods for in situ pavement instrumentation; specifications and calibration methods for equipment used in network and project-level pavement performance surveys, and specifications for the installation and performance of sensors embedded in the pavement; calibration and operating procedures for meeting these specifications; and equipment and the experimental design for accelerated testing of pavement sections or test samples, methods of data analysis, and methods for relating test results to field performance.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year

High Priority Area: Pavement Performance Evaluation for Network Management

- "Pavement Performance Data Collection and Analysis" (FHWA), the first study under the new high priority area, will review methods and equipment for collecting pavement condition data used in pavement management to determine the quality of the data (accuracy, resolution, repeatability, and ease of data collection), recommend required quality levels for improved pavement management, and recommend data processing and formatting for data base inclusion.

Other Studies:

- "Interpretation of Road Roughness Profile Data" (SP&R Pooled Fund) is designed to analyze longitudinal pavement profiles in terms of wavelengths and amplitudes. The research objective is to develop relationships between these profile descriptors and the effects on highway traffic, including ride quality, pavement performance, dynamic loads, highway safety, and vehicle and cargo wear. Sixteen State highway administrations are participating in this research. Besides financial support, the State representatives provide active support in the selection of test sites and in data collection.
- Overhaul of the Accelerated Loading Facility (ALF), after 6 years of continuous operation, was completed in order to provide the highest possible operating efficiency for future projects.
- A radiant pavement heating system, which will be mounted on the ALF, was designed. The ALF frame will support an enclosure of the test-section area.
- "Noncontact, Nondestructive Determination of Pavement Deflection" (SP&R), on the feasibility of measuring pavement deflection at travel speeds, was completed. Implementation of this concept will require highly accurate equipment. A decision to build a prototype is under consideration.

Work Underway: The following is a partial list of these studies with interim results:

- "International Experiment to Compare and Harmonize Skid Resistance and Texture Measurements" conducted tests on 58 sites in Belgium and Spain with 14 countries participating. Additional tests were conducted at a NASA facility on Wallops Island, Virginia. The FHWA provided support and equipment, including a texture van for collecting macrotexture data at travel speeds and ROSAN (Road Surface Analyzer) for simultaneously measuring friction and macrotexture at walking speeds. These measurements are used for predicting skid resistance at travel speeds, which is a major safety factor on wet roads. Data analysis is underway.
- Second generation PRORUT (Profiling and Rut Depth Measuring System) and ROSAN have been built through an inhouse effort by the Pavement Performance Laboratory, with support by the mechanical design and machine shop, the Electronics Laboratory, and the computer support group. PRORUT has been completed and has been used in comparison tests with similar equipment from the State highway agencies in Pennsylvania.
- "Evaluation, Rehabilitation, Development, and Operation of Pavement Condition Measuring Equipment" (FHWA Staff) is working on upgrading FHWA equipment in the Pavement Performance Laboratory. The new computer and software on PRORUT have much higher sampling rates, allowing positive identification of rigid pavement faulting.
- Equipment developed under two SHRP contracts will be evaluated for the Office of Technology Applications. Under one contract, a system using ground-penetrating radar (GPR) for recording sub-surface conditions at, or close to, highway speeds has been developed. However, further development is required. The other system is trailer-mounted, but operates in a stationary condition. It generates surface waves on the pavement and measures wave propagation. Pavement characteristics can be derived through data analysis. This system is ready for evaluation

High Priority Area: Accelerated Evaluation of Pavement Performance

- "Pavement Testing Facility Phase II Research" (FHWA Staff) continues detailed analysis of the wide-based single-tire data. A final report summarizing the results is expected in 1994.
- The Pavement Testing Facility (PTF) is being expanded from its current 12 sections to 24 test sections. The test sections will be in 12 parallel lanes to provide side-by-side testing capability for the ALF. The test lanes will be repositioned to provide better access to the site for pavement reconstruction. Test pits containing three different subgrades for prototype pavement construction are also being built as part of the PTF expansion.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Accelerated Evaluation of Pavement Performance

- A research program will be initiated at the PTF to validate the proposed SHRP Asphalt Binder Specifications. Test sections constructed with asphalt cements, having a wide range of performance characteristics based on the SHRP Asphalt Binder Specifications, will be tested using the ALF. The study will concentrate on the effect of asphalt binder on fatigue and rutting of asphalt pavements.
- A second ALF will be procured for the PTF. This will double the testing capabilities at the PTF, enabling completion of urgently needed research in a reasonable amount of time.
- Work will continue in the Pavement Performance Laboratory on various types of testing equipment.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: C.4
PROGRAM TITLE: Pavement Management Strategies
PROGRAM MANAGER: William J. Kenis

This research and development program addresses the technology of managing pavements to provide for optimal performance and productivity. This program also provides functional relationships between heavy vehicle configurations, suspension systems, truck axle-tire configurations, the pavement system, pavement response, and pavement damage to support the development of analysis techniques for the cost-effective design, construction, maintenance, and rehabilitation of pavements. It addresses the effects of environmental conditions, temperature and moisture, and the interaction with load on pavement performance.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Truck/Pavement Interaction

- Data from "FHWA Test Road Phase I Tests" (FHWA, FHWA Staff) evaluated pavement layer deflections and strains using the Instrumented Test Road at the Turner-Fairbank Highway Research Center (TFHRC). These variables were monitored in terms of three vehicle types, three axle loads, two pavement thicknesses, two tire pressures, and two vehicle speeds. The single-unit two-axle vehicle was used to apply the standard 80.1-kN load. Pavement primary responses were measured and used along with several selected Primary Response Load Equivalency Factor (LEF) methods to develop LEF's.
- A prototype Dynamic Truck Actuator System (DYNTRAC) was fabricated and installed at the TFHRC to simulate the dynamic forces generated by heavy vehicles due to accelerations caused by vehicles traveling over pavements (FHWA, FHWA Staff). It has four actuators, one for each tire or dual-tire unit of a two-axle truck. It can also be used to support each dual-tire unit of a tandem suspension trailer with the front of the trailer supported by a custom-designed fifth-wheel structure, under development, or a stationary tractor.
- "Effects of Heavy Vehicle Characteristics on Pavement Response and Performance—Phase II" (NCHRP) combined existing mechanistic models of trucks and pavements into a cohesive simulation system. A sensitivity study was conducted to determine the factors most significantly affecting rigid and flexible pavements.

Other Studies:

- "Microcomputer Analysis for Project-Level PMS Life-Cycle Cost Studies of Rigid Pavements" (MD SP&R) developed a design analysis of costs based on the 1986 AASHTO Design for Flexible Pavements.
- "An Investigation of AC Pavement Distress on Interstate 15 from Cajon Pass to the Nevada State Line" (CA SP&R) recommended attention be given to minus 200 material, reducing target asphalt content and limiting moisture-sensitive AC.
- "Development of Pavement Performance Prediction Models for Georgia Pavements" (GA

SP&R) will develop and calibrate evaluation models for typical Georgia pavement sections.

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Truck/Pavement Interaction

- "FHWA Test Road Phase I Experiments," conducted in 1991, evaluated the data collected. Results include statistical regression analyses to determine the significant influencing variables, truck speed, weight, tire pressure, pavement thickness, and axle configuration on pavement response.
- "Calibrated Mechanistic Structural Analysis Procedures for Pavements" (NCHRP) has prepared working versions of mechanistic-empirical, rigid, and flexible pavement design procedures for possible inclusion in the *AASHTO Guide for Design of Pavement Structures*.
- Equipment is being readied for the conduct of the "Test Road Phase II" (FHWA) experiments and for the DYNTRAC experiments at FHWA. Wheel force transducers are being developed and strain gauges are being installed on truck axles to provide an alternative means of measuring forces on pavements.

Other Studies:

- "Shear Force on Pavement by Heavy Trucks" (FHWA, KY) measured axle loads on WIM scales while trucks are accelerating and braking. The goal is to explain rutting by shear flow.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Truck/Pavement Interaction

- "FHWA Test Road Phase II Experiments" (FHWA Staff) will be conducted on the FHWA test road. A two-axle truck will be used as the primary test vehicle. The truck has been fully instrumented and equipped with an onboard data acquisition system. The signals from the strain gauges mounted on the axles are used to calculate wheel forces generated by the vehicle moving over a prefabricated "bump" strategically placed on the surface. The pavements response is simultaneously measured by 16 strain gauges placed on 1 meter centers at the bottom and top of the AC layer.
- Experiments will be conducted using DYNTRAC, wheel force transducers, accelerometers, and a variety of road profiles to evaluate the damage potential of different vehicle suspensions and configurations (FHWA).
- The FHWA will participate in the Organization for Economic Cooperation and Development's International Research Program (IR-6) truck dynamic studies.
- "Framework for Estimation of Maintenance and Rehabilitation Costs" (FHWA) will develop data bases to evaluate the economic impact of pavement construction, maintenance, and rehabilitation. Cost evaluation models will be developed from the data base and integrated into damage prediction models.

PUBLICATIONS AND PRODUCTS:

- *Heavy Vehicle Pavement Loading—A Comprehensive Testing Program*, Third International Symposium on Heavy Vehicle Weights and Dimensions, Queens College, Cambridge University, England, June 28, 1992, in the publication process.
- *Primary Response Under Heavy Truck Traffic*, Volume 2, Seventh International Conference

on Asphalt Pavements, Nottingham, England, August 1992.

- *Microcomputer Analysis for Project-Level PMS Life-Cycle Cost Studies of Rigid Pavements, Volumes 1 and 2 (FHWA/MD-9301).*
- *An Investigation of AC Pavement Distress on Interstate 15 from Cajon Pass to the Nevada State Line (CA/TL-92/06).*
- *Experimental Study of Factors Affecting the Spectral Analysis of Surface Waves (FHWA/TX-91 and 1125-5).*
- *Effect of Finite Width on Dynamic Deflections of Pavements (FHWA/TX-91 and 1123-6).*
- *Modulus 4.0 Expansion and Validation of the Modulus Back Calculation System (FHWA/TX-91/1123-3).*

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: C.5
PROGRAM TITLE: Construction Control and Management
PROGRAM MANAGER: Terry M. Mitchell, Ph.D.
PROGRAM PERSONNEL: Peter A. Kopac, P.E.

This program has three objectives: (1) to develop rapid and/or more significant test procedures for controlling the quality of highway construction; (2) to develop quality control and associated test procedures that relate directly to performance; and (3) to develop economic and technical data, statistical tools, and other support information to help highway agencies improve their construction management.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Performance-Related Specifications

- "PRS for Portland Cement Concrete (PCC): Laboratory Development and Accelerated Test Planning" (FHWA) produced a three-volume final report documenting the results of the study. Results included a prototype PRS and a computer program for use with the specification in simulations and in generating pay adjustments. The prototype specification considers the expected life-cycle cost of the as-constructed pavement (that pavement actually constructed by the contractor) as the overall measure of quality, and explicitly considers variability and multiple pay characteristics in the development of pay schedules. The pay schedules are based on comparisons between the target as-designed pavement (that pavement specified by the designer) and the as-constructed pavement.
- "Investigation of Contractor Quality Control and End-Result Acceptance Specifications of Bituminous Mixtures" (SC SP&R) surveyed State highway agencies and selected Canadian provinces to determine current practice regarding contractor quality control testing and end-result acceptance specifications. Recommendations were made as to how South Carolina should proceed with the development of these specifications.

Other Studies:

- "Criteria for Qualifying Contractors for Bidding Purposes" (NCHRP Synthesis) surveyed State practices and experiences with regard to qualification of contractors and to criteria for denial of bidding or award. The published synthesis report enables States to examine the practicality of using contractor performance and qualifications in the contract award process, and to evaluate their own current practices.
- "Rapid Test Methods for Asphalt Concrete and Portland Cement Concrete" (NCHRP Synthesis) summarized available information regarding rapid and/or accelerated test methods for those materials. The published synthesis report presents advantages and disadvantages of various test methods, as well as time, cost, and labor requirements.

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Performance-Related Specifications

- "Performance-Related Specifications" (NCHRP Synthesis) is summarizing the state-of-the-practice in PRS, including useful information on key materials and construction parameters, relationships between those parameters and performance, and rationales for acceptance criteria and for incentive/disincentive clauses.

Other Studies:

- "Field Procedures and Equipment to Implement SHRP Asphalt Specifications" (NCHRP) is establishing comprehensive procedures and developing equipment for quality control/quality assurance at the asphalt plant and laydown site to ensure asphalt pavements meet SHRP's performance-based specifications.
- "Calibration of Marshall Compaction Hammers" (FHWA) has produced a device and method for measuring the energy transmitted to Marshall AC specimens. During the coming year, the device will be evaluated at a number of field sites. It has promise as a tool for standardizing and improving the reproducibility of Marshall compaction procedures.
- "Use of Warranties in Road Construction" (NCHRP Synthesis) is examining warranty systems currently in use in the U.S. and Europe and studying the merits and drawbacks of widespread use of warranties in the U.S.
- "Construction Testing and Inspection Levels" (NCHRP) is developing administrative and technical guidelines for transportation agencies to use in establishing methods and optimal levels of inspection and testing for construction programs and projects.
- "Evaluation of the Components of Variability in Bituminous Concrete Pavements" (OK SP&R) is investigating the sources and magnitudes of variation in what is considered acceptable AC pavement material and construction in the State.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Performance-Related Specifications (PRS)

- "Accelerated Field Test of PRS for Hot Mix Asphalt Construction" (FHWA) will design, construct, and operate a pavement test track to verify SHRP mix design procedures and models, and to further the development of PRS by evaluating the impact on performance of deviations in materials and construction variables. Construction of the track is scheduled for the 1995 construction season and will be followed by multiple truck loading of the test sections over a 2-year period.
- "Interim PRS Criteria for PCC and AC Pavement" (FHWA) will continue the development of the prototype PRS and associated computer programs for both the PCC and AC. The focus will be on establishing interim criteria and on designing a system that will be implementable and able to incorporate future research findings.
- "Laboratory/Field Investigation of Performance-Related PCC Pavement Construction Variables" (FHWA) will identify typical variables in construction procedures, such as steel placement, concrete consolidation, joint sawing, and curing, and will quantify the needed relationships between construction variables and PCC pavement performance.

High Priority Area: Construction Quality Technology

- "Measurement and Specification of Construction Quality" (FHWA) will investigate the measurement of highway materials and construction quality, and will develop an accurate means of assessing quality in a construction project.

PUBLICATIONS AND PRODUCTS:

- *Performance-Related Specifications for Concrete Pavements, Volumes I through III* (FHWA-RD-93-042, FHWA-RD-93-043, and FHWA-RD-93-044).
- *Performance-Related Specifications for Asphalt Concrete—Phase II* (FHWA-RD-91-070).
- *Rapid Test Methods for Asphalt Concrete and Portland Cement Concrete* (NCHRP Synthesis 187).
- *Criteria for Qualifying Contractors for Bidding Purposes* (NCHRP Synthesis 190).
- *The Investigation of Contractor Quality Control and End-Result Acceptance Specifications of Bituminous Paving Mixtures for South Carolina* (FHWA-SC-93-04).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: C.6
PROGRAM TITLE: Long-Term Pavement Performance Evaluation
PROGRAM MANAGER: Paul Teng, P.E.

This Long-Term Pavement Performance (LTPP) Program, which is the largest and most comprehensive pavement performance research project ever undertaken, will extend the life of highway pavements through achievement of the following goals: evaluation of existing design methods; development of improved pavement design methodologies and strategies for the rehabilitation of existing pavements; development of improved design equations for new and reconstructed pavements; and determination of the effects of loading, environment, material properties and variability, construction quality, and maintenance levels on pavement distress and performance; determination of the effects of specific design features on pavement performance; and establishment of a national long-term pavement data base to support Strategic Highway Research Program (SHRP) objectives and future needs.

To achieve these goals, periodic data collection and condition monitoring of nearly 3,000 inservice pavement test sections, located throughout the United States and Canada, will be conducted over a 20-year period. The LTPP research includes two suites of experiments: General Pavement Studies (GPS) and Specific Pavement Studies (SPS). The GPS experiments focus on existing pavements and the designs most commonly used in the United States and Canada. The SPS experiments involve test sections constructed specifically for the LTPP research and focus on the efficacy of specific pavement design factors involved in new pavement construction, the application of maintenance treatments to existing pavements, and pavement rehabilitation. Highways selected for inclusion in the GPS and SPS experiments cover the full range of environmental conditions found in the United States and Canada, and, by virtue of being on inservice highways, are subjected to "real," non-idealized traffic loadings. Hence, the research results will be more broadly applicable than those of many earlier pavement performance studies.

From its inception in 1987 through June 30, 1992, the LTPP program was operated as one of the four program areas of the National Academy of Sciences (NAS) SHRP. As of July 1, 1992, the operation of the LTPP research transferred to the Long-Term Pavement Performance Division of the FHWA. Since that time, the LTPP Division has also assumed responsibility for follow-on efforts related to other SHRP program areas.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Long-Term Pavement Performance

- Developed a strategic plan to guide the Long-Term Pavement Performance research for the remainder of the planned program duration. This working document has the support of the American Association of State Highway and Transportation Officials (AASHTO) Joint Task Force on Pavements, the SHRP Executive Committee, and the TRB-SHRP Committee.

- Completed the fifth public release of data from the LTPP Information Management System (IMS).
- Completed review and update of SPS-1 and SPS-2 construction guidelines.
- Initiated and/or completed construction of seven SPS projects.
- Conducted a field review of the performance of the maintenance effectiveness test sections under study in the SPS-3 and SPS-4 experiments.
- Conducted four regional meetings to communicate program status and developments, and allowed State highway agencies to provide input on priorities.
- Entered into a cooperative agreement with the Canadian Strategic Highway Research Program (C-SHRP) to foster continued Canadian involvement in the LTPP experiments, and allowed the Federal Highway Administration (FHWA) to take advantage of C-SHRP's LTPP initiatives (such as those in the area of Bayesian analysis of pavement performance data).
- Completed initial training of LTPP staff and contractors in the use of C-SHRP's Bayesian pavement performance data analysis software to facilitate future efforts to take advantage of C-SHRP's investment in this methodology.
- Finalized plans for instrumentation of selected LTPP test sections were included in the Seasonal Monitoring Program. These sections will be intensively monitored to provide data on temperature- and moisture-related changes in pavement structures over time.
- Assumed operational responsibility for the Materials Reference Library, established under SHRP, to provide a source of "standard" pavement materials for use in pavement research.
- Completed procurements for traffic engineering technical assistance, operation of the Materials Reference Library, additional deflection testing equipment, and follow-on efforts related to the SHRP research on innovative materials for highway maintenance and repair (SHRP Contract H-106).
- Upgraded the computer and software systems used for the LTPP Information Management System at the national and regional levels.
- Established the LTPP Central Traffic Data Base at the Transportation Research Board that is connected to the National Information Management System.

Work Underway: The following is a partial list of these studies with interim results:

- Data collection to monitor distress, profile, structural characteristics (through deflection testing), maintenance activities, and traffic on the LTPP test sections continues.
- Review of the LTPP monitoring program to evaluate adequacy and identify areas where changes and refinements are warranted.
- Recruitment and construction of additional test sections continues, with the primary focus on the SPS experiments.
- Instrumentation of sections included in the Seasonal Monitoring Program to allow monitoring of in situ temperature, moisture, and frost penetration conditions.
- Continued development of the Information Management System for the LTPP data, including the implementation of more extensive data quality assurance and control checks, and the addition and adaptation of data tables for SPS data.
- Continued coordination with the international participants in LTPP, including the institution of annual workshops for LTPP International Coordinators following the annual meeting of the Transportation Research Board (TRB) in January of each year. The first such workshop was in January 1993; the second is being planned for January 1994.
- Evaluation of a prototype weather station to be used in the collection of climatic data for the SPS structural factors, environmental effects, and SUPERPAVE validation experiments.
- Procurement of replacement pavement profiling equipment and materials testing services to support the LTPP research.

- Refinement of experimental plans and guidelines for the SPS-9 experiment to validate the SUPERPAVE system.
- Development of guidelines for instrumenting SPS structural factors test sections for the evaluation of load effects.
- Completion of AASHTO and SHRP reports on LTPP data analyses and needs by their contractors.
- Development of forensic procedures to define, identify, evaluate, and document "failure" of LTPP test sections.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Long-Term Pavement Performance

- Data collection on the LTPP test sections will continue.
- Recruitment and construction of LTPP test sections will continue, especially for the SPS experiments.
- Complete procurements for follow-on efforts related to the SHRP research on concrete bridge protection and rehabilitation; effectiveness of preventative maintenance treatments; SUPERPAVE model refinement; SUPERPAVE material testing; and mixture and binder evaluation using SPS-9 cores and materials.
- Plans for near-term analyses of the LTPP data will be finalized based on the results of the initial SHRP (P-020) analyses, AASHTO's deliberations on pavement analysis needs, and feedback on the LTPP Strategic Plan. Procurements for one or more LTPP data analysis contracts will be initiated.
- Active recruitment and construction of SPS-9 (validation of SUPERPAVE) will begin.
- The sixth public release of data from the LTPP IMS will be executed.
- Preliminary analysis efforts to provide implementable interim results will continue.

PUBLICATIONS AND PRODUCTS:

- *Long-Term Pavement Performance Information Management System Data Users Guide* (FHWA-RD-93-094).
- *Distress Identification Manual for the Long-Term Pavement Performance Project* (SHRP-P-338).
- *Analysis of Section Homogeneity, Non-Representative Test Pit and Section Data, and Structural Capacity, Volumes I, II, and III* (SHRP-P-633 through 635).
- *SHRP's Layer Moduli Backcalculation Procedure* (SHRP-P-655).
- *SHRP Procedure for Temperature Correction of Maximum Deflections* (SHRP Publication No. SHRP-P-654).
- *Falling Weight Deflectometer Relative Calibration Analysis* (SHRP-P-652).
- *Comparison of the SHRP Profilometers* (SHRP-P-639).
- *SHRP's Layer Moduli Backcalculation Procedures* (SHRP-P-655).
- *Manual for FWD Testing in the Long-Term Pavement Performance Program* (SHRP-P-661).
- *LTPP Information Management System Demonstration Disk*.
- *LTPP IMS Abbreviated Schema Report*.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: C.9

PROGRAM TITLE: Technology Transfer for Pavements

PROGRAM COORDINATORS: Gary Henderson—Technology Applications
George Jones—National Highway Institute
Robert C. Kelly—Local Technical Assistance Program

The objectives of this program are to develop guidelines, technical manuals, slide-tapes, films, videotapes, and training courses related to pavement management strategies and the performance, design, construction, and rehabilitation of rigid and flexible pavements; and to provide technical assistance to highway agencies through reports, technical briefings, troubleshooting, technical expertise, and, where appropriate, hands-on demonstrations.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Technology transfer activities in pavement design, rehabilitation, construction, and management under this program include identifying suitable products from research and private industry, international, and internal sources; testing and evaluating these products, often through the cooperative efforts of the State highway agencies; and providing the results and recommendations to other highway agencies using technology-sharing reports, implementation packages, demonstrations, training courses, slide-tapes, videotapes, and workshops. The overall goal, as with any technology transfer activity, is to provide the necessary evidence to either improve existing practices, procedures, specifications, or policies, or to validate their continued use. Interaction with local jurisdictions occurs through the Local Technical Assistance Program (LTAP) and the 55 technology transfer centers nationwide.

TECHNOLOGY APPLICATION

The following major activities were conducted during fiscal year 1993:

- Under Test and Evaluation Project 18, Stone Matrix Asphalt, the design, construction, and evaluation of the European stone matrix asphalt (SMA) continues. In 1992, projects were constructed in Alaska (U.S. 1), California (I-40), Maryland (U.S. 15 and I-70), Ohio (U.S. 33), Texas (I-35), Virginia (U.S.-25), and Wisconsin (I-43). Additional projects planned or under construction in 1993 are Arizona (I-40), California (Route 101), Colorado (U.S. 85), Georgia (I-95), Illinois (U.S. 6), Maryland (I-95/I-295, I-270), Michigan (I-94 and I-96), Missouri (U.S. 63), New Jersey (U.S. 1), North Carolina (U.S. 264), Texas (U.S. 377), Virginia (I-95), Wisconsin (U.S. 51 [63/45]), and Wyoming (I-80). Data from these projects are being analyzed and model specifications have been disseminated. Further evaluation is targeting mixture design, cost reduction, quality control, and predictive performance of the SMA pavements. Eventually, SMA could be used by all States as a rut-resistant pavement surface.
- Demonstration Project 90, Innovative Asphalt Mix Laboratory Techniques uses a mobile laboratory to provide State highway agencies with hands-on demonstrations of the Strategic Highway Research Program (SHRP) asphalt mixture test equipment. The laboratory has been equipped with the gyratory compactor and resilient modulus asphalt test equipment.

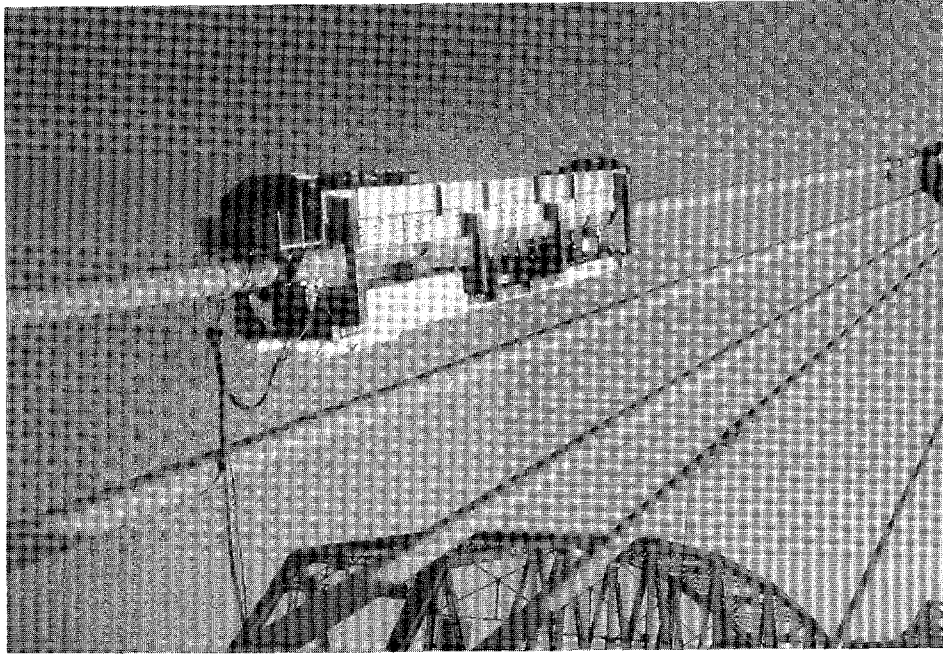
As additional SHRP equipment becomes available, it will be included in the laboratory. The laboratory also provided support to other technology applications asphalt testing activities, such as the SMA construction in Georgia.

