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Publication No. FHWA-PL-03-001
HPIP/10-02(5M)EW

Pavement Preservation Technology
In France, South Africa, And Australia

U.S. Department of Transportation
Federal Highway Administration

International Technology Exchange Program

OCTOBER 2002

NOTICE

The metric units reported are those used in common practice by the persons interviewed. They have not been converted to pure SI units because in some cases, the level of precision implied would have been changed.

The publication of this document was sponsored by the U.S. Federal Highway Administration under contract number DTFH61-99-C00005. awarded to American Trade Initiatives, Inc. Any opinions, options, findings, conclusions, or recommendations expressed herein are those of the authors and do not necessarily reflect those of the U.S. Government, the authors' parent institutions, or American Trade Initiatives, Inc.

Technical Report Documentation Page

1. Report No. FHWA- PL-03-001	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Pavement Preservation Technology in France, South Africa, and Australia		5. Report Date October 2002 6. Performing Organization Code
7. Author(s) Tommy L. Beatty, Dennis C. Jackson, Dan A. Dawood, Robert A. Ford, James S. Moulthrop, Gary D. Taylor, Frank L. Danchetz, Duane A. Blanck, Jerry M. Fay, David S. Keough, Luis M. Rodriguez, Michael D. Voth, and Zane L. Webb		8. Performing Organization Report No.
9. Performing Organization Name and Address American Trade Initiatives P.O. Box 8228 Alexandria, VA 22306-8228		10. Work Unit No.(TRAIS) 11. Contract or Grant No. DTFH61-99-C-0005
12. Sponsoring Agency Name and Address Office of International Programs Office of Policy Federal Highway Administration U.S. Department of Transportation American Association of State Highway and Transportation Officials		13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes FHWA COTR: Hana Maier, Office of International Programs		

16. Abstract

An increasing number of highway agencies have found that applying relatively low-cost surface preservation treatments can extend the service life of pavement. The Federal Highway Administration, American Association of State Highway and Transportation Officials, and National Cooperative Highway Research Program sponsored a scanning study of France, South Africa, and Australia to investigate innovative programs for pavement preservation.

The U.S. delegation observed that the countries visited are committed to designing and building long-lasting structural pavement sections on their national roadway networks. The countries focus on road maintenance, using low-cost seals and thin overlays on surfaces to protect their investment in underlying layers, rather than on more costly rehabilitation.

The scanning team's recommendations for U.S. application include developing demonstration projects using deep subbase and deep base roadway designs, testing innovative procedures to improve chip seal performance, conducting a best-practices seminar on long-term maintenance contracts, and evaluating pavement condition survey vehicles.

17. Key Words Key words Pavement preservation, preventive maintenance, pavement management system, pavement condition survey vehicle, chip seal, deep base, deep subbase, bitumen, aggregate, concrete, asphalt	18. Distribution Statement No restrictions. This document is available to the public from the Office of International Programs FHWA-HPIP, Room 3325 US Dept. of Transportation Washington, DC 20590 international@fhwa.dot.gov www.international.fhwa.dot.gov		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 56	22. Price Free

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Pavement Preservation technology
In France, South Africa, and Australia

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U.S. DEPARTMENT OF TRANSPORTATION

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

THE NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
(PANEL 20-36)
OF THE TRANSPORTATION RESEARCH BOARD

OCTOBER 2002

ACKNOWLEDGMENTS

As with all collegial efforts, this scanning study would not have been successful without the assistance of many individuals. The team is particularly appreciative of the outstanding contributions of the officials, engineers, technical personnel, and their staffs in the places we visited (Appendix A). These individuals and their organizations contributed countless hours both in front of and behind the scenes, responding to the team's amplifying questions, preparing and presenting technical information, arranging and guiding site reviews, and generously giving their time and expertise.

The advice, counsel, and organizational insight of the staff of American Trade Initiatives, Inc. (ATI) were invaluable to all facets of the trip and production of the scan report documents. ATI, under contract to the Federal Highway Administration (FHWA), managed travel logistics for the trip. ATI also assisted in preparing this report and other documents. The team would like to recognize the contributions of the following ATI staff:

- Joe Conn for his guidance, leadership, and insight.
- Jake Almborg for his tireless efforts and amazing organizational skills coordinating travel logistics, team finances, and meetings. The team was constantly amazed at Jake's decorum and dedication to the task at hand in the midst of changing schedules, overbooked flights, and the rigors of international travel.
- Alexandra Doumani for her indefatigable spirit and attention to detail in making travel arrangements, handling the team's finances, and coordinating trip reports.

Sponsors of the trip were the FHWA Office of International Programs, the American Association of State Highway and Transportation Officials through the National Cooperative Highway Research Program, and the Foundation for Pavement Preservation.

FHWA INTERNATIONAL TECHNOLOGY EXCHANGE PROGRAMS

The Federal Highway Administration's (FHWA) international programs focus on meeting the growing demands of its partners at the Federal, State, and local levels for access to information on state-of-the-art technology and the best practices used worldwide. While FHWA is considered a world leader in highway transportation, the domestic highway community is interested in advanced technologies being developed by other countries, as well as innovative organizational and financing techniques used by FHWA's international counterparts.

The International Technology Scanning Program accesses and evaluates foreign technologies and innovations that could significantly benefit United States highway transportation systems. Access to foreign innovations is strengthened by U.S. participation on the technical committees of international highway organizations and through bilateral technical exchange agreements with selected nations. The program is undertaken cooperatively with the American Association of State Highway and Transportation Officials (AASHTO) and its Select Committee on International Activities, and the Transportation Research Board's (TRB) National Highway Research Cooperative Program (Panel 20-36), the private sector, and academia.

FHWA and its partners jointly determine priority topic areas. Teams of specialists in the specific areas of expertise being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, and financing. Teams usually include Federal and State highway officials, private sector and industry association representatives, and members of the academic community.

FHWA has organized about 50 of these reviews and disseminated results nationwide. Topics have included pavements, bridge construction and maintenance, contracting, intermodal transport, organizational management, winter road maintenance, safety, intelligent transportation systems, planning, and policy. Findings are recommended for follow-up with further research and pilot or demonstration projects to verify adaptability to the United States. Information about the scan findings and results of pilot programs are then disseminated nationally to State and local highway and transportation officials and the private sector for implementation.

This program has resulted in significant improvements and savings in road program technologies and practices throughout the United States, particularly in the areas of structures, pavements, safety, and winter road maintenance. Joint research and technology-sharing projects have also been launched with international counterparts, further conserving resources and advancing the state of the art.

For a complete list of International Technology Scanning topics, and to order free copies of the reports, please see pages iv-v.

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ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ALD	average least dimension
APWA	American Public Works Association
AUSTROADS	Association of Australian and New Zealand Road Transport and Traffic Authorities
ATI	American Trade Initiatives
BOT	build, operate, and transfer
CAM	crack activity meter
CBR	California bearing ratio
CRCP	continuously reinforced concrete pavement
CRS	cationic rapid-setting emulsion asphalt
DOT	Department of Transportation
EMA	ethyl methacrylate
EVA	ethylene vinyl acetate
EVU	equivalent vehicle units
FHWA	Federal Highway Administration
FP2	Foundation for Pavement Preservation
GPS	global positioning system
GVM	gross vehicle mass
HMA	hot-mix asphalt
IRI	international roughness index
JPCP	jointed plain concrete pavement
LA	Los Angeles
NACE	National Association of County Engineers
NCHRP	National Cooperative Highway Research Program
PCCP	portland cement concrete pavement
PMS	pavement management system
RFP	request for proposal
RTA	Roads and Traffic Authority (New South Wales, Australia)
SAMI	stress-absorbing membrane interlayer
SANRAL	South African National Road Agency Limited
SBR	styrene butadiene rubber
SBS	styrene butadiene styrene
STIP	scan technology implementation plan
TRB	Transportation Research Board
VicRoads	Victorian State Road Authority
VOC	vehicle operating cost

CONTENTS

EXECUTIVE SUMMARY

BACKGROUND

Traditionally, highway agencies have allowed the ride quality and structural condition of their pavements to deteriorate to fair or poor condition before taking steps to rehabilitate them. The aim of rehabilitation is to repair structural damage and restore measurable pavement conditions such as ride, rutting, and cracking. This is a costly and time-consuming activity with associated traffic disruptions and inconvenience to adjacent businesses and residences.

In recent years, increasing numbers of highway agencies have found that applying a series of low-cost pavement preservation treatments can extend the service life of pavement. This translates into a better investment and increased customer satisfaction and support. France, South Africa, and Australia are recognized as nations with innovative programs and new treatments for pavement preservation.

OBJECTIVE AND PANEL COMPOSITION

The objective of the scanning study was to review and document innovative techniques, materials, procedures, and equipment used in the host countries for pavement preservation and to evaluate these elements for potential application in the United States. To this end, the scanning team met with government agencies and private-sector organizations involved with pavement preservation, and visited sites to observe the results of pavement preservation techniques and strategies.

The Federal Highway Administration (FHWA), an agency of the U.S. Department of Transportation, the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP) jointly sponsored the Pavement Preservation International Scanning Study. The delegation included members representing State departments of transportation in Georgia, Michigan, Pennsylvania, and Texas; National Association of County Engineers; FHWA; National Park Service; American Public Works Association; and from the private sector, Koch Materials Company and Kristen Betty and Associates.

KEY FINDINGS

The team noted several key findings or actions taken in the host countries that have had a marked impact on pavement preservation activities and program success:

- All the countries visited have made a commitment to designing and building long-lasting structural pavement sections on their national roadway networks. This decision has caused these nations to focus maintenance activities on surface courses to preserve the large investment in underlying layers. This, in turn, promotes the use of relatively low-cost seals and thin overlays as the primary maintenance techniques, instead of more costly types of rehabilitation.
- Providing initially high structural capacity enables highway agencies to use relatively low-cost seals and thin overlays on set, repeatable cycles. For the most part, rehabilitation is a minor part of agencies' maintenance programs. Consequently, agencies emphasize pavement preservation techniques.

- All three countries use only quality materials for both bitumen and aggregate. Generally, crushed aggregate and proven polymer-modified asphalt binders are used. This is ensured through the use of rigorous specifications. Materials sources are specified and there is no inhibition to using sources a great distance away from the project site.
- Warranties, usually four years in duration, are used in contracts when applying preventive maintenance techniques. The functional properties warranted are friction, rutting, and smoothness. The responsibility of the contractor for the repair of non-compliant sections reduces with time and traffic. A secondary effect of the application of warranties has been the innovation of materials and mixtures by contractors and material suppliers.
- France uses a system called the Charter of Innovation, through which the government and industry share in the risk of experiments to develop new and innovative products. Requests for proposals are issued annually for new products and test sections are constructed. Surveys are conducted with the company and government sharing in the cost. Successful products are then accepted nationally for inclusion in the preventive maintenance program.

