eveloped in 1984 as a pilot program for the San Francisco Bay Area, the pavement management system (PMS) of the Metropolitan Transportation Commission (MTC) is now used by public works departments nationwide. The PMS is a network-level, computer-assisted method of organizing and analyzing information about pavement conditions in order to develop the most cost-effective maintenance treatments and strategies.

MTC, a transportation planning agency responsible for the 9 San Francisco Bay Area counties, developed the PMS with the assistance of 6 local jurisdictions and at the recommendation of 15 area pavement experts. MTC hired ERES, Inc., developers of the PAVER PMS, to work with the local agencies and to assist in the development and early refinement of the system. Since the initial release of the PMS in the winter of 1986, the number of MTC PMS users has expanded from the original 6 to more than 100 jurisdictions. In addition to cities and counties, users today include universities, national forest agencies, and consulting firms that offer the program to their clients.

Paul Sachs is associate planner/analyst, PMS Group, Metropolitan Transportation Commission. San Francisco Bay Area Pavement Management System Benefits Users Throughout Nation

PAUL SACHS

Improving Pavements for Cities and Counties

Support Fosters Growth

The system's remarkable growth has been fostered by MTC's continued support. MTC offers regular training sessions on important aspects of implementing a successful PMS, such as establishing network components and pavement distress identification. The commission also offers assistance in making presentations to local boards or councils to secure additional funding for pavement maintenance. MTC has developed new modules to maintain a high level of interest in participating jurisdictions while keeping the program on the cutting edge of PMS technology, and it operates a computer hotline for users to call when problems arise.

Designed to be used on IBM personal computers or compatibles, the PMS uses the RBase family of data base managers. Once a potential user has acquired the necessary hardware and software, the PMS program can be purchased from MTC. In addition to training sessions, video training tapes are available, as is a user manual, which includes a pavement distress identification guide.

From the beginning of its involvement in pavement management, MTC has acted as a facilitator. In 1981 several local public works directors asked the commission to document shortfalls in pavement maintenance revenues. It was estimated in an MTC report, Determining Bay Area Street and Road Maintenance Needs, that spending for local roadway maintenance fell short by \$100 million per year and that the Bay Area's 17,000 miles of local streets and roads had deferred maintenance costs of \$300 to \$500 million. In response to the study, the state legislature increased the state gas tax from 7 to 9 cents a gallon in 1982. Cities and counties received half of the additional revenue for use on local streets and roads. The tax increase, although a step in the right direction, barely made a dent in the backlog of pavement maintenance projects. Until individual jurisdictions, with MTC's help, accurately defined their needs for pavement maintenance dollars, maintenance was funded by the limited money generated from the state gas tax.

Success Story

One of the first jurisdictions in the area to survey the condition of its entire network and accurately define its needs was one of the original six users of the PMS, the city of San Leandro in Alameda County. In April 1986 the San Leandro city council was informed that the city's five-year need for pavement maintenance was \$11.5 million. Revenue for pavement maintenance over that five-year period was estimated to be only \$5.5 million. Seven months later the council requested that Department of Public Works and MTC staff deliver a formal presentation on the needed pavement maintenance revenue.

In the meantime a referendum was placed before Alameda County voters that would increase the county's sales tax by 1/2 cent. Almost 20 percent of the revenue generated from the proposed increase would go to public works departments for use on streets and roads. The evening before the vote on the referendum, San Leandro public works and MTC staff went before the city council. The council, after hearing the presentation, determined that if the referendum passed the next day, the portion of funds to be returned to the city would be used for pavement maintenance. Voters passed the referendum, giving San Leandro a steady source of revenue for pavement maintenance.

The San Leandro city council asked MTC staff in February 1990 to deliver another presentation on the status of the PMS. This time San Leandro had a fivevear need of \$8 million, and MTC estimated that \$10 million was available for pavement maintenance (see Table 1). The Pavement Condition Index (PCI) rose from a yearly average of 66 in 1986 to 79 in 1990. The PCI is the MTC PMS ranking of street sections, 100 being excellent and 0 signifying failure. Other cities in Bay Area counties that have additional 1/2 cent sales taxes for transportation purposes, including Berkeley, Woodside, and Belmont, also have been successful in adopting administrative policies to use these funds for pavement maintenance.

Like many of the other cities and counties that use the MTC PMS, San Leandro has opportunities to take advantage of services provided by MTC. Over the course

of the four-year period in which San Leandro's maintenance need decreased from \$11.5 million to \$8 million, many personnel changes have occurred in the public works staff. Each time there has been a change, the new person has attended a variety of MTC training sessions.