NATIONAL HIGHWAY INSTITUTE

- Offered training courses on 2 different topics related to pavements and conducted a total of 13 presentations. The course in greatest demand was Techniques for Pavement Rehabilitation.

LOCAL TECHNICAL ASSISTANCE PROGRAM

- A new train-the-trainer course updating the workshop on Road Surface Management for Local Governments will be designed specifically for local transportation agencies to assist them in working with the State highway agencies to develop and implement a pavement management system (PMS). The course will cover both paved and unpaved or aggregate surface roads. Two pilot presentations will be followed by one train-the-trainer course in each FHWA Region. Principal participants at the workshops will be LTAP Technology Transfer Center Directors, local transportation officials, State highway agency personnel with responsibility for assisting local transportation agencies in developing a PMS, and FHWA Region and Division office personnel who have responsibilities in the PMS area and the LTAP. Examples of six public and six private sector PMS's will be described during the 2-day course to make local transportation agencies aware of the PMS programs available, and to assist them in choosing a PMS that reflects their needs.
- Four contracts are being developed and will be awarded at the end of fiscal year 1993 for pavement-related training products for the LTAP: course and training material on bituminous roadway rehabilitation alternatives; a videotape on contract paving inspection; a training manual and other material on common problems associated with aggregate surface roads; and a videotape on chip seal construction. Each product will be tailored to the needs of local transportation agencies. The products will be designed to be taught by LTAP Technology Transfer Center personnel or by the local transportation agency itself.
- A joint FHWA Regions 1 and 3 LTAP conference was held in spring 1993 to formulate revisions to the New Hampshire LTAP Technology Transfer Center's Road Surface Management System (RSMS) PMS software. The software is used by a number of LTAP Centers around the country and many local transportation agencies have adopted the RSMS as their PMS of choice. Since the person who developed the software is no longer at the New Hampshire LTAP Center, the Pennsylvania LTAP Technology Transfer Center volunteered to update the RSMS PMS software. The proposal submitted for accomplishing these revisions has been reviewed and an award for development of an updated version of the RSMS will occur at the end of fiscal year 1993.
- Proposals submitted by the U.S. Army Corps of Engineers for expanding the MicroPAVER software are under review. The MicroPAVER PMS software is already available primarily through the American Public Works Association, and is used by a number of local transportation agencies nationwide. The expansion will incorporate procedures and guidelines for the inventory, condition rating, and work planning for sidewalks, shoulders, and drainage facilities for roads. Most of the difficulties local transportation agencies face stem from tort actions associated with pedestrians' tripping on uneven sidewalks, shoulder dropoff accidents, and residential flooding because of poor drainage design or maintenance. Admittedly, inclusion of these elements extends the range of traditional PMS activities; however, many local transportation agencies have had difficulties in managing and devoting resources to correct problems that are, for the most part, ancillary to their roadway system.



D. Structures

High Priority Areas

- Critical Substructural Bridge Elements
- Corrosion Control of Structural Elements, Part 1
- Structural Composites and Adhesives
- Seismic Protection of Bridges
- Nondestructive Evaluation
- Timber Bridge

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: D.1
PROGRAM TITLE: Bridge Design
PROGRAM MANAGER: John O'Fallon

Program area D.1 seeks to find a realistic means of quantifying bridge loads of all types; to develop a better understanding of structural response and improved design criteria that will more accurately correspond to the loads and load paths; to identify the factors affecting bridge life and to find a rational approach to its determination; to develop new approaches for analysis, design, and construction of bridges; and to obtain better and more cost-effective culverts through improved design, construction, and material use. (Structural research related to bridge rating and rehabilitation is covered by NCP program area D.2.)

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

Program area D.1 includes research performed by FHWA through administrative contracts, staff studies, and the Graduate Research Fellowship (GRF) program. In addition, work is carried out with State Planning and Research (SP&R) funds and is performed by the National Cooperative Research Program (NCHRP) and by other academic and private researchers who are concerned with bridge design. The most urgent research is concentrated under high priority areas (HPA's) of research. For D.1, there are three high priority areas, listed below.

High Priority Areas: *Seismic Protection of Bridges*
 Timber Bridge Research
 Structural Composites and Adhesives

These high priority areas been recently initiated and tend to be large studies. Consequently, no significant results are available yet.

Other Studies:

- "Bridge Temporary Works" (FHWA) is complete and has produced five documents: a synthesis, a guide standard specification, a guide design specification, an industry certification program, and a construction handbook for temporary bridge works. These will be distributed through an FHWA Technical Advisory.
- "Development of Comprehensive Bridge Specifications and Commentary" (NCHRP) has developed an LRFD-based bridge design specification. If approved by AASHTO, it will be published as a separate specification from the current edition (fifteenth), which contains Allowable Stress Design and Load Factor Design.
- "Aerodynamic Response of the Deer Isle-Sedgewick Suspension Bridge" (FHWA Staff/Maine SP&R) has resulted in the design of fairings to be installed on the outside faces (webs) of the stiffening girders. Testing and analysis have indicated that these should eliminate the aerodynamic instability that the bridge has experienced since construction over 50 years

- ago. The fairings should be installed by the end of 1993. Monitoring will continue after bridge modification.
- "Variable Amplitude Load Fatigue" (FHWA) has completed fatigue testing of 10 full-size beams and 72 reduced-scale specimens to quantify fatigue under random truck traffic. This data will be useful in updating fatigue design criteria in the bridge specifications. The final report is being prepared.
 - "Performance of Epoxy-Coated Prestressing Strand at Elevated Temperatures" (FHWA Staff) tested 10 specimens and confirmed that epoxy-coated strand will slip at temperatures above 71 °C (160 °F) and will soften at 63 °C (145 °F), and concluded that the Prestressed Concrete Institute recommendations prohibiting transfer of prestress at temperatures above 66 °C (150 °F) should be followed. A report will be published in 1994.
 - "Compressive Membrane Effects on the Behavior of One-Way Structural Concrete Members with Application to Box Culverts" (FHWA Staff) analytically investigated the increase in the calculated load capacity of box culverts from consideration of membrane forces. A computer program to calculate the forces in areas of smooth stress gradients was developed.
 - "Fretting Fatigue in External Post-Tensioned Tendons" (Texas SP&R) performed fatigue testing on prestressing cables to verify their performance.

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Seismic Protection of Bridges

- "Seismic Vulnerability of the Highway System" (FHWA) has formed and convened two meetings of a Highway Seismic Research Council (HSRC). The HSRC is comprised of knowledgeable State, Federal, academic, and private engineers and researchers who are knowledgeable in the area of seismic-resistant design and construction of bridges.
- "Seismic Research Program" (FHWA) will also be performed by NCEER SUNY-Buffalo, and will use the same HSRC as the previous study.

High Priority Area: Timber Bridge Research

- "1990 Appropriations Act—Congressionally Mandated Research" (FHWA) has developed and crash-tested wooden rails for use on timber bridges. Design guidelines for stress-laminated decks and T-beams, bulb-T's, and box-beams are being prepared.
- "Section 1039(a) of Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)" (FHWA) has completed the second year of a 6-year timber bridge research program with the USDA Forest Products Laboratory. Fifteen studies dealing with areas delineated in ISTEA have been initiated.

High Priority Area: Structural Composites and Adhesives

- "Behavior of Adhesive Joints in Highway Structures" (FHWA) is studying the long-term performance of adhesive joints subjected to natural (temperature, moisture, ultraviolet) and man-made (deicers, solvents, fires) environments found on highway bridges.
- "Accelerated Test Methods to Determine Long-Term Behavior in FRP Composite Structures" (FHWA) will produce a series of test methods to measure fiber-reinforced polymers (FRP's) structural behavior for a range of FRP materials under a broad range of environmental and loading conditions. The test methods must be rapid enough to predict structural performance over a 50-year period within a reasonable amount of time.

- "Modular Concepts for FRP Bridge Decks" (FHWA) will examine available methods for developing models of structural behavior from fundamental mechanics of FRP materials and will then produce analytical models for use by bridge designers.
- "Advanced Composite Cable-Stayed Bridge" (FHWA) is a Congressionally mandated, systems development study of the design and construction of a two-lane, cable-stayed, vehicular bridge with a 133-m (435-ft) clear span in San Diego, CA. There will be a potential use for composites in every part of the structure.

Other Studies:

- "Curved Steel Bridge Research" (FHWA, SP&R Pooled Fund) is studying the behavior of curved steel I-beam and box-girder bridges to develop improved analytical procedures, and to design formulations and constructibility criteria to be used ultimately by NCHRP in developing a new design specification for curved steel bridges. A synthesis of current practice has been produced for immediate use by NCHRP in updating and revising the current AASHTO Guide Specification for Curved Bridges.
- "Investigation of Development Lengths of Uncoated and Epoxy-Coated Prestressing Strand" (FHWA Staff) has completed experimentation on the Phase I rectangular specimens and has found that the development-length equation in AASHTO may be unconservative for multiple uncoated strands. Next year, full-size PS/C I-beams and deck panels will be cast and tested to failure to determine the development lengths for strands in these members.
- "Aerodynamic Response of the Mississippi River Bridge at Luling" (FHWA Staff) continues to monitor high-speed wind events as part of its long-term characterization of wind and structural response.
- "High-Performance Steels for Bridge Construction" (FHWA) is a cooperative venture with the U.S. Navy and AISI to develop improved steels for use in bridges.
- "Innovative Bridge Design Using Enhanced-Performance Steel" (FHWA) will determine the extent to which high-performance steels can be used in present-day structures and will develop new innovative designs to use it more effectively.
- "Plasma Arc Cutting of Bridge Steels" (NCHRP) is developing a guide for using this technique in steel bridge fabrication.
- "Design and Construction of Backfill Envelopes, Foundations, and End Treatments for Underground Structures" (FHWA) is an interagency effort with the National Science Foundation (NSF) to develop improved design, material and construction specifications, and procedures for buried pipes and culverts. It will study the interaction between the pipe, backfill, and in situ soil.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Seismic Protection of Bridges

- "Analytical Studies for Base Isolation of Bridges" (FHWA Staff) will develop finite element models for non-linear behavior of isolators and design formulations for bridge components in base-isolated structures.

High Priority Area: Timber Bridges Research

- "Cooperative Research Joint Venture Agreements" (FHWA/Forest Products Laboratory) consists of seven small cooperative grants in seven problem areas: waterproof asphaltic wearing surfaces for timber decks; life-cycle costs of timber bridges; moisture protection (coatings) for timber bridges; preservative treatments for hardwoods; standard plans for

timber piers, abutments, and box culverts; timber sound barriers; and shear strength of sawn-lumber beams.

High Priority Area: Structural Composites and Adhesives

- "Environmental Durability of FRP" (FHWA) will determine the long-term performance of FRP subjected to the environments that are experienced on highway bridges, and will develop material and design criteria to eliminate or mitigate environmental effects upon their performance.
- "Anchorages for FRP Prestressing Tendons" (FHWA) will develop an economical post-tensioning anchorage system that would allow construction with existing techniques when using FRP tendons.
- "Development of FRP Prestressed Bridges" (FHWA) will develop design criteria and details for FRP prestressing tendons and study their behavior in the structure. It will also develop structural material and design specifications and construction procedures for both pre- and post-tensioned systems and bridges.

Other Studies:

- "Fatigue of Riveted Steel Highway Bridges" (FHWA) will perform tests on riveted structures to determine their fatigue performance. This data will be used to evaluate the condition of existing riveted bridges.
- "Optimized Sections for High-Strength Bridge Girders" (FHWA) will develop sections suitable for use with the new higher strength concretes.
- "Transfer and Development Lengths for Lightweight PS/C Members" (FHWA Staff) will look into bond and development of prestressing strand in lightweight concrete similar to the existing study on these topics for normal weight concrete; however, it will be on a smaller scale.
- "Aesthetic and Efficient New Structures Design for Standard Bridge Systems" (Texas SP&R) plans to improve the aesthetics and economy of moderate span, precast concrete bridges by use of conceptual plans and aesthetic guidelines.
- "Longitudinal Cracking and Spalling in Long Span PT/C Bulb-Tee Girders" (Florida SP&R) will investigate the cause of cracking in the webs of bulb-tees.

PUBLICATIONS AND PRODUCTS:

- *Guide Standard Specification for Bridge Temporary Works* (FHWA-RD-93-031).
- *Guide Design Specification for Bridge Temporary Works* (FHWA-RD-93-032).
- *Certification Program for Bridge Temporary Works* (FHWA-RD-93-033).
- *Construction Handbook for Bridge Temporary Works* (FHWA-RD-93-034).
- *Corrosion Protection of Steel Hardware in Modern Timber Bridges* (FHWA-RD-92-044).
- *Development of a Six-Year Research Needs Assessment for Timber Transportation Structures* (FPL-GTR-74).
- *Turner Truck Impact on Washington State Bridges* (WA-RD 287.1).
- *Failure Characteristics of a Structural Plate Pipe Arch* (FHWA/OH-92/004).
- *Strand Debonding in Pretensioned Beams—PS/C Bridge Girders with Debonded Strands, Part I: Continuity Issues* (FHWA/INDOT/JHRP-92-24) and *Part II: Simply Supported Tests* (FHWA/INDOT/JHRP-92-25).
- *Field Instrumentation and Measured Response of the I-295 Cable-Stayed Bridge Over the James River* (FHWA/VA-93-R12 and FHWA/VA-93-R13).

- *Feasibility Evaluation of Utilizing High-Strength Concrete in Design and Construction of Highway Bridges* (FHWA/LA-92/264).
- *Influence of Temperature on Precast Bridge Girders* (FHWA/FL/DOT/RMC/0583-3356).
- *Effect of Increased Truck Weight on Illinois Highway Bridges* (FHWA/IL/RC-013).
- *Resistance of Welded Details Under Variable Amplitude Long-Life Fatigue Loading* (NCHRP Report 354).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: D.2
PROGRAM TITLE: Bridge Management
PROGRAM MANAGER: Steven B. Chase, Ph.D.

This program develops a comprehensive Bridge Management System (BMS) that will rationally and effectively allocate the expenditure of bridge program funds for all types of highway bridges throughout the lifetime of each bridge. This begins with system planning and continues through design, construction, and maintenance, and eventual rehabilitation or replacement. The program also improves the following functional areas: bridge inspection, condition assessment, and rating; rehabilitation and replacement technology; and system management. (Design-related research is covered under NCP Program Area D.1.)

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Nondestructive Evaluation

- "Final Report on the National Conference on NDE in Bridge Inspection" (FHWA) documents the recommendations for further research and development in nondestructive evaluation (NDE) for bridge inspection as a result of the FHWA-sponsored conference on NDE in bridge inspection held in Rosslyn, Virginia, August 25-27, 1992. This conference included knowledgeable researchers, users, and manufacturers of NDE systems and assessed the state of the practice of NDE in bridge inspection.

Other Studies:

- "PONTIS, A Network Optimization System for Bridge Improvements and Maintenance" (FHWA), a software system, is a new generation network-level Bridge Management System (BMS), which incorporates dynamic, probabilistic models, and a detailed bridge data base to predict maintenance and improvement needs, recommend optimal policies, and schedule projects within budget and policy constraints.

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Nondestructive Evaluation

- "Magnetic Perturbation of Cables and Magnetic Field Disturbance of Bridge Cables and Prestressed Steel Inspection Systems" (FHWA) is designing and fabricating equipment for the detection and location of imperfections in the steel elements of prestressed concrete beams and the main cables of suspension bridges. This equipment will then be brought to the field to demonstrate its potential for routine use by bridge inspectors.
- "Nondestructive Load Testing for Bridge Evaluation" (NCHRP) will develop procedures for incorporating bridge testing in the evaluation of bridge load capacity. It will develop a testing manual that will include testing techniques and guidelines for interpreting the results

and incorporating them in load ratings, and will also develop a training program to help implement these procedures in a State or local transportation agency.

- "NDE Monitoring of Bridges" (FHWA), a Congressionally mandated study, will obtain a method for reliable analysis of data from stress wave techniques, including ultrasonics and acoustic emission signal characterization; will obtain a device that will indicate the cumulative fatigue loading of a typical highway bridge; and will develop related nondestructive evaluation automated decision procedures.
- "Nondestructive Evaluation Techniques" (FHWA), a Congressionally mandated study, will evaluate several advanced NDE techniques on the I-40 Bridge over the Rio Grande River in Albuquerque, New Mexico. The bridge is being replaced and will be used as a full-scale field laboratory. The study includes the evaluation of resonant ultrasound spectroscopy, electronic speckle pattern interferometry, modal analysis, and other NDE techniques as progressively more severe defects are introduced into the existing "fracture-critical" two-girder bridge.
- "Evaluation of Dual-Band Infrared Thermography" (FHWA) will evaluate whether the simultaneous use of two different infrared wavelengths will overcome some of the operational problems (primarily surface emissivity variations) that have been experienced with infrared thermography as applied to the detection and quantification of delaminations on bridge decks.

Other Studies:

- "Monitoring Program for Pennsylvania's Demonstration Timber Bridge Program" (PA SP&R) is monitoring the performance of 17 bridges being built under the timber bridge demonstration program.
- "BRIDGIT, Bridge Management System Software" (NCHRP) will develop, test, and document a fully operational microcomputer-based bridge management system software package that can be readily used by transportation agencies.
- "Load Rating Steel and Concrete Girder Bridges in Missouri" (MI SP&R) will evaluate different AASHTO rating procedures and design a bridge-rating strategy for Missouri.
- "Development and Implementation of the Connecticut Bridge Information System" (CT SP&R) is the second phase of the demonstration project. The project will create a fully functioning statewide bridge information system based on photolog videodisc technology.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Nondestructive Evaluation

- "Ground-Penetrating Imaging Radar (GPIR) for Bridge Deck Inspection" (FHWA) will develop an engineering prototype of a new generation ground-penetrating radar for bridge deck inspection. The system will use impulse radar, synthetic aperture techniques, and sophisticated signal processing and imaging algorithms to image an entire lane width of a bridge deck at one time. The goal is a system that will travel at traffic speeds, image a lane width of a bridge, and provide a two- or three-dimensional image of the interior of the bridge deck. The engineering prototype is under development and preliminary tests have been able to provide images of the interior of a reinforced concrete test bed that show test voids and reinforcement.
- "Fatigue Crack Detection System" (FHWA) will develop an improved device for the detection and quantification of fatigue cracks in steel bridges even though the cracks are obscured by paint. This was identified as the highest priority need for steel bridges at the National Conference on NDE in Bridge Inspection.

Other Studies:

- "Bridge Management Systems—Phase II" (SC SP&R) will implement a number of actions that were recommended in the phase I final report. Specific objectives include development of conceptual models to capture cost data, development and testing of a Pontis-compatible bridge inspection data acquisition system, and investigation of technologies to link various components of the South Carolina BMS.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: D.3
PROGRAM TITLE: Hydraulics and Hydrology
PROGRAM MANAGER: Roy E. Trent, Ph.D.

This program provides and coordinates research and development for cost-effective drainage design and stream stabilization procedures, and for protecting highway systems against flood hazards.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Critical Substructural Bridge Elements

- "Instrumentation for Measuring Scour at Bridge Piers and Abutments" (NCHRP Project 21-3) completed the phase I report on fixed instrumentation to monitor scour at critical bridges. Field tests of instrumentation are underway in the second phase.
- "Stability of Rock Riprap to Protect Bridge Abutments" (FHWA Staff, Grants for Research Fellowships) developed procedures for sizing riprap to protect bridge abutments on compound/flood plain stream crossings. Design procedures are incorporated in HEC-18. See PUBLICATIONS for HEC-18.
- "Integrated Drainage Design Computer System" (SP&R Pooled Fund) issued version 5.0 of HYDRAIN to the 30 participating State highway agencies, McTrans, and PC-TRANS. An NHI training course for HYDRAIN is available for up to 40 presentations.
- "Seismic and Radar Scour Instrumentation" (FHWA) has developed methods using geophysical techniques to detect the interfaces of refilled scour holes.
- "Hydraulic Analysis of Bridges on Streams with Moveable Beds and Banks" (NCHRP Project 21-3) developed a draft BRI-STARS model and users manual for review and evaluation. The model is capable of computing degradation, aggradation, and contraction scour at bridge crossings and local scour at piers and abutments.
- "Alternative Measures for Protecting Bridge Piers from Scour" (FHWA Staff, GRF) investigated and published results on the use of grout-filled bags, articulated mattresses, and concrete tetrapods to protect against scour at piers.
- "Pressure Flow Scour for Inundated Bridges" (FHWA Staff) published results of preliminary investigations of pressure flow bridge pier scour at the 1993 ASCE Hydraulics Conference.
- "Performance of Bridges During Floods" (FHWA) developed a comprehensive scour data base system and drafted a final report documenting 5 years of field scour measurements.
- "Remote Methods for Underwater Inspection of Bridge Structures" (FHWA) fabricated and fieldtested a robotic arm used to deploy transducers for measuring scour.

Other Studies:

- "Storm Drain Energy Losses in Junctions" (FHWA Staff) conducted over 600 simulations for a range of pipe, junction, and manhole combinations. The final report is being drafted.

- "Verification of the (HYDRAIN) Storm Drain System Simulations" (GRF/National Highway Institute) evaluated storm drains and junctions operating under pressure flow conditions. Results are published in FHWA-RD-92-100, available through NTIS.

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Critical Substructural Bridge Elements

- "Seismic and Radar Scour Instrumentation" (FHWA) is testing and evaluating improved methods based on geophysical techniques as forensic post-flood tools to detect the interface of refilled scour holes.
- "Scour Instrumentation and Deployment Methods" (FHWA) is developing and evaluating portable scour instrumentation for use during flood events, i.e., mobile equipment to be used by inspection and survey crews when scour is actually taking place. A remote-controlled boat with positioning system and onboard echo sounder will be used to survey the riverbed near bridges in three-dimensions.
- "Scour Performance of Bridges During Floods" (FHWA) is measuring scour processes at sites where existing equations are deficient (e.g., scour at abutments) and to verify simulation models currently under development (e.g., BRI-STARS and FESWMS-2DH). It also is maintaining a national data repository for bridge scour field studies sponsored by various State highway agencies.
- "State Scour Studies" (SP&R) measure scour in progress during actual flood events under a mix of SP&R and State programs. Data will be used to improve or establish reasonable limits for scour prediction procedures locally and nationally.
- "Numerical Two-Dimensional Model of Scour Processes" (FHWA) is providing enhancements to the two-dimensional finite element surface-water modeling system called FESWMS-2DH. Future model versions and offspring will include algorithms for scour and sediment transport, alluvial fan flow, and a three-dimensional flow module.
- "Effects of Gradation and Cohesion on Scour" (FHWA) is a large-scale laboratory study to test effects of a mix of bed materials, including cohesive soils and various gradations of noncohesive soils, on local scour. A portable apparatus for determining detachment rate coefficients from onsite soils is being developed.
- "Expert System for Bridge Scour Evaluation and Prevention" (NCHRP Project 24-6) is developing a counselor-type expert system to help bridge inspectors rapidly converge on a credible, even if subjective, evaluation of the scour-and-stream stability condition of a highway stream crossing.
- "Debris Loads on Highway Bridges" (NCHRP Project 12-39) is developing standard specifications for determining stresses imposed by dynamic and static loading caused by floating ice and debris on bridges.
- "Debris Loading [Hazards] to Highway Bridges" (FHWA) is providing quantitative regional estimates of the total amount, size, mass, and character of water-transported debris and ice for various discharges and different watersheds used as input to NCHRP Project 12-39.
- "Tidal Hydraulics and Scour Processes" (Regional SP&R Pooled Fund) will develop procedures for evaluating and simulating the hydraulics at highway crossings of tidal inlets and channels to help determine the scour potential.
- "Determination of Unknown Subsurface Bridge Foundations" (NCHRP Project 21-5) is developing and evaluating equipment and methods of determining the type and depth of bridge foundations where that information is unknown, yet essential, for scour evaluations.
- "Remote Methods for Underwater Inspection of Bridge Structures" (FHWA) is refining a prototype remote-operated probe system to be used for underwater inspection of bridge substructures and foundations, and the streambed.

- "BRI-STARS Enhancement and Development" (FHWA) will extend and add features to the BRidge StreamTube model for Alluvial River Simulation scour and sediment transport computer model recently developed by NCHRP.

Other Studies:

- "Flood Prediction Procedures for Ungauged Arid Watersheds in the Southwestern United States" (SP&R Regional Pooled Fund) is developing improved procedures for predicting peak flows from ungauged small arid watersheds.
- "Street Hardware Castings" (FHWA) is developing a design procedure, material specifications, and construction specifications for manhole and grate extension devices for raising manhole covers or grates when resurfacing highways or streets.
- "Management of the Discharge and Quality of Highway Runoff in Karst Areas to Control Impacts to Ground Water" (SP&R Pooled Fund) will evaluate the possible contamination of ground water from highway stormwater runoff for conditions where such impacts are most likely to occur and will evaluate means to divert and filter clean the water to reduce the ground water contamination.
- "Evaluation of Water Quality Monitoring Equipment for Measurements of the Constituents of Highway Stormwater Runoff" (FHWA) will be evaluating water quality measurement and associated sample collection equipment for stormwater runoff from highways.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Critical Substructural Bridge Elements

- "Pressure Flow Scour at Bridges" (FHWA) will investigate the scour processes in bridge openings when the deck becomes inundated, causing the flow under the bridge to operate under pressure. The study will include live bed scour and will extend the preliminary investigations that have been conducted at the FHWA Hydraulics Laboratory.
- "Large-Scale Model Bridge Scour and Countermeasure Studies" (FHWA) will evaluate scour processes on scales closer to prototype conditions. Tests would account for factors affecting scour (such as cohesion and gradation of sediments, irregular conveyance distribution in natural channels, and the effects of the length of the bridge approach embankment on abutment scour) that are aspects of prototype conditions that cannot be modeled at small scales and for conventional physical conditions.
- "Debris Effects on Local Scour" (FHWA) will evaluate typical debris accumulations and their effects on local and contraction scour. The study will be limited to non-cohesive sediments and will investigate a variety of bridge substructure configurations and debris mat parameters such as size, porosity, orientation, and relative depth.
- "FHWA Hydraulics Laboratory Studies" (FHWA Staff, NHI/GRF) will include topics on scour around pile groups and exposed footings, clear water pressure flow scour at piers and abutments, and culvert hydraulics under unsteady flow conditions.

PUBLICATIONS AND PRODUCTS:

- *Strategies for Managing Unknown Bridge Foundations* (FHWA-RD-92-030).
- *Verification of the Pressurized Flow Simulation Module of HYDRA* (FHWA-RD-92-100).
- *Evaluating Scour at Bridges* (FHWA-IP-90-017; Revised April 1993), HEC-18.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: D.4
PROGRAM TITLE: Corrosion Protection
PROGRAM MANAGER: Y. Paul Virmani, Ph.D.