RECOMMENDATIONS

After discussing and evaluating what they had observed in the three countries, the team developed the following recommendations with potential for implementation in the United States. The findings, observations, and recommendations are those of the scanning team and not of FHWA.

1. Initiate demonstration projects with deep subbase and deep base designs in different regions of the country to determine the effectiveness of this design strategy.
2. Encourage highway agencies to include pre-coating of chips in their chip seal specifications.
3. Test and evaluate geotextile-reinforced chip seals in both freeze and no-freeze environments.
4. Encourage agencies that do not use modified binders for chip seals to do so.
5. Encourage agencies to review their specifications and upgrade them where appropriate so that superior aggregates are used and improved service life is achieved.
6. Encourage agencies to review their design practices for chip seals and consider placing them on base or subbase courses to prevent moisture infiltration.
7. Encourage agencies to apply chip seals earlier in the distress cycle.
8. Investigate the practice in New South Wales of placing thin (40-to-60-millimeter) asphalt overlays on portland cement concrete pavement.
9. Encourage AASHTO and FHWA to develop a mechanism to evaluate and implement new and innovative products and processes.

10. Encourage AASHTO and/or FHWA to conduct a seminar to share best practices and investigate the possibility of demonstration projects in the United States using long-term maintenance contracts.
11. Conduct studies of Road Crackä , a pavement condition survey vehicle, and similar vehicles to evaluate the potential for use by transportation agencies. If warranted, develop a pilot program for a side-by-side field evaluation of these vehicles.

IMPLEMENTATION

A small group of scanning team members has developed a technology implementation plan that outlines a series of activities to document, showcase, apply, and evaluate the innovative pavement preservation techniques, processes, materials, and equipment used in the nations visited. These activities will be directed at educating the U.S. highway community about the effectiveness and value of these innovative technologies.

Chapter one
INTRODUCTION

BACKGROUND

Traditionally, highway agencies have allowed the ride quality and structural condition of their pavements to deteriorate to fair or poor condition before taking steps to rehabilitate them. The aim of rehabilitation is to repair structural damage and restore measurable pavement conditions, such as ride, rutting, and cracking. This is a costly and time-consuming activity with associated traffic disruptions and inconvenience to adjacent businesses and residences. In recent years, an increasing number of highway agencies have found that applying a series of low-cost pavement preservation treatments can extend the service lives of their pavements. This translates into a better investment and increased customer satisfaction and support.

The concept of highway system preservation using a variety of pavement preservation techniques and strategies is gaining interest in the United States. Scanning studies provide an invaluable opportunity to benchmark foreign technical and managerial practices for the benefit of public- and private-sector partners in the U.S. transportation community. In light of this, France, South Africa, and Australia were selected as

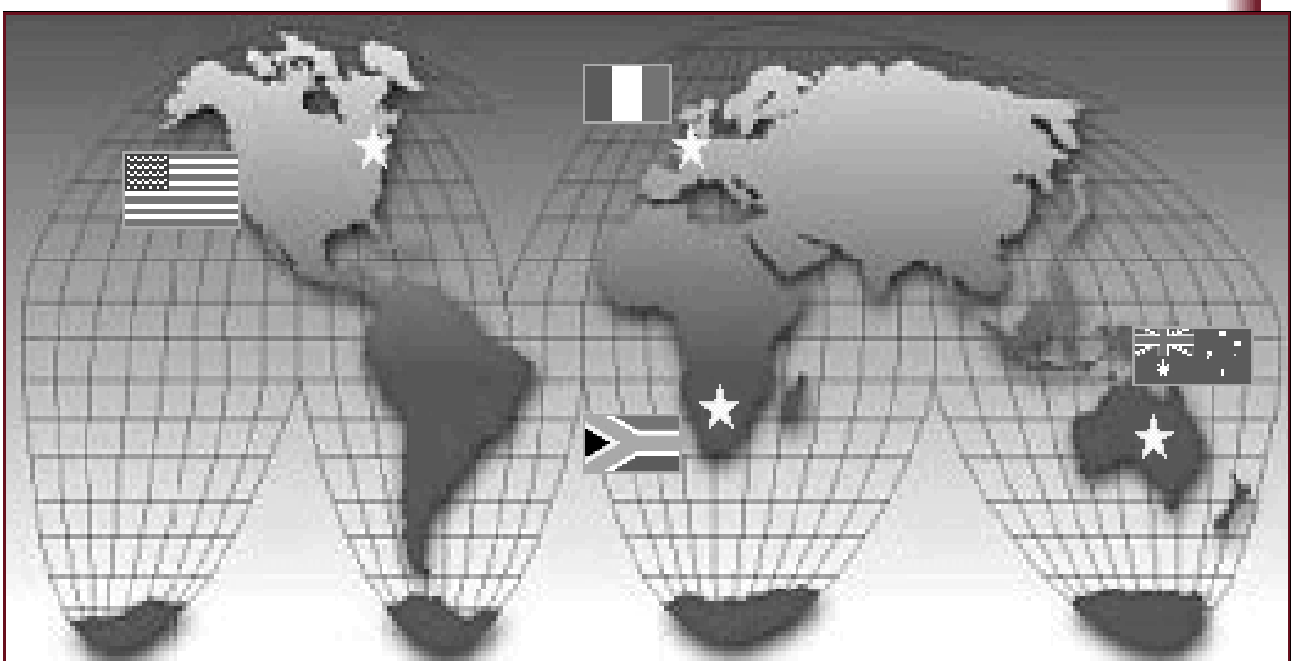

Figure 1. The scanning team visited France, South Africa, and Australia to observe pavement preservation innovations.

destinations for a scanning study team, having been identified as nations with innovative programs and state-of-the-art treatments for pavement preservation.

The scanning team started in Paris and Nantes, France; continued to Pretoria and Johannesburg, South Africa; and completed the study in Australia with visits to Perth in Western Australia, Melbourne in Victoria, Brisbane in Queensland, and Sydney in New South Wales.

OBJECTIVE AND PANEL COMPOSITION

The scanning study's objective was to review and document innovative techniques, materials, procedures, and equipment used in the host countries for pavement preservation and to evaluate these elements for potential application in the United States. To this end, the panel met with government agencies and private-sector organizations involved with pavement preservation, as well as visited sites to observe firsthand the results of pavement preservation techniques and strategies.

The Federal Highway Administration (FHWA), an agency of the U.S. Department of Transportation, the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP) jointly sponsored the Pavement Preservation International Scanning Study. The delegation included members representing State departments of transportation (DOT) in Georgia, Michigan, Pennsylvania, and Texas; National Association of County Engineers; FHWA; National Park Service; American Public Works Association; and from the private sector, Koch Materials Company and Kristen Betty and Associates (Appendix B). Team members have expertise in program development and administration, pavement design and management, construction, materials, and maintenance.

Team members developed a list of amplifying questions (Appendix C), which was sent to each country before the study. These questions provided the host countries with an understanding of the topics of interest to the U.S. team and enabled the hosts to plan their presentations and site visits accordingly. The amplifying questions focused on four major topics:

- Management perspective and policies
- Resource commitment and cost-effectiveness
- Treatments, techniques, and performance
- Innovative methods, practices, and procedures

Figure 2. Team members met frequently during the tour to share observations.

Team members shared their experience, expertise, and opinions among themselves and with the hosts. As a result of these exchanges, excellent formal presentations, and informative site visits, the team developed general observations and key findings relating to the practice of pavement preservation in the three countries. The team also developed recommendations for potential implementation in the United States.

The technical information gathered during the study is included in this report. Chapter Two, General Observations, covers information about pavement preservation that team members believe is of general interest to the highway community. Chapter Three, Key Findings, outlines actions the host nations have taken that have had a marked impact on pavement preservation activities and program success.

Team members met both before the trip and during the course of their travels. In addition, a formal meeting at the end of the trip and correspondence added further refinements to this report. The report is not intended to be a synthesis of international practice, but a compilation of the team's thoughts, observations, key findings, and recommendations.

Chapter Two
GENERAL OBSERVATIONS

Throughout the study, the team gathered valuable information not only at formal presentations and discussions, but also during site reviews and travel between venues. Other good sources of information were the informal one-on-one discussions and question-and-answer sessions individual team members had with their hosts. The information derived through these and other methods of communication is included below. These general observations are categorized by subject matter and country.

The study validated the fact that pavement preservation strategies and techniques used throughout the United States enjoy levels of success similar to those used in the host countries. Among them are institutionalizing systematic methods of programming and dedicated funding, using high-quality materials and sophisticated construction equipment, including pavement preservation as an internal element of long-term performance, and recognizing and overcoming potential barriers to success.

ROAD SYSTEM

France

- The roadway system in France includes the following networks:
  - 10,711 kilometers of Motorway toll roads (7,186 kilometers under concession)
  - 2,500 kilometers of non-toll Motorway roads
  - 28,000 kilometers of national (state) roads
  - 316,000 kilometers of department (county) roads
  - 580,000 kilometers of commune (city) roads

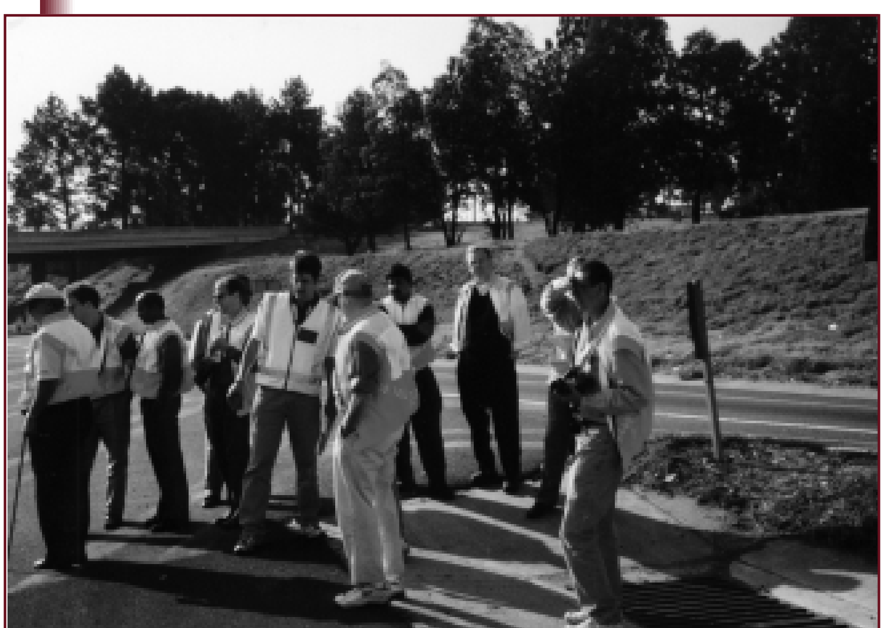

Figure 3. The team visited sites where pavement preservation treatments have been applied.