In many instances MTC PMS staff has taken the lead in making sure that the PMS, once started in a participating agency, does not get put on a shelf when there is staff turnover. New staff members are invited to MTC to receive an overview of the computer program and to allow MTC to evaluate their level of pavement management experience. Learning to use the computer program has been one of the major stumbling blocks for users in the implementation of the MTC PMS because many staff members have limited knowledge of microcomputers. The MTC PMS is a menu-driven application, but even so, MTC hired a staff person to assist users with computer problems. The computer hotline has proven to be an invaluable addition to the program because users may encounter difficulties in various aspects of the PMS, from the data entry feature to the budget scenario module.

Revenue Analysis

MTC initially became involved in pavement management to help document Bay Area revenue shortfalls for pavement maintenance. Cities that have implemented the MTC PMS have been successful in generating additional revenue for their pavement maintenance budgets, as well as in making better decisions on how to spend it. This success has been documented through comparison of Bay Area MTC PMS user and nonuser cities (see Table 2).

Each public works department in California is required by law to report the source of street and road revenues and how and where they are spent. MTC analysis included the nine-year period from fiscal year 1980–1981 to fiscal year 1988–1989. Overall, Bay Area MTC PMS user cities spent 32.2 percent of total street and road budgets on pavement maintenance, whereas nonusers spent 32.9 percent, an approximately 2 percent greater

TABLE 1 SAN LEANDRO PAVEMENT MAINTENANCE REVENUE ANALYSIS

	April 1986	January 1990
Average Pavement Condition Index (PCI)	66	79
5-year PMS recommended program	\$11.5 m	\$8 m
Estimated revenue for pavement repair	\$5 m	\$10 m
Pavement repair program deficit	\$6 m	_
Replacement cost for entire network	\$157.2 m	\$162 m
Percentage of pavement repair program to		
replacement cost	\$11.5 m/\$157.2 m = 7.3%	8 m/\$162 m = 4.9%

TABLE 2 COMPARISON OF REVENUES AND PAVEMENT EXPENDITURE CLASSES: BAY AREA MTC PMS USERS VERSUS NONUSERS

EXPENDITURE/	BAY AREA MTC PMS CITIES			OTHER BAY AREA CITIES				
REVENUE CLASS	1980/81-88/89	1980/81-83/84	1984/85-88/89	% CHANGE	1980/81-88/89	1980/81-83/84	1984/85-88/89	% CHANGE
PAVEMENT EXP. % TOTAL EXPENDITURES	32.2%	23.5%	37.8%	62.1%	32.9%	35.5%	31.4%	-11.5%
PAVEMENT EXPENDITURES PER MILE	\$8,348	\$5,294	\$10,792	103,9%	\$8,304	\$7,498	\$8,949	19.4%

DATA SOURCE: STATE CONTROLLER'S REPORTS; FY'S 1980/1981-1988/1989

TABLE 3 SUMMARY OF PMS BUDGET RESULTS

Miles Surveyed	Jurisdiction	Avg. PCI	Cost To Fix	Estimated Revenues	Shortfall
456	Alameda Co.	79	\$ 33.0	\$ 23.0	\$- 10.0
826	Placer Co.	49	69.0	15.0	- 54.0
724	Santa Clara Co.	66	49.0	33.0	- 16.0
500	Solano Co.	57	23.0	11.0	- 12.0
69	Belmont	57	5.0	1.0	- 4.0
218	Berkeley	49	59.0	10.0	- 49.0
65	El Cerrito	46	7.0	1.0	- 6.0
98	Menlo Park	57	7.0	3.0	- 4.0
32	Portola Valley	72	0.6	0.5	- 0.1
156	San Leandro	67	11.5	5,5	- 6.0
42	Suisun City	74	2.3	1.3	- 1.0
211	Vallejo	74	14.0	6.7	- 7.3
45	Woodside	61	4.6	0.6	- 4.0
45	Dublin	76	2,2	3.3	+ 1,1
105	Danville	82	5.2	1.7	- 3.5
725	Colusa Co.	65	21.0	4.0	- 17.C
46	Foster City	83	2.2	3.1	+ 0.9
1454	Sonoma County	66	75.0	20.0	- 55.0
29	Clayton	80	1,8	0.4	- 1.4
189	Livermore	84	8.2	4.7	- 3.5
79	Benicia	75	7.0	2.0	- 5.0
251	Richmond	83	13.4	5.8	- 7.6
160	Pleasanton	79	11.6	3.4	- 8.2
6525	AGGREGATE vailable \$160.0 = 37%	69	\$432.6	\$160.0	\$-272.6