This program provides research and development for cost-effective procedures and systems to protect new concrete members and cable-stays from adverse environmental effects, and to rehabilitate deteriorated bridge members subjected to adverse environments.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Corrosion Control of Structural Elements

- "Rehabilitation of PS/C Bridge Members by Non-Electrical (Conventional) Methods" (FHWA) has performed corrosion surveys on 12 prestressed concrete (PS/C) bridges. The most severe deterioration of prestressed elements was found in tropical marine environments. Both pre- and post-tensioned members were found to be extremely susceptible to corrosion from direct exposure to marine spray. In northern environments, the primary corrosive exposure was due to deicing salts leaking through exposed bridge joints and between box beams. Post-tensioned structures were found to be more durable with respect to corrosion in northern exposures.
- "Materials and Methods for Regrouting Partially Filled Ducts" (FHWA) has identified various grout mix designs through systematic indepth laboratory research. These corrosion-resistant, durable grouts are suitable for grouting or regrouting the ducts of post-tensioned bridge members with presently available equipment.
- "The Specification and Corrosion Resistance of Epoxy-Coated Reinforcement" (UKDOT) has concluded that coating adhesion is reduced at bends, but that loss of adhesion is not a necessary prerequisite for corrosion initiation.
- "Cathodic Protection of Reinforced Concrete Bridge Elements: A State-of-the-Art Report" (SHRP) has documented extensively the history of cathodic protection on reinforced concrete. In addition, detailed sections on condition survey, remedial action, anode systems, design aspects, and operation and maintenance are included.
- "Inspection and Determination of Damage to Epoxy-Coated Reinforcement" (TX) has concluded that corrosion starts at damaged areas in a severe environment, patching materials are ineffective, and the vibrators used during concrete placement may cause considerable damage to the coating.

Work Underway: The following is a partial list of these studies with interim results:

- "Field Evaluation of Cathodic Protection on Prestressed Concrete Bridge Members" (FHWA) is presently installing various cathodic protection systems on three deteriorating PS/C bridges located in Florida and Ohio.
- "Factors Affecting the Effectiveness of Organic Coatings in Protecting Reinforcing Steel Against Corrosion by Simulating Marine Environments" (FHWA) has found that the

disbonding of most commonly used fusion-bonded epoxy coating is within acceptable limits. Controlled experiments were performed on coated 102- by 102- by 6.4-mm (4- by 4- by 1/4-in) thick flat steel plates.

- "Rehabilitation of Prestressed Concrete Bridge Components by Non-Electrical (Conventional) Methods" (FHWA) has undertaken a detailed laboratory study to identify durable and cost-effective corrosion-protection systems for the rehabilitation of existing PS/C bridges. This detailed laboratory work plan was formulated based on indepth analysis of 12 PS/C bridges located in adverse environments. An interim report on the survey is available.
- "Long-Term Effects of Cathodic Protection on Prestressed Concrete Bridge Members" (FHWA) has prepared fifty 3-m (10-ft) long prestressed beams for evaluating the long-term effect of CP on the bond between prestressing steel and concrete and for developing a procedure to determine the suitability of a bridge member for CP application.
- "Corrosion Protection Systems for Bridges in Corrosive Environments" (FHWA) has developed a methodology for impregnating the fabricated R/C and PS/C specimens to a desired chloride concentration at the steel level. These chloride-contaminated specimens are being used for evaluating the performance of various concrete mix designs in resisting corrosion-induced concrete deterioration.
- "Corrosion-Resistant Reinforcement for Concrete Components" (FHWA) has developed a detailed screening program for the preliminary evaluation of organic, metallic, inorganic, and ceramic coatings submitted by the industry. This screening process will provide a basis for selection of suitable coatings for detailed indepth study.
- "Sacrificial CP Systems" (FHWA) is developing suitable alloys and conductive adhesive materials for delivering optimal amounts of sacrificial CP currents to stop ongoing corrosion. The systems developed will be installed in the field on selected bridges.
- "Underwater Bridge Maintenance and Repair" (NCHRP) has prepared a synthesis report that describes the current practices and innovative underwater repair techniques for problems associated with settlement; scour; and deterioration of concrete, timber, and steel elements. A draft report is available.
- "Transverse Cracking in Newly Constructed Bridge Decks" (NCHRP) has prepared a comprehensive detailed interim report on the factors responsible for observed cracking. These factors are broken down into three categories: design, materials, and construction. A draft report is available.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Corrosion Control of Structural Elements

- "Corrosion-Resistant Durable Materials and Protective Systems for PS/C" (FHWA) will evaluate the performance of fabricated PS/C bridge members with cost-effective corrosion-resistant materials under adverse environmental conditions and will develop guidelines and specifications. This was initially a fiscal year 1993 study, but due to the very short time provided for proposal preparation, none was received.
- "Corrosion Inhibitors in Deicers and Concrete" (FHWA) has two objectives: (1) to evaluate the effectiveness of deicers containing corrosion inhibitors in arresting the corrosion process in bridge decks, and (2) to compare newly developed corrosion inhibitors with calcium nitrite that is presently used in concrete bridge members.
- "Rehabilitation and Protection of Cracked Members" (FHWA) will identify materials and procedures for use in rehabilitating cracked R/C and PS/C bridge members, permitting them to perform satisfactorily for their planned service life.

PUBLICATIONS AND PRODUCTS:

- *Condition of Prestressed/Concrete Bridge Components: Technology Review and Field Survey* (FHWA-RD-93-037), in the publication process.
- *Cathodic Protection of Reinforced Concrete Bridge Elements: A State-of-the-Art Report* (SHRP-S-337).
- *Cathodic Protection Developments for Prestressed Concrete Components* (FHWA-RD-92-056).
- *Evaluation of Post-Tensioned Concrete Bridge Structures by the Impact-Echo Technique* (FHWA-RD-92-096), in the publication process.
- *Grouts for Post-Tensioned Bridge Structures* (FHWA-RD-92-095), in the publication process.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: D.9

PROGRAM TITLE: Technology Transfer for Structural, Geotechnical, and Hydraulic Technology

PROGRAM COORDINATORS: John M. Hooks—Technology Applications
Larry Jones—National Highway Institute
Robert C. Kelly—Local Technical Assistance Program

The objectives of this program are: (1) to promote the cost-effective use of new and innovative technology related to bridge loading and design criteria, procedures for design and construction of bridges, analysis of hydrology and hydraulic design of culverts and bridges, bridge rehabilitation technology, bridge deck investigations, design and construction of bridge foundations, bridge maintenance, and protection against corrosion damage to concrete members; (2) to develop and promote technology transfer products or media, such as guidelines, technical manuals, computer programs, slide-tapes, films, videotapes, evaluation reports, and conferences related to this technology; and (3) to develop and conduct demonstration and test and evaluation projects and training courses.

EXECUTIVE SUMMARY AND PROGRAM STATUS

This program is intended to accelerate the application of new technology related to bridge structures, bridge foundations, geotechnical engineering, and hydraulics and hydrology in the functional areas of design, construction, inspection, maintenance, and rehabilitation. New technology is derived from research studies, including State Planning and Research (SP&R) and National Cooperative Highway Research Program (NCHRP) studies, and from problem statements from FHWA field and operations offices. Promising technology is packaged into products that are easily understood and applied by potential users, and are then directed to the appropriate personnel at Federal, State, and local levels.

The program involves a wide range of activities, including fieldtesting and evaluation of promising hardware, test methods, and construction procedures; preparing users manuals for hardware and test methods; developing new design and construction procedures and implementation packages; developing and conducting demonstration projects and experimental projects; developing and implementing new inspection hardware and techniques; conducting conferences and workshops as a forum for technology transfer; developing new computer programs, evaluating their usefulness, and providing technical support to users; documenting the design and construction of unique or unusual structures; and developing and conducting training courses on selected topics in bridge engineering. Interaction with local jurisdictions occurs through the Local Technical Assistance Program (LTAP) and the 55 technology transfer centers nationwide.

TECHNOLOGY APPLICATIONS

The following major activities were conducted during fiscal year 1993:

- Contracts to develop two new demonstration projects dealing with bridge inspection, evaluation, and repair are nearing completion: Demonstration Project 97, Scour Monitoring

and Instrumentation and Demonstration Project 98, Underwater Evaluation and Repair of Bridge Components.

- Under Application Project 26, Bridge Deck Drainage, Hydraulic Engineering Circular (HEC) 21, *Design of Bridge Deck Drainage* (FHWA-SA-92-010) was published. Now in a single manual, criteria for determining if and when bridge deck drainage appurtenances are required and sound guidelines and procedures for designing them are provided.
- Demonstration Project 73, Highway Drainage Design has been closed out. Because of its continued popularity, much of the material in this project is being incorporated into the training course, Culvert Design, which will be available through the National Highway Institute (NHI) in early 1994.
- Demonstration Project 81, Load-Factor Bridge Design was presented three times, including a special presentation to the Texas Department of Transportation that covered both the MERLIN-DASH and DESCUS computer programs. The presentation phase of this project is closed out, but a metric version of the MERLIN-DASH program will be completed before the project is finished.
- Under Demonstration Project 99, Load and Resistance Factor Design (LRFD), development of training materials for a course on the new AASHTO LRFD Bridge Specifications is underway with pilot sessions planned for early 1994.
- As a part of Test and Evaluation Project 23, Evaluation of Bridge Inspection Techniques, the impact-echo system for nondestructive evaluation of post-tensioned concrete bridge structures is being evaluated and demonstrated.
- In conjunction with FHWA Region 8, a request for proposals was issued to develop a new training course, Seismic Bridge Design Applications. An advanced course, it will replace Seismic Design of Highway Bridges, which has been very successful for the NHI for several years. The new course should be available in late 1994.
- Under Application Project 89, Hydrology, a new manual in the hydraulic design series (HDS), *Hydrology*, HDS-2, is under development and will be available in 1994.
- Under Application Project 13, Storm Drain Design, a new hydraulic engineering circular, HEC-22, will be developed. The manual will be available in mid-1995.
- Under Application Project 133, Update Hydraulic Software and Guidelines, efforts will begin for the conversion to the metric system of computer programs, design manuals, training materials, and associated materials related to hydraulics and hydrology.
- Demonstration Project 88, High-Strength Bolts has been completed. Future presentations will be made through the NHI.
- Work was initiated on Demonstration Project 100, Bridge Computer Programs Workshops, with plans for workshops on the Florida Department of Transportation's Bridge Rating Using the Finite Element Method (BRUFEM) and the Wyoming Department of Transportation's Bridge Rating and Analysis of Structural Systems (BRASS). Connecticut was the site of the first BRASS workshop. Under a separate activity, the AASHTO-BDS (bridge design system) will be enhanced.
- Under Test and Evaluation Project 15, Acoustic Emission Field Trials, the use of acoustic emission (AE) technology was evaluated on four inservice steel bridges.
- Under Demonstration Project 71, Bridge Management Systems, a state-of-the-art bridge management system (BMS) called PONTIS (Latin for bridge) has been developed. PONTIS is scheduled to become an AASHTOWARE product supported by at least 38 States in the first year. Training for bridge inspectors and for bridge managers will be developed under a new contract being initiated.
- Demonstration Project 84, Corrosion Survey Techniques is available to demonstrate the latest equipment and techniques for evaluating and measuring corrosion activity and corrosion damage in reinforced concrete structures.
- Under Test and Evaluation Project 4, Protective Coatings for Structural Steel, monitoring of

the performance of several projects continues.

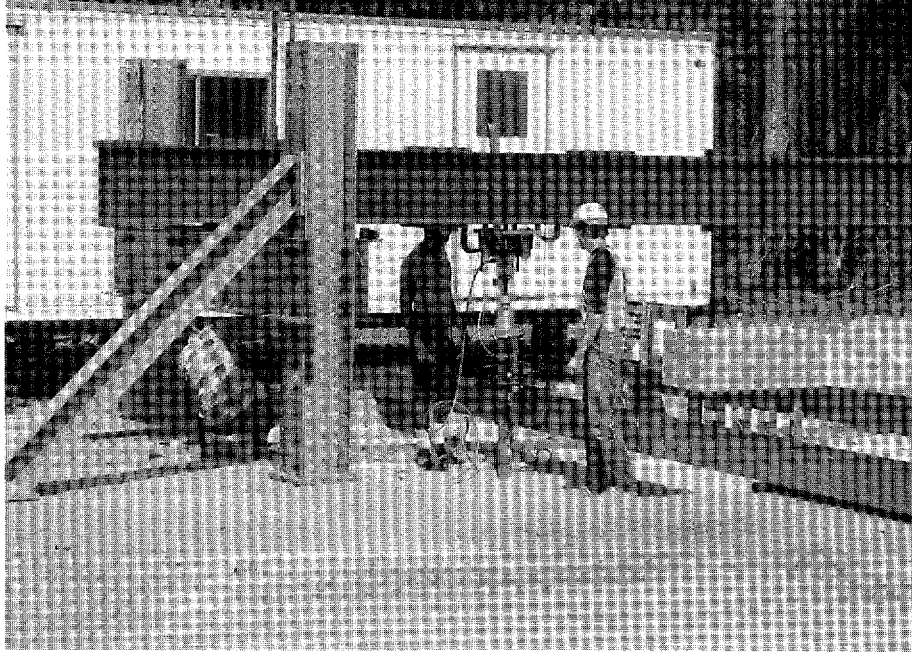
- Under Demonstration Project 82, Ground Modification Systems, two modules are currently being developed. Mechanically stabilized earth (MSE) and soil nailing are scheduled to be announced in fiscal years 1994 and 1995, respectively.
- Under Demonstration Project 102, Electroslag Welding (ESW), a contract has been awarded to develop a series of workshops demonstrating the proper application of the recently developed ESW specifications.
- Under Application Project 131, Geotechnical Engineering Circulars, a new series of manuals on geotechnical engineering is being initiated. The first manual will provide state-of-the-art guidelines on dynamic compaction for highway construction.
- Under Demonstration Project 95, Rockfall Rating and Mitigation, pilot workshops of both modules on rating rockfall hazards and providing systems to mitigate hazards were presented. Future sessions will be presented by the NHI.
- Contracts for two SHRP showcase efforts, "Assessment of Physical Condition of Reinforced Concrete Structures" and "Protection and Rehabilitation of Reinforced Concrete Structures," were initiated.

NATIONAL HIGHWAY INSTITUTE

- Offered training courses on 17 different topics related to highway structures and conducted a total of 137 presentations. The courses in highest demand were:
 - ◆ Safety Inspection of Inservice Bridges
 - ◆ Engineering Concepts for Bridge Inspectors
 - ◆ Stream Stability and Scour at Highway Bridges
 - ◆ HYDRAIN: Integrated Drainage Design Computer Systems
 - ◆ Urban Drainage Design
 - ◆ Inspection of Fracture-Critical Bridge Members

LOCAL TECHNICAL ASSISTANCE PROGRAM

- The two-volume training course, Soil and Base Stabilization and Associated Drainage Considerations, as well as a reproduction of an accompanying videotape and slides for the course, have been completed and were distributed to the LTAP Technology Transfer Centers in August 1993.
- Two contracts to develop structure-related training products for the LTAP will be issued during fiscal year 1994: a videotape on local road drainage and a culvert-management system for local transportation agencies. Each product will be tailored to the needs of local transportation agencies. The products will be designed to be taught by LTAP Technology Transfer Center personnel or by the local transportation agency.
- The introductory videotape for FHWA's PONTIS bridge management system was translated into Spanish by the University of Texas at El Paso in conjunction with the Texas and Arizona LTAP Technology Transfer Centers. Copies were distributed to the FHWA Bridge Division, the Pan American Institute of Highways, and LTAP Technology Transfer Centers in the U.S. having a large number of Hispanic communities.



E. Materials and Operations

High Priority Areas

- Asphalt Materials and Mixtures
- Geotechnology
- Corrosion Control of Structural Elements, Part 2

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: E.1
PROGRAM TITLE: Asphalt and Asphaltic Mixtures
PROGRAM MANAGER: Ernest J. Bastian, Jr., Ph.D.
PROGRAM PERSONNEL: Brian H. Chollar, Ph.D. and Kevin D. Stuart, M.S.C.E.

This program investigates materials, techniques, and specifications to improve the quality and handling of petroleum asphalt paving mixes used in highway construction and maintenance, and evaluates synthetic binders for use in high-quality flexible paving mixes.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Asphalt Materials and Mixtures

- "Nature of the Chemical Reaction of Furfural and Asphalt" (FHWA Staff) concluded from many types of chemical analyses that the reaction between asphalt and furfural is a typical phenol-aldehyde-type addition reaction involving the phenolic groups in asphalt. This reaction gave a more polar asphalt with better temperature susceptibility and adhesion properties. The goal of this research is to provide inexpensive rational paths toward improving the performance properties of asphalts, e.g., by chemical modification.
- "Stone Matrix Asphalt (SMA)—Development of Mixture Tests" (FHWA Staff) evaluated the applicability of testing SMA's using tests developed for dense-graded mixtures and compared SMA and dense-graded mixtures in terms of their resistances to rutting, moisture damage, low-temperature cracking, and aging. None of the SMA mixtures were susceptible to rutting. The SMA's had less potential for moisture damage and age hardening and equal or better low-temperature properties than the dense-graded conventional mixtures.
- "Stone Matrix Asphalt (SMA) Stabilizing Additives" (FHWA Staff) conducted a laboratory evaluation of the effects of using different fiber and polymer stabilizers in an SMA placed on U.S. Route 15 in Maryland. The stabilizers had no significant effect on rutting susceptibility or low-temperature properties. The two polymers tested were not as effective as the four fibers for preventing asphalt drainage through the mix, although they were better at controlling age hardening.
- A "Shale Oil Modified Asphalt (SOMAT) Test Strip" (FHWA) was constructed in late summer 1993 in Grand Teton National Park, Wyoming. This is part of a Congressionally mandated study in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 to demonstrate and evaluate the energy, environmental, and performance advantages of using SOMAT, which has shown some preliminary promise under extreme climatic conditions.

Work Underway: The following is a partial list of these studies with interim results:

- "Laboratory Development of Third-Generation Sulphlex Binders" (FHWA) has shown the feasibility of making Sulphlex synthetic asphalt binder (from 70 percent sulfur and 30 percent organic chemicals) in a one-vessel synthesis rather than in two separate reactions

and mixing the two resulting components. A one-reaction-vessel synthesis, described in an interim report, has very significant practical (including economic) advantages over the two-step reaction in field use.

- "Validation of SHRP Binder and Mixture Tests" (FHWA Staff) will use the ALF (Accelerated Loading Facility) to test 12 different strips; asphalt type will be the primary variable, but pavement thickness and aggregate gradation effects will also be examined. A comparison will be made between the observed pavement distresses and SHRP performance-based laboratory predictions.
- "Ruggedness Testing of SHRP-Proposed Binder Tests" (FHWA Staff) is using the ASTM C1067 ruggedness protocol to evaluate SHRP performance-related asphalt (binder) tests. Asphalt samples have been prepared and distributed to the four laboratories involved in the testing, and instrument calibration and sample reproducibility have been accomplished. The actual ruggedness procedures are now being conducted.
- "Low-Temperature Rheological/Mechanical Properties of Asphalts" (FHWA Staff) is a fundamental study of asphalt using the SHRP binder specification instrumentation to understand the low-temperature rheological behavior of asphalts and how this relates to the asphalts' other material properties. The study of temperature of PAV (pressure air vessel) aging vs. the rheological properties of asphalts is currently being conducted.
- "An Investigation of the Impact of Varying the Amount of Aggregate Passing the 4.75-mm Sieve on Stone Matrix Asphalt (SMA) Properties" (FHWA Staff) is investigating the effects of the middle-size aggregate fraction on rutting, aging, cracking, and moisture damage and developing test procedures to measure these properties in SMA.
- "Evaluation of FHWA Gyratory Testing Machine (GTM)" (FHWA Staff) is studying the effects of specimen height and diameter on test results. This machine is used to test the rutting potential of pavements in addition to compacting samples for further testing.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Asphalt Materials and Mixtures

- "Other Chemical Reactions of Asphalts" (FHWA Staff) continues to study chemical reactions to obtain modified asphalts with improved properties. Reactions more environmentally favorable and industrially feasible will be studied.
- "Effects of the Minus 75-mm Aggregate on SMA Mixture Properties" (FHWA Staff) will focus on the effects of such fine material on the optimal binder content and susceptibility of the mixture to permanent deformation.

PUBLICATIONS AND PRODUCTS:

- *Asphalt Mixtures Containing Chemically Modified Binders* (FHWA-RD-92-101).
- *Disposal of Waste from Highway Materials Testing Laboratories* (FHWA-RD-91-125).
- *Establishment of Acceptance Limits for 5-Cycle MSS and Modified Wet Ball Mill Tests for Aggregates Used in Seal Coats & HMAC Surfaces* (FHWA/TX-92 + 1222-IF).
- *Evaluation of Natural Sands Used in Asphalt Mixtures* (FHWA-RD-93-070).
- *Characteristics of the Furfural-Modified Asphalt* as presented at the Transportation Research Board, Washington, DC, January 1993, in the publication process.
- "Nature of the Chemical Reaction for Furfural-Modified Asphalt," presented at the 30th Annual Petersen Asphalt Research Conference, July 13, 1993, at the Western Research Institute, Laramie, Wyoming.
- "Ruggedness Testing of SHRP Binder Specification Tests," presented at the 30th Annual Petersen Asphalt Research Conference, July 14, 1993, at the Western Research Institute,

Laramie, Wyoming.

- *Evaluation of Test Methods Used to Quantify Sand Shape* (Transportation Research Record 1362), 1992.
- *Comparison of Results Obtained from the French Tester with Pavements of Known Performance* (CDOT-DTD-R-92-11).
- *Description of the Demonstration of European Testing Equipment for Hot Mix Asphalt Pavement* (CDOT-DTD-R-92-10).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: E.2
PROGRAM TITLE: Cement and Concrete
PROGRAM MANAGER: Stephen W. Forster, Ph.D.

This program is investigating the physical and chemical development of concrete, mechanisms of concrete distress, and the characteristics of concrete components and hardened concrete necessary to combat these distresses. Concrete formulations and mix designs are being developed that will result in concrete that is more resistant to distress. Also, the use of new technology and enhanced quality control methods are being investigated as a means of improving the functional capability, mechanical properties, and durability of concrete.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

- "Resistance of Concrete to Freezing and Thawing" (SHRP) investigated the freeze/thaw durability of concrete and concrete aggregates. A modification of the current laboratory procedure for concrete freeze/thaw testing was developed, including a more accurate method of measuring the fundamental frequency of the test specimens. A new test method was developed for the testing of D-cracking susceptibility of concrete aggregates. This test involves cycling the saturated aggregate sample through a series of high-pressure cycles and determining the fracturing of the aggregate that occurs as a result of rapid pressure release.
- "Eliminating or Minimizing Alkali-Silica Reactivity" (SHRP) first surveyed the country to determine the extent of the problem. It was found that alkali-silica reactivity (ASR) and distress were often present, but unrecognized by highway agencies. To correct this, a field identification manual was published. For preventing ASR in new concrete, improved methods of rapid testing of aggregates for ASR susceptibility were investigated. The method chosen provides test results in 14 to 28 days. It was found that various lithium compounds show promise of preventing ASR expansion when added to the concrete mix. Several field trials were done to evaluate methods of arresting ASR in existing pavements. These field sites will continue to be monitored.
- "Mechanical Behavior of High Performance Concrete" (SHRP) investigated the mechanical behavior of concretes made with other than "ordinary" mix designs. For the purposes of the study, these concretes were categorized according to compressive strength into Very Early Strength (VES), High Early Strength (HES), Very High Strength (VHS), and High Early Strength Fiber-Reinforced (HESFR) concretes. In order to keep the concretes practical, the mixes used were limited to the use of locally available conventional constituent materials and normal production and curing procedures. It was found that these concretes behaved much like conventional concretes of similar strength, except that they attained their strength characteristics much more rapidly. Modulus of elasticity, splitting tensile strength, and modulus of rupture could all be predicted by current relationships for conventional concretes. On the other hand, creep and shrinkage of these concretes were significantly less than for conventional concretes.

Work Underway: The following is a partial list of these studies with interim results:

- "Thermal Coefficient of Expansion of Portland Cement Concrete" (FHWA Staff) has developed a standard method for the measurement of this property in order to evaluate its significance in the design and performance of concrete pavements. The method uses a temperature-controlled water bath to reach the desired temperatures and Linear Variable Differential Transducers with automatic data recording to collect length-change information. As part of the SHRP/FHWA Long-Term Pavement Performance studies, cores were collected from concrete pavements across the country for characterization of their properties. Thermal coefficient of expansion will be measured on these cores to develop a data base for analysis.
- "Optimization of Highway Concrete" (SHRP) is consolidating the results of all the other studies on concrete under the SHRP program. Various computer programs and implementation packages are being prepared to facilitate transmitting the findings into the hands of the user in a friendly format.
- "Influence of the Original Aggregate and Other Factors on the Properties of Concrete Using Recycled Concrete Coarse Aggregate" (FHWA Staff) is investigating the effects that the recycled concrete's original aggregate type, maximum size, and other properties will have on the characteristics of the new concrete. The recycled aggregate is being mixed both clean and dirty, and also blended with certain proportions of virgin aggregate.
- "Physical and Mechanical Properties of Recycled PCC Aggregate Concrete" (FHWA) is examining the effects that use of recycled concrete as concrete aggregate can have on the behavior of that concrete in pavements, and the performance and service life of those pavements.
- "Fast-Track Paving: Concrete Temperature Control and Traffic Opening Criteria for Bonded Concrete Overlays" (FHWA) is investigating typical ranges, acceptable levels, and means to control temperature in fast-track concrete pavements. Also being investigated is the bond development for bonded concrete overlays, including rate of development and means to monitor its development during construction.
- "Evaluation of the Soundness Test on Florida Aggregates" (FL SP&R) will investigate the applicability of the sulfate soundness test to certain Florida limestones that are good performers in portland cement concrete, but have variable results in the test.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Evaluation of the Accelerated Concrete Prism Test for Alkali-Silica Reactivity" (FHWA Staff) will evaluate the reliability of the modified test procedure developed under SHRP.
- "Evaluation of the Modified Freeze-Thaw Test for Portland Cement Concrete" (FHWA Staff) will evaluate the modified procedure developed under SHRP that is a combination of the current ASTM C666 methods A and B. The modified method freezes the specimens in water, but in an unconfined condition by wrapping them in saturated towels.
- "Effects of Microcracking on Long-Term Performance of Rigid Pavements" (FHWA) will investigate the prevalence and effect of microcracking on rigid pavements, and will include laboratory evaluation of the effect of microcracking on the properties of concrete.