- Each network is managed separately and has a distinct purpose and expected level of service. Generally, toll roads are maintained at a higher level than the rest of the system because of a dedicated, toll-supported revenue stream.
- Construction of the French Motorway system, which serves as the equivalent of the U.S. Interstate system, began in the 1960s. Pavement sections built since 1980

were designed with an expected life span of 30 years. Since the system is relatively young, its overall condition is quite good. Forty percent of traffic is on the national network and 90 percent of the system is asphalt concrete.

- Although research and development activities are centralized, contractors are involved both in quality assurance and in developing technologies to achieve better results through the use of proprietary products.

South Africa

- The Republic of South Africa's road network includes national, provincial, and local systems. The national system includes about 19,000 kilometers of primary roadway, which is similar in function to the U.S. Interstate system. The South African National Road Agency Limited (SANRAL) manages about 7,000 kilometers. The remainder is managed provincially but has been identified as serving a national function. SANRAL is a registered company of which the National Minister of Transport is the sole shareholder. It was created in 1998 to replace the Chief Directorate, National Roads of the National Department of Transport. It is run like a business instead of a government department. Provincial road systems total about 170,000 kilometers, while local systems include about 350,000 kilometers. About 64,000 kilometers of the local system is surfaced. It is up to the provinces to fund, build, repair, and operate their individual systems.
- The national network consists of 45 percent seals, 46 percent hot-mix asphalt of various types, 8.7 percent jointed plain concrete pavement, and 0.3 percent continuously reinforced concrete pavement. South Africa has 100 kilometers of concrete overlays on flexible pavements and 30 kilometers of 160-to-230-millimeter concrete inlays on flexible pavements.

Australia

- The Australian road network is made up of national, state, and local systems. The national system includes roads that connect states and have been federally identified as serving national needs. Maintenance responsibility for the national road system lies with the states. Funding for maintaining this system comes from the national government. The remainder of the state-maintained system provides arterial service within each state. More than 75 percent of all traffic occurs on the state-maintained network. States are broken up into smaller regions that manage maintenance of the state system at the local level. Municipalities and other local entities manage local systems. Approximate network lengths are included in the following table:

STATE	NATIONAL (KM)	STATE (KM)	LOCAL (KM)
WESTERN AUSTRALIA	4,600	12,600	78,100
VICTORIA	18,000	22,200	127,000
QUEENSLAND	4,000	34,000	133,000
NEW SOUTH WALES	19,000	20,700	142,000

Table 1. Breakdown of Australian system lengths by state networks.

- Truck rates are growing at rates similar to those in the United States. This has a significant impact on Australian roads because of permissible triple axle configurations.
- States use benchmarking to evaluate the progress and effectiveness of pavement maintenance strategies. The Victorian State Road Authority (VicRoads), for example, reduced routine maintenance costs from $920 per lane kilometer in 1993 to $730 per lane kilometer in 2000.

PRIVATIZATION

France

- Of the total Motorway network, 7,186 kilometers are owned and operated by concessionaires (builder/operator). A toll of half a franc per kilometer (6 cents per mile) is charged to users to cover costs of financing, construction, operation, and maintenance and to generate a profit. Concessionaires sell shares in the road system and are allowed to hire whomever they wish to do repairs. Concessionaires are totally liable for safety issues. The French government is a shareholder in the concessionaire companies and over half of the total system budget is generated from toll revenues. This partnership appears to be successful.
- French concessionaires are totally integrated in both design and construction. France's unique contractor/owner relationship encourages innovation and has led to a number of patented processes and mixes.

Australia

- The general trend is toward privatization of road functions, including design, maintenance, and construction. The extent varies from state to state. According to the states' data, this has led to cost reductions. Western Australia has contracted out more than 90 percent of its activities and has reduced its staff from more than 2,500 to 700 employees. State agencies have some concerns about their ability to adequately administer maintenance contracts, but are committed to the success of the program.
- Privatization is carried out through a number of contract strategies:
  - Single-invitation contracts – Negotiated contracts with local governments to do work. Because rural populations are sparse and local economies may not remain viable, contracts are negotiated with local governments to support the local economy. This may have some effect on the type of work performed on the local network.
  - Performance-specified maintenance contracts – Long-term (10-year) contracts based on roughness, cracking, rutting, and texture for pavement performance and other measures for additional routine maintenance items.
  - Scheduled-rate contracts – Contracts with set schedules for unit costs of work necessary for maintenance items and rehabilitation work.
  - Tendered contracts – Low-bid contracts.

FUNDING

France

- With the exception of tolls, no dedicated public funding source generates funds for roads. All taxes, including fuel taxes, go to a general fund from which a road budget is allocated. Funding allocations for preventive maintenance are based primarily on roadway use, not on condition. Specific treatments are selected at the local level. Funding allocations for rehabilitation, or structural repair, are based on condition. In both cases, funds available for allocation are obtained from a general fund and the magnitude of funds available for maintenance is determined through the political process.
- The Ministry of Transport's 1998 budget was:
  - 1.3 billion euros – state budget
  - 643 million euros – local authority financing (regions, counties, towns)
  - 2.4 billion euros – Motorway concession company financing (loans, self-financing, equity capital)
  - 564 million euros – proportion of toll revenue allocated to maintenance
- Maintenance of tollways where funding is consistent and predictable is good, but a 2001 analysis of government activities indicated not enough money is available for preventive maintenance on the national system.

South Africa

- SANRAL's policy is to foster social equity and sustained economic growth, as well as to promote employment and redistribution of wealth. Consequently, social needs have a high priority and are weighted against the role transportation plays in the country's economy.
- No ongoing dedicated funding source is available for road building and repair, although a three-year conditional grant provides some funding. Money is appropriated to SANRAL for national roads from a central budget system, but there is no specific formula or amount. The government also allocates money for each provincial budget. The provincial government then determines how much to spend on building and repairing roads. In most cases, toll revenues can be spent only on toll roads.

Australia

- No dedicated funding sources are available for transportation in Australia. Taxes are collected on fuel, automobile sales, and licensing and are deposited into general government accounts. Funds are then allocated to the states from the federal government through the budget process.
- Maintenance responsibility for the national road system lies with individual states. Funding for managing the system comes from the federal government, but in most cases funds provided are insufficient to fully maintain these facilities. Some states subsidize the funding shortfall, while others modify their

national roads maintenance by optimizing their programs with the funds provided. These allocations are not based on pavement management analysis. For the most part, states spend a high percentage of their maintenance funding on preservation rather than rehabilitation. Some agencies such as VicRoads make minor improvements in each of their preservation projects without committing to a rehabilitation treatment.

PAVEMENT MAINTENANCE STRATEGIES

France

- In the French road system, the philosophy is to build a strong base so that the wearing surface needs repaving only every 10 or 15 years and a structural overlay needs to be placed every 20 years. Reconstruction is not common. Several overlay types (thin, ultra thin, etc.) are used, with a specific course thickness assigned to each. For the national highway system, rehabilitation projects are selected at the national level. For all other roadways, decisions on types of treatments are made locally.
- Pavement preservation and maintenance activities focus on functional issues, such as improved skid resistance, noise reduction, and enhanced ride. This emphasis mirrors the Ministry of Transportation's stated goals for maintenance of improved safety, environmental protection, and greater efficiency of public service.

South Africa

- Pre-coating of aggregate is used to a large extent to prevent aggregate loss. Pre-coating is accomplished by blending bitumen and aggregate in the stockpile. The primary pavement maintenance treatment is a variety of surface seals, selected on the basis of both research and hands-on experience. Each maintenance project is engineered on the basis of established design guidelines, including a decision-tree approach.

Australia

- Asset management programs for pavement maintenance and rehabilitation are used by all state road agencies in Australia. These programs, similar to pavement management systems in the United States, vary from state to state. Asset management programs are well thought out and include prioritization modeling as well as cost-benefit analysis. Asset management programs have been used effectively in identifying needs and in convincing management that more funding is needed for road maintenance.
- Except in urban areas, the road-building philosophy in Australia is to build a deep subbase and a strong unbonded base course with a thin asphalt wearing course.
- In New South Wales, the Roads and Traffic Authority has developed a strategy that includes a five-year infrastructure maintenance plan. This plan identifies road maintenance needs based on road system performance, assessment of road features, condition, and community benefits.