expenditure on pavement maintenance by nonusers. The data for the nine-year period were broken down into two separate analysis periods: 1980-1981 to 1983-1984 and 1984-1985 to 1988-1989. The reason for the breakdown is that the PMS became available to Bay Area users in fiscal year 1984-1985. From 1980-1981 to 1983-1984 Bay Area MTC PMS users spent 23.5 percent of total street- and road-related revenues on pavement maintenance, whereas from 1984-1985 to 1988-1989 users spent 37.8 percent, a 62.1 percent increase in expenditures for pavement maintenance. From 1980-1981 to 1983-1984 other Bay Area cities spent 35.5 percent of total street and road revenues on pavement maintenance, whereas from 1984-1985 to 1988-1989 they spent 31.4 percent, an 11.5 percent decrease in expenditures for pavement maintenance.

Pavement maintenance expenditure per mile also was analyzed. The data in Table 2 show that Bay Area MTC PMS users averaged a total of \$8,348 per mile for the entire nine-year period, whereas other Bay Area cities averaged \$8,304 per mile. Broken down into the same time periods mentioned previously, the data show that MTC PMS user cities outperformed nonuser cities. From 1980-1981 to 1983-1984 MTC PMS users spent an average of \$5,294 per mile on pavement maintenance. From 1984-1985 to 1988-1989 an average of \$10,792 per mile was spent, an increase of 103.9 percent. Other Bay Area cities spent an average of \$7,498 per mile on pavement maintenance from 1980-1981 to 1983-1984. From 1984-1985 to 1988-1989 an average of \$8,949 per mile was spent, a 19.4 percent increase. MTC staff has yet to extensively analyze the data for these cities as has been done for San Leandro, but it is suggested that users of the MTC PMS have been able to document their needs and make pavement maintenance an important issue in their cities' budgeting processes.

Mutual Benefits

The continued support that MTC provides users in turn benefits MTC. As each user completes the survey of its street network,

it can develop its budget needs, enabling the agency to determine how much it will cost to bring the street network up to a "very good" condition (average PCI of 85) over a five-year period. With the needs analysis complete, MTC can estimate how much money the agency can expect to generate for pavement maintenance, which is subtracted from the needs estimate. The resultant amount is then used in the budget scenario module, which shows an agency where its dollars may be best spent.

As more and more agencies complete needs analyses, MTC is able to refine its growing Bay Area aggregate chart (see Table 3), which helps to better document Bay Area needs and shortfalls and gain support in the state legislature for more revenues for cities and counties. Proposition 111, recently passed in California, provided for \$3 billion from the gas tax increase (a total of \$15 billion over ten continued on page 28

FHWA PMS Requirements

While the focus of this article is on a pavement management system for local jurisdictions, information relating to state management system requirements is given below.

Federal Highway Administration policy requires that each state establish a PMS to assist decision makers in finding cost-effective strategies to evaluate and maintain pavements in a serviceable condition. According to the policy, PMSs should include the following components.

Inventory

An inventory of the federal-aid system that emphasizes high-volume roads should be established. The inventory should include all necessary data, such as materials and structural composition, to ensure that location and composition of each section of pavement can be readily accessed.

Data Base

The data base should contain collection, storage, processing, and retrieval of pavement condition and serviceability data for the federal-aid system. These data should not only be adequate to satisfy determinations of need, but should form the basis for a historical data bank that can be used for the establishment of criteria for design, construction, maintenance, and rehabilitation of pavements.

Assessment of Pavement Performance

Measurements should be taken of the change in pavement condition or serviceability over time. History of pavement performance indicating the serviceability of various materials, structure layers, and pavement composition for use in determining trends and capabilities of various design, construction, maintenance, and rehabilitation standards should be accumulated.

Network Needs Assessment

Current and projected network needs with consideration of budget and other constraints should be provided.

Analysis

Analyses should include (a) a procedure to provide and analyze performance data over time for construction, reconstruction, and rehabilitation alternatives and strategies; (b) a mechanism to analyze project alternatives and strategies, including cost-effectiveness and prioritization with consideration of restraints; and (c) an ability to provide and consider feedback. Reliable performance data on rehabilitation techniques is necessary in the rehabilitation design process.

Pavement Design

Design and rehabilitation strategies should be guided by the 1986 AASHTO Guide for Design of Pavement Structures or other practices and procedures that have proven satisfactory in a particular location.