PUBLICATIONS AND PRODUCTS:

- *Petrographic Methods of Examining Hardened Concrete: A Petrographic Manual* (FHWA/VA-92-R14).
- *Petrographic Characteristics of Florida Limestone Aggregates Used in Concrete—Phase II* (FHWA/FL-517-3533).

- *Evaluation of Concrete and Aggregate Durability Test (FHWA/MCHRP 86-1).*
- *Effects of Air Entrainment on Portland Cement Concrete (FHWA/TX-92/1245-1).*
- *Early Age Strength of Concrete: A Comparison of Several Nondestructive Test Methods (FHWA/TX-91 + 1198-1F).*
- *Early Age Behavior of Continuously Reinforced Concrete Pavement and Calibration of the Failure Prediction Model in the CRCP-7 Program (FHWA/TX-93-1244-3).*

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: E.3
PROGRAM TITLE: Geotechnology
PROGRAM MANAGER: Albert F. DiMillio, P.E.

This program develops improved design and predictive techniques for bridge foundations and ground improvement methods such as reinforced soil, stone columns, dynamic compaction, soil nailing, and prefabricated vertical drains.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Geotechnology

- "Determination of Pile Driveability and Capacity from In Situ Test Parameters" (FHWA) developed a data base of pile foundation sites containing research-quality soils data, driving records, load-test information, and pile-driving analyzer data. These data were used to make correlations between quake and damping factors, wave equation predictions, and in situ soil-test data. A new computer design model was developed for future validation testing. Dynamic and static testing of instrumented SPT rods was also completed at several sites where corresponding load tests to failure were done to obtain data for validating the new model.
- "Load Transfer Between Drilled Shafts and Intermediate Geomaterials" (FHWA) has developed preliminary criteria for exploration and sampling of soil materials to use for developing new load transfer functions for the design of drilled shafts in shales, tills, mudstones, and other materials between soils and hard rock. A fieldtesting program was designed to validate the new design methods during the next phase of the research.
- FHWA and the Direction des Routes of the French Ministry of Transport established a cooperative research program agreement to evaluate the use of soil nailing and micropile techniques to reinforce ground slopes and provide support for bridge foundation elements.
- FHWA teamed with the National Science Foundation to fund the establishment of the "National Geotechnical Experimentation Sites" program to accelerate innovative geotechnical research for solving serious foundation engineering and soil support problems facing the highway community today. A national management board, system director, and individual site managers were selected to supervise the operation of the multiple-user sites program. A central data repository was also developed to provide a user-friendly system shell with online computer search and data retrieval capabilities that will enable geotechnical researchers to select an appropriate site for their work. It can accommodate all essential information about each site, such as generalized soil conditions, listing all available test data, site logistics and limitations, and published references.

Work Underway: The following is a partial list of these studies with interim results:

- "Permanent Ground Anchor Walls" (FHWA) is developing improved design procedures from the results of small-scale laboratory model studies and load tests on full-scale field structures. Several model walls and a full-scale wall were constructed and monitored to provide data for evaluating current design procedures. A new and/or improved design procedure will be developed at the conclusion of the analysis period.
- "Durability of Geosynthetics" (FHWA, SP&R Pooled Fund) is developing a rational prediction methodology for the design life of structures and embankments reinforced with geosynthetic materials. The research includes an analysis of the principal aging factors in a soil environment, e.g., temperature, moisture, chemicals, and biological agents. Tests for oxidation degradation analysis and hydrolytic attack of the polymer materials were initiated to determine the extent of decomposition that typically occurs in the highway environment.
- "Spread Footing Performance" (FHWA) is developing a computerized storage, search, and retrieval system for use in design and analysis of spread footing foundations for highway bridges. Several load tests were performed on medium-sized footings to add to the value of the data base. Correlation studies will be made to determine the best methods for predicting the settlement of spread footings on sand.
- "Pile Friction Freeze" (FHWA) is developing empirical guidelines for taking advantage of pile friction freeze in design, and where the advantage might permit smaller or fewer piles.
- "Sealing of Geotechnical Boreholes" (FHWA) is developing methods and devices for evaluating the effectiveness of various sealants used to keep pollutants and other unwanted materials from entering the boreholes and damaging existing ground water levels.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Geotechnology

- "Instrumentation and Monitoring of the Boston Central Artery Wall Project" (FHWA) will provide data to clarify earth and water pressure design loads for a tied-back soil-mixed wall at the mainline tunnel project, and also provide a detailed assessment of ground deformation patterns adjacent to the wall excavation. The data will be used to improve current design methods that are known to be very conservative and not cost-effective.
- FHWA will team with the National Science Foundation and the Civil Engineering Research Foundation to develop a national program on "High Performance Geomedia Materials and Systems." A workshop of experts in this field assess the national planning and coordinating status of this program. The workshop participants will also initiate the process to identify major research needs in each geomedia group.
- "Soil Nailing" (FHWA) will develop engineering guidelines for the use of soil nails in the reinforcement of ground slopes.
- "Micropiles" (FHWA) will develop engineering guidelines for the use of micropiles to support bridge foundations.

PUBLICATIONS AND PRODUCTS:

- *Drilled Shafts for Bridge Foundations* (FHWA-RD-93-004).
- *Data Dictionary for the Central Data Repository of the National Geotechnical Experimentation Sites* program. (Available to users of this program.)

- Development of an in situ geotechnical testing method to estimate various soil characteristics needed for earthquake-resistant design. The prototype device can be used to estimate shear stress vs. strain characteristics at low to reasonably high strains.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: E.4
PROGRAM TITLE: Bridge Paints
PROGRAM MANAGER: John W. Peart

This program provides research to develop environmentally acceptable coatings and corrosion control alternatives to effectively protect highway structures and components, and to develop technology to provide methods to remove old bridge coatings that protect both the environment and the worker. This effort reduces the life-cycle cost of the structures and ensures reliable and safe operation throughout their design life.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Corrosion Control of Structural Elements, Part 2

- In cooperation with the National Institute of Science and Technology (NIST), a consortium of private sector companies have been identified to participate in FHWA's study "Improved Accelerated Test Methods to Predict Coating Life." A Cooperative Research and Development Agreement (CRADA) will be executed to initiate this research. The objective of the research is to develop accelerated test methods to accurately define coating life and performance.
- "Performance/Durability of Waterborne Maintenance Coatings" (FHWA Staff) has been completed. The study compares the performance of reduced solvent-containing and waterborne bridge maintenance coatings to that of current systems. Equivalent systems have been identified that will meet the reduced Volatile Organic Compound (VOC) coating regulations.

Work Underway: The following is a partial list of these studies with interim results:

- "Characterization of Corrosion Environments" (FHWA) will define the components that contribute to bridge corrosion rates and develop methods of measurement. The corrosiveness of representative bridge environments will be determined, providing the required data to select the most cost-effective materials/methods of corrosion control.
- "Repair Guidelines for Bridge Coatings" (FHWA) will identify environmentally compliant materials/procedures to enhance coating performance and the life of operational steel highway structures. Emphasis will be placed on extending the lives of structures protected by paint systems containing lead.
- "Application of Lasers for the Removal of Lead-Containing Paint" (FHWA) is developing a hand-held pulsating laser with a vacuum system to remove paint containing lead and other toxic materials. The work is being accomplished in collaboration with the Army's Construction Engineering Research Laboratory (CERL). Fieldtesting of the new hardware is scheduled for spring 1994.
- Field evaluation of materials performance in the study "Corrosion Control of Highway Structural Components by the Application of Powder Coatings" (FHWA) is near completion.

The final report, scheduled for April 1994, will identify the powder coatings that will perform best in exterior exposure environments.

- The Coating Research Center (FHWA) has completed its effort on "Bridge Waste Management and Disposal." Additional elements of the research on productivity improvement and on alternate bridge repair coatings are near completion. The study will provide implementable guidelines for the repair of aged bridge-coating systems and recommendations for improved productivity in the repair process.

Other Studies:

- "Impedance Spectroscopy and Electrochemical Noise Analysis for the Evaluation of Corrosion Inhibitors in Highway Deicers" (FHWA staff). The objective of this study is to compare the performance of these two electrochemical measurement methods in evaluating the effects of corrosion-inhibiting commercial deicers on the corrosion rate on concrete steel reinforcing bars. The study objective is to develop an accelerated test method to better predict the long-term corrosion rates of available deicers.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Corrosion Control of Structural Elements, Part 2

- A CRADA will be executed to initiate the "Improved Accelerated Test Methods to Predict Coating Life." In the new study, researchers will evaluate and develop accelerated testing methods and regimens to predict coating performance and durability in field environments.

PUBLICATIONS AND PRODUCTS:

- *Environmentally Acceptable Materials for the Corrosion Protection of Steel Bridges: Task C, Laboratory Evaluation* (FHWA-RD-91-066).
- *Maintenance Coating of Weathering Steel: Field Evaluation and Guidelines* (FHWA-RD-92-055).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: E.5
PROGRAM TITLE: Highway Maintenance
PROGRAM MANAGER: Peter A. Kopac, P.E.

This program identifies, evaluates, and improves methods for routine maintenance of highway facilities, and improves the efficiency and effectiveness of scheduling, budgeting, and administering highway maintenance programs.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

- "Effectiveness of Preventive Maintenance" (SHRP) developed a method to quantify the quality of the application of a pavement maintenance treatment. The method was developed for chip seals, slurry seals, and crack sealing, but could also be applied for other types of treatments.
- "Innovative Materials and Equipment for Pavement Surface Repairs" (SHRP) developed manuals of practice describing when and how to perform pothole repairs and crack maintenance on asphalt concrete pavement, and spall repairs and joint resealing on portland cement concrete (PCC) pavement. These manuals are based on experience gained in the study during installation of the materials and subsequent field evaluations.
- "Impacts of Environmental, Health, and Safety Regulations on Highway Maintenance" (NCHRP) identified and highlighted the technical, operational, and economic impacts of environmental, health, and safety regulations on highway maintenance programs, and provided information for transportation agencies and legislative personnel on the cost consequences of regulatory compliance.
- "Chip Seals for High-Traffic-Volume Asphalt Concrete Pavements" (NCHRP) demonstrated that chip seals can be successfully constructed on high-traffic-volume asphalt pavements. The study developed improved design and construction procedures and a guide specification.
- "A Study of Patching Methods for Continuously Reinforced Concrete Pavement" (SC SP&R) determined that the patches placed with a fast, labor-saving, full-depth technique developed in South Carolina were not performing satisfactorily. It was recommended that a revised design be placed on future projects and monitored to determine its effectiveness.

Work Underway: The following is a partial list of these studies with interim results:

- "Innovative Maintenance Materials Development and Testing" (SHRP) documented interim results after 18 months of monitoring the condition of the following experimental projects: pothole repair in asphalt pavement, crack sealing/filling in asphalt pavement, joint resealing in PCC pavement, and partial-depth spall repair in PCC pavement. Performance evaluations will continue by the FHWA.
- "Using Ground-Penetrating Radar for Pavement Evaluation" (TX SP&R) conducted field demonstration tests using radar on Texas projects. The collected data are being used to assist the State in selecting appropriate rehabilitation strategies for these projects.

- "Improved Prime Coat Methods" (TX SP&R) summarized responses to a questionnaire to determine what Texas is doing to decrease its use of cutback asphalts, and what materials and/or processes have been successful in applying a prime coat to a granular base in preparation for an asphalt surface course. The goal of the study is to establish practical applications of successful prime coats to replace cutback asphalts.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Evaluation of Joint Sealants" (TX SP&R) will investigate different types of joint sealants, both in the laboratory and the field, with respect to material properties, geometric and shape characteristics of the joint wells, climatic factors, and construction practice.
- "Mower-Thrown-Object Accidents" (TX SP&R) will provide an identification of the safety issues associated with preventing mower-thrown-object accidents, determine possible measures for reducing such accidents, and study the cost-effectiveness of the measures.
- "Cost-Effective Preventive Maintenance" (NCHRP) will synthesize State practices and cost data appropriate in developing cost-effective preventive maintenance strategies.

PUBLICATIONS AND PRODUCTS:

- *Development of a Procedure to Rate the Application of Pavement Maintenance Treatments* (SHRP-M/FR-92-102).
- *Maintenance Considerations in Highway Design* (NCHRP Report 349).
- *A Study of Patching Methods for Continuously Reinforced Concrete Pavement* (FHWA-SC-92-03).
- *Investigation of Laboratory Test Methods to Determine Curing Rate of Asphalt Emulsion* (FHWA/TX-92-1157).
- *Multi-Objective Design of Service Route* (FHWA/IN/JHRP-91/12).
- *Life-Cycle Reconstructibility* (FL/DOT/RMC/99700-7557-119).
- *Management of Hazardous Waste from Highway Maintenance Operations* (WA-RD 286.1).
- *Cost-Effective Maintenance Contracting* (KTC-92-3).
- *Engineering Properties of Brittle Repair Materials* (FHWA/LA-92/254).
- *Roadside Vegetation Management* [FHWA/OK 91(10)].

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: E.6
PROGRAM TITLE: Snow and Ice Control
PROGRAM MANAGER: Howard A. Jongedyk, Ph.D.
PROGRAM PERSONNEL: Brian H. Chollar, Ph.D.

This program focuses on the development of methods for snow and ice control that provide safe, serviceable highways, and minimize adverse effects to the highway environment. The program also focuses on the development of procedures for selecting optimal strategies for snow and ice control.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

The Strategic Highway Research Program (SHRP) investigations on snow and ice control subjects were ended during the past year, and the Federal Highway Administration started extensive implementation of selected SHRP products.

Work Underway: The following is a partial list of these studies with interim results:

- "Implementation of Anti-Icing Technology" (SP&R Pooled Fund/FHWA) has begun with 15 States participating in new anti-icing activities. Many of the 15 States are using prewetting salt applications, and some are using liquid deicers for their anti-icing efforts. The objectives of this anti-icing study are to continue the SHRP project to collect friction data and make visual observations from the field tests for an additional two winters (1993-1994 and 1994-1995), and to perform an analysis of anti-icing effectiveness considering such factors as accidents; time delays; and material, equipment, and labor costs during that 2-year period. The Army's Cold Regions Research and Engineering Laboratories are conducting this study and working with the 15 States.
- "Calcium Magnesium Acetate at Lower Production Cost" (SP&R Pooled Fund/FHWA) will be developing methods for manufacturing CMA at lower production cost and will be studying the laboratory conversion of waste materials such as sewage sludge and cheese whey permeate to CMA using high-yield anaerobic bacteria. The researchers will determine the yields and purity of the product based on their processes, the costs involved with the commercialization of the product, and the market strategy and industry interest to bring their processes into commercial use.
- "Alternate Deicing Chemicals" (CO SP&R) is examining a number of possible replacements or supplements for sodium chloride deicing salt.
- "Effectiveness of Highway Drainage Features for Ground Water Pollution Control" (MA SP&R) has found that partial or total diversion of highway drainage water carrying winter deicing salts will significantly reduce ground water contamination.

- "Oxygen Consumption Characteristics of Calcium Magnesium Acetate (CMA)" (MA SP&R) is evaluating the environmental impacts of this alternative deicing salt on a highway site immediately adjacent to sites employing conventional deicing salts and/or special drainage features.
- "Effects of Highway Deicing Chemicals on Shallow Unconsolidated Aquifers in Ohio" (OH SP&R) has been investigating the vulnerability of sole-source aquifer water supply located near State highways. No significant chemical contamination was found at sites in southern Ohio where snowfalls and chemical applications have been small. At northern Ohio sites with much heavier snows and salt applications, salt impacts were clearly noted in ground water wells "downstream" from highways during the winter and spring, but these impacts appeared to be dissipated adequately by mid-summer.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Glenwood Canyon Ice-Detector System Evaluation" (CO SP&R) will begin to make evaluations during the winter of 1993-1994. Ice detection equipment was installed during the summer of 1993.
- Under an Intermodal Surface Transportation Efficiency Act of 1991-mandated program, heating systems to minimize deck icing problems are being installed on bridges in several States. Bridges are selected from those being rehabilitated or reconstructed. A number of different heat sources and heat distribution systems have been, or are now being, installed in Maryland, Texas, Minnesota, Oregon, and Nebraska. Some 50 more installations are considered in this investigation of the performance of heated bridge decks.

PUBLICATIONS AND PRODUCTS:

- *Improved Cutting Edges for Ice Removal* (SHRP-H-346), 1993.
- *Designing for Blowing Snow Control* (SHRP), in the publication process.
- *Improved Displacement Snow Plow* (SHRP), in the publication process.
- *Road Weather Information Systems, Volumes 1 and 2* (SHRP-H-350 and SHRP-H-351), 1993.
- *Operations Guide for Anti-Icing Technology* (SHRP), in the publication process.
- *Chemicals for Anti-Icing* (SHRP), in the publication process.
- *Ice-Pavement Bond Disbonding—Surface Modification and Disbonding* (SHRP-H-644), 1993.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: E.9

PROGRAM TITLE: Technology Transfer for Materials and Operations

PROGRAM COORDINATORS: Gary Henderson—Technology Applications
George Jones—National Highway Institute
Robert C. Kelly—Local Technical Assistance Program

The objectives of this program are to assess the usefulness of new materials, products, and procedures, and promote the adoption of cost-effective technology in highway materials and operations; to provide technical assistance to the users of the new technology; and to develop technology transfer products such as guidelines, computer programs, technical manuals, audiovisual products, demonstration projects, and training courses in the materials and operations area for use by Federal, State, and local highway agencies.

EXECUTIVE SUMMARY AND PROGRAM STATUS

The implementation of new technology in the above areas has been conducted by the development and presentation of training courses and demonstration projects, the presentation of workshops, the development of equipment, the field evaluation of new materials and techniques, and the preparation of technology-sharing reports and implementation packages. Interaction with local jurisdictions occurs through the Local Technical Assistance Program (LTAP) and the 55 technology transfer centers nationwide.

TECHNOLOGY APPLICATION

The following major activities were conducted during fiscal year 1993:

- Field tests and evaluations were performed under Demonstration Project 75, Field Management of Concrete Mixes in Hawaii, North Carolina, Montana, and Utah, using the mobile concrete laboratory. A 2-day workshop was held in Utah and Montana. A 1-day pilot workshop on nondestructive testing (NDT) was held in Massachusetts. The availability of this NDT workshop was announced in September 1993 and will be presented in several States over the next few years. This workshop includes some of the SHRP-developed products. Concrete admixtures seminars were presented in Connecticut, Rhode Island, New Jersey, Indiana, Minnesota, North Carolina, Washington, DC, and Puerto Rico.
- Under Demonstration Project 74, Field Management of Asphalt Mixes, the mobile asphalt laboratory was used to perform simulation studies and to test and evaluate mixes in Nevada, New Mexico, the State of Washington, and Colorado. Two 2-day workshops were held to present indepth data in highway agencies' classrooms. Several studies comparing gyratory compaction to Marshall compaction were also conducted.
- Under Test and Evaluation Project 17, Innovative Testing—Asphalt Series, two of five States have completed evaluation of the Georgia rut tester as a low-cost tool to evaluate the rut potential of asphalt pavements. These evaluations have concluded that the Georgia rut tester is accurate in predicting rut-susceptible mixes. The first prototype of the second-generation rut tester has been developed. Evaluation of this new equipment will be underway soon.

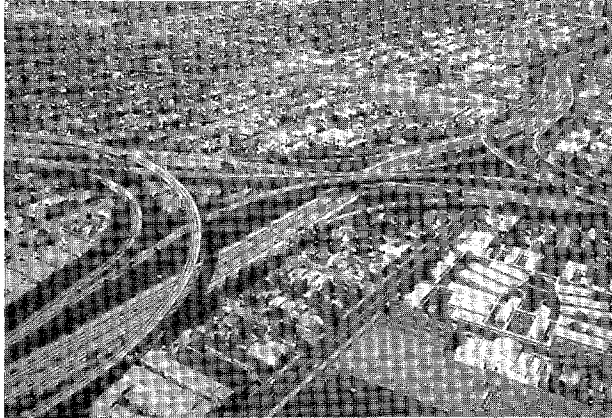
- Under Test and Evaluation Project 19, SHRP Asphalt Concrete Binder Tests, equipment is loaned to State highway agencies to give them the opportunity to try the latest test equipment available. Five complete sets of the SHRP asphalt binder equipment have been purchased and loaned to the five asphalt user/producer groups established around the country. The equipment will be set up in a highway agency's laboratory for a short time where staff can use and evaluate the equipment firsthand. The user/producer groups will coordinate the movement of the equipment between the State highway agency laboratories. In addition to the equipment, training workshops are being conducted in each user/producer group area. These workshops are to give initial training to the engineers and technicians that will be using the equipment.
- Several activities have occurred related to equipment developed under the SHRP. Some of the equipment was acquired under SHRP's Concrete and Structures Program. Impact-echo devices were loaned to Virginia, Wisconsin, New York, Iowa, Missouri, South Dakota, and California for testing and evaluation. Contracts have also been awarded to procure hydraulic fracture equipment and a surface air flow device for estimation of the concrete permeability. The contract action for the Concrete Durability showcase effort has been initiated and should be awarded by December 1993. The Alkali-Silica Reactivity (ASR) showcase contract has been awarded and regional workshops should be available in the summer of 1994.
- Under Demonstration Project 101, Mixed Design/Analysis Training Center, a classroom and laboratory facility was established to familiarize government and industry with the equipment and procedures of the SHRP asphalt binder/mixture design and analysis system. The center, located at the Asphalt Institute in Lexington, Kentucky, will also provide State highway agencies with technical assistance and support related to the SHRP asphalt equipment. Technical services are available and training courses take place on a monthly basis during 1993 and 1994.
- Under Demonstration Project 89, Quality Management, a unique partnership between FHWA, AASHTO, and various industry associations has been established to form a National Quality Initiative (NQI) Steering Committee. This committee will provide guidance on the national direction of construction quality issues. The 19 representatives on the steering committee met four times in fiscal year 1993. On November 10, 1992, approximately 250 top administrators came together in Dallas, Texas, to witness the signing of the National Policy on the Quality of Highways. In April and May 1993, four Regional NQI Seminars were held (1 in each AASHTO region) where nearly 1,300 managers learned managerial and technical concepts for quality improvement in the highway industry. Two regional quality management workshops were sponsored under this project and were held in FHWA Regions 1 and 4. A 5-day training course, Materials Control and Acceptance—Quality Assurance, and a 2-day workshop, Construction Quality Management for Managers, were made available in spring 1993. This training is cosponsored by the National Highway Institute. Pilots for the 5-day and 2-day courses were held in addition to six 2-day workshops and six 5-day courses held in fiscal year 1993.

NATIONAL HIGHWAY INSTITUTE

- Offered training courses on 9 different topics related to highway materials and operations and conducted a total of 91 presentations. The courses in highest demand were:
 - ◆ Principles of Writing Construction Specifications
 - ◆ Value Engineering
 - ◆ Avoidance and Handling of Construction Contract Claims
 - ◆ Geotextile Engineering Workshop

LOCAL TECHNICAL ASSISTANCE PROGRAM

- Fifty copies of AASHTO's CD-I ROM Computer-Assisted Transportation Training (CATT) program on Snow and Ice Control will be distributed to the 12 LTAP Technology Transfer Centers participating in a pilot project to evaluate the effectiveness of CD-I ROM as a training medium to supplement their circuit-rider programs. The 12 pilot centers were provided with 50 Phillips Model CDI220BK01 CD-I players.
- Two of the Utah LTAP Technology Transfer Centers' videotapes on temporary patching and permanent patching were translated into Spanish by the University of Texas at El Paso in conjunction with the Texas and Arizona LTAP Technology Transfer Centers. Copies have been sent to the Pan American Institute of Highways, the LTAP Technology Transfer Centers, and the FHWA Regions and Divisions in the U.S. that serve a large number of Hispanic communities.



F. Policy

High Priority Areas

Effective through 3/93

- Improving Tools for Highway Cost Allocation and Truck Size and Weight Policy Analysis
- Improving Policy Analysis of Emerging Energy, Environmental, and Highway Revenue Issues
- Interrelationships Between Highway Investment and Economic Productivity
- Strategic System Performance Analysis
- Improving Transportation Data Acquisition and Management

High Priority Areas

Revised and Effective 4/93

- Improving Transportation Data Acquisition and Management
- Analysis of Economic, Energy, and Financing Issues in Highway Transportation
- Enhancing the Performance, Productivity, and Efficiency of Highway Investments

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: F.1
PROGRAM TITLE: Highway Financing
PROGRAM MANAGER: James R. Link

The statement in the Department's National Transportation Policy that "the policy process is fundamentally a balancing of complex and often competing goals and interests" is nowhere truer than in the areas of highway finance, energy, and the environment. Balancing the often conflicting goals of promoting energy security, improving environmental quality, and financing highway programs will be one of the most important challenges facing transportation decisionmakers in the 1990's and beyond. The objective of the Office of Policy Development's high priority area, *Analysis of Economic, Energy, and Financing Issues in Highway Transportation*, is to develop and refine the tools and information needed to formulate FHWA's strategic policy position in areas related to highway financing, particularly in areas where energy, environmental, and financial goals are interrelated, and to ensure that its analysis capabilities are responsive to rapidly changing issues.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Analysis of Economic, Energy, and Financing Issues in Highway Transportation

Past reports and activities that have been supported by contract work in this high priority area include:

- Reports used by the Federal Highway Administration (FHWA) and the Department of Transportation for policy development, include the documents issued as part of the Policy Discussion series, sponsored by the Office of Policy, Federal Highway Administration. These documents include: *Building a Better Partnership: Public-Private Cost-Sharing and Toll Financing Provisions of the Intermodal Surface Transportation Efficiency Act of 1991*, *Exploring the Role of Pricing as a Congestion Management Tool*, *Exploring Key Issues in Public-Private Partnerships for Highway Development*, *Public and Private Sector Roles in Intelligent Vehicle Highway Systems (IVHS) Deployment*, *Transportation and Air Quality*, and *Examining Congestion Pricing Implementation Issues*.
- Investigations of emerging energy and financing areas of national interest have been supported by contracts involving a survey of private financing of highway investment, and studies of congestion pricing for its environmental benefits and financial impacts.

Work Underway: The following is a partial list of these studies with interim results:

- "Identification and Evaluation of Alternative Highway Revenue Sources" (FHWA) initiated in fiscal year 1991, is evaluating the effects of increased use of alternative fuels and the improvement of fuel efficiency on Federal highway revenues, and will identify and evaluate potential revenue alternatives.
- "Alternatives to Motor Fuel Taxes for Financing Surface Transportation Improvements"

(NCHRP) will involve a number of issues related to those being examined in the 1991 project, but will include a review of revenue programs of all levels of government and consideration of foreign experience. The two studies are being closely coordinated to ensure that they are mutually supportive.