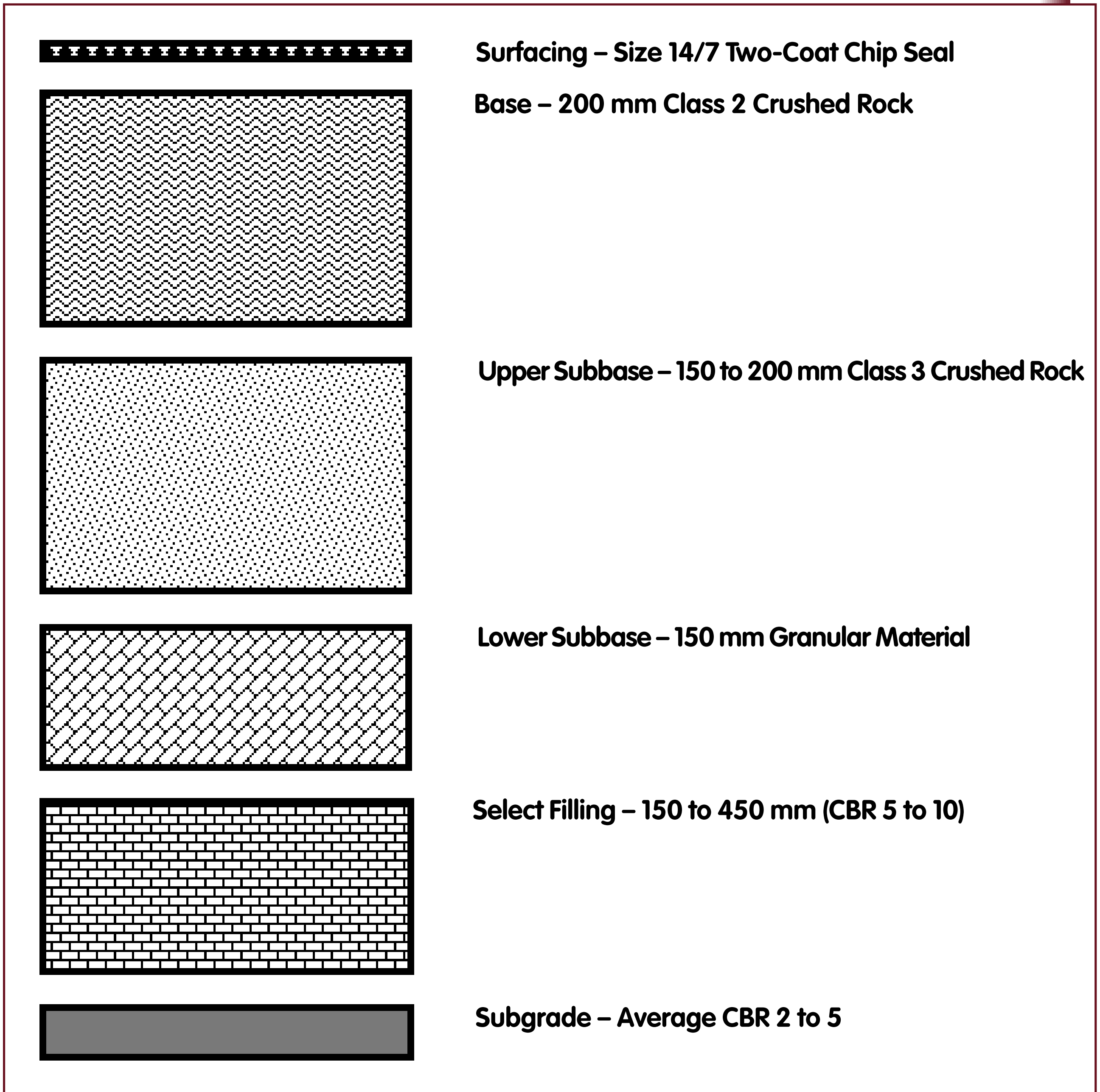

Figure 4. A typical heavy-duty granular pavement section includes a deep subbase.

- In Western Australia, the most commonly used preservation treatment in urban areas is milling the surface layer and applying a stress-absorbing membrane interlayer followed by a thin (30-millimeter) overlay. On lower-volume roads, they reseal (chip seal) roadways and achieve good performance. Seals are expected to last 12 to 15 years and asphalt overlays 20 years. Crack sealing is often done to prevent water from getting into the base course, as keeping the subgrade dry is considered crucial.
- In VicRoads, the maintenance strategy consists of a six-year program with the goal of maintaining the pavement roughness of the network at an international roughness index (IRI) of less than 4.2 meters per kilometer (270 inches per

mile). Since 1994, 10 percent of the network each year has been preserved using this strategy.

MATERIALS

France

- Quality aggregates, considered very important, are the foundation for the performance and longevity of both initial construction and pavement preservation or maintenance treatments, including the use of gap-graded fine mixes.
- Aggregate properties include 100 percent fully crushed, Los Angeles (LA) abrasion loss less than 15, micro-duval less than 20, and polished stone value less than 0.5. The gradations range from continuously graded to gap-graded. Gradation bands are also tight, which ensures a quality material.
- Half of surface dressings are done with hot bitumen and half are done with emulsions.
- The primary crude oil source for bitumen is Venezuela.
- A number of hot mixture types are used and include the following:

Type	Top Size (mm)	Thickness (cm)	Bitumen Type	Modifier
Thin	6-14	3-4	Pure Bitumen	
Very Thin	6-10	2	30-50/50-70 pen	SBS, EVA, EMA, SBR, FIBERS
Ultra Thin	6-10	Equals Maximum Size	30-50/50-70 pen	SBS, EVA, EMA, SBR, FIBERS
Porous Asphalt		4		
High Modulus		6-8	10-20/15-25 pen	

Table 2. Typical hot-mix pavements in France.

- For microsurfacing applications, a concentrated solvent sealer emulsion made from 50-70/70-100 penetration grade base stock is used. Often fibers are used with an additive system attached to a standard microsurfacing machine. These fibers improve adhesion.

South Africa

- Factors critical to the success of pavement preservation treatments include a willingness to invest in quality aggregates, even if they must be transported long distances, along with paying significant attention to size and gradation. Specifications require 100 percent crushed material with 0.5 percent or less passing the 200 sieve for a single aggregate used in hot and cold applications.

- Typical aggregate top sizes, lift thickness, names, and binders used for hot mixes are as follows:

Top Size	Lift Thickness	Name	Top Size
9.5 mm	20 mm	Ultra Thin &,Thin	60/70
13.2 mm	30 mm	Thin	
19.0 mm	40 mm	Conventional	60/70
26.5 mm	60 mm	Thick Surfaces & Bases	
37.5 mm	80 mm	Asphalt Bases	40/50

Table 3. Typical hot-mix pavements in South Africa.

- Refiners are available and crude is imported from a variety of sources.
- The principal use of emulsions is for fog sprays and rejuvenation for seals. Most surface dressing is done using modified hot binder.
- Some surface treatments use aggregates with a maximum size of 19 millimeters.
- Crumb rubber asphalts and other types of modified bitumens are used in a variety of pavement applications, ranging from surface dressing to hot-mix asphalt.

Australia

- Polymer-modified binders are used extensively in Australia for both chip seals and hot-mix asphalt. For chip seals, hot applied bitumen is used predominantly. Some cutbacks and emulsions are used as well. The hot applied bitumen is modified with a number of different types of additives – styrene butadiene styrene (SBS), styrene butadiene rubber (SBR), ethylene vinyl acetate (EVA), ethyl methacrylate (EMA), and crumb rubber – but SBS and crumb rubber are the two most widely used. The same is true for hot-mix asphalt mixes. Most are SBS-modified class 170 (80-100 penetration grade), class 320 (50-60 pen), and class 600 (40 pen) binders. The polymer loadings are normally in the six percent range, nearly twice the amount generally used in the United States. The amount of crumb rubber ranges from 16 to 20 percent.
- In general, the Australians have strict requirements for the quality and gradation of aggregates used in surface courses. For example, chip seal aggregate is friction resistant, clean (maximum of 0.5 percent passing the 200 sieve), a maximum size of 10 or 14 millimeters, and single sized. In most instances, chips are pre-coated with bitumen to promote adhesion and early return to traffic. Typical aggregate spread rates for single-layer seals are as follows:

Nominal Size (mm)	Average Least Dimension (mm)	Application Rate (m^2m^3)
20	10.5 - 13.7	60 - 75
16	8.6 - 12.0	70 - 85
14	6.4 - 9.7	80 - 105
10	4.1 - 7.1	100 - 155
5 5 (Matrix)	3.8 - 4-6 -	135 - 190 135 - 250

Table 4. Typical aggregate spread rates for single-layer seals.

- In rural areas, poor-quality materials called bush gravel with California bearing ratio (CBR) values of 10 or less are used for base material. A "grass-roots grade" is prepared. The poor material is treated with lime for stabilization, and then a cutback asphalt primer is applied and finished with a chip seal. The local gravels are often sensitive to moisture infiltration. This use of local materials for base courses is one reason for the Australian emphasis on maintaining a waterproof surface and the country's intensive chip seal program.
- If locally available base course materials are of a lower quality, they are stabilized with a number of different products, including lime, fly ash, bitumen, and cement. In some areas, crushed rock base is treated with two percent cement and left in stockpiles at the quarry to be hydrated.
- In New South Wales, crushed basic rocks such as basalt, intermediate rocks such as dacite, and less frequently acidic rocks such as granite are used in asphalt and sprayed seals. Crushed river rubble is also used on low-traffic roads. In addition, specialized aggregates are used in surface courses to increase friction and improve skid resistance.
- Geotextiles are used in most states in a number of different applications. They can be used as a stress-absorbing membrane interlayer, in a sandwich seal, in a double application, and directly under a chip seal. The primary reason for use is the delay of reflective cracks from the treated base courses.
- In Western Australia's rural areas, natural gravel base courses are sometimes primed with cutback bitumen, covered with river sand or crusher dust, and left open to traffic for six to eight months. A single chip seal is then applied to serve as final wearing surface.

PAVEMENT MANAGEMENT SYSTEM

France

- A large variety and amount of data are generated about pavement and roadway conditions on all roads through the use of specially developed equipment. The entire roadway system is evaluated on a three-year cycle. France's ultimate goal is to use its pavement management system for designing surface preservation treatments, as well for as providing information to management about system pavement conditions.

South Africa

- The data-intensive system uses state-of-the-art technology, computer programs, and global positioning system technology. The information is used for measuring system condition, predicting service life, and selecting future projects. The well-managed program is used to validate cost benefits of pavement preservation and maintenance activities.
- The pavement management system applies a two-step process of generating strategies and their optimization. The optimization process aids in selection of the most economical strategy within budget parameters. Even though the pavement management system determines optimum strategies, a field panel selects the final construction work program. This selection is then reviewed and final project selection may be modified to meet local needs and considerations.
- A key component of the pavement management system road condition analysis is the annual visual evaluation, which is based on a national standard (TMH9). Raters are trained and certified to insure consistency among the provinces. The annual evaluation is combined with mechanical measurements for use in the calculation of road condition indices. Mechanical measurements of the road, done every two to three years, include transverse and longitudinal profiling. The road indices are then used to formulate optimization of preventive maintenance based on available funds.

Australia

- All states use pavement data collection systems. Data gathered includes, but is not limited to roughness, rutting, strength (deflection), texture, cracking, skid resistance, and seal coat age.
- Queensland has developed in-house software to serve as a decision support tool for the road asset maintenance policy and strategy at the state and district levels. Other states use commercially available software for this purpose.

MISCELLANEOUS

France

- The French are concerned about the impact of traffic noise in urban areas and require open-graded mixes to reduce noise and increase friction.
- Most maintenance is under contract, with the exception of mowing, winter maintenance, signs, and trash pickup. Consequently, concession providers are typically roadway contractors partnered with toll operators.
- The Ministry of Transport completes an annual user survey, pulling highway users off the road to ask them a set of questions. The same questions are asked each year to determine trends and measure performance. Each year, 10,000 users on the Motorway system and another 20,000 users on the national system are surveyed. The maintenance division responds to the survey by modifying priorities and budget. On department and municipal roads, comment cards

located at gas stations are available for users to complete with any comments they desire – positive or negative.

South Africa

- SANRAL and provinces rely on consultants for design, analysis, and on-site construction management.
- Build, operate, and transfer facilities constructed by concessionaires are gaining popularity. These are constructed and operated using performance-based contracts and the concessionaire has full maintenance responsibility for the life of the contract, up to 30 years. This approach not only provides capital for road construction in a tight budget environment, but it also generates revenue because concession profits are shared with the government above a certain rate of return. Also in use is a product certification and product performance guarantee system that requires guaranteed results for various distresses, such as skid, rut, and ride.
- The product certification and product performance guarantee system has three levels. Level I is a one-to-three-year guarantee on workmanship. Level II is a guarantee on product of three to 10 years. Level III is a guarantee on product performance by the contractor of 10 to 30 years.
- Surfaces are kept sealed to keep water from getting into the base. Visual observation or inspection by experienced personnel is critical to an effective pavement preservation or maintenance program.
- A serious problem for managing pavement assets in South Africa is overweight vehicles. It is estimated that 17 to 20 percent of all trucks are overloaded and that these trucks account for 60 percent of road damage. The legal single axle load is 9,000 kilograms = less than 9 kN, and the maximum truck weight is 56,000 kilograms = less than 56 kN. It is not uncommon to have greater than 900 kPa tire pressures.

Australia

- National guidelines for pavement condition data collection and treatment selection have been established in Australia through AUSTROADS.
- Overweight trucks are a problem in Australia. Large trucks called road trains are used in various states. The largest of these trucks are 53 meters long, weigh 250,000 pounds, and have 98 wheels and 25 axles. The loads on these trucks meet Australian axle load limits of 80 kN. Tires on these trucks cause significant shear stresses on pavement, however, because of their drive axle configuration and high tire pressures that can reach 900 kPa. Australia discourages the use of wide single tires known as super singles by reducing loading allowances, as these tires have been shown to cause seven times more damage than dual tire configurations.
- In Queensland, state weight enforcement includes not only fines on the driver, but also fines on the trucking company and possible impoundment of the vehicle. Telemetric devices are used to read weight-in-motion data and identify trucks for detailed weighing.

- On rural roads in New South Wales with good sight distance, edge stripes are used without centerlines on two-lane, eight-meter-wide roads. Trucks are encouraged to use the center of these roads to preserve roadway edges.
- Regions submit projects to state transportation offices, where a mix of projects is selected. The project mix is based in part on pavement management data and analysis and in part on local factors.
- For low-volume, unsealed roads, a technique of stabilizing the edges of the formed roadway is used occasionally to keep moisture out of the traveled way. This is used in lieu of edge drains.
- Road safety is an important aspect of overall maintenance activities. Special programs focus on localized roadway improvements, including surface or pavement treatments for high-accident locations. Special funding derived from vehicle insurance company profits supports some of these programs.

Chapter Three
KEY FINDINGS

The countries visited were thorough in their preparations for the scanning team's visit and were generous in sharing their experience and expertise. Based on discussions with experts in the countries visited, the team documented several key findings, or actions taken that have had a marked impact on pavement preservation activities and program success. These key findings are categorized in the same topic areas as the amplifying questions sent to the host agencies before the team's visit. They are outlined below by topic area and country.

MANAGEMENT PERSPECTIVE AND POLICIES

All the countries visited have made a commitment to designing and building long-lasting structural pavement sections on their national roadway networks. This decision has caused all of these nations to focus maintenance activities on surface courses to preserve the large investment in the underlying layers. This, in turn, promotes the use of relatively low-cost seals and thin overlays as the primary maintenance techniques, instead of more costly types of rehabilitation.

France

- As noted above, the French government has made a conscious decision to design and build extremely durable, long-lasting structural pavement sections – which include surfacing, base, and subbase materials – on the Motorway system.
- Every five years, a comprehensive road investment plan is developed for France's entire road system.

South Africa

- The South Africans, like the French, also build robust structural sections with a long service life into their national network. The methodology used, however, is quite different. In South Africa, roadway sections are constructed of cement-treated subbase covered by a high-quality crushed aggregate base course. The total thickness of these layers is typically 450 millimeters (subbase and base) in a total pavement structure thickness of 1 to 1.2 meters. The final layer is a thin asphalt section of 30 to 50 millimeters. In France, the bituminous layers are considerably thicker.
- A rolling five-year road improvement plan is developed each year using pavement management system data and funding optimization strategies. Consequences of various funding scenarios are evaluated and a program is selected that maximizes road conditions at a total program cost within the budget available. Potential savings for vehicle operating costs are also included in the optimization analysis, but user costs are not.
- The pavement management system has been used effectively to justify increased funding for road maintenance and preservation. Simple but clear presentations of network analyses and maintenance needs have been made to local and national politicians. These presentations have been successful in obtaining additional pavement preservation funds.

Australia

- Australia uses long-term (10-year) maintenance contracts to turn over total control and responsibility for roadway system maintenance, rehabilitation, and capital improvements to private contractors. These contracts are performance based and require contractors to meet a set of standards. Standards include roughness, texture, rutting, skid resistance, and remaining service life. These standards are measured and established at the beginning of the contract and monitored during the contract. Contractors are prequalified before they submit a contract proposal.
- Asset management programs for pavements have been used as effective methods for determining maintenance needs and increasing funding. Australian states have realized the importance of asset management for two reasons. First, asset management provides information and data that enable state transportation authorities to better manage their systems. Second, it provides a means to demonstrate to management the importance of additional funding for road assets.

RESOURCE COMMITMENT AND COST-EFFECTIVENESS

France

- Maintenance focus is on the wearing course. Providing initially high structural capacity enables officials to emphasize protecting the structure with relatively low-cost seals and thin overlays on a seven-to-10-year cycle. This also allows for a focus on maintaining good surface characteristics, such as high grip (skid resistance) and reduced noise.

South Africa

- Distress definitions for pavement management systems are conservative (i.e., severe crack threshold above three millimeters). This focuses maintenance intervention early in the pavement life cycle. In so doing, the South Africans use a higher percentage of relatively inexpensive techniques to keep water from the base structure.
- The South Africans schedule a high percentage of pavement management system-selected projects for implementation, including 80 to 90 percent for the national system. This is achievable because pavement management is accepted at the national level and by some maintenance communities at the provincial levels. This allows for network conditions to be optimized to as high a degree as funding will permit.

Australia

- Australia has tried to maximize operational efficiency and cost-effectiveness in the execution and implementation of maintenance works. This was initiated in part because of national policy requirements that mandate competitive procedures. This is accomplished differently in some states. Queensland, New South Wales, and Victoria have retained some in-house maintenance capabilities, but they have complied with the national policy by requiring their own forces to meet competitive requirements, such as prequalification of skills or tendering offers to perform work. In Western Australia, maintenance operations are competitively negotiated with private contractors. This has resulted in seven-to-17-percent savings for performing maintenance activities compared to benchmark estimates. Estimates assume that work will be performed at or above current standards. Ten-year contracts have just been initiated.

- Pavement management strategies for allocating maintenance resources vary by state, according to state perception of user needs. In more urbanized areas, roughness and functional considerations, such as ride and noise abatement, drive project selection in the pavement management systems employed. In more rural areas, structural considerations are emphasized. In Queensland in particular, the age of surface seals is modeled in the pavement management system and used as the primary predictive trigger for reseal applications. Modeling is based on both empirical and mechanistic analysis.
- For most states, rehabilitation is a minor part of the maintenance program and pavement preservation techniques are emphasized. This is partially because of budget constraints that require low-cost treatments in the early stages of pavement life. In Victoria, for example, it is typical for 90 percent of the annual maintenance budget to be committed to preservation, while 10 percent is committed to rehabilitation.
- Operating costs for vehicles are used in cost modeling for pavement management systems in most states. This drives treatment selection toward measures that reduce operating costs, such as improved smoothness.

TREATMENTS, TECHNIQUES, AND PERFORMANCE

All three countries use only quality materials for both bitumen and aggregate. Generally, crushed granite and proven polymer-modified asphalt binders are used. This is ensured through the use of rigorous specifications. Materials sources are specified and there is no inhibition to using sources a great distance from the project site.

France

- The primary preservation treatment on high-volume roadways is mill and inlay. Often, a high modulus asphalt mix that has proven to be rut resistant (limited to a 10/20 penetration grade) is incorporated into the projects.
- Cold asphalt concrete has been used extensively with good success on low-volume roads as a riding surface (75 to 100 millimeters). The cold asphalt concrete mix process focuses on achieving good coating of the aggregates and is preferred over hot-mix asphalt for low-volume roads.

South Africa

- South Africa makes extensive use of chip seals. Well-established and standardized guidelines based on research and practical experience are used. Chip seals are routinely used on routes with 50,000 equivalent vehicle units

(EVU) or higher. The pavement management system has verified that surface seals are effective treatments for preserving pavement life.

- In some instances, hot-mix asphalt overlays are covered immediately with chip seals to provide sufficient surface friction and, at the same time, ensure a system more impervious to water.

Australia

- All the states visited use a treatment called geotextile-reinforced sprayed seal. The construction sequence involves spraying a tack coat, placing the geotextile, and then applying a chip seal on top. Information was presented showing that this treatment reduced reflective cracking. In Victoria, 12 to 15 years of performance is expected from this treatment. Typically, a crumb-rubber bitumen or conventional bitumen is used for these seals.
- The technique of pre-coating aggregates for chip seals is used throughout Australia. This practice prevents or reduces the loss of aggregates on chip seals.
- All the Australian states make extensive use of polymerized asphalts. Considering the heavy and large amounts of trucks using rural roads, states believe there is a need for the best-performing bitumen possible. Styrene butadiene styrene-type polymers are predominately used in their bitumens (at twice the rate used in the United States) for both hot-mix asphalt and chip seal applications.

Figure 5. Australia uses a technique of pre-coating aggregates for chip seals to reduce aggregate loss.

- Crumb rubber modifier (15 to 20 percent) is used in bitumen for chip seals. This has been effective in reducing reflecting cracking.
- Even when using full-depth hot-mix asphalt pavements, a chip seal is placed on the base material (or subbase) before the asphalt layers are placed. This prevents moisture infiltration or capillary action.
- New South Wales has been successful in placing thin (40-to-60-millimeter) asphalt overlays on existing concrete pavements by placing hydrocarbon curing and a tack coat before placing the overlay on the concrete. The overlays on more recent plain concrete pavements are done primarily for noise control, while

those on older jointed reinforced concrete pavements are done for ride quality when large-scale diamond grinding equipment is not available. There are also economic benefits, as well as benefits in locations where there are level constraints but maintenance of reflective cracking is necessary.