- "Experiences in Overcoming Federal, State, and Local Legislative/Administrative Barriers to Implementing Private-Public Highway Projects" (FHWA) is looking at the issues in implementing public-private partnerships for highways. This study is designed to describe experiences in the development of projects with innovative finance components, and to document legislation that will encourage such projects. Key issues have been identified and experiences are being documented. The final report is expected to be released in the last quarter of fiscal year 1993.
- "Implications of Changes in Procedures and Laws to Advance Public-Private Partnerships" (FHWA) is examining the advantages, disadvantages, and implications of potential changes in procedures, regulations, and laws to stimulate public-private partnerships. An extensive list of issues has been developed in conjunction with private sector representatives. These are currently being examined in detail and will be discussed in a resource report to be used in conjunction with a symposium, to be held in December 1993, to obtain State and industry responses. A final report will be published in fiscal year 1994.
- "Policy Analysis of Congestion Pricing for Transportation Facilities" (FHWA), a multiyear research project is investigating issues related to the use of congestion pricing as a means of transportation demand management. Funds from this project are being used to support a Transportation Research Board (TRB) study of congestion pricing. The TRB has convened a panel of experts who developed a symposium on congestion pricing. The symposium was held in June 1993. A report on major issues related to congestion pricing will be delivered in fiscal year 1994.
- "Project Development Support for the Congestion Pricing Pilot Program" (FHWA) involves developing and providing expert technical assistance to support implementation of the Congestion Pricing Pilot Program. A guidebook providing an overview of congestion pricing approaches and goals and describing a process for conducting feasibility studies, has been distributed to interested parties. The results of these studies should provide valuable information for the formulation of highway policy in this area and will assist in the development of guidelines for implementing congestion pricing projects.
- "Development of the Highway Revenue Forecasts and Evaluation of Alternative Revenue Sources" (FHWA), a project proposed for fiscal year 1993, will extend and modify FHWA's Highway Revenue Forecasting Model to incorporate forecasting equations for revenues generated by alternative fuels or other alternative sources of Federal highway revenue.
- "Highway Transportation and Greenhouse Gas Emissions" (FHWA) involves surveying, assessing, and synthesizing currently available literature and research underway on the highway transportation's contribution to greenhouse gas emissions and the costs and effectiveness of highway program options for reducing these emissions while maintaining mobility goals.
- "State and Local Government Highway Financing" (FHWA) will develop a conceptual framework to describe and explain how State and local expenditures are determined. Information will be developed largely from data obtained through interviews with experts in State and local finance and a literature review. The conceptual framework will be translated into a formal model of the determinants of State and local expenditures on highways and bridges. The parameters of the model will then be estimated statistically so that it can be used to generate forecasts of State and local expenditures at least 10 years into the future.
- While States have extensive experience in creating public-private partnerships in the areas of economic development, health care, and research and development, successful efforts to create public-private partnerships to support transportation investments are not widespread.

"Innovative State Funding Techniques for Highway Facilities and Services" (FHWA) identifies mechanisms that States can use to encourage private involvement in all phases of developing, financing, constructing, owning, and operating highway facilities. It includes examining mechanisms used to encourage private investment in other public policy areas, assessing the applicability of these mechanisms to highway investment, and assisting States in exploring the feasibility of implementing new approaches to public-private cost sharing for highway investment.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Analysis of Economic, Energy, and Financing Issues in Highway Transportation

- "Public-Private Sector Finance" (FHWA) will provide an analysis of the use of public-private cost-sharing techniques. Financial mechanisms commonly used in privately financed projects may be used to advance public-private partnerships and additional information about these mechanisms will be required by the highway community. In addition, further analysis is needed of the relationships between State departments of transportation and toll authorities, with a view towards identifying barriers to coordinated actions between these institutions in developing highway projects.
- "Joint Federal/State Motor Fuel Tax Compliance" (FHWA) will provide for the development and presentation of training courses to assist State and Federal revenue agencies in improving the effectiveness of motor fuel tax enforcement programs, and to enhance State and IRS motor fuel tax compliance. One course, entitled Motor Fuel Tax Evasion Training for Tax Auditors and Investigators (FHWA) has already been developed and will be continued; and one advanced course emphasizing criminal prosecution requirements and investigative techniques will be developed and offered.
- "Assessment of Public and Private Sector Roles in Deployment of IVHS" (FHWA), a project on public-private partnerships and their relationships to IVHS and enhanced traffic engineering programs is investigating broader roles for public-private partnerships to develop and implement the IVHS technology. While traditional methods of operating and improving transportation systems have almost exclusively involved the public sector, IVHS and newer traffic engineering options allow for a much greater involvement of the private sector. Six regional workshops will examine the roles the private sector may play as well as the barriers encountered in developing public/private partnerships for enhanced traffic engineering and IVHS. Information on topics such as the roles of the private sector; the range of opportunities; institutional issues; procurement/contracting issues; financial issues; legal/liability issues; and other issues will be covered through a series of presentations, case studies, and panel discussions. A handbook, developed for the workshops, will further examine issues related to IVHS implementation and will be a valuable guide to groups interested in developing and implementing IVHS.

PUBLICATIONS AND PRODUCTS:

- *Searching for Solutions—Edge Cities and the Intermodal Surface Transportation Efficiency Act of 1991—So What?* (FHWA-PL-93-010).
- *Searching for Solutions—Examining Congestion Pricing Implementation Issues* (FHWA-PL-93-008).
- *Roundtable Discussion of Federal-Aid Toll Financing of ISTEA* (FHWA-PL-93-011).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: F.2
PROGRAM TITLE: Freight Transportation
PROGRAM MANAGER: James W. March

An important goal of the National Transportation Policy is "to maximize efficiency and use of system capacity and ensure that existing facilities are used to the best advantage to meet transportation needs." Increasing the productivity of the Nation's highway system is an important element of the Federal Highway Administration's mission reflecting that goal. Equitable highway cost allocation; truck size and weight policy; and characteristics of freight demand, including intermodal shifts and terminal operations, are continuing issues related to highway system productivity and efficiency. The objective of this effort is to develop and refine the tools and information needed to formulate FHWA's policy position in these areas and to respond to legislative initiatives from other interest groups. This research supports the Office of Policy Development's continuing inhouse projects to update and improve data bases and models used for highway cost allocation, truck size and weight policy analysis, and related freight analysis.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Enhancing the Performance, Productivity, and Efficiency of Highway Investments

In prior years, major research efforts have been devoted to the development of analytical tools for highway cost allocation, and truck size and weight policy analysis. Prior work has focused on three major activities: collection and analysis of data on travel by different vehicle classes, principally through the Bureau of the Census and Oak Ridge National Laboratory (ORNL); development of models to estimate the impacts of truck size and weight policy options, primarily through the Volpe National Transportation Systems Center (VNTSC) and ORNL; and development and improvement of highway cost allocation models, through the VNTSC and other contractors.

Most current research involves updating and refining tools that were developed for major congressional studies of highway cost allocation and truck size and weight policy conducted during the late 1970's and early 1980's. The rapidly changing state of the art in pavement and bridge cost allocation, and the changing economic and regulatory environment facing the trucking industry require that data and models be continuously updated to address the ever expanding set of factors that must be considered in cost allocation and truck size and weight policy development.

In response to this requirement in the area of pavements, a conference was held in December 1992 to discuss and identify potential improvements to the Nationwide Pavement Cost Model (NAPCOM) process. Virginia DOT, California (Caltrans), American Trucking Associations, Association of American Railroads, and affected FHWA offices were represented. Many recommendations resulted from the conference, such as: (1) considering other factors affecting crack progression from narrow to wide cracking in the fatigue cracking model, (2) distinguishing between polishing and nonpolishing aggregates in the skid resistance model, (3) changing the form of the skid resistance

model to include axle weight as well as number of axles, (4) including inflation and discount rates for better estimation of future program costs and current values of those costs, and (5) allowing the user to specify any number of weight distributions and to which highway classes and States each applies. Most of the recommendations are being pursued by the contractor. Data are also being improved for all facets of cost allocation and truck size and weight policy analysis. Tabulation of the *1990 Nationwide Truck Activity and Commodity Survey* was completed and a report of selected tabulations was prepared.

Work Underway: The following is a partial list of these studies with interim results:

- Among cost allocation processes being continuously improved is the NAPCOM process. The original contract under which NAPCOM was developed has been completed. Additional research is required, however, to further refine various aspects of the model. Results obtained from applying NAPCOM include shares of pavement rehabilitation cost responsibility and total axle loadings by vehicle class and weight group, estimates of load versus non-load related costs, and estimates of cost by improvement type.
- The NAPCOM process is being modified to improve the reliability and representativeness of its results. This includes improved source code and data bases. Among expected improvements are: (1) modifications to more closely resemble the States' pavement rehabilitation strategies, (2) modifications to incorporate a mechanism to allow traffic growth rates to vary by individual pavement section, (3) modifications to attribute only serviceability costs and to use corresponding model parameters to attribute other pavement costs, (4) modifications to incorporate the non-load share of pavement cost as a variable rather than a fixed percentage of overall costs, and (5) modifications to allow the user to specify annual budgets over an entire 20-year analysis period.
- Another major current research effort is the Highway Traffic Forecasting System (HTFS). The HTFS encompasses the principal models used by the FHWA to forecast highway use and the sensitivity of highway use to national transportation policies. It provides 5- to 10-year forecasts for analyses of the impacts of truck size and weight policy options, highway user taxes, national economic conditions, regional economic conditions, and highway performance on vehicle miles of travel by type of vehicle, highway, and highway user. The HTFS also estimates those impacts on payload-ton-miles by type of vehicle and highway user.
- "Impacts of Heavier Trucks on Bridge Investment Requirements" (FHWA) will evaluate the bridge costs that may arise from operations of heavier vehicles, and will include an update of incremental costs used in bridge cost allocation.
- "Effects of Truck Size and Weight Policy Options on Carrier and Shipper Productivity" (FHWA) will evaluate effects of Federal truck size and weight policy options on shipper/receiver business logistics cost, and assess intramodal and intermodal freight diversion from a demand-side perspective.
- "National Highway Travel Forecasts and Policy Analysis" (FHWA) will update and refine relationships used to forecast nationwide travel by vehicle classes at different weights.
- "Nationwide Truck Activity Survey" (FHWA) examines alternatives to improve the linkage between the Nationwide Truck Activity Survey and the Truck Inventory and Use Survey.
- "National Pavement Cost Model (NAPCOM) Refinements" (FHWA) is providing refinements to improve the performance and use of NAPCOM, update key input data, and incorporate later research findings related to pavement deterioration models.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Enhancing the Performance, Productivity, and Efficiency of Highway Investments

- "Update and Refine Truck Size and Weight Policy Analysis Models" (FHWA) will test the sensitivity of various segments of the modeling system and extend the model to include international trade.
- "Update and Refine Highway Cost Allocation Models" (FHWA) will incorporate the latest research on pavement and bridge deterioration and update data on highway program costs and travel by different vehicle classes at different weights. Implications for cost allocation of the funding flexibility provided by the ISTEA will also be investigated.
- "Incorporation of External Cost Considerations into Highway Cost Allocation" (FHWA) will update estimates of various social costs of highway transportation, including congestion, noise, and air pollution costs.
- "Life-Cycle Cost Symposium" (FHWA) will define the state of the practice in life-cycle cost analysis, recommend items for implementation of life-cycle cost analysis within FHWA by managers and staff, and make recommendations for use of life-cycle cost analysis by State and local transportation decisionmakers.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: F.3
PROGRAM TITLE: Highways and Economic Productivity
PROGRAM MANAGER: Susan J. Binder

This effort will develop a better understanding of the linkage between investment in highways and bridges and the Nation's capacity to sustain economic performance and growth. This research will clarify, as quantitatively as possible, both the short- and the long-term influences of highway infrastructure investment and service on the economy; will make more informed decisionmaking possible; and will respond to the productivity slowdown. That is, it will address the question—"How do changes in highway investment translate to private productivity at the national level?" This research agenda uses three approaches. The first approach—macroeconomic analysis—investigates national and State-level linkages using econometric methodologies such as the production function. The second approach—microeconomic industry analysis—explores the connection between individual industries and transportation infrastructure from the perspective of firms. A third approach—highway systems assessment—examines the value of infrastructure with an emphasis on its service, network, or system characteristics.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Analysis of Economic, Energy, and Financing Issues in Highway Transportation

- In November 1992, modal agencies, the Bureau of Transportation Statistics, the Bureau of Labor Statistics, the Bureau of Economic Analysis, the Interstate Commerce Commission, modal associations, academia, and the private sector participated in a symposium entitled Highway-Related Transportation Industry Productivity Measures to discuss and assess the credibility of current measures. Conference participants acknowledged the difficulty of gathering useful and complete measures of modal transportation industry productivity. Lack of sufficient data and a need for new methodologies to assess service sector output, quality, and productivity was cited by many as a cause for concern. A conference summary with research recommendations was published as part of the Searching for Solutions: A Policy Discussion Series in August 1993.
- As part of the microeconomic industry analysis approach, "Industry Studies of the Relationship Between Highway Transportation and Productivity" (FHWA) pursues case studies to identify firm-specific relationships between transportation—specifically highways—and productivity in a selected first set of industries. Logistics costs, as well as service characteristics such as reliability, flexibility, and just-in-time service, were incorporated in this project that started in fiscal year 1991. This effort focused on measuring the "indirect impacts" of industrial gains in productivity and the resulting gains in economic development, rather than savings in direct transportation costs or the effect on transportation industries themselves. A final report presenting results from the six industries analyzed in this project was received in August 1993. An FHWA paper evaluating the results of this work and a collaborative effort by the National Cooperative Highway Research Program (NCHRP) will be prepared in late 1993 or early 1994.

Work Underway: The following is a partial list of these studies with interim results:

- "Performance-Based Measures of the Transportation Productivity Linkage" (FHWA) will develop and test various indicators of principal arterial system performance for their ability to contribute to business efficiency and productivity. A Phase I report offering correlation analyses for system performance measures and State economic performance measures was received in April 1993. A Phase II report using simultaneous equations analysis to investigate the relationship between highway system effectiveness and economic vitality is expected in September 1993.
- "Impact of Intermodal Freight Movements on Infrastructure, Capacity, and Productivity" (FHWA), a study of intermodal operations and facilities in the U.S., focuses on industry and infrastructure needs associated with highway movements of intermodal freight. A systematic approach will be followed to identify and assess the relative economic importance of problems at the modal interface, including bottlenecks and barriers associated with infrastructure, operational efficiencies, information systems, and institutional issues. The result, an assessment of the economic impacts of effective and/or ineffectual intermodal connections, is expected in June 1994.
- "The Contribution of Transportation to Aggregate and Sectoral Efficiency" (FHWA), a macroeconomic study, will assess the contribution of various modes of transport to national and industrial sector efficiency. This effort will build upon an existing private input-output model to measure efficiency gained or lost through transportation's own input usage as well as efficiency gained or lost in other industries due to technological advances in transportation adopted in each industry sector. A report is anticipated for fall 1994.
- "Employment Impacts of Highway Spending" (FHWA), will extend inhouse research and model-building efforts to assess the employment effects of highway spending. FHWA data is being used to update estimates of the direct, construction industry jobs created by highway spending. Differences in employment impacts by region and type of highway project will be identified using an input-output model.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Analysis of Economic, Energy, and Financing Issues in Highway Transportation

- "Industry Studies of the Relationship Between Highway Transportation and Productivity—Part II" (FHWA). Building on the effort begun in fiscal year 1991 industry studies and those conducted under NCHRP, this project will be extended to additional industries, will evaluate methodologies used to date, and will attempt to extrapolate the methods and approaches discovered in the earlier project to the economy-wide level. This research is part of the microeconomic industry analysis approach.
- "Business' Stake in Transportation Planning" (FHWA). The business location decision has long been recognized as a key decision point in which transportation either implicitly or explicitly plays a vital role. No basic research has been conducted to assess the changes in location impacts since the 1960's. A large part of the analytical problems lies in the invisibility of transportation services to the business decisionmaker. This study will relate the importance of transportation planning to the business community and will consider the significance of location, vis-à-vis transportation, to firm productivity in light of radically changed economic geography, urban form, and national economic structure. In order to implement the highway system assessment approach, this study will require interviews with firms as well as econometric analysis. A final report is expected after 24 months.
- "Longitudinal Analysis of Firms and Industries to Address Transportation Productivity

Relationships" (FHWA) concentrates on the firm-level data contained in the census' longitudinal data base in order to study influences at the firm level over time. This research, as a part of the microeconomic industry analysis approach, will test for unique characteristics effects experienced by firms over time. Analytical extensions may be pursued after the initial research stage.

- "Valuation of Network Attributes" (FHWA), as part of the highway system assessment approach, will incorporate the distinct system aspect of highways by reviewing the existing literature on network service and performance measures. This classification effort will also assess product characteristics such as pervasiveness, connectivity, and accessibility. Literature on spatial economics and location theory will be used to develop a framework for categorizing highway network services.

PUBLICATIONS AND PRODUCTS:

- *Searching for Solutions—An Examination of Transportation Industry Productivity Measures* (FHWA-PL-93-019).
- "The Linkage Between Transportation Infrastructure Investment and Productivity: A U.S. Federal Research Perspective," Susan Binder and Theresa Smith, forthcoming in the proceedings of an international workshop Infrastructure, Economic Growth and Regional Development: The Case of Industrialized High Income Countries, held in Jonkoping, Sweden in June 1993.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: F.4
PROGRAM TITLE: Improving Transportation Data Acquisition and Management
PROGRAM MANAGER: David R. McElhaney

In keeping with the National Transportation Policy and the FHWA Vision 2000 goal, this program will ensure that timely and accurate information regarding highway finance, use, and performance is identified, collected, developed, exchanged, and used in-house and with our transportation partners and customers. Numerous contract efforts to improve data reporting and analysis are underway. These efforts include support of regular programs for assembling information on the Nation's highway system, its usage, and expected demands, and the identification of methods to meet the emerging needs for domestic and international transportation data. In addition, efforts to provide data taken from the U.S. Census, the Nationwide Personal Transportation Study (NPTS), and agency policy studies to public and private transportation planning groups are continuing. This data will be responsive to the users needs and reflect current issues.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Transportation Data Acquisition and Management

- A new *Highway Performance Monitoring System (HPMS) Field Manual* (FHWA Order M5600.1B) was written, discussed in detail during five HPMS Redevelopment Workshops, and was published in late 1993.
- Notice of Proposed Rulemaking, which covered traffic monitoring, was issued.
- FHWA research on the use of a prototype expert system to review continuous count data was completed.
- Prototype Comprehensive Transportation Information Planning System (CTIPS) was evaluated and input data sets were provided.
- "National Intercity/Intercounty Travel Survey Scoping Analysis" (FHWA) was completed.
- A program of user support for the NPTS data tape/diskettes was implemented.
- A "Snapshot Report of Journey-to-Work Data," based on the 1990 data was developed and distributed.
- First year reporting of Surface Transportation Program (STP) project-related statistical data was completed and results disseminated.
- Enhanced procedures for estimating nonhighway use of recreational motor fuel were completed.
- STP product data reporting software was prototyped and provided to States for reporting 1993-1994 data.

Work Underway: The following is a partial list of these studies with interim results:

- FHWA developed a prototype expert system-based procedure to edit traffic data in any State; this procedure was initiated using the completed prototype as a foundation.
- Testing of vehicle class and counting equipment under freeway conditions continues.

- The feasibility study of a national traffic data equipment test center, "Feasibility of National Testing" (New Mexico State Highway and Transportation Department), has been initiated.
- FHWA study of the use of earth satellites for the collection of traffic data continues.
- Work on development of enhanced procedures for better estimating nonhighway use of motor fuel and public vehicle use of motor fuel continues.
- Improved travel time data collection methods are being fieldtested.
- Evaluation of neural network methods to detect atypical traffic patterns continues.
- FHWA continues to support efforts to improve the coordination of traffic operations and traffic data collection.
- FHWA fieldtested the use of non-intrusive methods to collect traffic data in urban areas.
- "Estimation Methods for Gasoline/Alcohol Blends" (FHWA) is developing a procedure to estimate local highway capital outlays.
- FHWA initiated a study to estimate State-level use of gasoline/alcohol blends as a highway motor fuel.
- FHWA is continuing development of new state-of-the-art HPMS software systems.
- Additional reports from the 1990 NPTS are being developed.
- Continued distribution of public-use data set from the 1990 NPTS is being made on diskette and on tape.
- Work on developing an international transportation data base is in progress.
- FHWA continued coordination with the Bureau of the Census regarding development, dissemination, and user support for the Census Transportation Planning Package.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Transportation Data Acquisition and Management

- Start work on FHWA-sponsored short-range forecast procedures for State-level revenue and expenditure data.
- FHWA, through staff and sponsored research, continues new software systems to enhance HPMS data accessibility. CTIPS and the American Association of State Highway and Transportation Officials Value-Added Network (AASHTOVAN) are among future HPMS data user supply lines.
- Test the submittal of HPMS data via AASHTOVAN and other electronic media. Investigate extending electronic reporting to Highway Statistics and traffic data.
- Study methods of developing the most cost-effective traffic data collection programs at the State level.
- Apply Total Quality Management (TQM) to traffic data collection programs.
- FHWA will sponsor a traffic data collection conference.
- Further coordinate data dissemination with user community and other government agencies to transfer information and to ensure that data systems are supportive, but not duplicative.
- FHWA, through staff and sponsored research, will begin work on integrating geographic systems.
- FHWA, through staff and sponsored research, will update and expand our knowledge of personal travel patterns through the conduct of the 1995 NPTS.
- FHWA, through staff and sponsored research, will continue involvement in applying journey-to-work data from the 1990 Census and planning for meeting transportation data needs in Census 2000.

PUBLICATIONS AND PRODUCTS:

- *Highway Statistics 1992* (FHWA-PL-93-023).
- *Selected Highway Statistics and Charts 1992* (FHWA-PL-94-007).
- *Highway Taxes and Fees—1993* (FHWA-PL-93-018).
- *Monthly Motor Fuel Reported by States* (FHWA-PL-92-011).
- *A Guide to Reporting Highway Statistics, 1993* (September 1993).
- *Highway Performance Monitoring System Field Manual* (FHWA Order M5600.1) (September 1993).
- *Toll Facilities in the United States* (FHWA-PL-93-009).
- *Traffic Monitoring Guide* (FHWA-PL-92-017).
- *Monthly Traffic Volume Trends* (FHWA-PL-93-009).
- *Summary and Recommendations of the Conference on FHWA Truck Travel Data* (FHWA-PL-93-018).
- *Driver Licenses, 1992* (FHWA-PL-94-006).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: F.5
PROGRAM TITLE: Strategic System Performance Analysis
PROGRAM MANAGER: Harry Caldwell

This research incorporates several major independent, but related, basic and applied research areas that address systems analysis. This includes continued improvements to existing data systems and application tools as well as the development of new and improved tools to advance assessment capabilities. The research includes improved methods to estimate highway program needs and evaluate impacts of highway investment levels on the condition and performance of the highway system, development of improved geographically oriented surface transportation information systems for use in transportation analysis, and procedures to evaluate alternative highway and transit investment options.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Enhancing the Performance, Productivity, and Efficiency of Highway Investments

- The "Highway Economic Requirements System" (HERS) (FHWA), used to estimate highway needs and to evaluate alternative highway investment strategies, has been brought to the initial implementation stage. This model was developed to use incremental cost/benefit analysis to determine which highway improvements to simulate and the timing of these improvements. It uses both engineering and economic criteria in the decisionmaking process. This model will add significantly to the capabilities of the FHWA to evaluate highway system investments.
- "Relationships between Pavement Roughness and Condition Assessments" (FHWA) is a project to develop relationships between pavement condition, roughness, and distress for use in the Highway Performance Monitoring System (HPMS) and HERS analytical models. This will provide for more accurate determination of pavement deficiencies and improvement costs, and allow use of the International Roughness Index now included in the HPMS data base.
- "National Highway Network Development and Evaluation" (FHWA) has developed high-quality maps of the proposed National Highway System (NHS) for each State and urbanized area to be included in the NHS report to Congress. In addition, Geographic Information System (GIS) graphics files for each map have been developed. This includes a set of 1:100,000-scale GIS data bases that incorporate the National Highway Planning Network (NHPN) and the NHS. The State and county data include projections for population and other economic variables through the year 2,020. Several example networks of different total mileage were generated, showing relative flow volumes by segment.

Work Underway: The following is a partial list of these studies with interim results:

- "Speed Determination Models for the Highway Performance Monitoring System" (FHWA) will update procedures to model traffic speeds used by the analytical process to calculate vehicle operating costs and congestion delay. This study will evaluate existing speed models and speed prediction procedures for use in the HPMS and HERS models.
- "Urban Usage Patterns: Case Studies" (FHWA) will determine actual traffic patterns on highway systems in urban areas. This will provide more accurate data for modeling traffic congestion in the analytical environment. Data will be collected that describes traffic patterns on a variety of urban streets and highways.
- "National Highway Network Development and Evaluation" (FHWA) will produce a model for the development and evaluation of alternative national highway networks. The major activities for this year are to obtain the workstation-based network evaluation system, to continue to enhance this system for the purpose of comparing alternative National Highway System subnetworks, and to add a network design algorithm to the software.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Enhancing the Performance, Productivity, and Efficiency of Highway Investments

- "Highway/Transit Investment Options" (FHWA) will develop an operations plan for developing a highway and transit investment performance system. This system is intended to provide analysis of trade-offs between highway and transit options when analyzing such options are appropriate. Current research will determine the feasibility of developing the system, and will develop a plan for further research. This will include evaluations of existing models that may have application to this project, and will determine the scope of the additional research required to reach the objective of the project. The work will include developing a study design, determining the data requirements, developing analysis procedures, and beginning development of modeling requirements for the proposed modeling system.
- "HPMS/HERS Analytical Procedures" (FHWA) covers a number of improvements that will be developed to enhance the analytical capabilities of the HPMS Analytical Process and the HERS. These include improvements to the relationships of highway accidents to highway type and characteristics, economic analysis applied to bridge replacement and rehabilitation, types of low-cost capacity improvement for highway investment modeling, forecasting of vehicle emissions as related to highway capital investments, and other improvements to the modeling procedures.
- "Low-Cost Capacity Improvements" (FHWA) covers a number of improvements that will be developed to enhance the analytical capabilities of the HPMS Analytical Process and the HERS will develop procedures to model the impacts and costs of low-cost improvements to increase urban street and highway capacity. These are primarily traffic system management and traffic demand management procedures. The highway investment models used to evaluate highway investment strategies at the policy level have, in the past, used lane additions to increase capacity where feasible. This project is aimed at using low-cost alternatives to minimize requirements for additional lanes.
- "Vehicle Emissions Procedures" (FHWA) will update the modeling procedures to assess the impact of highway improvements on vehicle emissions. The modeling of vehicle emissions resulting from a given highway investment strategy is done by the Impact Assessment Model of the HPMS Analytical Process. The emissions model will be updated to use results compatible with MOBILE 5.