- A chip seal system incorporating glass fibers is used in New South Wales to prevent reflective cracking. The process involves spraying a coat of polymer-modified bitumen emulsion, followed by blowing chopped fibers on the surface and spraying a second coat of polymer-modified bitumen emulsion, all in one operation. As with all emulsion seals, control of early trafficking is needed until a degree of curing (evaporation of water as opposed to breaking of emulsion) has occurred.

INNOVATIVE METHODS, PRACTICES, AND PROCEDURES

France

- Four-year warranties are used in contracts when applying preventive maintenance techniques. The functional properties warranted are friction, rutting, and smoothness. The responsibility of the contractor for the repair of non-compliant sections reduces with time and traffic. A secondary effect of the application of warranties has been the innovation of materials and mixtures by contractors and material suppliers. In most instances, contractors are vertically integrated so the innovation takes place within the company.
- Under a system called the Charter of Innovation, the government and industry share in the risk of experiments to develop new and innovative products. Requests for proposals are issued annually for new products and test sections are constructed. The company and government share in the cost of conducting surveys. Successful products are then accepted nationally for inclusion in the preventive maintenance program.
- A process has been developed by a contracting firm that incorporates vegetable oil in a 70-100 penetration grade bitumen, some of which has been modified. This is called a bio-binder. The objective has been to produce an emulsion that is safe (handling temperatures), environmentally friendly (non-solvent-based renewable resource), and has the necessary technical properties to perform. The first experimental section was built in 1997 and seven million square meters were placed in 2000.

South Africa

- A stress-in-motion device to measure contact stresses in vehicles has been developed and is in regular use.
- A crack activity meter has been developed to measure reflective cracking potential and the need to restore the surface before placing an overlay. The meter can measure both horizontal and vertical movement simultaneously and fits between the dual wheels of a test vehicle. Data is captured and processed electronically.

- SANRAL has developed a fitness-for-purpose certification system for bituminous products that allows for the early implementation of innovative and proprietary products not covered by existing standards. The program provides potential users with a scientifically sound basis for their decisions on whether a product is fit for its intended purpose.

Australia

- In New South Wales, sandwich seals with two-coat geotextile reinforced treatment have resulted in an acceptable performance (no reflective cracking) for 11 years on roadways with traffic volumes of 1,200 vehicles per lane per day.
- In New South Wales, a pavement condition survey vehicle called Road Crackä has been developed to detect cracking on the pavement surface. This vehicle measures the full lane width at 80 kilometers per hour with real-time processing, measuring cracks down to a millimeter and classifying them as longitudinal, transverse, and crocodile. Sawn joints are identified. Alternatively, at lower speeds, a full digital image of the road surface can be retained. Funding is being sought to develop and market this vehicle.

Chapter Four
RECOMMENDATIONS

The scan team was provided with a wealth of information at the formal presentations, during informal discussions and gatherings, and in written documents and materials. Throughout the study, team members discussed their perceptions of what they observed in the context of which techniques and strategies used in the host countries could be practically and successfully put into place in the United States. Team members met at the end of the study to review their findings and developed the following recommendations with potential for implementation in the United States. The findings, observations, and recommendations are those of the scanning team and not FHWA.

DEEP SUBBASE, DEEP BASE, AND EXTENDED PAVEMENT DESIGN LIFE

The scanning team recommends that demonstration projects with deep subbase and deep base designs be initiated in different regions of the United States to determine the effectiveness of this design strategy.

As a first step, a seminar presenting the experience of South Africa and Australia with these design concepts would be of value. A second step would be to develop a pooled-fund study to design and construct these demonstration sections with a companion NCHRP project to monitor long-term performance. These sections should also be integrated with other recommendations in this report for thin surface treatments, including chip seals. Treatments outlined in this chapter's Chip Sealing section should be incorporated into these demonstration projects.

The countries visited made decisions to develop pavement sections that include long-life pavements. These pavements consist of deep subbase and deep base sections with a thin, high-quality wearing course to provide a good riding surface and moisture protection for the base. Pavement maintenance activities consist mainly of periodic thin surface treatments to renew the ride quality and reestablish an impervious layer. This allows for the maintenance investment to be directed to less-expensive surface treatments and not toward costly rehabilitation activities.

In addition, for major sections of the U.S. Interstate system beyond the 20-year design life, the team recommends that consideration be given to design using deep subbase and deep base sections to provide 30- and 40-year design life.

CHIP SEALING

The team believes the following innovative procedures and applications have a high probability of improving the performance of chip seals in the United States.

Although chip seals are commonly used in the United States, two of the countries visited, South Africa and Australia, have developed innovative design procedures and application techniques not normally seen in the United States. Performance lives of up to 15 years are being achieved on sections with up to 60,000 vehicles per day. This outstanding performance is due in part to the deep-strength pavement designs employed.

The team recommends that highway agencies include pre-coating of chips in their chip seal specifications. Pre-coating of aggregates will improve the adhesion of chips to the binder. The South Africans use this technique on their highest-volume roads with good success.

The team recommends that geotextile-reinforced chip seals be tested and evaluated in both freeze and no-freeze environments. Throughout Australia, a treatment called geotextile-reinforced sprayed seals has been successful. The treatment – which involves tack coating the existing pavement, spreading a geotextile, and capping with a chip seal – is used on roadways with moderate cracking. This treatment retards reflective cracking in Australia's wet and dry no-freeze climates. In addition to the geotextile, it is believed that modified binders, including crumb rubber, aid in the retardation of reflective cracking.

"Guide to Geotextile-Reinforced Sprayed Seal Surfacing" (Technical Bulletin No. 38, April 2001, GeoPave) provides information and guidance for geotextile reinforcement in sprayed seal bituminous surfacing. It describes the required materials, processes, and equipment used in the application of geotextile seals in sprayed bituminous surfacing. This treatment has also been used directly on subgrade and has been successful in retarding damage to this material, provided no traffic is allowed during saturated conditions.

The team encourages agencies that do not use modified binders for chip seals to do so. Quality chip seals exhibiting long service life use bitumen modified with a variety of products. The predominant modifiers are styrene butadiene styrene, which is used extensively, and crumb rubber, which is used to a lesser degree. A unique application used in France and Australia that deserves evaluation is the use of fibers applied directly on the bitumen before the application of the cover aggregate. The fibers enhance both aggregate retention and treatment performance.

Figure 6. The team recommends application of chip seals earlier in the distress cycle to prevent premature pavement failure.

The team encourages agencies to review their specifications and upgrade them where appropriate so that superior aggregates are used and improved service life is accomplished. The success of chip seals in all the countries visited is due in large part to the high quality of the aggregate and the emphasis placed on design. High-quality aggregate (clean, less than 0.05 percent passing the 200 sieve, LA abrasion of less than 15, and micro-duval less than 20) of a single size is routinely used. In many instances, aggregate is hauled great distances, more than

500 kilometers. In addition, application rates are optimized for the type of aggregate and bitumen used.

The team encourages agencies to review their design practices for chip seals and consider placing them on base or subbase courses to prevent moisture infiltration. To prevent moisture infiltration and capillary action, the Australians often place a chip seal on the base or subbase before applying the asphalt surface. This technique is especially useful on highly moisture-susceptible bases and subbases. The Australians also perform designs to optimize application rates for the type and grade of aggregates and bitumen used.

Figure 7. The team recommends developing a national mechanism to evaluate innovative products and processes for pavement preservation.

TIMELY PREVENTIVE MAINTENANCE

The team recommends that chip seals be applied earlier in the distress cycle. All the countries visited try to detect cracking in the one-to-three-millimeter range, at which time a chip seal is applied. The typical U.S. treatment is to wait for visible cracks of four millimeters or greater to appear before applying a crack seal. Often, a chip seal is applied in the United States only after several years of crack sealing. Applying a chip seal earlier in the distress cycle would prevent water infiltration into the base and deter premature pavement failure. This approach may extend the life of roadway pavement structures and reduce the need for expensive rehabilitation projects.

The team recommends investigating the successful practice used in New South Wales of placing thin (40-to- 60-millimeter) asphalt overlays on existing portland cement concrete pavement. Placing thin overlays on portland cement concrete pavement has not been very successful in the United States. The Australians have designed a system specifically for this application that may provide additional preservation options for U.S. pavements. In Australia, the portland cement concrete pavement is cured with a hydrocarbon compound, followed by application of a tack coat in the normal manner.

INNOVATIVE METHODS, PRACTICES, AND PROCEDURES

The team recommends that AASHTO and FHWA develop a mechanism to evaluate and implement new and innovative products and processes. A national institutional process needs to be established to foster and manage innovation. This process needs to include proprietary products that private-sector investment has developed. AASHTO and FHWA also should consider the concept of risk sharing, as exemplified by the French Charter of Innovation system. This would encourage innovation by giving contractors and suppliers greater opportunities to market new technology.

CONTRACT MAINTENANCE

The team recommends that AASHTO and/or FHWA conduct a seminar to share best practices and investigate the possibility of demonstration projects in the United States using long-term maintenance contracts. Contracting or outsourcing maintenance activities has moved to long-term contracts of three to 10 years for various types of total maintenance. These contracts are monitored for performance by means of various asset management techniques. Additional evaluation of the associated benefits of such long-term contracts for pavement preservation is needed.

PAVEMENT CONDITION SURVEY EQUIPMENT

The team recommends that investigation of Road Crackä and similar vehicles be conducted to fully evaluate the potential for use by transportation agencies. If warranted, the team recommends that a pilot program be developed for a side-by-side field evaluation of these vehicles.

Early and accurate detection of pavement distress is essential for an effective pavement preventive maintenance program. Transportation agencies in the United States invest significant amounts of resources in the collection of road condition information. Transportation agencies are in constant search of more efficient and cost-effective ways of collecting this information.

In New South Wales, the team learned about a high-speed pavement condition survey vehicle capable of detecting pavement cracks as small as a millimeter in width. The Road Transportation Authority of New South Wales has developed the Road Crackä vehicle that meets this need. This vehicle has the potential of saving significant resources for transportation agencies throughout the United States and other countries.

Chapter Five
IMPLEMENTATION

The scanning team formed a small group to develop a scan technology implementation plan. The plan outlines a series of activities to document, showcase, apply, and evaluate the innovative pavement preservation techniques, processes, materials, and equipment observed in the host nations. These activities focus on educating and demonstrating to the U.S. highway community the effectiveness and value of these innovative technologies. The implementation plan team includes James Moulthrop of the Foundation for Pavement Preservation, Luis Rodriguez and Michael Voth of FHWA, and Zane Webb of Texas DOT.

IMPLEMENTATION RECOMMENDATIONS

The scanning team identified five major technologies worthy of further evaluation and subsequent implementation. They include innovative chip seal design and construction procedures, preventive maintenance as part of pavement management strategies, high-speed road condition survey equipment, deep subbase and deep base design, and contract maintenance. The team has developed implementation recommendations on the first four technologies. Contract maintenance will be handled separately.

The implementation proposal is divided into three major tasks. The first two tasks involve information gathering, while the third calls for a project to demonstrate the technology evaluated as part of the first two tasks.

Task 1 – Gather Additional Information in Australia

While the host countries provided ample information on many subjects, the implementation plan team does not believe it has enough detailed data to warrant proceeding with its recommendations without further investigation. The team proposes that a four-person scout team be assembled to investigate further the following topics:

Investigate chip seal design procedure, including use on bases and subbases – Although chip seals are commonly used in the United States, Australia is one of the countries visited that has developed innovative design procedures and application techniques not normally used in the United States. Performance lives of up to 15 years are being achieved on sections with up to 60,000 vehicles per day. This outstanding performance is due in part to the deep-strength pavement designs employed.

Throughout Australia, treatments called geotextile-reinforced sprayed seals have been successful. These treatments – which involve tack coating the existing pavement, spreading a geotextile, and capping with a chip seal – are used on roadways with moderate cracking. These treatments retard reflective cracking in Australia's wet and dry no-freeze climates. In addition to geotextile, it is believed that modified binders, including crumb rubber, aid in the retardation of reflective cracking. These treatments have also been used directly on subgrade and have proven successful in slowing damage to this material, provided no traffic is allowed during saturated conditions.

Another unique application used in Australia that deserves evaluation is the use of fibers applied directly on the bitumen before application of the cover aggregate. The fibers enhance both aggregate retention and treatment performance.

To prevent moisture infiltration and capillary action, the Australians often place a chip seal on the base or subbase before placing the asphalt surface. This technique is especially useful on bases and subbases highly susceptible to moisture. The Australians also perform designs to optimize application rates for the type and grade of aggregates and bitumen used. Pre-coating of chip seal aggregates with polymer-modified binders is an example of this aggregate and bitumen use.

The scout team plans to gather detailed information on design procedures, construction specifications, materials selection, material-testing concepts, and pre-construction pavement conditions. The primary goal of the chip seal study, however, is to witness active construction, evaluate constructed sites, and review management data.

Investigate the use of preventive maintenance strategies in pavement management systems – Asset management programs for pavement maintenance are used by all state road agencies in Australia. These programs, similar to pavement management systems in the United States, vary from state to state. Australian states have realized the importance of asset management for two reasons. First, asset management provides information and data that enable the state transportation authorities to better manage their systems. Second, it provides a way to demonstrate to management the importance of and need for additional funding for their road assets.

Queensland Main Roads has developed in-house software to serve as a decision support tool for the road asset maintenance policy and strategy at the state and district levels. The age of surface seals is modeled in pavement management systems and used as the primary predictive trigger for reseal applications. Modeling is based on empirical as well as mechanistic analysis. Other states, such as Western Australia, use commercially available software for this purpose. Regions submit projects to the state transportation offices, where a mix of projects is selected. The project mix is based in part on pavement management data and analysis and in part on local factors.

Deliverable: The team would create a detailed report on the procedures and factors used to identify and program preventive maintenance strategies in pavement management systems. The report would document preventive maintenance policies and how agencies gain top management support for preventive maintenance programs. The gathered information would be used in the development of the National Highway Institute course "Integration of Preventive Maintenance into Pavement Management Systems."

Investigate Road Crackä equipment – In New South Wales, the team learned about a high-speed pavement condition survey vehicle capable of detecting pavement cracks as small as a millimeter wide. The Road Transportation Authority of New South Wales developed the Road Crackä vehicle. The vehicle has the potential of saving significant resources in transportation agencies throughout the United States and other countries. The team did not see the equipment while in Australia and would like to learn more about it. The team will ask New South Wales officials for more information and conduct a survey to determine the availability of similar technology in the United States and Canada.

Deliverable: The team would prepare detailed reports with specific implementation recommendations on all three subjects, including hands-on experience with the specific technologies. A workshop to demonstrate the capabilities of vendors of this technology would be conducted as part of Task 3.

Task 2 – Examine Deep Subbase, Deep Base, and Extended Pavement Design Life

This topic was identified on previous scans. Some work has been done in the United States, but it is not clear what impact the technology might have on U.S. practices. The team recommends that FHWA staff prepare a status report on work contemplated or completed and make a recommendation to the implementation plan team on the merits of moving forward with this work.

Deliverable: FHWA staff would prepare a complete analysis of the concept, presentation of work done in the United States and its performance, and a recommendation on how it should be further implemented nationwide. The report would be detailed enough to allow movement towards actual demonstrations in Task 3.

Task 3 – Develop Seminar and Demonstration Project

Once the scout team and FHWA staff complete their work, the information gathered needs to be disseminated broadly to transportation engineers and managers throughout the United States. The goal is to construct a demonstration project that includes the new techniques investigated. A seminar would be included with the open house for the project. A host State would be chosen from those represented on the scanning team. Texas, Michigan, Pennsylvania, and Georgia DOTs all have expressed interest in building demonstration projects and hosting a seminar and open house. The Foundation for Pavement Preservation has expressed interest in helping coordinate the demonstration projects.

Timeline

The scout team hopes to visit Australia in 2002. When it returns, a technical working group plans to evaluate the information, select the specific climates and sites for demonstration projects, and help the host State develop design and construction documents by the end of 2002. The actual demonstration projects would be constructed in 2003.

MISCELLANEOUS PRODUCTS AND ACTIVITIES

The following list identifies recommended products and activities that would complement the main implementation tasks identified in the first part of the scan technology implementation plan. Sponsoring agencies and organizations have not yet been determined for each.

Products:

- Scanning Study General Report.
- FOCUS article showcasing the scan's key findings and recommendations.
- Brief reports highlighting key technical and management concepts and features of the innovative pavement preservation techniques and processes identified by the scanning team.

- Web site dedicated to disseminating scanning study findings and implementation activities. The site would include links to other pavement preservation sites, such as those of the Foundation for Pavement Preservation, International Slurry Surfacing Association, and Asphalt Recycling and Reclaiming Association, plus web sites from transportation agencies and industry organizations in the visited countries. This would be coordinated with the FHWA Office of International Programs and the Construction and System Preservation Team in the Office of Asset Management.
- Compact disc with presentations, technical reports, and examples of innovative pavement preservation techniques and processes in the countries visited and the United States.
- Technical modules that could be included in present and/or future pavement preservation training courses.
- Guide to specifications or procedures for pavement preventive maintenance tailored to U.S. conditions.
- Research statements to evaluate the use of better aggregates, geotextiles, and binder application procedures in preventive maintenance treatments.
- Reports documenting the implementation and results of the field demonstrations.

Activities:

- Presentations at international, national, and local meetings sponsored by FHWA, AASHTO, Transportation Research Board, National Association of County Engineers, Foundation for Pavement Preservation, American Public Works Association, American Concrete Pavement Association, etc.
- National workshop on innovative maintenance contracting sponsor by AASHTO, FHWA, and the American Public Works Association. This would be coordinated with the AASHTO Contract Maintenance Task Force.
- Regional pavement preservation workshops, including international technology-sharing activities.
- Showcasing of innovative pavement preservation techniques in National Highway Institute pavement preservation training courses.
- Field demonstration projects in various States using the innovative techniques, processes, materials, and equipment identified during the scanning study, such as chip seal applications and deep subbase and deep base pavement structural design.
- National workshop to demonstrate the latest international pavement distress survey technology.

Chapter Six
CONCLUSION

Early in the study, Co-Chair Frank Danchetz told one of the host audiences that the scanning team hoped to gather "nuggets of information" during its visits to three of the leading countries in pavement preservation and to develop strategies to put this information to use in the United States. As the study progressed, team members realized that many of the pavement preservation strategies and best practices used with great success by the host countries are already in place, to some degree, in the United States.

Each country visited recognizes the systematic method of programming, funding, and placing preventive maintenance treatments as the most successful strategy for pavement preservation. The need to apply the right treatment to the right roadway at the right time came up on several occasions during the study. Many of the agencies deal with the same barriers facing AASHTO's member States, including dedicated funding, public and management perception, and data management. In retrospect, although the scanning team uncovered no major nuggets of information, it determined from its international observations that pavement preservation in the United States is headed in the right direction.

Chapter Four includes several recommendations that team members believe have potential for implementation in the United States. The true value of the study will be the extent to which these recommendations are shared, evaluated, and, as appropriate, put into place. The challenge is to find champions to carry the torch forward.

Appendix A
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Frank Danchetz (Team Co-Chair) is chief engineer for the Georgia Department of Transportation. He is responsible for design, construction, and operations of the State's highway system. A major priority is preserving the existing system to maximize pavement life and reduce capital expenditures for reconstruction. He has been involved in research activities at the State and national levels involving Superpave (superior performing asphalt pavement system) and other pavement issues. Early in his career, he gained extensive pavement design experience. He graduated from the Georgia Institute of Technology with a bachelor's degree in civil engineering and attended management courses at Harvard's Kennedy School of Government and Indiana University. Danchetz is a licensed professional engineer in Georgia. He is a member of the American Association of State Highway and Transportation Officials (AASHTO) and served as vice chair for the AASHTO Standing Committee on Highways, as well as on the Transportation Research Board and other committees dealing with asset management and pavement.

Duane Blanck is the county highway engineer for Crow Wing County in Brainerd, Minnesota. He is responsible for 600 miles of local roads, including all aspects of maintenance, engineering, and construction. He also is responsible for transportation-related planning activities and several management functions, including pavement management. In addition to extensive county engineering experience dating back to 1975, Blanck has experience in municipal engineering, railroad engineering, structural engineering, research, and education. Blanck has a bachelor's degree in civil engineering from the University of North Dakota and a master's degree in construction management from the University of Missouri. He is a licensed professional engineer in Minnesota and serves on the board of directors of the Foundation for Pavement Preservation. He has served on technical advisory committees for the low-volume road portion of the Minnesota ROAD test facility and as president of the National Association of County Engineers.