- The "National Bridge Optimization Model" (FHWA) will enhance procedures to assess bridge capital investments. The model currently used to assess bridge investment strategies (Bridge Needs and Investment Process) is based on engineering criteria with little economic input. Pontis, a model recently developed for use in State bridge management systems, will be modified for use at the national level.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: F.9

PROGRAM TITLE: Technology Transfer for Policy

PROGRAM COORDINATORS: James W. March—Office of Policy Development
Edward Kashuba—Office of Highway Information Management
Al Miller—National Highway Institute

The objectives of this program are to assess the value of new findings and procedures; to promote their adoption by other transportation planning, policymaking, and data collection agencies; and to develop technology and information-sharing products such as training courses, guidelines, and informational reports.

EXECUTIVE SUMMARY AND PROGRAM STATUS

The implementation of technology in the above areas has been conducted by the development and presentation of training courses, supporting demonstration projects, the presentation of workshops, the sponsoring of symposiums, field evaluation of new processes and equipment, and the preparation of reports sharing the findings on transportation issues and trends as well as historic data.

TECHNOLOGY APPLICATIONS

The following major activities were conducted during fiscal year 1993:

- Demonstration Project 76, Automated Traffic/Truck Weight Monitoring Equipment (Weigh-in-Motion) concluded with an international close-out conference on traffic data collection.
- Provided microcomputer-supported procedures for the determination of temporal factors used in the estimation of annual average traffic.
- On June 10-12, 1992, the FHWA sponsored a symposium on Examining Congestion Pricing Implementation Issues. Summary results were published under the same title (see FHWA-PL-93-008).
- On September 9-10, 1993, a workshop entitled Metropolitan America in Transition: Implications for Land Use and Transportation Planning was held in Arlington, Virginia. Jointly sponsored by the FHWA and the Lincoln Institute of Land Policy, the workshop was a follow-on to last year's Edge City and ISTEA—So What? seminar. The workshop examined the impacts of current suburban development patterns on the environment, economy, and transportation.
- On September 28, 1993, the FHWA sponsored a symposium entitled Bond Financing and Transportation Infrastructure: Exploring Concepts and Roles. Summary results will be published in early fiscal year 1994.
- On May 31 through June 4, 1993, the FHWA and the Transportation Research Board cosponsored the International Symposium on Motor Carrier Transportation at Williamsburg, Virginia. The symposium reviewed operational and technological trends, explored potential impacts on motor carrier transportation in the 21st century, disseminated research findings, identified research needs and policy questions, and fostered effective cross-disciplinary interaction.

NATIONAL HIGHWAY INSTITUTE

- Offered training courses on four different topics related to policy analysis and revenue issues. Forty-two presentations were made.
 - ◆ Highway Program Financing
 - ◆ Innovative Highway Financing—An Overview
 - ◆ Application of the Traffic Monitoring Guide

OTHER TRAINING

- Made presentations at traffic data conferences sponsored by Regions 1 and 10.



G. Motor Carrier Transportation

High Priority Areas

- Commercial Vehicle Safety and Performance
- Driver Proficiency
- Motor Carrier Safety Analysis and Information

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: G.1
PROGRAM TITLE: Driver Proficiency
PROGRAM MANAGER: Thomas P. Kozlowski, P.E.
PROGRAM PERSONNEL: Eliane Viner, R.N., Deborah Freund, P.E., and Jerry Robin

This program area has been revised to focus on driver-related research for both truck and motor coach drivers. The research concentrates on issues concerning driver fatigue; medical qualifications; substance and alcohol abuse; and licensing, testing, and driver proficiency. Each of the categories within this program are classified as high priority areas.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Driver Proficiency

- "Hearing Disorders and Commercial Motor Vehicle Drivers" (FHWA) examined the role of hearing in the driving task, hearing loss, the relationship between hearing loss and accidents, existing standards, and hearing standards in force in individual States and foreign countries. The workshop that was convened to discuss hearing disorders produced a summary that recommended granting waivers to hearing-impaired drivers who could meet several criteria.

Work Underway: The following is a partial list of these studies with interim results:

- "Driver Fatigue and Alertness" (FHWA) is measuring alertness levels of commercial motor vehicle drivers through comprehensive and continuous monitoring of driving performance and physiological state, and their driving environment. The first two U.S. elements of the field experiment are complete, and work on the second two elements, to be done in Canada under extended driving hours, began in September. Data analysis will follow.
- "LCV Driver Fatigue" (NHTSA, FHWA) is completing the design phase of a study of the stress and fatigue experienced by commercial drivers of multi-trailer vehicles. The results are being compared to that of drivers operating conventional tractor-semitrailers. This research, one task in a larger contract, is a requirement of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).
- "Prototype State Medical Review Pilots" (FHWA) is piloting the medical certification procedures with six States to develop a State-based fitness program.
- "Assessment of the Driver Waiver Program" (FHWA) is collecting accident-related data from medically waived drivers and determining associated levels of risk. The risk will be compared to a case-controlled matched group of drivers who do not meet medical criteria under 49 CFR Part 391.41.
- "Training of Entry-Level Commercial Motor Vehicle (CMV) Drivers" (FHWA), in part, is supporting the research and rulemaking preparation activities related to CMV driver training as mandated by section 4007(a) of ISTEA. This study has been expanded to include a task

on training motor coach operators, CMV simulators for training and licensing purposes, and a "safe" driver profile purpose.

- "Development of Voluntary Criteria for Training Drivers in the Safe Operation of Multiple-Trailer Vehicles" (FHWA) is developing an outline curriculum that consists of an instructor's manual, a training manual, and a testing system. This study is a follow-on to an earlier effort that produced training materials for drivers of double-trailer vehicles.
- "Research to Enhance the Safe-Driving Performance of Older Truck Drivers" (FHWA, American Trucking Associations) is exploring factors such as cognitive and sensing skills as well as physical limitations that may create problems for older commercial-vehicle operators. The goal of this project is to identify and assess potential interventions that may compensate for declining driver abilities.
- "Motor Coach Passenger Safety" (FHWA) is identifying the scope, severity, and cause of motorcoach passenger injuries, including those from boarding and alighting, falls in aisle, lavatory falls, struck or thrown against objects, and safety issues related to standing passengers or employees. The study will include a search and evaluation of existing literature, accident data, industry procedures, and government regulations pertaining to passenger injuries and safety. A final report will enumerate potential options to improve motorcoach passenger safety, including potential regulatory options, education and training programs, and further research needs.
- "Longer Combination Vehicle Driver Training and Instructor Requirements" (FHWA) is developing potential LCV driver and instructor training components as a result of ISTE requirements. Ultimately, the driver training standards will also include a certification of the operators' proficiency by an instructor who has met FHWA requirements.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Driver Proficiency

- "Implementation of State-Based Medical Procedures and Development of Training for Medical Examiners on the Federal Motor Carrier Safety Regulations (FMCSR)" (FHWA) will work to implement a State-based medical review program as part of State procedures to license and review commercial driver qualifications under the Commercial Drivers License Program. The project will investigate the appropriate interval for recertification of driver physical fitness, develop model legislation and regulations, detail procedures, and produce training modules and materials. As part of this effort, the contract will develop a program for State medical examiners that ensures their timely understanding and uniform application of FMCSR's in the medical certification of commercial vehicle drivers.
- "Medical Advisory Board" (FHWA) will overview existing medical advisory mechanisms in an effort to streamline individual driver petitions, mediate medical conflicts, develop regulations, and establish monitoring procedures for assessing the program's medical standards.
- "CDL Effectiveness and Benefits Study" (FHWA) will assess the effectiveness and benefits realized from implementing the Commercial Drivers License (CDL) Program. This effort will identify measures, review available data, and summarize results in order to describe any changes that should be made in the CDL program or regulations that would enhance its effectiveness.

PUBLICATIONS AND PRODUCTS:

- *Hearing Disorders and Commercial Drivers* (FHWA-MC-93-004).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: G.2
PROGRAM TITLE: Vehicle Safety/Performance
PROGRAM MANAGERS: Thomas P. Kozlowski, P.E. and Thomas E. Klimek
PROGRAM PERSONNEL: Dennis Miller, P.E. and Larry Minor

This program is comprised of vehicle-related research focusing on ensuring the safe operation and maintenance of a vehicle's mechanical components, including braking systems, fuel systems, and cargo securement methods. It also addresses design standards for highway access.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Commercial Vehicle Safety and Performance

- "Evaluation of Brake Adjustment Criteria for Heavy Trucks" (FHWA) conducted mechanical analyses of the influence of brake adjustment on stopping capability, statistical analyses of brake inspection data, combined statistical and mechanical analyses of the "20-percent" rule (as it is used in placing vehicles out of service for brake adjustment), and development of procedures for estimating or predicting brake adjustment intervals. The results indicate that the current inspection criteria result in a significant percentage of "false positives" in placing vehicles out of service. The report provides recommendations for improvements to the inspection criteria.

Work Underway: The following is a partial list of these studies with interim results:

- "Evaluation of Tire Properties" (FHWA, NHTSA), currently in its second year, is developing methods for measuring and reporting stability-related tire performance. A catalog of data on the range of heavy vehicle tires presently in use will be developed during 1995.
- "Feasibility of Using Weigh-in-Motion (WIM)" (FHWA), in Oregon, is determining the accuracy of low-speed weigh-in-motion equipment. Florida is preparing a final report on the extent of weigh scale bypassing.
- "Longer Combination Vehicle Operations Tests" (FHWA) is determining if Federal commercial motor vehicle safety standards need to be modified to include special requirements applicable to these vehicles. This project will also determine if driving a Longer Combination Vehicle (LCV) is more stressful or fatiguing compared to driving a non-LCV truck, and whether anti-lock braking systems and advanced systems can be practicably and reliably installed and maintained in use on LCV's.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Commercial Vehicle Safety and Performance

- "Preventive Maintenance Model for Buses" (FHWA) will study rates of wear and breakdown of bus components, survey current practices, and determine which predictors of component failure exist. The study will also establish guidelines for preventative maintenance.
- "Develop Model Training Curriculum for Bus Mechanics" (FHWA) will determine which standards are needed for motor coach mechanics and will develop a training curriculum to meet those standards.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: G.3
PROGRAM TITLE: Motor Carrier Safety Analysis and Information
PROGRAM MANAGER: Thomas Hillegass

This program develops information systems that will provide accessible, comprehensive, reliable, and up-to-date information on motor carriers. Included in this area are data collection, accident and carrier analysis, information processing and dissemination, and program management and evaluation.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Motor Carrier Safety Analysis and Information

- "Motor Carrier Programs Safety Performance" (FHWA) determined the feasibility of developing a Motor Carrier Safety Investment and Performance Model that will evaluate the relationship between safety investments in various motor carrier safety activities and the reduction and/or prevention of accidents.
- "MCMIS Configuration Study" (FHWA) analyzed options for moving the Motor Carrier Management Information System data base off of a mainframe computer system to a less expensive microcomputer environment. It resulted in the initiation of a pilot test to determine if this is feasible.

Work Underway: The following is a partial list of these studies with interim results:

- "Supplemental Data for NHTSA's General Estimate System (GES)" (FHWA, NHTSA) continues to include heavy truck data in the GES and to provide a statistically reliable source for accidents involving motor carriers.
- "Trucks Involved in Fatal Accidents" (FHWA) continues to compile data files of a census of medium/heavy trucks involved in fatal accidents. This project will provide truck accident data together with the corresponding configuration and operational characteristics of commercial vehicles.
- "Motor Carrier Safety Fitness Determination" (FHWA) is developing a statement of the goals and objectives of FHWA's Safety Fitness Determination procedures, and identifying affected public and private stakeholders in the fitness process. Furthermore, this research effort will evaluate the current procedures, identify problems and weaknesses, and recommend and prioritize potential improvements.
- "Lap-Top Training and Technical Support" (FHWA) provides continued technical assistance to States and the Office of Motor Carriers field staff by resolving software and hardware operational problems.
- "MCMIS Information Dissemination and Quality Control" (FHWA) continues responding to the information data needs of the FHWA and the public, and makes improvements to the MCMIS when identified or needed.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Motor Carrier Safety Analysis and Information

- "Alternatives for Annual Census Update" (FHWA) will develop several alternative methods for updating the national census file on an annual basis.
- "Conduct Demo Interfacing SAFETYNET with the IVHS Information System" (FHWA) will design modifications to interface SAFETYNET with the IVHS Information System to exchange carrier/safety fitness and vehicle/driver out-of-service status information for State and FHWA enforcement use.
- "Automated Regulations and Interpretations Data Base" (FHWA) will update, format, package, distribute, and maintain an automated regulation system that would include the Federal Motor Carrier Safety Regulations, Hazardous Materials Regulations, and all regulatory interpretations and program office policy manuals.
- "Office of Motor Carrier Resource Allocation Model" (FHWA) will provide information on the geographic location of commercial truck and bus companies. Their safety ratings would be compared by FHWA field staff and resources to evaluate program delivery effectiveness.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: G.4
PROGRAM TITLE: Regulatory Review and Enforcement
PROGRAM MANAGER: Michael Trentacoste
PROGRAM PERSONNEL: Thomas E. Klimek, William H. Nalley, and Richard Singer

The research conducted in this program area seeks to identify and assess new technologies and procedures that will improve the efficiency of motor carrier inspections; allow onboard monitoring of a commercial vehicle's weight as well as the detection of hazardous materials (HM) leaks; identify and monitor high-risk hazardous materials shippers; and permit real-time screening of driver certification, hours-of-service compliance, violations, and location. Research in this category also will seek to determine those shipper and receiver demands that may have a detrimental effect on hours-of-service rule compliance, and whether Federal regulations are needed.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

- "Identification of High-Risk Shippers" (FHWA) is developing a risk index of hazardous materials shippers that will correlate HM shipment types and number of shipments made.

Work Underway: The following is a partial list of these studies with interim results:

- "Relevant Evidence Studies" (FHWA) will assist four States in developing procedures to implement relevant evidence as a tool to be used in taking "after the fact" enforcement actions against commercial motor carriers that violate vehicle weight requirements.
- "Safety Education and Technical Assistance" (FHWA) is providing technical assistance to the Office of Motor Carriers on selected topics for the commercial motor carrier and hazardous materials carrier/shipper industries.
- "HazMat Incident Countermeasures" (FHWA) is investigating current hazardous materials data sources in an effort to identify leading causes of hazardous materials incidents and those motor carriers with the highest risk of incidents. Countermeasures to mitigate or eliminate such risks will also be identified.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Evaluate HM Performance, Including 'Wet Lines'" (FHWA) will review previous work conducted in this area and determine the root causes of cargo tank failures in accident and non-accident situations. This effort will also pursue alternatives to the "Wet Lines" issues that involve the carriage of hazardous materials substances within a pipe system attached to the cargo tank.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: G.5
PROGRAM TITLE: Regulatory Reform
PROGRAM MANAGER: James E. Scapellato
PROGRAM PERSONNEL: David Osiecki

This program area focuses on a multiyear "zero-base" review of the Federal Motor Carrier Safety Regulations (FMCSRs) to establish more enforceable safety requirements that have a basis in performance data. The Office of Motor Carriers is taking a fresh look at its existing regulations in order to improve understanding of and compliance with critical safety requirements.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

- "Zero-Base Review of Regulations—Phase I" (FHWA) has recently completed the final report for phase I of the multiphase study to obtain views, comments, and opinions from industry and other interested parties on how to develop a comprehensive, unified set of safety requirements that will best enhance commercial motor vehicle safety from a "zero-base" approach. This final report contains a complete summary and analysis of all of the data and information, as well as recommendations collected from the zero-base docket (MC-92-33) and the public outreach and focus group sessions.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Zero-Base Review of Regulations—Phase II" (FHWA) will conduct a literature search in an attempt to validate the recommendations provided through the outreach effort in phase I. The effort will also provide an initial summary of recommended standards that have a basis in performance data; prepare option papers to describe the processes needed to achieve implementation; or recommend that additional research or other validation alternatives are needed.

PUBLICATIONS AND PRODUCTS:

- *Zero Base Review of FMCSRs Final Report Executive Summary Volume I* (FHWA-MC-94-002).
- *Zero Base Review of FMCSRs Final Report The Data Analysis Volume II* (FHWA-MC-94-003).
- *Zero Base Review of FMCSRs Final Report The Data Summary Volume III* (FHWA-MC-94-004).
(The previous publications are available from the National Technical Information Service, Springfield, VA.)

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: G.6
PROGRAM TITLE: Motor Carrier Industry Economic Health
PROGRAM MANAGERS: Bonnie Bass and Ralph Craft

The purpose of this program area is to develop methods to reduce the costs of motor carrier compliance with State taxes and regulations. The goal is met through base (or home) State agreements such as the International Registration Plan (IRP) and the International Fuel Tax Agreement (IFTA). Under base State agreements, the State of domicile of the carrier acts on behalf of all States that are members of the agreement, thus eliminating the need for carriers to contact more than one State per agreement. The research will further examine a means to implement a base State system for registering/permitting hazardous materials carriers.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

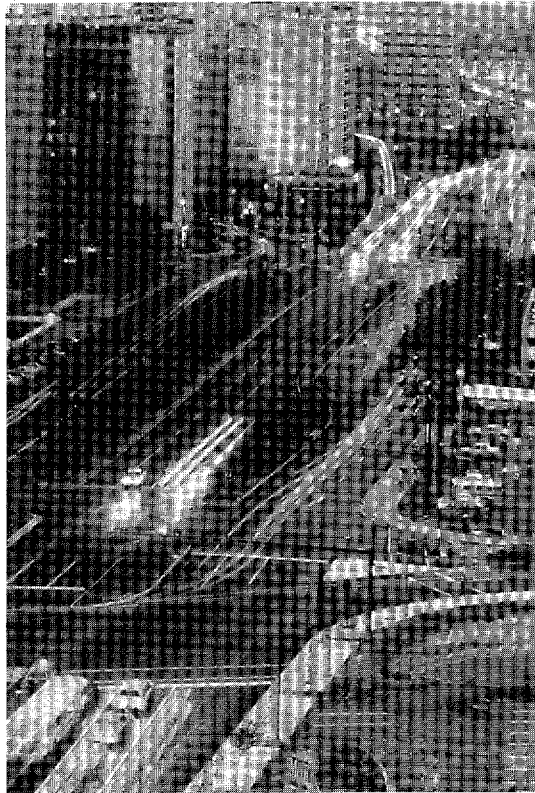
- "International Fuel Tax Agreement" has substantially increased State memberships.
- "Section 22 HM Uniformity Study" (FHWA) developed a model base State compact for State and local registration and safety permitting of motor carriers that haul hazardous materials (HM or HazMat). A final report is planned for November 1993.

Work Underway: The following is a partial list of these studies with interim results:

- "Pilot Section 22" (FHWA) is pilot testing the model base State agreement developed by the Alliance for Uniform HazMat Transportation Procedures for State and local registration and safety permitting of hazardous materials carriers.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Combined Registration/Fuel Tax System for Interstate Motor Carriers" (FHWA) will provide a plan for establishing one-stop operations for motor carriers in the States that combine IFTA, IRP, and other motor carrier taxation and regulation functions, such as hazardous materials and oversize/overweight permits.



J. Planning

High Priority Areas

Effective through 3/93

- Ensuring the Efficiency of Future Transportation Systems
- Congestion Management
- Effects of Transportation Improvements on Travel

High Priority Areas

Revised and Effective and 4/93

- Improving Mobility and Producing the Efficiency of Future Transportation Systems

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: J.1
PROGRAM TITLE: Ensuring the Efficiency of Future Urban Transportation Systems
PROGRAM MANAGER: Patrick DeCorla-Souza

This program focuses on the efficiency and environmental impacts of urban transportation and land use strategies. It develops technical procedures to aid in the evaluation of a variety of strategies, including land use, pricing, demand management, and infrastructure investment strategies.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Mobility and Promoting the Efficiency of Future Transportation Systems

- "Comparing Alternatives Across Modes" (FHWA) develops a new approach for evaluating multimodal transportation and land use options.
- "Applying the Cashing Out Option to Congestion Pricing" (FHWA) develops a new concept to improve the public acceptability of congestion pricing.
- "A Trip-Based Approach to Estimating Emissions Using EPA's Mobile Model" (FHWA) develops a new approach to developing transportation data inputs for emissions estimation.
- Introduction to Travel Demand Forecasting (NHI Course No. 15254) was updated to include multimodal analysis.
- Project Traffic Forecasting (NHI Course No. 15251) was updated to enhance the environmental analysis module.
- Interim Transportation-Air Quality Analysis Workshop (NHI Course No. 15265) was developed to provide training in response to the new requirements of 1990 Clean Air Act Amendments.

Work Underway: The following is a partial list of these studies with interim results:

- "Analysis of Suburban/Urban Activity Centers" (FHWA) researches the joint effects of demand management and urban design on transportation system efficiency.
- "Efficient Suburban Activity Centers" (FHWA) develops strategies and guidelines to make new and existing suburban centers more efficient from a transportation perspective.
- "Land Use/Transportation/Air Quality Study" (FHWA) is an inhouse research effort on the transportation and air quality impacts of land use, transportation management, pricing, and multimodal investment strategies.

Other Studies:

- "Multimodal Planning: A Comparison of Alternative Methodologies for Evaluating Bus Transit and High Occupancy Vehicle Lane Fixed Guideway Investments" (FHWA) examines capital investment evaluation procedures for transit and HOV lanes.
- "Transportation Planner's Handbook of Conversion Factors for Use of Census Data" (FHWA)

- develops a set of conversion factors that can be applied to 1990 Census Transportation Planning Package data for use in transportation planning.
- "Congestion Pricing: A Guide for Project Development" (FHWA) is producing a guidebook for State and local planners and policymakers who are interested in developing congestion pricing projects.
- Estimating the Impacts of Multimodal Transportation Alternatives (NHI Course No. 15257) is being developed to assist State and local planners in preparing evaluation measures for both highway and transit modes.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Mobility and Promoting the Efficiency of Future Transportation Systems

- "Land Use Policies and Social, Environmental, Public Infrastructure, and Service Costs" will examine the costs of alternative land development policies.
- "Case Studies for Corridor Planning Seminar" will develop case studies of good practice in corridor planning for major investments.

PUBLICATIONS AND PRODUCTS:

- *Considering Land Use and Pricing in Transportation Planning*, Metropolitan Planning Technical Report No. 1, March 1993.
- "Peak Period Tolls: Precepts and Prospects," *Transportation* (19:293-311), 1992.
- "Comparing Alternatives Across Modes," *Proceedings of the Fourth National Conference on Transportation Planning Applications*, May 1993.
- "Congestion Pricing: Towards Implementation," *Proceedings of the Fourth National Conference on Transportation Planning Applications*, May 1993.
- "Congestion Pricing: Issues and Opportunities," *ITE Journal*, in the publication process.
- *Applying the "Cashing Out" Approach to Congestion Pricing*, in the publication process.
- *Comparing Multimodal Alternatives in Major Travel Corridors*, in the publication process.
- *A Trip-Based Approach to Estimate Emissions Using EPA's MOBILE Model*, in the publication process.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: J.2
PROGRAM TITLE: Strategic Systems Performance—HPMS/GIS
PROGRAM MANAGER: James E. Gruver

This research complements policy-related research conducted under category F, Strategic System Performance Analysis, and the high priority area, *Enhancing the Performance, Productivity, and Efficiency of Highway Investments*. The emphasis of program J.2 is on the Highway Performance Monitoring System (HPMS) analytical applications for Federal, State, and local agencies, and on the development and applications of an operational HPMS Geographic Information System (GIS) tool.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Enhancing the Performance, Productivity, and Efficiency of Highway Investments

- "Speed Determination Models" (FHWA) developed improved procedures for computing vehicle speeds within the HPMS simulation models. The procedures are being reviewed by the FHWA, and there is the potential for the future incorporation of these procedures into HPMS-based models.
- An inhouse analysis of traffic congestion on freeways in major urbanized areas was conducted. The analysis used HPMS data. The results were summarized in a paper entitled "The Growth of Recurring Roadway Congestion: Cumulative Analysis of Selected Urbanized Areas," which is in the publication process. The findings, showing significant increases in congestion, were presented at the Transportation Research Board Planning Methods Application Conference held in May 1993.
- Contributions to the development of an updated *Highway Performance Monitoring System (HPMS) Field Manual* (FHWA Order M5600.1B) were made. The efforts included the revision of the descriptions and codes for the HPMS urban location data element. Also, instructions to the States for submitting linear referencing system data for the HPMS were prepared for inclusion in the manual.
- An inhouse analysis of directional traffic volume distributions was conducted using the findings of a research project completed last year ("Statistical Analysis of Continuous Traffic Counter Data"). Results of the inhouse work were applied to the congestion measurement paper discussed above. An ongoing project, "Roadway Usage Patterns" (FHWA), will statistically strengthen the findings of the inhouse effort.
- The digitizing of small urban boundaries, including U.S. census designations and congressional districts, was completed. This information will serve as one component of the illustration of the proposed National Highway System (NHS) and of the development of an operational HPMS GIS.

Work Underway: The following is a partial list of these studies with interim results:

- "Roadway Usage Patterns: Urban Case Studies" (FHWA) continues the analysis and will enhance the findings of "Statistical Analysis of Continuous Traffic Counter Data." The results will enable the updating of the traffic volume distributions currently used in the HPMS simulation models for speed and traffic-peaking-related analyses.
- "Incident Detection Issues," a research project co-sponsored by the Turner-Fairbank Highway Research Center and the Office of Environment and Planning, is an ongoing multiyear effort. A portion of this project features the collection and analysis of traffic incident data. The results will improve the HPMS-based methods used to analyze the impacts of incidents on freeway operations.
- Traffic congestion measurement expertise is being provided to researchers who are conducting such work for sponsoring agencies. Research projects sponsored by the National Cooperative Highway Research Program and by the State of California are among the efforts included.
- Work continues toward developing an operational HPMS GIS and illustrating the proposed Congressionally mandated National Highway System on an HPMS GIS network.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Enhancing the Performance, Productivity, and Efficiency of Highway Investments

- "Vehicle Emissions Procedures" (FHWA), a 1-year research project, will update the emissions computations procedures of the HPMS simulation models. The current procedure is based on the methods of the MOBILE 1 mobile source emissions model. The new procedure will be based on a MOBILE 5 series model.
- "Low-Cost Capacity Improvements" (FHWA), a 2-year research project, will include the development of procedures for assessing the costs and impacts of low-cost highway capacity improvements and travel demand management schemes. The FHWA will incorporate the approaches into the HPMS simulation models as cost-efficient alternatives to major capital investment for the relief of capacity-related deficiencies.
- Inhouse research will be conducted on traffic congestion measurement methods. A recommendation will be made as to the most effective method that can be used with HPMS data. This method may be applied in the future to analyses of traffic congestion by the FHWA.
- The HPMS GIS network for rural and urban principal arterials will be completed. Maps showing the proposed NHS will be developed using this network and will be included in a report to Congress on the NHS.
- An FHWA 2-year effort will attach linear referencing system data to the HPMS GIS network. These data, in turn, will be used to mount HPMS data on the network.
- As part of the development of an HPMS GIS, an effort will be made to comply with the Metadata and Spatial Data Transfer Standards to improve the exchange of information among users.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: J.3
PROGRAM TITLE: Congestion Management
PROGRAM MANAGER: Sheldon Edner

This program researches, develops, and disseminates the tools and information needed to facilitate improved congestion management and establish and implement congestion management systems. The research will assist State and local transportation agencies to enhance the performance and efficiency of existing, as well as future, transportation systems.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Mobility and Promoting the Efficiency of Future Transportation Systems

- The first National Conference on Access Management (FHWA) was held in Vail, Colorado.
- A national technical working group of experts from States, Metropolitan Planning Organizations, transit operators, and other transportation agencies was formed to assist the FHWA and the Federal Transit Administration (FTA) in developing a program to provide effective guidance on congestion management and congestion management systems.
- A newsletter entitled *Managing Congestion* was developed and released as an insert to the *Mobility Time* newsletter published by George Mason University, and sponsored by FTA and FHWA.