Dan Dawood is pavement engineer for the Pennsylvania Department of Transportation in Harrisburg, Pennsylvania. He is responsible for developing and issuing statewide policies and procedures for pavement design and management features used in transportation programs. He also has a role in researching and implementing innovative technology in the pavement field in Pennsylvania. Dawood has been with the department for more than 16 years and has more than 20 years' experience in transportation engineering for State highway administrations and private engineering firms. He has a bachelor's degree in civil engineering from Pennsylvania State University and is a licensed professional engineer in Pennsylvania. He chairs the American Association of State Highway and Transportation Officials' (AASHTO) DarWIN Task Force, and serves on AASHTO's Joint Task Force on Pavements and several other technical committees of the Transportation Research Board.

Jerry Fay is national program director for public works for HDR Engineering, Inc., where he focuses on local government transportation. In 2001 he retired from his post as executive director of the State of Washington Transportation Improvement Board. The board provides funding for local government transportation projects and works with local governments on pavement management systems. Fay has more than 33 years' experience in the field of public works in State and local government, with the past 12 primarily in transportation. He is immediate past president of the American Public Works Association (APWA). Fay recently helped develop and moderate an APWA national teleconference on pavement management issues called "Moving Roadway Maintenance into the 21st Century." He serves on the national APWA TEA-21 Reauthorization Task Force. He has a bachelor's degree in civil engineering from the University of Washington and is a licensed professional engineer in Washington and Arizona.

Bob Ford was division chief of the Federal Highway Administration's Office of International Programs in Washington, D.C., and in that capacity heads up the International Scanning Program. Ford also has 15 years' experience in pavement management and design, having served as pavements engineer in FHWA's Washington, D.C., headquarters office, Kansas City regional office, and Nevada division office. He worked for the State of Wyoming for seven years as resident and project engineer in charge of major paving projects. His experience includes overseeing one of the nation's first asphalt recycling projects in the early 1970s in Las Vegas, Nevada, and establishing the first long-term pavement-monitoring projects in eight pilot States. Ford was a member of the first scanning study team on asphalt pavements. He brings with him a background in air quality, having served as air quality engineer in Kansas City and Nevada. He has a bachelor's degree in civil engineering from the University of Wyoming and a master's degree in public administration from the University of Kansas. He holds professional engineer and land surveying licenses.

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Luis Rodriguez is the pavement management engineer at the Federal Highway Administration's Southern Resource Center in Atlanta, Georgia. Rodriguez provides technical assistance to State and local highway agencies and FHWA field offices on pavement management, preservation, and smoothness. He has worked for FHWA in various job assignments since 1985. Before moving to the Southern Resource Center, he worked as a pavement management engineer at the FHWA Pavement Division (now Office of Pavement Technology) in Washington, D.C., and in field assignments in Alabama and Georgia. He developed and served as an instructor of the FHWA pavement management multiyear prioritization training course presented throughout the United States and at the Fourth International Conference on Managing Pavements in Durban, South Africa. He prepared the technical report on the Georgia Department of Transportation Pavement Preservation Program and Smoothness Requirements, one of the key technical products of the FHWA Pavement Smoothness Initiative. Rodriguez has a bachelor's degree in civil engineering from the University of Puerto Rico. He is a registered professional engineer in Georgia and a member of the Transportation Research Board Committee on Pavement Management Systems.

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Michael Voth is a pavement engineer for the Federal Highway Administration at the Central Federal Lands Highway Division in Denver, Colorado. Voth is responsible for managing the division's pavement project scoping, design, and preservation programs. He is developing a pavement preservation team composed of representatives from the Federal Lands Divisions and their agency partners. He also serves as a member of FHWA's Pavement Preservation Expert Task Group. Earlier, Voth served as pavement engineer in the FHWA Kansas Division. He has a bachelor's degree in physics from Bethel College in Kansas and a bachelor's degree in civil engineering from Washington University in St. Louis, Missouri. He also has a master's degree in civil engineering from the University of Kansas. He is a member of the American Society of Civil Engineers.

Zane Webb is director of the Maintenance Division of the Texas Department of Transportation in Austin, Texas. He is responsible for all maintenance activities on the State's 187,000 lane miles, including oversight of preventive maintenance, maintenance operations, field engineering, vegetation management, marine operations, and architectural services. Webb provides oversight to the Preventive Maintenance Program, which Texas established as a formally funded program in 1986. His past Texas experience includes seven years as an area engineer in which he selected, designed, and oversaw the construction of overlays, seal coat, and microsurfacing. Before that, Webb was director of maintenance at the Waco District Office, where he was responsible for all maintenance activities in that area. Webb has a bachelor's degree in civil engineering from the University of Texas at Austin. He is a licensed professional engineer in Texas and is chairman of the Western Association of State Highway Officials' Committee on Maintenance.

APPENDIX C
AMPLIFYING QUESTIONS

The following is a list of questions about pavement preservation that the U.S. scanning study team would like to discuss with you. These questions are intended to clarify and expand the topics of interest described in the team's overview paper. The questions are arranged by topic and grouped by major elements within each of four areas.

Recognizing that the terms "pavement preservation" and "preventive maintenance" have different meanings to different agencies, the U.S. panel provides the following definitions for a common understanding:

> Pavement preservation – A program of activities aimed at preserving our investment in the nation's highway system, enhancing pavement performance, extending pavement life, and meeting our customers' needs. This includes corrective and preventive maintenance, as well as minor and major rehabilitation.
>
> Preventive maintenance – The planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without increasing structural capacity.

The team is interested in visiting sites where some of the treatments discussed are being applied or have been applied and are open to traffic. If possible, the team would like to devote 50 percent or more of its time with you to site visits. Examples of successful and not-so-successful applications are of interest to the panel to allow for a broader understanding of these treatments.

1. MANAGEMENT PERSPECTIVE AND POLICIES

1-1. What techniques do you use to obtain top management support for your program? What is the overall management approach to various pavement preservation activities?

1-2. How have pavement preservation concepts been marketed and sold inside and outside of your agency? Do users of the system perceive there is a benefit? What is the acceptance of the program with staff and employees?

1-3. What administrative rules or laws – such as weight restrictions, seasonal or otherwise – are used in controlling use of a roadway and thus preserving the pavement?

1-4. Do you have a pavement preservation plan for your system? Is it a multi-year (five-year) plan? How is pavement preservation performance quantified (i.e., improved serviceability, increased structural value, etc.)?

1-5. Do you have an effective pavement management system and is it integrated with maintenance needs?

1-6. How do you decide when, where, and what type of pavement treatments need to be used (traffic volumes, percentage of trucks, cost, environmental concerns, political pressure)?

1-7. For pavement preservation on low-volume roads (less than 1,000 average daily trips), please indicate the types of treatments used, their performance, and specifications.

1-8. Do you have an asset management system? What role does your pavement preservation program play in this system?

1-9. Do you have long-term pavement preservation contracts?

1-10. How do treatment cycles and overlay cycles interplay?

2. RESOURCE COMMITMENT AND COST-EFFECTIVENESS

2-1. What are the relative costs associated with various treatments? Is this supported with a database?

2-2. Do you perform a cost-benefit analysis to determine treatment use?

2-3. How do you manage your pavement preservation program (i.e., is it centralized or decentralized?)

2-4. What percentage of your transportation budget is dedicated to pavement preservation? Are these funds consistent from year to year?

2-5. What percentage of your system is enhanced with pavement preservation techniques yearly and at what cost?

3. TREATMENTS, TECHNIQUES, AND PERFORMANCE

Treatments – Asphalt Pavements

3-1. What types of treatments are commonly used?

3-2. How is the optimum timing of preservation treatments determined (i.e., function of distress, function of time, etc.)?

3-3. Do you have a guide or policy on what treatments to apply under what conditions?

3-4. What are the selection criteria for different types of surface treatments? (e.g., When is micro-surfacing used versus slurry and why? When is slurry used versus chip seal and why?)

Treatments – Concrete Pavements

3-5. What types of treatments are commonly used?

3-6. How is the optimum timing of preservation treatments determined (i.e., function of distress, function of time, etc.)?

3-7. Do you have a guide or policy on what treatments to apply under what conditions?

3-8. What are the selection criteria for different types of treatments?

Techniques – General

3-9. Do your methods or techniques include non-pavement enhancements such as base or drainage? What techniques are used to drain roadbeds?

3-10. What type of pavement analysis procedures (distress surveys, etc.) do you use?

3-11. Traffic: How do you alleviate long traffic delays and interruptions during construction?

a. Does your agency use special additives and materials to accelerate curing (quick set) and thus allow earlier opening of the treatment to traffic?

b. What is your history of use with nighttime application of surface treatments?

Performance

3-12. Are your pavement preservation contracts performance based? If so, what criteria are used?

3-13. How do you measure pavement performance and how often?

3-14. Which treatments have given you the best performance? Which ones give the best cost/benefit?

3-15. How are surface treatments evaluated? Skid related? Preservation of structure? Reemergence of surface distress? Timing on a cycle? What decisions are based on these results?

3-16. How are treatment lives determined?

3-17. Do you have different levels of treatments based on different qualities of materials (i.e., 100 percent crushed, high-quality aggregates and polymer-modified bitumens versus lower-quality materials, such as uncrushed salacious aggregates and commodity bitumens)?

Other

3-18. What treatments are the easiest to construct? What treatments are the most difficult to construct?

3-19. What types of failures have you experienced? What was done to repair this work?

3-20. What treatments have you abandoned and why?

3-21. Which treatments are most sensitive to weather conditions when constructed?

3-22. Do you have contractors that specialize in pavement preservation techniques or do general contractors do the work?

4. INNOVATIVE METHODS, PRACTICES, AND PROCEDURES

4-1. Do you warranty pavement preservation treatments? If so, which treatments? For how long and by what performance criteria?

4-2. How involved is your research program in pavement preservation?

4-3. Are you experimenting with any new treatments, innovations with equipment, or processes used to construct pavement preservation projects that have not been adopted as a standard practice?

4-4. Have improved specifications been recently developed for pavement preservation treatments?

4-5. How is innovation encouraged in the public and private sectors? How are these innovations integrated into your pavement preservation program? Is this partnership formalized?

4-6. Are you using automated repair systems for rapid pavement repair? Are such systems expensive to own and maintain?

4-7. How do you assure that designers, project inspectors, and quality control technicians have the proper knowledge and experience to work on pavement preservation projects?

4-8. Who does the testing (i.e., contractor, agency, or third party)?

4-9. How do you assure contractor compliance with specification/performance requirements?