Work Underway: The following is a partial list of these studies with interim results:

- Assessment of the state of the practice in congestion management, measurement, and evaluation (FHWA). Draft report completed.
- Design and evaluation of prototype congestion management systems (FHWA).
- Development of areawide measures of congestion.
- Development of an interim course on congestion management systems to be available during the time period between the release of the final rule on management systems and the availability of the NHI courses described below.
- Development of NHI Course Nos. 15258, Congestion Management for Managers and 15259, Congestion Management for Technical Staff.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- Development of a demonstration project on congestion management and congestion management systems.
- Initiation of a project on developing effective congestion management systems (FHWA).

PUBLICATIONS AND PRODUCTS:

- "Travel Data Needs to Respond Effectively to Congestion Management and Air Quality," *Proceedings of the GIS for Transportation Symposium, Albuquerque, New Mexico, March 29-31, 1993.*
- "Evaluating the Operational Impacts of Access Control Strategies Using TRAF-NETSIM," *Proceedings of the Access Management Conference, Vail Colorado, August 1-4, 1993.*

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: J.4
PROGRAM TITLE: Travel Model Improvement Program
PROGRAM MANAGER: Frederick W. Ducca, Ph.D.

This program researches, develops, and disseminates tools and information necessary to respond to the travel forecasting requirements of the Clean Air Act Amendments (CAAA), the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, and the planning process. The research will assist State and local transportation agencies to foster economic development, implement state-of-the-art methods, enhance the performance of existing and future transportation systems, and integrate transportation with environmental considerations. This program is sponsored by the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the Environmental Protection Agency (EPA), and the Department of Energy (DOE).

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Mobility and Promoting the Efficiency of Future Transportation Systems

- Data collection was completed for an FHWA project to analyze the interactive effects of urban design and demand management.
- A review panel, composed of representatives of State and local government, Metropolitan Planning Organizations (MPO's), academics, environmental groups, and developers met and gave overall guidance to the program.

Work Underway: The following is a partial list of these studies with interim results:

- FHWA, EPA, Oregon DOT, Portland MPO, and several private foundations continued support for the 1000 Friends of Oregon "LUTRAQ" project. This project will develop innovative methods of analyzing land use and transportation inter-relationships.
- "Travel Forecasting and Feedback Loops" (FHWA) has begun to address equilibrium between assignment, mode choice, distribution, and land use within the travel forecasting process.
- "Network Model Improvements" (FHWA) addresses making network procedures more sensitive to pricing and combining mode choice with traffic assignment procedures.
- "Transportation Simulation Project" (TRANSIMS) (FHWA), begun at the Los Alamos National Laboratory, is exploring theories of systems analysis and non-linear programming to improve travel forecasting procedures.
- "Boston Longitudinal Land Use Changes" (FHWA) identified data sources for analyzing land use and transportation pattern changes in Boston over the last 40 years.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Mobility and Promoting the Efficiency of Future Transportation Systems

- "Alternative Mode Choice Procedures" (FHWA) will examine methods of forecasting shifts of time of day for travel in response to transportation measures such as peak hour pricing and congestion management.
- "Network Model Improvements" (FHWA) will begin work on developing dynamic assignment procedures (i.e., travel assignment by time of day).
- "Near-Term Model Improvements" (FHWA) will begin to examine improvements to the existing travel forecasting process.
- Continue the development of the FHWA TRANSIMS project and perform further analysis of network and goal-setting submodules.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: J.5
PROGRAM TITLE: Intermodal Transportation Planning
PROGRAM MANAGERS: George Schoener and Dane Ismart

This program develops and refines the tools and information needed to facilitate state-of-the-art intermodal passenger and freight transportation planning. The FHWA has also initiated an intermodal outreach program to identify the most feasible direction for research and the best methodologies to measure intermodal relationships.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Mobility and Promoting the Efficiency of Future Transportation Systems

- Intermodal Planning and Management Systems Regional Workshop (FHWA) was a series of 2- and 3-day seminars on intermodal issues and practices.
- Intermodal Management System Regulations were drafted by FHWA in cooperation with the Office of the Secretary and the other modal administrations.
- The First National Conference on the Intermodal Surface Transportation Efficiency Act and Intermodal Planning Issues: The Concept, the Practice, the Vision (Transportation Research Board) was held in Irvine, California in December 1992.

Work Underway: The following is a partial list of these studies with interim results:

- "The Development of Evaluation Methodologies for the Design of Intermodal Passenger Transfer Facilities" (FHWA) will create a unified set of documented tools for evaluating the effectiveness of intermodal passenger transfer facilities.
- "Freight Modeling Procedures" (FHWA) will review literature on existing data and freight models for forecasting freight movement by single or multiple transportation modes, assess the appropriateness and practicality of these models for inter/intrastate and inter/intraurban freight movement forecasting, assess the availability and accessibility of freight data for Massachusetts, investigate the relationship between freight planning tools and techniques for measuring air quality, and establish a procedure for integrating freight planning into statewide planning and the ISTE management systems for Massachusetts.
- "Potential Performance Measures and Standards for Intermodal Management Systems" (FHWA) is a series of studies being conducted by State DOT's to develop candidate performance measures and performance standards for intermodal management systems.
- "Evaluating Bus Transit and HOV Alternatives" (FHWA) will assess the investment worthiness of HOV projects when evaluated according to the FTA and AASHTO methodologies, and other variations on these methodologies.
- Intermodal Freight Videotape is being developed jointly with the Maritime Administration.
- "Development of Notebook Computer Software to Collect Trip Generation Data at Intermodal Passenger and Freight Terminal Facilities: Phase 1 Feasibility Study" (FHWA) will

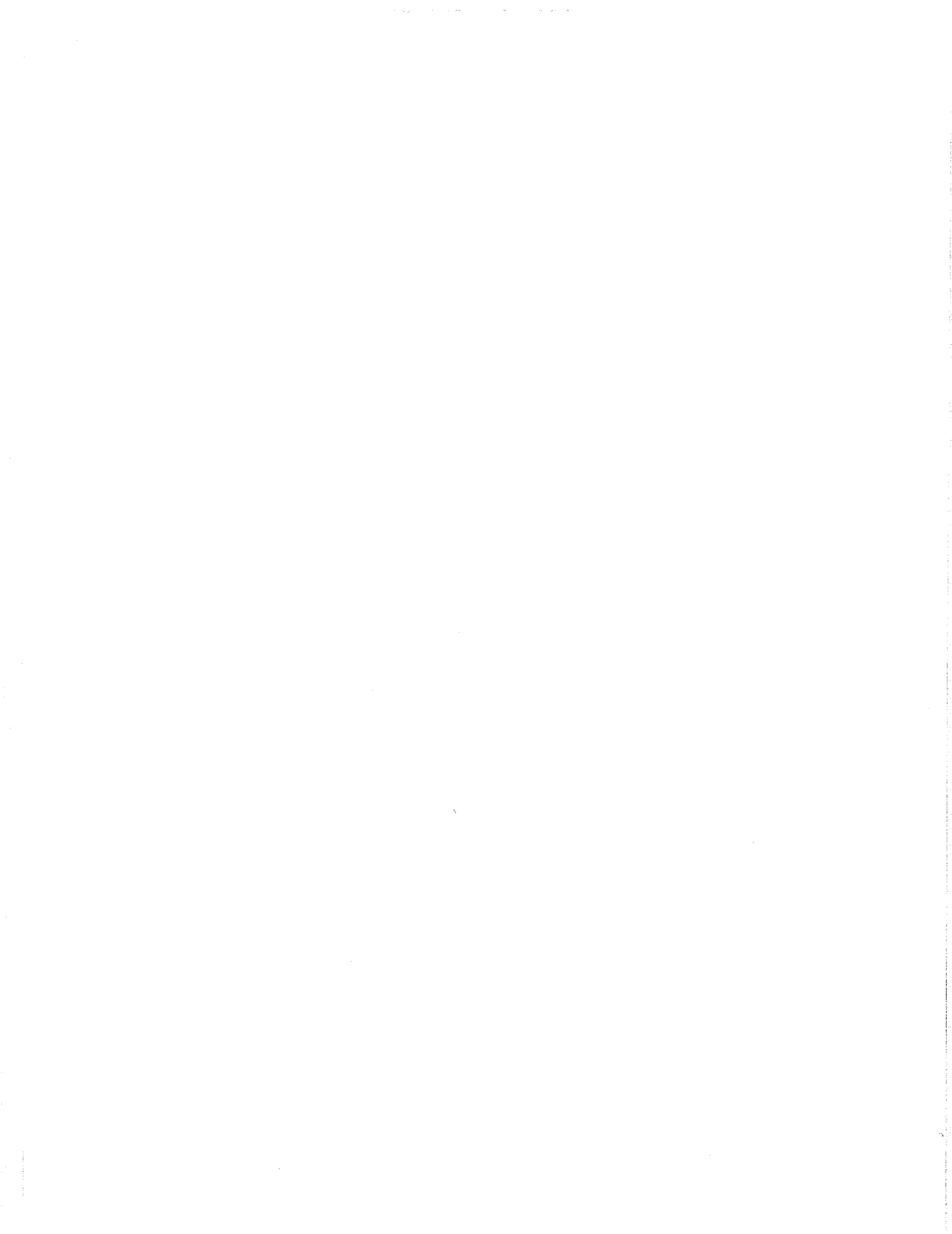
develop notebook computer software that will collect and analyze trip generation data at intermodal passenger and freight terminal facilities.

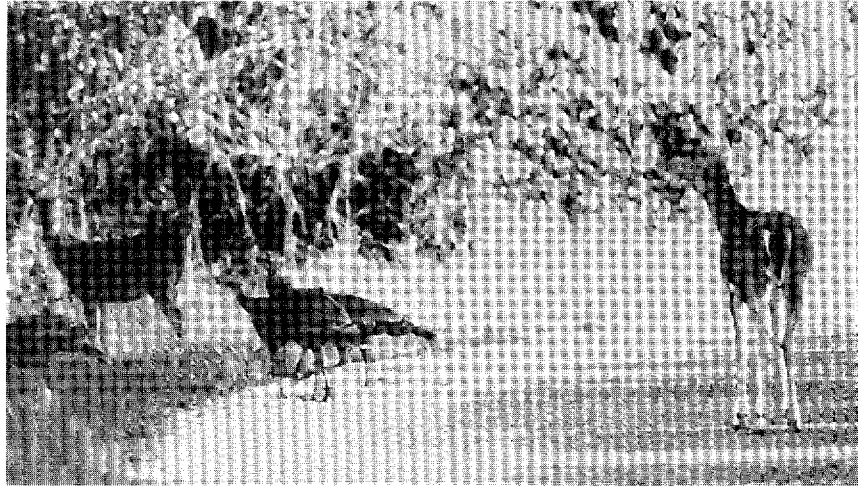
- European intermodal facilities were evaluated via a scanning tour of representatives from FHWA, AASHTO, and the Port Authorities of New York and New Jersey.
- Model statewide intermodal plans will be reviewed and a recommended practice developed for statewide intermodal plans.
- "The Lower Mississippi River Case Study" (FHWA) will evaluate the impact of intermodalism on rural economic development.
- "Model Economic Tradeoffs and Evaluation Procedures" (FHWA) will determine the procedures available for evaluating economic tradeoffs between transportation modes.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Mobility and Promoting the Efficiency of Future Transportation Systems

- Second National Conference on the Intermodal Surface Transportation Efficiency Act and Intermodal Planning Issues (Transportation Research Board) is being planned for mid-1994.
- "Intermodal Ground Access to Airports: A Planning Guide" will be developed jointly with the Federal Aviation Administration.
- "Truck Trip-Generation Update" (FHWA) will establish truck trip-generation rates by land-use type.
- The FHWA will conduct research in new intermodal technology, including evaluating the potential economic impact of new technology on the financial feasibility of intermodal facilities, and evaluating the potential of the Geographic Information System (GIS) for evaluating intermodal projects and identifying data sources and technologies for GIS applications.
- The FHWA will conduct research in the economic, performance, and legal aspects of intermodal facilities, including conducting a relative cost comparison by mode for equivalent freight and distance; identifying performance measures and industry standards for evaluating intermodal facilities; and identifying institutional, regulatory, and legal barriers, as well as their impact.
- The FHWA will conduct research in intermodal outreach, plans, and experiences, including contacting operators and users to identify problems, deficiencies, and funding sources.





K. Environment

High Priority Areas

Effective through 3/93

- Evaluating Highway-Related Air Quality Impacts
- Improving the Effectiveness of Wetland Assessment Techniques

High Priority Area

Revised and Effective 4/93

- Improving Environmental Tools, Techniques, and Information

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.1
PROGRAM TITLE: Air Quality
PROGRAM MANAGER: Richard Schoeneberg

Research in this program will improve the techniques available for cost-effective analysis of transportation system operation and transportation project proposals to ensure attainment and maintenance of the National Ambient Air Quality Standards. This research includes evaluations of vehicle emissions and the dispersion, transport, and expected impacts at receptor locations for highway air pollutants.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- Transportation Air Quality Planning Conference (FHWA, FTA, EPA) was presented to Federal, State, and local transportation, planning, and environmental personnel to familiarize them with Federal policy on transportation and air quality, and to inform them of new requirements mandated in the Clean Air Act Amendments of 1990 (CAAA) and the Intermodal Surface Transportation Efficiency Act of 1991.

Work Underway: The following is a partial list of these studies with interim results:

- "Assessment of Highway Particulate Impacts" (FHWA) is assessing PM₁₀ particulate concentrations in the air, determining the role of highway transportation in producing these concentrations, and, if appropriate, developing techniques to quantify and mitigate highway system impacts.
- "Improving the Integration of Transportation and Air Quality" (FHWA), a grant to the National Association of Regional Councils sponsored with the EPA and the FTA, uses Federal, State, and local air quality and transportation organizations as a resource in evaluating the technical, administrative, procedural, regulatory, and educational issues involved in the transportation provisions of the CAAA of 1990. Products thus far include a newsletter, seminars, air quality workshops, a *Manual of Regional Transportation Modeling Practices for Air Quality Analysis*, and transportation control measures research.
- "Air Quality Technical Services" (FHWA) is using the Volpe National Transportation Systems Center (TSC) staff to perform various transportation-related air quality tasks and retain and monitor a contractor who will also perform transportation-related air quality tasks.
- "Air Pollution Implications of Urban Transportation Investments" (TX SP&R) is examining the roles of highway private and public transportation in major Texas metropolitan areas on their attainment of Clean Air Act Standards.
- "Local Background Levels of Carbon Monoxide in Urban Areas" (WA SP&R) is examining the temporal carbon monoxide variations in Seattle as a function of topographical positions at locations adequately distant from highways to avoid short-term variation impacts from transportation facilities.

- "Measurement and Source Apportionment of PM₁₀ Roadway Emissions" (WA SP&R) is examining the source strengths of airborne fine particulate matter from paved and unpaved roadways.
- "Establishment of a Data Base for CO Concentration at Signalized Intersections and Refinement of the Modeling Approach" (NCHRP/FHWA) is studying the relationship between carbon monoxide (CO) levels and intersection operations, and developing analysis tools, including a new intersection model and software package, reflecting this relationship.
- "Performance and Assumptions Used in the MOBILE Models" (FHWA) is evaluating the structure of and assumptions used in MOBILE 4.0, 4.1, and 5a to better understand the relationships with transportation models.
- "Trip-Type Emission Estimates" (FHWA) is developing emission estimates for various trip types and lengths by commonly available modes, including door-to-door travel times and energy requirements.
- "Conformity-Finding Evaluations and Case Studies" (FHWA) is summarizing emission data collected, findings, and observations from conformity determinations and developing case studies in six to nine cross sections of areas, using the DOT/EPA Interim Conformity Guidelines.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Assessment of Transportation Emission Trends and Violations of the National Ambient Air Quality Standards (NAAQS)" (FHWA) will review violations of the NAAQS for carbon monoxide, ozone, and dust (PM₁₀); determine the role of mobile sources in those violations; and explore methods of reducing and eliminating mobile source contributions.
- "Future Motor Vehicle Emission Model Development" (FHWA) will support an EPA research effort to identify important variables needed to predict vehicle emission rates based on recent and projected emission control technology.
- "Evaluation of Heavy-Duty Vehicle Emission Characteristics" (FHWA) will evaluate methods used to estimate heavy-duty vehicle emission rates and identify ways for improving these estimates.

PUBLICATIONS AND PRODUCTS:

- *Air Quality Programs and Provisions of the Intermodal Surface Transportation Efficiency Act of 1991* (FHWA-PD-92-022).
- *Transportation Programs and Provisions of the Clean Air Act Amendments of 1990* (FHWA-PD-92-023).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.2
PROGRAM TITLE: Highway Traffic Noise and Vibration
PROGRAM MANAGER: Robert E. Armstrong

This program assesses the impacts of highway construction, operation, and maintenance on traffic noise and vibration levels. Traffic noise and vibration considerations are important elements of efficient project development programs. This program develops tools and procedures (including a traffic noise prediction model and resulting computer software) to aid in avoiding, minimizing, and mitigating adverse traffic noise and vibration impacts, and to enhance the environment to the fullest extent possible. Efforts in this program support the Federal Highway Administration Environmental Policy Statement.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Improving Highway Traffic Noise Prediction Procedures" (FHWA) reviewed the current field of national and international technical knowledge related to highway traffic noise prediction. Phase 1 resulted in an extensive literature review and recommended improved prediction procedures.

Work Underway: The following is a partial list of these studies with interim results:

- "Improving Highway Traffic Noise Prediction Procedures" (FHWA), phase 2, is developing a new highway traffic noise prediction model with implementing computer software.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Improving Highway Traffic Noise Prediction Procedures" (FHWA) will continue to improve procedures. Phase 2 will determine new reference energy mean emission levels and will incorporate recent advances in traffic noise acoustics and computer technology. A new highway traffic noise prediction model with implementing computer software will be developed.

PUBLICATIONS AND PRODUCTS:

- *Investigation of the Tire/Pavement Interaction Mechanism: Phase III Final Report, Volume 1, Tire/Pavement Contact Force Modeling (DOT-T-93-10).*
- *Investigation of the Tire/Pavement Interaction Mechanism: Phase III Final Report, Volume 2, Dynamic Response Modeling of the Inflated Tire Structure (DOT-T-93-11).*

- *Investigation of the Tire/Pavement Interaction Mechanism: Phase III Final Report, Volume 3, Modeling Tire Acoustic Response (DOT-T-93-12).*
- *Evaluation of Performance of Experimental Highway Noise Barriers (DOT-VNTSC-FHWA-92-2).*

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.3
PROGRAM TITLE: Wetlands
PROGRAM MANAGER: Paul Garrett

This program assesses the impacts of highway construction, operation, and maintenance on wetlands resources; develops methods for identifying, measuring, and assessing wetlands values and functions; and evaluates and investigates means and procedures for implementation of wetland mitigation. Wetlands have been identified as important national ecological resources of which a substantial part have been lost and continue to be lost due to human activities, including road construction. The program develops tools, manuals, and procedures to aid in avoiding, minimizing, and mitigating wetland impacts and enhancing the environment to the fullest extent possible. Efforts in the program support the Federal Highway Administration Environmental Policy Statement.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Guidelines for the Development of Wetland Replacement Areas" (Transportation Research Board) is developing guidelines for project development and construction practices applicable to creation and restoration of wetlands in all areas of the United States. Problems to be considered include water management, landscape design and revegetation practices, use of topsoil and other soil treatments, post-construction monitoring of mitigation sites, and appropriate corrective actions. A management and methods manual for the development of wetland mitigation areas is expected by March 1994.

Work Underway: The following is a partial list of these studies with interim results:

- "Regionalization of Wetland Evaluation Methodology" (FHWA, USCoE). The Wetland Evaluation Technique (WET 2.0) has been used by the FHWA to assess wetlands since the summer of 1987. This wetland assessment methodology was developed jointly by the United States Army Corps of Engineers and the FHWA, with input from the US Fish and Wildlife Service, USDA, and the Environmental Protection Agency. The procedure qualitatively assesses 11 wetland functions and values, and evaluates the probability of occurrence of a function or value at a given site. Because of extensive data requirements and the qualitative nature of the output, this methodology has not been widely accepted in assessing wetlands' impacts related to highway projects. A new assessment methodology is being developed cooperatively with the USCoE, other federal agencies, and the private sector, that will streamline data requirements, update the data base for assessment, and provide regional functional models for wetlands. The new procedure will be the choice method for routine review of section 404 permit applications. Section 404 of the Clean Water Act regulates the placement or discharge of fill material in waters of the U.S., including wetlands. The draft implementation manual was completed and fieldtested in late 1993. The new method is scheduled for implementation in fiscal year 1995.

- "Wetlands Habitat/Faunal Relationships in the Northeastern United States" (FHWA, New England Transportation Consortium) developed a data base and an interactive personal computer-based method to determine potential impacts from highway projects and other development activities on wetland-dependent species of mammals and amphibians that are compatible with other assessment approaches. The project relates critical elements in species' life histories and habitat requirements to wetlands in the Northeast. The output will be used to assess potential wetland impacts from highway construction and will determine mitigation needs. The first section of the report, which deals with mammals and amphibians, was completed in late 1993. Modification of the computer program to provide additional documentation and user-friendly features was initiated in October 1993 and completed in December 1993.
- "Evaluation of Methods of Wetland Creation Relative to Cost, Overall Effectiveness, and Practicality" (FHWA, USCoE, EPA), initiated in fiscal year 1992, evaluated the rate of recovery of wetland ecological functions in constructed and restored wetlands, and the relative cost of wetland mitigation projects in different regions of the country. Wetlands on the floodplain of the Des Plains River are being restored and enhanced. The development of wetlands soils, biological communities, and biogeochemical cycles are being investigated in these wetlands to determine the rate of recovery and the magnitude of chemical and physical changes and functional pathways. Animal populations are being monitored to determine the effectiveness of habitat recovery. Plant productivity and community structure are being measured. Hydrology and water chemistry are being studied to determine the effectiveness of wetlands in removing and/or detoxifying pollutants of various types. The second element of this study is an analysis of the cost of specific elements in wetland mitigation projects to provide a line-item cost breakout of mitigation activities. This will allow better evaluation of bids for construction of wetlands mitigation projects and will result in reduced mitigation costs. Other factors that may be evaluated include the use of soil treatments in wetland creation, timing and type of revegetation, hydrologic regime management and influence, and competitive effects on mitigation. An annual report has been submitted to the Environmental Planning Division.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Wetlands Habitat/Faunal Relationships in the Northeastern United States" (FHWA, New England Transportation Consortium), an extension of the previous work, will develop an interactive computer-based methodology to determine potential impacts from highway projects and other development activities on wetland-dependent species of birds, compatible with other assessment approaches. This project will relate critical elements in bird species' life histories and habitat requirements to wetlands in the Northeastern United States. The output will be used to assess potential wetland impacts from highway construction and determine mitigation needs.
- "Improvement of Identification and Characterization of Hydric Soils" (FHWA). The National Technical Committee for Hydric Soils published the first definition of hydric soils and classification criteria in 1985. The main assumption for defining hydric soils is that the saturation, flooding, and ponding criteria define soil conditions that are anaerobic in the upper part of the soil column. Additional information is required to refine the definition and classification of hydric soil and understand the interrelationship between hydrology, hydric soil formation, soil chemistry, and the presence of hydrophytic vegetation. Successful wetland restoration and replacement requires a thorough understanding of biological processes above and below the ground. Information on the biogeochemical soil processes is

needed to more fully appreciate the impact of soil modification on these restoration and mitigation projects. Experience with the field identification of hydric soils—a key element in identifying jurisdictional wetlands under section 404 indicates that the positive identification of hydric soils is the most difficult classification element. Positive determination of hydric soils is important in altered environments, since vegetation may be removed and normal hydrologic patterns modified. In such environments, identification of hydric soil may be a substitute for the other two key criteria—vegetation and hydrology—or may be required as verification in problem wetlands. An interagency cooperative agreement has been developed under which the Soil Survey Division of the Soil Conservation Service, USDA will investigate the geochemical characteristics, and soil-vegetation relationships and field identification of hydric soils in the Southeastern and Lake States of the United States. Output from the project is expected to be regional guides for hydric soils and the identification of suitable soil types and soil modification procedures for wetland restoration and mitigation projects.

PUBLICATIONS AND PRODUCTS:

- *Habitat Evaluation Methodology for Wetland-Dependent Reptiles, Amphibians, and Mammals in New England* (manual for a PC-based interactive program that will identify habitats and species impacts), in the publication process.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.4
PROGRAM TITLE: Environmental Processes
PROGRAM COORDINATOR: Harold E. Peaks

This research is designed to evaluate and streamline Federal environmental review requirements for highway projects. The goal is to integrate environmental considerations into the project planning and development process through improved program management techniques, better interagency coordination, and the integration of an environmental ethic throughout the Federal Highway Administration (FHWA) and the State Departments of Transportation.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Examples of Successful Mitigation and Enhancement Approaches" (FHWA) has resulted in the development of four brochures that demonstrate visually and via text how highway projects can be sensitively incorporated into the surrounding communities and the natural environment.

Work Underway: The following is a partial list of these studies with interim results:

- "Determine Appropriate Level of Environmental Analysis for Corridor Preservation" (FHWA) is supporting the efforts of North Carolina DOT and the City of Asheville to merge the environmental and thoroughfare planning processes for corridor preservation, employing the latest thinking in interagency coordination, public involvement, and environmental analysis.
- "Cumulative Effects Assessment Handbook for the National Environmental Policy Act Practices" (FHWA) is a cooperative effort with the Council on Environmental Quality and several other Federal agencies to lay out practical methods for identifying and evaluating the environmental impacts of Federal actions and actions by others when taken collectively.
- "Innovative Environmental Protection, Mitigation, and Enhancement Strategies: Case Studies" (FHWA) will examine factors associated with planning for and the implementation of mitigation measures. In addition to successful techniques and practices, the study will identify potential pitfalls and problems that can occur, and will gather information to document a variety of innovative mitigation projects.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Innovative Environmental Protection, Mitigation, and Enhancement Strategies: Case Studies" (FHWA) will produce mitigation guidelines that should be valuable under a variety of situations through the determination of how successful proposals are developed and why problems may appear. Using the information gathered, a report and a video will be

produced to document the planning and execution of selected innovative mitigation projects. These products will be made available to the State to help them plan and implement successful mitigation projects.

- "Guidelines for Determining Secondary and Cumulative Impacts, and Related Mitigation Approaches" (FHWA), a cooperative effort with the Council on Environmental Quality, will consider the effectiveness of State practices in identifying, quantifying, and mitigating potential secondary and cumulative impacts resulting from surface transportation projects, through a case study approach. Guidelines for determining both secondary and cumulative impacts will be produced to cover both early planning and project development.
- "Development of an Expert System for the Environmental Process" (FHWA) will conduct an evaluation to identify the adaptability of the environmental, social, and economic factors to a computerized expert system; examine commercially available computer software to determine program accommodation; and identify the type of computer program that can be developed.

PUBLICATIONS AND PRODUCTS:

- *Transportation Programs and Provisions of the Clean Air Act Amendment of 1990* (FHWA-PD-92-023).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.5
PROGRAM TITLE: Hazardous Materials
PROGRAM COORDINATOR: Edie Chalk

This program area is designed to provide information and guidance on management and technical problems and issues of hazardous waste and materials management in all stages of highway project development, construction, maintenance, and operations.

EXECUTIVE SUMMARY AND PROGRAM STATUS

High Priority Area: Improving Environmental Tools, Techniques, and Information

Although this is a new program area, hazardous materials-related research has been conducted by the Federal Highway Administration and State Highway Administrations for a number of years. Refer to NCP Category E, Materials and Operations, particularly E.4, Paints and Coatings for Highways and E.5, Highway Maintenance, for information on hazardous materials-related research.

Plans for Next Year: The following study is planned for fiscal year 1994:

- "Methods and Equipment to Identify, Investigate, Control, Treat, and Dispose of Right-of-Way Hazardous Substances, Materials, and Wastes" (FHWA) will catalog materials most commonly discovered in highway project rights-of-way, and accepted methodologies and equipment to handle them. It will also evaluate how successful, practicable, and economical efforts are to restore or enhance existing sites located in rights-of-way.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.6
PROGRAM TITLE: Historic Preservation and Archeological Resources
PROGRAM MANAGER: Bruce A. Eberle

The objectives of this program are to assess the usefulness of new procedures, methodologies, and technologies; to promote cost-effective historic and archeological preservation work; and to develop technology transfer products such as guidelines, computer programs, technical manuals and syntheses, video and audiovisual products, and training courses for use by Federal, State, and local transportation agencies. Efforts in this program area support the Federal Highway Administration Environmental Policy Statement and the transportation enhancements section of the Intermodal Surface Transportation Efficiency Act of 1991.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Seneca Nation of Indians Cultural Resource GIS Application Project" and "New Mexico Archeological Resource Management and GIS Project" (Soil Conservation Service, Department of Agriculture), a multiyear agreement that has been developed in conjunction with the SCS, will use remote-sensing methods and techniques to identify and evaluate subsurface archeological resources. The work will support and enlarge the scope of efforts begun earlier to combine archeological resource data, soil types, and other environmental data to help SCS and State departments of transportation to predict the locations of presently unknown resources. States from two different regions, New York and New Mexico, were selected to serve as models for this study. Efforts are currently underway to collect and enter environmental and cultural data.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Seneca Nation of Indians Cultural Resource GIS Application Project" and "New Mexico Archeological Resource Management and GIS Project," a continuation of the remote-sensing study in cooperation with the SCS, will extend into 1994.
- "Determine Innovative Techniques and Methodologies to Rehabilitate Historic and Scenic Roads" (FHWA), a multiyear study, will determine innovative techniques and methodologies to rehabilitate historic and scenic roads. This effort will be coordinated with the National Park Service, which is presently studying the historic aspects of roads in national parks.

PUBLICATIONS AND PRODUCTS:

- Participate in Archeology, (FHWA, the National Park Service, Bureau of Reclamation, U.S. Forest Service, and the Department of the Army).

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.7
PROGRAM TITLE: Water Quality
PROGRAM MANAGER: Fred Bank

This program will promote the development of improved methods, techniques, tools, models, and procedures to evaluate the water quality impacts of highway development and operation activities, particularly stormwater runoff and changes in hydrology. Research will include the identification and development of innovative best management practices, devices, and other mitigation measures.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Work Underway: The following is a partial list of these studies with interim results:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Management of the Discharge and Quality of Highway Runoff in Karst Areas to Control Impacts to Ground Water" (SP&R Pooled Fund) will be supported by possibly 12 or more States having identified problems with highways in karst regions.
- "Water Quality Synthesis" (FHWA) will combine the results of past water quality research on highway runoff and water resources. This will include computer software developed in conjunction with runoff predictive methodologies. The effort will produce a single report that should be immediately useful to highway designers and environmental personnel to determine potential problems and formulate mitigation solutions.
- "Evaluation of Water Quality Monitoring Equipment Used to Measure the Constituents of Highway Stormwater Runoff" (FHWA) will study the sampling of highway stormwater runoff with commercially available "off-the-shelf" water quality monitoring equipment. A guidance document will be prepared that describes the benefits and problems associated with various types of equipment. The results of the effort may lead to improvements in sampling equipment specifically adapted to highway drainage situations.

Plans for Next Year: The following is a planned study for fiscal year 1994:

High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Update Existing Baseline Data Used to Predict Highway Stormwater Constituents and Loading Characteristics" (FHWA) will involve extensive monitoring and evaluation of highway stormwater runoff data gathered from various types of facilities and climatic regimes. The data will be used to validate or revise existing baseline figures used in the current predictive methodology. Based on the data gathered, the predictive model will probably have to be amended to reflect revised runoff constituent concentrations, receiving water loading estimations, and background pollutant levels.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.8
PROGRAM TITLE: Community Impacts and Public Involvement
PROGRAM MANAGERS: Brenda C. Kragh—Community Impacts
Florence W. Mills—Public Involvement

This new program area consists of two closely related subareas: community impacts and public involvement. The community impacts area will identify, evaluate, and improve impact identification, assessment, and mitigation methods as they relate to community impacts. It will address direct, indirect, immediate, and projected impacts to existing and planned communities in and around surface transportation project areas at the various stages of project planning and development. Practical data needs for each stage will also be of interest.

The public involvement area will identify effective and practical methods for involving the public in transportation planning and project development. Existing public involvement methods from a wide variety of program areas will be identified and evaluated for use in transportation planning and project development. Some methods may be further developed for use specifically in a transportation setting.

EXECUTIVE SUMMARY AND PROGRAM STATUS

High Priority Area: Improving Environmental Tools, Techniques, and Information

Work Underway: The following is a partial list of these studies with interim results:

- "Update 1977 Citizen Involvement Report" (FHWA) will update an FHWA report and relate the report findings to the new ISTEA public involvement requirements in metropolitan areas.
- "Innovations in Public Involvement for Transportation Planning" (FHWA/FTA) will generate a looseleaf document of current public involvement practices at the planning level.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- "Evaluate Community Impact Assessment Methods" (FHWA), a state-of-the-art effort, will gather technical and State procedural information.
- "Innovative Techniques for Public Involvement in Transportation Planning and Project Development" (FHWA) is expected to investigate tools and techniques for involving the public in transportation planning and project development.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: K.9

PROGRAM TITLE: Technology Transfer for Environment

PROGRAM COORDINATORS: Ralph J. Rizzo—Environment
George Jones—National Highway Institute
Robert C. Kelly—Local Technical Assistance Program

This program makes the results of the environmental research program available to program managers and practitioners in Federal, State, and local highway agencies, and includes a public education component.

EXECUTIVE SUMMARY AND PROGRAM STATUS

Technology transfer is an integral component in the planning of environmental research projects, and therefore any publications, computer software programs, and/or training courses developed as a result of specific research can generally be found listed in the specific program categories. Major highlights are listed below.

TECHNOLOGY APPLICATIONS

- Transportation Air Quality Planning Conferences (FHWA, FTA, EPA, National Association of Regional Councils) were presented to Federal, State, and local transportation, planning, and environmental personnel to familiarize them with Federal policy on air quality and transportation and to inform them of new requirements mandated in the Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act of 1991. Conferences were held in Washington, DC; Atlanta; Los Angeles; and Chicago.
- Transportation Planning for Livable Communities was a series of 11 regional conferences co-sponsored by FHWA with the Surface Transportation Policy Project, the Bicycle Federation of America, the National Trust for Historic Preservation, Scenic America, the National Park Service, and the Environmental Protection Agency. The conferences brought Federal, State, and local transportation, environmental, parks, and planning officials together with environmental groups, recreation advocates, and members of the general public. The purpose was to educate those groups not historically involved in the transportation planning process to initiate dialogue and to begin building new partnerships.
- Building Partnerships—Building Bridges: Meeting Transportation and Environmental Goals, The Inside Story About South Carolina's Isle of Palms Connector is a video produced by the South Carolina Department of Highways and Public Transportation with a grant from the FHWA. The video explains how environmental considerations and public participation were built into the planning process for the Isle of Palms Connector project.
- National Symposium for State and Federal Senior Executives on Transportation and Air Quality will be sponsored by the National Governors' Association with funding support from FHWA, the FTA, and the EPA. The purpose of the conference is to foster cooperation between transportation and environmental officials at the State level. This conference will build upon a similar conference held among senior executives of FHWA, FTA, and EPA during fiscal year 1993.

NATIONAL HIGHWAY INSTITUTE

- Environmental Training Center, presented through NHI, gave environmental coordinators from the Regions, Divisions, and State departments of transportation an overview of environmental impacts that must be taken into account during the project planning and development process.
- Offered training courses on 10 different topics related to the environment and conducted a total of 52 presentations. The courses in highest demand were:
 - ◆ Project Development and Environmental Documentation
 - ◆ Hazardous Waste: Impacts on Highway Project Development
 - ◆ Practical Conflict Resolution for NEPA/404 Process

LOCAL TECHNICAL ASSISTANCE PROGRAM

- Three contracts will be developed and awarded in fiscal year 1994 for environment-related training products for LTAP: training aids for decreasing hazardous materials liability for public works agencies; recycling information package (exclusive of pavement recycling) for local transportation agencies; and informational package and videotape on understanding wetland requirements. Each product will be tailored to the needs of local transportation agencies. The products will be designed to be taught by LTAP Technology Transfer Center personnel or by the local transportation agency themselves.



L. Right-of-Way

High Priority Area

- Improving Environmental Tools, Techniques, and Information

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: L.1
PROGRAM TITLE: Corridor Preservation
PROGRAM MANAGER: Robert A. Johnson

This program identifies, evaluates, and promotes methods to preserve transportation corridors. The program makes available information to assist State and local agencies in preventing inconsistent development, and minimizing environmental, social, and economic impacts within existing and proposed corridors.

EXECUTIVE SUMMARY AND PROGRAM STATUS

High Priority Area: Improving Environmental Tools, Techniques, and Information

Work Underway: The following is a partial list of these studies with interim results:

- "Corridor Preservation: Case Studies and Analysis of Factors in Decisionmaking" (FHWA) has produced a draft report to be used by transportation program administrators in evaluating projects as candidates for corridor preservation. A number of case studies have identified the range of techniques available to protect transportation corridors, and have pinpointed critical factors to decide if the use of preservation measures should be pursued.
- "Corridor Preservation: Legal and Institutional Barriers" (FHWA) will produce a document for use by State and local government officials to identify ways to overcome barriers that exist for successfully implementing corridor preservation strategies. A draft report has been prepared that contains proposals for ways to overcome key legal and institutional barriers, and enhance efforts to implement various forms of preservation programs.

TECHNOLOGY APPLICATIONS

- "Corridor Preservation: Techniques and Applications" (NHI) involved development of a training course to provide technical staff with the tools necessary to apply corridor preservation techniques to specific projects. The course was finalized in mid-1993 and is available for presentation as NHI Course No. 15130. The 2-day course was scheduled for three to four presentations during fiscal 1993.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- Schedule presentation of NHI Course No. 15130, Corridor Preservation: Techniques and Applications, throughout the country to promote concepts, and issue final reports based on active research studies.

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: L.2
PROGRAM TITLE: Right-of-Way—Hazardous Waste and Land-Use Management
PROGRAM MANAGER: Janis Gramatins

EXECUTIVE SUMMARY AND PROGRAM STATUS

Significant Results During the Past Year:

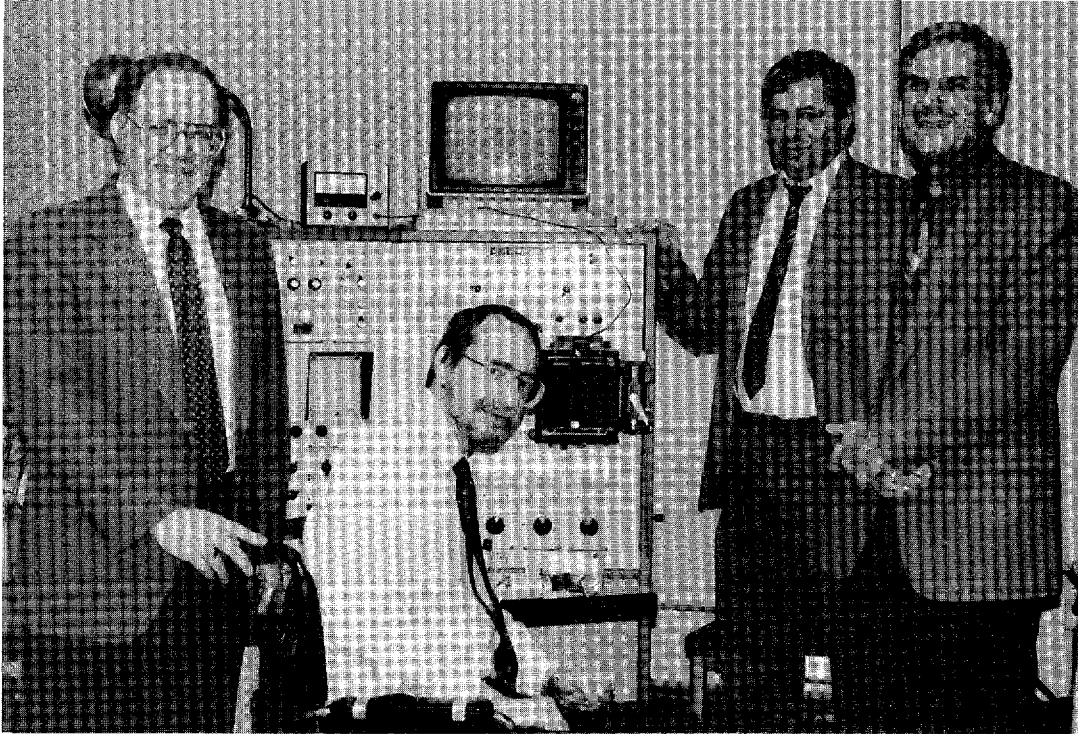
High Priority Area: Improving Environmental Tools, Techniques, and Information

- "Real Estate Market Reaction to Contamination" (FHWA) determined the real estate market's reaction to contaminated properties that are or have been contaminated by hazardous waste and/or properties that have been cleaned to State or industry standards, but suffer a reduction in value ("stigma effect"). Particular emphasis was on the appraisal of such property impacting acquisition for highway purposes.

Plans for Next Year: The following are planned research efforts for fiscal year 1994:

- The Office of Right-of-Way is preparing a task-order research study emphasizing the maintenance of transportation corridor options and the development of real estate management expertise. Areas of proposed research may include the evaluation of applicable legal and technical considerations, as well as the feasibility and methodology of establishing land banks to preserve vital transportation corridors; research on local land-use controls affecting corridor preservation; development of improved right-of-way program management techniques; identification of proper management and maintenance issues affecting joint and multiple uses of right of way; support of implementation of computerized right-of-way information (including Geographic Information Systems); review of the implementation of metrication in right of way; and the evaluation of specific legal and appraisal/acquisition issues.





M. Advanced Research

NATIONALLY COORDINATED PROGRAM OF HIGHWAY RD&T

PROGRAM NUMBER: M
PROGRAM TITLE: Advanced Research
PROGRAM MANAGER: Thomas J. Pasko, Jr., P.E.

This program conducts research and performs innovative adaptations of emerging and advanced technologies that have long-range application in the highway program. The research and technology adaptation is coordinated with the National Science Foundation, Federal and State agencies, and others, in the following areas:

Highway Innovative Technology Evaluation Center (HITEC)—Lou Colucci

- The office has a cooperative agreement with the Civil Engineering Research Foundation to evaluate innovative highway technologies. This center will assist private industry in introducing new technology into the highway program.

Decision Analysis in Transportation—Mort Oskard, Ph.D.

- Provides R&D for technology to improve the accuracy and efficiency of engineering analyses performed at the FHWA and the State highway agencies. Areas include optimization methods in planning R&D, neural networks, multi-criteria decision methods, nonlinear finite element methods, and investment analysis (life-cycle costs). One topic of current prime interest is an upgrading of pavement system analysis methods based on a phenomenological understanding rather than an empirical approach. Many other subject areas are also being investigated.
- Provides internal training opportunities for the TFHRC staff in advanced methods. Typical subjects are neural network fundamentals, advanced mathematical methods, nonlinear finite element method, optimization methods, and others. Non-linear finite element models are currently being constructed in five different research areas where this modeling approach offers significant benefits over current practice.
- Provide an introspective evaluation of the technical activities at TFHRC. This Operations Research approach will place emphasis on the fundamental disciplines that are of concern to the highway community and how well those disciplines are being applied to highway-related issues. This work is a precursor to a systematic search for new technologies that can extend the quality of our present performance.

High Performance Materials—Thomas J. Pasko, Jr., P.E.

- Includes R&D into optimizing prototype structures, minimizing quantities (lighter/longer structures, composite action), and institutional issues.
- A task group from 16 government agencies is working on a plan for an interagency research, development and technology transfer effort for improving infrastructure/construction materials.

- A parallel FHWA effort is underway led by the Civil Engineering Research Foundation (CERF) to bring together the private and public sectors for a program on "High-Performance Construction Materials and Systems: An Essential Program for America and Its Infrastructure."
- A cooperative research effort has been initiated with Texas to construct a high-strength concrete bridge from 70 to 105 MPa (10,000 to 15,000 lbf/in²). Parallel efforts are being explored in Louisiana and Minnesota, and a pooled fund study has been proposed.

Self-Monitoring Systems—Chuck McGogney, P.E.

- Provides R&D for inspection techniques, smart materials (sensors, visual warning, reactive), multi-property nondestructive evaluation (NDE), and global NDE.
- An interagency agreement has been set up with the National Institute of Standards and Technology, (NIST) Boulder, Colorado, to investigate the fundamental relationship between fracture mechanics and the generation of acoustic emission signals.
- "Relating Acoustic Emission Signals to Microfailure Events" (FHWA) will obtain more information on bridge integrity from self-monitoring systems.
- "Monitoring Structural Degradation using Magnetostrictive Sensors" (FHWA) will evaluate magnetostriction as a nondestructive test method for steel and reinforced concrete structures.

Robotics/Automation/Man-Machines— Dah-Cheng "Charles" Woo, Ph.D.

- Provides R&D to incorporate these automation technologies into the areas of highway construction, maintenance and operations in order to improve safety, reduce costs, and maintain continuous quality control.
- Two workshops, Automation/Robotics for Road Construction, Maintenance, and Operations and Application of Robotics and Automation to Highway Construction, Maintenance and Operations (FHWA, NIST), reviewed the state of the art of construction robotics and automation in road construction, maintenance, and operations, and identified candidate technologies for future development.
- "Robotic Bridge Paint Removal, Fieldtesting, and Evaluation of Promising Technologies" (FHWA) is evaluating paint removal technologies for their suitability for robotic control.
- Several highway construction sites are under consideration to serve as testbeds for streamlined construction using site integration through hierarchical control.
- "Automated Measurement of Aggregate Indices of Shape" (FHWA) will construct a second generation imager, optimized for aggregate analysis.

Computer-Driven Technologies—James A. Wentworth, P.E.

- Provides R&D for artificial intelligence and computer-based technologies, including expert systems, fuzzy logic, machine vision synthesis, advanced communications/computer systems, and statistical computation methods and other advanced mathematical concepts for application in highway programs.
- In expert systems there is ongoing research on methods for program verification, validation and evaluation. Also, a prototype Inductive Loop Detector Expert Analyst has been developed to demonstrate the feasibility of embedding an expert system in field test hardware. Followup in these areas is scheduled. Separate projects to apply voice recognition/synthesis to incident management situations and to evaluate virtual reality to highway R&D are under development.

- In sensor technology, an overhead infrared vehicle detector developed under administrative contract and the SBIR program, has been successfully tested in Los Angeles. Planned additional work includes combining this sensor with a solar-powered communications system and interfacing it with a neural network for vehicle classification and travel time calculations.

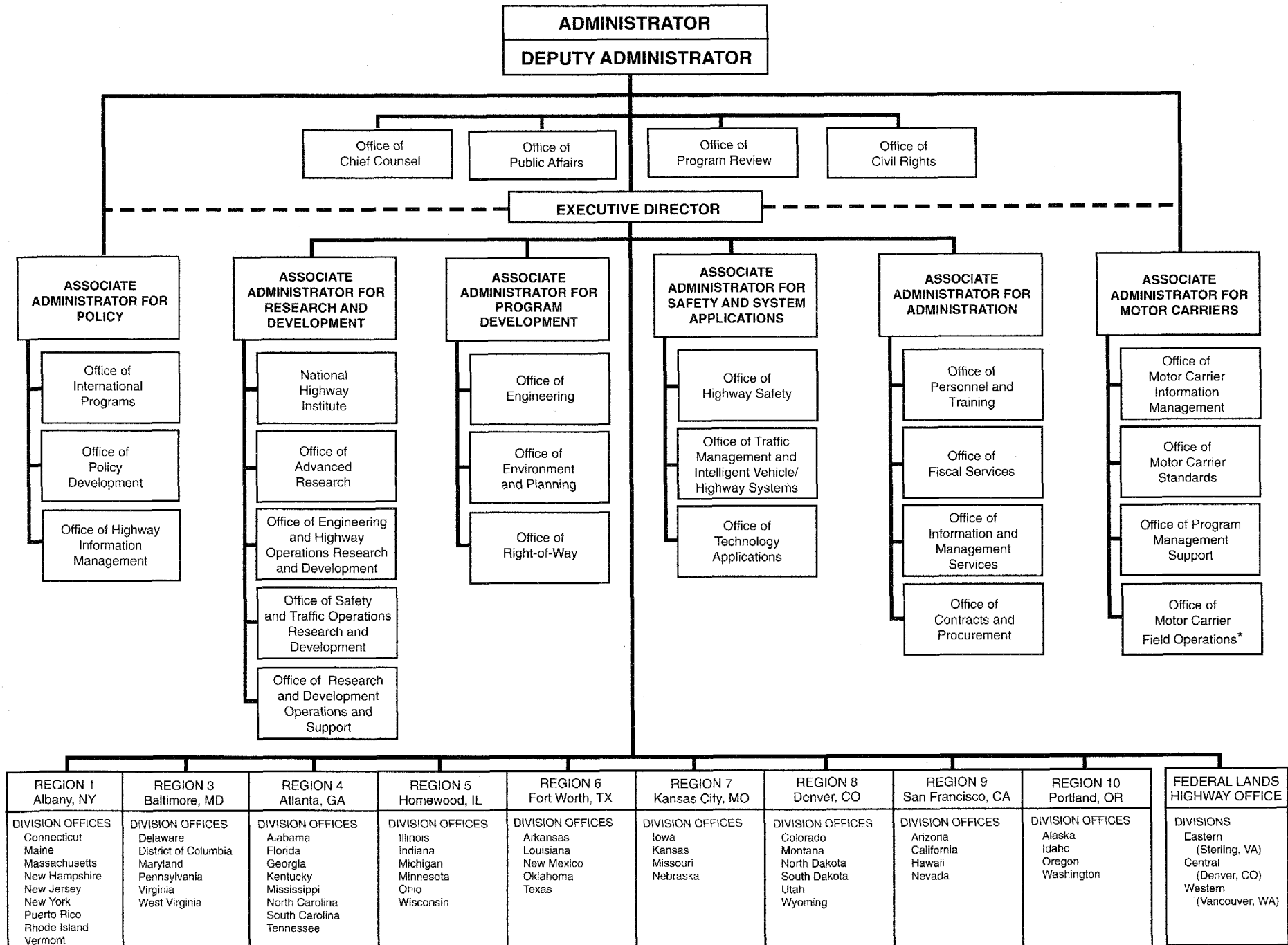
Energy and Conservation-Related Technologies—Richard Livingston, Ph.D.

- Provides R&D for incorporating the use of waste and byproduct materials into highway construction and maintenance in the following areas: upgrading materials via chemical treatment, high temperature materials processing, laser-fused surfaces, new cements as well as institutional, and environmental and safety issues.
- The TFHRC X-ray diffraction instrument is being upgraded and interfaced with desktop computers to use advanced software for quantitative materials analysis. This will be to analyze waste materials such as blast furnace slag, fly ash, and fused incinerator ash to develop more reliable predictors of their performance in concrete.
- An interagency agreement has been set up with NIST's Cold Neutron Research Facility to apply neutron scattering techniques to study the development of concrete microstructure as a function of the addition of silica fume, pozzolans, or reactive aggregates.

Future Freight Movements—Milton K. Mills

- A cooperative agreement has been executed with the Volpe National Transportation Systems Center for a preliminary analysis of a system that uses self-powered freight-carrying capsules in tubes.
- An effort is planned for conducting deployment community interviews with transportation companies, users, and others to determine the best application of self-powered freight-carrying capsules in tubes, truck-only roadways, and separate truck lanes on multilane roadways.

FEDERAL HIGHWAY ADMINISTRATION



* Federal-aid Regional Offices and Regional Offices of Motor Carriers are collocated in each of the Regions. The Regional Directors of Motor Carriers report to the Associate Administrator for Motor Carriers through the Office of Motor Carrier Field Operations.

